Sustainable Economy in the West of England?

A report by the Sustainable Economies Research Group (SERG)

with input from Centre for Environment, Society and Resilience

UWE Bristol

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About the Sustainable Economies Research Group

The Sustainable Economies Research Group (SERG) conducts ground-breaking research in the field of sustainable economy. The Group's members are drawn from across the University of the West of England as well as externally. SERG is premised on the belief that bringing forth a sustainable economy requires a systems approach by inter-disciplinary experts combining deep understandings from economics and finance (other social sciences), engineering and physical sciences. Members are concerned with the task of connecting with organisations, government and civil society in driving change in the world to ensure a realistic and just transition, but also one that is empirically robust and informed.

SERG webpage: https://www.uwe.ac.uk/research/centres-and-groups/serg

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Executive summary

The report enquires into the sustainability of the economy in the West of England. The purpose of this report is to identify the key climate change and biodiversity challenges facing the West of England, and to recommend how the region's economic strategy could address them. In this report the geographic area of the West of England region is defined as WECA area (Bristol, Bath and North East Somerset and South Gloucestershire) as well as North Somerset. The research assesses how the region can remain within thresholds for global environmental pressures (and a safe operating space for humanity), while developing value propositions that support long-term regional prosperity. The findings are intended to inform policy decisions that deliver economic development and environmental sustainability simultaneously.

The report provides insight on:

1. Characterise some of the key natural environment and nature attributes and challenges for the region and strategies for nature recovery that can be impacted by policy decisions. 2. Estimates of scope 1 greenhouse gas (GHG) producing sectors in the region, including those associated with air transport services. This is provided in a detailed disaggregated form and employment by sector.

3. Identification of practical pathways to reduce emissions in high-emitting sectors.

4. Estimates of embodied (scopes 1, 2 and 3) GHGs attributable to final goods and services of sectors, and strategies to address them.

5. A synthesis of current knowledge on climate risks and adaptation needs in the region.

6. Highlight examples and case studies that demonstrate progress local leadership and progress.

7. A synthesis of regional challenges and value propositions, highlighting the economic measures that must be redefined to enable a sustainable economic transition at both regional and national levels.

Overall, this report finds that the West of England faces significant environmental sustainability challenges[1] and that not all economic growth (in its current form) will be compatible with long-term prosperity. However, it also identifies strong regional ambition and leadership, alongside major opportunities to address environmental pressures while improving regional economic outcomes.

Key findings include:

- Transport-related emissions are key to decarbonising the region. Transport accounts for 54% of direct GHG emissions, comprising 32% from road transport and 21% flight related), as shown in Table 6[2]. Progress in reducing road transport emissions has been slow. **Recommendations:** Support the electric vehicle (EV) transition as a core component of meeting GHG targets, while recognising that large-scale EV uptake may be constrained by space, infrastructure and affordability (and other constraints), particularly in urban areas. Address inequalities in EV transition to help ensure fairness It will be important to return to policies which emphasise cars as one supporting part of the transport system, with most people making most of their journeys by other means or taking advantage of the digital solutions.
- Air transport services emissions are substantial, the majority of which come from flights. Bristol Airport aims to deliver Net Zero Operations by 2030, but, currently, “operations” do not include flight emissions, which reside with the airlines. Passenger numbers are rapidly increasing with further GHG implications.

[1] A selection of global environmental impacts were looked at in this report, including nature/biodiversity, climate and greenhouse gas-related impacts.

[2] Transport-related emissions includes an estimate of flight-related emissions.

Recommendations: Consider carefully the impact of air transport services on meeting future regional and national GHG targets and budgets and consider how increases in passenger numbers and expansion may impact these. When evaluating the economic impact of airports look at case by case and account for monetary injections as well as withdrawal from the UK economy and externalities when assessing overall economic impact. The Climate Change Committee recommends demand management for aviation until emissions are addressed, given that large scale decarbonisation of aviation looks to be at least a decade from being achievable and the fast growth but large externalities. The aerospace sector will be vital in achieving this. Frequent flyer levies are one of the more popular climate mitigation policies.

- Eighty percent of direct (scope 1) GHGs from the region's commercial, industrial (C&I) and public sectors arise from 15 sectors, with the top five responsible for 60% once electricity and transport emissions are reallocated to their producing sectors. The latter account shows that the region can focus efforts on key sectors to address the vast majority of C&I and public sector GHGs. **Recommendations:** Prioritise GHG mitigation in the highest-emitting sectors and provide tailored support to help them transition.

- The top emitting sectors together account for only 1.8% of total regional employment, while nine of the top fifteen sectors by employment are very low direct emitters. This suggests that reducing emissions in the top sectors is unlikely to have a significant negative impact on overall jobs for the region. Moreover, the transition to net zero offers opportunities for green job creation.
  Recommendations: Recognise that the regional transition to net zero is unlikely to harm overall employment, and design policies that support

workers in high-emitting sectors to transition smoothly where needed.

- There are opportunities for economic, human and natural capital to benefit from the transition to net zero. Realising these opportunities requires a strategic approach that integrates regional value propositions into economic planning. **Recommendations:** Make the realisation of regional value propositions a central component of the sustainable economy transition, ensuring they feed directly into the region's economic strategy. Examine how devolution can enhance the region's ability to recognise, capture and reinvest in these value propositions, enabling a green economy that supports long-term prosperity.

- There is a substantial delivery gap in household retrofits. **Recommendations:** Unitary Authorities (UAs) and Local Authorities (LAs) should examine opportunities to address this ambition-reality gap and incorporate opportunities to address regional inequalities. The UK government's Warm Homes Plan outlines a plan to dedicate £15 billion to households across the UK over the next five years for solar panels and other green tech.

- Embodied GHG emissions (scopes 1, 2 and 3) attributable to final demand of sectors in the region are over three times higher than direct emission. The final demand of wholesale trade accounts for thirty-three percent of these emissions. Some of these are easy to address via sustainable procurement and choice editing without adversely impacting businesses. Strong circular economy business models can be key in addressing these embodied GHGs (and other environmental impacts) and can help address future resource security and productivity (via reduce input costs and exposure to future inflation). Many of the embodied emissions are associated with food and drinks and other products that firms use in delivering their final goods and services. **Recommendations:** The West of England Combined Authority (WECA) and LAs should incorporate the promotion of a strong circular economy into both short-term and long-term strategies to increase environmental integrity and supply chain resilience.

Particularly circular services and reuse models, which can help ensure regional jobs and value whilst strongly addressing environmental and input costs. Total loss of green economy production (and related jobs) from the UK to foreign competitors is also less likely with such models.

- The region has a constrained land base and spatial limitations on renewable energy and industrial expansion. Flood risk compounds this constraint.
  Recommendations: Focus development strategies on brownfield reuse, rooftop generation and targeting low-sensitivity locations for renewable energy. Check that we have an integrated land use strategy for the WoE, one that is fully integrated with the Local Plan for each of the UAs.

- Farming is the most major land use in the region and innovation in the sector. **Recommendation**: innovation and a supportive and regional approach could be important in addressing GHGs but also nature recovery and food security, with the potential for economic benefits for the region. It is recommended that a full assessment of the benefits to economy, prosperity and resilience from taking a joined-up approach and regional plan to address these interlinked challenges should be assessed as well as research to identify which business models deliver improved productivity and maximise environmental and societal benefits.

- Current renewable generation is significantly lower than the region's electricity demand. Certain sector growth, such as AI, will exacerbate this gap and could cause trade-offs between renewable energy and nature recovery given the constrained land-based for renewables and at the same time trade-offs in developing tidal resources and nature recovery within the ecosystem rich and nature sensitive Severn estuary.
  Recommendation: Assess how the WECA 2025 strategy will affect energy demand, water use and nature recovery, particularly in high-growth sectors.

- The region is under-prepared for several climate-related risks, such as flooding.
  Recommendations: Accelerated and coordinated adaptation action is required. LAs and the WECA must accelerate adaptation measures across all priority risks. Ensure adaptation measures embed equity and just transition principles. Integrate adaptation across policy areas, especially the water sector and in relation to net zero commitments. Strengthen multilevel governance between WECA and LAs to support joint planning, data sharing and capacity building. Improve monitoring, evaluation and reporting of adaptation actions, including through deliverability checklists.

- The Discussion section highlights the need to understand productivity in relation to all five capitals (human, financial, environmental, social and manufactured) and to improve the balance between them. This is essential for a sustainable economic transition.
  Recommendations: Ensure that regional and national economic management accounts for the five-capitals framework and redefines productivity to reflect outcomes across all capitals, not just financial output.

- A sustainable and prosperous economy requires optimising the balance of all five capitals so that economic activity does not erode the foundations of long-term wellbeing.
  Recommendations: Shift towards a more systems-informed approach to economic strategy, using broader productivity metrics that reflect environmental, social and human outcomes, not only output per hour worked.

- The research highlights that national security, including food and water security, resilience to climate impacts, and risks from ecosystem collapse, must be considered within economic policy. This is reinforced by recent assessments such as *Global biodiversity loss, ecosystem collapse and national security* (Defra, 2026).
  Recommendations: Integrate national security resilience into regional and national economic planning, ensuring investment supports long-term stability and

sustainability.

- There are significant opportunities for the region to lead in sustainable-economy investment and value-proposition development. However, there are also risks in moving too slowly, given the pace of environmental and economic change. **Recommendations:** Undertake action research and strengthen data and insight generation in collaboration with national, regional and local stakeholders to identify the most effective investments and value propositions. Recognise that the risks of not taking leadership in the sustainable-economy transition are likely greater than the risks of acting early.

Introduction and background

In 2025, WECA set out their West of England Growth Strategy (WECA, 2025). The growth strategy claims to help bring together local plans for a vibrant and sustainable economy[3]. However, this will be challenging in the current context. Global economic growth paths are driving unsustainable and worsening pressures on the natural environment.

Planetary boundaries allow a scientific understanding of anthropogenic global environmental pressures in relation to the state of the Earth system as a whole (Richardson et al., 2023). They demonstrate the need to stay within critical threshold values for a safe operating space for humanity, as defined in Rockström et al. (2009) and later in Richardson et al. (2023) (see Figure 1 and further explanation below).

Action is needed to direct economic growth paths in more sustainable trajectories. The state of the economy and the environment will be increasingly

[3] Each of the West of England's unitary authorities has developed plans that set out clear action and ambition for their areas. These strategies are consistently underpinned by a commitment to inclusive and sustainable growth, providing a strong foundation for coordinated regional progress.

interconnected as fallout from further breaches of key threshold values for global environmental pressures materialises.

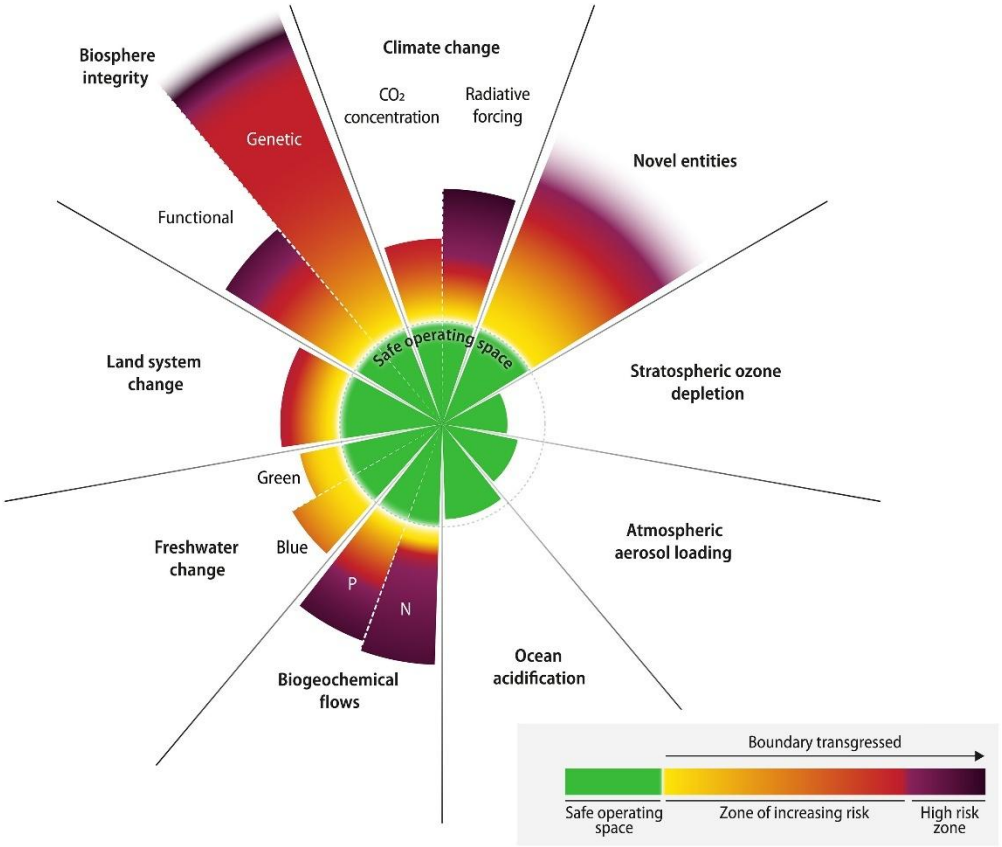
As illustrated in Figure 1, the Earth is now outside of a safe operating space for humanity. Six of the nine key control variables for planetary boundaries have been transgressed. These are largely being driven by the nature of global economic development. If economic growth continues without sense checking in terms of environmental impact, the situation will deteriorate further.

Past assessments of planetary boundaries (see Rockström et al., 2013, and Steffen et al., 2015) show a rapid deterioration in a relatively short time span (see Richardson et al., 2023). There is increasing recognition that rapid degradation caused by climate change poses potentially existential risks for human survival (Kemp et al., 2022)[4].

At a regional level, the West of England is already facing shifting weather patterns, rising sea levels and increased frequency of extreme weather events (WECA, 2025e). With the onset of greater levels of devolution in England, there is opportunity for the region to show leadership and illustrate intra-regional collaboration to drive the economic transition, developing a coordinated governance that engenders strong sustainability principles and prioritises reduced inequalities.

Figure 1: Current state of control variables for all nine planetary boundaries (Richardson et al. 2023).

[4] https://www.pnas.org/doi/full/10.1073/pnas.2108146119



Within the WECA (2025) growth strategy, five priority sectors are identified that will drive growth potential of the region for the next decade:

1. Advanced manufacturing
2. Digital technologies
3. Clean energy industries
4. Creative industries
5. Everyday economy[5].

Much of the growth strategy relates to sustainable growth[6]. It states that growth is key to improving living standards across the region. Helen Godwin, the Mayor of the West of England, says "*growth means that the residents of this region will*

[5] The Everyday economy mentions the caring economy, nighttime economy is also mentioned, as well as mentioning decisions around skills, housing, and transport that deliver for essential workers.
[6] Sustainability is referenced regularly in the WECA Growth Strategy (2025). For example, the word "sustainable" is mentioned 52 times, "green" 97 times and "nature" 40 times.

see and feel a real difference in the opportunities they and their families can access, the services available to them and the places they live". (WECA, 2025, p.2).

Although increasing productivity is cited as important, it is stated that productivity growth is not pursued for its own sake. Rather, the growth strategy states that it seeks "*securing investment for our part of the world: new jobs for local people; better transport to cut congestion and boost productivity; and cleaner, cheaper energy."* and that WECA is *"committed to ensuring it's a place where everyone can live well*". (WECA, 2025, p.10). Central to the growth strategy is the ambition to deliver regional growth and prosperity[7], and to make the region a great place to live.

To deliver prosperity it is first critical to define what prosperity is.

From an in-depth analysis and examination of the relationship between prosperity and growth, the UK Sustainable Development Commission (2009) report stated that: "*Prosperity consists in our ability to flourish as human beings – within the ecological limits of a finite planet. The challenge for our society is to create the conditions under which this is possible. It is the most urgent task of our times*." (Sustainable Development Commission, 2009, p.102). The report systematically identifies the positive and negative relationships between growth and prosperity[8]. It emphasises that although growth can improve wellbeing, the

[7] See for example: "*The West of England's unique fusion of people, place and nature is a strategic advantage – attracting talent, improving health and wellbeing, boosting productivity, and securing long-term prosperity. Protecting and enhancing our landscapes is not an optional extra: it is integral to our growth story*" (WECA, 2025a, p.26). There is also mention of long-term prosperity and rural prosperity with the document. See also: *"Beyond financial returns, investors will play a central role in delivering inclusive, sustainable communities – supporting innovative construction methods, climate-resilient infrastructure, and a diversified development sector. The Future Places Fund is not just a funding mechanism – it's a strategic platform for unlocking long-term value, regional prosperity, and impactful private sector partnership." (WECA, 2025, p.103). "While our Growth Strategy will focus on our core areas of strength, the decade ahead will unlock broad investment potential across the West of England; driving prosperity"* (WECAa 2025a, p.33).

[8] Much of the document emphasises the importance of living well. The report makes clear that not all growth is good growth. As a simple example, wars can generate government demand-led growth, but they bring substantial suffering to humankind.

‘blind pursuit’ of growth can substantially degrade the environment, human wellbeing and create inequalities; all potentially damaging prosperity.

It is, therefore, positive that the growth strategy (WECA, 2025) emphasise a focus on living well and a focus on sectors such as clean energy industries, creative industries and the care sector. These are existing regional strengths and align closely with the UK’s Industrial Strategy (2025), aiding the region’s ability to contribute to national priorities.

This report aims to complement and add further insight to the growth strategy by highlighting opportunities and challenges for biodiversity and GHG reductions in the region, alongside important insights on land use and climate change for a sustainable economic transition.

Conceptualising a sustainable economy

Economic opportunities can derive from getting ahead of the curve in the sustainability transition. For example, renewable energy capacity is projected to globally increase almost 4 600 GW between 2025 and 2030, double the deployment of the previous five years, conferring competitive advantages as well as environmental benefits relative to traditional thermal generation technologies (IEA, 2025).

Additionally, cities in the region, such as Bristol, are renowned for their leadership on climate change and green economy. The growth strategy (WECA, 2025) could be strengthened by a clear conceptualisation and description of sustainable economy, outlining critical aspects to achieving a sustainable economic transition.

To achieve this, we start by identifying three primary aims of sustainable development.

The Brundtland definition of sustainable development is currently the most widely accepted starting point for scholars and practitioners focused on environment and development dilemmas: “*development that meets the needs*

of the present without compromising the ability of future generations to meet their own needs'' (World Commission on Environment and Development, 1987).

Aligned with this landmark report on sustainable development the concept has three key aims:

1. Economic aim: improved equity in resource distribution across and within societies.

2. Social aim: improving human wellbeing.
3. Environmental aim: development that stays within environmental constraints and maintains ecological integrity over intergenerational timescales (Sneddon et al., 2006)[9].

From this, we define and conceptualise sustainable economy as "*one that is economically viable, facilitates high levels of wellbeing for its citizens and communities (partially through reducing inequalities), creating sustainable value, and avoiding dis-value for society and environment and is resilient.*"[10] Sustainable economic growth can be defined in a similar way[11].

Disvalue for society is defined as damage to humans' 'capabilities to flourish'. Disvalue for the environment is defined as damage inflicted on the environment and earths systems contributing to transgressing ecological limits and jeopardising integrity of ecological systems (Bradley et al., 2020) [12].

[9] These three key aims of sustainable development that this project applies draw on Sneddon et al. (2006) because are reasonably robust and well regarded in academic circles. The third aim is important not just for nature but for humans also as ultimately humans rely on inputs from the environment to survive (clean air, water and food, etc.) and also attain wellbeing from nature and the environment (REF), there is also increasing recognition that rapid degradation in relation to key global environmental pressures such as climate change does pose risks for human survival (Kemp et al, 2022).

[10] Synthesis drawing on work by Bradley et al. (2020) and Bradley (2021) and other work such as World Economic Forum (2022) (in relation to resilience).

[11] Sustainable economic growth is defined as "additional economic activity that better meets needs and improves peoples' capabilities to flourish (partially through reducing inequalities) whilst avoiding disvalue for society and environment (and sometimes improving integrity of ecological systems)".
[12] See key global environmental pressures outlined in Steffen et al. (2015) and later updates on these. A challenge is that our current economies miss much value and disvalue that can be generated by economies in the processes of production and consumption, as very large amount of social and environmental value are not included in market prices and excluded from the cost, benefit calculations and prices we see in market economies.

It is becoming increasingly clear that a sustainable economy needs to be resilient to climate change and other threats that we may face moving forward into the future[13] and that the ways we generate prosperity itself are resilient (World Economic Forum, 2022; Defra, 2026). Economic viability and productivity (particularly for some sectors) are important for a sustainable economy, but these need to be achieved in a way that does not erode the five fundamental capitals (financial, human, natural, social and man-made) that enable a region, its economy and people to function and flourish.

All implementation takes place at the local level[14]. The region therefore needs investment to deliver a sustainable economy that can deliver both good economic outcomes and positive outcomes for human, natural and social capital, as well as the maintenance and improvement of manufactured capital to achieve these. To do this well, regional strategies need to be more data-informed. Intelligent approaches will be needed to recognise potential synergies and trade-offs, as well as beneficial and adverse impacts on the capitals from economic growth. Evidence and analysis will be key to identify the best options for sustainable and inclusive economic development and a selection environment to encourage (potentially making use of new devolution powers) the generation of good impacts across all five capitals.

Evidence from the Sustainable Development Commission (SDC) (2009) demonstrates how poorly informed or mismanaged economic policy can lead to growth that erodes other forms of capital, such natural, human and social capital.[15] This report, alongside Richardson et al. (2023), makes clear that current economic systems are environmentally unsustainable, even when considering only a subset of key environmental pressures. A sustainable economic transition for the region will require an intelligent, data-driven and

[13] For example, in relation to key aspects such as infrastructure, housing, food and water provision.

[14] High-level, national strategies need to be implemented by businesses, citizens and people on the ground, to be realised. There is, therefore, a place dynamic to this.

[15] As identified by the Sustainable Development Commission (2009) and in Bradley (2021), growth often leads to environmental degradation because our technologies and institutions do not currently avoid significant externalities and disvalue to the environment.

well-governed approach, supported by strong regional strategy, investment, monitoring, evaluation and continuous learning.

At the micro level, Evans et al. (2017) identify five principles that can guide businesses seeking to lead on sustainability:

- "*Principle 1: Sustainable value should incorporate economic, social and environmental benefits conceptualised as value forms*.
- *Principle 2: Sustainable business models (SBMs) require a system of sustainable value flows among multiple stakeholders including the natural environment and society as primary stakeholders*.
- *Principle 3: SBMs require a value network with a new purpose, design and governance*.
- *Principle 4: SBMs require a systemic consideration of stakeholder interests and responsibilities for mutual value creation*.
- *Principle 5: Internalising externalities through product service systems (PSS) enables innovation towards SBMs*".

(Evans et al., 2017, p.605)

With evidence-based policy and governance, the region can deliver productivity, jobs, incomes and environmental regeneration, while decoupling growth from environmental harm. Economic viability remains essential, but it should not be prioritised above the delivery of social and environmental goods that underpin long-term prosperity.

The economy should serve people and the ecology on which it depends, helping people adopt ways of living and consuming that entail substantially reduced ecological footprints alongside benefits to wellbeing and health. Prioritising economic growth above all else undermines both current and future

prosperity[16]. This is reinforced in the SDC report (2009) and major economic evaluations showing that failures to address climate change and biodiversity loss represent the largest market failures in history (Stern, 2006; Dasgupta, 2021).

Poor economic decisions already weigh on the region's prosperity, and the wrong forms of growth will further erode long-term wellbeing. A data-informed and systemic approach is therefore essential.

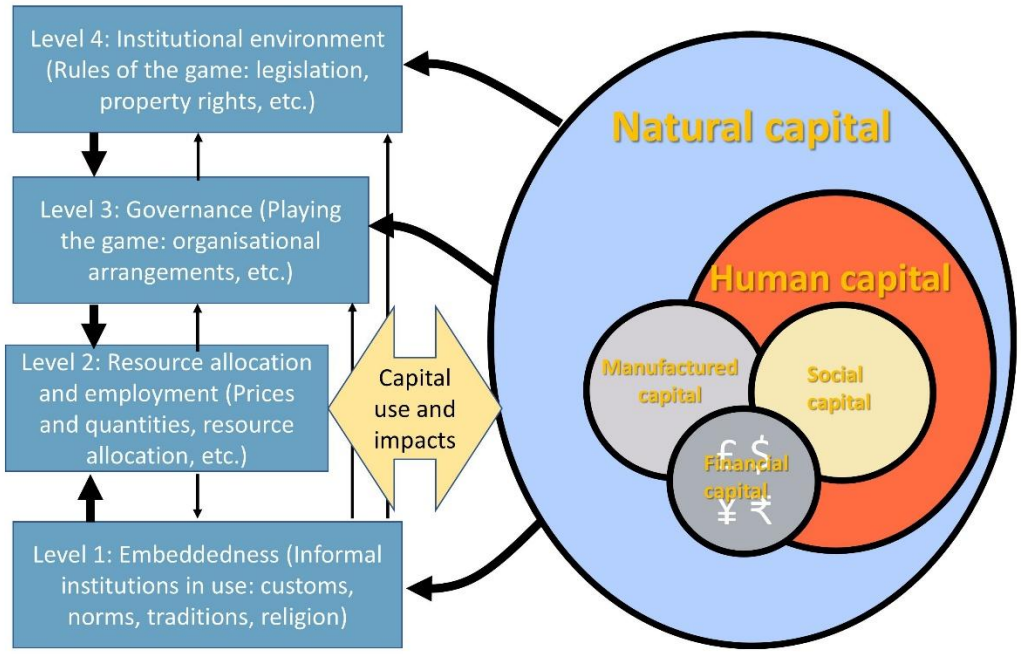
To support critical thinking on sustainable economy design, this report applies the five-capitals framework (Porritt, 2007), integrated into a sustainable-economy model (Bradley, 2021). All physical inputs to the economy originate from the natural environment, and all waste ultimately returns to it; only some of which can be safely absorbed.

- Natural capital (biodiversity and ecosystem services) is the foundational capital on which all others depend.
- Financial capital enables investment and production.
- Human, social and manufactured capital interact with natural capital to generate economic value, jobs and wellbeing.

Different products and services affect these capitals in different ways depending on how they are produced, used and managed at end-of-life. Economic structures (pricing, business models, policy, regulation) and social norms shape these outcomes and ultimately determine whether economic cycles are sustainable (see Figure 2).

[16] Also see report by Jackson (2024).

Figure 2: Conceptual framework to inform sustainable economy strategy (Bradley et al 2026 building on Bradley 2021).



The economic factors shown in Figure 2, such as pricing (L2), business models (L3), and policy, incentives and regulation (L4), together with the wider social context and narratives that shape how people think, feel and act (L1), determine how the five capitals gain or lose value[17] (or result in dis-value[18]) over an economic cycle[19]. These influences ultimately decide whether economic activity is sustainable and whether the economy as a whole moves towards, or away from, a sustainable economy.

[17] Value is defined in Bradley 2021, essentially this can be in the form of use value, non-use value and exchange value.

[18] Dis-value is defined to society is defined as damage to humans' 'capabilities to flourish'; dis-value to the environment is defined as: 'damage inflicted on the environment and earths systems contributing to transgressing ecological limits and jeopardising integrity of ecological systems' (see Bradley 2021, p. 1326 and earlier discussion in Bradley et al 2020).

[19] This is an extension and development on Bradley 2021.

Reconciling differing capital impacts from different sustainable economy strategies – an illustration

Global evidence shows that the scale of material flows through economies drives many environmental impacts (Allwood et al., 2011; Steffen et al., 2015). This creates a challenge for regions pursuing green growth. For example, shifting from fossil-fuel cars to privately owned electric vehicles only partially reduces environmental impact because EVs still require large quantities of materials that are only partly recyclable. This can shift environmental burdens elsewhere in the system (problem and cost shifting).

This underscores why a systems and data-driven approach is essential to inform optimal sustainable growth pathways (maximising sustainable value). Evans et al.'s (2017) Principle 5 highlights the potential of product-service systems (PSS): *"Internalising externalities through PSS enables innovation towards sustainable business models (SBMs)"* which build on performance-economy principles (Stahel, 2013). Business model change towards circular economy offers many potential solutions particularly those focused on reuse and remanufacturing (Bocken et al 2016).

Advanced PSS business models (an innovation in business governance at Level 3 in Figure 2) have high potential to decouple materials and environmental impact (improving the natural capital balance) from growth and value creation (Stahel, 2013).[20] For example, the business model shift from making money from selling physical products or 'stuff' to selling guaranteed outcomes, capabilities or services. For example, an energy company transforms its business model from selling electricity and gas to providing useful energy service (e.g. warmth) that the consumer requires, at the same time incentives for energy and resource conservation dramatically change (Governance, L3 in Figure 2 matters). They can also be strong economically; such business models can generate some of the highest economic surplus and productivity (improving financial capital balance) while substantially improving the natural

[20] For examples see Yang et al (2018).

capitals balance, offering higher environmental integrity. They can also generate substantial regional jobs (improved human capital balance).

However, one caveat (and potential trade off) is that such green growth approaches can transfer the means of consumption to the producer, giving the producer an increased level of power. Therefore, one of the key challenges in adopting advanced services for green growth, is to ensure that consumers do not end up getting 'locked in' or paying unnecessary high prices for the services provisioned to them. Regions must ensure strong governance and competition frameworks to help mitigate adverse impacts on social and human capitals balances. Care must be taken to create a selection environment (at Level 4 and 1 in Figure 2) that gives consumers choice and a share of the economic benefits. These considerations are essential if advanced service models are to support the first and second aims of sustainable development, keeping social sentiment (also at Level 1) aligned with the green transition. Further evidence is provided in Appendix 1.

How we attempt to get there matters

WECA (2025) have a focus on just transition. 'Just transition' can relate to fairness, equity or distributional impacts though different definitions are emerging in the literature. Equity can be thought about in different ways from equity of access to resources or equity of outcomes. There is a need to discuss "fair transition". This has been borne out of the recognition from within the labour movement that the fate of the environment and workers is intertwined (Sun et al., 2023). As the number of entities working towards achieving Net Zero has grown, the concept has gained traction recently (Wang and Lo, 2021), however definitional consensus has yet to emerge. Heffron (2024) categorises this diversity of approaches as relating to climate justice (sharing the benefits and burdens of climate change from a human rights perspective); energy justice (the application of human rights across the energy life cycle); and environmental justice (aiming to treat all citizens equally and to involve them in the development, implementation and enforcement of environmental laws and

policies). Cross cutting each of these disciplinary perspectives is a common thread which emphasises the salience of ensuring distributional, procedural and restorative justice across space and time (Heffron and McCauley, 2019). Recognition is not the same as establishing a means of making the concept work in practice. It is clear that fairness matters to people in relation to addressing climate change (see Sweetman & Whitmarsh, 2015). In democracies, the transition to a sustainable economy relies critically upon keeping social sentiment and the social and political embeddedness (L1 of the framework in Figure 2) aligned with positive perceptions and of it being a good thing and the right thing to do and progress with. Trust and social capital (right hand side of Figure 2) matter for the transition, it will not happen without. As can be seen social capital on the right side of the diagram is one of the five capital outcomes of the prevailing interaction of the institutional economic regime and set up (at the different levels) that is attempting to facilitate a sustainable economy.

1. Natural environment and economy

The natural environment in the West of England, is one of the reasons why so many people are attracted to work and live in the region (WECA 2025).

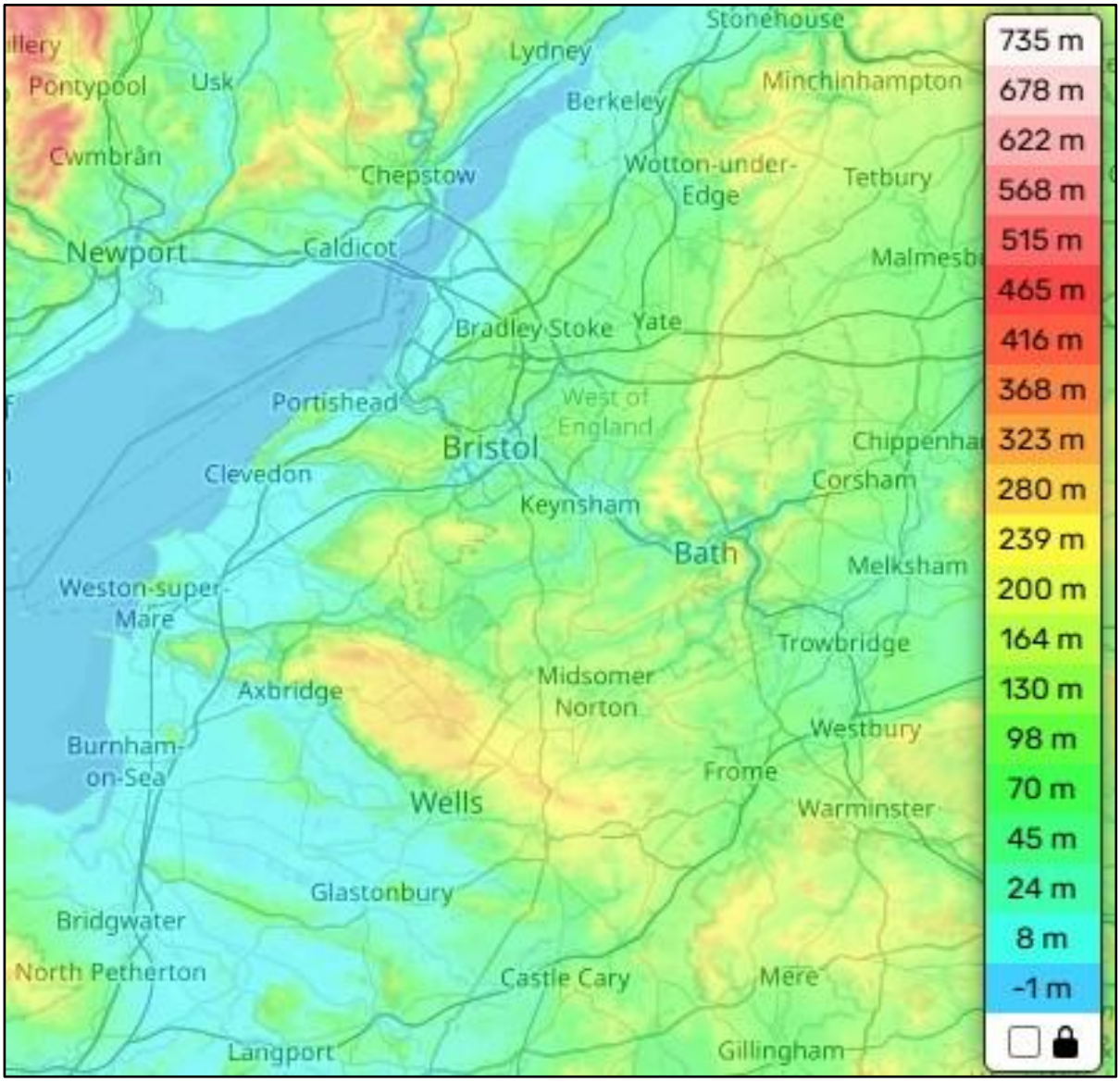
This section characterises some of the natural capital capabilities and realities of the region including key challenges and opportunities for nature recovery.

WECA declared a Nature Emergency in 2023. All the Unitary Authorities in the region have declared a Nature Emergency and have related plans (BANES 2025, North Somerset Council, 2025, Bristol City Council, 2025a, South Gloucestershire Council, 2025, 2025a).

1.1 Natural environment in the region

The region is ecologically diverse. It encompasses coastal zones, prominent hills, river valleys, woodlands, grasslands, wetlands and urban green spaces. In addition, it intersects with several National Character Areas (natural subdivisions of England based on a combination of landscape, biodiversity, geodiversity and economic activity defined by Natural England) including the Mendip Hills, the Cotswolds, the Severn Estuary and the Avon Valleys. See Figure 3 for the topography of the region.

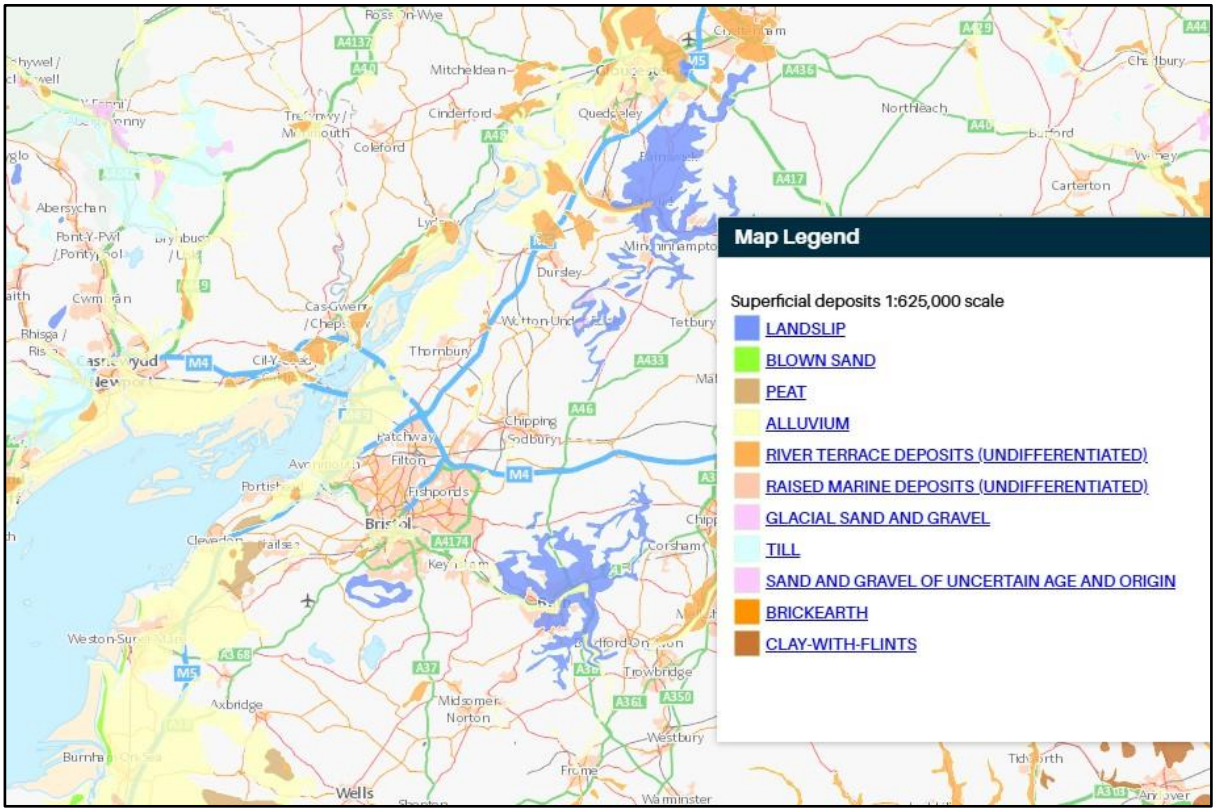
Figure 3: Topography of the West of England[21].



As can be seen on the map, certain parts of the region are low lying, particularly parts of North Somerset, South Gloucestershire. The geology of the region is presented in Figure 4.

[21] England topographic map. Available at: https://en-gb.topographic-map.com/map-kb57/England/?center=51.43518%2C-2.80426&zoom=10

Figure 4: Surface Geology (British Geological Survey, 2025).



Forest cover of the region is estimated to be approximately 10–12% of total land area (WECA, 2025b), aligning with the broader woodland coverage in England of around 10% nationally (ONS, 2024). WECA has targeted an increase in semi-natural broadleaved woodland cover by 2,500 hectares (from 8,000 ha to 10,500 ha, or by 31%) by 2030 (WECA, 2025d).

The region also interacts with several Areas of Outstanding Natural Beauty (AONBs) due to its geographical location and proximity to protected landscapes. Overlapping AONBs include the Cotswolds AONB (one of England's largest AONBs comprising rolling hills, limestone grasslands and historic villages covering parts of South Gloucestershire and Bath and North East Somerset) and the Mendip Hills AONB (characterised by limestone ridges, caves and gorges and lying south of Bristol and Bath and North East Somerset). Other AONBs that are not directly within the West of England but adjacent to its boundaries and may affect aspects of planning include the Cranborne Chase and West Wiltshire Downs AONB and the Wye Valley AONB.

Interactions with the wider Severn estuary are significant for the region. The estuary has the second-highest tidal range in the world (up to 15 metres range), it is also fished (commercially and recreationally) yielding economic values, and is an important nursery for organisms for the surrounding seas. There are good prospects for renewable tidal related energy to decarbonise future increases in electricity generation, but care needs to be taken in its scale, design, delivery and implementation due to impacts on nature recovery and biodiversity. To see most recent discussions around feasibility of various energy related generation opportunities of the Severn estuary and the trade-offs for ecology and nature of the estuary which can be significant see the latest Severn Estuary Commission Report (2025). Taking account of commercial issues, legislative challenges, and stakeholder views, the Commission has concluded that, at this stage, the development of a large barrage should not be pursued. The Severn estuary is one of the most biologically significant estuarine systems in the UK, designated as a Special Area of Conservation (SAC) and a Ramsar site, recognising its importance for rare habitats and species. It supports over 100 species of fish including those of conservation importance such as migratory Atlantic salmon, European eel and twaite shad as well as numerous non-fish species and habitats of national and international importance (BART 2025). The estuary also supports substantial populations of migratory and overwintering wading birds including significant populations of species such as redshank, dunlin and curlew (Ferns 1994). Significantly, the Severn estuary provides ecological connectivity between river basins including the Bristol Avon, Usk, Severn and Wye, forming a network of habitats upon which many freshwater and marine species depend. Coastal processes provide benefits to areas within the West of England adjacent to the estuary and, conversely, activities undertaken on land bordering the coast has ramifications for the estuary and its wider connections. It is noteworthy that the Severn estuary has been substantially polluted in the past from industrial activity (and other activities) but, in some instances, has recovered somewhat for example in relation to past heavy metal pollution (Nkopuyo and Everard 2021). Habitat loss remains widespread due to decline in

management practices, agricultural practices and development for housing and industry (and consequent loss of river and floodplain habitats) and barriers such as weirs in river obstacles, with pollution also impacting the Severn Estuary (Rivers Trust 2025).

1.2 Population and water use

The estimated human population of the region is currently approximately 1,225,000 people (WECA 2025d). Water use is primarily managed by two utility companies: Bristol Water and Wessex Water. The water is sourced from surface water reservoirs including Chew Valley Lake, Blagdon Lake, Barrow Gurney and Cheddar Reservoirs (noting that plans are in hand to build a second Cheddar Reservoir) with a substantial amount also abstracted from groundwater aquifers in the Cotswolds, Mendip Hills and surrounding areas but only limited direct abstraction from rivers. Global averages of water use (UNESCO, 2024) include approximately 12–15% of total freshwater withdrawals for domestic use, approximately 70% for agriculture and 15-25% for industry.

Analysis by the market operator MOSL suggest that, like many water operators across the UK, both Wessex Water and Bristol Water operate with a surplus of water relative to demand (MOSL 2025). However, the region is just a small subset of the operating range of Wessex Water and represents a dense agglomeration relative to the wider operational landscape. The cities and agglomerations across the WECA region therefore have asymmetrical water demand, and water security on a localised basis depends on import of water abstracted from a wider area. As water stress across the British Isles is compounded by the impacts of climate change, such as rising atmospheric evaporative demand (AED) as well as domestic and other human uses (Gebrechorkos et al. 2025). These factors withdraw moisture from soils, rivers and vegetation even in areas such as the West of England where rainfall remains stable (Environment Agency 2025). By 2050, if no action is taken to improve resilience, there is likely to be a significant shortfall in water availability for the wider west country (Bristol, Wiltshire through Somerset to Devon and Cornwall),

possibly by as much as 202 million litres per day which is the amount needed to supply 1.87 million customers (West Country Water and Environment, 2025)[22]. The region requires a strategy and governance approach spanning households, industry and land uses for water conservation and more accurate predictions of how water use by industry is likely to change in future due to the potential growth of AI and other sectors[23]. Commercial and industrial water use could change significantly in future if the region encourages AI as part of its economic strategy but does not plan well for this, data centres being notoriously demanding of water and energy compared with other forms of activity related to the application of AI. Intelligent design and positioning can address some of the substantial water footprint of data centres. This will be a very important consideration for the implementation of the WECA (2025) growth strategy as well as the very high energy use implication of such sectors, as it has the potential to adversely impact water and energy required in the region and hence could also have adverse natural capital balance outcomes.

1.3 Nature

The declaration of a Nature Emergency by WECA led to a commitment to protecting 30% of council land for nature and increase wildlife abundance by 30% by 2030, to plan to double tree and woodland cover by mid-century, and to embed nature recovery in planning and infrastructure. These nature-based goals are supported by the Climate and Ecological Strategy, Green Infrastructure Strategy and Forest of Avon Plan (Bristol and Avon Catchment Partnership, 2025). The WECA Local Nature Recovery Strategy (LNRS) also provides spatial guidance identifying focus areas for nature recovery and recognises areas of importance for biodiversity (see Figure 5) and prioritising the protection, restoration and creation of a range of key habitat types listed in Table 1. Further guidance and practical tools are included in *The Local Nature Recovery Strategy*

[22] In relation to predicting future climate change impacts also see: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/summaries/index

[23] The environment agency are experiencing difficulties in predicting future water shortages due to the AI boom (Guardian 2025)

and Toolkit (WECA, 2025c). This is a positive move for the region's environment and the restoration of natural capital, but also for the economy due to the many beneficial ecosystem services that these habitats provide. As stated, failure to address climate change and ecosystem loss represents the largest market failures our economies have ever seen (Stern, 2006 and Dasgupta, 2021). There are strong links between nature access, wellbeing and productivity. Assessment of productivity most often overlooks the implications of environmental factors, natural capital, and climate change and their implications on growth and productivity (The Productivity Institute, 2024, 2025).

There are also significant national security implications for certain global ecosystem collapse. As part of a national security assessment, Defra (2026) published a report that linking global biodiversity loss and ecosystem collapse with national security implications. The report identifies six ecosystems of strategic importance for the UK and explores how their decline could drive impacts. A key judgment within the report is that critical ecosystems that support major global food production areas and impact global climate, water and weather cycles are the most important for UK national security, ascribed a high analytical confidence rating. More broadly the Defra report identifies that environmental degradation could trigger wider geopolitical instability, with moderate analytical confidence.

Figure 5: WECA Local Nature Recovery Strategy map: purple denotes Focus Areas for Nature Recovery; amber denotes Areas of Importance to Biodiversity; and black line denotes the LNRS Boundary[24]

[24] *Source:* https://westofenglandca.opendatasoft.com/map/embed/lnrs_local_habitat_map/?static=false&scrollWheelZoom=true&location=10,51.60395,-1.88896&basemap=jawg.streets

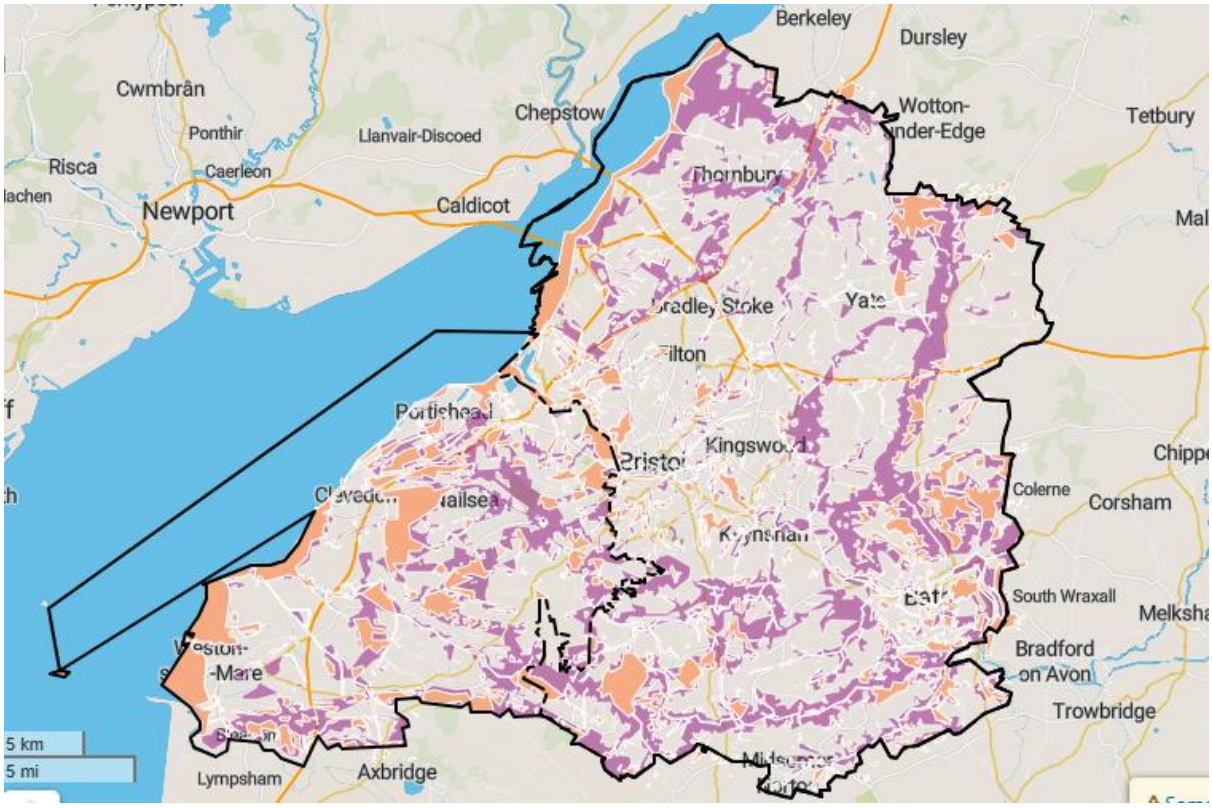


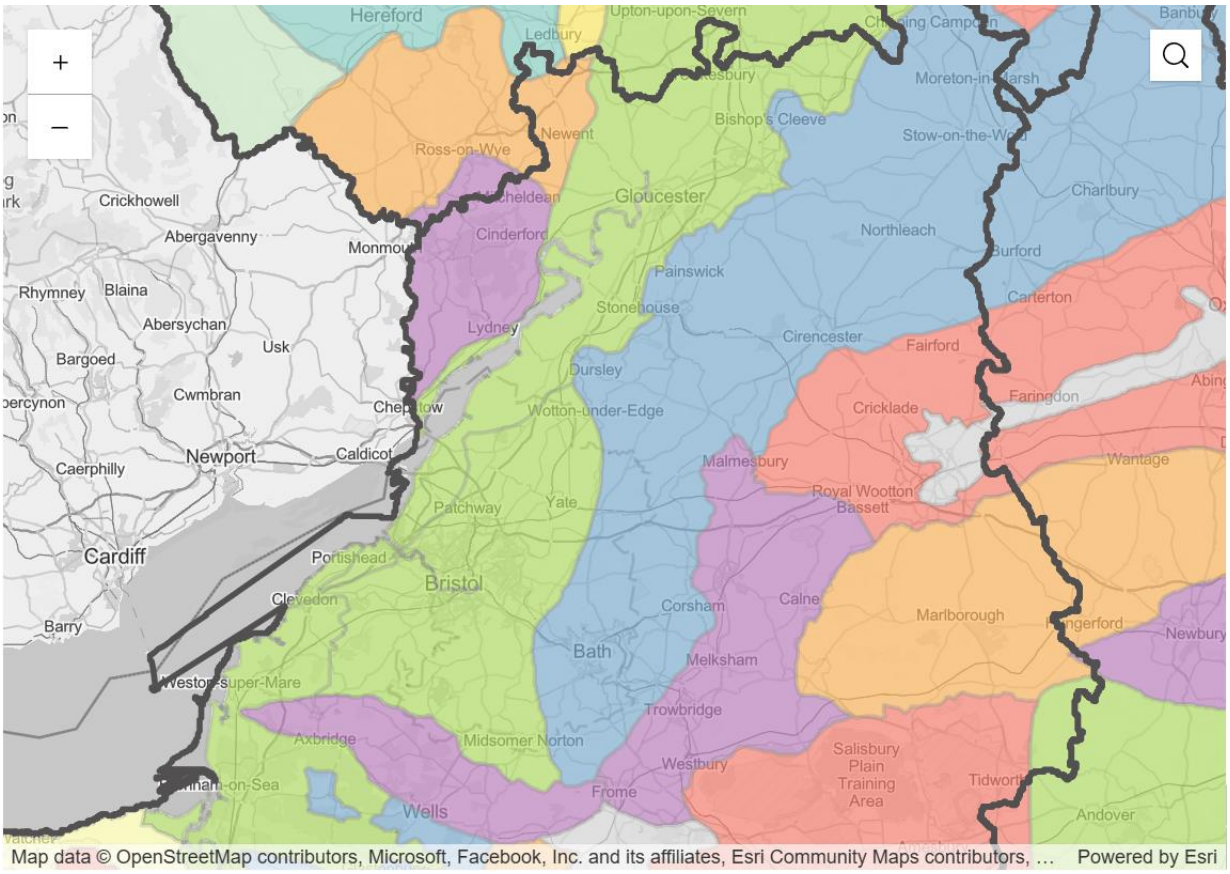
Table 1: Key habitat types listed in the WECA LNRS

Habitat Category	Key Types
1. Woodland and Trees	Ancient woodland; Urban tree canopy; Hedgerows and shelterbelts
2. Wetlands	Reedbeds; Wet grasslands; Floodplain meadows; Ponds and lakes
3. Grasslands	Species-rich meadows; Calcareous grasslands; Neutral and acid grasslands
4. Heathland and Scrub	Lowland heath; Transitional scrub habitats
5. Rivers and Streams	Riparian corridors; Naturalised river channels
6. Coastal and Estuarine Habitats	Saltmarsh; Intertidal mudflats; Coastal grasslands (especially in North Somerset)
7. Urban and Built Environments	Green roofs and walls; Community gardens; Brownfield sites with ecological value

Habitat Category	Key Types
8. Farmland Habitats	Field margins; Agroforestry systems; Pollinator strips

National character maps produced by Natural England to support planning and nature recovery recognise 159 generic blocks of habitat units nationally, of which a subset span WECA and the surrounding region as illustrated in Figure 6. All these generic habitat units are highly interdependent and interactive not merely as the classification of habitats is necessarily crude, but also as species span narrowly defined political units and many also make use of multiple habitats across their life cycles. Furthermore, rivers such as the Bristol Avon as well as the Severn Estuary are interconnected across broader landscapes and ecosystems.

Figure 6: Extract from Natural England's national character map coving the WECA area comprising: pale green coastal band (106 Severn and Avon Vales to the north and 118 Bristol, Avon Valleys and Ridges to the south); blue band (107 Cotswolds); purple (117 Avon Vales) red (108 Upper Thames Clay Vales). Source Nature England (2025).



The extent to which nature has declined at scales from the global to the regional and local is not widely realised. Some relevant data of its rapid and continuing declines is summarised in Box 1 below. The case for nature's recovery is far more than merely intrinsic but relates to the fact that biodiversity and geodiversity are the core resources upon which humanity depends for diverse and generally irreplaceable life-support, economic and other contributions to human wellbeing. When the foundational capital of nature and its supportive processes declines, so do human prospects at all geographical scales for security and opportunity. This emphasises the importance of prioritising this in the development of Regional Spatial Development Strategies.

Box 1: Key habitat types listed in the WECA LNRS

At a global scale, the Living Planet Index revels a 73% average decline in monitored mammals, birds, amphibians, reptiles and fish populations globally between 1970 and 2020 (WWF 2024). Freshwater species showed the steepest decline averaging 85% (WWF 2022). With an average decline of 94% in wildlife populations, Latin America and the Caribbean saw a massive decline in wildlife populations (WWF

2022), with a lower decline of 35% in Europe and Central Asia which would have been better news had this not been for the substantial depletion of wildlife prior to the 1970 baseline (WWF 2024). On aggregate, it is estimated that 1 million species are at risk of extinction due to human activities (IPBES 2019), the principal drivers of which include land-use change, overexploitation, climate change, pollution and invasive species significantly altered by human activity across 75% of terrestrial environments and 66% of marine environments (UNEP 2019)[25].

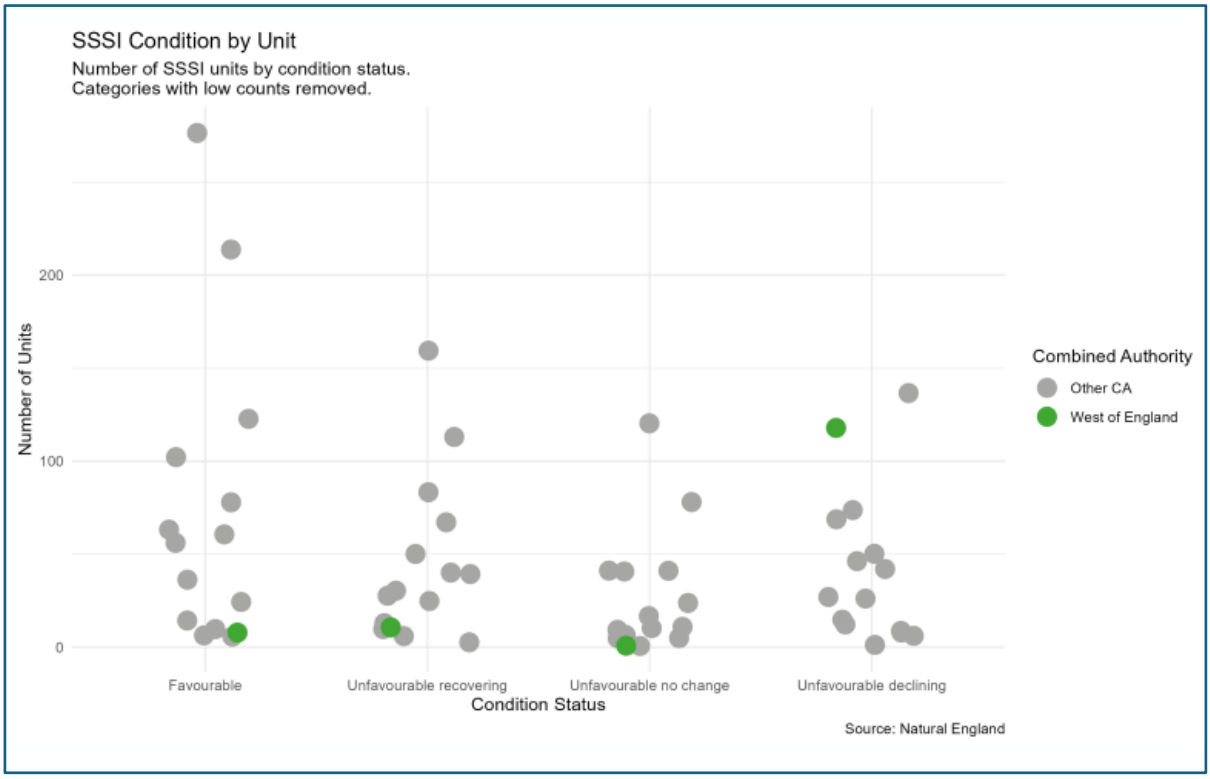
At national scale, the UK has become one of the most nature-depleted nations on Earth with continuing declines in abundance of on average 19% since 1970 with 16% of species now threatened with extinction (Burns et al., 2023). 43% of bird species are assessed as at risk of extinction including a decline of 58% in farmland birds numbers. 26% of terrestrial mammals are threatened, 31% of amphibians and reptiles are at risk, there has been a loss of valuable ecosystem services including an 18% decline of pollinators (bees, hoverflies, moths) and a 34% decline in pest-controlling insects like the 2-spot ladybird that has declined by 34%. Furthermore, 54% of flowering plant species and 59% of bryophytes have declined in distribution. The principal drivers of decline were assessed as comprising intensive agriculture and land-use change, climate change, pollution, urban development and habitat fragmentation.

Examples of biodiversity decline in the WECA region over the past two decades including ongoing significant degradation of grassland, wetland and woodland habitats due to urban expansion, agricultural intensification and infrastructure development with many Sites of Special Scientific Interest (SSSIs) now in unfavourable condition particularly including wetlands and lowland grasslands (WECA 2024). Across the region, there have been commensurate declines in pollinators including bees and hoverflies as well as butterflies such as the Small Heath and Common Blue, attributed to habitat loss and pesticide use, as well as of amphibians and reptiles due to loss of ponds and connectivity (BRERC 2024).

The state of SSSIs in the region can be seen below in Figure 7. The vast majority of the West of England SSIs (118 out of 138) are both ‘unfavourable’ and ‘declining’ in quality.

25

Figure 7: The number of Sites of Special Scientific Interest (SSSIs) in each combined authority that fall into four different status categories (WECA 2025d[26]).



1.4 Nature and its services

Biodiversity and habitats are far more than just spatially distinct entities. The complex interactions of ecosystems, chemically, physically and biologically, produce a diversity of benefits enjoyed by society. The benefits provided to society by nature are known as ecosystem services. Whilst units of nature may be spatially distinct, the benefits that they and the natural processes to which they contribute have far broader geographical spread and benefits to society ranging from the local to the regional, national, continental and up to global. Examples of the ecosystem services provided by nature, based on the Millennium Ecosystem Assessment model, are listed in Table 2.

Table 2: Examples of a subset of ecosystem services and their scale of benefits

[26] Source: Natural England Open Data Portal, Sites of Special Scientific Interest, 2025.

Ecosystem service category	Example services	Scale of societal benefits
Provisioning services	Food provision	Local, regional and national
	Extractable fresh water	Local and regional
Regulating services	Global climate regulation	Global
	Microclimate	Local and regional
	Storm buffering	Local and regional
	Pollination	Local and regional
Cultural services	Tourism and recreation	Local, regional and global
Supporting services	Soil formation	Local
	Nutrient cycling	Local and regional
	Habitat for wildlife	Local, regional and global

More detailed information about major habitats and ecosystem services for the UK can be found in the 2011 and 2014 National Ecosystem Assessment programmes[27].

1.5 Benefits from nature

The benefits provided by nature include the air we breathe, the water we drink and the food we eat as well as our sense of place, the ambient climate and our sense of natural beauty and a range of recreational opportunities.

Table 2 comprises just a subset of the full suite of ecosystem services through which humanity derives benefits from nature. Some of these benefits are directly enjoyed and can have market values but many, though essential, have

[27] http://uknea.unep-wcmc.org/Default.aspx, accessed 8 October 2025.

indirect benefits or else play supporting roles maintaining system integrity and continued functioning, and so defy ready quantification and representation in monetary terms. For example, freshwater abstracted from ecosystems is monitored and charged, noting that this economic value does not represent true value though does addresses the costs of abstraction, water treatment and reticulation with additional profit for operators. The same applies to food harvested or produced from landscapes and water bodies in the region. By contrast, soil formation (a supporting service) is essential to replace soil lost or degraded through agriculture and other uses as well as performing carbon sequestration processes (contributing to regulating services) and providing habitat for wildlife, yet is not currently value directly in the economy. Natural regulation of flooding is valued to the extent that it informs emerging Natural Flood Management approaches, yet of itself is not valued. Other services, such as spiritual values imputed by sectors of society to facets of ecosystems, are inherently incommensurable with money (though can be approximated by travel cost and other crude methods albeit imperfectly).

Representation of all these multiple values within narrow financial metrics is simply not attainable and not advisable, as market values now and in the future are heavily dependent on current and future demand and scarcity and so are inherently unstable and changeable. These important services need to be acknowledged and represented in development in ways that ensure that they are not inadvertently undermined or that their substantial life-giving and enabling values are underestimated or assumed substitutable with other forms of capital (such as financial) potentially and often leading to poor sustainable development outcomes[28].

Direct benefits from nature

The values of some facets of the natural environment are represented in one way or another in the regional economy, though with inclusions and exclusions.

[28] The conceptualisation of substitutability of natural with other forms of capital is classified as entering the economy into a weak form of sustainable development (as opposed to strong sustainable development).

Where these facets are overlooked, it is possible that they may become externalities undermining supporting ecosystems upon which future regional resilience depends. Examples from across the range of ecosystem services are listed below in Table 3.

Table 3: Examples of ecosystem services directly exploited in the regional economy noting facets that are overlooked potentially undermining future resilience

Ecosystem services (and service category)	Included in economy	Potentially excluded factors (unaccounted costs)
Mineral extraction (provisioning)	Stone and gravel sales	Disruption of aquifers and pollution from mining operations
Water abstracted for uses (provisioning)	Sales of water to domestic, industrial and agricultural users	Failure to ensure that aquifer and other resource recharge balances abstracted volumes, including subsequent impact on river flows and wider biodiversity
Agricultural food and fibre production (provisioning)	Marketing of food, hay and straw	Impacts on landscape soil retention, hydrology, biodiversity and landscape character
Capture fisheries (provisioning)	Marketing of seafood	Damage to aquatic ecosystems from fishing methods
Recreational angling (cultural)	Angling licences, travel and accommodation for fishing opportunities	Impacts of stocking with alien species where this is practiced
Tourism (cultural)	Income for tourism in charismatic areas (Cheddar, Bath, Bristol, Mendips, Cotswolds, etc.)	Tourism footfall can exceed local carrying capacities if not controlled with impacts on nature and ecosystem functions
Recreational bird/nature-watching (cultural)	'Honeypot' sites such as Slimbridge but also more informal use of nature reserves, estuary banks, etc.	Footfall needs to be balanced with potential for disturbance

It is not coincidental that these examples arise from the provisioning services and some from cultural services categories, as these are the most directly 'consumed' forms of service.

It is noteworthy, and a point to which we will return, that consumption of any one service has potential externalities for other services if not carefully managed.

Indirect benefits from nature

In contrast to the directly enjoyed benefits flowing from nature, most benefits (particularly flowing from regulating and supporting services) are indirect but nonetheless of crucial significance. Whilst some reclassifications of ecosystem services demote supporting and some regulating services to processes without economic value, these categories of services are vital for the continued structure and functioning of ecosystems and their capacities to produce flows of other more directly 'consumed' services. These services are therefore of foundational importance; disregarding them through too narrow and purely utilitarian an economic lens undermines the integrity of the core resources underpinning the continuing wellbeing not only of residents of the West of England area but of the wider region, nation and global ecosystems. Some examples of the importance of these inherently non-monetisable services are outlined in Table 4.

Table 4: Examples of ecosystem services of foundational value yet that are incommensurable with monetisation

Ecosystem services (and service category)	Indirect contributions to human wellbeing (noting service categories)
Soil formation (supporting)	Replacement of eroded soil, maintenance of soil fertility enabling continued productivity, habitat for wildlife often at the base of food chains, site of important biogeochemical cycling, sequestration of carbon supporting climate
Physicochemical purification of water (regulating)	Contribution to extractable water suppressing processing costs (provisioning), improved habitat for fish and other wildlife (supporting)

Ecosystem services (and service category)	Indirect contributions to human wellbeing (noting service categories)
	and their enjoyment through recreational angling and nature-watching (cultural)
Spiritual and aesthetic importances (cultural)	Contributes to sense of place and regional identity as well spiritual wellbeing, often in a highly culturally relative manner, retaining the identity of individuals, faiths and communities and their social cohesion
Nutrient cycling (supporting)	Maintaining the vitality and functioning of ecosystems (supporting) including aspects of pollutant breakdown (regulating) with multiple benefits for capacities for production of all other services (supporting)
Storm and natural hazard buffering (regulating)	Avoiding damage to physical assets and agricultural productivity (provisioning) as well as wider ecosystem functioning (supporting)

Whilst some economic methods are available to represent the importance of some of these services (such as 'willingness to pay' surveys, travel cost methods or revealed preference), these are in many ways crude metrics illustrating the likely significance of the services rather than their true values which may be incommensurable with money.

It is notable that ecosystem services that can be privately owned and valorised (food, piped water, fibre such as hay and straw, etc.) tend to be better recognised, quantified and valued in markets; this contrasts with services that are inherently not privately owned but of wider public benefit (habitat for wildlife, aesthetic values, regulation of air quality, etc.) but that are rarely quantified and valued in robust and policy-relevant terms.

Valuing all forms of natural asset

There is a tendency to conflate 'nature' with rural areas. It is true that the benefits of nature can be particularly concentrated in 'honeypot sites' where certain services are most highly exploited. Examples include the tourism potential of the Mendips, Cotswolds and other important landscape regions, recreational angling on prime stretches of river and still waters, or culturally

important regions such as the hot springs and architecture of natural stone in Bath. However, all ecosystems from the urban to the rural are functionally important as well as holding their own distinctive biodiversity. It is important that all such habitat types and their ecosystem processes are recognised and valued, as for example addressed at a national scale under the UK's National Ecosystem Assessment (National Ecosystem Assessment 2011).

A significant change in emphasis in nature conservation was summarised under the UK's Lawton Review 2010, recognising that hemming biodiversity into fragmented nature reserves – often too small in relation to the changing climate and the genetic diversity of the species they encompassed – was manifestly failing in a more complex and populated world. The Lawton Review recognised a need for novel management approaches to achieve "*bigger, better, more joined up*" habitats, valuing nature reserves as concentrated resources but recognising the need for nature and its services to spread across the wider landscapes from which they had been substantially denuded by intensification of agriculture and other forms of development. As one example, private gardens comprise 25% of urban greenspace and support a diversity of wildlife[29], comprising a principal component of urban green infrastructure around the world (Delahay et al., 2023), yielding benefits including serving as wildlife corridors linking fragmented habitats, supporting pollination and natural pest control, and enhancing soil health and climate resilience. Simple steps like putting in place hedges rather than fences or having fences with spaces at the bottom can help enable wildlife corridors and serve species such as hedgehog, newts and others.

On the latter aspect, nature should also not be regarded simply in terms of physical and spatially based assets such as habitat types and species. This is often the approach taken under the concept of 'natural capital'. Rather, nature and its processes are interconnected across broader geographical ranges from the relatively local (such as insect dispersal including pollination services over

[29] See the series of papers linked in Impact Case Study https://ref2014impact.azurewebsites.net/casestudies2/refservice.svc/GetCaseStudyPDF/11853, accessed 8 October 2025.

wider areas) through to reginal (as in fish using the Severn estuary and rivers as migratory routes) or the global (in the case of migratory birds occupying global flyways).

Furthermore, chemical, physical and ecological processes within ecosystems yield a range of interconnected ecosystem services, defined as benefits to people, that also ramify across wider geographical ranges (examples include localised predation of crop pests, regional nature-based tourism and global carbon sequestration affecting the climate), the range of which need to be integrated into planning and regional development processes.

All these aspects of the natural environment of the region comprise important considerations for resilient and sustainable development.

Recognising interdependencies

A further facet observable from the above discussions is how all ecosystems are an indivisibly interconnected, generating a broad and also interconnected suite of benefits flowing to society. The historic tendency has been to look at single or a small subset of services in isolation, for example maximising food production or water extraction. Attempts have been made to manage them accounting for some limited wider ramification, such as represented by agri-environment schemes. However, if ramifications for the wider breadth of interconnected ecosystem services are not also considered in policies and management strategies, there are real risks of, and many examples of, harm ensuing leading to degradation of the supporting ecosystem. Globally, for example, agriculture – vital for feeding the world and the backbone of England's 'green and pleasant land' – is the major driver of the decline of species and habitats (Dudley and Alexader 2017), though there are breakthroughs in the practice of regenerative forms of farming focus on rebuilding soil health and productivity as a more sustainable basis for production of food and other farmed commodities. Good intentions alone, for example, in increasing the efficiency of intensive fishing of marine waters, can ultimately undermine future resilience if not moderated

through a systemic approach recognising and avoiding or mitigating collateral impacts.

As a further current example relating to region, proposals for tidal barrages can aid transition to low-carbon energy sources. However, if barrages change sediment flows affecting the structure, nutrient cycling and wider functioning of the Severn Estuary, this can have substantial unintended consequences, and systemic ramifications can be cumulatively potentially serious. Further unintended consequences if overlooked in planning may include inhibition of the movement and reproduction of migratory fishes, many of which are scheduled under nature conservation legislation.

Another ostensibly pro-development move being considered in the region is promotion of AI centres. However, AI and data centres have heavy energy demands and water requirements for cooling. Energy demands have obvious associated climate change implications that need to be considered, and ideally mitigated, rather than being overlooked in planning, with even an assumption that energy can be derived from renewable sources (such as tidal) having its own systemic implications for species that live in the estuary and wider ecosystem processes. Additionally, intensive demands for cooling water can overload resources that are already stretched in the region and may deny access to sufficient water for other sectors of society. If AI-based development is perceived as a priority regional direction, it is essential to consider, design and issue consents fully cognisant of these wider systemic ramifications for foundational ecosystem services and those that depend upon them. These impacts can be significant, for example, with Ireland's Central Statistics Office showing that data centres accounted for 21% of Ireland's electricity consumption in 2024, overtaking domestic residential use, with a sharp rise from 5% in 2015 (CSO, 024). This trend will be mirrored by increases in the use of water.

This is not to suggest that some of these new development directions should not proceed, but rather that they should be informed systemically in terms of

understanding the range of impacts on nature, pollution and interactions with the foundational ecosystems upon which the wider wellbeing of people in the region depend. Addressing connected wellbeing endpoints is a more evolved approach to economic thinking (see Fioramonti et al., 2022, and past approaches applied in in Bhutan[30]) rather than solely a traditional GDP focus that more often than not leads to myopically framed financial drivers leading to substantial degradation of the natural environment and natural capital. There is a need for an informed and intelligent approach to growth in the region that focuses on systemic outcomes (citizens and community wellbeing, protection of natural capital, etc) rather than simplistic metrics such as GDP; for example, war boosts GDP through increasing economic throughput but is certainly not desirable for society or the natural environment.

1.6 Major drivers of change for nature in the West of England region and what can we do about it

Table 5 outlines the major drivers of change for nature in the WECA region. These substantially mirror national and global pressures (see Box 1). Practical steps are also suggested to halt pressures on ecosystems, or optimally to contribute to their regeneration along with their supportive capacities.

Table 5: Major drivers of change in nature and practical solutions

Major drivers of change	Practical solutions
Intensive agriculture[31]	Soil loss, in particular, represents a major threat to food security globally, nationally as well as regionally, soil underpinning 95% of global food production yet with one-third of the world's soils already degraded (Vargas 2022) with continuing degradation likely to reduce global crop yields by up to 30% within 50 years with cascading effects

[30] Kingdom of Bhutan. (2008). *The Constitution of The Kingdom of Bhutan*. Kingdom of Bhutan. [Online.] https://www.nationalcouncil.bt/assets/uploads/files/Constitution%20%20of%20Bhutan%20English.pdf, 04 March 2023.

[31] This global trend has relevance to the West of England in terms of pressures on regional watercourses, wildlife habitats and air quality that can be affected by upstream agricultural pressures, while climate related vulnerabilities may intensify. The trend also intersects with food security and rural economic resilience

Major drivers of change	Practical solutions
	on food supply chains and geopolitical stability (Carswell et al., 2025) . This is compounded by other land use pressures, addressed when considering land use change below. To address the downward pressure on biodiversity, soil degradation, water stress and greenhouse gas emissions, relevant solutions include promotion of agroecological methods integrating ecological principles into farming (crop rotation, intercropping, zero or reduced tillage and other methods) as well as precision agriculture, reductions in chemical inputs, a shift to climate-resilient crops, along with strategic sparing of land important to hosting pollinators and with significant roles in the water cycle (Benton et al., 2011) . Investment in natural capital mapping can guide land use decisions, including where to intensify, where to adapt methods and where to revert to landscape scale habitat restoration where agricultural returns are marginal but the value of ecosystem services (such as water resource regeneration supporting West of England water security) is more societally beneficial. Strengthening local food supply chains and promoting low impact procurement can further reduce environmental pressures while supporting regional producers in the West of England's agricultural sector
Urban development[32]	Poorly planned urban sprawl contributes to the loss of natural habitats as well as agricultural land. In addition to consuming green spaces and reducing biodiversity and ecosystem services, it increases overall carbon emissions due to driving car-dependent communities and can exacerbate water and air pollution, social inequalities and climate vulnerability (Environment Agency 2023) . Measures to address these worst excesses include strengthening spatial planning to curb low density expansion and instead to encourage higher-density, mixed-use neighbourhoods, integrating public transport hubs, mandating the integration of green Infrastructure including designating ecological and greenbelt corridors and other nature-based solutions, as well as zoning. Increasing the alignment of development planning with climate resilient, compact, transit oriented growth principles can offer economic benefits through safeguarding natural capital and community wellbeing
Land-use change[33]	Land use change is a significant driver of environmental change, converting forests, wetlands and grasslands into urban areas, farmland or infrastructure exacerbating biodiversity loss, habitat fragmentation, emissions of climate-active gases, and degradation of the water cycle and ecosystem services (JNCC 2019). Since 2000, the

[32] Particularly risks from sprawl (uncontrolled expansion of urban areas into rural or undeveloped land, typically characterised by low-density housing, car dependency, and fragmented infrastructure) intensifies climate vulnerabilities in the West of England. This occurs through fragmenting ecosystems and their processes undermining regional resilience (as highlighted in the WECA 2025 Climate Adaptation Report). Sprawl also conflicts with the WECA 2023 Climate and Ecological Strategy, which warns that environmental decline could significantly reduce long-term economic prosperity without stronger nature-recovery action and sustained investment

[33] Land-use is a cover-all definition that spans the wider impacts of farming intensification and sprawl of urban development and infrastructure, which continues to reshape landscapes and diminish ecological resilience. This trend is evident in the West of England placing pressure on greenbelt areas, fragmentation of wildlife corridors, increased flood risk and loss of carbon-rich habitats. These changes have knock-on implications affecting transport planning and resilience, housing delivery and long-term climate goals

Major drivers of change	Practical solutions
	UK has lost 771,000 hectares of farmland, and projections suggest up to 23% of farmland could vanish by 2050 due to competing land uses such as housing, solar and tree planting (Wilkinson 2025). No directly comparable farmland-loss figures have been published for the West of England, but this UK trend is assumed to be representative of the region. Strategic land use planning integrating data on habitat maps and ecosystem service assessments to can better guide development combined with priorities for conserving nature and ecosystem services recognising their economically value contributions to the functioning and resilience of the region. This will provide a multifunctional basis for land management, integrating and protecting nature recovery networks and wider green infrastructure to restore and connect habitats, and to promote community engagement. Enhancing natural capital assessments can guide investment, while partnerships with landowners and communities can support habitat restoration, sustainable drainage and multifunctional landscapes that balance growth with environmental resilience
Habitat fragmentation[34]	Many facets of habitat fragmentation are considered above when considering under land use change, agricultural and urban development and their associated infrastructure. Expanding and, perhaps more significantly, better linking up subunits of the West of England Green Infrastructure Network (rivers, woodlands, ponds, parks, allotments and other green and blue spaces in both urban and rural areas) can enhance clean air, plentiful water, climate moderation. Enhanced protection of existing high-quality habitats, backed up by measures to restore degraded and lost habitats valuing the natural functions they serve and the ecosystem benefits that they provide can be integrated into planning policies. This can be enabled by prioritising biodiversity net gain delivery that builds upon planning policy and investment priorities, and targeting nature recovery zones that reconnect key ecological corridors. Habitat connectivity can also be integrated into transport and housing strategies, including co-beneficial uses as 'green transport' routes (walking, cycling, etc.) Optimally, planning can be undertaken in partnership with local authorities, landowners and communities to co design landscape scale restoration that is both liveable and functional
Overexploitation[35]	Resource overexploitation is deeply embedded in established value chain practices and market norms, for example with local depletion of critical resources often

[34] Habitat fragmentation across the West of England increases pressure on already sensitive ecological networks, limiting species movement between the region's green spaces and reducing the resilience of ecosystems and the many, often unappreciated but societally valuable ecosystem services that they provide. Fragmentation of formerly large, continuous habitats into smaller, isolated patches due to human activities such as urban development, agriculture, and infrastructure expansion further isolates woodland, wetland, grassland and other habitats, undermining biodiversity and associated benefits including natural carbon sequestration and flood mitigation functions, increasing climate risk exposure for communities

[35] Overexploitation is a broad category, including unsustainable extraction and use of natural resources (water, forests, fisheries, minerals, wildlife, etc.) at rates exceeding natural regeneration. Overexploitation of natural resources is increasingly relevant to the West of England as population growth and economic expansion intensify pressure on finite water supplies, soil health, timber and biodiversity. Water resources are a particular priority as they are already stressed in the West of England, and so opportunities not merely for demand reduction but also resource recharge offer potential solutions. Unsustainable land uses include overextraction of soils and loss of woodland as well as recreational pressures,

Major drivers of change	Practical solutions
	addressed by outsourcing and unsustainable extraction of remote resources with wider environmental and social consequences. Bristol as a historic trading port, was complicit in imports from the colonial era to compensate for depletion of local and national resources of many kinds. Solutions challenging legacy norms with downward pressures on ecosystems and their services include a focus on sustainable resource management with associated market instruments, progress with the circular economy commitment, with strengthening of environmental regulations (Milson et al., 2025). Supporting sustainable water resource management has been recognised as a priority in the West of England, including demand reduction measures such as water use efficiency and leakage reduction but also exploring opportunities for water harvesting and regeneration of groundwater resources linked with sympathetic land uses such as regenerative agriculture and sustainable forestry. As suggested above, investment in natural capital mapping can guide more far-sighted land use decisions, strengthening planning policy to limit resource intensive development whilst seeking to optimise protection or regeneration of ecosystem services with their multiple societal benefits. These measures can be supported by promoting community stewardship and responsible consumption
Climate change[36]	Climate change is deeply interconnected with biodiversity loss and degradation of ecosystem service flows (Natural History Museum 2023) . Solutions of particular relevance to the West of England include accelerating delivery of the regional Climate and Nature Strategy recognising benefits for both nature and people. This can include presumptions in favour of nature based solutions for flood and heat mitigation in preference to engineered solutions, embedding climate resilience thinking into transport and housing design, and broader support for low carbon industry transitions. Partnerships with local communities can help develop local adaptation initiatives. In the longer term accelerating transition to renewable energy sources can help mitigate pressures, though noting that some such as hydropower have their own significant impacts on riverine processes and biodiversity. Wider progression towards a circular economy and sustainable consumption measures can also offer significant mitigation
Invasive species[37]	Invasive species as a major driver of environmental change, assessed as among the 'top five' global drivers of biodiversity loss (IPBES 2019) . This can be enacted in the

which put pressure on wildlife and weaken ecosystem resilience as well as compromising climate adaptation efforts and long term regional prosperity

[36] Climate change is one of the most pervasive and accelerating drivers of environmental transformation with multiple ramifications ranging from increasing risks from flooding, heatwaves, drought, water scarcity and soil degradation. Rising temperatures and more extreme weather threaten transport networks and other civil infrastructure, agricultural productivity, public health and the region's nature rich landscapes including the Avon, Frome and Severn catchments. Vulnerable communities in Bristol, Bath and coastal areas face escalating resilience challenges

[37] Invasive species (organisms introduced to environments where they are not native) pose increasing risks to the West of England by displacing native wildlife, altering habitats and increasing management costs. Species such as Himalayan balsam, Japanese knotweed and signal crayfish threaten riverbanks, transport corridors and urban green spaces, reducing biodiversity and undermining flood mitigation capacity. Climate change may further accelerate the spread of invasive species, increasing pressure on sensitive ecosystems across Bristol, Bath and rural areas. Invasive species also pose risks

Major drivers of change	Practical solutions
	West of England by promoting coordinated regional monitoring and rapid response systems to address invasive species, including funding of catchment based eradication and habitat restoration programmes to avert them undermining economic, biodiversity and other societal benefits. As prevention is a high priority including monitoring high-risk pathways followed by rapid response and eradication, integrating these measures into policy (Cornwell 2023) , building biosecurity requirements into planning, procurement and construction are priorities. These measures can be enhanced by supporting community led reporting and removal initiatives, and by partnering with landowners to manage high risk sites on a strategic basis

The *WECA Local Nature Recovery Strategy* presents a framework not just to reduce pressures on nature, but to guide its recovery along with the multiple benefits that it confers to society (WECA 2025c). Further specific model multi-beneficial initiatives regenerating biodiversity in Bristol include, for example, the Capricorn Quay Floating Ecosystem Project in the Floating Harbour funded by the WECA, can help mitigate ecological pressures (Bristol City Council 2025). Other targeted initiatives in the West of England to enhance both biodiversity and the beneficial ecosystem services that it provides can not only rebuild lost beneficial flows of these services but can also elicit public support and engagement.

Links to relevant organisations and initiatives

Relevant organisations working in this space are listed in below.

Relevant organisations with common objectives

- West of England Nature Partnership 'Bringing people together to put nature back together'
- Bristol Avon Rivers Trust (BART): under the mission of "*A clear future for our river*" addressing the 75-mile reach of the main river and its many tributaries

for infrastructure, agriculture and community spaces, and management measures to address them can divert resources from other environmental and investment priorities

- Bristol Climate and Nature Partnership: a network united by the zero-carbon, nature-rich, socially just vision of the future of Bristol
- Severn and Devon Inshore Fisheries and Conservation Authority (IFCA): seeking shared responsibility for the health and benefits of the marine environment

Ongoing initiatives relevant to the matters dealt with in the report are listed below.

Relevant ongoing initiatives

- Periodic environmental accounts produced by the Office for National Statistics: seeking to put monetary values on natural assets (though noting concerns expressed earlier in this report about the externalisation of less directly consumed benefits flowing from ecosystems)
- The UK Circular Economy Task Force
- The Economics of Biodiversity: The Dasgupta Review (2021)
- The Economics of Ecosystems and Biodiversity (TEEB) (2000)

1.7 Discussions and conclusions

The *State of Natural Capital Report* (2024) and also the *Global biodiversity loss, ecosystem collapse and national security* report (Defra 2026) demonstrate how risks to supportive ecosystems are also risks to society and the economy. Biodiversity and geodiversity are the core resources upon which humanity depends for a range of irreplaceable life-support, economic and other contributions to human wellbeing. When the foundational capital of nature and its supportive processes declines, so do human prospects at all geographical scales for security and opportunity. When development results in losses of nature or other natural capital-related assets, this impacts the natural capital balance negatively (Figure 2). The UK is now one of the most nature-depleted countries on Earth (State on Nature Report 2023). An essential strand to navigate sustainable development is to recognise the inherent interdependence

between all ecosystem services. To ensure sustainable outcomes, it is essential to take a systemic approach when making decisions addressing potential impacts across the full range of ecosystem services. This is also important in identifying economic viability of a sustainable economy.

The natural environment in the West of England is ecologically diverse. Many people and talents are attracted to work and live in our region due to the natural environment and landscape (WECA 2025). This said, past development of the UK (and the West of England) economy has substantially degraded the natural environment: a continuing trend. This has led to the current generations inheritance of a substantially degraded physical environment, and we cannot keep degrading what ultimately gets passed onto our children; this is neither sustainable for humanity nor morally right. Degradation has substantial implications for our people and the economy (Green Finance Institute 2024).

It is clear that past and current development (production and related consumption) of the regional economy has not sufficiently addressed the third aim of sustainable development: balancing economic development with social progress and environmental capacities. Very often ,our major rivers and lakes have poor ecological status in the region mainly due to agricultural runoff and release of sewage (West of England Nature Partnership 2025). Other examples of past pollution from economic activity are that some of our freshwaters in the region have high levels of perfluorooctane sulphonate (PFOS) and other chemical pollutants that are hazardous to human health (for example see the PFOS map for the West of England in the ENDS Report, 2023s). PFOS is persistent and bioaccumulates in living organisms, including humans, and in environmental media. This illustrates the clear importance of developing the economy sustainably, addressing multiple dimensions beyond Net Zero considerations, also considering issues of pollution from economic and household activities that re-enter the environment after some delay with adverse implications for environmental and human health.

On a positive note, the region has shown some strong leadership. The declaration of a Nature Emergency by WECA (local authorities have also declared) led to a commitment to protecting 30% of council land for nature and increase wildlife abundance by 30% by 2030, doubling tree and woodland cover by mid-century, and embedding nature recovery in planning and infrastructure. These nature-based goals are supported by the Climate and Ecological Strategy, Green Infrastructure Strategy and Forest of Avon Plan (Bristol and Avon Catchment Partnership 2025). Key habitat types listed in the WECA LNRS include woodland and trees, wetlands, grasslands, heathland and Scrub, Rivers and Streams, coastal and estuarine habitats, urban and built environments, and farmland habitats. The regions water resources – rivers and streams, lake and ponds, reservoirs, groundwater and coastal seas – also require sustainable management to protect their quality but also, critically, to balance their exploitation with regeneration such that benefits provided to society and ecosystems can be sustained indefinitely. So too the region's valuable resource of soil, which is often overlooked in policy and land use decisions but is inherently renewable and a valuable source of many ecosystem services beneficial both practically (such as for food production) but also functionally (such as the roles that soil plays in carbon storage and climate regulation, buffering of flooding and drought, support of wildlife and recreational uses, and the purification of water and air).

In summary, valuing and safeguarding the natural assets in the region and beyond is vital not merely for nature to flourish and recover, but also to support a diversity of societal needs ranging from continuing flows of food and fresh water to maintaining characteristic landscapes and recreational opportunities and a diversity of economic resources. Sustainable use of these natural assets requires understanding and moderating the main drivers of nature decline as a platform for alternative models and practices of economic development and regional accounting founded on balancing uses with the supportive capacities of the region's ecosystems.

2 Greenhouse Gases (GHGs) in the West of England

WECA have a declaration of a climate emergency and have a strategic ambition to achieve net zero carbon emissions by 2030, a goal significantly more ambitious than the UK Government's statutory target of 2050 (WECA 2022a). The Unitary Authorities also have Declarations and Action Plans, Bristol City Council Climate Emergency Action Plan (Bristol City Council, 2022c) and South Gloucester (2025) Climate and Nature Emergency Action Plan. As well as South Gloucester Climate Declarations and Action Plans (South Gloucester Council, 2022, 2025, 2025a, 2025b). North Sommerset Council have a declaration and action plan and strategic action document (North Somerset Council, 2025a, 2025b). BANES also have (BANES, 2025).

Growing the regional economy currently generates GHG implications both within the region and outside. Different sectors can however have very different outcomes in terms of GHGs generation per £ of good or service delivered and in terms of absolute GHGs generated per annum. Some sectors have much lower greenhouse gases than others. This section shows this and provides an overall summary of GHGs for the region (scope 1 and 2) for the various parts of the overall economy.

This includes for the first time, a detailed analysis of commercial, industrial and public sector (scope 1) emissions for the region to provide insight on priority sectors to inform the region's net zero strategy. The section starts with a high-level summary of largely published data and then proceeds to the more disaggregated account for the region. This is then followed up by a detailed account of the emissions embodied and attributable to final goods and services of the region's sectors (scope 1, 2 and 3). This has not been conducted previously, and this analysis provides new insight into estimates of the extent to which each sector impacts at a regional level. The section then looks at the opportunities and barriers to GHG abatement in key sectors.

The UK's 2035 Nationally Determined Contribution (NDC) target, announced at COP29 in 2024, is to reduce all GHGs by at least 81% on 1990 levels by 2035,

excluding international aviation and shipping emissions. (DESNZ 2025a). Recently it has been announced that the UK's share of international aviation and shipping emissions will be within scope of the UK's domestic legally binding Carbon Budget 6 (2033-37) to address net zero (UK Government, 2025). Given that 2033 is only seven years away and at the national level that aviation now contributes a greater share of total UK emissions than the entire electricity supply sector, it is important to have an understanding of the extent of these emissions in the region. The Climate Change Committee (2020) recognise the need to address these emissions[38] and more recently identify that that continued emissions growth in this sector could put future targets at risk (Climate Change Committee, 2025), so it is worth starting to account for this. No recent data was available on aviation flight related emissions in the region, so they were estimated in the year for which consistent data across sectors (2022) could be accessed.

2.1 Direct GHG account: profile for West of England

The GHG emission profile for the region in 2022 is provided below in Table 6. This shows that total estimated emissions for the region were 6394 $KtCO_2e$[39] (or the aggregated account, mainly making use of published GHG figures). Fifty four percent of these total emissions were estimated to come from transport; most are related to road transport (thirty two percent of total emissions - goes up to forty two percent if air transport GHGs excluded[40]) and air transport services (twenty one percent of total emissions). In relation to road transport emissions, motorway emissions are important in North Somerset and South Gloucester, but Unitary Authorities have little or no influence over. The second most prevalent sector is domestic household emissions (twenty percent of total emissions). According to data inputted into the table (from DESNZ 2025c data for 2022 used in Table 6) this shows only fifteen percent of emissions are from

[38] to understand current and future implications.

[39] electricity emission allocated to the consuming sectors.

[40] 44% in 2023, see WECA 2025.

industrial and commercial emissions, and five percent is from agriculture, three percent from the public sector and three percent from waste[41].

Table 6: GHG emission profile for the West of England

Emissions allocated to sector	City of Bristol	Bath and North East Somerset	South Gloucestershire	North Somerset	West of England
Industry Electricity	34	12	37	17	101
Industry Gas	11	4	49	84	148
Large Industrial Installations	1	0	17	3	21
Industry 'Other'	52	21	58	28	158
Industry Total	**98**	**37**	**161**	**132**	**428**
Commercial Electricity	149	38	88	50	324
Commercial Gas	93	23	47	24	187
Commercial 'Other'	19	7	9	7	42
Commercial Total	**261**	**68**	**143**	**81**	**553**
Public Sector Electricity	28	13	14	9	64
Public Sector Gas	68	30	13	12	123
Public Sector 'Other'	10	2	8	3	23
Public Sector Total	**106**	**46**	**34**	**24**	**211**
Domestic Electricity	129	61	85	67	343
Domestic Gas	330	154	204	169	856
Domestic 'Other'	8	19	27	20	75
Domestic Total	**467**	**234**	**317**	**256**	**1274**
Road Transport (A roads)	133	105	143	83	464
Road Transport (Motorways)	73	0	437	215	726
Road Transport (Minor roads)	307	127	255	193	882
Diesel Railways	8	8	10	7	33
Air transport services				1310	1310
Transport 'Other'	8	4	12	16	40
Transport Total	**529**	**243**	**858**	**1825**	**3455**
Net Emissions: Forestry	-4	-18	-20	-28	-69
Net Emissions: Cropland mineral soils under LUC	0	7	11	2	20

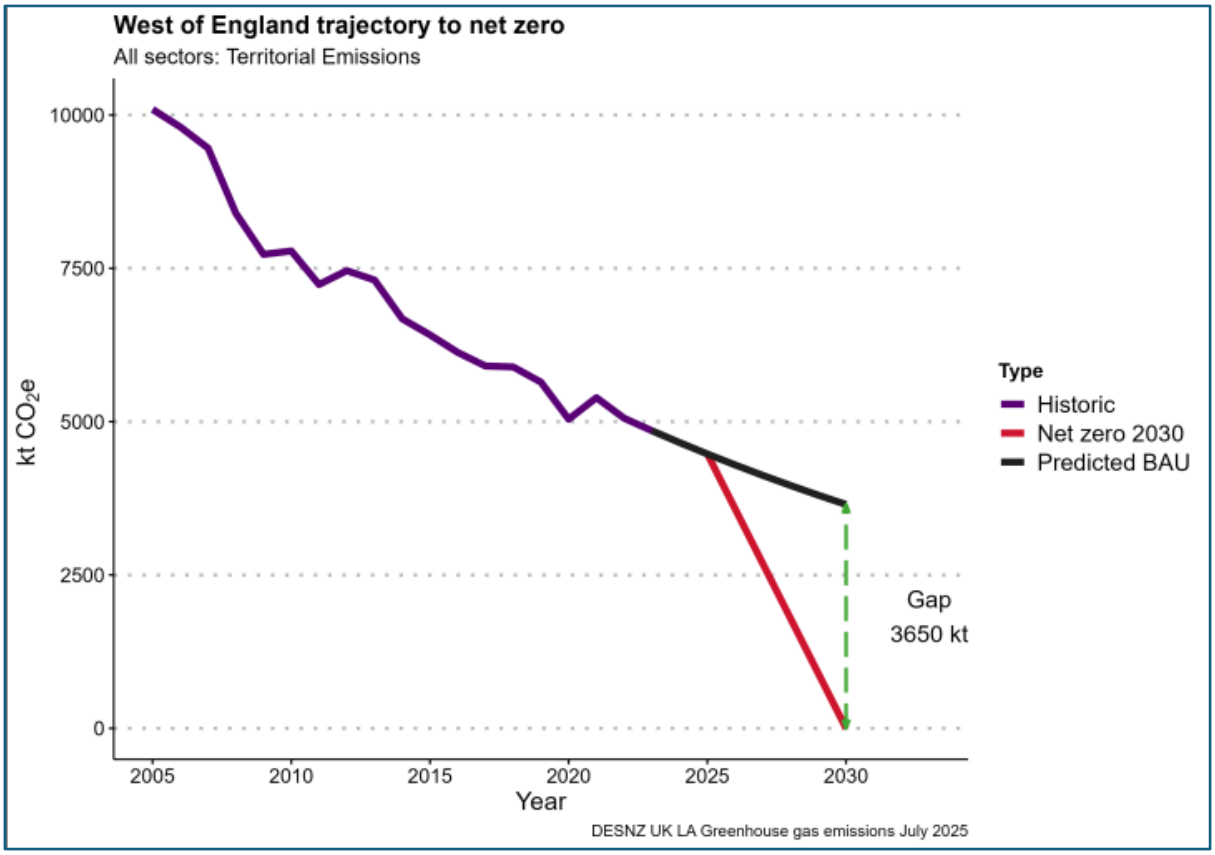
[41] These percentages may be different to percentages reported in some other regional publications, primarily because they do not account for emissions from outbound flights as DESNZ 2025c do not provide. This study attempted to estimate them.

Net Emissions: Grassland mineral soils under LUC	-1	-12	-16	-11	-40
Net Emissions: Settlements	7	5	9	6	27
Net Emissions: Peatland	0	0	2	11	13
Net Emissions: Bioenergy crops	0	0	0	0	0
Net Emissions: Other LULUCF	0	0	0	0	0
LULUCF Net Emissions	**3**	**-19**	**-13**	**-20**	**-49**
Agriculture Electricity	0	1	2	3	6
Agriculture Gas	0	0	0	3	4
Agriculture 'Other'	0	9	14	18	42
Agriculture Livestock	3	67	82	70	222
Agriculture Soils	1	18	22	16	57
Agriculture Total	**5**	**96**	**120**	**110**	**331**
Landfill	75	4	16	28	123
Waste 'Other'	26	9	22	10	67
Waste Total	**100**	**13**	**39**	**38**	**190**
Grand Total	**1570**	**717**	**1660**	**3757**	**6394**
Population ('000s, mid-year estimate)	479	196	295	219	1189
Per Capita Emissions (tCO2e)	**3**	**4**	**6**	**17**	**5**
Area (km2)	235	351	536	391	1514
Emissions per km2 (kt CO2e)	7	2	3	10	4

Progress on emissions reduction

If one excludes GHGs from air transport services from the account above as these are not technically included as part of the NDC until 2033. Then Figure 8 shows substantial progress by the region in decarbonising, but still a significant gap. The region has reduced carbon dioxide emissions by 1,825 $KtCO_2e$ over the past decade (2014-2023), reduction in domestic emissions accounts for around a third of this. Emissions reductions progress is comparable with other combined authorities (2014 -2023) and only two other combined authorities had lower GHG emissions in 2023 (WECA 2025d).

Figure 8: Progress in addressing Net Zero in the region and the 2030 Net Zero Gap[42].



Aviation will become part of Net Zero in 2033, adding at least another 1310 $KtCO_2e$ and likely quite a lot more, as passenger flight numbers in 2024 were 25% higher than 2022 (the consistent benchmark year we use for our estimations in Table 6).

[42] DESNZ, UK LA data, July 2025; Climate Change Committee, 2025; Open CO_2 Net, 2025

Road transport

The West of England is not unusual in having a high amount of GHG emissions associated with road transport: at the UK national and local levels better performance in other sectors has left transport with a growing share. The local authorities' responses to transport emissions target-setting derive from the climate emergencies and 'net zero' emissions targets that each has endorsed for 2030 as stated. However, it is not clear what 'net' means in the transport sector, which does not itself offer prospects for removal of ambient carbon. No other sector is expected to have a surplus of reductions to offer compensation by then. Therefore, for transport it seems 'net zero' means 'zero', or complete elimination of emissions by 2030.

The West of England local authorities have worked through the 'calculus' of achieving the 2030 target. For example, Bristol City identified that 90% of cars would need to be electric by 2030 and car journeys reduced by 40%. Similarly, but reflecting the more rural context, one of Bath and North East Somerset's scenarios combines a 7% decrease in the number of car journeys and a 25% reduction in distance travelled by car with 90% of cars substituted with electric vehicles (allowing for 15% of these being hybrid). North Somerset shares the 25% target for reducing road traffic and combines this with supporting the national Zero Emission Vehicle Mandate (ZEVM) targets for transitioning to electric vehicles (EV). South Gloucestershire places greater emphasis on its own leadership of processes and qualitative assessment rather than specific quantitative targets. All the local authorities make a distinction between what is in their direct influence and where they can only facilitate. In general, the local authorities have reduced their own transport emissions to a larger degree than the 9% headline for the subregion (WECA 2025d).

Broadly speaking, the transport strategies include elements of the 'avoid-shift-improve' hierarchy. 'Avoid' measures rely heavily on integrating transport and spatial planning. Existing development needs to be evolved towards the '15-minute city' principles which mean daily goods and services can be reached within 15 minutes' travel on foot, by bike (or similar) or public transport. New developments need to be located in places where it is realistic that they can be public transport-oriented and designed in a way that is not 'car centric'. Neither of these approaches is easy to deliver. The location choices of businesses providing goods and services is a market-led activity, and other than a minority of low-car developments in the heart of major cities, developers continue to provide housing solutions which are in practice reliant on car access and use.

In respect of 'shifting' mobility, the recipe is well understood: people and goods need to transfer from low energy efficiency, high emissions modes to high energy efficiency, low or zero emissions modes. Particular cities around the world have made significant progress. If Copenhagen achieves its 'net zero' goal by 2030, which seems possible, that will be on the basis of 70% of trips - both to and within the city - being by bike, foot or public transport and 30% by car (City of Copenhagen, 2022).

Similarly in the West of England, the bicycle and the bus, as the centrepieces of an integrated transport system, offer the best means of modal shift by 2030. Light rail may play a role in the medium and long term but cannot be provided quickly enough for 2030. Other options, such as electric scooters to connect to the public transport network or car-pooling by employees travelling to the same site, can appeal to specific types of travellers for particular types of trips. However, in terms of capacity, flexibility and availability to all, buses and bikes are the most deliverable solutions.

Both the bus and the bicycle have been much more important as providing mobility for the majority in the past, prior to the rise of mass car ownership which pushed them, almost literally, off the road. Buses will not be a mode of choice for those with a car available unless they are given obvious and effective on-street priority (bus only streets). Priority enables both a competitive journey time and, even more important, reliability. Having certainty about connections underpins an integrated transport system within which a user can be confident about moving between services and types of transport. Priority also reduces operating costs, enabling a virtuous circle of better, more efficient services attracting more passengers who provide more revenue. The West of England Metrobus has achieved a step-change in service quality, but reliability continues to be affected by congestion. WECA reports that the high-priority Metrobus network saw reduced journey times and a thirty percent patronage growth 2019-2024, however, punctuality and reliability across the bus network were identified as inadequate and are to be targeted by measures including further bus priority in the Authority's Bus Service Improvement Plan (WECA, 2024e). Despite passengers needing to possess a ticket prior to boarding, each passenger has to validate the ticket with the driver before the vehicle departs, which takes a small number of seconds per passenger, but at busy stops the total time can exceed a minute. A change of revenue protection policy or application of a new validation technology is needed to speed this process.

Buses also need to be understood as a cost-attractive option. Motoring costs have tended to fall in recent years, whilst electrification to date has increased the fixed-cost investment in cars whilst reducing the operating costs. The package of motoring costs set by local authorities (parking charges and permits, workplace parking levy, Clean Air Zones) and national authorities (fuel duties and the new road user charge for EVs) will need to be managed to increase the competitiveness of public transport. This can be politically challenging where the system does not reach all citizens.

The barriers identified to cycling include hilly terrain, rider capabilities, weather, and safety. The rise of electric bikes has helped to reduce these barriers for many. The weather conditions in The Netherlands are little different from our own. However, safety remains the key challenge. Safe infrastructure and traffic management is important here: some people will only begin to cycle if there is effective calming of car traffic. Others will only cycle if completely segregated from traffic in lanes protected by kerbs or on off-road routes. The design of off-road routes needs to consider personal security. Lighting may be appropriate in some times and places. Again, a virtuous circle needs to develop from better infrastructure (manufactured capital) and other supporting measures encouraging cycling, so cycling becomes a more shared and visible practice. In turn, motorists will become more accommodating of cyclists, in part due to traffic management and in part because many drivers will also be cyclists themselves for some of their trips. Cargo bikes can also play an important role in 'civilising' urban freight deliveries where consignment weight and size allow.
The suburban and rural areas remain more challenging territory for public transport and cycling, but these are also the domains in which most car emissions are produced. Long journeys pollute more but are relatively infrequent. Short journeys may be frequent but are too short to impact the emissions inventory in an important way. It is the daily car journeys of 2-25 miles which have been shown to contribute most carbon (Department for Transport, 2009). The suburbs and rural areas are therefore too important for decarbonisation policy to abandon to the car. Bus priority needs to be applied outside cities, on trunk roads and at bottlenecks. Local transport interchanges or 'mobility hubs' will be critical to enable people to transfer from car or cycle to enhanced, limited-stop buses, and where they exist, or can be rapidly provided, trains (Parkhurst & Meek, 2014).

Turning to ‘improvement’ measures, the United Nations International Panel on Climate Change (2022) leaves no doubt that the electrification of the vehicle fleet, provided it is powered with low-GHG electricity, is the single most important transport decarbonisation measure globally. It is also worth noting the road transport can be important to economic growth. In other words, to the extent that we need motor vehicles, let them be electric. However, we cannot rely solely on electrification as a behaviour-change-free technical fix (Parkhurst, 2025). First, the West of England authorities have set 2030 targets of up to 90% for fleet electrification, a target which is not achievable. Even the Zero Emission Vehicle Mandate (ZEVM) now requires only 80% of new cars sold in 2030 to be zero emission (the other 20% can be hybrids). It would take around a decade longer to achieve 90% fleet penetration. Second, current EVs are far from being ‘net zero’. Given vehicle production practices and the degree of decarbonisation of the energy grid which recharges them, EVs to date have approximately halved emissions compared with an equivalent internal combustion engine vehicle, although this advantage is expected to grow sharply in line with decarbonisation of the energy and automotive production sectors. Third, the electrification transition is itself an uncertain target subject to political and technical constraints. The ZEVM targets may yet prove politically untenable. Around one-third of UK households have no home charging possibility (ChargeUK, 2024), but energy sector practices and taxation policy have resulted in a situation that public charging costs can be up to 13 times higher than the most attractive domestic tariffs for home charging, creating clear winners and losers from the transition. If the differential is not significantly reduced then the EV-only road user charge may prove to be the ‘final straw’ breaking the back of public support.

To conclude, it is important to note that the 2030 targets set by West of England authorities were the right ones, if transport decarbonisation is to be achieved at the national scale. That the subregion is clearly a long way from meeting them on time underscores that greater national leadership, as well as local action, is needed. The limited progress in relation to transport is the product – by no means unique to the West of England - of placing an emphasis on the wrong end of the 'avoid-shift-improve' hierarchy (SLOCAT Partnership, updated). The intended logic of the approach is to start with avoiding carbon-emitting travel, then shift to more sustainable modes for travel that cannot be avoided, and then only 'improve' that travel that cannot be shifted.

In practice, behaviour change solutions have not to date led the process, as they have not had sufficiently broad and deep political support. This lack of support reflects the so called 'structural' constraints which mean society has become dependent on the car. Instead, we have emphasised 'improving', but only since the beginning of the decade have the conditions for the main measure (vehicle electrification) enabled it to enter the mass market, too late to have sufficient impact on the 2030 targets. As the subregion steels itself for a reset towards the 2050 targets, it will be important to emphasise that the GHG problem is one of cumulative emissions, so the timing of progress will become even more important. With the EV transition likely to prove a 'rough ride', it will be important to return to policies which emphasise cars as one supporting part of the transport system, with most people making most of their journeys by other means or taking advantage of the digital solutions which saved us in another recent emergency.

Flight emissions from Air transport services (SIC 51)[43]

The GHGs of outbound flights in 2022 are estimated to be the equivalent of all household GHG emissions for the West for England. At the national level,

[43]This is the flight related emissions from outgoing flights for the aggregated SIC code 51 see appendix 2. Flight emissions from Freight air transport 51210 could not be found from data, but if these occur in tandem

emissions from air transport are projected to decline by only 17% by 2040 relative to 2023 levels, positioning it nationally as the sector with the greatest residual emissions at that time (Climate Change Committee, 2024)[44]. The relatively modest projected reduction reflects both the technical challenges of decarbonizing aviation and continued growth in demand for air travel (Climate Change Committee, 2024).

Decarbonization pathways in aviation encompass several complementary approaches. The rollout of sustainable aviation fuel represents a near-term option, though supply constraints and cost considerations remain significant barriers. Efficiency improvements, including the adoption of hybrid-electric, battery-electric, and hydrogen propulsion systems, offer longer-term potential, though these technologies remain at early stages of development with considerable uncertainty regarding their viability and scalability. Given this technological uncertainty, maintaining optionality across multiple decarbonization pathways is prudent.

Demand management policies constitute another critical lever, operating primarily through price mechanisms. The Climate Change Committee (2025) state, a precautionary approach engaging demand management strategies may be required, due to risk in overrunning climate change targets. Additionally, past performance of the aviation industry in meeting climate change targets has been identified as poor (Green Gumpton and Possible, 2022). Climate Change Committee (2025) cite that the cost of decarbonising aviation and addressing non-CO_2 impacts should be reflected in the cost to fly, either through direct taxation or indirectly through costs passed on by airlines to moderate growth in

with passenger flights then they will have been picked up, but the authors suspect they are freight air transport has specific flights separate from passenger flights. Further research is required on the latter. Please note that in In Table 7, other scope 1 GHGs (non-flight generated) from: 51101 : Scheduled passenger air transport; 51102 : Non-scheduled passenger air transport; 51210 Freight air transport were included were also included for the aggregated category SIC 51. Flight related emissions dominate this aggregated category of 51.

[44] Climate Change Committee (2024, p. 222).

aviation demand[45]. The region may however be constrained and reliant on national policy to implement an approach such as additional charges for frequent flyers.

Airports also drive future flights by putting on new destinations and making the case for increased passenger number allocations[46]. In terms of local policy maker control, this is limited currently, the government Department for Transport (DfT) sets policy with airport operators and airlines. The extent to which this may change with devolution is currently unknown. Airports can provide economic benefits to regions. There is however not consensus on whether overall they economically benefit a region, it seems to depend on a range of factors, context and system boundary of study etc (this is later discussed). Factors such as the extent to which they bring in visitors and business from other parts of the world to the region (who invest/spend money in the region and inject expenditure into the regional and UK economy) versus taking regional citizens on holidays abroad who then spend their money outside the UK etc (leakage, takes money out of the regional and UK economy) seem to be important amongst other factors. Two references with regard to economic benefits with differing system boundary and perspective are provided later in the report. Beyond airports, The West of England's significant aerospace sector presence creates both responsibility and a significant opportunity and value proposition for the region in the complementary manufacturing of supplying plains. While decarbonization options for air transport remain limited in the near term, the region is well-positioned to lead innovation in energy-efficient aircraft design and novel propulsion technologies. Additionally, Hydrogen South West is a consortium looking at connecting people, places and projects, to drive the development of hydrogen infrastructure. Regional support for aerospace R&D focused on decarbonization could generate both local economic benefits

[45] The sector's non-CO_2 climate effects, including emissions of nitrogen oxides, water vapor, black carbon, and sulphur dioxide, require separate policy attention.

[46] External foreign ownership and profit maximisation (is at the centre of the business model) exacerbating the pursuit of increased flights.

and global climate impact. The concentration of aerospace expertise in the region represents a strategic asset that should be leveraged to accelerate the development and deployment of low-carbon aviation technologies, as solutions could be sold round the world if successful and there is clearly a need for solutions on demand side policy on frequent flyers.

Domestic Household

A seen in Figure 6 domestic household emissions make up twenty percent of total emissions for the region in the direct GHG account. There are two non-mutually exclusive approaches to reducing CO_2 emissions from households: the individual retrofit of the entire stock of thermally inefficient buildings, which is costly, intrusive and sometimes not as effective as anticipated due to the performance gap (Gupta and Kotopouleas, 2018), but is nonetheless necessary, and the development of a clean and economical community energy network. See section 5.3 regarding the latter.

The main way to address the regions domestic household emissions is though retrofitting housing. Retrofitting is required and emphasised as most housing is existing and not recently built properties, so a good household retrofitting strategy is necessary to make traction with reducing these GHGs. In this section we provide a summary of the progress with Net Zero related retrofitting of households, including governance, targets, and delivery trajectories in the West of England. Central to the GHG reduction strategy for the region is the decarbonisation of the built environment. To align with the 2030 trajectory, the region has set a headline target to improve the energy efficiency of 250,000 homes and 8,000 non-domestic buildings (WECA 2024b). This section audits the region's capacity to deliver this transformation, synthesising evidence from WECA and its constituent Unitary Authorities.

One component of household emissions comes from the energy required to heat homes. Making properties more thermally efficient (to reduce usage) and decarbonising sources of heat (to replace usage) are therefore central to

meeting household emissions reduction targets. Yet at present, there is a profound disparity between the West of England's ambition to reduce these emissions and its operational delivery.

The region has a target to improve the energy efficiency of 250,000 homes, to align with WECA's ambition to reach net zero by 2030 (WECA, 2024a). Achieving this 250,000-home target required an installation rate of approximately 32,500 retrofits per year (WECA, 2022). But baseline assessments indicate a current annual delivery capacity of approximately 1,700 homes (ADEPT, 2022). This represents a 'delivery gap' of a nineteen-fold magnitude (ie the delivery rate is about 1/20th of the aspirational rate). However, there are partial evidences available since, including local authority monitoring data and independent programme evaluations, suggests that overall delivery has not yet accelerated to the scale the target demands and that the gap is unlikely to have narrowed in the intervening period and might've even increased, the difference between aspiration and reality might've increased somewhere between 20-fold and a 40-fold difference in retrofitting rates to meet the 2030 target.

Since the launch of the Retrofit Accelerator in 2022, the region has made meaningful strides in building the infrastructure for scaled delivery. Retrofit West, the Community Interest Company established by the Centre for Sustainable Energy (CSE) with WECA funding and launched in 2023, has become one of the UK's few examples of a coordinated local retrofit one-stop-shop, connecting homeowners with independent advice and vetted installers whilst developing a thriving local supply chain (Centre for Sustainable Energy, 2025). An independent evaluation commissioned by WECA found that businesses on the Retrofit West installer hub reported a 43% increase in enquiries for their services and a 31% increase in completed retrofit jobs (ibid). In Bath and North East Somerset, the proportion of homes achieving an EPC rating of Band C or above rose from 19% in 2023 to 36% by 2025, driven primarily

by Social Housing Decarbonisation Fund investment, though private homes lag considerably with just 22% reaching Band C (Inside Housing, 2025). Whilst these are encouraging indicators of growing market activity, the absolute scale of delivery remains a fraction of what the 2030 target demands and the delivery gap might've increased since then.

Understanding the ambition-delivery gap

As the UK has some of the oldest housing stock in the world, with associated thermal inefficiencies, retrofit policies have a significant role to play in reducing household emissions. 'Retrofitting' encompasses a range of interventions made to the existing housing stock – from installing low-carbon technologies like heat pumps, battery storage and photovoltaic and thermal solar panels to energy efficiency measures like loft, cavity or solid wall insulation and window upgrades. Within some densely populated areas and within some forms of collective housing (flats), the supply of heating through collective heat networks offers both efficiency and decarbonisation benefits. By providing heating and hot water from centralised generation sources, such as heat pumps, geothermal energy or industrial waste heat, networks can utilise waste heat, manage peak demand and minimise the need for grid upgrades (see the policy insight on the Bristol Heat Network). However, for the bulk of suburban individual homes in the West of England under individual home ownership, connecting to district heat systems will be impossible, impractical or financially unviable. In such cases, individual retrofitting is required to improve a building's thermal performance.

The reasons for the massive disconnect between aspiration and reality are multiple. There is a lack of demand for and confidence in retrofitted systems amongst householders (demand-side barriers). There is a lack of skilled trades people and companies who produce the goods and services to retrofit these technologies. There is a lack of finance to both help householders buy goods

and services and for businesses to invest in retrofitting as a product/service. This is a stand-off between consumers, suppliers and financiers.

As an example of the supply-side barriers to retrofitting in the region, there is a critical skills shortage in the retrofitting construction sector. Analysis indicates that the workforce for solid wall insulation would need to expand 48-fold to meet the 2030 deadline (WECA, 2021). At 2021 installation rates, estimates suggest that completing the necessary solid wall insulation alone would take 557 years (ibid). These figures relate specifically to solid wall insulation, one of the most technically demanding retrofit measures and are complementary to the programme-level delivery gap rather than a substitute for it.

Governance and asymmetric delivery

There is no shortage of programmes and projects that attempt to address the knotty issue of increasing retrofitting rates in the West of England. The West of England has already pioneered novel delivery modes to address heat decarbonisation. Bristol has launched the 'City Leap Energy Partnership', a joint venture with the private sector designed to attract £1 billion of investment into low-carbon infrastructure (Bristol City Council, 2024). Meanwhile, Bath and North East Somerset Council (BANES) operates the 'Energy at Home' scheme, which offers unconditional loans to homeowners for energy improvements (Livewell BANES, 2024). WECA acts as a strategic enabler, managing the £10 million 'Retrofit West' programme to address skills and advice barriers (WECA 2024b). Despite these initiatives, retrofitting rates remains stubbornly low.

Beyond the overarching retrofit goal, target-setting is devolved to unitary authorities, resulting in significant regional divergence. Bath and North East Somerset has adopted a prescriptive approach, setting targets for 65,000 retrofits and a 40% phase-out of gas heating by 2030 (BANES, 2023). Similarly, Bristol City Council has set a requirement to replace 160,000 boilers (Bristol City

Council, 2024). Conversely, public strategies for South Gloucestershire and North Somerset lack equivalent quantified targets for retrofitting the existing housing stock, focusing instead on new-build standards (South Gloucestershire Council, 2023; North Somerset Council, 2023). Councils and other stakeholders in the region are involved with other projects such as 'Mission Net Zero' that aims to aid retrofitting of households.

Despite these interventions, progress has been slow and progress tracking remains a critical weakness. There is no unified regional dashboard to monitor overall retrofit numbers and proxy metrics suggest only incremental gains. For example, South Gloucestershire reported a rise in homes with energy performance certificates (EPC) rated A-C of just one percentage point between 2023 and 2024 (South Gloucestershire Council, 2024). Meanwhile, North Somerset Council has formally admitted that the authority is "*not on course to meet our target of being net zero by 2030*" (North Somerset Council, 2025). EPC monitoring does not capture the 50% of homes that are not being sold nor being rented. There is a need to up the game of monitoring, evaluating and learning from the multiple initiatives. There is a massive need to share the learning and to join up what is being done. Only through such efforts can we hope to massively increase the uptake of retrofitting in the West of England.

Based on the last published whole-region assessment, the difference between aspiration and reality represents a nineteen-fold gap in annual retrofitting rates, a figure that is unlikely to have improved given the absence of any published evidence of step-change acceleration since the Retrofit Accelerator's launch in 2022. Despite the plethora of initiatives, pilots and projects, evidence indicates that current retrofit delivery rates are massively insufficient to meet the region's 2030 ambition – the difference between aspiration and reality might've increased somewhere between 20-fold and a 40-fold difference in retrofitting rates to meet the 2030 target. We are not monitoring sufficiently, we are not evaluating sufficiently, we are not learning sufficiently. The region is currently

flying blind on this process of transition and needs to adopt a joined-up structure of evidencing – whether that relates to rates of adoption or changes to the market of tradespeople and businesses required to fit and install the technologies.

Commercial & industrial and public sector

The published C&I and public sector estimate of Table 6 are heavily aggregated. Also, these published GHGs figures seem very low, and this is illustrated by the fact that both the 'Sector Employment and sector $KtCO_2e$ coefficient approach' and the LIDP 'bottom-up approach' (which substantially made use of actual company data) had much higher estimates of GHGs for key C&I sectors. See discussion in Appendix 2[47]. We outline here the prioritisation of key GHG emitting sectors in Table 7 for C&I and public GHGs and are reasonably confident that the prioritisation is correct (see discussion in Appendix 2). The DESNZ 2025c data for 2022 provides very little sector disaggregation, which is why this study needed to implement an alternative approach to estimate detailed sector breakdowns. The prioritisation of different C&I and public sectors for the West of England provide key insight on important GHG emitting sectors in the region (in terms of scope 1 GHGs). Top ranking commercial, industrial and public sectors (with electricity and transport emissions reallocated back to the producing sector) for the West of England and UK are presented below in Table 7.

[47] For example, total C&I and public sector GHGs according to the Sector employment and sector KtCO2e coefficient approach' for the region are 4577 $KtCO_2e$ (if we exclude scheduled and charter passenger flights as these were not included in the DESNZ (2025c) data for 2022). This compares with the estimate of 1192 $KtCO_2e$ in the published data (and this is even when our estimates are only scope 1 as opposed to scope 1 and 2 in the DESNZ (2025c) data for 2022). This difference could be due to a bug or error in the DESNZ 2025c C & I data, or perhaps under reporting by industry in the Environment Agency point source data which informs this dataset, but the current authors are fairly sure there is a substantial underestimation in the published C&I figure of DESNZ 2025c data for the year 2022, as highlighted and discussed in Appendix 2.

Table 7: Top 15 direct GHG contributing C&I and public sectors in the West of England and compared to the UK

West of England	% Employment	% GHGs	United Kingdom	% GHGs
Air transport services (SIC 51)	0.2	22.0	Products of agriculture, hunting and related services (SIC 1)	14
Electricity production – gas (SIC 35.1/1)	0.1	12.2	Electricity production - gas (35.1/1)	13
Manufacture of articles of concrete, cement and plaster (SIC 23.6)	0.1	11.0	Air transport (SIC 51)	9
Waste collection, treatment and disposal services; materials recovery services (SIC 38)	0.8	10.9	Waste collection, treatment and disposal services; materials recovery services (SIC 38)	6
Products of agriculture, hunting and related services (SIC 1)	0.6	6.7	Extraction of crude petroleum and natural gas (SIC 6)	4
Public defence services (SIC 84.22)	1.8	6	Manufacture of refined petroleum products (SIC 19.2)	4
Freight transport by road and removal services (SIC 49.4)	0.7	3.3	Freight transport by road and removal services (SIC 49.4)	4
Human health services (SIC 86)	9.6	2.1	Manufacture of basic iron and steel (SIC 24.1-3)	3
Wholesale trade services, except of motor vehicles and motorcycles (SIC 45)	2.8	1.5	Electricity production - other (SIC 35.1/5)	2
Specialised construction works (SIC 43)	2.9	1.5	Manufacture of gas; distribution of gaseous fuels through mains and steam and air conditioning supply (SIC 35.2-3)	2
Retail trade services, expect of motor vehicles and motorcycles (SIC 47)	7.1	1.2	Wholesale trade services, except of motor vehicles and motorcycles (SIC 45)	2
Fabricated metal products, except machinery and equipment, excluding weapons and ammunition (SIC 25.2-3+25.5-9)	0.6	1.1	Manufacture of cement (SIC 23.51)	2
Manufacture of gas; distribution of gaseous fuels through mains and steam and air conditioning supplies (SIC 35.2-3)	0.0	1.1	Electricity production - coal (SIC 35.1/2)	2
Food and beverage serving services (SIC 56)	6.3	1.0	Human health services (SIC 86)	2
Warehousing and support services for transportation (SIC 52)	2.6	1.0	Retail trade services, except of motor vehicles and motorcycles (SIC 47)	1
Percentage of total	36	83	**Percentage of total**	69

Sectors with relatively low GHGs (outside of top 15) and high employment (in top 15)		
West of England Sectors	**% Employment**	**% C&I and public GHGs**
Education services (SIC 85)	9.2	0.8

Public administration; compulsory social security services (SIC 84 (not 84.22))	4.1	0.8
Architectural and engineering services; technical testing and analysis services (SIC 71)	3.3	0.2
Employment services (SIC 78)	2.8	0.1
Computer programming, consultancy and related services (SIC 62)	2.7	0.1
Social work services without accommodation (SIC 88)	2.4	0.1
Services auxiliary to financial services and insurance services (SIC 66)	2.4	0.1
Services to buildings and landscape (SIC 81)	2.0	0.2
Services of head offices; management consulting services (SIC 70)	1.9	0.1
Percentage of total	**31**	**2.5**

Interestingly as seen in Table 7 the priority sectors for the West of England region in terms of emissions produced by sectors (Scope 1) are somewhat different to the those for the UK as a whole. With GHG emissions of flights included in the aggregated air transport services (SIC 51) the highest for the region (22%), these were discussed above (so is not treated further here). The second and third highest emitting sectors were electricity production – gas (12%) and the manufacture of articles of concrete, cement and plaster (11%). For GHG intensive activities for the latter, these relate to manufacturing of plaster products for construction as well as manufacture of ready mixed concrete, mortars and concrete products (and GHGs were broadly in that order). Waste collection is another GHG intensive sector (11%), GHG activities here mainly relate to collection of non-hazardous and hazardous waste (collection of non-Hazardous likely generating most GHGs due to transport), and treatment via incineration an important contributor. Other sectors such as agriculture, freight/logistics, human health services[48] are also prominent scope 1 GHG generating sectors in the region. Importantly, the top 15 sectors here make up

[48] It is believed that the percentage for public defence services is likely an overestimate here (as much of the activities on defence in the region are believed to be services based and with lower SCOPE 1 emissions).

over 80% of the C&I GHGs directly produced by sectors in the region, so strategically important in reducing commercial and industrial GHGs. It is important to note that 63% of emissions occur in the top 5 sectors alone[49]. These percentages are quite different from an identical and consistent analysis for the UK where the top 15 sectors make up only 51% of overall GHGs, so if we focus on these key sectors, then we can substantially decarbonise the overall C&I and public sector GHGs produced in the region.

Employment in sectors with low and high GHG emissions

Highlighted towards the bottom half of Table 7 are those sectors that employ most people in the region, 9 of the top 15 sector employers are very low direct emitters of GHGs. This is very promising and shows that some sectors can grow with limited impact on the regions direct GHGs. It is also notable that the top five GHG generating sectors are not substantial employers in the region in terms of overall West of England employment (only making up 1.8% of employment in the region). So these findings indicate that moving towards a Net Zero economy in the region, will have very limited detrimental impact on overall employment for the region. It should be possible to decarbonise most high GHG emitting sectors without substantial reductions in employment via strategy and technology (see section 5.3). This said for the sectors generating most GHGs in the region it would be unwise to prioritise growth in these sectors without realising tangible decarbonisation progress, otherwise this growth does not align with the third aim of sustainable development. This said care needs to be taken that sectors are helped to transition and work done to avoid job losses wherever possible. We now look at decarbonising some of the key sectors (not already discussed).

[49] The totals in this analysis do not include emissions associated with Consumer expenditure - not travel, Consumer expenditure – travel, and Land use, land use change and forestry (LULUCF).

Electricity Production

Electricity generation from gas represents 12% of direct C&I and public sector emissions in the West of England according to our estimates. The decarbonisation trajectory for this sector is more favourable than for aviation, with national projections indicating an 88% reduction in emissions by 2040 relative to 2023, and full decarbonisation by 2050. This substantial progress builds on the sector's transformation since 1990, during which emissions have declined by nearly 80%, primarily through the replacement of coal-fired generation with low-carbon alternatives after 2012 (Climate Change Committee, 2024[50]). See West of England industrial cluster discussions in later sections of this report which provide further regional insight.

At the national level, the electricity system must simultaneously decarbonise supply and accommodate substantial demand growth. Electricity demand is projected to double by 2050 relative to 2023 levels, driven by the electrification of transport, buildings, and manufacturing (Climate Change Committee, 2024[51]). Meeting this combined challenge requires the deployment of low-carbon generation capacity at unprecedented scale. And of course, this is without considering implications on energy demand from the growth of AI.

Offshore wind is positioned as the backbone of the future electricity generation system. The UK has established 15 GW of offshore wind capacity as of 2023, half of which was installed after 2019, ranking second globally only to China (Climate Change Committee, 2024)[52]. Achieving net zero requires accelerating deployment from the current 1-2 GW per year to 5.7 GW annually before 2030, followed by approximately 4.0 GW per year through 2050 (Climate Change Committee, 2024)[53]. Onshore wind and solar capacity, which can be deployed

[50] p. 205.

[51] p. 208.

[52] p. 209.

[53] p. 209

more rapidly, provide important complements. Storable energy sources including gas with carbon capture and storage, hydrogen, (green hydrogen is needed, rather than blue as the latter is made from fossil fuels) nuclear, bioenergy, and grid-scale battery storage are essential for maintaining system reliability as variable renewable generation expands. This said to date CCS is proving operationally problematic where deployed and may not be the 'magic bullet' some envision it to be.

The projected doubling of electricity demand necessitates substantial upgrading and extension of transmission and distribution networks before demand growth materialises. Current deployment faces bottlenecks related to planning processes, grid connection capacity, and supply chain constraints. Nationally (and somewhat also regionally) policy interventions must address planning and consenting reform, provide adequate regulatory funding for network expansion, and support supply chain development. The scale of infrastructure investment (manufactured capital) required is substantial and represents a key implementation challenge.

Manufacture of Articles of Concrete, Cement and Plaster

This manufacturing subsector accounts for 11% of direct emissions in the West of England, with particularly intensive activities in the production of plaster products, ready-mixed concrete, mortars, and concrete products. The subsector presents distinct decarbonisation challenges compared to other manufacturing activities, as emissions predominantly result from process emissions inherent to cement production rather than combustion for energy. These process emissions cannot be eliminated through fuel switching alone.

Carbon capture and storage (CCS) emerges as the primary abatement option, expected to contribute approximately 60% of emissions reductions in this subsector. Resource efficiency measures represent the second-largest contributor at approximately 20%, with bioenergy accounting for the remainder

(Climate Change Committee, 2024)[54]. The prominence of resource efficiency reflects the subsector's material intensity and the substantial emissions embedded in production processes.

Specific resource efficiency interventions include clinker substitution in cement production, which can reduce the emission intensity of cement; refurbishment of existing buildings rather than new construction, which reduces demand for cement and concrete; waste reduction in construction processes; reduction of over-design in structural engineering; and reuse of building components. By 2035, resource efficiency measures are projected to contribute 26% of emissions reductions in the cement subsector (Climate Change Committee 2024)[55]. The technical challenges associated with fuel switching to electricity or hydrogen in this subsector underscore the importance of CCS deployment and resource efficiency improvements. Also, see discussion by Jacobsen (2025) on how to decarbonise steel and cement.

Waste Collection and Treatment

The waste sector accounts for 11% of direct emissions in the region, with emissions concentrated in the collection of non-hazardous and hazardous waste and in waste treatment through incineration. Emissions from non-hazardous waste collection likely generate the largest share due to transport requirements. By 2050, waste sector emissions are projected to decline by 67% through increased recycling, waste prevention, and deployment of CCS (Climate Change Committee 2024)[56]. However, residual emissions will persist beyond 2050 due to hard-to-abate processes in wastewater treatment, legacy landfill emissions, and uncaptured CO_2 from energy-from-waste facilities.

Progress in waste sector decarbonisation has stalled over the past decade, with recycling rates remaining essentially flat since 2010 (Climate Change

[54] p. 181.

[55] p. 179.

[56] p. 244.

Committee 2024)[57]. Achieving emissions reduction targets requires increasing recycling rates to 68% by 2035, a level unlikely to be reached under currently planned policies (Climate Change Committee 2024)[58]. This performance gap indicates the need for stronger policy interventions and greater clarity in government plans for recycling, reuse, and resource efficiency.

Local authorities, which manage approximately 40% of waste in the UK, require both adequate funding and policy certainty to improve recycling infrastructure and performance (Climate Change Committee 2024) [59]. The distinction between fossil waste (from fossil-carbon sources such as plastics) and biogenic waste (from biological sources such as food waste) has important implications for emissions accounting: while fossil waste incineration generates net CO_2 emissions, biogenic waste does not contribute new emissions to the atmosphere unless it decomposes into methane, which occurs when such waste is sent to landfill.

The projected 67% reduction in waste emissions by 2040 will be achieved primarily by reducing waste sent to landfill and energy-from-waste facilities through increased recycling, waste prevention, and circular economy approaches Climate Change Committee (2024)[60]. Investment in advanced wastewater treatment technologies, including advanced anaerobic digestion for both municipal and industrial facilities, is necessary to address emissions from wastewater treatment. Such improvements would also contribute to water quality objectives by reducing sewage spills into rivers.

Agriculture and Land Use

Agriculture and land use constitute a prominent source of Scope 1 emissions in the region. The sector's emissions derive primarily from methane released by livestock, nitrous oxide from fertilizer application and manure management, and

[57] p. 245.

[58] p. 245.

[59] p. 251.

[60] p. 245.

CO_2 from land use changes. Achieving net zero in this sector requires a combination of low-carbon farming techniques, carbon sequestration through woodland expansion and peatland restoration, and adjustments to livestock numbers.

Low-carbon farming techniques are projected to account for 35% of emissions reductions by 2040 (Climate Change Committee 2024)[61]. These interventions include feed additives to inhibit methane production in cattle, breeding and livestock health measures to reduce emissions intensity per unit of output, and improved management of animal waste to reduce both methane and nitrous oxide emissions. Methane emitted from ruminant livestock, particularly cattle and sheep, represents the single largest contributor to agricultural emissions.

Electrification of agricultural operations will contribute approximately 20% of emissions reductions by 2040 (Climate Change Committee 2024)[62]. Machinery used for heating and cooling agricultural buildings is expected to achieve full decarbonization by 2050 through electrification. Mobile machinery will also transition to electric power, though larger vehicles may require alternative solutions. This represents a straightforward application of established electrification technologies to the agricultural context.

Reductions in livestock numbers are projected to contribute 32% of emissions reductions in the sector. This reflects anticipated declines in meat and dairy consumption, which would release approximately 70% of land currently devoted to livestock production (Climate Change Committee 2024) [63]. This released land can be redirected toward woodland creation, peatland restoration, and cultivation of energy crops, all of which contribute to carbon sequestration. Policy vigilance regarding imported agricultural products is necessary to ensure

[61] p. 193.

[62] p. 194.

[63] p. 194.

that domestic emissions reductions are not simply displaced to other countries through increased imports of meat and dairy products.

Unlike many other sectors where decarbonisation can be achieved through cost-saving efficiency improvements, agricultural decarbonisation registers a net cost to the economy according to the Climate Change Committee. These costs reflect expenditure on machinery electrification, implementation of low-carbon farming measures, and woodland creation. This net cost profile must be acknowledged in policy design and may require targeted support mechanisms to enable the transition. While adaptive measures like shifting business models may help address impacts. See our discussion later in the report regarding potential for business model change and economies of scope to have potential in increasing economic productivity and resilience of farms. This area deserves future research to explore and share innovations in the sector.

Freight and Logistics

Freight and logistics represent another prominent scope 1 emissions source in the region[64]. The sector encompasses road freight, rail freight, and shipping activities, each with distinct decarbonisation pathways. Here we primarily discuss the decarbonisation policies for shipping activities as it constitutes the majority of freight activities. The transition timeline for this sector is projected to occur in two distinct phases, reflecting the current immaturity of low-carbon fuel markets and technologies.

Through 2040, emissions reductions will be driven primarily by technology development and energy efficiency improvements. Between 2040 and 2050, the sector will transition to reliance on low-carbon fuels and electrification as the primary decarbonisation mechanisms (Climate Change Committee 2024)[65]. This

[64] We did not have data to estimate the freight emissions from shipping as the main dataset used contained emissions only occurring within UK boarders.

[65] p. 260.

phased approach reflects the lead time required to develop production capacity for alternative fuels and to establish the necessary refuelling infrastructure.

Fuel switching will constitute the primary driver of decarbonisation in the shipping sector, though considerable uncertainty remains regarding the optimal fuel mix. Low-carbon ammonia and synthetic methanol emerge as the most reliable alternatives to conventional fuels (Climate Change Committee 2024)[66]. However, these fuels are not currently produced at scale, and markets for them remain underdeveloped. Ammonia presents implementation challenges: it is highly toxic, requiring specialised skills for handling and dedicated storage infrastructure, limiting its application primarily to large cargo vessels where these requirements can be met. This said, there is a long history of ammonia production using the Haber-Bosch process. About 2% of CO_2 emissions globally come from ammonia production. The challenge will be to produce green ammonia at scale alongside ensuring the chemical engineering expertise and skill sets are available to manage production and distribution.

The diversity of vessel types, sizes, and operational profiles necessitates a broad portfolio of policy options and technological solutions. Energy efficiency improvements in shipping include wind assistance systems, propeller ducts, rudder bulbs, and speed optimisation. These near-term efficiency measures can deliver emissions reductions while longer-term fuel switching solutions mature.

The shipping sector requires coordinated policy intervention to support alternative fuel production capacity development, establish refuelling infrastructure, and manage the transition across diverse vehicle and vessel types. The extended timeline for this transition underscores the importance of early action to enable the necessary infrastructure and supply chain development.

[66] p. 258.

Human Health Services

The human health sector accounts for a notable share of both direct GHG emissions (2.1% of the regions C&I and public sector GHGs), primarily reflecting its use of non-residential buildings. As a structures-intensive sector, its emissions profile largely mirrors that of commercial and public buildings more generally.

Electrification of heating represents the primary decarbonisation strategy for non-residential buildings. Heat pumps are technically suitable for most of these buildings and can be deployed either as individual building systems or as part of larger-scale heat networks. Heat networks are particularly appropriate for areas with high heat density, where non-residential buildings could serve as anchor loads for networks that also serve residential properties.

The main barrier to heat pump adoption is the current price differential between electricity and gas, which creates unfavourable economics despite the superior efficiency of heat pumps. In contrast, energy efficiency measures in buildings are typically cost-effective and can deliver immediate cost savings, suggesting potential for rapid deployment. Specific energy efficiency interventions include building management systems, zone and timing controls, and improved management practices (collectively accounting for 60% of efficiency improvements); insulation (26%); and heating and hot water system improvements the remainder (Climate Change Committee 2024)[67].

The public sector, including the health service sector, should lead decarbonisation efforts in non-residential buildings. Emissions reductions in this building category have been largely driven by public sector action to date, though progress has been relatively flat over the past decade (Climate Change Committee 2024)[68]. Sustained deployment of heat pumps in the public sector

[67] p. 255.

[68] p. 251.

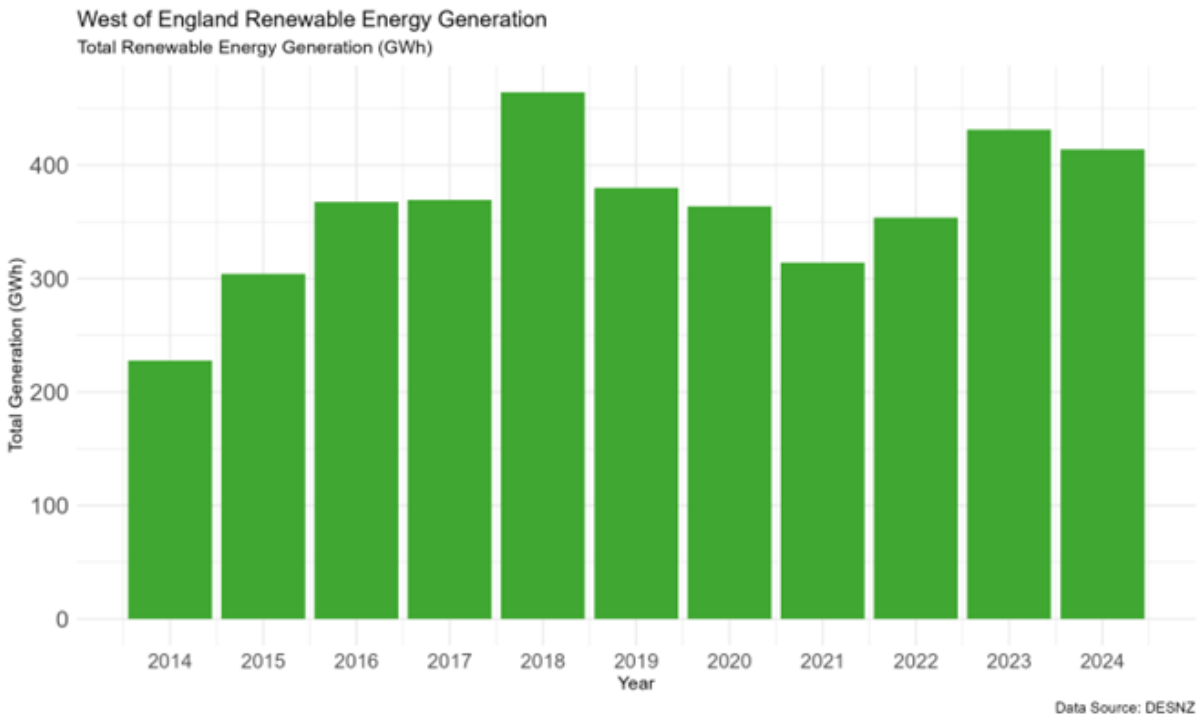
requires long-term policy commitments, adequate funding, and development of supply chains capable of supporting rapid installation rates.

A consistent, long-term approach to public sector building decarbonisation can catalyse supply chain development and workforce training that subsequently benefits commercial and residential building decarbonization. Policy interventions to reduce the relative price of electricity would incentivize heating electrification, though options for price intervention remain limited. Planning support for heat networks and market development for heat pumps represent additional policy priorities

2.2 Renewable generation in the West of England

Renewable electricity generation in 2024 amounted to 414 GWh in the region most of this came from solar (about two thirds of the renewable energy total), and onshore wind made up about 30%. Renewable electricity generation is going up see figure 9, it is however still small compared to demand. Total electricity consumption in the region in 2023 was 4,008 GWh (a 13% decrease on 2014). This is important as the region needs substantially more renewable generation to meet regional GHGs targets (electrification is a keyway to decarbonise for both households and industry) and to support more renewable generation nationally in addressing Net Zero.

Figure 9: West of England Renewable Generation (WECA 2025d[69])



2.3 Embodied GHG account: GHG profile for West of England

The scope 1 GHG account only provides a partial view of the overall GHGs embodied in the region's production, as this does not account for the upstream embodied emissions (occurring in the UK and abroad) attributable to producing the final goods and services of sectors in the region. Importantly, it provides some deep insight on the extent to which the region is outsourcing pollution to enable its final end products and services (via imports). It was possible to estimate these GHG emissions by applying the estimation approach outlined in section in Appendix 2. We have estimated a carbon footprint ($KtCO_2e$) of emissions attributable to final demand of sectors in our region (scopes 1, 2 and 3). This account is provided below in table 8 and is the first such account for the West of England region, providing new insight to inform strategies to address GHG mitigation and climate change.

[69] Data from DESNZ (2025b).

Table 8: Top 15 GHG sectors in terms of embodied GHGs attributable to final demanded products and services of West of England sectors compared to the UK

West of England	% Employment	% GHGs	United Kingdom	% GHGs
Wholesale trade services, except of motor vehicles and motorcycles (SIC 46)	3	30	Wholesale trade services, except of motor vehicles and motorcycles	33
Public administration and defence services; compulsory social security services (SIC 84)	6	6	Construction	5
Construction (SIC 41, 42, 43)	5	6	Public administration and defence services; compulsory social security services	4
Human health services (SIC 86)	10	5	Human health services	4
Electricity, transmission and distribution (SIC 85.1)	0	5	Retail trade services, except of motor vehicles and motorcycles	4
Air and spacecraft and related machinery (SIC 30.3)	1	4	Products of agriculture, hunting and related services	3
Retail trade services, except of motor vehicles and motorcycles (SIC 47)	7	4	Electricity, transmission and distribution	3
Waste collection, treatment and disposal services; materials recovery services (SIC 38)	1	4	Food and beverage serving services	3
Food and beverage serving services (SIC 56)	6	3	Motor vehicles, trailers and semi-trailers	2
Education services (SIC 85)	9	2	Coke and refined petroleum products	2
Air transport services (SIC 51)	0	2	Gas; distribution of gaseous fuels through mains; steam and air conditioning supply	2
Products of agriculture, hunting and related services (SIC 01)	1	2	Water transport services	2
Dairy products (SIC 10.5)	0	2	Waste collection, treatment and disposal services; materials recovery services	2
Machinery and equipment n.e.c. (SIC 28)	1	1	Extraction Of Crude Petroleum And Natural Gas & Mining Of Metal Ores	2
Gas; distribution of gaseous fuels through mains; steam and air conditioning supply (SIC 35.2-3)	0	1	Education services (SIC 85)	1
Percentage of total	50	77	**Percentage of total**	72

The total GHGs attributable to final demand of sectors in the West of England region was 20147 $KtCO_2e$ (scope 1,2 and 3), which was over three times the total estimate of direct GHGs for the region represented in table 6. This sector

embodied GHG account, includes all upstream emissions (within and outside the region) embodied in producing the regions sector final demand goods and services. Some of these GHG emissions will be emitted in the rest of the UK, Europe, China and elsewhere in the world depending on the supply chain, these are the total GHGs attributable to servicing the final demand goods and services provisioned by sectors in the region.

The top three sectors of table 8 (total embodied GHGs) are quite different from the top three sectors of table 7 (scope 1 direct GHG account). The prominent sectors are wholesale trade services (33%), Public administration and defence services and compulsory social security (6%), and construction (6%), human Health services (5%) and electricity transmission and distribution (5%). The top 15 sectors make up 77% of the total embodied GHGs attributable to regional sectors final products and services produced for final demand.

Among sectors with highest embodied GHG emissions, the wholesale trade sector's prominence (33% of embodied emissions) reflects the direct emissions from the range of the sectors products it distributes. The most significant three forms of wholesale in the region are food and drinks; wholesale of wood, construction materials and sanitary equipment; and other manufacturing equipment. The construction sector's embodied emissions (6% of total) primarily derive from extracted and manufactured inputs, construction activities rely heavily on manufactured materials such as cement, steel, and other building products (embodying high GHGs). See Appendix 3 for strategies for decarbonisation relevant manufacturing sectors.

There is substantial scope for these West of England sectors to reduce these emissions via working with their supply chains, substitution (for less GHG intensive inputs to production) or reducing/avoiding GHG intensive inputs altogether via sustainable procurement. Addressing product design and supply chain impacts along the life of the product or services (with a full life cycle perspective) is the most effective way to substantially decarbonise products and

services. Only looking at one stage of the supply chain or one businesses activity provides much lower opportunity to decarbonise (See Bradley 2013).

Implementing the strong circular economy approaches could also substantially address these embodied emissions, avoiding GHGs occurring elsewhere in the UK or globally in provisioning end products and services in the region. GHGs are a global pollutant, so it does not matter where on land the emissions are released the impact is the same (unlike some more localised pollutant impacts).

Employment in sectors with high embodied emissions

The top15 sectors in table 8 make up 50% of overall employment as opposed to only 31% when looking at the top 15 direct GHG contributing sectors in the West of England**.** The top four sectors make up 24%**.** Employing strategies in these sectors such as substituting GHG intensive inputs for less GHG intensive ones (or offering and promoting lower GHG products and services in wholesale or retail) is unlikely to lead to job losses for these sectors (as there are often low GHG substitutes) and so decarbonisation of these sectors is a positive approach for sustainable development – but business models do need to be pivoted to take advantage of and leverage the opportunity and avoid potential adverse impacts from changes in the nature of production (and sometimes consumption) related to industries. This said care needs to be taken that sectors are helped to transition and avoid job losses. Some of the embodied GHGs will be occurring in manufacturing in the region and elsewhere.

2.4 Conclusion

This section has outlined which parts of the West of England economy most GHGs are associated with. Transport is the most important sector in terms of direct GHGs of the region. GHGs from households, C&I and public sector[70] are also significant, as well as agriculture. In relation to the households much of the

[70] The published estimate of C&I and public sector GHGs in the DESNEZ (2025) published local authority data seem low, the current authors believe emissions are higher than publicly reported in the DESNEZ 2022 data (see Appendix 3).

more difficult to reduce emissions are related to water and space heating of houses, there have been significant local and regional attempts to increase household retrofitting, but to date progress towards the retrofit targets in the region have been slow. Progress on decarbonisation of transport has also been slow. Detailed discussions on transport and addressing household GHGs in the region were provided and future actions identified.

A detailed estimation of priority scope 1 GHGs[71] of C&I and public sectors was provided (alongside estimates of employment). The section identified key priority C&I and public sectors, and we are confident that we have broadly identified the priority C&I and public sectors in the more detailed account, these more disaggregated estimates complements the DESNZ (2025c) data for the year 2022 used in Table 6. This analysis also shows that reducing these emissions in the region is unlikely to significantly impact overall employment of the region, this said there could be impacts on individual sectors. Care needs to be taken in these more exposed sectors to make sure that measures to reduce these emissions do not adversely harm these sectors employment or negatively impact a just transition. After looking at direct GHGs the section looked at decarbonisation transitions for key sectors and key insights on this were provided (see also further regional insight on this in 5.3 when we explore three key regional case studies).

As part of the report, we also estimated GHGs from the perspective of all upstream emissions attributable to sectors final goods and services (scopes 1,2 and 3). It is clear that these emissions are orders of magnitude greater than GHGs directly generated in the region. The most prominent sectors were wholesale trade services 33% (particularly wholesale of food and drinks; wood, construction materials and sanitary equipment; and other manufacturing equipment), public administration and defence services and compulsory social

[71] Electricity related emissions were re-allocated e.g. C&I and pubic sector electricity user are in Electricity generation and transmission (rather than the consuming sector), as the DESNEZ local authority data allocated electricity to the consuming sector. Transport related C&I emissions were in the relevant transport related C &I activity e.g. freight and logistics etc.

security (6%), and construction (6%), human health services (5%) and electricity transmission and distribution (5%). Employment in these sectors is much higher than for those directly generating GHGs in the region, so care needs to be taken to make sure that measures to reduce these emissions do not adversely harm these sectors employment. This should be possible. The sectors offer substantial opportunities for emissions reduction through supply chain interventions, input substitution, and circular economy approaches without adversely affecting employment levels. We know that certain products such as food and drink embody a disproportionate amount of GHGs compared to other products, so a targeted strategy to reduce emissions embodied in certain key wholesale product types could go a long way in addressing GHG emissions. Tackling these sources of emissions also offers new opportunities for decarbonisation as these have not yet been a major focus for WECA or the local authority targets or policy. Therefore, there is potential to do more on this regionally with increasing levels of devolved powers.

The transition to net zero in the West of England is achievable with appropriately targeted interventions. The region's distinctive emissions profile, characterised by sectoral concentration and limited overlap with major employment sectors, combined with its aerospace sector strengths, positions it to pursue ambitious decarbonisation goals while maintaining economic vitality.

Public sector leadership: public administration, defence services, and health services feature prominently in the GHG account. The public sector can demonstrate leadership by implementing comprehensive decarbonisation strategies in its building stock, procurement practices, and other operations (additionally, a useful report setting out actions that local authorities can take in addressing GHGs is set out in Ashden (2020). Success in public sector decarbonisation can catalyse supply chain development and workforce training that subsequently enables wider deployment across the regional economy.

Infrastructure investment: electricity network capacity expansion and heat network development represent critical enablers for decarbonisation across

multiple sectors and Bristol is pioneering in some of the progress on moving forward with its heat network. Strategic infrastructure planning must anticipate demand growth from electrification rather than react to it. It was notable that currently the region generates substantially lower amounts of renewable energy than electricity consumed, strategic expansion of sectors such as AI in the WECA 2025 growth strategy will exacerbate this further, depending on which forms of AI they decide to embrace and encourage as electricity requirements in provisioning generative AI (though data centres for example) are very high as seen in Priest 2025 (potentially therefore generating ecological impact though both form of electricity drawn on and also potential for substantial water use). Such considerations need critical thinking, as in the region there is reasonable potential for renewable energy, but it is not endless and cost free in terms of wider externalities on nature. The next section shows that much of the land based renewable energy will likely need to come from roof top solar due to green belt restrictions. Additionally, nuclear power comes with a unique set of associated costs, challenge and risk, particularly regarding waste and decommissioning.

Circular economy: Given the prominence of construction, wholesale trade, and manufacturing in the region's embodied emissions profile, circular economy approaches including resource efficiency, waste reduction, material reuse, and product lifetime extension represent cross-cutting strategies with potentially high impact.

3 Land Use in the West of England, implications for net zero and nature

This section sets out the nature of land use in the region and implications for net zero and nature recovery. Firstly, the section starts by identifying land that is developed on. Land is a critical resource for achieving sustainable development, net zero and the nature recovery, but in the West of England the competing demands between industrial transformation, renewable energy infrastructure, housing growth and environmental protection make land-use choices somewhat complex.

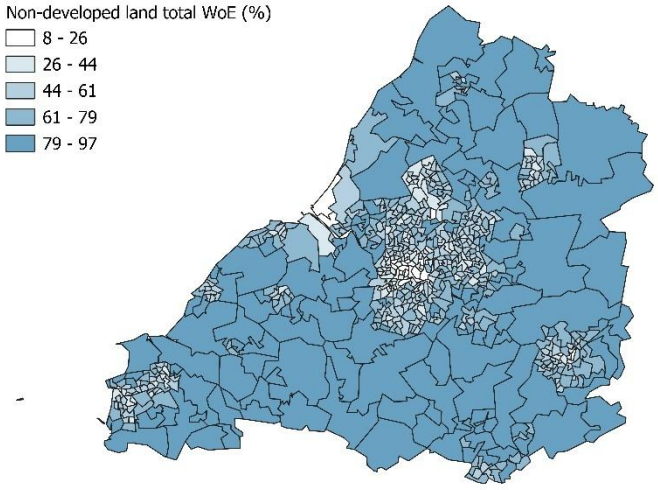
The region's land-use profile is characterised by high proportions of land that is agriculture, forests, open land, gardens and similar uses. This is alongside developed dense urban and industrial cores. What we term as 'undeveloped land' i.e. agriculture, forests, open land, gardens and similar uses is often still used for critical provisioning activities for the West of England population, food and drink production (predominantly), recreation, and a range of important ecosystem services. Some of the land has Green Belt, statutory conservation designations and flood risk zones, all of which restrict opportunities for large-scale renewable energy development. Understanding this geography is central to planning a sustainable economy and transition to net zero and nature recovery and will be an essential component of an effective and successful spatial development strategy in the region. There is a need for an integrated land use strategy for the region, and one that is integrated with the local plans of each Unitary Authority.

3.1 Regional Land Use Profile and Trends

The map (Figure 10) shows the predominance of non-developed land (defined as agriculture, forests, open land, gardens and other undeveloped uses) is in Bath & North East Somerset, South Gloucestershire and North Somerset. This reflects a landscape shaped by agricultural activity and sensitive environments with environmental protection. In BANES, more than 70 per cent of land falls

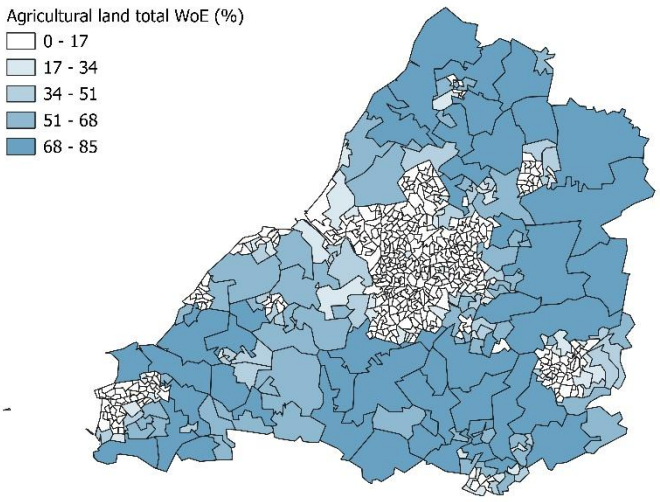
within the Green Belt (Bath and North East Somerset Council, 2008), there is also the Cotswolds National Landscape (Cotswolds National Landscape, 2025). In North Somerset, the Mendip Hills National Landscape accounts for 39 km^2, (InfoSomerset, 2023).

Figure 10: Map of non-developed land distribution, West of England and North Somerset[72]



[72] Source: analysis of data from Department for Levelling Up, Housing and Communities, 2022.

Figure 11: Map of agricultural land[73]



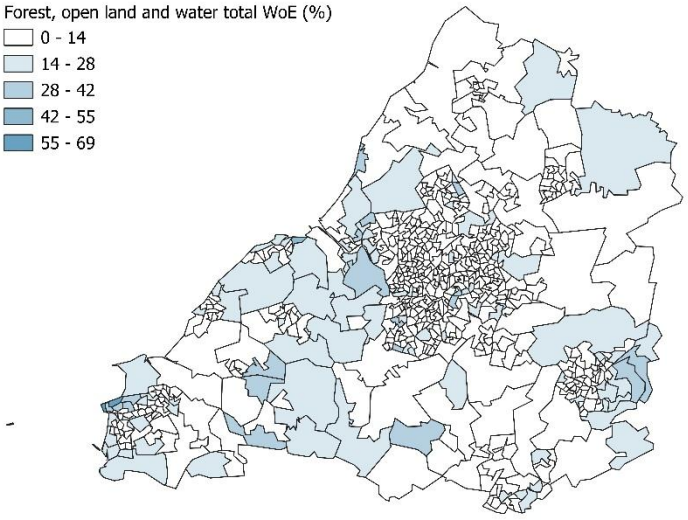
The map in Figure 11 displays the percentage of ward area classified as agricultural land. It shows one of the most pronounced patterns across all maps: dark blue areas dominate South Gloucestershire, North Somerset, and much of Bath & North East Somerset, reflecting extensive agricultural landscapes. The urbanised centre of Bristol stands out in white, with very low agricultural shares. The spatial gradient from urban centre to rural periphery is exceptionally clear, emphasising the importance of agricultural land as both a regional asset and a constraint on large-scale development.

Agricultural land dominates certain rural hinterlands such as South Gloucestershire and North Somerset. While this land offers theoretical space for ground-mount renewables, in practice it is constrained by Green Belt designations, landscape protections, and ecological sensitivities (North Somerset Council, 2021; Natural England, 2023). The agricultural landscape is

[73] Source: see Appendix 2

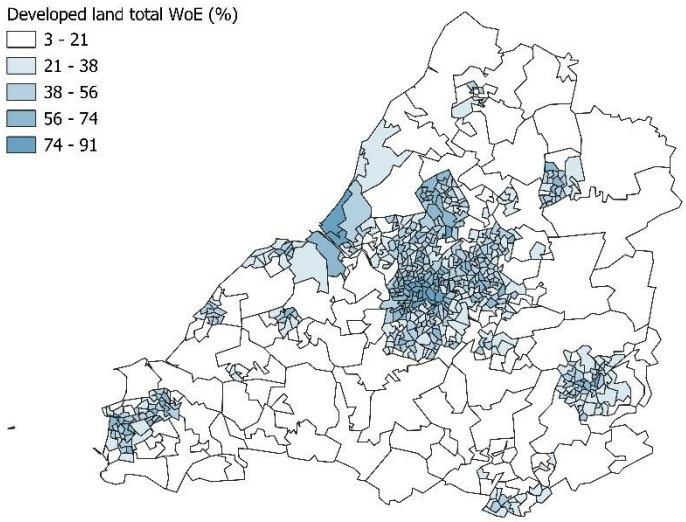
therefore more likely to contribute through farm-based solar, anaerobic digestion, and agroforestry rather than wholesale net zero industrial conversion.

Figure 12: Map of forest, open land, recreation areas, and water bodies



The map in Figure 12 shows woodland, open land, recreation areas, and water bodies as a share of total ward land. The pattern is more dispersed than agricultural land but still highlights specific concentrations. Higher shares appear around coastal North Somerset, parts of the Mendip Hills fringe, and selected green spaces around the north and east of the region. There are also smaller pockets in the Bristol urban area where major parks or woodland exist. Most wards display low to moderate percentages, but the map indicates where natural or semi-natural landscapes form significant components of local land-use profiles. Services from nature are wide ranging as identified in section 1 and include some carbon sequestration (see Table 1).

Figure 13: Map of developed land[74]

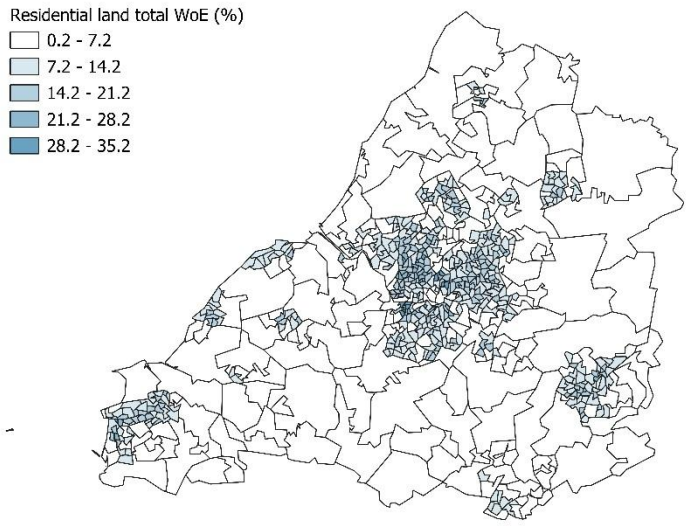


The map in Figure 13 brings together all developed categories—residential, industry and commerce, community services, transport, minerals, military uses and unknown/built-up land. The darker shades showing highest shares of developed land, Bristol and its immediate urban fringe forming a clearly defined metropolitan core. Higher concentrations also appear in Avonmouth/Severnside, Patchway–Filton–Bradley Stoke, Weston-super-Mare, and Bath. Conversely, outer rural wards are dominated by lighter colours, underscoring the strong urban–rural contrast in land development intensity across the region.

Figure 14: Map of residential land[75]

[74] Source: see Appendix 2

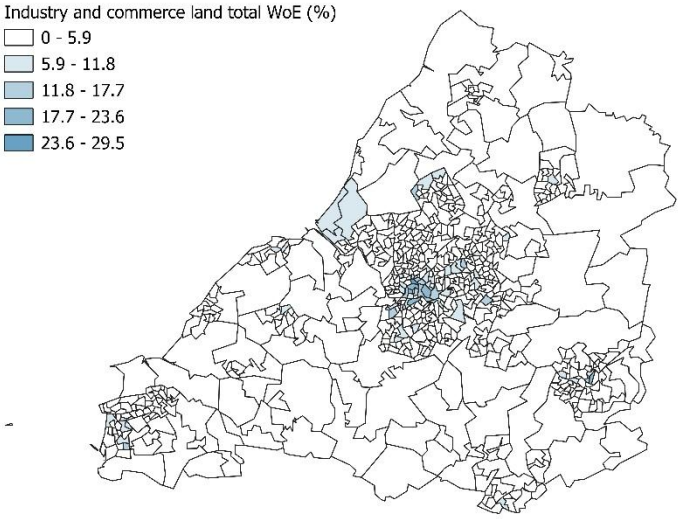
[75] Source: see Appendix 2



The map in Figure 14 displays the share of land in each ward occupied by residential uses. The darkest shading is concentrated in central and inner-urban areas of Bristol, reflecting dense settlement patterns. Additional pockets of higher residential land share can be seen in Weston-super-Mare, Bath, Keynsham, Yate and other established towns, indicating suburban and peri-urban concentrations. Rural wards to the north, south and east of the region show much lighter shading, consistent with sparse residential development. Overall, the pattern reinforces the spatial concentration of housing within key settlements and along transport corridors. These settlement patterns underline two important dynamics for net zero. First, the scale of existing housing creates significant potential for distributed rooftop solar and domestic retrofits, which can deliver carbon savings without new land take. Regional programmes such as Solar Together West of England have installed over 1,700 systems (WECA, 2025f). Second, the growth pressure on towns at the urban edge interacts directly with Green Belt boundaries, sharpening trade-offs between housing

expansion and land needed for renewable infrastructure (Department for Levelling Up, Housing and Communities, 2023/24).

Figure 15: Map of industry and commerce[76]



The map in Figure 15 shows the share of land used for industrial and commercial purposes across each ward. The spatial pattern is highly concentrated: see for example Avonmouth and Severnside, reflecting the region's largest industrial cluster, and in selected inner-Bristol wards with dense commercial activity. Smaller pockets of industrial land are visible around Patchway/Filton, Emersons Green, and Weston-super-Mare.

[76] Source: see Appendix 2

3.2 Development constraints and land availability

Green belt and landscape protections

Green Belt is prevalent in the region, BANES (70.4 per cent), South Gloucestershire (46.3 per cent), North Somerset (41.5 per cent) and Bristol (5.5 per cent) (Bath and North East Somerset Council, 2008; South Gloucestershire Council, 2025; North Somerset Council, 2025). The 63,000 ha of designated land within the West of England compares with approximately 43,000 ha of designated land in Nottingham and Derby, an area with a similar population (CPRE, n.d.). These designations purposefully prevent urban sprawl and protect countryside openness but restrict scope for large-scale renewable energy. There are also statutory landscape protections in place in the region. The Cotswolds and Mendip Hills National Landscapes require evidence that proposals will not undermine their landscape character (Natural England, 2023; InfoSomerset, 2023). Local planning guidance in North Somerset explicitly states that wind turbines are unlikely to be supported within such designations (North Somerset Council, 2021). Similarly, solar farms near the Mendip Hills have been subject to rigorous Environmental Impact Assessments and, in some cases, rejection due to landscape and visual impacts (Mendip Hills AONB, 2011).

Flood Risk Constraints

The West of England Mayoral Combined Authority Climate Adaptation report (2024) identifies the region as facing flooding risks from coastal, tidal, fluvial and surface water sources (See pages 26 and 27 for summary of flood risks and 34 and 35 for flood mitigation actions). Flood risk represents a critical constraint. At Avonmouth and Severnside, tidal flooding threatens industrial and logistics facilities that are central to the region's economy and future low-carbon industries. Around 2,500 properties are at risk along 17 km of the Severn Estuary frontage (ASEA Project, 2021). Although an £80 million flood defence scheme is underway to protect this area and unlock up to 12,000 jobs, residual risk remains and planning for flood-compatible industrial layouts is essential (South Gloucestershire Council, 2020).

In Bristol, approximately 7 per cent of properties lie within medium or high flood-risk zones, primarily associated with the tidal River Avon (Urban Water, 2025). North Somerset faces both coastal and surface-water flooding, compounded by projected sea-level rise of over one metre over the next century (North Somerset Council, 2025d). Climate change is expected to exacerbate these risks, with wetter winters and more frequent storms leading to more severe flood events (Thomson Environmental Consultants, 2024).

3.3 Implications for net zero and nature recovery

The Green Belt, landscape designations and flood risk restrict the availability of land for land-based renewables in the region. Large-scale renewable energy projects are particularly affected. Nationally, between 2018 and 2023, over 60 per cent of renewable energy projects failed to clear the planning system, with refusals and withdrawals most common in sensitive landscapes (Cornwall Insight, 2024). In the West of England this suggests that scalable renewable decarbonisation must rely on a different mix of interventions. In relation to energy generation, three key implications follow. First, building-integrated and rooftop solar offers the most immediate route to expand renewable capacity without using additional need for land. Regional initiatives such as Solar Together West of England have already delivered over 1,700 installations, adding 6.5 MW of capacity and avoiding 33,000 tonnes of carbon over 25 years (WECA, 2025f). Second, brownfield regeneration and industrial site reuse offer opportunities for renewable energy development on previously developed land, though site selection must carefully account for flood vulnerability. While areas such as Avonmouth/Severnside host existing industrial capacity, their documented flood risks raise questions about long-term viability for critical net zero infrastructure. Strategic planning could prioritize less constrained brownfield sites where such production/manufacturing does not have adverse environment (from chemical releases etc) or human health impacts. Third, integration of nature recovery priorities is essential. The Local Nature Recovery

Strategy maps focus areas where habitat creation and renewable development can be aligned, helping to reduce ecological conflict (WECA, 2025).

Drawing on the previous sections, given the large amount of green belt and agriculture in the region, reasonably high levels of GHGs and intensive agriculture being one of the major drivers of changes in nature nationally and regionally, it would make sense to explore opportunities for decarbonising agriculture via approaches such as regenerative agriculture and precision agriculture to restore nature and address net zero.

At the same time with the onset of climate change food security is increasingly becoming a critical concern, see most recently O'Brien and Kirk (2025) and AFN + (2025) and Defra (2026). So, food provision and food security is important, alongside a need to substantially decouple GHGs and nature impacts. Vickers et al. (2025) as well as AFN+ (2025), identify national roadmaps and strategy to address this challenge and decouple environmental impacts and regenerate nature. See also, Bridle et al. (2025) on 'Key action areas for transforming the UK food system'. Business model innovation and strong regional governance will be critical to enabling these roadmaps to be successful.

Given the region's focus and targets on net zero and nature recovery and at the same time resilience, there is synergy and opportunity for a regional governance and business model innovation approach (with systems thinking in built) to address interlinked problems and help farmers 1.) maintain and build financial viability[77], 2.) aid food security alongside nature recovery and addressing net zero[78] and; 3.) at the same time offer services to improve nature access as part of their business models to rural (and other) citizens which (ironically) have less

[77] The agriculture sector is struggling with financial viability currently. A third of farmers made no profit over the last year with 35% of the farmers reporting making a loss or breaking even and only 14% of farmers reported to have had 10% or more profit margin primarily due to the drop in subsidies since Brexit. Diversification is essential for many farms irrespective of size (McCain 2025).

[78] Given large direct GHGs and nature impacts and the very large GHGs occurring largely outside the region to import and provision wholesale of food and drink (as well as other key products) in the region (seen in section 2.3).

nature access. This would seem an opportunity given other sector restrictions on green belt.

The significance of 'place' and regional strategy in transitioning to more sustainable provision of food and drink should not be underestimated (Böhm and Alexander 2024) [79], but strategy, business models, innovation and governance approaches require more research on the best regional approaches to deliver financially viable solutions. There is potential to address climate and nature emergencies whilst generating jobs and food security for the region. Diversification and economies of scope[80] can enable resilience and improved productivity (Farmdex 2025).

3.4 Conclusion

Land use in the West of England reveals a significant tension between ambitious net zero targets and a constrained land base as this limits the space available for renewable energy and such industry. Flood risk compounds this constraint, particularly in the region's most important industrial cluster at Avonmouth/Severnside. The strategic response must therefore emphasise brownfield reuse, rooftop generation, and targeted development in low-sensitivity locations for renewable energy, supported by robust evidence and regional coordination.

Achieving net zero in the region will not be a matter of finding vast new land parcels but of creatively reusing, intensifying and adapting the land that is already available. As highlighted, given that significant amounts of green belt land cannot be developed beyond agriculture, there is an opportunity for regional governance and strategic innovation to help address food security and at the same time address the net zero and nature related externalities of agriculture. No doubt it will be challenging but the food security, nature and

[79] The regional will need to work closely with farmers, restaurants, food purchasers, food retailers and others to explore and realise the opportunity

[80] Economies of scope describe saving gained by producing two or more distinct goods, when the cost of doing so is less than that of producing each separately. Oxford Languages 2025.

climate related benefits of getting it right could be substantial, given that agriculture it by far the largest land use in the region currently as well as significant embodied GHGs of wholesale earlier identified (much of which is from imported food and drinks products).

4 Climate adaptation in the West of England: key drivers and priorities

This section presents analysis from a qualitative content analysis of 13 key adaptation strategy documents published by the Local Authorities in the region and by the WECA. The analysis highlights commonalities and divergences across authorities, as well as synergies and areas where more coordination and integration would enhance local adaptation efforts as well as some of the key challenges for the region.

4.1 Overview

The UK Climate Change Act 2008 introduced a legal commitment for climate adaptation, requiring a national Climate Change Risk Assessment and a National Adaptation Programme every five years. Currently, the Third National Adaptation Programme (NAP3) covers the period 2023-2028. The UK Climate Change Committee has highlighted the shortcomings of the UK approach to adaptation and defined it as inadequate or too slow (Climate Change Committee, 2025a).

The Climate Change Committee has outlined that the UK should prepare for a 2°C of Global Warming Level (GWL) by 2050 and called for urgent action to minimise the country's vulnerability to climate risks and avoid more impactful scenarios that will be far more costly (Climate Change Committee , 2025b). The five-year assessment, delivered under the Climate Change Act 2008 and following close work with the Climate Change Committee, shows that climate change will generate a range of risks to society and economy. For eight individual risks, economic damage costs could be in excess of £1 billion per year each by 2050 with a 2°C temperature increase, the cost of climate change to the UK rising to at least 1% of GDP by 2045 (UK Government, 2022).

In addition, while national-level strategies and measures set the overarching framework, climate risks manifest locally and vary across geographies and communities. This means not only that effective climate adaptation responses

need to be adopted at a faster pace and show higher ambition, but they also need to be tailored, context sensitive and equitable. Furthermore, given the cross-cutting and inter-sectoral nature of climate risks, integrated actions across policy sectors and governance levels are also key.

This section considers priority adaptation drivers in the West of England region and reviews local and combined authorities' climate adaptation approaches regarding cross-sectoral and multi-level coordination, alongside the decision-making frameworks guiding these efforts.

Climate adaptation drivers in the West of England region

The region faces significant climate adaptation challenges driven by global warming, changes in precipitation patterns, and sea level rise. Local variations notwithstanding, these drivers result in increased risks from floods, extreme heat, drought and water scarcity. While extreme cold remains part of regional climate risks, the trends point towards a declining trajectory for this particular risk.

Observed trends already show rising average temperatures and more frequent heavy rainfall events, which stress drainage systems and increase pluvial flood risks in urban areas. Regional climate projections from the MET Office's Local Climate Service (LACS) point to hotter, drier summers, and warmer, wetter winters with an increase in extreme weather events. These changes amplify risks of tidal and fluvial flooding, surface water flooding, heatwaves, drought, and cascading infrastructure failures. The recommendation from the Climate Change Committee is to conduct climate risk assessment looking out to 2080 under a high emissions scenario.

In particular, the LACS report for Bristol City Council (MET Office, 2025a) indicates that even in a scenario that is in line with the Paris Agreement goal (1.5°C GWL), the area will face an increase in the annual average temperature of 1.1°C, with the summer average temperature increasing by 1.3 °C and a winter average temperature increasing by 1°C. Furthermore, the summer precipitation

rate indicates a -6% change and a winter precipitation rate change of +5%. Sea levels in the local authority area are also expected to rise by 28cm by 2050 in the central future scenario and by 46cm by 2050 in the high-impact future scenario. By 2080, under high emissions scenarios (4°C GWL), sea levels could rise by approximately 89cm; winter precipitation may increase by 20% and summer precipitation could drop by 32%; summer average temperatures could exceed +4.3°C and winter average temperatures +2.7°C compared to baseline conditions.

Other local authorities in the region present comparable projections (LACS, 2025b; LACS, 2025c; LACS, 2025d), with North Somerset experiencing slightly more marked changes under a high emissions scenario on both annual average temperatures and precipitation rates. The LACS report for SG does not provide local sea level rise information linked to the estuary area.

Flood risks

Currently, flooding remains the most significant climate risk for the region, particularly in low-lying coastal and estuarine areas such as Severnside, which is strategically important for an economic as well as ecological and residential perspective.

Bristol records 7% of properties at flood risk, representing 15,861 properties at medium or high flood risk The frequency of flood warnings demonstrates the ongoing nature of this threat, with the Tidal River Avon affecting Bristol, Pill and Shirehampton receiving 89 flood alerts over the past five years (Thomson Environmental Consultants, 2024). North Somerset faces surface water flood risk across the area, compounded by projected sea level rises of 1 - 2m over the next 100 years that will affect coastal industrial areas (North Somerset Council, 2025d). Climate change impacts are expected to intensify, with projections indicating wetter winters, drier summers, and more frequent storms likely to cause localized flooding (North Somerset Council, 2025d).

Existing flood defences do not provide consistent levels of protection across the area, creating vulnerabilities for industrial facilities that are essential for renewable energy manufacturing, green technology development, and other net zero industrial activities (ASEA Project, 2021). The Avonmouth Severnside location is expected to continue attracting major manufacturing, logistics and distribution companies over the next 30-40 years, making flood protection investments relevant for the region's long-term industrial strategy and net zero transition capabilities.

The intersection of Green Belt designations, environmental protections, and flood risk zones creates constraints where available land for net zero industrial development is scarce and geographically fragmented. This means that Bristol's non-Green Belt zones and South Gloucestershire's areas outside environmental designations become pressure points where industrial expansion, renewable energy development, and flood resilience investments must be coordinated. The cumulative effect of these constraint layers necessitates a strategic approach to land use planning that recognizes the limitations across the region and identifies opportunities for coordinated development in less constrained areas.

Extreme heat

Extreme heat is an emerging challenge, with urban heat island effects intensifying vulnerability in densely populated wards especially in urban areas like Bristol (Bristol City Council, Keep Bristol Cool map). Heat-health risks affect older populations, children, and those in poorly insulated housing and can lead to increased risks of other hazards such as wildfires. The West of England Mayoral Combined Authority's report indicates that over the previous 12 months, 30% of adults reported that they'd been affected by heatwaves (MCA, 2024, p. 15). Known areas of investment for this decade in the region include £1bn per year for housing retrofit to reduce overheating risks. This is likely to remain a significant gap to address. South Gloucestershire's ARP4 report emphasises the need to increase capacity building on adaptation to extreme heat: due to the UK's low historical exposure to this risk, the report highlights

how the area is less adapted and therefore less resilient to these risks. For example, building standards do not include an expectation of resilience to future hot temperatures (SG, 2024, p. 23).

Drought and water scarcity

Drought and water scarcity risks are less visible but critical, given interdependencies between water supply, energy, and food systems. WECA's 2024 Climate Adaptation Report and North Somerset's adaptation strategy highlight the need for integrated water resource planning in collaboration with water companies to address projected Summer deficits and ensure resilience to 1-in-500-year drought events by 2040.

Implications for equity, economy, infrastructure

These risks can bring about compound and cascading risks, for example power outages or flood-induced transport disruption, which can be characterised as systemic threats.

Infrastructure stress-testing exercises like the Local Resilience Forum's Exercise King Canute, tested emergency response for a major tidal flood event along the Severn Estuary coastline to identify vulnerabilities across critical systems, including energy grids, digital connectivity, water supply, and transport networks.

Beyond emergency responses, however, long-term planning is also critical to integrate consideration of social equity. There is strong evidence that economic disadvantage amplifies these challenges, as deprivation can exacerbate climate risks. The Keep Bristol Cool map demonstrates deprivation overlays with flood and heat vulnerability, highlighting disproportionate impacts on low-income households.

4.2 Climate adaptation governance in the region

The UK's preparations for climate change are currently inadequate (CCC, 2025) and at the regional level, there is still much to do. In this section we look at local authorities' current climate change adaptation governance in the region.

Key characteristics of Local Authorities' approaches

All local authorities in the region have declared a climate emergency and use different decision-making supporting tools and frameworks to integrate adaptation into other policy decisions.

The West of England Combined Authority Climate Adaptation report (2024) is part of the UK Government's Adaptation Reporting Power (ARP4) pilot to embed resilience into regional planning. The document follows the Climate and Ecological Strategy and Action Plan (2023), which sets out a set of climate resilience actions focused both on emergency responses and long-term planning, and reflects its overarching approach. It outlines the key climate risks faced in the region and identifies pathways to integrate adaptation actions with net zero and nature recovery, with a focus on co-benefits. The document acknowledges that vulnerable communities are at higher risk and therefore calls for an equitable resilience planning approach. The report draws on evidence from local councils to discuss vulnerabilities: for example, the Heat Vulnerability Index is used to show how in Bristol, Lawrence Hill is the most vulnerable ward with significant deprivation challenges and a high proportion of homes at risk of overheating. Throughout the report nature is framed as a key solution for both resilience and mitigation while funding gap is identified as significant investments are needed beyond the resources currently available.

South Gloucester Council's climate strategy (2020) and related report (2024) and action plan (2025) centre on mitigation, adaptation and resilience, and nature recovery in an integrated way, with a strong focus on community engagement, health, and just transition. Key actions focus on building retrofit and embedding climate adaptation in the Local Plan, expanding GI infrastructure and future-proofing infrastructure through NBSs. The documents

highlight co-benefits for health, equity and biodiversity. Delivery is underpinned by governance integration and community engagement, with the support of a 'Climate and Nature Emergency Decision Wheel' to drive the inclusion of resilience considerations in major council decisions.

Bath and Northeast Somerset's climate emergency strategy (2023) and progress report (2024) is predominantly focused on mitigation rather than adaptation, which is an area that is significantly under-developed. The Progress on Action report contains one reference to scoping out opportunities for NBS solutions, with a new action to set the approach to climate change adaptation and resilience, including priority actions for 2024-25. Positively, the documents refer to active engagement with a West of England group set up to work on climate adaptation. With regard to decision-supporting tools, the report refers to a bespoke doughnut decision tool, which could be used to inform perspective adaptation actions.

Bristol City Council presents a distinct governance structure based on the One City Plan, which includes a Climate Resilience Strategy (2020a), a Climate Risk Assessment (2020b) and builds on governance structures that support integration and acknowledge interdependencies, such as the One City Board and the Bristol Advisory Committee on Climate Change. Bristol City Council's approach to adaptation is set out in multiple strategies and documents underpinned by the principles of just transition, integrated planning, evidence-based and collaborative governance. The identification of priority areas is closely aligned with the priority climate risks, including rising sea levels, flood risks, and heatwaves. The Avonmouth and Severnside flood defence project (BCC, 2023) is a major coastal defence investment, while other notable interventions include sustainable drainage systems, river restoration, and investments in Nature-Based solutions (NBSs). With specific reference to Urban Heat Resilience, the Keep Bristol Cool Framework (BCC, 2023b) addresses the high emission scenario to 2080 and identifies strategic goals to protect vulnerable people and services during extreme events, future proof

infrastructure through integration of adaptation in the Loca Plan, retrofit schemes to tackle overheating in homes, and use of NBSs at different scales. Moreover, the Bristol Avon Flood Strategy integrates considerations of economic benefits and social opportunities, for example through placemaking initiatives like greenways, improved walking/cycling routes, investment in community assets. The document highlights funding gaps as a significant barrier, as well as potential for more integration with other major regeneration projects.

North Somerset's Climate Change Adaptation Strategy (2024) is built on key principles, including embedding adaptation in council policies, infrastructure & transport investments, NBSs, support climate justice, health and wellbeing, engage businesses on climate risks and adaptation opportunities. The document demonstrates integration between environmental protection and strategic planning through a Green Infrastructure Strategy connecting places and habitats.

Regional collaboration and major projects

Regional collaboration across the West of England is evolving through joint projects and, to a less extent, through multi-agency forums.

The £80 million Avonmouth and Severnside Enterprise Area Flood Defence Project is underway to unlock up to 12,000 new jobs by 2026-2027 (South Gloucestershire Council, 2020). The project is jointly funded by the Environment Agency, South Gloucestershire, and Bristol Unitary Authorities. The infrastructure delivers 17km of new defences, providing protection against a 1 in 200-year flooding event until 2098.

At a smaller scale, South Gloucester Council takes part in the collaborative Natural Flood Management schemes such as the cross-boundary Resilient Frome project, in partnership with the Environment Agency and neighbouring authorities.

With regard to extreme heat, the Avon & Somerset Local Resilience Forum (ASLRF) is responsible for multi-agency coordination across the West of England

region, North Somerset and the County of Somerset. WECA does not have a statutory emergency response duty, though it is starting to liaise with the ASLRF.

The West of England industrial cluster: Local Industrial Decarbonisation Plan (2025)

Climate risks and the importance of developing climate resilience are recognised by partners[81] involved in the West of England Industrial Cluster and their Local Industrial Decarbonisation Plan (2025). While the plan states that the flood defences in the area contribute significantly to climate resilience, it identifies water scarcity and land scarcity as risks for local decarbonisation and local ecosystems, particularly where projects may require significant amounts of resources (e.g. cooling water). The plan calls for collaborative approaches to support optimal land use and for building on local success stories that show the potential for re-use of rainwater, storm overflow and industrial wastewater. See further detail in our case studies in section 5.3.

Areas for development

The adaptation landscape in the West of England region does not differ from the national context. While the need for adaptation is strongly recognised by all local authorities, delivery still lags behind, in particular with regard to adaptation to emerging risks such as extreme heat and to cascading systemic risks involving critical infrastructure and systems.

The analysis highlighted different levels of focus on adaptation in the region, with some councils showing a more proactive approach. For example, while BCC has several strategies and documents that address key climate risks and integration with other policy areas (e.g., housing, land use plan, transport), and South Gloucester Council shows a balanced approach between mitigation and

[81] WECA, Hydrogen South West, UWE, Black County Industrial Cluster, Severn Side Carbon Capture and Shipping Hub, SevernNet, copper, North Somerset Council, Bristol City Council, Ameresco, South Gloucestershire City Council, CR Plus, The Bristol Port Company

adaptation, BANES is currently working on setting out their approach to adaptation and resilience

Through this analysis it is possible to identify two interrelated areas where more attention is required. One pertains to the key barriers faced by local authorities, that is the lack of funding for strategic and long-term investments. This is somewhat reflected in the fact that collaboration across multiple governance levels, including the national level, is stronger in the context of major projects. This constitutes a second area that could be improved and will be particularly relevant to tackle emerging risks that require approaches other than those based on major projects (e.g. housing retrofitting schemes, NBS).

Positively, WECA recognises the importance of multi-agency and multi-level coordination to go beyond approaches that see extreme events as isolated. To date, most collaborative adaptation initiatives have been project-based, with less focus on collaborative governance structures to increase analytical and operational adaptation capacities in the region. Despite this, major projects could serve as a foundation for long-term planning in the region.

4.3 Conclusion

The UK's preparations for climate change are currently inadequate and this will have economic implications. At the regional level this also seems to be the case, for example, North Somerset highlight that their action of "ensure a resilient infrastructure in North Somerset including retrofitting our built environment where necessary" and "ensure that work around our flood defences considers climate change and any local and regional effects" are red in terms of deliverability in their Climate Emergency Strategic Action Plan (North Somerset 2025b). South Gloucester highlights key risks in relation to flooding, including tidal flood risk, and extreme heat are hazards they already experience, and that their impacts will increase with a changing climate and are considered significant risks for South Gloucestershire. They also acknowledge other risks, including interacting and cascading risks (South Gloucester Council 2024).

Regardless of the ambition achieved towards net zero and decarbonisation, adaptation is critical to manage the effects of climate change that are already evident and those projected for the future. Indeed, adaptation efforts are gradually being integrated into policies, strategies and plans and its importance has been recognised also by key stakeholders, as exemplified by the West of England Industrial Cluster's local decarbonization plan.

Adaptation strategies in the West of England Region intersect strongly with land use planning, nature recovery, and decarbonisation agendas. Integration efforts are particularly visible with regard to the deployment of NBSs to enhance water retention, reduce runoff, and mitigation of urban heat island effects. Going forward, areas of focus for adaptation action should include transport and housing developments, to avoid increasing exposure to flood or heat hazards.

As economic and infrastructural developments in the region have a strong cross-border nature and include major investments that are of national strategic importance, WECA is emerging as a strategic lead for adaptation and could act as a platform or a catalyst for strengthening integration and coordination between different local authorities and stakeholders beyond project delivery.

5 Qualitative insight and examples of sustainable economy in West of England

The West of England is generally a climate-conscious region, and a place where there has been a significant organisational and institutional mobilisation in the face of environmental challenges. Responding to climate change demands an integrated response from diverse stakeholders, including the private sector. This section combines insights from qualitative interviews with key stakeholders and presents four case studies. The interview summaries scope the region's political and economic response, while the case studies discuss specific areas in more detail. The first case study, on the Bristol Heat Network illustrates how the city has established a public-private partnership to combine long-term strategic vision with the investment necessary to decarbonise the city's heat provision; the second outlines how the Local Industrial Decarbonisation Plan coordinates action from heavy industry; the third outlines decarbonisation measures taken by the city's beer brewing industry; the fourth considers the contributions made in the West of England to the development of hydrogen aviation.

5.1 Insights from key stakeholder interviews

Interviews were held with some of the key industry and public stakeholders in the region, the participant descriptions can be found in the Appendix 5 for the fourteen participants.

Civic infrastructure

Since recognising the scale of the challenge represented by climate change, Bristol has mainstreamed climate within its governance organisations and engaged with private sector partners to provide financial commitment and expertise. The city has a series of distinctive institutions designed to engage with different aspects of the green transition. The response from local government has been consistently proactive, with Bristol City Council spearheading and funding many initiatives. The council put together the One City plan in 2020 (BCC 2025b) to plot the long-term steps necessary to

decarbonise the city. To facilitate the plan, it instituted the Environment Board which operates as a local equivalent to the Climate Change Committee, providing technical expertise and feedback. Within their own activities, they have begun decarbonising their building stock (Bristol City Council. (2024a) and compelling their directorate organisations like Bristol Waste to improve their environmental record and contribution. Toward these aims, they have launched partnerships with the wider city community including City Leap (discussed in case study 1) and the Bristol Climate and Nature Partnership.

The Bristol Climate and Nature Partnership, reportedly the largest place-based climate organisation of its kind, is a collaboration of over 1300 organisations (BCNP 2025) to drive climate action, share mutual challenges and learning and connect stakeholders across the city's communities, charities and public and private sectors. The organisation reflects the widespread concern around climate-related issues in the city's civic society. The organisation had a central role in submitting the bid for Bristol to become European Green Capital in 2015 (the only UK city to do so) (European Commission 2015), further enhancing Bristol's reputation as one of the most environmentally conscious cities in the UK.

A green place to start a business

In addition to strong civic institutions, the region is home to start-up companies designing solutions to significant environmental challenges. From heat pumps, fossil fuel sensor technology, sustainable agriculture and hydrogen aviation technologies, RnD assets are attempting to mainstream solutions. These companies benefit from the strong financial and labour market assets of the region. Growing companies are frequently found within university-led incubators, where they can cluster around with other businesses facing similar challenges, and have access to the technical and business support to facilitate success. Finance for these projects is frequently awarded by national grant-making institutions from InnovateUK to the Aerospace Technology Institute. Succeeding with these bids require that companies in the West of

England operate to nationally competitive standards and illustrate the strength of the region's companies. Bristol's perception as a climate-conscious city extends past reputation and was a stated reason for firms being interviewed to locate in the city, while those that are already in the city found it possible to recruit highly educated and climate-conscious staff.

Engineering excellence

Much of the physical work associated with decarbonisation is reliant on engineering expertise. From installing heat pumps, ensuring new building projects meet ESG requirements, designing new low-carbon hardware and iterating on proven technologies from aeroplane wings to wind turbine blades, there is clear benefit from the existing concentration of engineering firms and expertise within the region. Many large engineering firms have a strong historical presence in the city. As environmental impacts become more salient and regulatory requirements more stringent, existing firms are being tasked with ensuring that infrastructure projects meet environmental and social imperatives. The city has played an important role in the development of offshore wind power in the UK and internationally and remains a significant hub of wind power technical capacity and support. Keystone employers attract talent to the region and develop critical skills for staff; a proportion of whom go onto provide a workforce for decarbonisation activities. The region's intellectual assets include not only universities and educational institutions, but the 6th highest concentration of innovating businesses in the UK (WECA (2025d), and nationally significant research assets like the National Composites Centre.

Potential for new renewable power generation

The West of England is the proposed site for two significant renewable energy projects: a Tidal Lagoon in the Severn Estuary and Floating Offshore Wind (FLOW) in the Irish Sea. Both projects have the potential to generate low carbon electricity while creating local jobs. These proposals are strengthened by their proximate location to some of the most densely populated areas in the country

with high energy demand, minimising the need for expensive and time-consuming measures to upgrade and balance the grid.

There are however real and genuine concerns regarding the environmental impact of tidal energy and depending on how deployed. The Severn Estuary Commission (2025) highlight that a series of past well-funded studies on the Estuary's energy potential have generated consistent recommendations identifying the need for more research and systematic gathering of environmental data, yet few of these recommendations have been acted upon therefore leaving many data gaps. As part of their study the Severn Estuary Commission (2025) concluded a tidal lagoon (they have ruled out a tidal barrage for the time being) should be developed as a Commercial Demonstration Project (CDP), to generate a substantial amount of low-carbon electricity, but also to better understand the energy and socio-economic benefits of such a project and to provide a platform for full scale evaluation of its environmental impact. They conclude that development should not be delayed by waiting for innovation, and that priority should be given to proven technologies. Amongst a range of recommendations, the creation of a regional plan to enable the better management of the Severn Estuary is recommended. It is recommended that the new regional plan should be developed to manage all activities in the Severn Estuary, not just energy projects.

A tidal lagoon in West Somerset would have the potential to generate up to 2% of the UK's power while creating as many jobs as the Hinkley C nuclear power station (NIA 2025): 28,000, 17,000 of them locally (SEC 2025: 33)[82]. The Severn Estuary has one of the highest tidal ranges in the world, making it an attractive location for tidal generation (ibid)[83]. Past proposals for a tidal barrage in the Severn have been shelved due to concerns about biodiversity and disruption to port activity. The most recent Commission's recommendation for a tidal lagoon

[82] Ibid. p.33

[83] SEC (2025)

seeks to address these concerns while creating an important source of renewable energy in the region.

Conventional offshore wind farms require a shallow seabed for the direct installation of turbines, precluding areas of coastline with deeper waters. By attaching floating turbines to the seabed with deep sea anchors (similar to the technology used by offshore oil rigs) FLOW has the potential to unlock currently inaccessible seabed locations for the development of wind power. The technology is still in its infancy, but many ports are looking to develop FLOW terminals to service proposed new farms. Bristol Port has been named as one of eleven ports in the UK with the required depth and is to date the only port with consenting to proceed with development (Renewable UK 2023). The region is therefore advantageously placed to contribute towards the maturing of this technology. As Britain continues towards its ambition to become a Clean Energy Superpower, both projects have the potential to contribute low carbon electricity while providing employment and creating research and development activity for the region.

5.2 Regional case studies

Regional case study 1: West of England Industrial Cluster Local Industrial Decarbonisation Plan

The report "Enabling Net Zero: A Plan for UK Industrial Cluster Decarbonisation" (UKRI, 2023) specifies that most CO_2 reductions in UK industrial sector are expected to occur through four non-mutually exclusive strategies/solutions:

i) CCUS: Carbon Capture, Utilisation and Storage, from large industrial emitters, capturing, utilizing, or storing the carbon underground, primarily in the North Sea.

ii) Hydrogen: Switching from fossil fuels to green hydrogen as fuel for high-temperature industrial heat processes and/or transport.

iii) Electrification: Switching from fossil fuels for boilers, furnaces, engines, or vehicles to electric technologies powered by a decarbonised grid.

iv) Resource Efficiency and Energy Efficiency (REEE): Using less material and energy per unit of output through process optimization, waste heat recovery, improved equipment, etc.

Accordingly, the West of England Industrial Cluster Industrial Decarbonisation Plan (WCIDP) is creating a comprehensive strategy to decarbonise industry in the West of England, centring on a hub of major industrial activity around Portbury, Avonmouth, Severnside, and the Port of Bristol. The 'spokes' of the hub include dispersed industrial emitters across neighbouring areas including Swindon, Wiltshire, Gloucestershire and Somerset. Collectively they include diverse industries such as cement, chemicals, manufacturing, food production, waste, recycling and power (UKRI 2025).

The PAS cluster is a major industrial centre hosting a range of industries including: i) energy production, ii) waste management, iii) manufacturing of products related with construction, iv) manufacturing (air and vehicles), v) logistics, transport, supply, and vi) manufacturing (food and drink). Public and survey data was used for this calculation. Due to the need to maintain data anonymity, only aggregated rankings by sector and emissions available on public websites were shown here, to avoid any potential for disclosure. Table 9 shows the rankings of top sectors, and the main industrial emitter sectors. The LIDP only includes the industrial sector and the PAS area plus Bristol industry. However, the insight here allows one to broadly understand the impact of the industry sector in terms of GHGs and key strategies that will be implemented to decarbonise this portion of the total CO_2 emissions.

During the preparation of the forecast analysis of the West of England Industrial Cluster Local Industrial Decarbonisation Plan (LIDP, 2025) for the Portbury–Avonmouth–Severnside (PAS) industrial hub, a baseline was established for each industrial sector to understand the magnitude of emissions for each of them, which helped in defining the most appropriate decarbonization solutions. See table 9.

Table 9: Ranking of sectors for CO_2 emissions by industrial sectors in the PAS and Bristol area

Type of industry	Ranking of sector in PAS	Ranking of sector Bristol
Energy production	1	1
Waste Management	2	2
Manufacturing (Construction)	3	3
Logistics, transport, supply	4	4
Manufacturing (Air & Vehicles)	5	5
Manufacturing (Food and Beverages)	6	6

The total LIDP GHG emissions of the top six sectors was estimated at approximately 2,500 kt CO_2e, with emissions based on actual data collected from companies largely, so is thought to be reasonably robust. The PAS Hub has a small number of large emitters, primarily related to energy production and waste management.

The Seabank power station is one of the largest in the UK. A highly flexible gas-fired power station with a capacity of 1.2 GW, that can rapidly adjust its generation level to support the intermittent renewable energy supply on the National Grid in the southwest region. In 2023, Seabank reported 1,496 kt of CO_2e emissions (DESNZ, 2025).

There are also two major waste-to-energy (WTE) facilities in this area, crucial to preventing waste from ending up in landfills. SUEZ has the capacity to divert 370,000 tons of waste per year from landfill to its Energy Recovery Centre, and its processing also generates 37 MW of electricity, 90% of which is exported to the grid. This plant reported 358,254 kt CO2e according to the United Kingdom Without Incineration Network (2024a). The second plant is the Viridor

Avonmouth Energy Recovery Facility (ERF), which diverts 427,000 tonnes of non-recyclable household waste p.a. from landfill and generates a net electricity output of 32MW, reporting 301,335 kt CO2e emissions according to the United Kingdom Without Incineration Network (2024b).

The Hub also includes other plants dedicated to recycling and treating all types of waste from the construction, medical, automotive, or chemical industries, contributing to the local circular economy. GENeco Wessex Water management facility in Avonmouth treats over 700,000 tonnes of sewage and wastewater from the municipal areas of Bristol and surroundings through anaerobic digestion, converting the waste into biogas. This plant reports 46 kt CO2e emissions (DESNZ, 2025). There are also small medical and clinical waste treatment plants in the area that use pyrolysis, for example, Stericycle, which reported 10.31 kt of CO_2e emissions (DESNZ, 2025).

These two industrial sectors, energy generation and waste management, together representing emissions of over 2 million tonnes of CO_2 p.a. and around 95% of the total emissions from the industrial sector in the area (LIDP, 2025).

The two central strategies for decarbonising the industrial hub are the installation of Carbon Capture and Storage (CCS) and the development of hydrogen and renewable energy projects. The Severnside Carbon Capture and Shipping Hub (7CO2) will process carbon generated by the main emitters in the hub, as well as emitters in 'spoke' areas connected by pipeline and rail as far afield as Rugby, the Midlands and South Wales. Alongside CCS, there are proposals for the implementation of both hydrogen and renewable energy projects to reduce reliance on fossil fuels. Alongside these projects, improvements in efficiency and increasing circularity will be maximised to maintain the industry's competitiveness during the transition.

Regional case study 2: City Leap

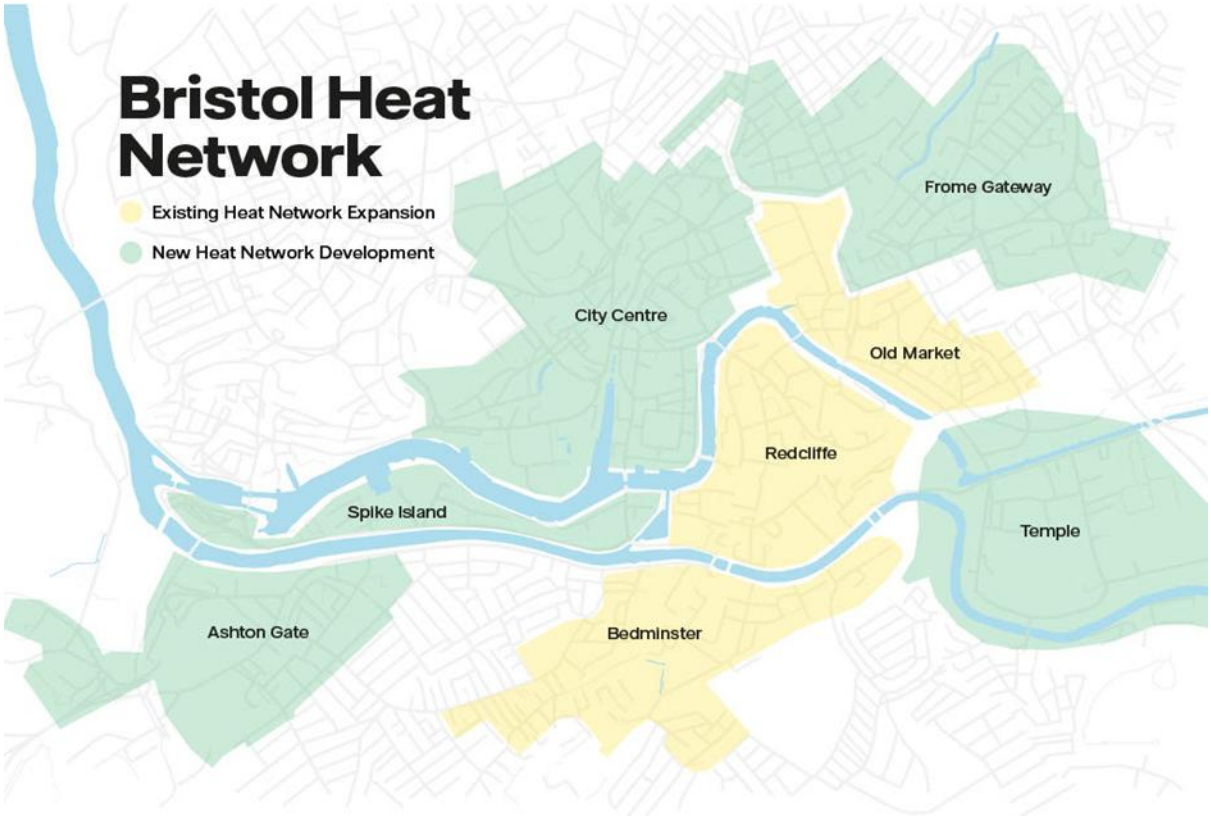
City Leap was initiated by Bristol City Council as part of Bristol's long term plan to decarbonise its built environment following the 2018 declaration of a climate

emergency (City Leap 2025). It has two main functions: to decarbonise Bristol's existing building stock and to build a heat network throughout much of the city. To achieve these goals, Bristol City Council partnered with Ameresco (who specialise in local decarbonisation solutions) and Vattenfall (who have built and operated heat networks in Amsterdam, Berlin and Sweden). The partnership mobilises private finance and international expertise to implement the infrastructure needed to meet the region's ambitious climate targets. Figure 16 shows the development and expansion of the Bristol Heat Network.

Heat networks, which supply hot water to buildings and preclude the need for a heat pump or gas boiler, have significant potential to reduce the 20% of emissions that derive from household energy use in urban centres (DESNZ 2025d). They use large, and therefore more efficient sources of generation, while low-carbon heat generation and the use of waste sources (from waste incineration, datacentres or excess heat generated by large buildings) reduces emissions (Vattenfall 2025). With dedicated maintenance and multiple generation sources, heat networks promise to be more reliable than individual gas boilers. Centralised heat pumps can be more efficiently coordinated than individual sources, and serve as energy storage, helping to balance the electricity grid (DESNZ 2025e). For many large, centrally located buildings, housing low-carbon heat generation is impractical, making heat networks their only viable decarbonisation solution (DESNZ 2025d).

Currently, the Bristol Heat Network operates in Redcliffe and Old Market, with expansion occurring in Bedminster and plans to expand into the 'Frome Gateway' along the M32 towards Cannon's Marsh alongside further longer-term target areas, (Bristol City Leap n.d.) (see map). The network currently supplies 6,500 homes equivalent, with goals to reach 12,000HE by 2030 and more than half of Bristolians by 2050 (ibid). At present, the heat network is serviced by a gas generator as well as the Castle Park Energy Centre, a 3 MW water-based heat pump. Construction is ongoing for the Bath Road Energy Centre which aims to generate 13MW and should enter service in 2028 (Vattenfall 2025).

Figure 16: Development and expansion of the Bristol Heat Network



Credit: Bristol City Leap n.d.

The benefits of heat networks result from advantages accumulated at scale and over decades, while individual buildings and developments may not have direct and immediate incentive to buy in. The distinct challenges faced by heat networks in attracting both existing buildings and new developments are outlined: misaligned price signals disincentivise switching from gas boilers while proposed planning regulation changes risk promotion of individual heat pump installation in new buildings. A key objective of the network should also be to stay abreast of wider developments in the city to maximise potential co-benefits. These forward facing challenges were identified during qualitative outreach with Vattenfall UK, and reflect the ongoing concerns of those operating and expanding the Bristol Heat Network.

For existing buildings, there is presently little financial advantage to joining the heat network, which entails both an installation cost and, currently, increasing operating costs. The central reason for this is the 'spark gap', or discrepancy between the price of electricity and gas, which is currently around four to one (Woollard 2025). The high cost of electricity in the UK is the result of reliance on fossil fuel commodity prices and environmental levies on electricity, but not gas, bills (ibid). Even though the heat network is more than twice as efficient as a gas boiler, this isn't sufficient to offset the price differential. As a result, signing up extant buildings is reliant on environmentally conscious consumers who place value on decarbonisation[84]. Given that boilers can last more than 20 years, the ongoing consequences of the present spark gap risks negatively affecting the heat network for decades to come.

An important facilitator to the success of the heat network is the Local Development Order requiring almost every building in the city to connect to the heat network or switch to low carbon heating. The order provides Vattenfall with the certainty required to invest in the upfront development cost of the network. However, there is an immediate risk that planning regulations allow developers to opt-out in favour of heat pumps (which have a similar operating cost, but lower installation cost) due to the residual presence of gas generation in the heat network.

We have inherited some high carbon assets, existing gas heat generation on the network from the Council. Our commitment has always been to decarbonize the network over time. But that that does come over time, we only do it with certainty that buildings will connect, because taking an FID [Final Investment Decision] on a multi tens of millions of pounds of energy centre is a big deal. In any case, even if there's a high-quality business case to enable that, which I think we'll get there, the decarbonisation of the network is going to be a journey. We're unlikely to get to a point where we're on parity with an air source heat

[84] Jon Sankey, Business Development Director, Vattenfall UK

pump from carbon perspective until about somewhere between 2030 and 2033, I would say. – Jon Sankey, Business Development Director of Vattenfall.

This disparity between the overall benefit to the city and the choice offered to developers of individual buildings creates a risk. Infrastructure that will have long-term benefits for the city may be passed over in favour of a short term financial or regulatory advantage. As such it is important to balance short-term decarbonisation with the long-term benefits of a mature heat network.

A final consideration for the success of the heat network will be realising the co-benefits of cooperation with stakeholders elsewhere in the city. For instance, the Temple Quarter Enterprise campus is going to have significant compute capacity, essentially a heat pump which will generate heat and hot water. When it's got more than needs for the building, they'll export it into the heat network, and when they don't have enough from those computers, they'll be importing it from us, so we have a two-way heat sharing relationship that's extremely mutually beneficial from a commercial perspective for both parties. For all the kilowatt hours that they give to us, we're basically paying about half what we would pay if we were generating ourselves, which means we can make a bit more gross margin on that heat sale when we sell it to a customer and that can support more infrastructure development. – Jon Sankey

For a major development like Brabazon, connecting up the heat network could significantly reduce the energy requirement of those new homes, serving not only as a 'nice to have, but a critical enabler'[85] by reducing the need for new grid infrastructure and utilising waste heat from waste to power plants in Avonmouth. Embedding the heat network into other ongoing development projects will be important to achieving scale and proliferation:

It will be nuts to go and build a Tram Network, dig up all the roads and not put a heat network in at the same time. The routes are almost identical. So, it's not just kind of "right we need to think about energy and heat networks". We need to

[85] Jon Sankey

join all of this stuff up across these different infrastructure vectors within this new town approach. – Jon Sankey

Regional Case Study 3: Beer manufacturing

The Bristol area is known for its bubbly beer industry. Medium and small size craft breweries is a thriving industry in Bristol. There are more than 18 plants[86]

The use of CSSU systems has the potential to mitigate the carbon emissions otherwise inherent in the brewing process. CO_2 recovery plants capture the gas produced during fermentation, eliminating most of the CO_2 emitted during the industrial process while allowing the brewery to be self-sufficient in CO_2 for beer carbonation. Although CCSU was not considered a viable option for the food and drink sector during the 2015 road maps because the emissions are not significant enough to warrant investment (FDF and SLR, 2020) the brewing industry found a system that was scaled and contextualized, so that the process became cost-effective.

Beer manufacturing is a light, low-emission industry; therefore, once the fermentation process is decarbonized, plans should focus primarily on deep REEE strategies, such as reusing waste heat; sustainable packaging; more efficient production methods; increasing the insulation of all elements, systems and resources involved in processes that require heating; and transitioning from fossil fuels to renewable electricity to power industrial processes. Delivery processes can be decarbonized by switching delivery fleets from fossil fuels to electricity if they are light/local vehicles, or to hydrogen or biofuel if they are heavy vehicles. Furthermore, comprehensive waste management plans connected to the local circular economy need to be developed.

A good example of this path is the Wiper and True Brewery strategy to achieve net-zero emissions by 2030 has implemented many of these principles. Their

[86] breweries include Wiper and True Brewery, Bristol Beer Factory, Moor Beer Co., Lost and Grounded,; Other smaller breweries: Arbor Ales; Left-Handed Giant Brewing Co.; Good Chemistry Brewing; New Bristol Brewery; Wild Beer Co.; Dawkins Ales; Croft Ales; Tapestry Brewery; Kettlesmith Brewing Company; Fierce & Noble Brewery; Gilt & Flint Brewery; Moncada Brewery (Bristol); Bristol Brewhouse; and The Incredible Brewing Company.

actions so far include i) installation of a CSS DALUM closed-loop CO_2 recovery plant, capable of capturing approximately 60-70 t of CO_2 per year from fermentation, scrub and liquefying it, and then reusing it for carbonation, tank purging, and packaging (Watts, 2023); ii) preference for cans over bottles for REEE (lighter, 50% recycled aluminium, lower transport and recycling energy); iii) installation of aa 159 kW solar array at the Old Market brewery, which generates a substantial portion of their electricity needs; and iv) transition to zero-emission logistics by using electric vans for zero-emission deliveries; v) transition to zero-carbon packaging by using 100% recyclable FSC-certified cardboard and sealing it with recyclable paper tape.

Another similar example is Moor Beer Co, which installed i) Roof Solar Energy (47kWp) providing electricity for their operations and feeding surplus energy back into the grid; ii) naturally carbonated beer (yeast-generated CO_2 only); iii) transition to sustainable packaging, using cornstarch for the can labels (recyclable with the can, made from renewable feedstocks), FSC-certified cardboard; iv) implementation of a circularity policy where used grain and hops are given to a local farmer for feed and fertilizer; v) zero carbon logistics with bicycle couriers handling most of Bristol's deliveries (Moor Beer Co., 2025).

Bristol Beer Factory (BBF) has a target of net-zero emissions by 2040 through carbon capture and storage, steam heat recovery, and rainwater harvesting to reduce CO_2 intensity per litre of beer. They also use Zevero (2025), a carbon management platform that measures emissions, calculates the carbon footprint (scopes 1, 2, and 3) of water, grain, hops, packaging, and logistics, and identifies high-emission areas in the brewing process to inform investment, from changes in packaging (from glass to cans) to improvements in delivery routes.

Arbor Ales has already installed the i) Rooftop solar (41kWp) providing 10% of their electricity for their operations, the remaining 90% from a 100% renewable energy supplier; ii) CO_2 recovery Dalum system from fermentation, to use it for the carbonation process and iii) Sustainable packaging.

Lost and Grounded Brewers has been the latest brewery to install a CO_2 recovery plant at Dalum in 2025, which captures up to one tonne of CO_2 per week (see Image 1); ii) It has also installed an energy recovery system that captures steam from the boil and uses it to heat approximately 500 litres of water for subsequent brewing and cleaning, resulting in an approximate 10% reduction in gas consumption; iii) it has also installed a 30-tonne malt silo (REEE) that reduces the waste of plastic grain bags, avoiding approximately 15,000 polypropylene sacks per year.

Although Tapestry by PROPS Brewery permanently closed its doors in, 2024, it is worth remembering the "Pie-oneering" beer. This was a great example of local circular economy where Tapestry collaborated with Pieminister (a local food manufacturer), by incorporating off cuts of its plant-based pastry. Starch within the pastry breaks down into sugars during the brewing process, which then ferments into alcohol. GENeco (a water waste anaerobic digestion plant in Avonmouth) produced the renewable energy used in the elaboration of the beer by recycling pie crust trimmings, at their Bristol Bioresources and Energy Park. “Pie-oneer” was a great example of circular economy model using food waste feedstocks plus renewable energy from waste management to produce carbon neutral beer.

Of the four industrial decarbonization solutions proposed by UKRI (2023), the most prevalent are a smaller-scale adaptation of the CSSU, cost-effective REEE measures, and electrification. Hydrogen has little place in industrial processes of low emissions and low temperature, with a product delivered locally. The following toolkit shows the contextualization of the four options within this specific industrial sector and the processes/elements to which they can be applied to achieve decarbonization and sustainability in the brewing industry: i) install a CO_2 recovery and reuse plant for fermentation; ii) install renewable electricity generation on site (PV panels); iii) install heat and steam recovery systems; iv) switch to low-carbon packaging; v) prioritize can production over bottle production; vi) implement packaging reduction measures such as silos or

partnerships with farmers who can reuse them; vii) decarbonize logistics through bicycle couriers, more efficient route deliveries, and/or cleaner vans (electric or biofuel); viii) use e-platforms based on AI and data to inform decarbonization decisions; ix) implement circular economy strategies that use waste products from local food manufacturers and waste energy.

Case study 4 – The development of hydrogen aviation

The aerospace industry in Bristol traces its roots back to 1910 when George White founded the Bristol Aeroplane Company. Filton, to the north of Bristol remains an important industrial cluster and the successors to the Bristol Aeroplane Company, Rolls Royce and BAE systems, retain a presence in the area while their original hanger is now an Airbus site. Cotswolds Airport, formerly RAF Kemble, is another longstanding testing and development site in the West of England. There are a diverse mix of companies within the region's aerospace industry, ranging from OEMs like Airbus and Rolls Royce, tier 1 suppliers like GKN Aerospace and Thales and RnD-heavy start-ups like ZeroAvia and Vertical Aerospace.

Aviation is an inherently difficult industry to decarbonise. Flying is energy intensive, planes need to be airborne for as many as 19 hours without refuelling, and passenger safety is paramount. Existing kerosene propulsion systems rely on abundant, energy-dense and therefore lightweight fuel and are the result of more than a century of continuous iterations in safety and efficiency. New technologies face considerable obstacles in matching the flight length, reliability and economy offered by conventional propulsion systems: battery technology is, at least currently, too heavy for long flights or large planes; sustainable Aviation Fuel (SAF) is expensive and land-intensive to produce, making delivery of the quantity required to meet commercial demand challenging. For these reasons, many experts consider hydrogen propulsion systems the likeliest solution for emission-free flight.

Successful commercial deployment of hydrogen aviation requires a number of coordinated systems to function alongside one another. First, a sufficient

quantity of hydrogen fuel must be delivered to the plane from a suitably dense network of airports. Within the plane, hydrogen is stored in fuel cells and converted to electricity during flight. This electricity powers the motor which propels the plane. Developing each of these key components and managing the transfer of energy through the two permutations are central engineering challenges. Unlike in the iteration of kerosene-based propulsion systems, companies developing hydrogen planes must work out how to improve all these concurrent elements to achieve technological maturity, as argued by Participant N: "Everything from how the fuel is delivered to the aircraft, how the power generation is achieved through fuel cells, how electrical power is distributed and managed", the design of electric motors and "utilising the cryogenic properties of hydrogen to develop hyper-conductive thermal networks and drive systems"[87].

Numerous companies in the West of England are currently engaged in the development of hydrogen-based aviation technology. The Jet Zero Taskforce (the national body set up to facilitate hydrogen aviation) includes members from Airbus, Rolls Royce and ZeroAvia. GKN Aerospace's Global Technology Centre in Filton (one of four worldwide and the only one in the UK), has several programmes researching hydrogen-based technologies. ZeroAvia has conducted some of the first UK test flights of hydrogen-fuelled planes at its site in Kemble and Vertical Aerospace have flown short-range aircraft using both battery and hydrogen-powered systems.

Interview responses supported the idea that the aerospace cluster is a self-reinforcing asset. "We've got a really rich aerospace ecosystem in the South West, particularly around the Bristol area, in terms of access to customers, specialist resources, people. You've got BAE, you've got NVDA, you've got Airbus, you've got Leonardo. There's a real rich vein of aerospace talent in the region."[88] This allowed firms to recruit from a deep talent pool as projects ended, company

[87] Participant N

[88] Participant N

priorities shift and employees look for different opportunities. Another participant highlighted that the UK offers an internationally competitive combination of excellent talent and cost advantage compared to other countries, including the US[89].

The second factor that is clearly significant is the importance of external funding. The Aerospace Technology Institute (ATI), partly funded by the Department for Business and Trade, is a significant issuer of grants that allow UK-based companies to conduct more R&D activities than would be possible using commercial proceeds. The Institute mirrors similar national grant-making organisations like LIT in the Netherlands and FMV in Sweden, as well as transnational bodies like the European Space Agency (which also provides funding to UK-based organisations). Developing mature hydrogen aviation technology requires the coordination of different complex elements and is unlikely to occur on a commercial timeline. State support has therefore been important in giving companies the capacity to innovate without relying on ongoing revenue streams, while the ATI ensures that innovation occurs in the UK and creates British jobs.

Hydrogen propulsion remains some way off replacing commercial aviation. The test flights currently taking place are Part 23 planes. These vehicles, which sit a maximum of 19 people, are primarily used by private individuals, for extremely short-haul 'island hopper' flights or in freight applications. Some companies have mature systems at this scale and hope to launch products to market within the next few years. Meanwhile, scaling the technology up remains a significant technical challenge. The next target engine size is a 2MW engine system, capable of powering planes with up to 100 people and requiring quadruple the power of current technologies.

Provided the ongoing resolve of companies, and ongoing financial support from grant-making organisations, the West of England is well placed to engage with

[89] Participant B

the technical challenges associated with next-generation aviation. Even without introducing products to market, important progress is being made here on the technology, supply chains and regulatory maturity that will be necessary for hydrogen aviation to succeed.

5.3 Conclusions

The transition to a decarbonised economy will take mobilisation at all levels. That includes international supply chains and national policies, but it also means local leaders and stakeholders collaborating to make their environment a place where people can live and work while progressing towards sustainability. The West of England has been proactive in coming together to collaborate over environmental challenges, in launching new initiatives and programmes to intervene in complicated systems long-term and in mobilising existing expertise to meet environmental concerns and obligations. This qualitative analysis has illustrated the West of England's strong civic culture, exemplified in institutions like the BCNP and the voluntary decarbonisation efforts of the city's breweries; innovative technical responses like the Bristol Heat Network and hydrogen aviation development; and the importance of collaboration shown throughout the region. It is clear however that there are still some significant uncertainties at times, such as how easy it is going to be to get actors to connect up to and sign up to the heat network.

6 Discussions and key insights

This section brings together the key insights on a sustainable economic transition and identifies key challenges opportunities, value propositions for the region in addressing Nature recovery and Net Zero that are revealed from synthesising the various insights from different sections of the report.

6.1 Sustainable economic transition

It is clear that society faces a set of environmental challenges, driven largely by the way we run our economies that threaten prosperity globally and regionally. The science shows that technical fixes can only partially address these and that societies need to look at the way their economies function and their end goals as part of a process of moving towards sustainable economic development (Sustainable Development Commission, 2009). There is no sustainable economy without a thriving business and natural ecosystem that stays within key threshold values for global environmental pressures set out in Richardson et al. (2023). This report shows that key parts of the current economy for the West of England are still fundamentally unsustainable. There has been some significant progress in addressing GHG mitigation in the region, but the region's economy still generates substantial direct and embodied GHGs. Climate change is just but one of six key global environmental pressures (planetary boundaries) that are identified as red in Figure 1.

As society moves from now into the future the state of the economy and environment are increasingly interconnected as the fallout from breaching threshold values for key global environmental pressures increasingly manifest without reform.

Very often, growth of the economy is narrowly framed on financial return to the detriment of other forms of capital such as natural, this approach to achieving prosperity is a dead end, the degradation of natural capital is not sustainable, and will not lead to prosperity. The report has shown that the region's people and their children face a substantially compromised future unless these issues are

addressed head on. The Sustainable Development Commission laid down the gauntlet in 2009:

"*Prosperity consists in our ability to flourish as human beings – within the ecological limits of a finite planet. The challenge for our society is to create the conditions under which this is possible. It is the most urgent task of our times*."

Tightening constraints imposed by environmental factors will change market conditions, creating challenges but also signposting opportunities for dynamic innovation to reduce input costs and invest and design products and businesses that are better suited to address these challenges within environmental limits. A proactive approach to recognising and responding to this inevitable tightening operating environment could place the West of England region into an advantageous position pre-empt and capitalise the opportunities presented by meeting human needs under different operative conditions, framing a more strategic and beneficial approach than waiting to react to challenges as they emerge in a piecemeal fashion (see also discussions in Everard 2026). If the region rejects sinking investment in the economies of the past, and instead seeks to identify and invest with foresight in technologies and services required by a future economy inevitably framed by environmental and wider sustainability constraints, it will be more resilient and will also avoid sinking resources in cul-de-sacs. Businesses in the region can stand out and draw back the curtain on a different tomorrow offering greater sustainability and prosperity.

Devolution presents an opportunity for the WECA region to double down on its trajectory in showing leadership to materialise how to work together to bring about and prioritise the actions and conditions that bring forth prosperity for the region, a journey on which it has already embarked. As seen from the report particular regional challenges relate to transport and the outsourcing of GHG emissions to provision our sectors final goods and services. The journey requires a 'cultural shift' by both citizens and business towards more sustainable consumption and production; innovation in governance structures

(for both markets and firms) alongside a carefully thought though and supportive institutional environment (that devolution can aid) to help create a selection environment where sustainable economy can flourish (Bradley et al., 2021 and Bradley 2026).

The WECA region can step up and show dynamic innovation and leadership to make sustainable economy and prosperity a reality and seize new market opportunities as they come along. This is necessary to overcome the current high levels of unsustainability of the regional economy, requiring a deep focus on a sustainable economic transition and developing governance approaches to achieve an economy that engenders strong sustainability principles.

For businesses, attainment or spiring towards a sustainable economy is a matter of self-benefit in recognition that environmental limits and wider sustainability pressures will change future markets, be that though inflationary pressures, changes in incentives/dis-incentives and regulation, consumer acceptance or otherwise. Businesses can be empowered with knowledge and support to innovate for self-advantage through more sustainable profit, reputational benefits, improvements in productivity, enhanced resilience through reducing exposure and risk to future input cost rises and other ESG related risks. A focus on addressing needs within a changing operating environment can help businesses recognise and realise the benefits of serving customers, wider communities and the environment upon which we all depend. Dynamic innovation towards this does not mean no to growth, but requires a different form of growth and value creation that generates wider positive externalities and reduces negative externalities whilst still being profitable and delivering prosperity for the region and its people.

A changing future includes both constraints but also novel opportunities; as a region, WECA can position itself to be part of the solution rather than part of the problem. Those that drive the problem will lose in the long run as their value propositions become irrelevant or unacceptable. It is essential to take a systemic approach when making decisions addressing potential impacts from

consumption and production across the full range of ecosystem, wellbeing and health outcomes – this is also important in identifying economic viability, economies of scope, and the opportunity for sustainable business and economy. A number of steps are required:

1. Foresee problems, which can be addressed by reflecting on sustainability pressures already and those that can increasingly impose themselves on society;
2. Forsee solutions, which can take the form of brainstorming and otherwise conceptualising societal needs in this different future and the products and services that best address them; and
3. Establishing an institutional environment and encouraging the social embeddedness (Figure 2) to support and realise the (economic, social and environmental) return on investing in the value proposition.

Essentially, we need to addressing multiple interlinked problems and solutions via a joined-up, systems approach and a value proposition for improved prosperity and one that serves the region across the problems we face as a region.

Within this section we now bring together the insights on impacts and drivers together with insights from 'Local Authorities and the Sixth Carbon Budget' (which looks at actions and influence that local authorities can have on GHG reduction and implementation of national strategy) to segue a strategic set of priority areas to address these impacts as well as highlighting opportunities. The climate and ecological emergencies require action to ensuring life and avoid future damages, but we need to develop a strategy that avoids loss of employment and one that can create opportunities to improve people's prosperity.

The conclusion adds value by identifying key areas for future action that can have most impact on both GHGs and nature recovery. As part of this we identify

the problem, potential solutions, and highlight potential value propositions[90] where they exist.

Before we look at each section it is worth briefly summarising Local authority levers to deliver Net Zero. Local authorities are typically only directly responsible for between 2- 5% of their local area's GHG emissions, they do however have many levers they can pull to enable wider local action on GHGs and prepare local areas for a changing climate. Particularly important powers and duties identified in CCC (2020) were as follows:

1. Their overall role to support economic, health and social wellbeing of people in their areas

2. Planning powers over buildings and transport

3. Building regulations enforcement

4. Powers to ensure basic energy efficiency standards are met in buildings

5. Duties to prevent homelessness and prevent hazards in housing

6. Risk management duties, including climate risks such as flooding

7. Duties and powers for environment, wildlife and heritage protections

8. Waste collection and dispose duties

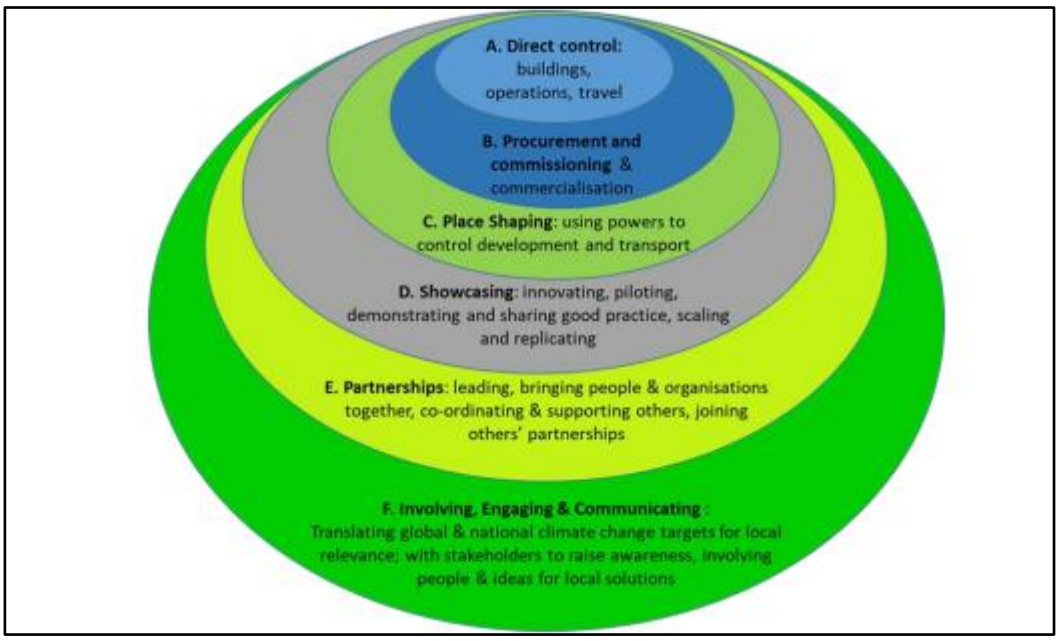
9. Powers in relation to borrowing and investment.

There are challenges however due to gaps in key powers that prevent systems-scale approaches, policy and funding barriers, and a lack of capacity and skills caused by funding cuts. Devolution may however help address these challenges somewhat. Figure 18 shows local authorities' can leverage and influence via their services, planning, enforcement roles, housing, regeneration, economic development actions, education and skills services and investments. Often,

[90] Promise of value from addressing a problem/problems

local authorities can work to address climate and nature challenges simultaneously.

Figure 18: How local authorities control and influence GHG emissions (Coxcoon and Roberts 2020[91])



6.2 Natural capital

Evidence indicates that the state of nature in the West of England has been worsening, for example as an indicator, the vast majority of the West of England SSIs (118 out of 138) are both 'unfavourable' and 'declining' in quality. Other examples include that very often our major rivers and lakes have poor ecological status in the region mainly due to agricultural runoff and release of sewage (West of England Nature Partnership 2025). As mentioned in the review there are also other pollution challenges in the region that impacting nature and human health. The report also identified a strong link between nature access, wellbeing and productivity. Additionally, productivity assessments often overlook the implications of changing natural capital, and climate change on growth and productivity.

[91]As seen in CCC (2020)

The UK is now one of the most nature-depleted countries on Earth (see State of Nature Report 2023). In this report we looked at nature challenges for the West of England and the major drivers of nature decline and their solutions (see Table 6). The CCC (2020) identify that local authorities can have significant influence over the first three drivers of nature loss (intensive agriculture, urban development and land use) and solutions via their control and influence in relation to land use, agriculture and development and buildings. As seen in the section there are already some excellent actions and initiative being taken in the region to address nature decline and recovery. The CCC (2020, p103) identify a range of ways that local and combined authorities can enable and communicate to help nature recovery and GHG mitigation:

• "Promote the benefits of woodlands, wildlife and nature. Support and promote voluntary planting schemes and engage volunteer tree wardens, support Bog Day, to raise awareness about peat.

• Retain County Farms with an Acre for an Acre policy to protect sell-offs and review leases to enable tenants to adopt agro-forestry, low-carbon farming practices, tree planting and hedges. Support tenants in learning about sustainable low-carbon farming, feed additives, cover crops and ecosystems services.

• Provide business support to farmers and landowners to integrate climate change and farming through low-carbon farming methods, woodland cover, tree nurseries, sawmills and wood processors; support agricultural research and development, promote use of wood in construction, provide advice on the transition to ELMS, actively work with the local National Farmers' Union and Young Farmers to assist skills development. Support farm building and infrastructure modernisation and low-carbon refurbishment through planning policy encouraging broadband and on farm mobile infrastructure. Help move farmhouses off oil and LPG. Promote and support on-farm renewable energy generation including AD.

• Support peatland restoration and engage with farmers on cover cropping, re-wetting and ELMs. The Peatland Code45 provides metrics for emissions from peatland restoration.

• Food: Promote government healthy eating guidelines, local procurement, offer a fully plant-based option every day and ensure public sector catering staff are trained in vegan and vegetarian cooking."

Analysis in this report, shows agriculture as the most major land use in the region. The GHG section however identified modest direct GHGs from Agriculture, but very large embodied GHGs in provisioning reginal sector final goods and services (much of the later GHGs relate to food) embodied in imports to the region. At the same time food national security is increasingly becoming an issue as highlighted in the report (and Defra 2026), we will need a higher level of self-sufficiency in food production in future, yet agriculture businesses are facing very strong headwinds currently and need help, support and collaboration to aid their transition to be more sustainable.

Recommendations: Addressing the nature emergency, drivers impacting nature include intensive agriculture, land use change, and habitat fragmentation and climate change amongst others[92]. The areas that local authorities have some control over are agriculture, land use, building, and transport infrastructure. So, in this sense the region has strong potential to effect integrated land use planning, nature sensitive building and infrastructure decisions and implementation actions to address nature recovery and address the drivers cited. Part of the role of local authorities is to work with its people to show case exemplar approaches. Local authorities could work in the region with farmers and other stakeholders, academics and business to develop farming strategies and cases for others to learn from, that are both profitable (and suitable for the land), low GHG generating and that regenerate nature as much as possible. This should include case studies that include dairy/meat production as people will

[92] As noted, there is also potential for other aspects such as energy production (in the case of tidal) to adversely impact.

still need some milk and meat as well as cases that are mainly horticulture based. Similarly, the region needs to show examples and case studies of how best to put in place new development that is as low impact on nature as possible (and also choose sites carefully in this regard) and that create spaces and opportunities for nature in the built infrastructure and reduce or help avoid habitat fragmentation. See discussion on other recommended solutions for key drivers in the relevant section.

Value proposition: business model innovation in the agriculture sector to explore improvement in productivity and environmental sustainability.

Given the national strategy and the significant green belt land that exits in the region (with limited development potential) and yet as this report shows, significant embodied GHGs of food and drinks and ecological impacts of intensive agriculture, the region should explore business model innovation strategy to leverage low GHG farming, alongside delivery of nature and ecosystem services and nature access/experience services might leverage economies of scope (addressing a number of problems food security, GHGs, nature recovery, nature services) to improve productivity and resilience of farming and at the same time address food security. McCain 2025 recommend diversifying farm incomes via on farm solar, farm shops; it is worth exploring productivity and system wide benefits from business models that leverage economies of scope across a range of related challenges. Business model innovation could look to engage critical anchor institutions, e.g. WECA, local authorities and others to help explore innovation for financial viability and deliver a different value proposition that provides food but also other services. Services in nature related experiences for people[93] may have positive impacts on wellbeing and productivity[94] and it is worth exploring business model innovation

[93] At the regional level 36% of the region's households have reasonable access to green space. Reasonable access to green space is defined as living within 15 minutes' walk of publicly accessible green spaces of at least 10 hectares in area. Fifty percent of households in Bristol have reasonable access to green space. Less than 30% of households in the region's three other, more rural UA areas meet this standard, mainly due to accessibility (city parks are publicly accessible while fields are not) (Defra 2025).

[94] https://publications.naturalengland.org.uk/publication/5939107801595904

in relation to. Britain is one of the least 'nature-connected' nations[95]. We need research to identify the best business model innovations for productivity improvement and environmental sustainability improvement in agriculture.

Regarding some of the WECA targets for forest cover other aspects. The CCC (2020) state that (p. 39): *"Woodland creation schemes need to be planned to ensure the ongoing protection of species rich grassland and fauna and heritage landscapes shaped over decades by extensive agriculture. These concerns can be addressed by local area partnerships integrating plans for increasing afforestation with Biodiversity Net Gain policies, new Nature Recovery Networks and assessing Landscape Character areas. Land use and development should also address Natural Flood Management, cooling and climate adaptation priorities".*

In our region some good partnerships are already well underway, but it will be important to keep up momentum and work constructively with the range of stakeholders to collectively find solutions. There are also innovative initiatives such as the Bristol Avon Catchment Market (Bristol Avon Catchment Market 2025) which can help incentivise farmers and other landowners to integrate nature recovery more deeply into their business model. Ideally the region needs regulators and the range of stakeholders to help create a selection environment where the value of nature is recognised and integrated into investment and decision making by relevant stakeholders. As stated in the report farmers already face substantial economic headwinds so they need help and support to aid food security and to the leverage the economies of scope across the range of interlinked problems identified.

6.3 GHGs and the West of England

Section 2 looked at GHGs in the West of England. Estimated total emissions for the region are 6394 $KtCO_2e$[96] in 2022. Fifty two percent of these total emissions

[95] https://link.springer.com/article/10.1007/s13280-025-02275-w

[96] Electricity emission allocated to the consuming sectors.

come from transport in that year; most are related to road transport (thirty two percent of total emissions) and air transport services (twenty one percent of total emissions). The second most prevalent sector is domestic household emissions (twenty percent of total emissions). Using the DESNZ 2025c data for 2022, fifteen percent is from industrial and commercial emissions, and five percent is from Agriculture and three percent from the public sector and three percent from waste. In terms of direct GHGs emissions the most important sector is transport, so we now highlight some key discussion points. The CCC (2020) identify that nearly sixty percent of the changes in the CCC's Sixth Carbon Budget Balanced pathway rely on societal or behavioural changes and this was particularly the case regarding decarbonised transport, buildings, waste but also in relation to renewable energy and changes to land-use and agriculture that affect the local landscape. So clearly impacting direct GHGs cannot just rely on a technical fix alone. Societal or behavioural changes is an area that LAs and CAs can substantially engage.

Road transport

The West of England is clearly a long way from meeting its 2030 GHG reduction targets on time primarily this underscores that greater national leadership, as well as local action needed. The limited progress is the product – by no means unique to the West of England - of placing an emphasis on the wrong end of the 'avoid-shift-improve' hierarchy (SLOCAT Partnership, undated). The intended logic of the approach is to start with avoiding carbon-emitting travel, then shift to more sustainable modes for travel that cannot be avoided, and then only 'improve' that travel that cannot be shifted. In practice, behaviour change solutions have not to date led the process, as they have not had sufficiently broad and deep political support. This lack of support reflects the so called 'structural' constraints which mean society has become dependent on the car. Instead, we have emphasised 'improving', but only since the beginning of the decade have the conditions for the main measure (vehicle electrification) enabled it to enter the mass market, too late to have sufficient impact on the 2030 targets. In relation to the role of LAs, the CCC (2020, p. 69) state that: "*Local authorities as well as the Government will need to review and change policies that prevent or impede low-carbon choices. Local authorities, combined authorities and regional organisations will need to cooperate and lead on designing and planning places that are Zero Carbon, green and healthy. They will need to boost their skills and capacity to deliver investment in heat decarbonisation and transport systems that are efficient and that work for local people. Building a strong evidence base to back up decisions, supported by national policies will be critical to make sure that developers step up. Net Zero housing and commercial developments, connected to sustainable transport infrastructure, walking and cycling and public transport need to become the norm, not the exception*."

EV transition is important to meeting the target but is likely to prove difficult for some to transition, due to space and other constraints (particularly in cities etc). Alongside helping aid the transition to electric vehicles, it will be important to return to policies which emphasise cars as one supporting part of the transport system, with most people making most of their journeys by other means or taking advantage of the digital solutions which saved us in another recent emergency. Transport is one critical area where local authorities have substantial oversight in the region, so could substantially impact the regions GHGs. We do not discuss this further here as the relevant transport aspects are also discussed by a recent Brunel Centre report[97] when looking at infrastructure. In relation to environmentally stronger forms of green growth and employment, strong circular economy principle could be deployed to develop this aspect of our regions strategy, it would be worth exploring how advanced services type business models can de supported and deployed to substantially address some of the potential adverse impacts of a straight swap of the owned fossil fuel based car fleet with electric vehicles. This could provide important physical material efficiencies improvements for the region (given the substantial amount of GHGs and other environmental pollutant loads embodied in producing each electric car and change incentives for reuse, remanufacture and end of options for each car – hopefully avoiding some of the adverse pollution impacts). The move away from fossil fuel cars can address a number of the localised pollution issues associated with road transport in cities that substantial impact human health.

Air transport services

There are quite stark trade-offs from further growth of scheduled air transport in the region, in terms of jobs (human capital) the sector only accounts for 0.2% of overall employment of the region, yet generates around 21% of the regions overall GHGs in the year 2022 (comparable to all household GHGs in the region). Passenger numbers have experienced substantially growth since 2022 (by

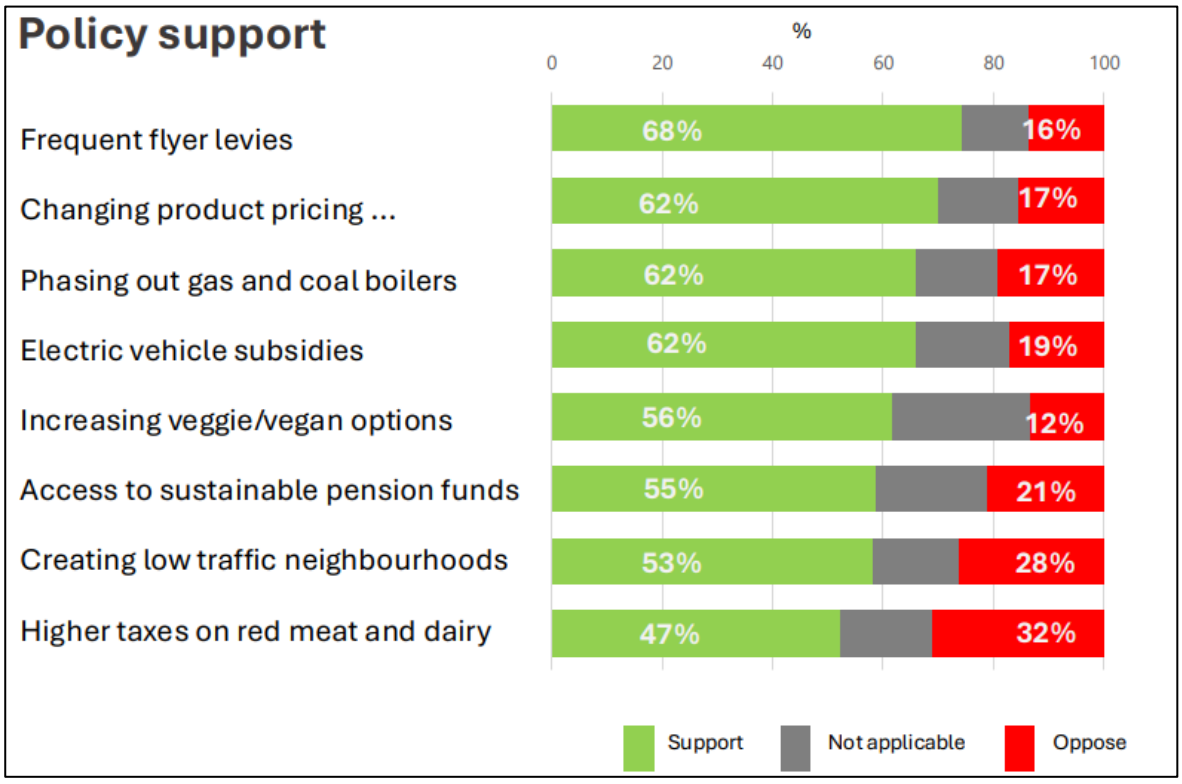
[97] The Brunel Centre 2026.

around 25%), so the sectors emissions are likely quite a lot higher in 2025. In terms of who flies and equity, seventy percent of flights in the UK are made by a wealthy 15% of the population, with 57% not flying abroad at all[98]. This said for those jobs that do exist in the sector, they are an important source of income and stability for those employed. In financial capital balance terms, there is a mixed picture, a report by Chapman and Pot (2025) for the New Economics Foundation identify that a causal relationship in which air connectivity growth drives GDP per capita growth can only be statistically supported in 37% of European regions (primarily in Eastern Europe and tourist-receiving areas). The study did not take account of the damage cost of the GHGs generated. A smaller scale study by Oxford economics (2014) sponsored predominantly by airports and air services providers presents a more positive account when looking at the economic impacts of air transport in the UK generally (they include economic impact of aerospace and spending of employees as part of the impacts amongst other aspects) they estimate that the aviation sector contributed £52 billion (3.4%) to UK GDP in 2012. In relation to wellbeing, air transport services sector can provide substantial wellbeing related impacts via helping enable a portion of the population experiences holidays abroad, travelling and allowing connectivity to other parts of the world for residents and (as a smaller scale) business of the West of England and the wider UK population that use the airport. There are however significant dis-value impacts from air transport services on local populations health and wellbeing (human capital) relating to both pollution (Settler et al., 2011; Yim et al., 2013; Department for Transport, 2018) noise (Park et al., 2024; Civil Aviation Authority, 2016) annoyance and loss of tranquillity affecting localised populations (Amoatey et al., 2022). The latter impacts are unequally distributed across the West of England region. In relation to GHGs, technological options are not currently readily deployable to reduce GHGs at scale and because of this the Climate Change Committee (CCC) identify that demand management may be

[98] https://www.bbc.co.uk/news/science-environment-56582094

needed and in 2020, the CCC (2020) recommend keeping plane kilometres travelled per person static until 2035, so in this sense are advocating a level of demand management in relation to air transport to address the climate emergency. Policy options to consider in the context of flying are a carbon tax on frequent flyers, quotas or flight limits for individuals or halting or caping of airport passenger number increases until substantial externalities are addressed. Poortinga et al., 2023 show that in terms of support for Net Zero Policies, a frequent flier levy is one of the most popular, see Figure 19[99].

Figure 19: Support for eight net zero policies in the United Kingdom (Poortinga et al., 2023).



Perceived fairness is a strong predictor of policy support and can be more important than effectiveness of policies (Sweetman & Whitmarsh, 2015;

[99] More recently Poortinga 2025 found more generally that restrictive 'push' measures are much less supported than non-coercive 'pull' measures; financial measures are less popular than regulatory measures; and measures looking to change dietary behaviours are supported less than energy and travel behaviour measures.

Bergquist et al., 2022)[100]. This said, currently regional authorities could not easily implement a frequent flyer tax on their own and it would likely require national government support, the extent to which devolution in England will change this is unclear, this is worth considering given the very rapid growth and impact of air travel on climate change. The CCC suggest that local authorities should not ignore aviation emission in their climate conversations. CCC (2020) identify that local authorities as well as the Government will need to review and change policies that prevent or impede low-carbon choices, although local authorities may have limited levers to pull currently, awareness and behaviour change campaigns are one lever. This study provided a first proxy benchmarking estimate of the GHGs of aviation in the region. A more in depth and detailed study in future would be advantageous.

Value proposition for addressing net zero aviation via aerospace

The problem of GHGs of air transport services is a major one and needs a solution from the wider aerospace sector (the West of England is a leader in aerospace). Pressures for change in GHGs from air transport services noted here, are likely to grow across the world, and our regional strength in aerospace could lead low GHGs solutions required across the world. Hydrogen South West[101] (which include aerospace stakeholders amongst others) look to be engaging with this challenge (also see relevant case study 4 in section 5). The value to wider society and environment (as well as the industry itself) could be massive, if they can innovate and drive change in the system to address GHGs and related externalities, in a sector where the end services (SIC 51) currently generate highly unequal outcomes and externalities for different people in the region and beyond.

[100]Procedural, as well as distributional, justice is important (Jagers et al., 2010). It is also found that participatory policymaking can lead to better and fairer outcomes (instrumental rationale: Fiorini, 1990). Citizen engagement building block for political mandate (e.g., citizens assemblies and juries etc).

[101] https://www.hydrogensouthwest.com/

Households

Household sector GHGs is an area that local and regional and local authorities can have substantial control and influence. Household emissions in the region are significant, twenty percent. The main approach the region has taken to address these is though the heat network and retrofitting of household in the W West of England region. Actual progress on targets for retrofitting households has been slow and is substantially behind where it needs to be to meet the targets as outlined. There is a need to significantly speed this up. One of the challenges is that some forms of retrofitting such as in relation to heat pumps can be expensive and require substantial research to understand if a good and reliable solution for a house, sometimes technologies such as heat pumps are not suitable in older houses. It is not just an issue of household demand; there are challenges for households in finding trusted and reliable suppliers and having the right knowledge and self-efficacy. This is one of the reasons for the setting up of organisations such as Retrofit West in the region. The heat network and Bristol City Leap is seen by many around the country as a standout example of how local authorities can engage with the private sector to drive change to decarbonise household energy use in a local area and region. So, although progress has been slower than desired, there has been some excellent work in the region to take things forward and many of the struggles with retrofit progress are also seen nationally. Recent updates and finance related to the warmer homes initiative is likely to speed up uptake somewhat.

Commercial, industrial and the public sector

The second and third most important C&I and public sectors in terms of scope 1 GHGs are electricity production – gas,12% of all C&I and public sector emissions (with air transport services included) and Manufacture of articles of concrete, cement and plaster (11%). Waste collection is another GHG intensive sector (11%), other sectors such as Agriculture, Freight/logistics, Human health services are also significant. Sixty percent of the total C&I and public sector emissions occur in the top 5 sectors, so if we focus on these key sectors, then

we can substantially decarbonise the overall C&I and public sector GHGs in the region. It is notable that the top five GHG generating sectors are not substantial employers in the region in terms of overall West of England employment (only making up only 1.8% of employment in the region). This signals that moving towards Net Zero, will have limited detrimental impact on overall direct regional employment. It is hoped it should be possible to decarbonise the highest GHG emitting sectors without much reduction in employment. See discussions in relation to each sectors transition and just transition in the relevant section. Again, the region has some excellent and leading initiatives with regards to decarbonisation of the industry sectors, as seen from the Local Industrial Decarbonisation Plan (LIDP) for the West of England Industrial Cluster (WEIC), a standout example of initiative and attempts to actively decarbonise the regions industry and building on circular economy principles. The brewing case studies also highlight high ingenuity and ambition to address Net Zero.

In addition to decarbonisation a literature review of circular economy solutions for key sectors is provided in Appendix 4. The region should look increasingly to circular economy and business model innovation to decouple material flows and environmental impact from end products and services delivered by firms (this comes out clearly when looking at embodied GHGs of final goods and services of the region). The scale of material flows though society that is driving many of the key global environmental pressures (Allwood et al., 2011). With the latter regard, innovation toward advanced services and reuse business models (generally much more effective in reducing environmental impact than recycling) can be a strong way of increasing productivity and at the same time substantially decoupling environmental impact from meeting people's needs (if implemented well).

GHGs attributable to sector final demand in the region

The total GHGs attributable to final demand of sectors in our region was 20147 $KtCO_2e$, over three times the direct GHG account for the West of England region presented in Table 6. This sector account includes upstream emissions (scope

1, 2 and 3 emissions) embodied in producing the regions sector final demand goods and services. What this shows is that the regions final goods and services are effectively outsourcing there GHG emissions to other regions though imports, which is problematic, GHGs are a global pollutant, and it does not matter which region or county they are released, the impact is the same. There is substantial scope for reducing these GHGs via sustainable procurement, choice editing (retail/wholesale), or reducing/avoiding GHG intensive inputs, working with supply chains, substitution (for less GHG intensive), changing the business model towards strong circular economy approaches. The top sectors are Wholesale trade services (33%), also Public administration and defence services and compulsory social security (6%), and construction (6%), Human Health services (5%) and electricity transmission and distribution (5%). Employing strategies in these sectors such as substituting GHG intensive inputs for less GHG intensive ones is unlikely to lead to job losses, but can substantially reduce embodied GHGs. One of the top sectors is Public administration and defence services and compulsory social security, the CCC 2020 identified sustainable procurement as an action the local and combined authorities can lead on.[102]

6.4 Land use in the West of England, net zero and nature recovery

Analysis of land use in the region reveals the tension between ambitious net zero targets and a constrained land base as this limits the space available for renewable energy as well as industrial expansion. Flood risk compounds the

[102] We also noted above the potential to develop a regional strategy to aid more local provisioning of food and drink, this can both aid food security and reduce these substantial embodied GHGs many of which are related to food and drink, particularly in wholesale (the top sector). In relation to the value proposition to address both direct Agriculture GHGs and embodied GHGs of food and drink, the CCC (2020) states that cutting emissions from agriculture and storing more carbon through land use and forestry are dependent on delivery at a local scale, so this is an are the region could engage strongly. There is strong potential for local authorities, Business West, FinTech West and other regional organisations to help identify exemplar case studies in each sector, and educate and facilitate the changes required to enable more sustainable consumption (as unsustainable consumption is often linked to the business model employed) and production decisions in the region. They could be a critical agent of change in helping drive sustainable business in the region to address key global environmental pressures (cited above) not just GHGs.

constraint, particularly in the region's most important industrial cluster at Avonmouth/Severnside.

The major land use in the region is Agriculture, and green belt limits on other forms of development. Delivering more renewable energy will not therefore be a case of finding vast new land parcels but of creatively reusing, intensifying and adapting the land that is already available.

At the national level, the CCC (2020, p.66) state: "*A transformation is needed in the UK's land while supporting UK farmers. By 2035 CCC scenarios involve planting 440,000 hectares of mixed woodland to remove CO2 from the atmosphere as they grow, with a further 260,000 hectares of agricultural land shifting to bioenergy production (including short rotation forestry). This would see UK woodland cover growing from 13% now to 15% by 2035. Peatlands must be restored widely and managed sustainably. Low carbon farming practices must be adopted widely, while raising farm productivity. Alongside the nature-based removals, by 2035 the UK should be using bioenergy (largely grown in the UK) with CCS to deliver engineered removals of CO2 at scale. The CCC's scenarios for 2050 see a reduction in agricultural emissions associated with a shift in diets, and increased tree-planting and peatland restoration restoring the UK's land use (outside of agriculture) to be a carbon sink.*"

Value proposition for more sustainable food systems in the region:

Agriculture and the food system can be substantially damaging to the environment, at the same time food security matters and is likely to become more important for national security (Defra 2026). Ensuring resilience and profitability in farming is challenging given changing climate and difficult economic circumstances farmers face. It is interesting to note that the current processing and wider food system that the UK employs to provision final food and drink provided to consumers cause substantial externalities for health and environment. AFN + (2025) and others put forward a roadmap to address: 'Roadmap for Resilience: A UK Food Plan for 2050' that provides deep insights on some of the solutions for stronger more resilient farming, smarter integrated

land use, and healthier diets and that substantially reduces environmental and ecological externalities. It would be worth setting out at a regional level response and economic case for implementation such a road map. There is potential for such an approach to address environmental and health externalities and at the same time generate jobs, resilience, opportunity, and sustainability if implemented well but we need to better understand the economic case (including addressing externalities) and economies of scope that can be achieved by a more systemic, intelligent and data driven approach, this will highlight the value proposition for the region and provide confidence for actors that it is right move. It would also be important to understand best business models to achieve and what the regional governance approach might look like. Engaging the wider food system will be particularly important (this is where a regional governance approach could help), e.g. major regional food purchasers (wholesalers, restaurants, food retailers, hospitals and other key food purchasers in the region) as part of an approach to address the interlinked challenges in relation to food security, GHGs, nature recovery, nature access and health.

6.5 Climate adaptation

Regardless of the ambition achieved towards Net Zero and Decarbonisation, adaptation is critical to manage the effects of climate change that are already evident and those projected for the future. Indeed, adaptation efforts are gradually being integrated into policies, strategies and plans and its importance has been recognised also by key stakeholders, as exemplified by the West of England Industrial Cluster's local decarbonization plan.

Adaptation strategies in the West of England Region intersect strongly with land use planning, nature recovery, and decarbonization agendas. Integration efforts are particularly visible with regard to the deployment of NBSs to enhance water retention, reduce runoff, and mitigation of urban heat island effects. Going forward, areas of focus for adaptation action should include transport and housing developments, to avoid increasing exposure to flood or heat hazards.

As economic and infrastructural developments in the region have a strong cross-border nature and include major investments that are of national strategic importance, the West of England Mayoral Combined Authority is emerging as a strategic lead for adaptation, and could act as a platform or a catalyst for strengthening integration and coordination between different local authorities and stakeholders beyond project delivery.

As noted, the region is under prepared. The region has yet to consciously integrate constraints relating to the needs to adapt to a changing climate with the region's growth ambitions. With the rebirth of the WECA led spatial development strategy (SDS) as the 'strategic Authority' and a time horizon of 2050 (unlike the 15 years of local plans) the consideration of the impacts of a changing climate on both the existing and future economy will need to drive future options. Given that government advice is to plan for 2°C of warming but prepare for 4°C, (temp above preindustrial levels) if this is taken as a corner stone of future policy then the policy approaches to deal with this level of risk would need to be at a scale never seen before, and it would dramatically re shape the map of the west of England (see for example Central Climate 2025 to see land projected to be below annual flood level by 2050).

6.6 The devils is in the detail for the success of a green growth strategy

The Jevons paradox (1865) posited that that as technology increases the efficiency with which a resource is used, the total consumption of that resource can increase rather than decrease. So that improved efficiency does not necessarily reduce consumption of a resource, it can actually increase consumption. In the case of fossil fuels this can translate into also increased GHGs, see discussion of the rebound effect in relation to GHGs in Sorrell et al (2009) and Chitnis et al (2014), so that as improved energy efficiency occurs emissions increase, not decrease.

This phenomenon does however depend on the wider GHGs of the world economy (world level in an open country like the UK) – as global GHG emissions reduce then the GHG impact of efficiency savings being invested in other parts of the economy should decrease in prominence. They key issue however is how long this takes, particularly as the vast majority of the GHG footprint of goods and services comes from embodied emissions occurring outside the WOE region as seen in Table 8. It will be extremely important to keep an eye on these embodied GHGs (in their own right but also specifically because of the Jevons paradox and potential for rebound effect in relation to GHGs as mentioned.

The above suggests a need to not just avoid the disvalue from goods and services but also the need to invest in and actively be designing goods and services that regenerate ecosystems and sequester GHGs (to bank against adverse impacts such as the rebound effect). Given embodied GHGs alongside the Jevons paradox issue, it really does emphasise the importance of the WOE focusing wherever possible on disconnecting material flows and GHGs from meeting the end needs and services that sectors provision for the region though the stronger circular economy principles and approaches set out in Stahel et al (2013) such as reuse business models and advanced services etc.

These stronger circular economy approaches effectively reduce input requirements to services end needs and wants, but in so doing effectively may reduce the multiplier effect of investing in some sectors, which can have impact of wider industries possibly within the region, but more particularly outside the region and in the rest of the world. But this said, effectively the 'reuse business models and advanced services' can lead to efficiency improvements (though reduced input expenditure) that can be invested in activities elsewhere in the economy and this partially or even in some cases can full address these negative reduced multiplier effects, via generating additional expenditures elsewhere in the economy (much as technical innovation may loose jobs in one sector but the make them up in another sector via businesses investing savings elsewhere in the economy). It would be good for future work to empirically analyses the latter aspects more. Overall, the 'reuse business models' and 'advanced services approaches' stand much greater chance of achieving the third aim of sustainable development, without such approaches the green growth strategy is a high risky option for the region in terms of addressing key global environmental pressures such as climate change on the timescales we need to. And therefore, are a serious and important consideration that needs embedding in any sustainable economy strategy that hopes to be successful. As stated before, not all growth is good growth.

A green growth strategy has risks associated with it in terms of truly addressing key global environmental pressures. So, it will be important for the region to keep a close eye on this and observe year by year how both direct and embodied emissions of the region are changing. If not, there is the risk that the state of key global environmental pressures just gets worse with a green growth strategy and people get disillusioned. If such strategy to address key global environmental pressures fails, then alternative economic strategies would need to be pursued (such as some of the alternative ones in the de-growth literature) which could entail other (non-environmental risks and challenges).

Another tool to keep the Jevons paradox issue at bay (and also to help accommodate reuse and advanced services business models) would be for the civil infrastructure and local and combined authorities to work with communities to develop a strong strategy to nurture responsible

6.7 Redefining productivity to align with the five capitals and framework

From this report it is clear that the reality is that we cannot have a strong or sustainable economy without: 1. Prioritising human wellbeing, physical, and mental and emotional capabilities (human capital); 2. Prioritising the

environment and key ecosystems that sustain us (natural capital); 3. Support trust and social sentiment (social capital) conducive to economic exchange but also the pursuit of a sustainable economy, and without maintenance and improvement of our infrastructure that facilitates economic activity and a lower ecological footprint (manufactured capital), alongside enough financial capital to live well and invest wisely to optimise the five capitals balance. We need to be prioritising all five capitals not just one, facilitating the social embeddedness, governance and institutional environment that attains the best capitals balance for a sustainable economy in the region (going back to our sustainable economy framework in Figure 2).

To this end focusing on the standard definition of productivity alone that only measures improvement in one form of capital to judge the success and improvement of the economy does not make sense. There is a need for a set of productivity indicators that address the five capitals. For example, in relation to human capital, one could include measures of value and disvalue to wellbeing (for producers but also consumers of the product or services) generated per hour of labour input in producing a good or services. **Recommendation: Conduct research to highlight and identify a set of measurable productivity indicators for the different five capitals and available data and datasets that could help construct.**

On aggregate the West of England and UK economies need to optimise the five capitals balance so that the economy facilitates prosperity as defined in this report. Moving towards such an economy will require a more intelligent, and systems informed (social, economic and environmental) approach and strategy to the way that economies are run and the forms of productivity pursued.

It will be useful to have tools to identify firms +ve and -ve contributions to different forms of productivity metrics and capital balances from their production and associated consumption (for the five capitals) and encourage change in those businesses and sectors where there are disproportionately

negative impacts on certain forms of productivity and five capital related metrics.

At the individual firm level, it is likely that different firms will have different contributions to productivity in their different forms, and this if fine so long as on aggregate for the region/regions of the UK we get the optimal balance for the different capitals. This will require a data informed and much more intelligent approach to the way we run our economies as well as strong strategy and a selection environment (see left hand of Figure 2) that can help bring this forth.

As we move into the future it will be important that productivity metrics relating to the five capitals determine future economic direction and drive growth rather than just one that optimises in relation to only one form of capital. Additionally, with the onset of environmental breakdown and potential for worsening conflict, considerations relating to national security and resilience will likely become increasingly important in economic management and policy (than purely just economics) for a resilient West of England and UK economy, such as those challenges relating to food security. See (Defra 2026).

6.8 Value added of the report and key trade-offs

The main contributions of the report are to: 1. characterise some of the key natural environment and nature attributes of the region and challenges for nature recovery. 2. Estimate key (scope 1) GHG producing sectors in the region (including those associated with air transport services) in a detailed disaggregated form; 3. To estimate embodied GHGs (scopes 1,2 and 3) attributable to sectors final goods and services. 4. Assessing land use in the region; 5. Identifying some of the key strategies for reducing emissions in these sectors and ways to address interlinked systemic challenges in relation to GHGs and nature recovery. 6. Synthesising key insight across key documents in relation to climate adaptation;

These new insights for the region provide added insight and strategy in addressing Net Zero in the region, for example they highlight that mitigating and

addressing growth of GHGs in air transport services in the region will be critical as we move towards 2033 and onwards. Addressing this can have more impact in addressing Net Zero than retrofitting all households in the West of England. This was not previously known. It was also not previously known that embodied emissions of sectors final goods and services account for orders of magnitude greater GHGs than the GHGs directly generated by activity in the region sectors final products and services significantly outsource GHGs to other regions (UK and abroad) via imports.

Though looking at land use also, the report was able to highlight a series of interlinked problems/challenges for the region: Agriculture is the main land use in the region but has significant direct GHGs and ecological impacts, yet farming is a vital rural sector of our region and needs prioritising, and needs help and support to maintain food security and transition to Net Zero and aid nature recovery. At the same time there are substantial embodied GHGs in provisioning the regions production, a significant amount of these are related to food and drink (often imported from elsewhere in the world). Current UK food systems generate substantial health costs for the UK (£268bn per year) see Jackson (2024). At the national level the AFN + 2025 report sets a road map to address these linked problems and challenges, this report emphasised it is worth exploring the economic case for a regional governance approach to engage the farming sector and wider food system of the region to address and better understanding the economic case and best business models to leverage the economies of scope to address these linked problems across the system. The land use sectional also made clear the constraints and limitations for land based renewable energy in the region suggesting the need to make use of roof top and other spaces that could be used to install renewable energy but also identified very careful planning in how we develop the economy in future. This section and the climate adaptation section highlight significant challenges and that not enough is currently being done to adapt to climate change given the regions vulnerabilities to climate change.

Additionally some key trade-offs were highlighted in the report: such as those in relation to harnessing tidal energy and ecological impact; AI growth and potential for energy/water use (and hence nature) implications; Growth of air transport services and potential for missing future climate change targets from 2033 onwards; Trade-offs between growth of housing and nature conservation; Agriculture, GHG and nature impacts. Some of these trade-offs could be reduced/avoided and potentially resolved via support and changes in business model and technology (as well as intelligent design and location of activity), whereas some are more difficult to avoid given the current state of technology development/deployment and high growth trajectory.

The report also highlights the substantial ambition and advances of the region in addressing NetZero and significant efforts and ambition in addressing nature recovery with some very nice case studies provided towards the end of the report.

Another value added of the concluding sector was to highlight where local and combined authorities have more scope and levers for change in addressing the challenges identified in the report. It is hoped that the report can inform strategy in the region to advance the sustainability and prosperity of the region.

A final value added was that the report evidenced and surfaced the need for the region to 1.) pay close attention to the forms of green economy that it embraces given the Jevons paradox and 2.) redefine the way we look at and measure productivity in the region so that aligns with the sustainable economy framework in Figure 2. On aggregate the West of England and UK economies will need to optimise the five capitals balance so that the economy facilitates prosperity within environmental limits. Moving towards such an economy will require a more intelligent, systems informed approach and strategy to the way we run our economy and the forms of productivity measures and pursued.

7 Conclusions

This report shows that the region has some major environmental sustainability challenges[103], and that in its current form not all growth is good growth. There is however, genuine leadership and ambition and action in the region and leading case studies of sustainable economy in action. Specifically, it was found that:

Transport related emissions are key in decarbonising the region, 54% of overall direct GHGs for the region (32% road and 21% flight related) as seen in Table 6[104]. Progress in reducing road transport emissions has been slow regionally. **Recommendation: Continue to support the EV transition as it is important in meeting the GHG targets but future growth of EVs may be challenging due to space and other constraints, particularly in cities etc. Regionally and nationally explore what can be done to reduce potential inequalities in the transition to EVs. Alongside helping aid the transition to electric vehicles. It will be important to return to policies which emphasise cars as one supporting part of the transport system, with most people making most of their journeys by other means or taking advantage of the digital solutions.** Air transport services related emissions are substantial, the vast majority of these relate to flights, Bristol Airport aims to have Net Zero Operations by 2030[105], but their operations do not include the flight related emissions which reside with the Airlines even though passenger number increases and expansions have implications major implications for these flight related GHGs. **Recommendation: Consider carefully the impact of air transport services on meeting future regional and national GHG targets and budgets how increases in passenger numbers and expansion may impact these. When evaluating the economic impact of airports look at case by case and account for monetary injections as well as withdrawal from the UK economy**

[103] And only a selection of key global environmental pressures were looked in this report.

[104] Which for the first time includes an estimate of flight related emissions.

[105] See: https://www.freshaviation.co.uk/bristol-airport-releases-its-final-master-plan-for-2040/

and externalities when assessing overall economic impact. The CCC recommends demand management for aviation until emissions are addressed, given that large scale decarbonisation of aviation looks to be at least a decade from being achievable and the fast growth but large externalities. Frequent flyer levies are one of the more popular climate mitigation policies.

Eighty percent of the regions C&I and public sectors direct GHGs (scope 1 as seen in Table 7) occur in the top 15 key sectors, top 5 is 60% (when electricity and transport emissions are reallocated back to their producing sector). The latter account shows that the region can focus efforts on key sectors to address the vast majority of C&I and public sector GHGs. **Recommendation: The region should focus on addressing GHG mitigation in these sectors and supporting these sectors in this task.**

Regarding GHG emitting C&I and Public sectors, nine of the top fifteen sectors in terms of employment are very low direct emitters of GHGs. It was also found that addressing C&I and public sector GHGs in the region is unlikely to substantially impact overall regional employment as the top 5 GHG producing sectors account for only 1.8% of overall employment. This said it is hoped that it should be possible to transition to net zero without major job losses in the GHG intensive sectors. **Recommendation: Realise that the regional transition to Net Zero is unlikely to adversely impacts jobs in the region.**

Some important regional value propositions could be realised as part of addressing Net Zero and nature recovery. These could contribute economic, human and natural capital benefits for the region and help realise regional prosperity. **Recommendation: realising regional value propositions needs to be a major part of the sustainable economy transition and feed directly into economic strategy. There is a need to better understand the economic case for each regional value proposition and to better understand how devolution could create a selection environment for value propositions to be realised.**

With regards to households retrofit, the report highlighted a major ambition reality gap. The 'delivery gap' to meet the targets was substantial. **Recommendation: UA's and LA's look at how best to address this without adversely impacting regional inequalities whether economic or other. The Warm Homes Plan that promises to provide £15bn to households across the UK over the next five years for solar panels and other green tech may help address.**

Embodied GHG emissions (scopes 1, 2 and 3) attributable to final demand of sectors in the region are over three times higher than direct emission. The final demand of Wholesale trade accounts thirty three percent of these emissions. Some of these are easy to address via sustainable procurement and choice editing without adversely impacting businesses. Strong circular economy bus models can be key in addressing these embodied GHGs and can help address future resource security and productivity (via reduce input costs and exposure to future inflation). Many of the embodied emissions are associated with food and drinks related as well as other products that firms use in delivering their final goods and services. **It is recommended that WECA and LA's Consider approaches to address embodied GHGs for the region and build into their short term and long-term prosperity and sustainability relevant strategies. In particular we recommend that the WECA promote strong circular economy approaches within the region to address embodied GHG (and other environmental impacts) and in so doing advance higher environmental integrity production and consumption, alongside addressing productivity and future supply chain resilience.**

The region has a constrained land base and limits on space for renewable energy and industrial expansion; flood risk compounds this constraint. **It is recommended that the strategic response should therefore emphasise brownfield reuse, rooftop generation, and targeted development in low-sensitivity locations for renewable energy and check that we have an**

integrated land use strategy for the West of England, one that is fully integrated with the Local Plan for each of the UAs;

Farming is the most major land use in the region and innovation in the sector, and a supportive and a regional approach could be important in addressing GHGs but also nature recovery and food security, with the potential for economic benefits for the region. **It is recommended that a full assessment of the benefits to economy, prosperity and resilience from taking a joined-up approach and regional plan to address these interlinked challenges should be assessed as well as research to identify which business models deliver high productivity and maximise environmental and societal benefits.**

Current renewable generation is nowhere near the level of the region's electricity demand. Certain sector growth, such as AI, will exacerbate this gap and could cause trade-offs between renewable energy and nature recovery given the constrained land-based for renewables and at the same time trade-offs in developing tidal resources and nature recovery within the ecosystem rich and nature sensitive Severn estuary. **Recommendation: Consider what the implications of the WECA 2025 strategy for certain key sectors will be on energy, water use and concurrently nature recovery.**

The report shows that there are major challenges for the region in future, particularly regarding flooding. The region is under prepared for some of these. **Recommendations are as follows: It is recommended that LAs and WECA accelerate action on adaptation tackling all the priority risks; 1. It is recommended that adaptation measures embed equity and just transition principles; 2. Integrate adaptation across policy areas, particularly with regard to the water sector and in relation to Net Zero commitments; 3. Strengthen multilevel (regional and between local authorities) governance for adaptation to enable joint planning and delivery, data sharing and capacity development. 4. Strengthen monitoring, evaluation and reporting of adaptation actions, including through deliverability checklists.**

The report evidenced and surfaced the need at a regional (as well as national) level to account for a broader set of capitals (that underpin the economy) in economic management and policy and the need to redefine productivity to reflect the five capitals. **Recommendation: On aggregate the West of England and UK economies will need to optimise the five capitals balance so that the economy facilitates prosperity without eroding fundamental capitals. Moving towards such an economy will require a more intelligent, and systems informed (social, economic and environmental) approach and strategy to the way we run our economies and the forms of productivity and measures (some of them being more outcomes rather than output based) pursued. As we move into the future it will be important that the broader set of productivity metrics relating to the five capitals determine future economic direction and drive growth rather than just output per hour worked which speaks and optimises in relation to only one form of capital (financial).**

The report highlighted that a critical component in the sustainable economic transition (often overlooked) relates to national security, and how the economic management and policy will aid investment in resilience and sustainability of the West of England and UK economy (considerations such as relating to food security). **The changing context relating to climate change and ecosystem collapse, and increasing conflict has brought this into sharper focus, for example see the recent report 'Global biodiversity loss, ecosystem collapse and national security. A national security assessment' (Defra 2026).**

It Is also clear from the report that there are both opportunity but also risks in the region getting ahead of the curb in pursuing investment and value propositions for sustainable economy. **Recommendation: action research and other forms of data and Insight are required in collaborate with the range of key (national, regional and local) stakeholders to inform investment and decisions about best investments and value propositions to pursue for a sustainable economic transition. It is judged that the wider**

risks in not taking leadership towards a sustainable economic transition are arguably greater that the risk in pursuing a sustainable economic transition.

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Appendices

Appendix 1: Circular economy discussion

Beyond the micro, there is also a conundrum in relation to efficiency versus scale. Often to ensure economic efficiency in industrial production, there is a need to increase scale 'resource and economic efficiency at scale'; and yet it is the scale of material flows that is driving quite a number of the key global environmental pressures (Allwood et al., 2011). For example, we can have an economy that is more efficient per £ in terms of tonnes of GHGs per £ (and less natural capital impact per £) but if the scale of growth of GHG intensive sectors is high, efficiency improvements will be superseded by scale (and the overall natural capital balance will be degraded at the end of production and consumption). How citizens spend their money (ideally avoiding high GHG activities) and how businesses design their business models (ideally towards PSS or business models that aim for absolute decoupling of environmental impact from the economic activity) matters hugely in determining the sustainability of different growth paths. Some products and services have different business models and entail substantially different natural capital balances at the end of production and consumption than others (hence principle 5 above).

A final point on developing a sustainable growth strategy, is that assessment of natural capital impact must take account of the pollution occurring elsewhere in the world when addressing global pollution problems such as climate change, as it does not matter which country the pollution is generated, it impacts all countries. So, the growth strategy needs to be evidence informed to avoid outsourcing pollution problems to elsewhere in the world. This is illustrated in recent past data. At the UK and European levels there is evidence of decoupling of material use from economic growth (Reg and diagram). The picture however changes once materials from imports are accounted for. Fig. 1A shows virtually no decoupling of material flows from GDP globally (once imports are accounted for). This illustrates the importance of going for growth strategies that have maximum potential to disconnect financial return from environmental impact (locally but also internationally) and taking account of system wide impacts from domestic production but also imports – input-output based but also process based life cycle assessment of products and services can aid this task. Again leveraging an evidence informed approach.

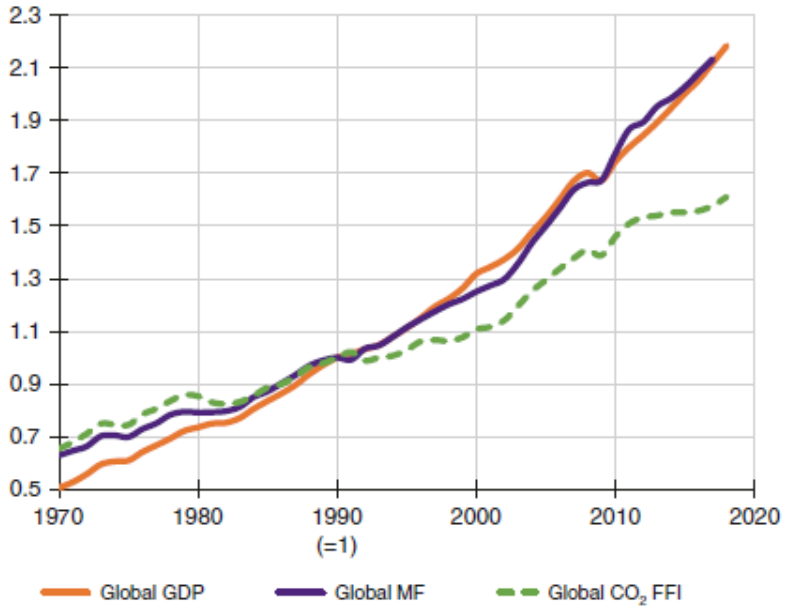

Figure 1A: Relative change in global economic and environmental indicators from 1970 to 2017 (Weidmann et al., 2020).

Advanced product service system business models (and innovation in business governance at level 3 in Figure 1) have the highest potential to overcome the conundrums outlined for green growth strategies and decoupling materials and environmental impact (improving the natural capital balance) from value creation (Stahel 2013). The business models can generate some of the highest economic surplus (improved financial capital balance), offer highest environmental integrity (improved natural capital balance), they can also and can also generate substantial regional jobs (improved social and human capital balance) - Stahel (2013). So, a green growth strategy and economic transition to consumption and production systems that align with this from of production and consumption is worth prioritising by regional policy makers. But there is a need to be aware that this type of business model often transfers the means of consumption to the producer, giving them a level of power. So, one of the challenges for an advanced services green growth models, is ensuring that consumers do not end up getting 'locked in' or paying unnecessary high prices for the services provisioned to them, so for such approaches to succeed regionally and enhance wellbeing, care needs to be taken to create a selection environment (level 4 and 1 in Figure 1) that gives consumers choice and a share of the economic benefits of such models, as well as helping overcoming barriers to these green growth models (e.g. existing norms of consumption - at L1 in Figure 1). This will be critical to just transition but also keeping social sentiment (also at L1) aligned with the green economy (an consequently election results in democracies) to deliver substantial improvements in various capital balances identified in Figure 1. One cannot underplay the importance of the latter as it shapes substantially the selection environment for green growth via levels 1 and 4 and therefore also the payoff for sustainable business model innovation at level 3 of Figure 1.

Appendix 2: Method

GHGs estimation approaches used in section 2

Data on local authority GHGs statistics are available from UK Gov 2025[106] and DESNZ (2022). These provide the data for the aggregate breakdown of GHGs for overall industry, commercial and public sector in Table 6. Domestic emissions households and transport related (rail, road and other). Land use related GHG emissions as well as those of Agriculture and Waste sectors are also provided. Flight related emissions for air transport related services are excluded in the DESNZ dataset and were not available for the region (or any region of the UK as these data are not publicly available), so a missing component of the account for the region. Due to missing regional data on emission from flights an approach to provide a conservative estimate of GHGs from outbound scheduled and charter passenger flights for the region was developed. The latter is integrated into the regional account of GHGs provided in Table 6 (we place them here under transport). Due to these new estimates being included, the percentage of GHGs attributable to transport and other aspects are a believed to provide a more accurate account for the proportion of GHGs from different parts of the West of England economy, but because of this are somewhat different in percentage than those published elsewhere (which do not take account of air transport services).

In order to inform industrial strategy, this report needed to identify the main priority GHG producing C&I and public sectors in the region as again these data were not available, and so was a weak spot in terms of data informing regional strategy. The current report applied an approach to identify the priority sectors for the region. Finally, the UK Gov 2025 (and DESNEZ 2022) do not provide any information on the total GHGs attributable (scopes 1,2 and 3) to the final demand goods and services generated by the region's sectors. This is the only way to have a full life cycle account of GHGs, without this one gets a partial view of the GHG footprint of different end goods and services demand. This is an important account to generate as sectors can significantly influence these via sustainable procurement, choice editing, working with suppliers and other strategies. It also shows the extent to which the region outsources GHGs to other regions in providing final goods and services demanded. Therefore, the report applies an estimation approach to generate an account for these missing data also.

Approach to estimating GHG emissions from flights for air transport services in the region.

The main airport of the region is Bristol Airport which handles the vast majority of all flights in the region. Data was available that identified total passenger numbers in 2022 (and other

[106] https://www.gov.uk/government/collections/uk-local-authority-and-regional-greenhouse-gas-emissions-statistics

years) as well as the top 10 destinations (Bristol Airport 2022[107]), and a breakdown of scheduled versus charter flights etc. In this study outgoing flights were deemed to be the responsibility of the West of England region, it was decided that incoming flights should not be within the jurisdiction of the West of England, but with the region from which the flight took off (so we did not attempt to estimate the latter). The study estimated the GHG emissions of outgoing scheduled and charter flights applying the following method.

For scheduled flights, the estimation approach started by estimating GHGs from the top ten destinations. The estimation approach was as follows: we took the number of outgoing passenger flights to each top ten destination from Bristol Airport's report and multiplied this by the distance to each destination (to fly to) in kilometres (km). This gave an estimate of total km travelled to service this destination from the airport. We then used the Greenhouse gas reporting: conversion factors 2024[108] data (depending on whether the flight was short haul or domestic flight) to apply the relevant emissions factor (average passenger GHG emissions per passenger km) to the total km travelled. This allowed estimation of the GHGs from these flights specified by destination in Bristol Airport (2022).

There was then the need to develop a conservative estimation approach for the remainder of both international and domestic flights not captured by the top 10 destinations. So, for these flights we took the remaining international passenger flight numbers (divided by two as we assume that these numbers included outgoing and incoming flights and we only wanted to estimate for the outgoing passenger flight[109]) and assumed that these were primarily short haul flights and so multiplied these by the 1500 km[110]. In reality not all international flights will have been short haul some may be long haul (but by estimating short haul this kept the estimate conservative). This gave an estimate of km travelled, this km number was then multiplied by the emissions factor (average passenger emissions kg CO_2e per passenger km for short haul flights) to attain an estimate of GHGs from remaining GHGs for international outgoing scheduled flights. For remaining domestic flights, the remaining outgoing domestic passenger flight numbers was multiplied by the average distance of a UK domestic flight 446km to give an estimate of km travelled. This km number was then multiplied by the emissions factor (average passenger emissions kg CO_2e per passenger km for a domestic UK flight) to attain a figure for total remaining GHGs for domestic scheduled flights. After this process we had an estimate of total GHGs of outgoing scheduled flights from the airport. All estimates of GHGs were converted into $KtCO_2e$ (to be comparable with other sector GHG accounts).

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[107] https://www.bristolairport.co.uk/media/gx2j4wab/annual-monitoring-report-2022-180923.pdf

[108] Greenhouse gas reporting: conversion factors 2024 - GOV.UK

[109] In practice there may be some flights that are one way but the vast majority of flights are likely to be return flights. So it seemed reasonable to take the approach we took as part of an estimation approach.

[110] Short haul flights are defined as less than 1500km.

Most flight from Bristol airport are scheduled flights, but there is also a significant number of charter flights. Little information is given on the specific destination of these charter flights in the Bristol Airport (2022). Therefore, we took the following approach, to generate a conservative estimate of GHGs for these passenger flights. Data on the domestic passenger numbers for charter flights was available. In reality these flights are much more GHG intensive per passenger than scheduled flights, releasing up to 14 times more CO_2 per passenger than commercial jets (Sitolpul and Rutherford, 2025). We only counted the outgoing flights, so half the number of total passenger flights identified. We then estimated GHGs attributable to these flights in the same way as we did for passengers of scheduled flights, even though we know GHGs per passenger of these flights are generally much more GHG intensive (we did this to avoid over estimation). It was hard to find official air travel GHG intensities per km for non-scheduled flights, so this was why it was assumed (that a domestic/international flight) carbon intensities were the same as scheduled flights (for which we did have available data). This is likely to have led to a substantial underestimate of GHGs from these flights, charter flights however make up a significant minority of overall flights from the airport. By estimating GHGs for these flights we captured the vast majority of outgoing flights (there are others such as position flights, flying club related but these are very minimal in overall flight terms). It is worth noting that for the full year of 2024, Bristol Airport handled approximately 10.48 million passengers in total (around 25% more that in the 2022 estimate). Given the conservative assumptions and flight growth an accurate estimation of emissions in 2024 is actually likely to be larger. The airport also has increasing flights to further away international destinations, which could also contribute towards higher estimates of GHGs in future. Given the short time to generate an estimate here, there is a need for a more detailed and in-depth analysis of these GHGs in future study, but the conservative provisional estimates here, show they are significant and growing for the region, after 2033 they will impact progress towards Net Zero officially.

Approach to estimating priority C&I and public sectors in terms of Scope 1 GHGs

The approach to generating a proxy disaggregated account for GHGs of each sector in the region, so that we can understand those sectors more important in the region in GHG terms, was as follows. Firstly, we used data from NOMIS[111] to download detailed SIC code employment data by for each sector in the region. These estimate of employment then needed an equivalent detailed GHG coefficient (GHGs per employee for the same sector). To generate the GHG coefficient we used data from DESNZ (2025)[112] that provided GHGs by each sector and divided these by detailed sector UK employment figures[113]. We then took the

[111] Dataset Selection - Query - Nomis - Official Census and Labour Market Statistics

[112]https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fassets.publishing.service.gov.uk%2Fmedia%2F685a8ea9e9509f1a908eb10d%2Ffinal-greenhouse-gas-emissions-sic-tables-2023.xlsx&wdOrigin=BROWSELINK

[113] Derived from NOMIS and other data.

detailed sector regional employment accounts and multiplied each sectors employment by the detailed GHG coefficient for that sector to estimate each sector's GHGs (scope 1) in the region. When presenting this account, we identify the top 15 sectors for the region in terms of GHGs (scope 1) and their employment (the latter gives some sense of whether reducing GHGs has potential to substantially impact regional employment).

As a rough check of these estimates, we checked estimates with actual company data that we had from the Local Industrial Decarbonisation Plan (LIDP) project which covered the West of England Industrial Cluster, to see whether similar priority sectors were coming though and that estimates were is a similar ballpark in terms of orders of magnitude. The LIPD project did not use SIC codes and did not estimate emissions from agriculture or flying, they only looked at industrial GHGs (so there prioritisation will be different from this study's), but from looking at, there top five sectors are (see Figure 2 below): 1. Energy production, 2. Waste management, 3. Manufacturing (construction), Logistics, transport and supply, Manufacturing (air and vehicles) and manufacturing (food and beverages). Comparing the estimates of this study with most similar sectors to theirs in terms of priority sectors (this study's overall estimates will be different as they cover a wider geography, services and flying) we still found that the actual top sectors were similar if we exclude air transport related services in our data. For example, their 1. Energy production (was 1 in our estimates if we ignore air transport services), 2. Waste management (3 in our dataset), 3. Manufacturing construction (2 in our dataset)), 4.Logistics , transport and supply (6 in our dataset), 5. Manufacturing air and vehicles (11th in our dataset) and 6. manufacturing food and beverages (not in our top 15 but food and beverage services was). Given that we looked at a wider variety of sectors and on a wider geographical basis you would expect some differences but certainly the top five sectors are similar in terms of priority sectors. The total LIDP emissions of the top six sectors was closed to 2,500 (kt CO_2e) emissions based on actual data collected from companies largely. The total emissions of our top sic sectors (excluding Air Trasport services) in our dataset was 3,025 ktCO_2e so similar but larger (as you would expect) as covering a larger geography and more sectors, such as residential, defence and public sector. From our estimate one sector that we think should not be in the top 15 is Public admin and defence (in terms of scope 1 GHGs) as most of the activity in the region is believed to be services related rather than heavy energy using activity, this is a quirk of using the employee multiplied by GHG coefficient method for estimating for regions, we also think our estimate for Manufacture of articles of concrete, cement and plaster is a bit high, although we are sure that it is in the top 3 priority sectors based on comparison with the LIPD data. In the latter regard, we think our estimate is an over estimate as some of the semi-finished/finished products are brought into the region and then amended somewhat before sale (so some of the businesses in this sector are not heavy manufacturers). LIDP data also shows the sector is in the top 3. So it is a priority sector..

Both estimates (ours and the LIPD estimates) are substantially higher than the estimates in the DESNZ (2025c) data for 2022 in Table 1 that estimates the total GHGs of C&I and public sector as 1,192,000 TCO_2e, even when the estimate generated here only cover scope 1 GHGs (as opposed to scope 1 and 2 in the DESNZ 2025c data for the year 2022). On this basis it is believed the published DESNZ 2025c data for 2022 are substantially underestimated for C&I and public sectors. We now provide further detail on the LIDP for readers.

Approach to estimating GHGs embodied in final demand goods and services generated by the region's sectors.

The first stage in estimating this was to estimate the final demand of the region's sectors as the research team did not have this was not available, only national final demand data relating to sectors. To estimate the total associated final demand of West of England sectors in basic prices, firstly estimated the proportion of West of England output over the same sectors UK output to indicate the representation of the UK sector in the West of England (West of England sector output/UK sector output). We then multiplied this number by the UK final demand for each sector to estimate the final demand associated with the sector in the West of England. Once a figure of final demand in £M was produced, these final demand figures were multiplied by the GHG multipliers for each relevant sector using the Defra 2022 GHG multipliers[114] to estimate the GHGs embodied in each of the West of England sectors final demand.

Generation of maps on Land-use:

The analysis draws on the Department for Levelling Up, Housing and Communities (DLUHC) 2022 Land Use dataset, combined with West of England ward boundaries to visualise how different land-use categories are distributed across the region. The DLUHC dataset classifies land into multiple developed and undeveloped categories. Here we use two of the aggregated categories in maps as well as some the more disaggregated ones. Two main aggregated categories: developed uses (for community, defence, industry, minerals, residential, transport and unknown purposes) and non-developed uses (agriculture, forest, outdoor recreation, private gardens and undeveloped land). The data are available at the ward level. For each ward, the share of total land dedicated to a given category is calculated in percentage terms and mapped using graduated colour bands to show relative concentration across the geography. Note that colour bands for each map indicate different percentages depending on the type of land use

Content analysis for climate adaptation

This analysis was conducted through a qualitative content analysis of 13 key adaptation strategy documents published by the Local Authorities in the region and by the WECA.

[114] https://www.gov.uk/government/statistics/uks-carbon-footprint

Sources included climate emergency strategies, adaptation plans, annual progress reports, and ARP4 submissions. The list of documents analysed is available in the Reference List. The document analysis focused on priority adaptation drivers, governance structures, and decision-making frameworks. Content was coded for categories such as climate hazards (flooding, heat, drought), cross-sectoral integration and decision-making frameworks, key interventions planned, and equity considerations. The analysis highlights commonalities and divergences across authorities, as well as synergies and areas where more coordination and integration would enhance local adaptation efforts.

Appendix 3: Strategies for decarbonisation of manufacturing.

Manufacturing Sector

Manufacturing represents the third-largest source of emissions nationally, responsible for 12% of total UK carbon emissions. By 2040, manufacturing emissions are projected to decline by 78% relative to current levels, with full decarbonization expected by 2050, achieved primarily through electrification complemented by CCS and hydrogen where appropriate (Climate Change Committee 2024) [115].

Industrial emissions in 2023 were 63% below 1990 levels. This substantial reduction reflects both declining production volumes in the most carbon-intensive industries (particularly steel and cement) and structural change within UK manufacturing toward lower-carbon, higher-value-added subsectors such as pharmaceuticals and aerospace. The chemicals, iron and steel subsectors remain the largest contributors to manufacturing emissions (Climate Change Committee 2024)[116].

High electricity costs relative to natural gas presents a significant barrier to manufacturing decarbonization through electrification. The UK's energy prices are among the highest in Europe, creating competitiveness concerns as manufacturers face increased costs in transitioning to net zero. Additionally, lengthy timelines for upgrading electricity grid connections constrain the pace at which industrial electrification can proceed.

Decarbonization Pathways by Manufacturing Subsector

Optimal decarbonization strategies vary substantially across manufacturing subsectors, reflecting differences in temperature requirements, process emissions, and the technical feasibility of alternative energy sources.

Subsectors with low-temperature heat demand: Food and drink, vehicle manufacturing, paper, and miscellaneous light industry have relatively low-temperature heat requirements and minimal process emissions. These characteristics make them particularly suitable for electric technologies including heat pumps, electric boilers, and direct resistance heating. Electrification is expected to contribute more than 90% of emissions reductions in these subsectors (Climate Change Committee 2024[117])

Iron and steel: This subsector will decarbonize primarily through electrification, which is projected to contribute more than 95% of abatement. The viability of electric arc furnaces for steel production using low-carbon electricity underpins this pathway (Climate Change Committee 2024).

Chemicals: The diversity of products and processes in chemicals manufacturing complicates modeling of decarbonization pathways. CCS is expected to contribute approximately 50% of

[115] p. 174.
[116] P. 174.

[117] p. 181

emissions abatement, followed by electrification (30%) and hydrogen (10%). The substantial role for CCS reflects the prevalence of process emissions that cannot be eliminated through fuel switching alone (Climate Change Committee 2024).

Glass and other minerals: The glass subsector can decarbonize through both electrification and hydrogen. The production of ceramics (bricks and tiles), which dominates the "other minerals" category, requires equipment operating at very high temperatures that are difficult to achieve through electrification. For this subsector, hydrogen emerges as the most viable decarbonization option, contributing approximately 65% of emissions reductions (Climate Change Committee 2024).

Non-road mobile machinery: This category encompasses equipment used in mining, construction, infrastructure development, and waste management. Electrification represents the primary decarbonization pathway, with electric options becoming available even for very large equipment.

Cement manufacturing: As discussed previously, cement manufacturing presents unique challenges due to the predominance of process emissions. CCS is expected to contribute approximately 60% of emissions reductions, with resource efficiency measures (20%) and bioenergy comprising the remainder (Climate Change Committee 2024).

Cross-Cutting Considerations for Manufacturing

Electrification is projected to contribute 57% of emissions reductions in manufacturing by 2040 (Climate Change Committee 2024). While manufacturing already consumes substantial electricity to power machinery and equipment, electrification of heat represents the primary frontier for further decarbonization. Electric alternatives exist for most fossil fuel-fired heating equipment used in industry, including electric boilers, ovens, furnaces, and industrial heat pumps.

Hydrogen could technically substitute for natural gas in most gas-fired industrial processes. However, it's a technology that's still under development, its relatively lower efficiency compared to direct electrification, that needs to consume green electricity to be produced, and right now the price of electricity is very high. combined with supply constraints without sufficient installations to generate and cover the demand and cost considerations, means that hydrogen is most appropriately deployed in a limited set of applications where electrification is technically challenging: specifically in chemicals, glass and other minerals, iron and steel, and non-road mobile machinery.

Bioenergy use is prioritized in subsectors where it offers the greatest benefit relative to alternative options, particularly in cement production where high-temperature heat requirements and process emissions limit other decarbonization options.

Carbon capture and storage plays a critical role in addressing process emissions that cannot be eliminated through fuel switching, particularly in chemicals and cement manufacturing. The required infrastructure is starting to be developed around big industrial hubs, one of them being the PAS hub and its Severnside Carbon Capture and Shipping Hub (7CO2).

Resource efficiency and energy efficiency reduce emissions by decreasing demand for both energy and materials. In manufacturing, energy efficiency improvements can often be implemented cost-effectively, while resource efficiency contributes to broader circular economy objectives.

Infrastructure and planning: A potential impediment to low-carbon technology deployment across all manufacturing subsectors is the pace of planning and permitting processes, which often prove slower than technology development and industrial investment cycles.

Appendix 4: Literature review of circular economy approaches for key sectors

Introduction

With analysis of the most emissions intensive sectors within the regional economy we know where emission reductions should focus. Five sectors have been selected due to their current high emissions: wholesale, waste management, construction, healthcare and agriculture. A scoping literature reviews was carried out for each sector to identify circular economy interventions that could be implemented to reduce sectoral emissions.

Wholesale

The wholesale sector includes two broad categories of products: fast moving consumer goods (FMCG) including food, beverages, cosmetics and pharmaceuticals; durable household goods including furniture, machinery; and hardware including heating equipment and plumbing.

All wholesale products have embodied emission which occur upstream in their supply chains. These embodied emissions are incurred during processes of resource extraction, material processing and manufacturing. These emissions can be significantly reduced through the integration of Industry 4.0 digital technologies such as the Internet of Things, artificial intelligence and big data analytics and the adoption of lean production practices that enable resource efficiency and reduce waste. Taking a lean production approach includes incorporating eco-design principles, dematerializing and de-energizing both production and finished products, and promoting the use of low environmental impact materials (Ciliberto et al, 2021). Four areas of intervention to leverage Industry 4.0 technologies to promote circularity in manufacturing processes are: production processes optimization, product customization, supply chain transparency and business model innovation (Dolci et al, 2024). These circular economy practices have great potential for reducing embodied emission in wholesale good but are outside of the jurisdiction of decision makers in the WoE and therefore difficult to implement. All wholesale products also include emissions from transport and logistics throughout their supply chain. These emissions can be greatly reduced by promoting the sourcing of products through local supply chains.

FMCG are products that temporarily satisfy customer needs before the remaining materials (packaging) enter waste streams. Circular business models (CBM) can be employed to address the inherent wastefulness of such goods by slowing down and closing resource cycles (Bocken et al, 2016). These CBMs promote the use of renewable and sustainable materials in the production of packaging as well as designing packaging to be reuseable and eventually recyclable (Muranko et al,

2021). Drivers of success factors for CBMs in the FMCG sector include brand and retailer partnerships, consumer participation and establishment of a product ecosystem (Bocken et al, 2022). Businesses and consumers within the WoE can promote the adoption of CBMs in FMCG through these drivers to make the sector more circular.

Durable household goods are products that satisfy consumer needs for longer periods of time. Consumers buy such goods for the service they provide; a washing machine for washing or a heating system for heating. Circular business models known broadly as 'product-as-a-service' or 'PaaS' sell the service directly to the consumer and incentivise producers to make more durable products. Remanufacturing business models could be applied to products that are already in use to ensure maximum provision of the value embedded in household goods (Spadafora & Rapaccini, 2025). These circular business models could be adopted by businesses in the WoE to promote greater utilisation of durable household goods, reducing the need to produce new products and the creation of waste.

Waste Management

The major contributions of GHG emissions from the waste management sector are from landfilling of municipal solid waste (MSW), collection and transport of waste, and the sorting of MSW (Oo et al, 2024)). Of these activities landfilling is by far the greatest emitter and can be addressed through the implementation of the 'waste hierarchy', a central principle of the circular economy. The waste hierarchy ranks waste management options based on what is best for the environment. The UK government's hierarchy includes 5 categories which are: prevention, re-use, recycling, recovery, and disposal (DEFRA, 2011). Collaboration between government, private sector and communities is essential in implementing effective waste hierarchies.

Prevention is the most environmentally friendly practice and focuses on minimizing waste production at the source through efficient resource use and sustainable consumption practices. Top of the waste hierarchy, waste prevention should be a priority for the WoE and can be achieved through increasing public awareness around the negative impacts of waste as well as responsible consumption behaviours that households and businesses can adopt. When prevention of waste is not possible reuse is the next best thing and involves extending the lifecycles of products through repair and refurbishing practices. These practices help to maintain the value of products, therefore reducing demand for new products as well as lowering the amount of waste produced. If a product cannot be reused then recycling processes turn used materials into new products, normally of a lower value. Recycling can be greatly improved through effective household sorting of waste as well as the employment of automated sorting technologies (Sesay & Fang 2025). Products that use composite or mixed materials are challenging to recycle and therefore should be used sparingly. Recovery practices should only be used when all 'higher-R' strategies are not possible. This involves either biotechnical techniques that convert organic waste into valuable resources such as energy or nutrient-rich compost, for non-biological materials energy can be recovered during incineration. At the bottom of the hierarchy is disposal which includes incineration without recovery or landfilling.

The release of methane, a potent greenhouse gas, from food waste is a major contributor to GHG emissions in the waste management sector. Strategies for managing food waste in the city of Bristol with the greatest benefits for the environment, society and the economy are (i) the reduction of food waste in consumer sectors and (ii) redistribution in the supply sectors (Parsa et al 2024). Another prominent issue in the waste sector is the management of e-waste due to the complex nature of electrical goods, toxicity of materials included in e-waste and the potential to recover valuable materials. London is progressing with a resilient e-waste management system based on awareness campaigns, recycling programs, extended producer responsibility, and landfill bans (Moradi et al 2024). These policies are great examples of sustainable waste management practices that the WoE can implement to improve circularity in the region.

Construction

There is great potential to apply circular economic principles in the construction sector and therefore reduce sectoral waste and emissions. Most importantly, building renovation should be promoted over the demolition and subsequent reconstruction of buildings. However, if buildings must be demolished then efforts can be made to recover materials for reuse and recycling. For example, there is high potential for the salvage and repurposing of timber elements from existing buildings within the UK (Godina et al 2025). Furthermore, there is great potential to apply circular business models that implement reuse and recycling in UK construction material supply chains such as gypsum, an infinitely recyclable material used in plasterboards (Mhlanga et al 2025). Unfortunately, material recovery and circularity were rarely considered when building and designing the current built environment and therefore it is a costly and labour-intensive process.

During the design phase for new buildings architects can reduce material use through spatial efficiencies by reducing floor-to-floor height and span length, as well as energy efficiencies by promoting natural ventilation, insulation and natural light within buildings (Myint et al 2025). Smart bio-based construction materials such as hempcrete and cross laminated timber provide biogenic storage of carbon in buildings in addition to reducing the demand for emission-intensive alternatives such as concrete and steel (Martin et al 2024). Automated design of prefabricated concrete elements for modular construction can optimize structural qualities of concrete when it is used (Kromoser et al 2025) as well as making material recovery easier at the end of the building's life.

Drivers of circularity within the construction sector include collaboration throughout the supply chain and the use of policies to promote the reuse of materials and create markets for secondary building materials (Martin et al 2024). Collaboration between demolition and construction partners can help to include material recovery considerations during design and construction as well as providing necessary information to inform both renovation and material recovery at current end of life.

Barriers to circularity in the sector include a lack of secondary material certification processes and markets, as well as safety concerns and related legal challenges (Martin et al 2024). Furthermore, knowledge of circular economy practices within the sector is limited and economic factors often incentivise the use of primary over secondary materials.

Healthcare

Applying circular economy in the healthcare sector is unique due to the issue of contamination. Strick regulations are in place within healthcare systems to prioritise patient welfare through contamination and infection control measures. Unfortunately, in many cases this has led to the de-prioritisation of sustainability and the creation of modern healthcare systems which are inherently resource and waste intensive (Saha et al 2025). In this context research focusses primarily on enhancing waste treatment methods and the promotion of circularity in medical product design. Most waste from healthcare systems is non-hazardous but can become mixed with hazardous waste that necessitates special treatment and disposal. Therefore, more effective segregation of waste and the use of sorting technologies are key factors to continue to minimise contamination risk whilst creating opportunities for circular treatment of non-hazardous waste streams. Circularity in medical product design includes the production of high-performance reuseable medical technologies that can withstand sterilisation processes without compromising safety or functionality. In addition, modular design can ease the separation of contaminated and non-contaminated equipment in preparation for appropriate processing.

Systemic solutions to the sustainability of the healthcare system include the prevention of ill health through preventative healthcare practices, and the increased delivery of out-of-hospital care including digitally enabled care (NHS 2024). Hospital care is especially environmentally impactful due to the use of single use personal protective equipment, hotspots in intensive care units include non-sterile gloves, isolation gowns, bed liners, surgical masks and syringes (Hunfield et al 2023). The environmental impacts of masks became a prominent issue during the Covid-19 pandemic, reuse mask options are environmentally preferable to “use-to-dispose" masks and benefits of reuseable masks increases with the number of reuses (Chai et al 2022). Interestingly inhaler use is responsible for 20% of the NHS’s greenhouse gas footprint and therefore efforts are being made to find lower-impact alternatives (NHS 2025).

Healthcare professionals determine the judicious use of single-use items and other resources making them key players in the integration of circular practices in the healthcare sector. Furthermore, the close relationship healthcare providers have with their suppliers provides opportunities for reverse logistics and associated value recovery of medical equipment. The most prominent barrier to circular economy adoption in the sector is regulatory barriers and success will hinge greatly on establishing clear regulatory frameworks that address safety concerns and are compatible with existing healthcare systems.

Agriculture

The sector addressed here includes multiple elements of the agricultural food system including the production of agricultural crops and animals for final human consumption, the processing of primary agricultural products into edible food and beverages, and the distribution and sale of food and beverages through service providers such as restaurants. Globally, trade in final agriculture products accounts for 78.3% of total agricultural emissions meaning the emissions of final products is 3.57 times that of intermediate products (Zhao et al 2023). This implies that massive reductions in agricultural emissions can be achieved by addressing demand side factors - what people eat and where they get it. The current combination of changing climate, resource shortages and geopolitical instabilities imply very real risks if populations cannot produce enough food for their population year-round. The availability of fresh, locally sourced and seasonally appropriate food is essential for a resilient food system. As well as providing a more resilient food supply chain, circular agriculture has unique potential to achieve net zero emission goals due to the huge potential of agricultural carbon

sinks. This net negative emission effect is achieved through the sequestration of carbon by plants during the process of photosynthesis and subsequent storage of carbon in flora, fauna and soils. Transforming the UK agricultural system through resilient production, smarter land use and healthier diets contributes to climate goals, health imperatives, nature recovery and food security (AFN 2025). Redesigning food systems based on circular principles has great potential to feed a population with sufficient healthy food, while reducing environmental impacts (Zanten et al 2023).

The UK population consumes too many ultra-processed foods high in fat, salt and sugar and not enough fibre, fruits, vegetables and oily fish (AFN 2025). From a circular economy perspective, the overconsumption of nutrients is wasteful. Circular food system scenarios include a dietary shift to reduce the ratio between animal and plant proteins by reducing red meat and chicken consumption whilst increasing the consumption of pulses. They also include lower production of cereals and fodder crops and relatively higher production of vegetables and fruits (Zanten et al 2023). In such scenarios the amount of land needed for agriculture is reduced and therefore more land can be made available for nature-based solutions such as rewilding, reforesting and regeneration of peatlands. These activities provide valuable services to human societies by sequestering carbon, increasing biodiversity, improving water cycling and reducing flooding risks.

On the supply side circularity should be implemented from the soil up through the adoption of regenerative agricultural practices. Three central principles include the minimization of mechanical soil disturbance, permanent organic soil coverage, and the diversification of species (Marcelino et al 2023). Zero tillage practices reduce soil disturbance leading to lower rates of soil erosion and preservation of soil organic matter. Soil coverage using cover crops maintains a protective layer of vegetation that protects the soil from extreme weather and preserves soil moisture. Diversification through the adoption of multiple crop sequences promotes good soil structure and better nutrient utilization. Although animals are reduced in circular food systems, they play an important role as recyclers, being fed inedible foodstuffs such as cover crops and agricultural byproducts as well as being used for grazing in integrated land (Zanten et al 2023) such as silvopasture where animals are grazed in woodlands. This necessitates a redesigning of livestock sectors from industrial farms to integrated livestock management.

Due to the biological nature of the agricultural sector, there are a multitude of practices that can be employed to close nutrient loops and retain value. Circular food systems require alternative organic fertilizers as substitutes for fossil fuel intensive mineral fertilisers. Agricultural waste products can be composted and applied as a fertilizer directly or fed to animals and their manure used as fertilizers, alternatively they can be used in agricultural biogas plants to produce bio-based fuels and the remaining digestate can be used as fertilizer (Burg et al 2023). Biomass from crop waste can also be converted into biochar through the process of pyrolysis. As a soil amendment biochar improves soil productivity and moisture retention as well as reducing soil emissions (Kurniawan et al 2023). Another prominent solution is the use of human excreta to return nutrients to the soil after human consumption, therefore closing agricultural nutrient cycles. However, nutrient recovery from human excreta is highly dependent on sanitation systems and risks include health hazards from pathogens and heavy metals (Zanten et al 2023).

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Appendix 5: Interview sample

Participant A	Key informant	CEO, civil society institution
Participant B	Stakeholder	CTO, low-carbon technology start-up
Participant C	Stakeholder	Public Affairs Officer, infrastructure company
Participant D	Key informant	Professor Emeritus
Participant E	Stakeholder	Carbon Reduction Expert, engineering firm
Participant F	Stakeholder	CEO, low-carbon technology start-up
Participant G	Stakeholder	Business Engagement Officer, infrastructure project
Participant H	Key informant	Former CEO, wind industry
Participant I	Stakeholder	Public Affairs Officer, low-carbon services company
Participant J	Stakeholder	Public Affairs Officer, infrastructure company
Participant K	Stakeholder	Public Affairs Officer, infrastructure company
Participant L	Stakeholder	Director, low-carbon developer
Participant M	Stakeholder	Director, engineering firm
Participant N	Stakeholder	Senior Technical Officer, Aviation Company