Building Sustainable Food Systems

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Case Studies in this section:

The Challenge

It is estimated that the climate impact of the food system is such that, even if fossil fuel emissions were eliminated immediately, a business-as-usual food sector would put the target of restricting global warming to 1.5°C, or even 2°C, out of reach[1].

Unless there are major reductions to the climate impact of the global food system, including large scale decarbonisation and landscape restoration, we are unlikely to meet the central goal of the Paris Agreement in 'holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C'[2]. The Intergovernmental Panel on Climate Change (IPCC) predicts that even if warming is restricted to 1.5°C, it would be enough to destabilise whole ecosystems and impact weather patterns[3]. This calls for urgent action from all actors across the global food system to work together to limit the impacts of global temperature rises on climate and nature systems while preparing to adapt to coming weather uncertainties to build resilient food and nature systems fit for the future.

At the South Yorkshire Sustainability Centre (SYSC), our response to the food system emergency has been two-fold; to think globally - within the sustainable development framework laid out by the UN[4] - and to work locally with partners to build knowledge and capacity within our region around how to make South Yorkshire's food system, and the landscape it resides in, more sustainable.

South Yorkshire's Natural and Food System Landscape

The Natural Capital Solutions (NCS) report states that South Yorkshire covers 1,552 km² area and has a diversity of habitats within its boundary, but is dominated by improved grassland in the west and arable land in the east (44%)[5], with lowland areas around Doncaster and Barnsley supporting much of the farming activity. Although data for the South Yorkshire region only is not publicly available, according to OS MasterMap data for South Yorkshire, the area of agricultural land is 79,269 hectares (ha). South Yorkshire is included in the Yorkshire and the Humber geographical area for the Department for Environment, Food and Rural Affairs (DEFRA) agricultural statistics, which state that in 2024 the average farm size in the Yorkshire and the Humber region was about 91 ha, slightly above the English average of 87 ha. Around 26% of farms are 100 ha or larger, with most of the agricultural land area contained in these larger holdings. Smaller farms (less than 20 ha) are less prevalent by area, though more common in number. The predominant farm types were grazing livestock (41%) and cereal (20%) and the region's total income from farming was £582 million, with the average income per farm of £50,700 (a 43% decrease from the previous year)[6].

Whilst regional agriculture contributes to the rural economy through food production and related employment, South Yorkshire's food and drink manufacturing sector is an equally important

1 Clark, M.A., Domingo, N.G.G., Colgan, K., Thakrar, S.K., Tilman, D., Lynch, J., Azevedo, I.L. and Hill, J.D. (2020). Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. Science, [online] 370(6517), pp.705–708.
2 UNFCCC (2015). Paris Agreement. United Nations.
3 IPCC (2018). Summary for Policymakers — Global Warming of 1.5°C. IPCC.
4 UNSDG (2019) UNITED NATIONS SUSTAINABLE DEVELOPMENT COOPERATION FRAMEWORK.
5 NCS (2021) South Yorkshire natural capital and biodiversity mapping.
6 DEFRA (2025) Agricultural facts: Yorkshire and the Humber region.

part of the regional food system. A report carried out on behalf of Sheffield Hallam Advanced Food Innovation Centre (AFIC) places the value of the local food and drink manufacturing industry at around £434 million, with roughly 170 businesses and about 9,000 jobs tied to food and drink production. Including agriculture, catering, retail and wholesale, the total "agri-food" sector accounts for £1.58 billion in economic output and 68,500 jobs in South Yorkshire. This represents 11.6% of all jobs[7]. The report also found the productivity of food and drink manufacturing workers matches that of key targeted sectors like advanced manufacturing and digital at approximately £65,000 per worker[8].

Furthermore, local universities including centres like Sheffield Hallam's AFIC are actively working on sustainable processing, efficiency improvements, and innovation in food manufacturing. There are also emerging efforts in controlled environment agriculture (CEA), vertical farming or glasshouse technologies, alongside urban agriculture and community growing which could enhance local production capacity, improve local food security[9], whilst also promoting sustainable land use. Collaboration between universities, urban growers and councils aims to support nature-friendly food production and strengthen local supply chains[10].

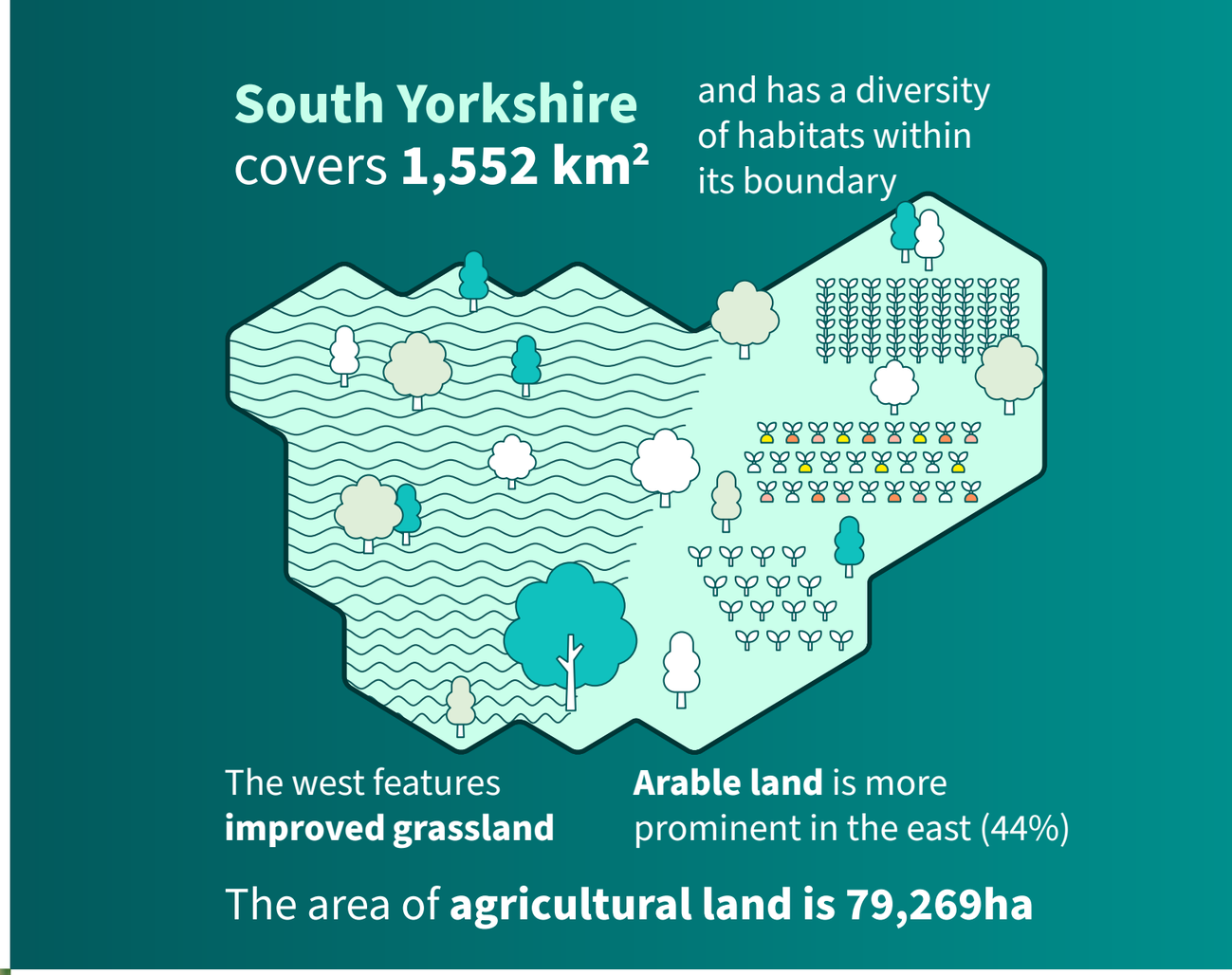
Overarching Challenges

The 2023 State of Nature report found the UK to be of the most nature-depleted countries on Earth, with significant nature and biodiversity degradation resulting in vast declines of many species of birds, plants, and insects that are crucial for keeping our habitats and ecosystems healthy[11]. According to the Green Finance Institute's analysis, the deterioration of the natural environment in the UK could lead to an estimated 12% reduction to Gross Domestic Product (GDP) in the years ahead - larger than the hit to GDP from the global financial crisis or Covid-19[12].

Outside of biodiversity loss, the UK is also facing significant soil degradation. Soils are the largest terrestrial carbon reservoirs and provide fundamental ecosystem services, including the provision of food and habitats and the regulation of water and climate[13, 14]. Soil organic matter (SOM) is a fundamental component of soils and a major determinant of soil health, containing stores of carbon and nitrogen bound together with other mineral nutrients. Soil organic carbon (SOC) makes up about 40-60% of SOM, and strongly influences the physical, chemical and biological structure and function of soils[15, 16]. The UK Centre for Ecology and Hydrology's Countryside Survey found an 11% increase in SOC on arable and horticulture land between 1978 and 2007[17]. Completed in 2007, the survey did not find an overall SOC decrease due to increase of woodland areas and improved grassland soils[18], however, the survey comprised of relatively small soil sampling (1,197 plots within 256 1km squares in 1978, 1,098 plots within 256 squares in 1998 and 2,614 plots within 591 squares

7 Food and Drink Technology (2023) South Yorkshire's hidden gem: food and drink manufacturing sector valued at £434m, reveals report.
8 Sheffield Hallam University (2023) South Yorkshire's 'overlooked' food and drink manufacturing sector worth £434m – new report.
9 South Yorkshire Sustainability Centre (n.d.) Establish South Yorkshire green infrastructure to enable delivery of the net-zero food system roadmap.
10 The University of Sheffield. (2023) South Yorkshire Sustainability Centre Launch.
11 State of Nature (2023) STATE OF NATURE 2023.

12 Green Finance Institute (2025) Assessing the Materiality of Nature-Related Financial Risks for the UK.
13 Harden, J.W., Sanderman, J. and Hugelius, G. (2017). Soils and the Carbon Cycle. International Encyclopedia of Geography, Wiley, pp.1–14.
14 Haygarth, P.M. and Ritz, K. (2009) The future of soils and land use in the UK: Soil systems for the provision of land-based ecosystem services. Land Use Policy, 26(1), pp.S187–S197.
15 Lal, R. (2016). Soil health and carbon management. Food and Energy Security, 5(4)
16 Lal, R. (2025). Soil organic matter: The heart of soil health. Journal of Soil and Water Conservation, 80(4), pp.320–326.
17 ONS (2022) Habitat extent and condition, natural capital.
18 UKCEH (2007) Soils in UKCEH Countryside Survey.



in 2007[19]) and used the Loss on Ignition (LOI) method which can estimate, but not measure, exact organic matter content. According to the Environment Agency, in 2010 soil degradation was calculated to cost £1.2 billion every year[20]. Since then to 2020, land used for organic farming, which helps to promote and restore soil health, decreased by 32%[21].

In South Yorkshire, the NCS evaluation of 91% of the region, found the majority (~57%) of the region's natural habitats to be in poor condition, due to the predominance of arable and improved grassland habitat and the extent of domestic gardens and amenity grasslands. The ecosystem services provided by the South Yorkshire's natural capital were carbon storage and sequestration, air purification, noise, local climate, water flow and water quality regulation, food production, timber production, recreation and accessible nature, with the demand focussed in the urban centres of Sheffield, Barnsley, Rotherham and Doncaster. The value of these services was estimated to be £550 million per annum, with air quality regulation (£237 million annually), recreation (£188 million annually), and physical health (£68 million annually) being particularly large. Despite this, the region is overall a net emitter of carbon at 105,300 tCO_2e per year at a cost of £8 million annually[22].

Furthermore, South Yorkshire faces the same soil degradation issues as has been observed nationally. Natural England Agricultural Land Classification (ALC), which maps agricultural land and assesses its fertility according to multiple factors, such as texture, structure, depth and chemical composition, shows that although a lot of South Yorkshire's agricultural land falls into 'good' to 'moderate' condition, there are big parcels of land rated as 'poor' or 'very poor' condition[23]. It is also important to mention, that the ALC methodology has its limitations, e.g. it only assesses the levels of soil inorganic carbon (SIC) in terms of calcium carbonate and does not measure or take into consideration SOC, thw importance of which was described previously[24].

19 UKCEH (2007) Countryside Survey: Soils report from 2007.
20 Environment Agency (2023). Summary of the state of the environment: soil.
21 ONS (2022) Habitat extent and condition, natural capital.
22 NCS (2021) South Yorkshire natural capital and biodiversity mapping.
23 Natural England (2010) Agricultural Land Classification Yorkshire and The Humber - ALC003.
24 DEFRA (2025) Agricultural Land Classification of England and Wales. Guidelines for grading the quality of agricultural land

The value of the local food and drink manufacturing industry in South Yorkshire is estimated at **£434m**

9,000 jobs and **170 businesses** are tied to food and drink production in South Yorkshire

In South Yorkshire, including agriculture, catering, retail and wholesale, the **total "agri-food" sector** accounts for

£1.58bn in economic output and **68,500 jobs**

This represents **11.6%** of all jobs

SYSC Research Response

The SYSC has worked to identify ways of addressing these challenges whilst also making the regional food system better for the people of South Yorkshire. Using local knowledge and local partnerships, our projects have a regional focus, but can offer perspectives with national relevance, with implications for local, regional and national strategies and policies.

As described previously, currently there is a very limited understanding and insufficient data on soil health nationally, with the Environment Agency claiming that more investment is needed to monitor soils effectively[25]. To address this knowledge gap in South Yorkshire, a SYSC research project is sampling and analysing soils from sites under agricultural and conservation land management to generate better insights into how different land uses influence soil carbon storage across distinct carbon pools. Across South Yorkshire farms, soils were collected from arable, long-term arable, mixed arable-pasture, long-term pasture and woodland sites, with some sites being sampled at different depths. Carbon content and bulk density of soils from both agricultural and conservation settings were measured, and SOC, black carbon and total organic carbon stocks calculated. Whilst this research project and result analysis is still ongoing, the emerging findings suggest that regardless of land use, the denser soils tend to store less carbon and that carbon decreases with depth, displaying declines in SOC between surface soils (uppermost 10 cm) and lower depths – which is a typical pattern even in healthy soils. However, this decline was less obvious on land that is under conservation land management and on one site the total organic carbon stocks were greater than the UK national average.

The research also highlights the vulnerability of surface soils to disturbances and compaction associated with unmanaged grazing, noting the importance of incorporating soil health assessments into grazing regimes for the mitigation of substantial carbon losses. With grazing farms being the predominant type in Yorkshire and the Humber, this is particularly relevant for South Yorkshire.

However, placing land under management plans, requires resources, knowledge and skills that may be inaccessible to some farmers. Whilst there is commitment in legislation to support new environmental management via the Agricultural Act (2020) and Environment Act (2021), there is

25 Environment Agency (2023). Summary of the state of the environment: soil.

Ecosystem Services in South Yorkshire

~57% of South Yorkshire's natural habitats are in poor condition

The value of ecosystem services is estimated to be £550m per annum

£237m/a
Air quality regulation

£188m/a
Recreation

£68m/a
Physical health

Despite all this, the region is a **net emitter of carbon** at **105,300** tCO_2e/a

considerable uncertainty about how policy and legislation will translate into a tangible funding regime. Although current government grants to increase productivity and manage land to benefit the environment exist via different funding streams of environmental land management (ELM) scheme, these can also be difficult to navigate and require time and know-how to apply for and administrate successfully.

Another SYSC project explored nature recovery farming in South Yorkshire, by interviewing people working in land management and farming in South Yorkshire and the Peak District National Park about their experiences of navigating the current funding and policy landscape. The research found that remaining financially viable is the most pressing concern amongst farmers and whilst many are willing to take some land out of production in order to access funding and support nature restoration, many felt driven to do this because of unstable markets for farm produce. Farmers and land managers need stable funding sources that support financial viability alongside pro-environmental interventions as well as support from trusted people and organisations to access and manage grants so that they can carry out the day to day work of producing food and ecosystem services for the region. Whilst collaboration is welcomed, there is also wariness about it leading to a loss of control over land, and decision making being transferred to the collective.

The importance of agency, the ability to participate in decision making and accessible support was also evident in SYSC research that focused specifically on micro and small scale growers in the region. The project conducted fieldwork in rural and peri-urban areas around South Yorkshire to understand the decarbonisation journeys for small growers and asked how these pathways could be designed so that they were fair-for-all. The research found that there was a need for greater inclusion in sustainability and decarbonisation policy and regulatory frameworks. Study participants noted their distinct characteristics which brought specific challenges 'due to their size'. Growers made an urgent call for a greater focus on the ways they operate, as well as on the vital role they play at ensuring a more sustainable agri-food system, and supporting the local economy.

Food Production and Manufacturing

Nature, agriculture and farming is where our food system often begins, but food production and manufacturing forms another branch of this system and has a set of its own unique challenges. South Yorkshire is a hub for food production and manufacturing, with 170 businesses including bakeries, breweries, ready-meal producers, distilleries and others. Along with its economic significance, the sector causes negative environmental impacts, with the most frequently reported impacts being high greenhouse gas (GHG) emissions and high water and energy consumption. On a national level, approximately 30.31 TWh of energy is used each year to support the industry[26]. However, this data is aggregated from multiple manufacturers of different size and type of manufacturing and lacks specificity that would help to address decarbonisation and resource efficiency challenges in South Yorkshire, especially in terms of small and medium-sized enterprises (SMEs), that form a large part of the region's economic landscape.

To properly target funding and interventions and to understand where energy, water, and emissions arise in day-to-day operations, regional policymakers and support programs require actual site-level data. This is urgently needed because SMEs are under immediate pressure to reduce expenses and emissions, but they frequently lack the information and standards necessary to support workable solutions. To address this gap in data, SYSC collected and analysed the environmental impact of products from 12 different food and drink manufacturing facilities in South Yorkshire (11 of them being SMEs), including annual energy use, water consumption, and carbon emissions. Out of approximately 170 food and drink manufacturing businesses, this study covered 7.05% of the industry population. The study found that the annual total consumption of energy of all 12 businesses was 34.63 GWh, the majority of which (32. 51 GWh) attributed to the one large manufacturer, with the remaining

26 DEFRA (2025) Food Statistics in your pocket.

contribution coming from a diverse group of SME manufacturers with lower, yet still significant, energy demands. This amounts to 7.15 tCO_2e of operational emissions per year, assuming that electricity generation follows the same grid energy mix contributions as the entirety of the Yorkshire region, as currently there is no South Yorkshire specific dataset - a limitation that the study discovered. The study also discovered a higher than the UK average reliance on natural gas in the overall energy consumption of the 12 study participants - this has important implications, as gas-fired equipment typically consumes more energy than electric alternatives. Although gas-fired equipment heats rapidly, it is generally less efficient and is associated with greater heat losses. Energy efficiency could also be improved by replacing gas-powered boilers, ovens, stoves, and steamers with renewable energy sources or by implementing heat recovery on dryers, wastewater steam, refrigeration systems, and ovens. The greater emphasis on natural gas in South Yorkshire is likely related to the kind of businesses operating and the age of the appliances. Many sites are still reliant on gas-fired systems because they were historically the most affordable option. Simultaneously, limited budget and practical concerns about switching to electric alternatives cause gas to remain the key energy resource in daily operations in this region.

The study also collected and analysed the data and energy performance from the three study participants that already implemented various measures to decarbonise and improve environmental performance, such as solar PV, aerobic food waste disposal system and a combined heat and power system, with the results described in the “From Data to Impact: Quantifying Environmental Footprint and Transforming Sustainability in South Yorkshire’s Food and Drink Manufacturing Industry” case study.

The study highlighted the importance of local, site-specific data collection and analysis, as well as barriers, such as reluctance of businesses to participate in research. There is a long-term opportunity to shift the culture and behaviour of food and drink manufacturers towards renewable resource use and energy efficiency. During SYSC’s research, many SMEs rejected participating because they were unconvinced of the benefits, lacked awareness of energy-saving opportunities, and faced practical barriers, including limited expertise, insufficient time, and a lack of internal capacity or resources to collect data and undertake energy-efficiency tasks. By actively engaging with the industrial community and continuing to collect data to encourage energy efficiency, this work prompts factories to check in on their energy and encourages integrating decarbonisation into supply chains, which can shift cultural assumptions about sustainability in food production.

The Case for a South Yorkshire Food Network

The key question is how can the region tackle these challenges whilst also benefitting from the opportunities available in a way that is fair for all of the region’s residents? It is clear that the food system is highly complex, nature recovery and conservation, farming and food production and manufacturing, health, education, economy and social wellbeing are intertwined. Trying to detangle and address only one of these strands risks incurring damage to others and thus a unified, holistic approach is needed.

Despite the vital work of local food partnerships in each of the four local authorities, South Yorkshire currently lacks a unified regional food network that brings together large-scale producers, small businesses, and community groups, allowing them to speak with a common voice on key issues of mutual concern.

SYSC’s South Yorkshire Food Network feasibility project aimed to address these issues whilst building on previous work on public procurement in Sheffield, that showed how the city’s ‘anchor institutions’ such as hospitals, schools and colleges could improve the health and sustainability of the food they serve to the public by increasing their purchasing from local small- and medium-sized producers.

The South Yorkshire Food Network feasibility project explored the idea of extending this work to a regional scale, evaluating the prospects of establishing a regional food network that could bring together key food system actors from across South Yorkshire. The study included a survey of 56 local businesses, policymakers and civil society organizations from all four local authorities in the South Yorkshire region. The survey demonstrated strong support for a regional food network, with high levels of perceived value, openness to change and depth of commitment. This vision was shared across all geographies and sectors.

While confirming their strong support for this initiative, participants expressed the importance of transparent governance and accountability, focusing on practical outcomes and actionable objectives. Respondents wanted a function that added value to local initiatives and avoided duplicating what already exists, emphasising that there should be a clarity of purpose with a focus on tangible benefits.

This multi-partner approach is ambitious and challenging, it is difficult to build coherent shared goals and objectives with tangible outputs and outcomes where partners have different competing priorities, pressures and resources available. However, another SYSC project, the Urban Agriculture Task Force (UATF), demonstrates how this can be achieved and the value it could have for

the region. The Task Force, which initially focused on the Gleadless Valley ward, and then the wider South Sheffield Local Area, aimed to contribute to a food system that is both socially just and environmentally sustainable, while demonstrating methods that can be replicated elsewhere in the region.

A core feature of the UATF's approach has been to work across nested governance structures: beginning at neighbourhood level, and building outward to wards, Local Area Committees, the local authority, regional networks, and national campaigns. This has allowed the UATF to develop a grounded understanding of local issues, identify systemic gaps, and design interventions that can be strategically scaled.

The UATF has also prioritised a multidisciplinary and multi-partner approach, combining practical farming, landscape design, education, research, and policy advocacy. By connecting community groups, public institutions, and academic research, the UATF has acted as a connector and enabler, bringing coherence to a fragmented food system and working towards the shared goal of a sustainable, fairer, and more accessible food system.

The UATF work programme revolved around 3 clusters:

1. **Developing a layered approach to urban horticulture, linking research, policy advocacy, infrastructure reuse, and hands-on design.** This involved mapping Sheffield's existing growing spaces, assessing socio-economic dynamics, and identifying new opportunities for food-growing using Geographical Information Systems (GIS); contributing to the national Right to Grow campaign, led by Incredible Edible; responding to the Sheffield Local Plan consultation noting equitable food access as a core component of good landscape design and management policy; supporting the Growing and Composting Working Group and playing a key role in helping the social enterprise Food Works to secure the lease for Norton Nurseries - the only large-scale glasshouse site in Sheffield and thus helping to bring underutilised infrastructure back into productive use.

2. **Focusing on education, training, and the cultivation of food system literacy across age groups and professions.** The UATF hosted a month-long Social Accountability Placement for four medical students from the University of Sheffield; worked with Year 6 SEN pupils from Woodlands Primary School on a bespoke farm-based education programme; members of the UATF have become approved practitioners to the national Climate Ambassadors scheme which connects climate and environmental sustainability volunteers with nurseries, schools and colleges across the UK.

3. **Connecting urban neighbourhoods with peri-urban farms, demonstrating the value of a joined-up landscape approach.** The UATF has contributed extensively to the Gleadless Valley regeneration programme, advocating for the integration of agroecological urbanism and nature-based solutions as well as supporting smaller interventions such as a raised herb and wildflower bed at the Gaunt Shopping Precinct in Sheffield.

By working through nested governance structures, the UATF has shown how local initiatives can inform ward-level, city-level, regional, and even national strategies. This offers a practical alternative to "bigger is better" models, and aligns the findings of international research on food system transformation.

Taken together, the projects featured in the case studies supporting this Building Sustainable Food Systems narrative provide a vision for the future. The UATF demonstrates concrete and scalable steps to support this vision for the region - where communities in rural, peri-urban and urban spaces are happy, prosperous and healthy. Everyone has access to food sufficient for nourishment and personal taste, with excess food redistributed rather than wasted. The whole regional food system is decarbonised, from on-farm production to distribution to food processing and manufacturing.

A vibrant, robust and sustainable local food economy is flourishing, attracting inward investment from innovative green businesses. A sustainable regional food system is helping to regenerate the landscape, working together with nature, and bringing benefits to human health and wellbeing for every resident in South Yorkshire.

Building Sustainable Food Systems Recommendations for Regional Policymakers

1. Local policymakers should use the delivery of the Local Nature Recovery Strategy to allocate funding for a **'One-Stop-Shop', delivered through trusted partners, for farmers and growers that aims to enable successful engagement with nature friendly farming grants and subsidies.** SYSC research shows that practical support is needed to access and administer grants that reward environmental action, as well as advice, knowledge sharing and advocacy to support farmers and growers to maintain financial viability alongside environmental action i.e. supporting new entrants into the sector through the creative use of land leasing and tenancies.

    i. Nature Recovery Farming: Supporting Regional Landscape Scale Resilience.

2. Local policymakers should recognise the importance of soil health, as well as other ecosystem services, for building landscape scale resilience and regional prosperity in South Yorkshire. **As part of the Local Nature Recovery Strategy delivery, local policymakers should initiate a South Yorkshire Resilient Landscapes programme that aims to build resilience through nature recovery** by bringing together key regional stakeholders through research, knowledge sharing events and collaborative projects. This should include coordination with existing alliances such as Connected by Water.

    i. Soil Carbon Storage Across South Yorkshire: Understanding Soil Carbon Stocks Across Pools in the Context of Agricultural and Conservation Land Management.

3. **Support electrification and efficiency in the food processing and manufacturing industry:** Policymakers should consider ways of providing financial and business change support to food processors and manufacturers to replace gas-powered equipment (boilers, ovens, steamers) with renewable energy sources or implement heat recovery systems on dryers and refrigeration units.

4. **Local policymakers should commit resources to set-up and service a South Yorkshire regional food network** that aims to establish a "common voice" for the regional food system, providing a space for innovation, confronting shared challenges (i.e. funding and policy gaps), knowledge exchange and mutual support. Research on horticultural SMEs suggests that sub-groups could be effective in addressing specific needs of different types of actors within the network.

    i. South Yorkshire Food Network Feasibility Study.

5. **Local authorities should adopt a "Right to Grow" model,** replacing a permissions-based with a rights-based model for land access. This would allow community groups to apply for licenses to utilise underused council assets for food production (e.g. land, glasshouses, public spaces).

    i. Urban Agriculture Task Force: Building a Just and Sustainable Food System in Sheffield.

6. Public sector landowners should **support peri-urban agroecological clusters to establish viable businesses** by providing secure land tenure, providing or facilitating investment in infrastructure, and supporting the set-up of public procurement contracts.

    i. Urban Agriculture Task Force: Building a Just and Sustainable Food System in Sheffield.

7. **Integrate food into regional health strategies, recognising the critical role it plays in public health:** Embed food-growing and food education initiatives into broader health, climate, and greenspace strategies to address health inequalities in deprived areas such as the Gleadless Valley.

    i. Urban Agriculture Task Force: Building a Just and Sustainable Food System in Sheffield.

Further Research Opportunities

Sustainable agriculture: Further research could consider how we can effectively incentivise and compensate farmers and land managers to deliver valuable ecosystem services such as biodiversity restoration, natural flood management, and carbon storage.

Landscape Resilience: Collaborative research is needed to determine how landscape scale resilience can be effectively monitored and evaluated, which should include exploration of the metrics and indicators that would satisfy the demands of environmental, social and economic resilience for our region.

Landscape Resilience: Collaborative research needed to determine how effective collaboration can be fostered between different actors within the farming and land management sector in order to deliver regional landscape resilience.

Soil health: More research is needed to determine how quickly organic carbon stocks in disturbed/compacted soil recover through restorative measures i.e. through well-managed conservation grazing or appropriate agricultural management practices.

Soil health: Further research could explore how effective conservation grazing is at enhancing and maintaining high-quality soil organic carbon stocks in South Yorkshire grasslands.

Food Processing & Manufacturing Processing: Work with businesses to identify which production stages are most energy intensive and strategies to improve efficiency and implement alternative low carbon technologies.

Horticultural SME decarbonisation: Further research could bring together policy-makers, SMEs, and stakeholder organisations to build relationships and start the process of co-creating a net zero transition plan for the sector.

Urban Agriculture Task Force: Building a Just and Sustainable Food System in Sheffield

Project team:
Regather: Gareth Roberts, Alice Farmery, Fran Halsall
University of Sheffield: Prof. Jill Edmondson, Prof. Peter Jackson

Project team:
Gleadless Valley Wildlife Trust, Incredible Edible, Food Works, ShefFood, Sheffield City Council, schools, GP medical centres, and community groups

Challenge and Response

South Yorkshire's food system faces a familiar set of challenges that mirror wider national trends: insecure land tenure, underutilised assets, fragmented governance, diet-related health inequalities, and a lack of consistent policy support for sustainable local food production. In Sheffield, these challenges are felt acutely in areas such as Gleadless Valley, where health inequalities, food poverty, and limited access to appropriate green space intersect.

The Urban Agriculture Task Force (UATF) was created to interrogate and intervene in this system, focusing initially on the Gleadless Valley ward, and the wider South Sheffield Local Area. The Task Force's aim is to contribute to a food system that is both socially just and environmentally sustainable, while demonstrating methods that can be replicated elsewhere in the region.

A core feature of the UATF's approach has been to work across nested governance structures: beginning at neighbourhood level, and building outward to wards, Local Area Committees, the local authority, regional networks, and national campaigns. This has allowed the UATF to develop a grounded understanding of local issues, identify systemic gaps, and design interventions that can be strategically scaled.

The UATF has also prioritised a multidisciplinary and multi-partner approach, combining practical farming, landscape design, education, research, and policy advocacy. By connecting community groups, public institutions, and academic research, the UATF has acted as a connector and enabler, bringing coherence to a fragmented food system and working towards the shared goal of a sustainable, fairer, and more accessible food system.

Findings and Potential Impacts

The work of the UATF can be grouped into three achievement clusters, each of which demonstrates progress at different scales of intervention.

Cluster 1: Urban Horticulture – Evidence, Policy, Infrastructure, and Design

A major contribution of the UATF has been to develop a layered approach to urban horticulture, linking research, policy advocacy, infrastructure reuse, and hands-on design.

- Urban Horticulture Mapping Project: In partnership with Jill Edmondson at the University of Sheffield, UATF researchers mapped Sheffield's existing growing spaces, assessed socio-economic dynamics, and identified new opportunities for food-growing using Geographical Information Systems (GIS). While the research highlighted the potential for expansion, it also revealed systemic barriers: lack of secure land tenure, inadequate funding, limited training opportunities, and insufficient policy support.

- Right to Grow Campaign: Building on this foundation, the UATF contributed to the national Right to Grow campaign, led by Incredible Edible. Working with local authorities in Sheffield, Hull, Leeds, and Liverpool, the project explored pathways to move from a permissions-based to a rights-based model of access to land for food growing. This work has seeded practical conversations with councils about embedding food growing into health, climate, and greenspace strategies.

- Sheffield Local Plan: The UATF responded to the Sheffield Local Plan consultation, noting each instance where food growing was omitted from greenspace, urban renewal and housing development proposals, and suggesting new phrasing that positions equitable food access as a core component of good landscape design and management policy.

- Norton Nurseries: The UATF also played a key role in bringing underutilised infrastructure back into productive use. After years of advocacy, Sheffield City Council tendered the lease of Norton Nurseries, the city's only large-scale glasshouse site (1,650 m^2). In 2024, the social enterprise Food Works successfully secured the lease and began transforming the site into a hub for community food production, volunteer training, and sustainable catering.

- Growing and Composting Working Group: Supported by the UATF, this ShefFood working group provides a platform for growers, community groups, and researchers to collaborate on scaling agroecological food production and composting in Sheffield. Early meetings in 2025 built momentum on land access and circular waste systems, fostering new partnerships, policy engagement, and knowledge-sharing. The model offers strong potential for replication across South Yorkshire.

- Landscape Design and Installation Projects: Complementing these systemic interventions, the UATF has also designed and implemented a range of smaller-scale projects: orchards and sensory gardens at schools, edible beds at GP medical centres, raised planters in public spaces, and green infrastructure in regeneration schemes. These projects show how food-growing can be embedded into everyday community environments, linking education, health, and neighbourhood renewal.

Taken together, these initiatives show how research evidence, policy advocacy, infrastructure recovery, and practical design can be integrated to build a supportive environment for urban horticulture.

Cluster 2: Education & Training – Building Food System Literacy

A second strand of UATF's work has focused on education, training, and the cultivation of food system literacy across age groups and professions.

- Medical Student Placement: In 2024, the UATF hosted a month-long Social Accountability Placement for four medical students from the University of Sheffield. Students were immersed in local food system challenges in Gleadless Valley, contributing to projects at Regather Farm, S6 Foodbank, and Gleadless Valley Wildlife Trust. A Community Needs Assessment undertaken by the students generated new data on barriers to healthy eating and access to green space. The placement deepened the students' understanding of the social determinants of health and the role of food systems, while building practical skills in community engagement and interdisciplinary collaboration.

- Woodlands School Farm Education Pilot Project: Also in 2024, the UATF worked with Year 6 SEN pupils from Woodlands Primary School on a bespoke farm-based education programme at Regather Farm. Over two months, students participated in food-growing, habitat creation, and creative activities. Teachers reported remarkable gains in confidence, teamwork, and problem-solving, while families observed positive changes at home. The project culminated in a celebratory farm picnic, underscoring the value of hands-on, nature-based education. This programme has been repeated in 2025, and will continue in the future supported by DEFRA subsidy.

- Climate Ambassadors: Members of the UATF have become approved practitioners to the national Climate Ambassadors scheme which connects climate and environmental sustainability volunteers with nurseries, schools and colleges across the UK. The UATF participated in the Good Life Schools Summit (June 2025), and advice has been offered and/or workshops delivered at the following schools: Newfield School, Woodlands School, King Egbert's Secondary, Anns Grove Primary & Arbourthorne Primary.

- School and Community Designs: Complementing these programmes, the UATF has developed orchards, sensory gardens,

and edible beds in school grounds and public spaces. These projects provide outdoor classrooms for environmental learning, while supporting children and communities to connect with food and nature.

This cluster demonstrates how the UATF contributes to a lifelong learning pathway - from primary school children, to university students, to professional training - embedding sustainability, health, and food awareness into education at multiple levels.

Cluster 3: Connected Landscape – Neighbourhood to Peri-Urban Integration

The third cluster of activity has focused on connecting urban neighbourhoods with peri-urban farms, demonstrating the value of a joined-up landscape approach.

- Gleadless Valley Landscape Strategy: The UATF has contributed extensively to the Gleadless Valley regeneration programme, advocating for the integration of agroecological urbanism and nature-based solutions. Proposals include community orchards, composting sites, rain gardens, swales, wetlands, and green travel corridors. The newly acquired Regather site at 181 Blackstock Road will act as an anchor hub for coordinating these initiatives, linking food, nature, and community wellbeing.
- Moss Valley Cluster: Adjacent to Gleadless Valley, the Moss Valley is home to a cluster of agroecological enterprises, including Regather Farm, Moss Valley Market Garden and Sheffield Organic Growers, contributing to South Yorkshire's nature friendly farms, smallholdings and community gardens and allotments cultivate nearly 40 hectares, employ nearly 100 staff with a collective turnover of £8m, engage nearly 2,000 volunteers contributing 200,000 volunteer hours and support over 1,000 vulnerable people annually. They provide a working demonstration of how peri-urban agroecology can support local economies, health, and biodiversity.
- Food Growing in the Public Realm: Smaller interventions, such as a raised herb and wildflower bed at the Gaunt Shopping Precinct, illustrate how edible landscapes can be woven into regeneration schemes, making sustainable food visible and accessible in everyday spaces.

By linking neighbourhood initiatives with peri-urban farming, the UATF has developed a model for a resilient, regenerative city-countryside partnership, where local production, ecological restoration, and community wellbeing reinforce one another.

Scaling and Governance Insights

A cross-cutting theme of UATF's work is the question of scale. Traditional models of "scaling up" risk diluting the local connections and values that underpin food system transformation. The UATF has instead explored the potential of:

- Scaling out: replicating successful approaches in different localities.
- Deep scaling: embedding changes in cultural norms, behaviours, and institutional practices.

By working through nested governance structures, the UATF has shown how local initiatives can inform ward-level, city-level, regional, and even national strategies. This offers a practical alternative to "bigger is better" models, and aligns with international research on food system transformation[1, 2].

Recommendations

Based on the evidence and experience of the UATF, the following recommendations are made to policymakers:

1. Embed rights-based access to land for community food growing in planning and governance frameworks.
2. Audit and repurpose underutilised assets (e.g. land, glasshouses, public spaces) for food production through community or social enterprise leases.
3. Integrate food and farming education into school curricula, medical training, and health/social prescribing pathways.
4. Support peri-urban agroecological clusters with secure land tenure, investment in infrastructure, and public procurement contracts.
5. Adopt nested governance structures for food system policy, ensuring neighbourhood-level insights shape regional and national strategies.

Next Steps

The next stage of this work will be delivered through the INNATURE project (2025–2029), which represents a four-year continuation and expansion of the UATF's mission. INNATURE will:

- Establish eco-social hubs (such as 181 Blackstock Road) to anchor neighbourhood action.
- Deliver landscape connector demonstrators, linking urban regeneration sites with peri-urban farms.
- Scale education programmes into structured, accredited pathways for schools, universities, and professionals.
- Develop monitoring frameworks to evidence impacts on health, biodiversity, and economic resilience.

Through INNATURE, the work of the UATF will move from a series of pilots and prototypes to a connected regional model for just and sustainable food systems.

1 Connelly, S. & Beckie, M., 2016. Scaling up food system governance: From local to global. Agriculture and Human Values, 33(3), pp.501–514.
2 Friedmann, H., 2007. Scaling up: Bringing public institutions and food service corporations into the project for a local, sustainable food system in Ontario. Agriculture and Human Values, 24(3), pp.389–398.

A Just Transition for Small and Medium Enterprises: The Case of Small-Scale Horticulture Growers in South Yorkshire Area

Project team:
Sheffield Hallam University: Elpida Apostolopoulou, Prof. Will Eadson, Dr Caroline Linhares

Challenge and Response

Horticulture is a branch of agriculture that encompasses the growing of fresh fruit, vegetables and ornamental plants. Decarbonising horticulture is a fundamental element towards achieving net-zero futures, since it is an energy dense and vulnerable to climate change sector[1, 2]. Embedding Small and Medium Enterprises (SMEs) on the decarbonisation agenda, is also important, as smallholder agriculture accounts for over 80% of global agriculture - including horticulture[3] - and play a vital role in providing locally produced food, supporting local economies and sustaining sustainable livelihoods[4]. According to ONS data[5] in the UK, fruit, vegetable and flower businesses are predominantly SMEs; while according to the Horticulture Trades Association[6] over 90% of environmental horticulture businesses are also SMEs.

However, net-zero/sustainability transitions create a plethora of socio-economic and spatial inequalities, and fairness concerns are constantly raised for smaller actors, across different geographies[7, 8]. Nevertheless, very scarce research has previously focused on how horticultural SMEs are positioned within decarbonisation pathways and just transition frameworks; leaving a significant gap around justice considerations in this sector.

This PhD study aims at uncovering the just agri-food transition narrative through the lens of SMEs, and more specifically small and medium horticulture growers. For this study, we define small and medium horticulture growers, in line with the EU recommendation for SMEs i.e. employing <250 persons and having an annual turnover ≤€50 million[9]. Drawing upon empirical findings from our fieldwork in rural and peri-urban areas around South Yorkshire we develop an in-depth understanding on both what decarbonisation entails for small-scale growers, and also on how it can be designed in a fair-for-all manner. Focusing on the South Yorkshire Area specifically and building upon the existing community growing culture and rising number of agro-ecological market gardens[10], we further explore the opportunity for promoting horticulture food production in urban areas[11], simultaneously uncovering the potential for revitalising South Yorkshire's post-industrial landscape.

Via in-depth semi-structured interviews we: (i) shed light to the growers' vulnerability to climate change and current climate and decarbonisation action, (ii) uncover the transition-induced opportunities and challenges for smaller growers, and (iii) explore their visions of a just transition.

Through this qualitative research, we aspired to create a space of empowerment for the under-researched and under-represented groups, where they can share their perspectives and have their voices heard. Via re-thinking the just agri-food transition narrative, we position small-scale growers and local communities, at the epicentre of the net-zero transformation. This provides a creative pathway towards designing a resilient, equitable, and sustainable agri-food system.
In order to provide a broader spectrum on the just transition planning process, we have also conducted additional interviews with specialists across Regional Authorities and City Councils, as well as local stakeholder organisations.

1 Wentworth, J., & Bradshaw, S. (2023, October 30). Future of horticulture (POST PN 0707). UK Parliament POST.
2 EHG (2024). Mission green growth: A strategic plan. Environmental Horticulture Group.
3 Lowder, S. K., Sánchez, M. V., & Bertini, R. (2021). Which farms feed the world and has farmland become more concentrated?. World Development, 142, 105455.
4 Woodhill, J., Hasnain, S., & Griffith, A. (2020). What future for small-scale agriculture. Environmental Change Institute, University of Oxford: Oxford, UK.
5 ONS (2025). Enterprises in agriculture by region, employment size and turnover size for 2022, 2023 and 2024.
6 Horticultural Trades Association (2025) Written submission (SBS0083) to the Business and Trade Select Committee inquiry on the Small Business Strategy. UK Parliament.
7 Newell, P., & Mulvaney, D. (2013). The political economy of the 'just transition'. The geographical journal, 179(2), 132-140.
8 Sovacool, B. K. (2021) Who are the victims of low-carbon transitions? Towards a political ecology of climate change mitigation. Energy research & social science, 73, 101916.
9 European Commission (2003) Commission Recommendation 2003/361/EC concerning the definition of micro, small and medium-sized enterprises, Official Journal of the European Union L124.
10 Halsall, F., Roberts, G., Graham, K., & Logan, R. (2021). Farming Sheffield's Fringe: The potential of food growing and farming on peri-urban land around Sheffield. ShefFood / Shared Assets / Sustain.
11 Edmondson, J. L., Cunningham, H., Densley Tingley, D. O., Dobson, M. C., Grafius, D. R., Leake, J. R., McHugh, N., Nickles, J., Phoenix, G. K., Ryan, A. J., Stovin, V., Taylor Buck, N., Warren, P. H., & Cameron, D. D. (2020) The hidden potential of urban horticulture. Nature Food, 1(3), 155–159.

Findings and Potential Impacts

Whilst data analysis is still in progress, below is a summary of key findings emerging from our research:

- **Vulnerability to climate change and adaptation:** Growers have expressed their concerns over the impact of unpredictable weather patterns on crop yields - as most of them are growing outdoors - which they see as an important challenge in their efforts to adopt more sustainable practices, whilst also building adaptation and resilience.

- **Feelings towards net-zero:** Growers' feelings and attitude towards decarbonisation vary. Decarbonisation is perceived as a major challenge for growers who lack the necessary resources and technical know-how; thus, triggering reluctance and problematisation. In other cases, growers feel more optimistic and feel that the net-zero transition is an opportunity to move towards a more sustainable operation, focusing on a more conscious use of natural resources, ensuring more equitable benefits for the planet and the people.

- **Identities of small-scale:** Operating at a micro and small-scale, growers talk about their distinct characteristics, but also highlight numerous challenges that they are currently facing due to their size. Growers make an urgent call for a greater focus on the ways they operate, as well as on the vital role they play at ensuring a more sustainable agri-food system, and supporting the local economy. Growers also share a strong desire for greater accessibility and representation in the decision-making processes, as well as a greater inclusion in policy and regulatory frameworks related to sustainability, climate action and decarbonisation.

This research holds significant potential for scaling, by embedding different types of SMEs of the horticulture sector, such as processors, distributors, and retailers. Expanding the research to these actors will allow for a more holistic understanding of the opportunities and the challenges posed by decarbonisation across the horticulture supply chain, also providing a more solid foundation for an appropriate design of a just transition of the sector. Using a comparative case study approach allows the research to generate insights that can inform policymakers and foster more targeted interventions, whilst also enabling the replication of successful strategies across sectors and regions.

Recommendations

A key recommendation involves the development of tailored policies for horticulture SME growers. To support small-scale horticulture businesses in the transition toward low-carbon and sustainable practices, policies need to be specifically designed to address their unique needs. This might include financial support, such as grants and incentives for adopting low-carbon technologies, as well as guidance on the range of decarbonisation options that are available for fruit-vegetable growers and flower farmers operating at a smaller or micro scale. Implementation should involve tailored funding schemes, advisory services, and capacity-building programmes, which take into consideration the sector, scale, and business models of small growers; all of which at the moment are highly underserved by existing policy and regulatory frameworks. By providing this targeted support, small-scale horticulture businesses would be able to adopt sustainable practices more easily and without facing financial constraints, facilitating in this way the transition towards net-zero, whilst also fostering more equitable and achievable outcomes for SMEs, which are vital actors in the agri-food system.

A second recommendation revolves around the promotion of shared learning and the creation of collaboration networks within the horticulture community, in the form of peer-to-peer learning initiatives, information-sharing platforms, and structured networks that enable small growers to exchange knowledge on sustainable growing practices and low-carbon strategies. Facilitation of local collaboration networks - led by SMEs, and supported by the Local Councils - can aid growers to share insights, experiences, and practical solutions, fostering a sense of community, and reducing isolation. These collaborative spaces will not only enhance the collective capacity of small-scale growers to transition effectively but will also provide a supportive environment that encourages innovation and continuous improvement. This will ultimately strengthen the sector's resilience and contribution to a just and sustainable agri-food system for all.

Next Steps

In order to maximise the impact of this research, next steps need to involve the replication and expansion of the study. On this note it is important to highlight that this study has already been expanded to include the Western Greece Region. The City of Patras, which is the capital of the Region, was strategically chosen as it is also a post-industrial area and provides a robust comparative case study that will allow to extrapolate shared lessons, whilst also enhancing relevance and transferability findings.

The follow up will include data analysis and exploration of emerging findings, in order to initiate a comparative discussion and uncover lessons learned in different geographical settings. This will allow for a more in-depth understanding of small-scale growers' experiences across different regions, but will also provide a more robust foundation towards planning for a just transition.

A final step includes engaging stakeholders, through participatory approaches. In this study, we have targeted and conducted research with different groups of participants, separately. Future research should seek to take a further step towards bringing together policymakers, SMEs, and stakeholder organisations, in order to establish direct lines of communication, promote engagement, and enhance co-creation in the net-zero transition planning. Co-creation will foster a truly equitable decarbonisation, by equally taking into consideration the views of all actors involved, and by promoting a green regional transition, built upon sustainability and solidarity.

South Yorkshire Food Network Feasibility Study

Project team:
Sheffield Hallam University: Amanda Johnston, Dr Drew Woodhouse, Dr Saumya Kaushik

University of Sheffield: Prof. Peter Jackson

Challenge and Response

The South Yorkshire food sector makes a significant but often overlooked contribution to the regional economy. Food and drink is the UK's largest manufacturing industry, contributing more to the economy than automotive and aerospace combined. In South Yorkshire, the sector employs 9,000 people across 170 businesses and generates £434 million in Gross Value Added (GVA)[1], making it second only to advanced manufacturing. Barnsley leads the region in both employment and business density, while Sheffield's high proportion of micro-businesses offers substantial growth potential. Regionally, food and drink manufacturing is expanding faster than sectors such as digital, advanced manufacturing, health, and low-carbon, highlighting its strategic significance[2]. Nationally, the food sector is also critical in facing up to the current challenges around climate change (accounting for around one-third of the region's greenhouse gas (GHG) emissions[3]), public health, environmental sustainability and biodiversity loss.

Taking a "food systems" approach highlights the inter-connections between these issues and the importance of addressing them in an integrated and interdisciplinary way.

Despite the vital work of local food partnerships in each of the four local authorities, South Yorkshire currently lacks a unified regional food network that brings together large-scale producers, small businesses, and community groups, allowing them to speak with a common voice on key issues of mutual concern.

This project builds on previous work on public procurement in Sheffield which led to the publication of Feeding the Future[4], showing how the city's "anchor institutions" such as hospitals, schools and colleges could improve the health and sustainability of the food they serve to the public by increasing their purchasing from local small- and medium-sized producers.

The present project explored the feasibility of extending our previous Sheffield work to a regional scale, focusing specifically on the prospects for developing a regional food network, bringing together key food system actors from across South Yorkshire. The study included a survey of 56 local businesses, policymakers and civil society organizations from all four local authorities in the South Yorkshire Mayoral Combined Authority (SYMCA) region. The survey demonstrated strong support for a regional food network, with high levels of perceived value, openness to change and depth of commitment. This vision was shared across all geographies and sectors. Four clusters were identified among the survey respondents: champions, pragmatists, as-yet-unconvinced, and critics (the latter representing less than 3% of respondents). The results show a high degree of consensus on the need for a regional food network and suggest how different groups might be targeted to secure their further engagement in the process.

Our quantitative analysis of the survey data was followed up by 22 in-depth interviews, allowing us to probe respondents' views in more depth and detail. The interview data suggested a range of key areas that were of concern to our participants:

1. The current food system presents significant challenges to all stakeholder groups, including policy gaps and competing priorities; access to funding; resource and capacity constraints; and specific challenges for small businesses and struggling communities.

2. The legacy of the COVID pandemic has resulted in cash flow issues for small businesses as well as supply issues for charities and food retailers.

3. The vision for a food network shared by stakeholders prioritises people-centred challenges (health, equity, food security), with systemic and growth-focused priorities (sustainability, economic development) being secondary but still integral to the food system vision.

4. Stakeholders see the value of a regional Food Network as a cohesive, adaptive, and action-oriented platform for collaboration, knowledge sharing, and systemic change. However, success is contingent on overcoming practical, financial, and perceptual barriers, including stakeholder trust, resource allocation, and ensuring tangible impacts.

5. Respondents point to the fact that collective

1 Economic Analysis of the South Yorkshire Food and Drink Sector, A final report to the National Centre of Excellence for Food Engineering at Sheffield Hallam University, KADA, June 2023. Available upon request.
2 Ibid.
3 WRAP(2026)Tracking UK food system greenhouse gas emissions: 2015-2023 UK Food system GHG Emissions model 2015-2023.
4 Boys, J. and Benstead, S. (2025) Feeding the Future. Centre for Local Economic Strategies.

action is essential to address regional food system challenges. Knowledge-sharing, networking, and collaboration are seen as core enablers, while equitable representation, strategic prioritisation, and resource coordination strengthen the network's potential impact. Funding and the ability to be heard are key levers to turn collective intent into tangible outcomes, ensuring the network achieves meaningful change rather than isolated or fragmented efforts.

6. Shaping an effective regional food network is not just about convening stakeholders; it requires strategically assembling the right people, structuring governance, facilitating meaningful interactions, and embedding feedback loops. The network's credibility and sustainability will rely on the interplay between these dimensions; ensuring it is inclusive, practical, and capable of translating dialogue into action.

7. Stakeholders are willing to contribute time, expertise, and resources to the food network, but only if it delivers clear value. Engagement is driven by relevance, collaboration, and tangible outcomes, while limited capacity - especially for smaller organisations - makes clarity of purpose essential. Participation is therefore conditional: the network must be action-oriented and impactful rather than a "talking shop".

8. Understanding past experiences - both successes and failures - is critical for designing a resilient, effective, and inclusive regional food network.

9. A successful regional food network requires clarity, inclusivity, action-oriented design, and strong connections with both local participants and regional structures.

While confirming their strong support for this initiative, participants expressed the importance of transparent governance and accountability, focusing on practical outcomes and actionable objectives. They sought to add value to local initiatives and to avoid duplicating what already exists. They warned that the time commitments of participants should be acknowledged (and compensated where appropriate); that we should learn from other regions; and that there should be clarity of purpose (with a focus on tangible benefits).

What does this mean for the region?

This project found that there is strong support for the development of a regional (South Yorkshire) food network and that such a network has the potential to create a "virtuous circle" simultaneously addressing key issues of economic growth, environmental sustainability, public health, social justice and equity.

Scalability

The research also suggests how these ideas might be relevant to other regions beyond South Yorkshire. The question of how to "scale up" local initiatives to regional or national scales has been of widespread interest to food researchers in the UK and beyond (see, for example, Connelly & Beckie 2016). Various models have been proposed including "scaling out" (replicating successful initiatives in other localities) and "deep scaling" (making fundamental changes to cultural norms, behaviours and practices at the local, regional or national scale). These ideas are explored in more detail in a recent policy brief, produced by the Sheffield-based H3 project, which could be read here.

Recommendations

Our recommendations for establishing a regional (South Yorkshire) food network are consistent with the Local Growth Plan (creating the potential for a food system innovation hotspot/sector cluster within Advanced Manufacturing, improving health outcomes and reducing labour market inactivity and carbon emissions) and with the UK Government's recently-published Food Strategy[5] which emphasised the need for policy to be "grounded in place", and "supporting work at local and regional level delivered by local councils, strategic authorities, local food partnerships, civil society and citizen groups". Similar aims were expressed in Tim Lang's recent report for the National Preparedness Commission where he heralded the emergence of a new form of bottom-up regionalism for food system resilience, citing the potential role of England's 10 metro mayors in leading the development of a city-regional food focus[6]. Our work supports these policy directions, uncovering a consistent picture across diverse places and sectors within the region, providing a solid launch pad for further work in this area, leading to the successful development of a regional food network.

Next Steps

This project provided a robust strategic case for establishing a food network in South Yorkshire.The next steps will be to produce a blueprint, detailing how these ideas can be taken forward in the most practical and cost-effective way.

5 DEFRA (2025) A UK government food strategy for England, considering the wider UK food system.
6 Lang, T. (2025) Just In Case: 7 steps to narrow the UK civil food resilience gap.

From Data to Impact: Quantifying Environmental Footprint and Transforming Sustainability in South Yorkshire's Food and Drink Manufacturing Industry

Project team:
Sheffield Hallam University: Aida Daei, Cassandra Hayward, Donya Asgharzadeh, Zakary Diakité, Dr Mukesh Goel, Dr Hessam Jahangiri, Dr Hongwei Zhang

Context and Project Rationale

The food and drink industry is the UK's largest manufacturing sector, employing over 486,500 people and generating £148 billion in turnover, with a gross value added (GVA) of £37 billion[1]. Along with its economic significance, the sector causes negative environmental impacts, with the most frequently reported impacts being high greenhouse gas (GHG) emissions and high water and energy consumption. To support the industry, approximately 30.31 TWh of energy is used annually[2]. Achieving the UK's legally mandated climate goals, 68% emissions reduction by 2030 and net-zero by 2050, will be impossible without accelerating decarbonisation in high-emitting and energy-intensive sectors such as food and drink manufacturing[3]. South Yorkshire (SY) is a hub for production, with food and drink manufacturing generating £434 million GVA and providing 9,000 jobs across 170 businesses, including bakeries, breweries, other food producers, meat companies, and distilleries[4].

However, most of the currently available evidence is aggregated from multiple manufacturers of various sizes and on a national scale. This data lacks specificity that would help to address the unique decarbonisation challenges of small and medium sized (SME) businesses in SY, which account for 11 of the 12 sites analysed in this study. To properly target funding and interventions and to understand where energy, water, and emissions arise in day-to-day operations, regional policymakers and support programs require actual site-level data. This is urgently needed because SMEs are under immediate pressure to reduce expenses and emissions, but they frequently lack the information and standards necessary to support workable solutions.

This study has collected and analysed the environmental impact of products from 12 different food and drink manufacturing facilities in SY, including annual energy use, water consumption, and carbon emissions. Collecting operational data from multiple businesses is challenging because many are reluctant to participate in surveys. However, we overcame these challenges through persistent effort: we contacted more than 150 food and drink factories in SY and made repeated in-person visits to explain our project, taking the time to build relationships.

Out of approximately 170 food and drink manufacturing businesses, this study covers 7.05% of the industry population[5].

Table 1 presents summary characteristics of the facilities included in the survey. For ethical and confidentiality reasons, the names of the participating organisations are not disclosed. Instead, each facility is anonymised and identified using case study labels (A–L)

Results

Energy use

The aggregate annual energy consumption for the 12 manufacturers is 34.63 GWh, shown in Figure 1. The graph illustrates that a considerable amount of industrial energy demand is present in the food and drink industry in SY. One large manufacturer contributes 32.51 GWh due to their size and

Name	Product	Employees
A	Candy	15
B	Coffee	23
C	Bread	0-10
D	Traditional Bread	0-10
E	Milled grain (rice, barley, malt)	0-10
F	Ready meals	1000+
G	Potted meat	21
H	Ice cream	0-10
I	Beer	29
J	Milk	10
K	Beer	0-10
L	Multi-product in a commercial kitchen	50

Table 1: Characteristics of the food manufacturing facilities participating in the survey.

1 Food and Drink Federation (2026). Industry at a glance.
2 DEFRA (2025) Food Statistics in your pocket.
3 Ladha-Sabur, A., Bakalis, S., Fryer, P & Lopez-Quiroga. E. (2019). Mapping energy consumption in food manufacturing. Trends in Food Science & Technology, 86, 270-280.
4 Advanced Food Innovation Centre. (2023). South Yorkshire's 'overlooked' food and drink manufacturing sector worth £434m – new report.
5 Ibid

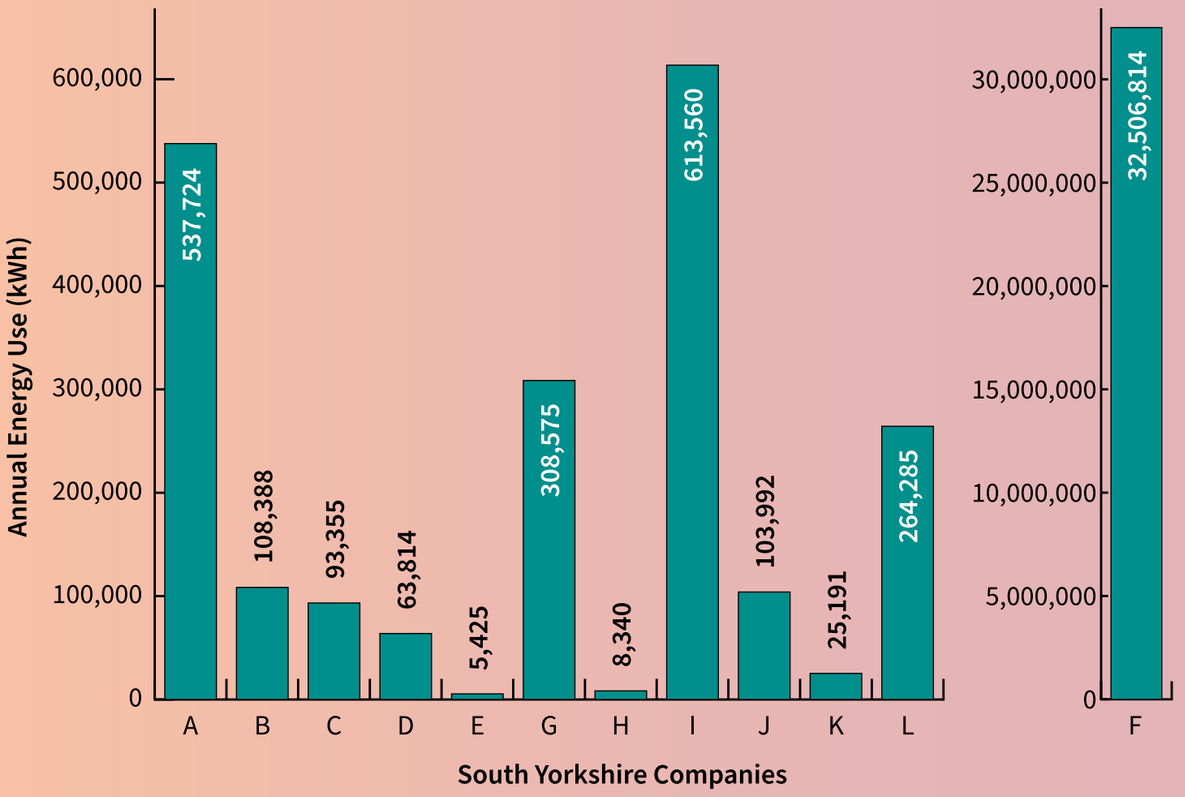


Figure 1: Total annual energy use from 12 food and drink manufacturing firms.

industrial intensity, whereas the remaining contribution comes from a diverse group of SME manufacturers with lower, yet still significant, energy demands. To put this data into perspective, a typical UK-based electric vehicle with a small battery size has a projected annual energy demand of approximately 1,900 kWh, and thus the collective annual energy demand for the twelve companies could theoretically support the annual operation of approximately 18,331 vehicles[6].

Annual energy use is divided between different energy sources, including fossil fuels and renewable energies, which is known as the energy mix. Determining the energy mix has two primary benefits: (a) understanding energy security and (b) enabling the calculation of carbon emissions. Energy security is important, as a diversified mix of energy types being used protects industry from supply disruptions and volatile prices. More relevant to this work, carbon emissions per kilowatt-hour of energy can be calculated to assess the environmental impact.

Based on our results, SY food and drink manufacturing facilities are using more natural gas than on average in the UK. The greater emphasis on natural gas in SY is likely related to the kind of businesses operating and the age of the appliances. Many sites are still reliant on gas-fired systems because they were historically the most affordable option. Simultaneously, limited budget and practical concerns about switching to electric alternatives cause gas to remain the key energy resource in daily operations in this region.

This has important implications, as gas-fired equipment typically consumes more energy than electric alternatives: although it heats rapidly, it is generally less efficient and associated with greater heat losses. Energy efficiency could be improved by replacing gas-powered boilers, ovens, stoves, and steamers with renewable energy sources or by implementing heat recovery on dryers, wastewater steam, refrigeration systems, and ovens. Additionally, the application of modern technologies such as artificial intelligence and machine learning can also help identify other

6 Subaru. (2025) How much does it cost to charge an electric car?

energy recovery resources. Recovered heat can be used for preheating air, products, or generating hot water, especially where switching to electric equipment is not feasible.

Following privatisation in 1989, the electricity system in the UK became highly fragmented between producers, suppliers, and distributors. Producers generate electricity and sell it to suppliers; however, some suppliers are also producers. Distributors are partnered with suppliers to maintain the infrastructure of the electricity grid. As of 2023, there were 56 major energy producers and 32 major energy suppliers spread across the regions[7]. **Determining which energy producers and suppliers currently supply the SY region is not straightforward**. The single distributor, Northern Power Grid, is consumer-facing and provides pricing options. If consumers wish to know who their energy supplier is, they must ask their network distributor. As such, it is extremely difficult to determine the energy mix used in SY. This is a major concern, as the decarbonisation agenda depends on clean electricity production. Therefore, future research should focus on determining the energy mix of the SY electricity grid to support sustainability assessments.

This represents a clear feasibility and system barrier: the lack of transparent, SY-specific grid-mix data limits precise attribution of electricity-related impacts. Instead of attempting to estimate site-specific electricity provenance, this study addressed this challenge by applying the same reporting boundary and UK Government electricity emission factors to all participating sites. Despite variations in the local grid mix, this ensured that carbon results were computed consistently and could be reliably compared across businesses.

In the Yorkshire region, electricity is generated from gas (55.6%), biomass (30.2%), wind (11.6%), and nuclear (1.8%)[8]. In some seasons, biomass stands higher than gas. If SY is assumed to follow broader Yorkshire trends, a substantial proportion

7 Neely, Hugo. (2023) Competition in UK electricity markets 2023. Department for Energy Security and Net-Zero.
8 National Energy System Operator. (2026) Carbon Intensity.

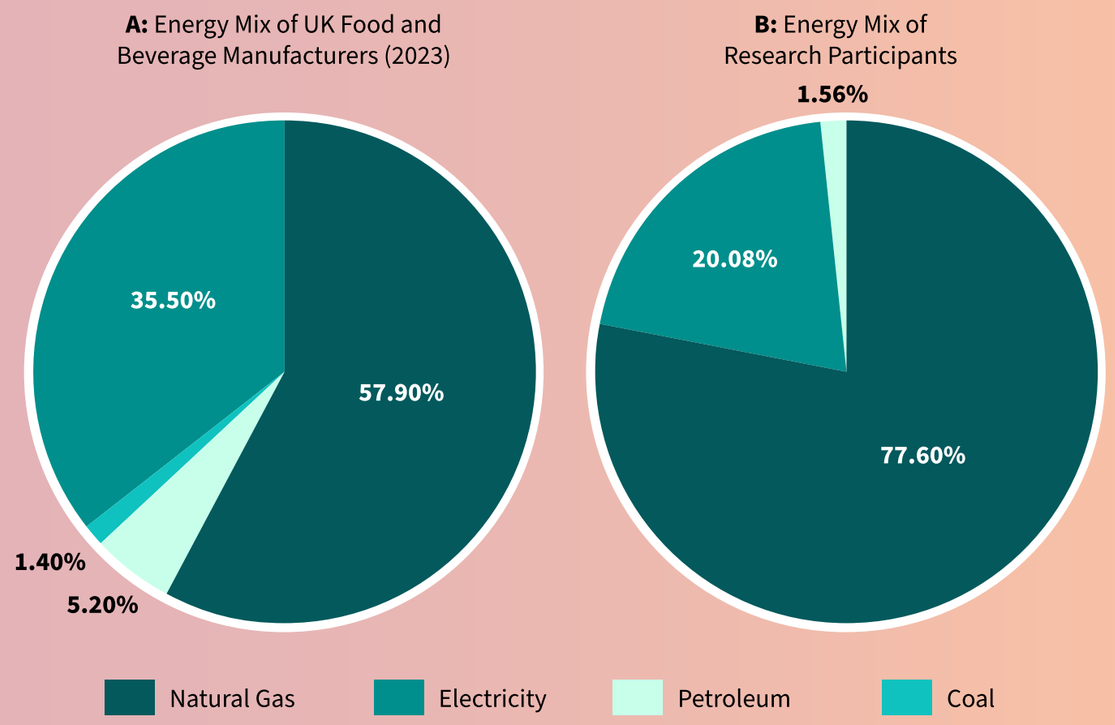


Figure 2: Energy mix of food and drink manufacturing: (a) UK national industry energy mix in 2023; (b) energy mix of the 12 SY food and drink manufacturers included in this study.

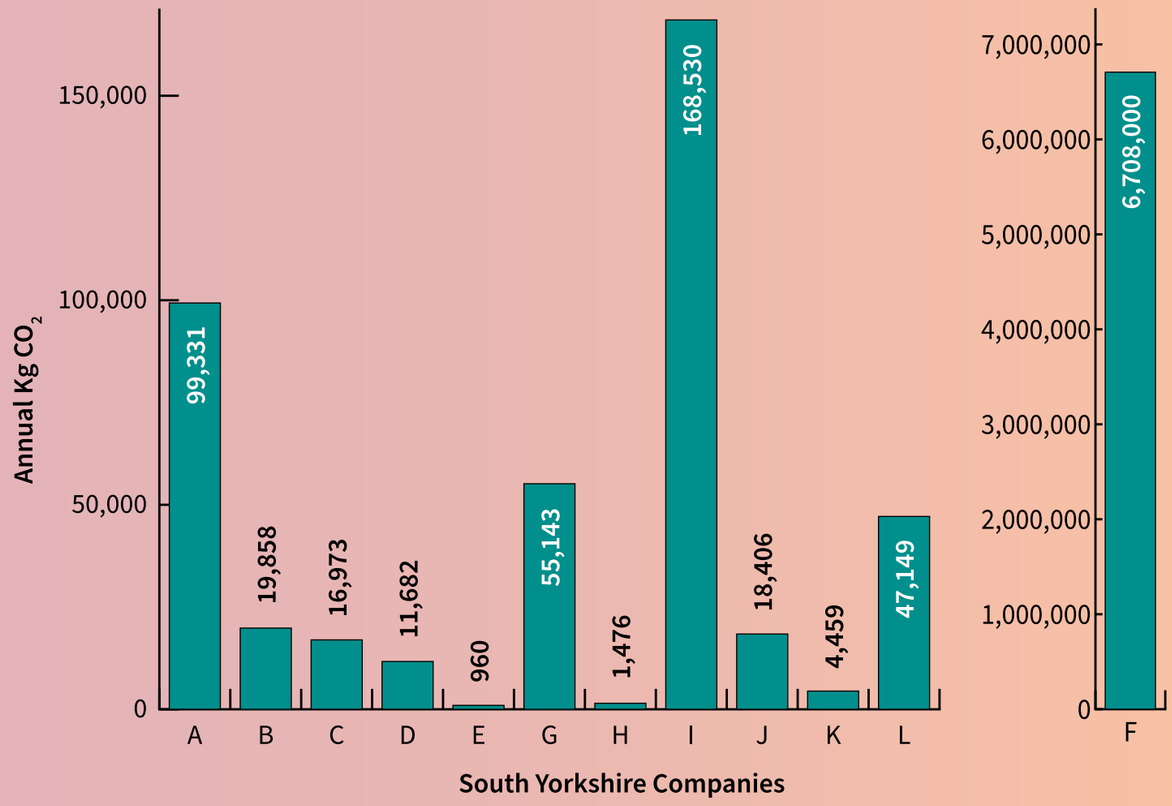


Figure 3: The annual carbon emissions for 12 food manufacturers from electricity and fuel use (Scope 1–2 only).

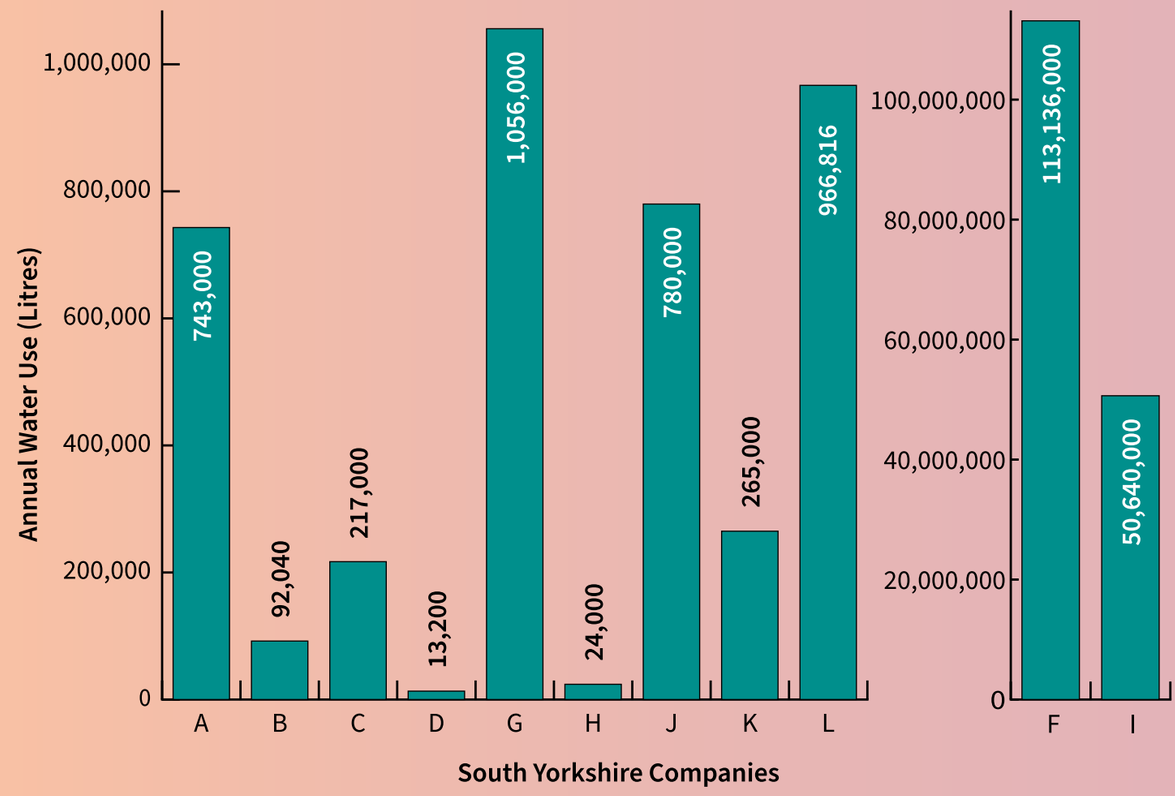


Figure 4: Annual water use for 11 companies. Company E is an experimental case, which does not consume water.

of electricity generation is likely to be imported, severely increasing associated emissions. With less than 15% of electricity coming from truly renewable energy sources, it is evident that there is an opportunity to decarbonise the grid for the entire region, including SY.

Understanding this background is essential to comprehending our findings. This background refers specifically to the regional electricity generation mix in Yorkshire and its likely implications for SY. In a regional grid dominated by gas, the carbon benefit of electrification may be restricted or time-dependent, underscoring the significance of tactics like demand reduction and on-site renewables. By combining actual operational data from SY manufacturers with regional grid context, this study provides helpful evidence to support practical decarbonisation decisions even in circumstances where system transparency is limited.

Carbon Emissions

Carbon emissions from research participants fall into both Scope 1 and Scope 2 categories. Scope 3 emissions, such as transportation, embedded carbon, etc., were outside of the study boundary. Scope 2 emissions come from the use of purchased electricity to run electric appliances, whereas scope 1 emissions come from the on-site burning of fuels, mainly natural gas used in boilers, ovens, and other thermal equipment[9]. We intentionally report Scope 1 and 2 operational emissions only (combustion/grid generation), excluding electricity transmission and distribution (T&D) and fuel well to tank (WTT), to keep a consistent boundary across all sites and utilities and to avoid mixing operational reporting with lifecycle accounting.

To convert energy use into carbon emissions, the UK government provides carbon emission conversion factors, which calculate and standardise energy consumption into carbon dioxide (CO_2). In 2025, the UK conversion factors for carbon dioxide equivalent (CO_2e) were 0.18494 kg CO_2e/kWh for natural gas, 0.177 kg CO_2e/kWh for electricity, and 2.661 kg CO_2e/L for Diesel[10].

In total, annual emissions amount to 7.15 tCO_2e. Figure 3 shows the carbon emissions from the 12 research participants. This figure only accounts for emissions from onsite fuel use and purchased electricity. Since these 12 firms represent only 7 percent of food and drink manufacturers in SY, the reality is that the sector's total contribution to regional emissions is much higher, which requires focused support for decarbonisation.

Water Consumption

Annual water use was another environmental indicator calculated for our research participants. Figure 4 shows that total annual water use is 166.96 million litres of water and that consumption differs widely across the food and drink manufacturers studied. These differences largely reflect the type of products made, as products that use water as an ingredient, such as beer, will have higher consumption, as well as the level of cleaning and processing required. Direct comparisons between facilities should be treated with caution. In many cases, water is only measured at the site level rather than by individual processes. This makes it difficult for businesses to see where water is being used. Better monitoring would help identify avoidable losses and inefficiencies. Improving water efficiency can also reduce energy use and associated carbon emissions.

We attempted to benchmark the findings of water consumption in this study against existing water-use assessments in Yorkshire or SY. However, regional water reports by providers such as Yorkshire Water focus on aggregate supply and demand metrics, without sector-disaggregated industrial water use. Additionally, economic analyses of the regional food sector do not include environmental or water consumption data. This constraint highlights a significant evidence gap in the systematic assessment of water consumption

9 United Nations. (2022) Category 3: Fuel- and Energy-Related Activities Not Included in Scope 1 or Scope 2.

10 UK Government (2025) Greenhouse gas reporting: conversion factors 2025.

within the food and drink industry at regional and sub-regional scales in Yorkshire.

Understanding and evaluating alternative approaches for highly efficient, low energy consumption/low carbon emissions

To understand the sustainability implications of the electricity grid, we are collecting data from three companies that have already implemented sustainability measures to improve how they use energy and other resources. We examine how these different approaches reduce environmental impacts in practice.

Case study J: Rooftop Solar photovoltaic (PV) Integration in a Dairy Processing Facility

The first case study examines the implementation of a rooftop solar PV system at a dairy processing facility located in SY. The intervention aims to reduce grid electricity consumption and associated operational carbon emissions through on-site renewable electricity generation. A combination of feasibility study data and real operational measurements from 2024 is used to evaluate system performance, electricity savings, and carbon emission reductions.

The PV system, consisting of 52 modules, supplies approximately 10.5% of the facility's annual electricity requirement. As a result of the PV installation, grid electricity consumption decreased to 93.06 MWh/year compared with the pre-installation period (from 103.99 MWh/year, with 10.93 MWh/year displaced by on-site PV generation). From an environmental perspective, the reduction in grid electricity consumption associated with on-site PV generation leads to an estimated annual saving of approximately 1.93 t CO_2e in operational emissions. Overall, the results indicate that rooftop PV provides clear energy, economic, and carbon benefits for the dairy processing facility. However, because the system supplies only a limited share of total electricity demand, further emission reductions through rooftop PV alone are constrained by site electricity requirements and available roof area, indicating the need for complementary decarbonisation measures.

Case study L: BioHiTech Eco-Safe Digester at a commercial kitchen

The second case study assesses changes in operational GHG emissions from food-waste management at a commercial kitchen following the installation of a BioHiTech Eco-Safe Digester. Annual food-waste generation was estimated at 5.2 t/yr. Two scenarios were compared: a baseline scenario in which food waste is collected and transported by Biffa to a landfill, and a post-installation scenario in which waste is treated on-site by the digester.

Overall, comparison of the two scenarios shows a net reduction of approximately 2.52 tCO_2e/year, corresponding to a reduction of around 69% relative to the baseline waste management pathway. These results demonstrate that the BioHiTech digester substantially reduces food waste–related operational emissions by avoiding the high methane emissions associated with landfill disposal.

Case Study F: Combined Heat and Power (CHP) in a Ready-to-Eat Food Manufacturing Facility

The third case study assesses the impact of a combined heat and power (CHP) system which simultaneously generates electricity and useful heat from a single fuel source, typically natural gas at a ready-to-eat food manufacturing facility, by comparing the current operation with CHP to an alternative scenario in which the CHP system is not in use. The analysis focuses on changes in fuel consumption and associated operational carbon emissions.

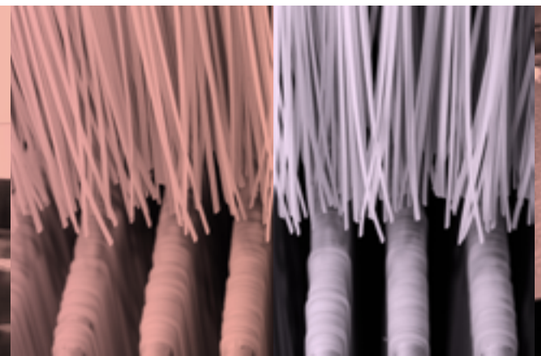
The results show that the total operational carbon emissions are higher when the CHP system is in use (5,960 tCO_2/year) than when it is removed (3,168 tCO_2/year). Although operating the CHP reduces emissions from grid electricity, this saving is offset by a significantly larger increase in emissions from natural gas consumption, resulting in higher overall emissions under current conditions.
This finding is consistent with previous research showing that CHP does not automatically reduce carbon emissions. Studies have shown that when electricity is supplied from a relatively low-carbon grid, replacing it with gas-fired on-site generation can increase total emissions.[11, 12] These findings underline that the carbon benefit of CHP is strongly context-specific rather than guaranteed.

Recommendations and Next Steps

1. Shifting corporate behaviour
    - There is a long-term opportunity to shift the culture and behaviour of food and drink manufacturers towards renewable resource use and energy efficiency. By actively engaging with the industrial community and continuing to collect data to encourage energy efficiency, this work prompts factories to check in on their energy and encourages integrating decarbonisation into supply chains, which can shift cultural assumptions about sustainability in food production.
    - However, as noted by Jackson et al. (2024) and the H3 Policy Brief, scaling up efforts may risk losing the local trust and relationships that are critical to project effectiveness[13]. During our research, many SMEs rejected participating because they were unconvinced of the benefits, lacked awareness of energy-saving opportunities, and faced practical barriers, including limited expertise, insufficient time, and a lack of internal capacity or resources to collect data and undertake energy-efficiency tasks.
2. Expand the survey to include more SY food manufacturers
    - A larger dataset will improve the accuracy of regional sustainability planning and provide stronger benchmarking evidence for businesses and policymakers.
3. Strengthen and maintain collaboration with politicians and business partners
    - Improved cooperation will ensure that findings affect funding decisions, support mechanisms, and objective guidance for industry.
4. Explore and address emerging research questions
    - Identify which production stages are most energy intensive.
    - Assess how regional insights can be integrated into a national energy and carbon map while preserving local specificity.
    - Determine the energy mix of the SY electricity grid to determine sustainability implications.

11 Dorer, V., Weber, R., & Weber, A. (2005) Performance assessment of fuel cell micro-cogeneration systems for residential buildings. Energy and Buildings, 37(11), 1132–1146.
12 Hawkes, A. D., & Leach, M. A. (2007) Cost-effective operating strategy for residential micro-combined heat and power. Energy, 32(5), 711–723.
13 Jackson, P., Yap, C., Parsons, K., Treuherz, S & Roberts, G. (2025) Values-based food systems: the role of local food partnerships in England. Agriculture and Human Values, 42, 1379–1393.





Soil Carbon Storage Across South Yorkshire: Understanding Soil Carbon Stocks Across Pools in the Context of Agricultural and Conservation Land Management

Project team:
University of Sheffield: Prof. Jill Edmondson, Prof. Gareth Phoenix, Prof. Katie Field, Dr Adenike Amoo, Matty Spratt, Anthony Turner, Ruby Woollard

Challenge and Response

Soils are the largest terrestrial carbon reservoirs and provide fundamental ecosystem services, including the provision of food and habitats and the regulation of water and climate[1, 2]. The delivery of such services is dependent on soil health – their continued capacity to function as a vital living ecosystem that sustains plants, animals, environmental quality and human needs[3]. Soil organic matter (SOM) is a fundamental component of soils and a major determinant of soil health, containing stores of carbon and nitrogen bound together with other mineral nutrients. Soil organic carbon (SOC) makes up about 40-60% of SOM, and strongly influences the physical, chemical and biological structure and function of soils[4, 5]. The long-term stability of these carbon stocks depends on how it is partitioned across different pools - total organic carbon (TOC), particulate organic carbon (POC), and mineral-associated organic carbon (MAOC)[6]. Land management involved in restorative conservation and regenerative agriculture aims to restore the biodiversity and soil health of degraded lands for the continued provision of ecosystem services; for UK grasslands, this can be achieved through well-managed conservation grazing, which is being implemented in Shire Brook Valley Nature Reserve. Restoring and maintaining soil health plays a key role in enhancing the sustainability of food production in regenerative agriculture (whether that be arable, pasture or a combination). Whilst both agricultural and conservation land management practices can influence carbon pool distribution, the direction and magnitude of these effects remain unclear for many UK landscapes, including South Yorkshire.

Black carbon (BC), the product of the incomplete combustion of fossil fuels and biomass, is ubiquitous in soils globally. It is deposited onto soils from naturally occurring wildfires and fire management of vegetation – for example in the moorlands of South Yorkshire – and from human activity from industry, domestic heating and transport. This poorly understood carbon pool occurs in addition to the organic carbon pools in soil derived from natural ecosystem processes. Research suggests BC can locally contribute >20% of total carbon in urban and some agricultural ecosystems. However, the overall contribution of BC to total carbon stocks in soils is not routinely quantified. In addition, there is increasing evidence that BC plays an important role in soil biogeochemical cycling and in particular soil carbon sequestration. For example, our recent soil microcosm experiment found that BC-soot reduced soil carbon loss by 18%, suggesting that BC can increase carbon sequestration into soils. Hence quantifying BC pools, and the effects of land management on them, is hugely important for a fuller understanding of soil carbon sequestration capacity.

These projects responded to three key challenges:

1. Limited understanding of how different land uses in South Yorkshire influence soil carbon storage across distinct carbon pools. Furthermore, while total SOC is often measured, the distribution between POC and MAOC - which differ dramatically in stability and turnover - is rarely assessed at a regional scale.

2. Uncertainty about how soil physical properties, particularly bulk density, constrain carbon sequestration potential. Compaction is widespread in agricultural soils and in degraded lands targeted for restoration, yet its effect on long-term carbon storage (especially in MAOC) is poorly quantified.

3. Ensuring that conservation management of grasslands for improved biodiversity through conservation grazing at Shire Brook Valley also conferred benefits for soil health and carbon sequestration. As unmanaged grazing can reduce carbon storage, baseline soil carbon assessments should be incorporated into grazing regimes and subsequent monitoring.

1 Harden, J.W., Sanderman, J. and Hugelius, G. (2017) Soils and the Carbon Cycle. International Encyclopedia of Geography, Wiley, pp.1–14.
2 Haygarth, P.M. and Ritz, K. (2009) The future of soils and land use in the UK: Soil systems for the provision of land-based ecosystem services. Land Use Policy, 26(1), pp.S187–S197.
3 Lehmann, J., Bossio, D.A., Kögel-Knabner, I. and Rillig, M.C. (2020) The concept and future prospects of soil health. Nature Reviews Earth & Environment, 1(10), pp.544–553.
4 Lal, R. (2025) Soil organic matter: The heart of soil health. Journal of Soil and Water Conservation, 80(4), pp.320–326.
5 Lal, R. (2016) Soil health and carbon management. Food and Energy Security, 5(4), pp.212–222.
6 Prairie, A.M., King, A.E. and M. Francesca Cotrufo (2023) Restoring particulate and mineral-associated organic carbon through regenerative agriculture. PNAS, 120(21).

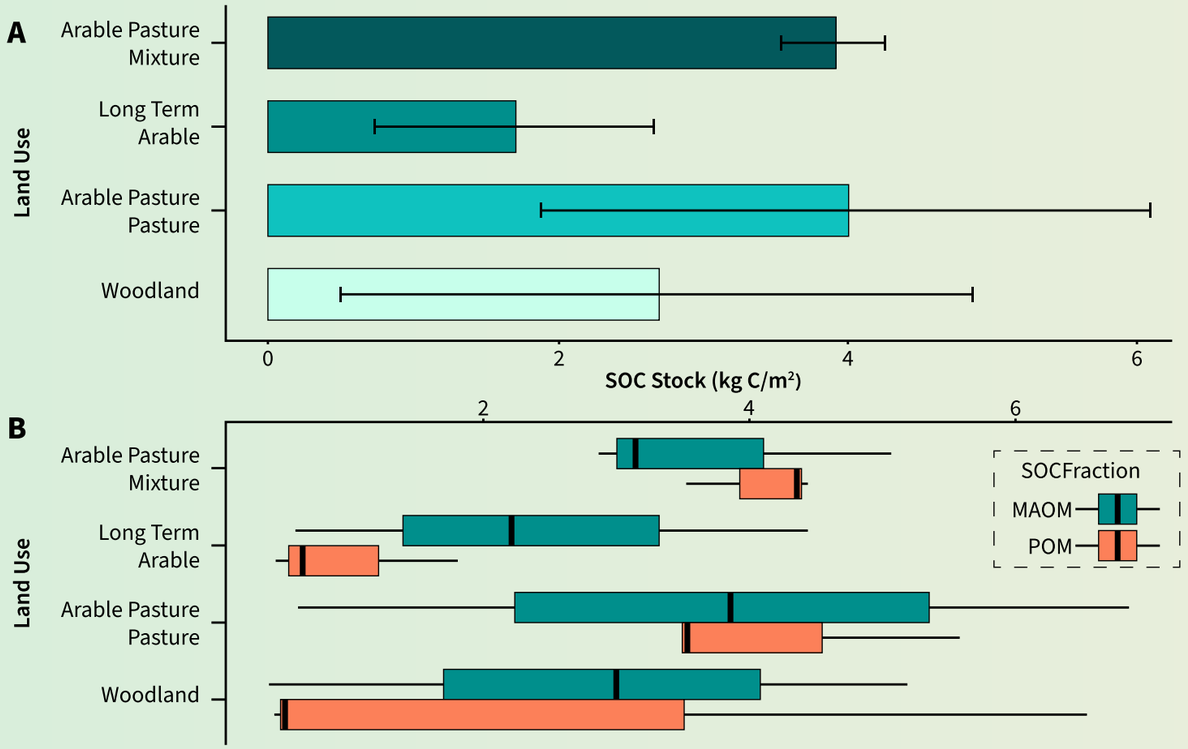


Figure 1: A) Whole-soil SOC stocks by land use. B) SOC stock variation by land use and fraction.

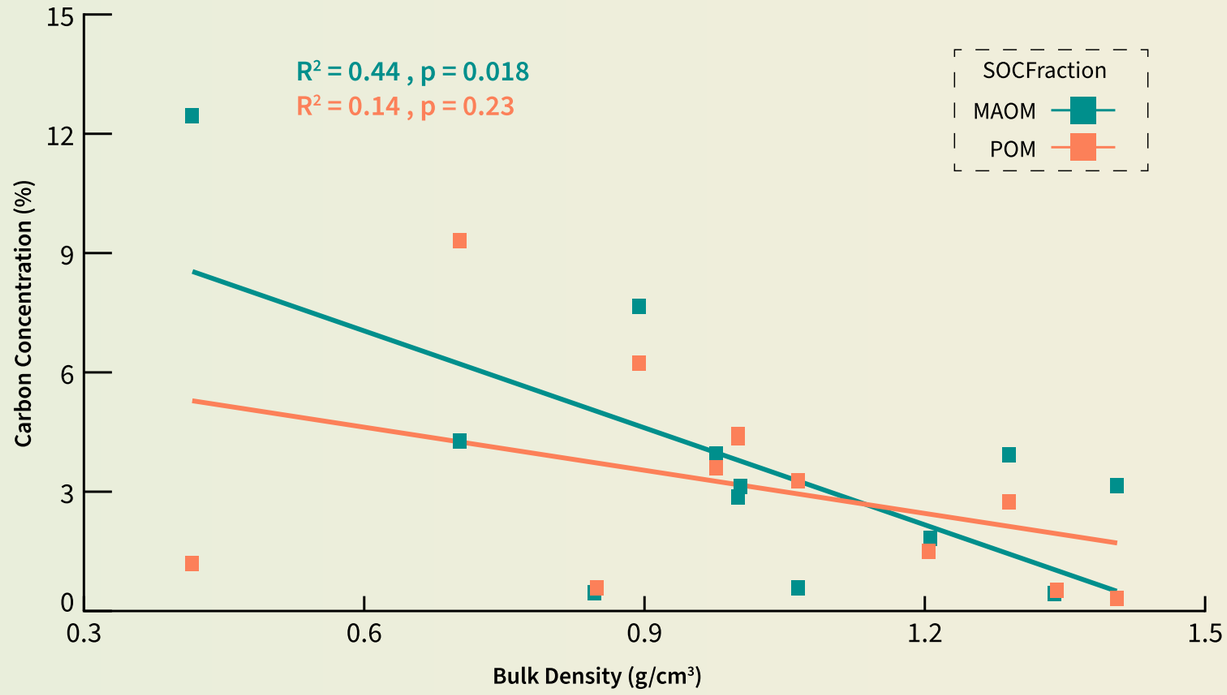


Figure 2: Correlation between carbon % vs bulk density.

What the work did:

- Soils were sampled across multiple land uses from both agricultural and conservation contexts. Across South Yorkshire farms, soils were collected from arable, long-term arable, mixed arable-pasture, long-term pasture and woodland sites. At Shire Brook Valley Nature Reserve, soils were collected at different soil depths across three selected fields: Rainbow Meadows and Sally Clarks which are semi-natural grasslands with agricultural land-use histories, and Linleybank which is a recently reclaimed landfill site.
- Carbon content and bulk density of soils from both agricultural and conservation settings were measured, and SOC, BC and TOC stocks calculated.
- In conservation soils, TOC stocks in the top 30 cm of soil were compared to UK national averages (for semi-natural grasslands and pastures (Bradley et al., 2006) and SOC stocks were compared across depth increments (0-10 cm, 10-20 cm, 20-30 cm) to assess carbon distribution and stability.
- Agricultural soils were fractionated into POC and MAOC to quantify carbon distribution between these pools. Bulk density measurements were also used to assess the relationship between soil compaction and carbon concentration in these soils.
- SOC stocks and pool distributions were compared across land uses (within agricultural and conservation settings separately) to identify management-relevant patterns.

Findings and Potential Impacts

Under agricultural land management:

Research is ongoing and final results will be reported in summer 2026. The key emerging findings are summarised below:

1. **Land-use differences in total SOC were small.** Across a sub-set of sampled sites, total SOC stocks showed only modest variation among land uses: long-term arable soils tended to have lower SOC, while mixed arable–pasture and long-term pasture systems displayed similar SOC levels.
2. **Mineral-associated organic matter (MAOM) consistently dominated carbon storage.** Fractionation revealed a clear and consistent pattern: MAOM held substantially more carbon than particulate organic matter (POM) across all land uses. This aligns with global evidence that MAOM is the primary long-term carbon pool due to its mineral protection and slower turnover.
3. **Soil compaction strongly limited carbon persistence**. Carbon concentration in MAOM showed a strong negative correlation with bulk density ($r \approx -0.67$, $p < 0.01$). Denser soils stored less carbon in MAOM, regardless of land use. This suggests that soil physical condition - not just management category - is a major determinant of carbon sequestration potential.

Under conservation land management (in Shire Brook Valley):

1. **Surface soil layers contained the most carbon.** Carbon decreased with depth in all fields, with Rainbow Meadows and Sally Clarks displaying sharp declines in SOC between surface soils (uppermost 10 cm) and lower depths - these patterns are typical of healthy soils. This decline was less obvious in Linleybank. Surface soils are highly vulnerable to disturbances and compaction associated with unmanaged grazing, highlighting the importance of incorporating soil health assessments into grazing regimes for the mitigation of substantial carbon losses.
2. **TOC stocks were generally consistent with UK national averages.** Carbon in soils is a key indicator of soil quality. The carbon content in Rainbow Meadows and Sally Clarks indicated these soils were of good quality, with TOC stocks greater than the UK national average for pasture soils and almost on par with semi-natural soils. Monitoring soil carbon stocks over time will provide an indication of whether these soils have capacity to store more organic carbon over time with the change in management to conservation grazing. Linleybank soils stored less carbon, as TOC stocks fell below both national averages.
3. **Land-use history had a significant impact on soil carbon stocks.** Soils in Linleybank were less healthy, more disturbed – as shown

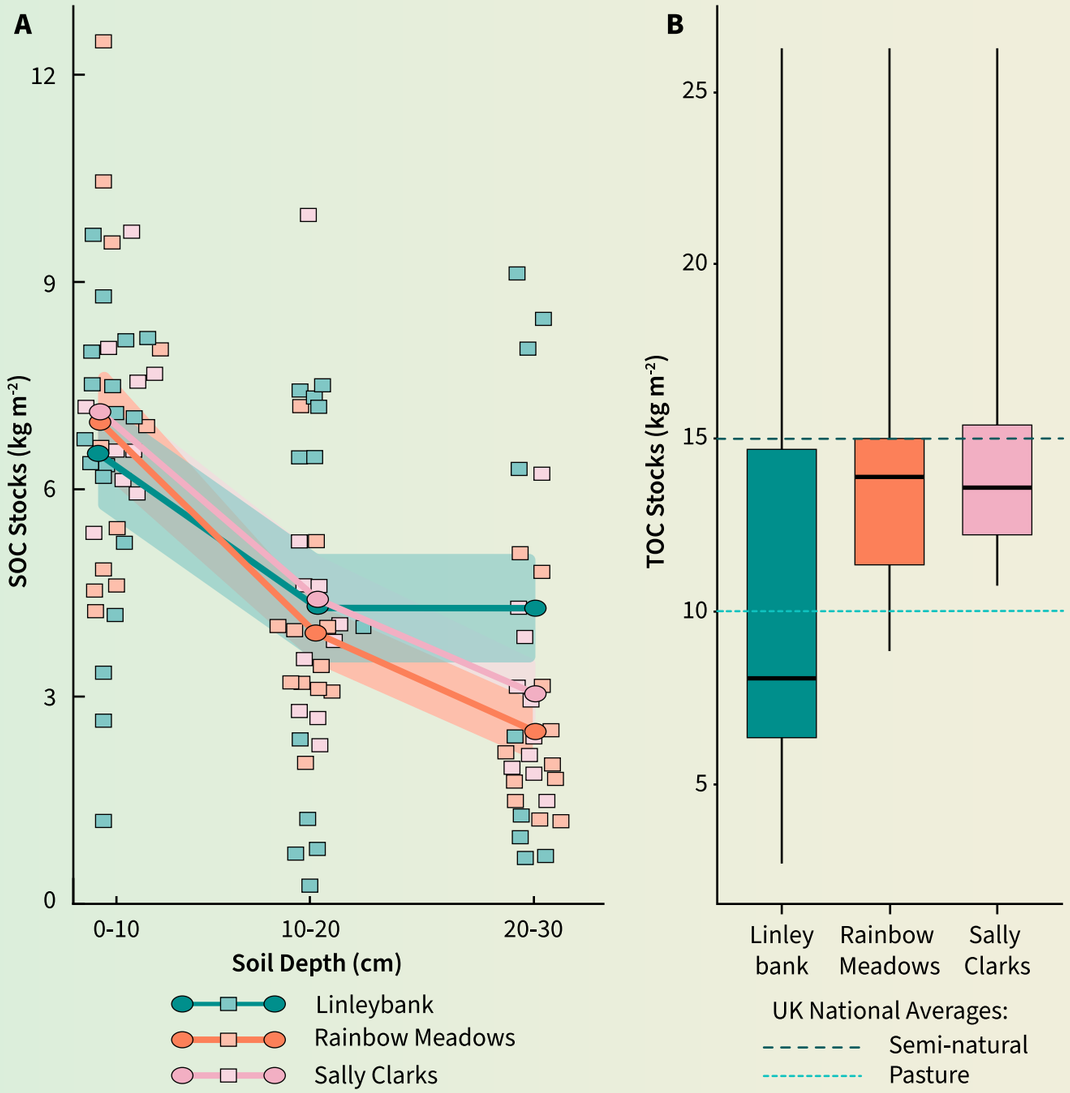


Figure 3: Distribution of carbon stocks across fields under conservation management in Shire Brook Valley: A) Depth profile of soil organic carbon (SOC) stocks across fields. B) Total organic carbon (TOC) in the top 30cm of soils compared to UK national averages (Bradley, 2006).

by less obvious declines in SOC with depth and highly variable SOC and TOC stocks – and stored less carbon compared to the other fields. This is likely indicative of its relatively recent landfill history and incomplete recovery since, showing that land-use histories can significantly influence soil health and carbon sequestration capacity. This may also identify Linleybank as a potential site that may benefit from conservation grazing.

Applicability Beyond South Yorkshire

These findings are highly transferable to other UK regions under either mixed agricultural management or conservation land management. Our research highlights the need to incorporate soil health assessments into land management regimes, as maintaining good soil health is fundamental to the long-term sustainability of agricultural and conservation practices.

Scaling the impact:

- **Scaling out:** Baseline soil health and carbon stock assessments can be replicated within other ecosystems, and are particularly relevant when changing land-use or management – for example when converting to either regenerative agricultural or restorative conservation land management practices – to ensure schemes have beneficial outcomes for soils. The sampling and fractionation approach can be applied outside of agriculture to conservation sites, and replicated across other UK regions to build a national picture of MAOC-based carbon storage.
- **Scaling up:** Insights can inform regional soil health frameworks, carbon accounting schemes, and advisory services at the individual level for farms and conservation practitioners.
- **Deep scaling:** Challenging the assumption that agricultural land-use change alone drives SOC gains, and highlighting the need for cultural and behavioural shifts toward soil-structure-focused management. Overall highlighting the importance of soil health assessments for both agricultural and conservation-based land management.

Recommendations:

1. **Integrate carbon pool measurements (POC/ MAOC) into soil monitoring frameworks.** Move beyond TOC alone to include fractionation in soil carbon assessments where feasible in both agricultural and conservation contexts.
   Expected improvement: More accurate assessments of long-term carbon sequestration potential.

2. **Support farm clusters, local demonstration farms and nature reserves (e.g., Shire Brook Valley) as hubs for soil carbon learning.** Facilitate knowledge exchange between farmers, researchers, and land managers.
   Expected improvement: Wider adoption of soil-structure-focused practices across South Yorkshire.

Next Steps:

- Resampling in the next 3-5 years in Shire Brook Valley to assess impacts of grazing regime implementation on soil carbon stocks. Resampling over multiple years in agricultural sites to investigate temporal dynamics of carbon pool distributions (TOC, POC and MAOC).
- Co-develop management trials with local farmers to test interventions that support enhancement of MAOC storage.
- Explore policy integration, ensuring findings inform local climate strategies, soil health action plans, advisory programmes for farms and conservation practitioners.

New Research Questions:

- How quickly can SOC stocks –in particular MAOC– in disturbed/compacted soil recover following compaction amelioration? (E.g. through well-managed conservation grazing or appropriate agricultural management practices.)
- How effective is conservation grazing at enhancing and maintaining high-quality SOC stocks in UK grasslands? How might carbon pool distributions be impacted?
- How might microbial communities mediate MAOC stabilisation under different management regimes?
- How does black carbon influence carbon stocks and distribution across pools in soil?

Notes:

‘The question of ‘scaling up’ local food initiatives has been a recurrent theme in research on food system transformation. ‘Scaling up’ to regional or national scales may present a challenge to maintaining these close connections to the locality. Other models are being explored. These do not assume that ‘bigger’ is always ‘better’ and include ‘scaling out’ (replicating successful initiatives in other localities) and ‘deep scaling’ (making fundamental changes to cultural norms, behaviours and practices at the local, regional or national scale). This issue of scale — how and under what conditions the values of local food partnerships might be ‘scaled up’, without compromising their founding values —represents another important area for future research’.

More on this can be found in our publications here and here

Nature Recovery Farming: Supporting Regional Landscape Scale Resilience

Project team:
Sheffield Hallam University: Dr Anna Hawkins, Dr Joseph Glentworth, Dr Catherine Hammond, Dr Ellen Bennett, Dr Emma Cary, Stephanie Webb

Challenge and Response

We are currently at a crucial transition point for English land management with the trailing out of European Union farming subsidies, changes to the legislative frameworks for farming and environmental policy, and the launch of the ambitious Environmental Improvement Plan 2023. Nature Recovery land management has been recognised as an essential part of our carbon strategy as well as addressing the biodiversity crises.

Despite promising ambitions from Defra to support new environmental management through the Agricultural Act (2020) and Environment Act (2021), we know from our work with local and national stakeholders, that there is considerable uncertainty about the how policy and legislation will translate into a tangible funding regime, with many current land owners and managers fearful that their livelihoods will become unviable and feeling unable to participate in the transition to new and more sustainable ways of managing land producing food, and enhancing biodiversity. This creates tensions around the long-term future of rural communities and their connection with land-based industries that to date has received limited attention from researchers. What we do know is that farmers make a significant contribution to the social, cultural and economic makeup of rural communities[1] meaning that farmers are central to securing a sustainable future of rural areas, with the support of appropriately designed policy and schemes[2,3].

This project responds to these challenges by interviewing people working in land management and farming in South Yorkshire and the Peak District National Park about their experiences of navigating the current funding and policy landscape. We gathered and present a range of expert opinions about the opportunities and threats they face when trying to contribute to regional environmental and economic resilience with the aim of informing regional and national policy and funding strategies, as well as speaking to a global community of people working towards a sustainable and equitable transition of land management for people and nature.

1 McCarthy, J., Meredith, D. and Bonnin, C. (2023) 'You have to keep it going': Relational values and social sustainability in upland agriculture. Sociologia Ruralis 63(3), pp. 588–610.
2 Holt, A. and Morris, J.(2022) Will environmental land management fill the income gap on upland-hill farms in England? Land Use Policy 122, p. 106339.
3 Ogawa, K., Garrod, G. and Yagi, H.(2023) Sustainability strategies and stakeholder management for upland farming. Land Use Policy 131, p. 106707.

Findings and Potential Impacts

Our findings highlight a wide range of issues and approaches to sustainable land management, but the key messages fall into four categories:

1. The need for sufficient and stable funding regimes so that farmers and land managers can plan for long-term viability whilst supporting restoration of nature and improved environmental and economic resilience for South Yorkshire and the Peak District.

Uncertainty and a need to work towards greater stability is a strong theme emerging from our interviews and analysis of agricultural funding and policy. Funding schemes for farmers have become much more complex and uncertain, with many farmers struggling to navigate the range of schemes and understand the eligibility criteria and what they need to do to access the payments. This complexity is leading to mistrust and putting some farmers off accessing funding for environmental land management.

"I feel as though they keep changing the rules as they go along" - *"[We] did look at woodland grants, but…we physically couldn't do what they wanted us to do with the trees. If we put all the arable land into it, it needed deer fencing, and you've got to deer fence before you can plant your trees, and they wanted all that doing in the first year, and then it's on a reclaim basis, so you've gotta have the capital upfront. And we just didn't have enough money in the bank to be able to do that."* - SY Farmer

"So at the moment, where we are [is] we don't have any concrete support from the rural payments agency as to what's next… An incredibly vulnerable situation. So… My next move was to put the arable land up for sale. That was the only way I could secure the rest of the farm. But we're in a situation now when nobody is buying because there is no incentive to invest in farmland." - SY Farmer

2. The need for stable support from trusted people and organisations for farmers and land managers so that they can access and engage with funding and strategy whilst carrying out the day to day work of producing food and ecosystem services for the region.

Many of the people we interviewed named people and organisations they trusted and valued as

part of their support infrastructure. Many of these trusted individuals and roles within organisations were seen as precarious because of funding cuts. Without the right kinds of support many farmers will fail to access funding because of the complexity involved in applying and reporting compliance to funders. Charities such as the National Trust and Wildlife Trusts are often better equipped to access funding than more traditional farmers, but this was named as a cause of tension between larger organisations and more traditional farming families.

"And of course, most of us are completely ignorant of what's going on, so we're just trying our best… Going around in circles and I come to the conclusion is that I have to get some sort of professional help to pay and of course when you mention professional help [it] means money and of course that does put me off of it, but it works." - SY Farmer

"I've always believed that for a long time now, that they're not interested in small family farms [be] cause what we contribute to the food pile is very small." - SY Farmer

3. Whilst collaboration is welcomed, there is also wariness about collaboration leading to a loss of control over land, and decision making being transferred to the collective. Policymakers should be mindful of these tensions when designing engagement strategies.

There is an assumption that collaboration is necessary to deliver landscape restoration at scale, but this conflicts with many farmers' sense of independence and autonomy. The commitment to enter into a land management scheme that could last up to 30 years is a daunting prospect for many individual landowners. There is some mistrust about handing over decision making to a collective; many farmers and growers enjoy the opportunity to meet other farmers in their area, to share ideas and discuss problems, but not everyone wants to formalise this "clustering". The presence of large third sector land management organisations further complicates the opportunities for collaboration, because the governance structures, expertise and scale of these organisations lends itself well to collaboration and agility to respond to changing funding and policy regimes, this can cause resentment for some farmers who feel that these organisations take funding away from more traditional farmers.

"[In] 30 years time. I'll be 70. You know what I mean? It's like a long old time. And at that point, I ain't doing any, like, starting up any new businesses. Maybe I will, but very unlikely. So are we doing the right thing by that?" - SY Farmer

4. Remaining financially viable is the most pressing concern amongst farmers and whilst many are willing to take some land out of production in order to access funding and support nature restoration, many felt driven to do this because of unstable markets for farm produce.

Remaining financially viable was a significant challenge for all farmers and growers we spoke to, and in the case of larger farms this was attributed to uncertain markets, as well as an unstable climate. In the case of smaller growers, viability depended upon access to local food systems for storage, distribution and processing as well as variable weather conditions. Taking land out of food production was sometimes seen as risky because the land could become unsuitable for cultivation quite quickly, and the reliance on unstable funding streams was a deterrent for some. But for some farmers, livestock farming had become unviable and unmanageable, and so taking some land out of production for tree and hedgerow planting, or planting wildflower hay meadows was seen as a financial lifeline for others.

Whilst the prospect of taking land out of food production may be challenging for some farmers because it is core to their identity, funding that allows them to retain their farms and keep working the land is an attractive prospect, especially for farmers operating in less favourable landscapes such as upland areas.

"I'm always willing to try things… It's the way it's going, isn't it? But I do want food production as well… because you're making it viable. It's another income stream, isn't it? But because you're a farm and you've still got to do that, I don't mind being a park keeper a little bit. I don't want to be a park keeper for myself." - SY Farmer

Scaling Up Our Findings

We analysed our regional findings against national consultation reports and found many similarities in these key messages, suggesting that whilst South Yorkshire has a unique set of challenges and opportunities for landscape transformation at scale, it would make a good demonstrator for projects that would have national and international relevance and applicability. Policies that work here would be likely to work elsewhere, and conversely we could learn from as well as shaping best practice in other regions.

Recommendations

Many farmers and growers are financially precarious, and strategies that require their cooperation and collaboration need to be accompanied by a funded delivery plan, or robust support to help farmers and growers access funding.

Local food systems need to be operationalised in ways that are tangible and beneficial to food producers at different scales, helping them to access local markets for their produce that are stable and financially rewarding. Agricultural and horticultural work is demanding and low paid, so collaboration needs to be targeted and clearly beneficial. Our research findings have produced the following recommendations:

1. Develop regional policies and strategies that support farmers, growers and land managers to deliver environmentally, economically and culturally resilient landscapes that include clear implementation strategies for delivering desirable outcomes.
2. Provide practical support for farmers wishing to access funding that supports the regional agenda as part of a regional implementation plan.
3. Develop a regional food strategy that:
    - Provides support for new entrants into the farming, growing and environmental land management sector through the creative use of land leasing and tenancies.
    - Develops a support infrastructure for producers that includes production, distribution and processing so that regional food producers are able to remain viable in a challenging financial climate.

Next Steps

To maximise the impact of this work, regional farmers, growers and land managers need to be involved in the development of strategies and policies for landscape scale environmental, economic and social resilience. This provides opportunities for ongoing collaborative research with regional stakeholders to co-produce policies and support packages that will be accessible and effective, as well as ongoing evaluation.

New research questions include:

- How can we effectively incentivise and compensate farmers and land managers to deliver valuable ecosystem services such as biodiversity restoration, natural flood management, and carbon storage?
- How can landscape scale resilience be effectively monitored and evaluated? What are the metrics and indicators that would satisfy the demands of environmental, social and economic resilience for our region?
- How can growers and producers operating at different scales be incorporated effectively into a regional food strategy?
- How can effective collaboration be fostered between different actors within the farming and land management sector in order to deliver regional landscape resilience?