

THE UNIVERSITY of EDINBURGH

Advancing **action**

The University of Edinburgh's research and reflections for **COP 31** and the future

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Foreword



Paul Dodds

Professor Sir Peter Mathieson

Principal and Vice-Chancellor of the University of Edinburgh

Building on last year's *Advancing action* COP 30 publication, I am delighted to welcome you to our second edition for COP 31.

Climate and the environment are key parts of the University's *Strategy 2030*, with our expertise in these areas helping to deliver benefits to communities around the world.

As you will see in this publication, our experts are at the forefront of efforts to tackle key challenges posed by the climate crisis.

It has been an important year for the University with the launch of our strategy *Regenerative sustainability: our pathway beyond net zero*. Aiming to go further than minimising harm, it sets out our plans to proactively restore natural systems to benefit both nature and people, to help address the interlinked crises of climate change, biodiversity loss and pollution. You can find out more about our strategy at the end of this publication.

Reflecting our commitment to taking meaningful action in these areas, the University was ranked fourth in the world in the QS World University Rankings: Sustainability 2026. This was a tremendous achievement and welcome recognition of the ongoing work, at every level of the institution, focused on fostering and promoting sustainability.



Keith Hunter

Solar panels on the roof of the University's Nucleus Building

Our commitment is also evidenced by our participation in COP 31. Not only in this publication but in the halls of the 2026 UN Climate Change Conference, we share the expert findings of our dedicated academic researchers, in order to directly grow our collective knowledge, knowledge that is vital in addressing the climate crisis and the need to move towards a circular economy. There can be no let-up in our efforts. We remain deeply committed to helping to drive the collaboration and collective action needed to face up to what is one of the greatest challenges of our time.

Introduction



Ian Hamilton

Professor Louise Horsfall

Head of the Institute of Quantitative Biology, Biochemistry and Biotechnology, and Earth Champion for Circular Economy at the University



Bangon Pitipong via Getty

A year on from COP 30 and our *Advancing action* publication, the climate picture has not improved. Temperatures continue to set records; biodiversity loss is accelerating and the demand for finite materials keeps climbing. What has changed is the tone of negotiations. Delegates arrive in Antalya, Türkiye, after a summit in Belém, Brazil, that set few new targets and instead pressed countries to act on the commitments they had already made. This year, Türkiye hosts COP 31, but with Australia leading the negotiations and a pre-COP meeting held in the Pacific, an unusual arrangement that brings very different national priorities into the same process. Perhaps as a result, the COP 31 Presidency has chosen to focus on implementation. It wants to move from agreed ambition to practical results. It has even attached numbers to that aim: raising the global electrification rate from just over 20 per cent to 35 per cent by 2035, and halving the growth in global waste over the same period. After years of target-setting, discussions have now taken aim at delivery.

The United Nations Framework Convention on Climate Change Action Agenda keeps its six thematic pillars: Transitioning energy, industry and transport; Stewarding forests, Oceans and biodiversity; Transforming agriculture and food systems; Building resilience for cities, Infrastructure and water; Fostering human and social development; and Unleashing enablers and accelerators. This framework was established for mobilising voluntary climate action from civil society, the private sector, investors, cities, regions, and national governments, engaging actors who do not participate directly in negotiations but who are responsible for progress and implementation.

In turn, this publication reflects the thematic pillars and enactors but this year the contributions in our collection keep returning to one idea. Whether they are writing about chemistry, forestry, fish farming or hospital theatres, our researchers are asking how we might stop treating resources as things to be extracted, used once and thrown away. In industry, that means recovering value from waste. A tonne of discarded electronics holds 200 to 300

grammes of gold, far more than the same weight of ore, and new chemical reagents developed at Edinburgh can now separate gold and copper from that mix. Engineering biology goes further still, using enzymes and microbes to break plastics back into their building blocks or turn them into medicines and flavourings. Recycled carbon fibre, glass and plastic are being developed into composites strong enough for car panels and flood barriers. Electrification brings its own complication. Data centre demand is rising quickly, and if it outpaces progress in new clean energy generation it could keep fossil fuel plants running for longer. The application of a circular approach to marine resources offers a way to double down on efforts to protect and restore the oceans. Whether on land or at sea, the same thinking applies.

The University's Forest and Peatland Programme has planted 1.1 million trees and is restoring peatland across Scotland, an approach based on insetting rather than buying offsets on the market. Aquaculture now relies on by-products, insect meal and single-cell proteins in place of wild-caught fish, while biochar made from crop residues offers farmers a stable way of returning carbon to the soil. Cities face their own pressures. In the summer of 2025, 60 people in Scotland died during heatwaves, many of them indoors. Contributors look at how older stone buildings can be adapted rather than demolished, and at why green space only protects health if people live close enough to use it. Water reuse, meanwhile, is held back by outdated regulation that lets forever chemicals and microplastics build up in wastewater and sludge. In NHS Scotland, small changes are adding up: a reusable steel 'cool stick' in place of single-use spray cans, slimmer surgical trays that need less sterilising, and a pilot exploring whether some single-use devices could be safely remanufactured. Underneath all of this sits a point about education. Circular transitions cross so many disciplines that universities must bring researchers, students, industry and government into the same room.

Our contributors are also candid about the limits of circularity. One warns that "circular does not mean sustainable" when replacing marine feed ingredients increases pressure on cropland. Another points out that Scotland had to postpone its ban on landfilling biodegradable waste because there was too little capacity to reprocess it. A third describes engineering biology as "not a magic wand". This caution matters for COP 31. Circular measures can reduce demand for virgin resources, but they cannot replace deep emissions cuts or adequate adaptation finance.

The University of Edinburgh has been influencing the world since 1583. The contributions herein reflect the depth and breadth of our transdisciplinary research and innovation expertise. Not to be overlooked, the University is committed to improving its own practices. Our regenerative sustainability strategy, launched in March 2026, commits us to net negative carbon across all our emissions, including international student travel and investments, and to ecologically regenerating an area five times the size of our campuses. In the 2026 QS World University Rankings, Edinburgh was placed fourth in the world for sustainability. Through this publication, the University aims to inform the ambitions of COP 31 to advance meaningful global action. We invite collaboration; find out more about these and other projects by contacting us. See page 33 for contact details.

Electrification and AI demand growth: A key challenge for the COP Global Action Agenda



Stewart Attwood

Professor Ronan Bolton

Personal Chair of Sustainable Energy

The promise of electrification

Electrification is a central driver for global emissions reductions, sitting at the heart of the COP 31 agenda to transition energy, industry and transport systems. This pivot towards electrification is underscored by the COP 31 Presidency, which has set out an ambitious target to increase the global electrification rate from just over 20 per cent today to 35 per cent by 2035.

Achieving this target is within reach. Sustained policy support for renewables over decades has created a virtuous circle of technological innovation and economies of scale, driving down wind and solar unit costs, displacing fossil fuels and further incentivising the electrification of end-use demand. Moreover, the target is less daunting than it first appears: given the lower conversion losses in electrical systems, less energy overall is required to heat homes, power industry, and transport people and goods using electricity compared to burning fossil fuels. Bolstered by these cost and efficiency advantages, global electricity demand is now growing faster than overall energy demand – two or three times faster since 2019.[1]



Andrey Metelev via Unsplash

AI and demand acceleration

However, electrification does not automatically equate to displacement of fossil fuels. A key question in the energy transition is the relative rate of growth between electricity demand and clean power generation. If demand rises more quickly than the deployment of clean power, it could lead to increased reliance on fossil fuels such as coal and gas. The promise of electrification may not be realised if demand growth outstrips the system's ability to build and integrate clean power sources.

Equal attention must therefore be paid to demand as to the supply of clean power. Particularly concerning from a climate change point of view are emergent uses of electricity which may compete for renewable supply and slow down the displacement of fossil fuels in transport, heating and energy-intensive industry. The rise of data centres is one prominent example. Electricity consumption in this sector has surged in recent years, with particularly rapid growth in the US, where it increased by more than 25 per cent in 2025 alone.[2]

Data-intensive economic development is a long-term structural trend which has been characterised by successive waves of investment: first, with the expansion of the internet in the 1990s, and later with the rise of cloud computing and hyperscale data centres in the 2010s. AI represents a third wave, and the impacts of this technological revolution on electricity demand are highly uncertain.

The International Energy Agency's 2024 scenario report illustrates a wide range of possibilities looking out to 2035:[3] from 700 TWh of electricity consumption from data centres in its Headwinds case, increasing to 1,700 TWh (around 4.4 per cent of global electricity demand) in its highly ambitious Lift-off case.

Energy system impacts of data centres

Whatever the scenario, the centralisation of computing services in ever-larger data centres will require significant electricity capacity to power servers and cool equipment. A key challenge has been the rapid growth of data centre clusters in high-growth cities and regions, which often has the effect of accelerating demand in already constrained electricity systems. This scaling and clustering effect can result in increased output from fossil fuel generation and increased emissions. It can also drive up energy prices, potentially creating new inequalities in how the costs and risks of the energy transition are allocated across society.

There are already well-known cases: In Virginia in the US, rapid demand growth has required major new investment in gas-fired generation and grid infrastructure. In Ireland, data centres accounted for more than 20 per cent of national electricity use in recent years, raising concerns about security of supply and the pace of renewable deployment. In the UK, while data centres currently account for a relatively modest share of electricity demand, at 2.5 per cent, this is forecast to quadruple by 2030.[4]

A vision for green data centres

There is a growing need to regulate data centre developments more stringently to ensure that decisions about their scale, location, energy procurement and operations align with decarbonisation goals. To fully align with the COP Global Action Agenda, policy and regulatory frameworks should also emphasise circular economy principles, to encourage the recycling of waste heat, water and IT hardware.

Scotland offers a potential case study for this systemic vision. It has a relatively cool climate and abundant renewable resources, generating far more renewable electricity than it consumes (38.5 TWh of renewable output and 20.8 TWh of net exports in 2025). Data centres of an appropriate scale, in the right locations and operated as 'grid-interactive assets',[5] could improve the utilisation of wind power in Scotland, which is often curtailed because of congestion on the grid.

At the University, we are working closely with policymakers, industry and other stakeholders to develop a framework for green data centres in Scotland. This is a complex systems challenge, requiring detailed energy systems modelling and analysis of the social and environmental contexts where data centres could be located in the coming years.

Whole systems and circular economy principles should underpin this 'twin transition' of AI and renewables, with data centre developments appropriately sized and located so as not to damage local environments and exceed the operating limits of key infrastructures.

This research programme is showing how universities, industry and policymakers can come together to forge a sustainable path for AI.

To see more on the University's research on green data centres, see **https://eil.ac/DataCentres**



Server cooling fans in a data centre

Winston Chen via Unsplash

Unlocking the potential of material circularity for a greener future



School of Engineering

Professor Dipa Roy

Personal Chair in Sustainable Materials

As the world transitions to a low-carbon economy, Pillar 1 of the COP Action Agenda highlights the critical role of material circularity in reducing greenhouse gas emissions and promoting sustainable development.

The transition to a low-carbon and sustainable future requires a fundamental shift in the way we produce, consume and dispose of materials. Pillar 1 of the Action Agenda, focused on transitioning energy, industry and transport, presents a critical opportunity to integrate material circularity principles, reducing the environmental footprint of these sectors by promoting the efficient use of resources and minimising waste. By prioritising the use of recycled and secondary materials in the production of low-carbon technologies and infrastructure, we can accelerate the transition to a more sustainable and regenerative economy.

The benefits of adopting circular economy principles in energy, industry and transport are numerous. By designing products and systems that are restorative and regenerative by design, companies and countries can reduce their material footprint, decrease waste and lower emissions. The implementation of closed-loop production systems in manufacturing and construction can minimise waste and maximise the use of recycled materials, such as those found in composite materials, which can be formulated using a combination of recycled carbon fibres (rCF), recycled glass fibres (rGlass) and recycled plastics (rPlastics). For instance, composite materials made from a blend of rCF, rGlass and rPlastics can be used to produce lightweight and durable automotive components, such as car bumpers and door panels, as well as construction materials, such as roof panels and insulation. The incorporation of these recycled composite materials into various products can result in significant greenhouse gas emissions savings, while also reducing the environmental footprint of industries and promoting a more circular economy.

Furthermore, the design of more efficient, lightweight and sustainable transport systems can also contribute to emissions reduction. The adoption of circular business



Shredded plastic for recycling

Phynart Studio via Getty

models, such as product-as-a-service and sharing economy platforms, can reduce material waste and increase the efficient use of resources. By prioritising the reuse and recycling of materials, companies can decrease their reliance on virgin materials, reduce waste and lower emissions.

Unlocking the potential of waste-derived composites and recycled materials

At the University we are actively working on a research initiative to unlock the potential of plastics wastes,[1] waste-derived composites and establish a circular model of materials recycling and reuse.[2] Our research is driven by the need to push the performance boundaries of recycled materials and create 'load-bearing',[3] 'value-added'[4] and 'structurally higher performing'[5] composites that surpass the capabilities of similar products currently available in the market. We are developing innovative technologies with recycled fibres and plastics, maximising their performance, investigating energy-efficient routes to shape them into product forms, making them fire resistant[6] to enable their application in construction and infrastructure, investigating their resistance to high-velocity impacts[7] that establish their potential as automotive panels, flood barriers or hurricane protection panels.

The goal of our research is to justify the recycling of these waste materials, upcycle composite wastes into high-value products,[8] establish their potential for high-performance applications, and facilitate a market for secondary feedstocks and second-generation products. To achieve this, we are collaborating with suppliers of industrial waste fibres, recyclers of fibres, plastics and composite wastes, and composite product manufacturers. By engaging with these stakeholders, we aim to establish a circular model of materials recycling and reuse, one that prioritises the efficient use of resources, minimises waste and reduces the environmental footprint of composite production. Our objective is to develop a collaborative environment that fosters interaction among materials scientists, engineers, life cycle analysts, social scientists and economists, enabling a comprehensive understanding of material circularity, identification of barriers and targeted actions to address them.

What action is needed now

- A more precise categorisation of waste materials, accompanied by clear guidelines for industrial sectors on the amount of secondary feedstock that can be absorbed, taking into account product performance criticality.
- The establishment of standardised testing protocols to validate the quality of recycled materials, and the revision of product testing standards to accommodate the use of recycled materials, rather than solely focusing on virgin feedstock.
- The development of reliable supply chains of secondary feedstock, and the incentivisation of local waste collection and recycling to reduce transportation costs.
- The implementation of new legislation to make the integration of secondary feedstock into product lines a mandatory requirement for industries, driving a systemic shift towards a more circular economy.
- More reliable studies on life cycle analysis of circular materials, second-generation products and in-depth understanding of techno-commercial aspects of secondary feedstock.


Bernd Christensen

Industrial waste fibres: discarded materials

- The identification of customer acceptance and procurement barriers alongside the technical work.
- The increased involvement of social scientists to address the stigma surrounding recycled materials that prevail in the society, and to promote behavioural change.

Conclusion

It is essential to acknowledge the vital role that circularity of materials plays in mitigating the climate crisis, as the extraction and processing of primary materials are significant contributors to greenhouse gas emissions. The alignment of circular materials strategies with the goals of Pillar 1 of the climate action framework, which emphasises the need for rapid reduction in emissions to mitigate the worst impacts of climate change. This is achieved by reducing the demand for virgin materials and subsequently decreasing the environmental footprint of industries. By adopting circular approaches, such as recycling, reusing and upcycling, we can significantly decrease waste and the continuous demand for new raw materials, thereby minimising the environmental degradation associated with extraction and processing.

Sustainable metal recycling for a circular economy



School of Chemistry

Professor Jason Love

Personal Chair of Molecular Inorganic Chemistry and Head of School of Chemistry

Metal recycling has hit a roadblock. Current processes use old, polluting, energy intensive methods that are inadequate for today's waste materials, such as end-of-life electronics. This is concerning as the increasing technological development and short lifetime of our electronics consumes more of our finite and critical metal resource. Of course, one remedy is to dig for Britain and mine for more metals, with all its societal and environmental consequences. An alternative solution is to target the urban mine of electronic waste using sustainable metal recycling processes. This would revalue waste, reduce energy demand, and provide much needed circularity to our linear world, and aligns to the COP Global Action Agenda objective for solid-waste management. To accomplish this, we need new and sustainable chemical solutions for the recycling industry.



Luke Kinsman

Gold compound retrieved from e-waste

E-waste recycling

Electronic waste is the fastest growing global solid waste stream, projected to be 82 million tonnes generated globally each year by 2030.[1] It is also highly hazardous and concerning that only 30 per cent is recycled formally, with the remainder treated informally, often in the global south, and using chemically toxic and environmentally damaging processes.

E-waste is also a fantastic resource of metals, comprising much higher concentrations of metals than found in virgin ores; 1 tonne of e-waste contains 200–300 grammes of gold, compared with 5–10 grammes of gold in its ore. Once e-waste is recycled, valuable metals such as gold, copper, gallium and platinum can be returned for reuse instead of sitting locked up in a bottom drawer of obsolete electronics.

Letting chemistry do the work

In the School of Chemistry at the University, my research group[2] has been studying new ways of recycling metals from e-waste. We think about the challenge of metal recycling from a fundamental chemical viewpoint and apply new principles and understanding to find new solutions.

One of these challenges is selectivity – how do you separate gold, which is present in a tiny amount in a mobile phone, from all the other metals? And separate it in an efficient, benign and cost-effective manner? Fortunately, we have been successful! We designed a new chemical reagent that can precipitate gold selectively from the soup of metals that arises from dissolving e-waste in acid. Also, we discovered a different chemical compound that targets and latches on to copper. Using these two reagents, we are now able to separate the two most important metals from e-waste and return them into use.



Translating impact

It is exciting undertaking fundamental chemistry research and expanding knowledge. However, it is also important to translate this research into impact that benefits society. This kind of work can be as challenging as blue-sky research, as it often needs a multitude of different skills and the ability to collaborate with different types of stakeholders. Talking with engineers, biologists, economists and social scientists can be very tough for a chemist!

In our case, we chose to patent our intellectual property with the help of Edinburgh Innovations, the University's commercialisation service, and engage with industries to help translate the basic chemistry research into a viable, engineered process. We are now collaborating under license with Lithium Universe Ltd, an Australian engineering company that has designed and built chemical plants to provide lithium carbonate to the lithium-ion battery sector. They aim to develop the technology to full-plant scale to add e-waste recycling to their expanding portfolio of chemical processes for a sustainable world.

Where there's muck, there's brass

It may be an adage, but it does contain some truths. Much of the waste generated by human society is valuable. E-waste contains metals that feature on global critical lists and metals of high value, so they need to be recycled to complete circularity. E-waste also contains toxic metals and materials that need to be removed from circulation to limit the pollution of our environment.

To do this in a sustainable and responsible manner, the recycling industry needs new tools and processes. These could be provided by chemists, as I have described above, but there are many different scientific and technological solutions available. As such, scientific disciplines need to get together to provide holistic solutions to these challenges. This effort is starting to happen, with investment in UKRI Centres for a Green Economy, such as REACT – the Centre for Responsible Electronics and Circular Technologies.

There is also the need to engage with industry such that basic research can be translated into impactful solutions – this needs different skill sets and funding to create opportunities for commercialisation. The challenge is evident, people with the skills are in place, and industry is engaged – the future of recycling for circularity is exciting!

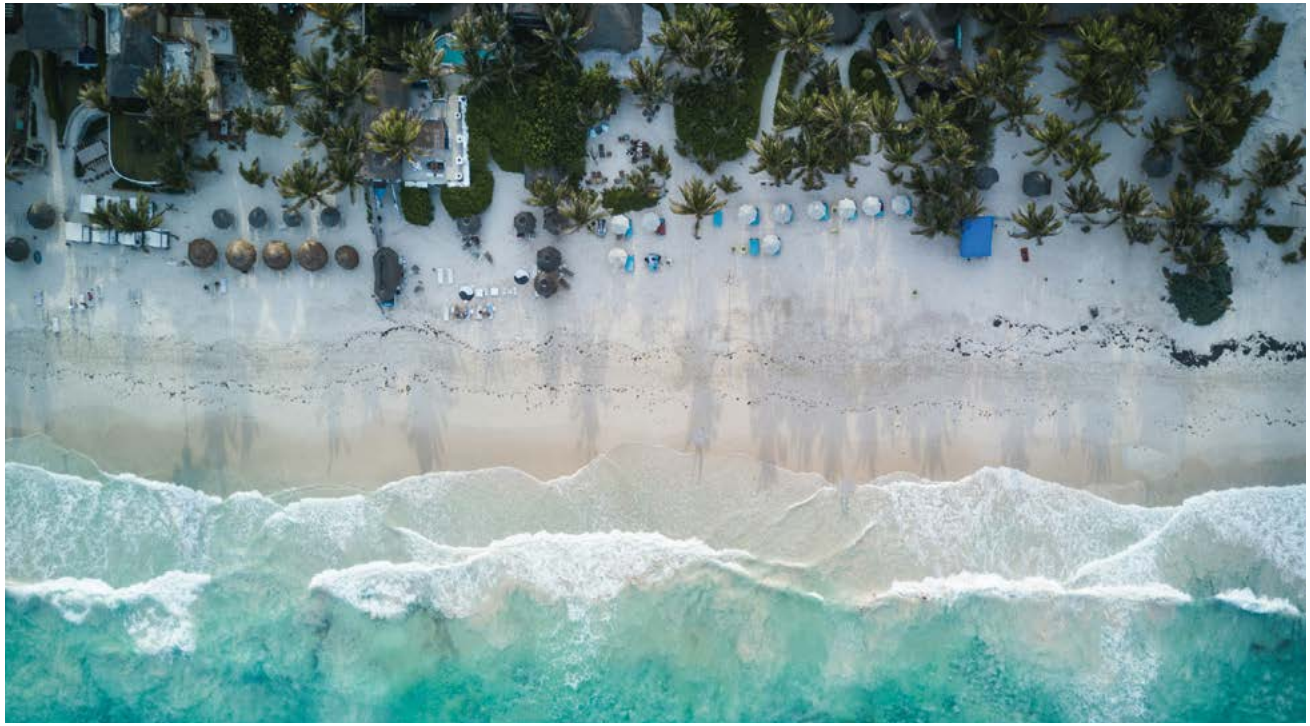
Circular economy and ocean resilience



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Spencer Watson via Unsplash

The ocean plays a vital role in regulating planetary health and the Earth's climate, supporting biodiversity, and sustaining human wellbeing and economic systems. However, climate change and overextraction of marine resources is putting increasing pressure on marine ecosystems and their resilience. The transboundary nature of the ocean, however, presents complex challenges for ocean governance.

Axis 2 of the Global Climate Action Agenda includes Objective 7 – to preserve and restore oceans and coastal ecosystems – focusing on: marine conservation with regenerative blue economy models, and sustainable ocean planning integrating ecosystems, economics and climate change. This contribution further considers the concepts of ocean resilience and circular economy in exploring solutions that are diverse and synergistic across all scales and sectors.

Is 'ocean resilience' possible?

The ocean covers 71 per cent of Earth's surface, comprises 90 per cent of the biosphere and regulates the Earth's climate, including absorbing anthropogenic carbon dioxide emissions and heat from the atmosphere. While it significantly buffers the worst impacts of climate change, today's ocean is warmer, more acidic and less oxygenated than has been recorded for decades, and potentially even millennia. Crucially, marine biodiversity is the key to ocean resilience but if the rate and scale of change outpaces adaptive response time, or exploitation reduces whole species groups, ecosystems can collapse, compromising various ocean functions.

The relationships between ocean health and ocean function are complex, intercoupled and poorly understood. Despite perceptions that the overall health of the ocean is declining, the ocean remains a vital resource to support a growing society. Today, marine species provide food security for over three billion people, the ocean's surface supports transport of more than 80 per cent of global goods and seabed cables transmit most of the world's internet communications. There is a clear need to transition to more sustainable use of the ocean for economic growth while preserving ecosystem health. Increasingly the term 'blue economy' is used to reflect the right balance of governance, policies and technical innovations that can achieve and sustain a thriving ocean and society over time.

A further challenge is the transboundary nature of the ocean from both oceanographic and political perspectives, as most of the ocean's resources are governed as open-access areas across national to international waters. This distinction, as compared to land, further requires progressive conceptualisation of ocean economies and benefits, especially about population growth, environmental and climate change, financial flows of trade and globalisation, energy transitions, technological advances, and geopolitics.

Can a circular economy be part of the solution?

Recognising the need for a shift in economic values that embrace ocean values, there is also emerging discourse around the concept of circular economy, and to what degree this framework provides opportunities for a resilient future for humanity and the ocean. The concept of circular economy (and regenerative economy) has largely focused on changing the paradigm from 'create-use-dispose' to 'create-reuse-transform', based on three principals: regenerate natural systems, recirculate materials, and design to minimise waste and pollution. In practice, application to the ocean has largely focused on marine pollution, for example, plastics and waste dumping, yet this concept has synergies with the concept of nature-based solutions (and nature-inclusive design), for ocean energy and coastal infrastructure. The circular economy notion can potentially be viewed through a wider lens of larger scale ocean ecosystem biodiversity protection and regeneration and blue economy investments that can positively integrate ecological dynamics into financial investment considerations. Interestingly, the circular economy concept is not new, as there are philosophical, ecological and economic alignments with what is broadly termed traditional knowledge, reflecting wisdom shared



Matheo via Unsplash

over generations, around food harvesting and distribution based on seasonal cycles and community rights.

Sectoral synergies

Bringing this all together, there is growing convergence on the merits of integrating the concepts of circularity and ocean regeneration into design and delivery of ocean-based economies to sustain ocean and societal resilience over time. Moreover, three foundational philosophies emerge from this nexus:

1. sustaining ecosystem function and restoring ecosystem imbalances to ensure what is removed from, or put into, the ocean has regenerative and replenishing impacts, rather than destructive effects;
2. building in nature-based design to infrastructure, incorporating ecosystem dynamics and features, and
3. collaborative knowledge exchange and capacity building for communities across all scales and sectors.

Accelerating cross-sectoral impacts – Edinburgh Ocean Leaders Programme

As an example of the above, the Edinburgh Ocean Leaders (EOL) programme has been supporting a network of mid-career changemakers working on the front lines of ocean conservation, policy, finance and innovation around the world. Hosted by the University of Edinburgh, and supported by the Prince Albert II of Monaco Foundation and other partners, EOLs are driving solutions for positive ocean change from local to global scales. Already, EOLs are driving solutions, influencing policy, and accelerating positive ocean change from local to global scales. The 2025 EOL Impact Report[1] illustrates how marine conservation and ocean planning can be central to governments and civil society alike in gaining a deeper understanding of the ocean as a fundamental integrated biophysical and socio-economic system, with people at the core.

To find out more please visit: **www.oceanleaders.org**

From extraction to regeneration: A circular blueprint for land and biodiversity



David Bruce
Forest and Peatland Land Manager



Dr Annie Yang
Forest and Peatland Academic Manager



Andrew Perry

Tree planting at Drumbrae

Introduction: The circular imperative for nature

As the global community gathers for COP 31, the focus has rightly shifted from setting new ambitions to implementing measurable action. The Presidency's goal to halve the growth in global waste by 2035 challenges us to rethink resource flows not just in industry, but in our natural capital. For the University, stewardship of forests and biodiversity is no longer about static conservation; it is about regenerative circularity.

This approach has been fully adopted in the University's newly launched regenerative sustainability strategy (2025–2040), published in March 2026. The strategy explicitly moves our institution 'beyond net zero', mandating a shift from minimizing harm to actively restoring ecosystems. This contribution outlines how the Forests and Peatlands Programme (FPP) serves as one of the flagship delivery mechanisms for this strategy, using 'insetting' to create a closed-loop system for our unavoidable carbon emissions.[1]

The core case study: Forests and peatlands as circular infrastructure

The University faces a significant challenge: Scope 3 emissions from international aviation, including staff business travel and the carbon from our international students travelling to and from Edinburgh, will equate to approximately one million tonnes of CO_2e over the period 2040–70. Guided by the principles of the regenerative sustainability strategy, it was decided that the traditional approach of purchasing transactional offsets in the market could lead to questions of transparency, additionality, longevity and co-benefits. Instead, in response to the climate and environment crisis, we adopted an insetting approach – based on the principles of circularity, regeneration and treating nature, and sustainable land management, informed by local communities. We believe this is more tangible for our community and stakeholders, addresses concerns and keeps action within our own operational and organisational sphere.

Launched in 2021, the FPP directly finances nature-based solutions across Scotland. By acquiring and partnering on land, we are restoring degraded peatlands and planting new native woodlands. This is hands-on delivery of natural capital at scale:

- **Restoring cycles**: Peatland restoration rewets drained landscapes, restarting the natural hydrological cycle and halting carbon leakage, while reinvigorating the land's inherent carbon storage capacity.
- **Biodiversity as a co-benefit**: Unlike some traditional forestry projects, our projects prioritise diverse native species mixes designed for climate resilience, pest resistance and ecological uplift, directly addressing the strategy's goal of ecological recovery.
- **Measurable impact**: Delivery is already underway. To date, we have successfully planted 1.1 million trees across 890 ha of acquired land. We are working in partnership with six landowners across Scotland to deliver approximately 4,500 ha of restored peatland and new woodlands. All of our carbon calculations adhere to best practice, ensuring transparency and permanence. From 2028 we will report progress annually.

This approach treats land not as a commodity, but as an essential part of our regenerative journey, locking up carbon for centuries while reversing biodiversity loss and delivering significant community benefits.

Living labs: Testing regenerative models and metrics

One of the defining features of the FPP is the opportunity the programme provides to utilise the sites as a huge living laboratory, and a specific example of this is the FPP involvement in the multi-country five-year CircHive project,[2] within which the FPP sites featuring as a best practice case study. The programme transforms our land holdings into active testbeds where academic theory meets practical application, driving innovation in how we measure ecological success.

- **Developing global standards**: Through the CircHive project, researchers are leveraging FPP sites to meet multi-benefit objectives, embedding nine core principles, to inform a biodiversity framework with related metrics. This framework helps move beyond simple carbon accounting to create a robust, standardised approach for assessing ecological health.
- **Advancing research**: Our sites host rigorous monitoring programmes and research, deploying advanced technologies to track hydrological changes in restored peatlands, measure carbon fluxes, and establish biodiversity baselines against the new CircHive principles.

Strategic alignment and social investment

The FPP also embeds:

- **Social responsibility**: Since true regeneration includes social as well as natural capital, the FPP encompasses significant community engagement, delivered through an embedded Community Ranger and bespoke plans for every site. From repairing footpaths to community archaeology digs and developing community spaces, we ensure communities are co-designers of these landscapes. Our site at Drumbrae supports 50,000 visitors annually and we work hard to maintain and enhance access provision for walkers as part of our woodland development.

Education, experiential learning and research

- **Curriculum integration**: The FPP aims to become integral to the student experience at the University. FPP supports fieldwork modules across multiple disciplines, where students experience restoration efforts through a multi-faceted lens. This hands-on learning ensures the next generation of leaders can rigorously evaluate regenerative land use. Last year, we engaged with more than 2,100 students, staff and community visitors and the ambition is to increase to 5,000 per annum in the coming years.
- **Educational integration**: Beyond formal curriculum, the programme has engaged so far with more than 500 staff and students through volunteer days and expert workshops. It has supported £1.5 million in research, demonstrating how environmental stewardship can drive educational and economic value.

Conclusion: Scaling the approach for COP 31

We believe that the University's FFP, by demonstrating our carbon responsibilities through insetting, guided by our published regenerative sustainability strategy and the innovative metrics of the CircHive project, shows that we have created a regenerative loop that restores ecosystems, empowers communities and advances academic knowledge.

As COP 31 emphasises the transition from ambition to action, the lesson from Edinburgh is clear: institutions can move beyond transactional offsetting toward deep, place-based stewardship backed by rigorous metrics. By treating land as a living laboratory and a community asset, we can turn the challenge of residual emissions into an opportunity for profound ecological renewal. Ultimately, this approach completes the circle from extraction to regeneration, ensuring that our institutional footprint actively feeds back into the natural systems it relies upon. This is the essence of regenerative circular action, closing the loop so that our legacy today leaves a richer, more biodiverse world for tomorrow.

A circular approach to aquaculture: Supporting sustainable food systems



Anooraag Basu

Dr Nick Wade

Group Leader at the Roslin Institute

Aquaculture at a crossroads

Aquaculture is at the forefront of supplying high-quality, nutritious protein for a growing population, with aquatic food seen as a key element of the COP 31 Agenda to develop resilient, adaptive and sustainable food systems.[1]

For the first time in 2022, global aquaculture production moved beyond capture fisheries (FAO).[2] While it is one of the most efficient ways to produce animal protein, challenges include emerging diseases, nutrient pollution, antimicrobial use, economic inequalities, habitat destruction and competing resource use, especially from marine systems.

Although expansion can be viewed as a success story, aquaculture, and particularly the intensive farming of carnivorous species, is at risk of exceeding the ecological boundaries which it was intended to benefit. Meeting these challenges requires an integrated approach known as One Health, to balance the health of people, animals and ecosystems.[3]



Farmed fish

Karl Muscat via Unsplash

Evolution of aquafeed sustainability metrics

The food we feed farmed fish accounts for at least three quarters of the environmental footprint of aquaculture.[4] A large focus to improve sustainability has been by reducing use of wild harvest marine fish meal (FM) and fish oil (FO).

Formulated aquafeeds have changed rapidly and now include more than 40 plant ingredients, insect meals and rendered by-products from terrestrial and aquatic sources. The forage fish dependency ratio (FFDR) is a modern holistic sustainability metric, which across all fed species now shows that 5 kg of fish is produced from around 1 kg of wild fish resources.[5]

Efficiency of marine ingredient use has been greatly improved over the last 20 years, with most species having reduced inclusions of marine FM and FO by five to ten fold, including nearly four-fold reduction in FFDR for salmon.[6]

Circular does not mean sustainable

With the shift from marine to terrestrial ingredients in aquafeeds to support increased production, another paradox emerges where significant trade-offs in

sustainability metrics must consider land and water use, carbon footprint and eutrophication.[7] The potential negative impacts of soy protein concentrates and rapeseed oil are a particular concern.

Novel ingredients can break this cycle, especially single cell ingredients[8] from bacteria, microalgae, yeast and fungi, providing novel sustainable alternative sources of protein, oils, including long chain polyunsaturated oils, and functional molecules such as natural carotenoid pigments that colour salmon muscle.

The aquafeed industry exemplifies how aquaculture can operate circularly, using by-products and waste streams, while developing new sustainable ingredients, producing diets with complementary beneficial ingredients. This allows iterative movement towards restorative approaches that balance ecosystem and human production system impacts.

Farming system innovations

Land-based or recirculated aquaculture systems are a new frontier that allow consistent, scalable and local production. By merging diverse technological innovations, these aim to provide enhanced fish health and welfare, with reduced environmental impacts.

Superior biosecurity prevents disease, largely eliminating chemical and antibiotic treatments and disease transmission to wild stocks and reducing risk of antimicrobial resistance. Closed water systems enable waste recovery, providing nutrient recovery for fertilisers and bioenergy while protecting natural water systems.

Significant challenges remain, however, including infrastructure costs, energy demands, system reliability and competing water resource use, all contributing to economic viability.

Genetics and biology: a circular driver of aquaculture sustainability

An animal's biology ultimately determines how it responds to disease and environmental challenges during production, and how efficiently it converts nutrients into growth. This requires fundamental science, aligned with industry and government, to translate discovery into accelerated breeding of resilient aquatic animals, and evidence to inform responsible policy and regulation that underpins sustainable aquaculture development.

My research, and that of others in the Royal (Dick) School of Veterinary Studies at the University, aims to do just that, harnessing the power of genomics to fast track genetic improvements in aquaculture.[9,10] This includes resolving regions of the genome responsible for disease resistance,[11] while defining unique molecular signatures in fish immune tissues,[12] the impacts of whole of life rearing conditions[13] and production environments.[14] Across diverse species from fish[15] to shrimp[16] and molluscs,[17] these innovations enable a data-driven cycle of continuous improvement that deliver incremental gains in resilience, welfare and resource use efficiency, and unlock the next generation of innovation that benefits animal, environmental and human health alike.

The wider food system opportunity: a One Health approach

The health of farmed aquatic animals is intrinsically linked with the health of humans and the environment, a concept known as One Health.[18] The human value of protein and lipids from seafood is unmatched, which when compared with other animal proteins provides the highest nutrient value and lowest carbon emissions.[19]

Additionally, replacing red meat with a range of alternatives that includes oily fish such as salmon has demonstrated benefits protecting the environment and raising human health standards.[20] Safe, responsible and sustainable production means greater access to more nutritious, minimally processed foods.

Looking forward

Aquaculture has the potential to fundamentally change how and where seafood is produced and how it is consumed. For most countries, locally farmed or caught whole fish and shellfish can sustainably increase nutrient availability.

The aquaculture industry is becoming circularity in practice – not simply recycling physical resources, but iteratively increasing knowledge, resources, genetic progress and biological efficiency to improve productivity, health and welfare.

Aquatic farming systems have great potential for further improvement and diversification, through the equitable supply of novel sustainable feeds to new genetically improved resilient aquatic animals, that deliver locally produced, nutrient-rich aquatic animal protein while enhancing local livelihoods and aquatic natural resources. Realising this potential will benefit from One Health approaches that link the surveillance and governance of animal, human and environmental health.

Transforming agriculture and food systems



School of GeoSciences

Professor Saran Sohi

Personal Chair of Land-based Carbon Removal, School of GeoSciences



Kesinee Bunsom via Getty

Biochar, the charcoal used as soil amendment made from agricultural waste

Building circularity in agriculture and food systems using biochar

Five times more CO_2 is built into new plant material each year than humans emit from burning fossil fuels. This removal of CO_2 is naturally balanced by a process of decomposition in soil organic matter, conducted primarily by microorganisms. In the Anthropocene, however, agriculture has expanded to dominate even natural forest and one-third of plant productivity is appropriated by humans. Agriculture is fundamentally extractive and the remains of harvested products are burned, buried or only partially recycled to land. This, as well as reduced vegetation cover and soil disturbance, reduces the amount of decomposing organic matter present in soils.

Soil decomposition is ordinarily gradual, where each step in the process leaves a smaller, less amenable residue for further transformation. The major portion of soil carbon is an accumulated stable fraction and its depletion in agriculture can take some decades to bottom out. Restoration and regeneration mitigate these losses by better regulating inputs and rates of decomposition. This speaks to Goal 8 of the Global Climate Action Agenda, which calls for the restoration of degraded landscapes and wider adoption of regenerative agriculture. How can we best harness the circular economy to improve soil health, strengthen climate resilience and support sustainable food production?

Recapitalising soils

Charcoal is a natural component of soil carbon that is so stable that it persists through land use change. It is present in most soils even though some landscapes rarely burn. Although only a few percent of plant biomass is convert to charcoal in wildfire, charcoal has come to comprise 13 per cent of the world's soil carbon. Strategic conversion of crop straw or the remains of used crop products into 'biochar' would build on this natural process, increasing soil carbon more efficiently and permanently than relying on biological processes. Although biological activity is essential for soil function, most of the carbon that plants naturally cycle between the air and soil is directly added below-ground by roots and only a small part of available material would be converted. Using biochar to support more productive crops increases overall biological activity and ultimately a more resilient soil environment.

Increasing circularity to maximise soil organic matter is an important part of regenerative concepts in farming. Introducing biochar provides a further 'natural' and efficient development of these approaches to rapidly recapitalise soil, putting back displaced carbon without reverting land-use. It integrates with a sector where addressing greenhouse gas emissions is particularly challenging, while offering a distinct opportunity for the bioeconomy.

How much is the carbon worth?

International measures to limit climate change revolve around individual countries devising policy measures, incentives or regulation to deliver against national and regional commitments. The price and scale of traded CO_2 removals reflects the voluntary nature of corporate engagement and the changing political and economic backdrop.

Tree planting is the most recognizable and traded option for CO_2 removal. Such 'nature-based' solutions are low cost but also non-permanent. Permanent CO_2 removal is synonymous with engineered solutions and reliance on geological storage. Biochar is viewed as permanent and has elements of both engineered and nature-based approaches.



Close-up of biochar produced through wood pyrolysis

Rene Notenbomer via Getty

Managing cost and value

Stabilising approximately 50 per cent of the carbon in crop straw into biochar requires careful engineering of preparation and processing. Carbon dioxide removal may offset a third of its market price, with another third covered by sale of the co-generated renewable heat. End-user value would need to make up the balance, along with a buffer to protect against cost fluctuations and other markets.

Biochar production is unlikely to be cheaper than traditional charcoal, given the comparability of process. Nevertheless, biochar sold under $500 per tonne could logically enter the fuel market but couldn't compete with organic inputs such as compost (ca. $50 per tonne). Rather, standard biochar compares in price with chemical fertiliser, but with small or negligible direct nutrient content. Modified biochars, through selection of process and preparation parameters, may present opportunities to develop synergies with the high value components of production systems, particularly fertiliser management and crop establishment.

Scaling carbon removal with a biochar industry

A vast amount of literature documents what biochar can do at both farm and landscape scale, but with less capacity to predict what it will do in relation to dose and therefore its cost as a farm input. One-off 'experimental' doses of biochar are also less informative than those that optimise dose, placement and frequency in relation to price, so that adequate value can be assured from small additions integrated into the farming calendar. The large dose studies also do not directly inform the design of integrated products, such as fertilisers directly enhanced by the inclusion of biochar.

Even less extensive uses of biochar might be part of the path to national scale relevance in the very near term – inclusion in manures via improved management of housed livestock for example. Reaching true climate relevance will depend on general adoption in mainstream management of crops and pasture, scaled later through gradual inflation of dose or frequency. The pace of scaling would greatly benefit from active creation of knowledge and markets, providing CO_2 removal through a requirement for co-addition or co-supply of biochar with nutrient inputs.

A vision for social benefits from circularity

Improving profitability and resource efficiency in farming while expanding industrial capacity and capability would benefit jobs and the wider economy. An industry emerging around the production and formulation of biochar products for general use in mainstream crops would be positive for employment, on-farm economics and eventually ecosystem services. Other societal benefits can arise through time, when general adoption and routine application can impact ecosystem services that are delivered at landscape scale.

Look after the urban landscape and it will take care of you



Professor Catharine Ward Thompson

Professor of Landscape Architecture and Director of OPENspace research centre

Urban green and blue spaces can cool our cities, reduce flooding, enhance biodiversity, and enhance our physical and mental health, but we need to take care of them and ensure everyone can access their benefits.

More than 80 per cent of our UK population live in urban areas; globally that's 60 per cent[1] and rising. Resilient cities need to maximise the benefits that open space can offer citizens as part of a resource-efficient, circular economy. 'Circular cities'[2] involve integrated blue-green infrastructure and regenerating ecosystem services that are vital for human health.

Urban open space and health

Research on resilience to the climate crisis has shown how natural open space can ameliorate the worst of the effects. Vegetation, especially trees, can counter the 'urban heat island' effect. Playing fields and lawns can generate energy via ground-source heat pumps.[3] Street trees can make pavements more tolerable to walk along, and wooded parks, urban forests and seaside or riverside paths can create havens of cool relief in hot weather. These are just some of the ways that natural spaces can make a difference to human health. A report for the World Health Organization (WHO)[4] highlights, for example, how urban green space can improve the functioning of people's immune system, enhance cardiovascular health and improve social connections. The UN Sustainable Development Goals, including their emphasis on access to urban green space, are important ways to support better health. The UN Climate Action Agenda emphasises nature-based solutions to the crisis and WHO highlights examples of effective ways to improve natural spaces.[5]



Pride Outside 2023, Malls Mire Woodland, Toryglen, Glasgow

© Lesley Martin for Scottish Forestry

This underlines how natural open space in cities can offer multiple benefits at a time of competing demands for land use, when the climate crisis is exacerbating damage to global meteorological and biological systems. OPENspace[6] has shown that living near urban green[7] and blue space such as parks, woodlands[8] and watersides, and having easy access to it,[9] can make a real difference to human wellbeing and reduce costly demands on health services.[10]

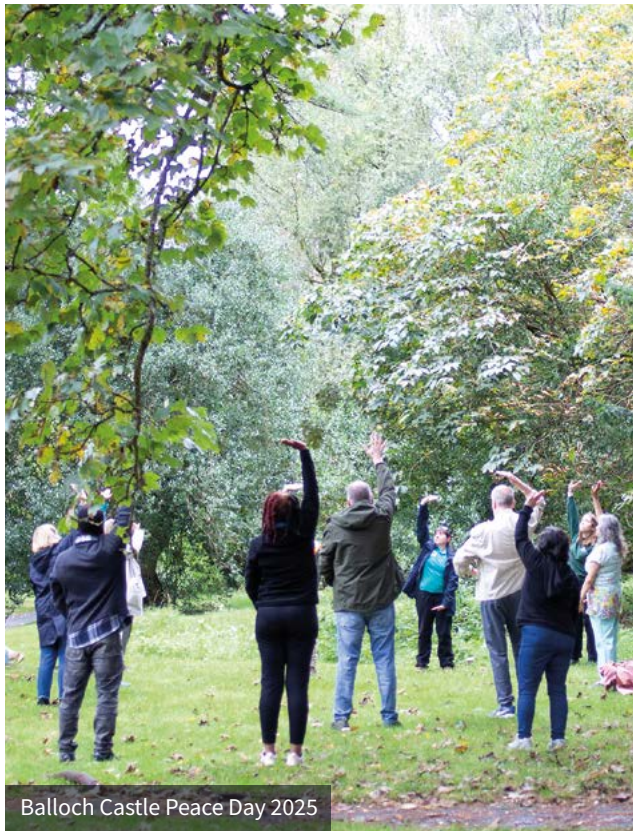
Urban open space and health equity

All this may sound positive – nature-based solutions in urban areas can deliver multiple benefits – but what about equity? Who does or doesn't have attractive and accessible green space near where they live? And if they do have such natural space nearby, do they actually visit and benefit from it? Recent evidence shows that more than 25 per cent of English adults visit green spaces less than once a month; across 33 European cities, more than 10 per cent of respondents never use urban green spaces. We have researched why people don't use urban green space – what we call the 'green gap'.[11] Our framework shows individual, political, societal, community or physical environmental factors often combine to make barriers to green space use. Unfortunately, those who are most likely not to visit green space are those most likely to get significant health and quality of life benefits if they do visit. How can we ensure nature-based solutions benefit them?

Planning, design and management of green space for all

We need to understand what attracts or deters green space use at different ages, in different contexts and walks of life. Research shows that natural open space offers opportunities for peace, relaxation and social activities, as well as physical activity.[12] Indeed, mental health benefits are key aspects of people's visits to blue spaces,[13] as well as green, so environments that help people destress, feel less isolated and engage with nature are especially important for people experiencing socio-economic disadvantage.

Childhood access to urban green space supports good child development but also establishes healthy patterns of green space use[14] that endure, even into very old age.[15]



Balloch Castle Peace Day 2025

© Miriam Ali for Scottish Forestry

Our urban green spaces must be accessible and attractive to people at every life stage,[16] and a key to this is that they're close to home. If the nearest usable open space isn't within 5–10 minutes' walk, then people are unlikely to use it often; yet frequent or everyday use is needed to benefit most from natural spaces. Professions responsible for planning, design and management of green space, especially landscape architects, have a vital role to play in ensuring it's available for every citizen. It must be easy to reach, but this may not be enough if it feels unattractive or lacks necessary facilities. To get this right, we must work with local communities as equal partners.

Working with people in different communities

A circular economy has a healthy natural environment that supports communities in their needs and aspirations and helps them engage with nature's benefits. In turn, they invite communities to care about the green and blue space nearby, help conserve and enhance biodiversity[17] and maintain sociable places for positive interactions with others. This creates a sustainable and virtuous cycle of benefit for human and ecosystem health.

One example of a programme that attempts to do this is Scottish Forestry's Woods In and Around Towns (WIAT) initiative,[18] which focuses on the most socioeconomically deprived urban communities. We've studied the effects of WIAT's programme to make local woodlands more attractive[19] and inviting. Recent research shows that it can make a significant difference to people's mental health, resulting in reduced demand for anti-anxiety and depression medication from health services.[20]

Working with communities on urban green space involves responding to a wide range of uses and users, from people wanting to grow vegetables in community gardens, through wilder space where young people can let off steam and test themselves, to places for relaxing, listening to the birds, or simply getting away from the stresses of everyday life.[21] For community members, exploring how they want to benefit from green space can be empowering.[22] This, in itself, may contribute to a sustainable and resilient circular economy, offering new opportunities for work or leisure activities that benefit all. People can experience how taking care of the natural environment, and getting involved in activities there, is good for society, but also good for them personally. Urban landscapes are therefore not 'nice-to-have' but a 'must-have' if we are all to survive and flourish.

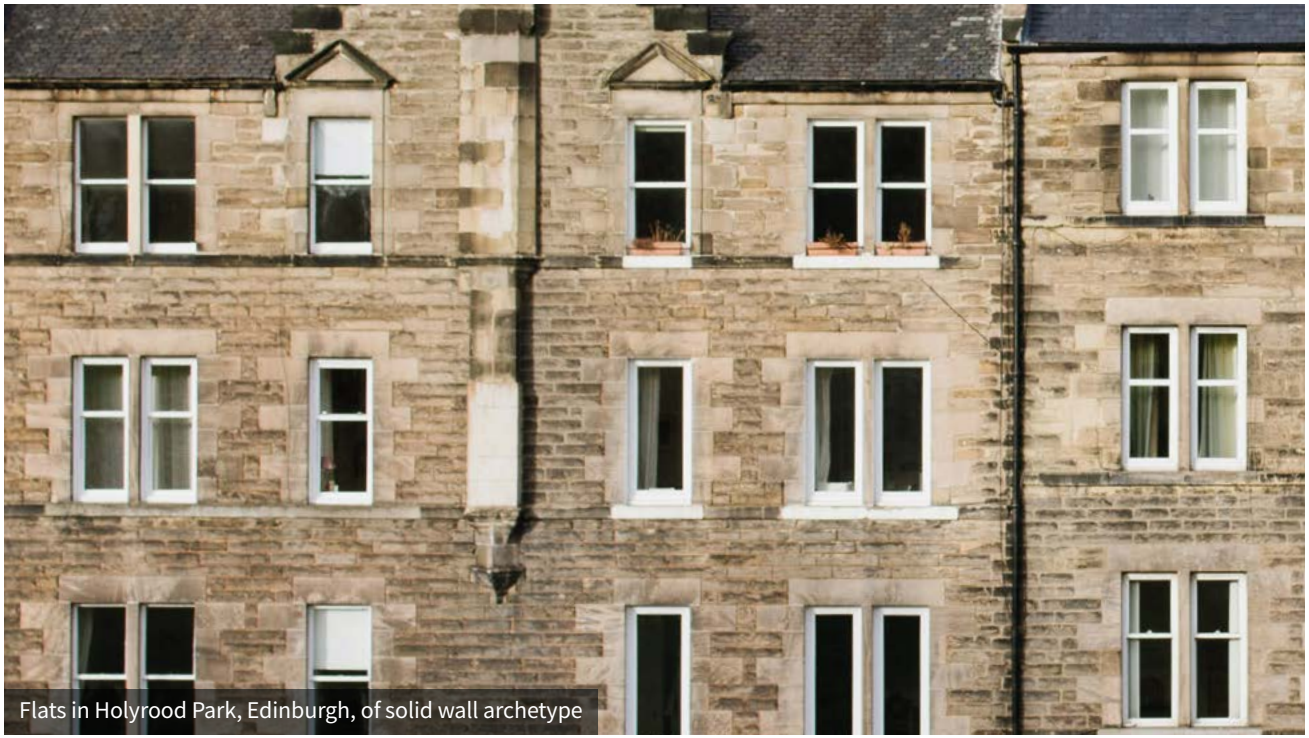
Rethinking how we can preserve and adapt our existing built heritage



Dr Julio Bros-Williamson

Lecturer and Chancellor's Fellow in Net-Zero Buildings

Across the UK, most people live in close proximity to a listed heritage site, and in Scotland, pre-1919 traditional stone buildings make up nearly a fifth of its entire housing stock. Climate change is no longer a future threat but a present reality and adapting to its impacts is one of Scotland's most urgent challenges. The Climate Change Committee warns that Scotland should prepare for global temperatures to exceed 2°C above pre-industrial levels within the next 25 years. While progress is being made to strengthen climate resilience in our towns and cities, significantly greater action is required to make our buildings more adaptable to these changes and to take occupants with us on this journey. Crucially, aligning local efforts with the Climate Action Agenda 4, which focuses on building resilience for cities, infrastructure and water, particularly the objective on sustainable and resilient construction and buildings. This requires actively promoting construction methods and materials that have a low embodied carbon for energy efficiency, materials innovation, and feed into projects of infrastructure resilience. Such actions can help ensure our urban areas successfully adapt to escalating climate risks.



Flats in Holyrood Park, Edinburgh, of solid wall archetype

Kirsten Drew via Unsplash

A heat(ed) topic

Focusing on Scotland, heatwaves are becoming more recurrent, with overheating in buildings and homes being a real issue for occupants health and wellbeing. During the summer of 2025, 60 people in Scotland died from climate-driven heatwaves, many of which were caused by high indoor temperatures.[1] The growing pace and scale of climate risks mean that adaptation efforts must accelerate, and buildings play an important role in mitigating these effects. Ultimately, effective climate resilience depends on acting early and working collectively across homeowners, building asset owners, communities, and public and private sectors. Notably, older buildings are more vulnerable and in the UK more than 80 per cent of the population live in homes built before the year 2000. Resilience and adaptation measures need to be in place to lower heat loss in winter and provide comfortable spaces during summer with good ventilation strategies and means of preventing heat from entering.

An approach to circular and adaptive climate-resilient building

The conditions in which our existing buildings are in can severely impact the occupants. If neglected, buildings can fall into disrepair or be used inefficiently by consuming high quantities of energy, emitting high carbon emissions, and being expensive to run. In many cases, this leads to existing buildings being earmarked for demolition due to their high maintenance and risk of structural damage (stone falling) and dangerous fires. In the case of older buildings, many have been built during different technological construction periods, implying the use of different materials and methods. Buildings constructed before the 1920s typically feature solid stone or brick walls, while interwar buildings experimented with hybrid systems and traditional cavity masonry systems with brick and concrete block.

Consequently, these building types respond differently to the effects of heat and colder conditions. Effective retrofit strategies therefore require a balanced assessment of building age, materials condition and performance characteristics to reduce energy waste, maintain thermal comfort, apply circular approaches and enhance climate resilience. Achieving these objectives demands coordinated action at an urban scale using datasets to identify similar building typologies and implement collective, no-regret retrofit interventions efficiently.

Climate solutions through archetype approaches

The Regional Energy Master Plan across six Scottish local authorities utilised housing archetype analysis for targeted carbon and energy retrofits. Employing open-source performance data, the analysis allowed local authority



Kieran Bennis

Performance testing of innovative homegrown natural fibre insulation

asset managers to prioritise low-performing dwellings for the use of retrofit funding. This framework generated standardised patternbooks in collaboration with Scottish architects, detailing optimal interventions and material specifications. Furthermore, the methodology integrates climate-resilient strategies to mitigate overheating, extreme storm impacts and water ingress, establishing a strategic approach to housing decarbonisation, structural longevity and sustained residential asset management practices.

Funded by UKRI, the University's Centre for Net Zero High-Density Buildings develops retrofit strategies in high-density towns and cities. A primary thematic focus examines building performance via retrofit, archetypes and green materials. Some of the innovations and new methods applied develop solutions that prioritise thermal performance and innovation in low-carbon materials to mitigate summer heatwaves and winter heat loss, while significantly enhancing buildings energy efficiency to increase grid capacity and low-carbon heating solutions.

The development of innovative green materials has also prioritised natural and less energy-intensive methods of production, which allows for reduced levels of embodied carbon during their production and encourages design for optimisation, adopting efficient maintenance and deconstruction methods and a circular economy approach. This also highlights the importance of addressing the lack of skills in the sector to move from high-carbon to low-carbon jobs as promoted by Zero Waste Scotland through their Circular Economy Construction Retrofit Training Programme within the Climate Emergency Skills Action Plan.

A final contribution: better knowledge

Proactive climate mitigation requires advanced knowledge and structural awareness. Utilising standardised archetype patternbooks that are predicated by circular economy approaches empowers property owners to enhance building resilience and occupant comfort. Furthermore, training younger generations is essential for resolving systemic climate challenges. The University and its Edinburgh Futures Institute address this through the Future Infrastructure, Climate Change and Sustainability masters programme. This interdisciplinary postgraduate programme prepares students to plan, adapt and design critical infrastructure for a resilient, net-zero future, while forming professionals capable of influencing policy, directing sustainable investments and delivering innovative socio-environmental solutions. As climate change pushes into our everyday life and more people are conscious of its origins and life-changing effects, there is an opportunity to support and prepare those more vulnerable, and to seek ways in which buildings can be the focus of many solutions and ways forward.

Enhancing a circular economy model to water management



Dr Efthalia Chatzisymeon
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Witthaya Prasongsin via Getty

Environmental scientists collect wastewater samples at a factory outfall into a river

Emerging contaminants pose new risks to health, the environment and to circularity of wastewater. Outdated water regulations and lack of incentives for the water industry allow the build-up of persistent contaminants in water and wastewater resources. This prevents the safe recycling and repurposing of wastewater. Only by strengthening water policies, to enforce the industry to monitor and control these persistent contaminants, the development of sustainable treatment solutions will be accelerated, and the water sector will increase its circularity in this regard.

Wastewater is a valuable resource

Increasing moves towards a sustainable circular economy are gradually replacing the traditional linear economic model in all sectors; the water sector is one of them. The COP 31 Action Agenda rightly seeks to improve water management by expanding resilient supply and sanitation and integrated resource governance. Wastewater is a resource that can be reused, recycled or repurposed. Our research team at the University reported several approaches to valorise municipal wastewater into irrigation water, aquifer recharge, or even drinking water in areas with severe water scarcity.[1] We recovered struvite, a very common fertiliser, through advanced precipitation processes in wastewater treatment plants.[2] We produced biochar from the pyrolysis of wastewater sludge and used it as an absorbent material for water treatment or for making construction materials. We used anaerobic digestion to produce biogas and generate electricity from wastewater.[3]

Modern wastewater contains persistent and forever chemicals

Despite being a valuable resource, over the last few decades there has been increasing evidence of the occurrence of persistent contaminants in wastewaters,

natural waters and the environment. These contaminants include pharmaceuticals and their metabolites, synthetic hormones, antibiotics, plastic compounds and, more recently, the so-called 'forever chemicals'. Forever chemicals do not degrade naturally and they can remain in the environment and in human bodies indefinitely. We reported also issues associated with the presence of artificial sweeteners in wastewater,[4] as well as the fact that microplastics have permeated the aquatic environment and are regularly detected in drinking water.[5]

Wastewater contains higher amounts of all of these contaminants since these chemicals are used to manufacture products ubiquitous in our everyday life (for example, personal care products, clothing and non-stick kitchen equipment). Persistent contaminants eventually end up in the sewage system and wastewater treatment plants, where they remain intact because existing plants were not initially designed to treat such types of synthetic chemicals. As a result, they are released into the environment and, flowing through the water cycle and the food chain, they build up in ecosystems, animals and humans. Researchers reported that, even though these contaminants are found in trace concentrations in the environment and in humans, long-term exposure to these chemicals can cause cancers, genetic abnormalities, infertilities and other health issues. Alarmingly, there is a rapid increase in studies that report the presence of such contaminants in human blood[6] and breast milk.[7]

Trace contaminants jeopardise circular economy

Circular economy in water management is threatened by the presence of these contaminants because they prevent safe reclamation and repurposing of the wastewater.

An example of this is the widespread and long-term agricultural use of treated sewage sludge in the UK. Water companies promoted the wastewater sludge to farmers as biofertilizer for decades, even though it contained forever chemicals, pharmaceuticals and microplastics.

This practice was deemed safe at that time since it complied with existing water regulations from the 1980s, when modern chemicals had not penetrated into the whole ecosystem. However, Scottish researchers reported recently a more than 1,000 per cent increase in microplastic levels in UK soil samples after just four years of wastewater sludge application.[8] This sparked strong reaction from environmental organisations who are calling for stricter regulations about the release of modern contaminants in the environment. Similar concerns exist when reusing treated wastewater for irrigation or other purposes, since it can transfer persistent contaminants in soil, natural waters, plants, animals and eventually to humans.



Andrew Linscott via Getty

Agricultural slurry spreading in a field in England

There is an opportunity to address this water pollution problem

Persistent contaminants and forever chemicals will be removed from water and wastewater only when regulatory gaps will be addressed. There are technologies and tools that can remove trace contaminants from water and wastewater. We developed lab-scale photocatalytic processes which were able to remove up to 87 per cent of ceftazidime[9] and up to 84 per cent of sulfamethoxazole[10] antibiotics from water. To increase the sustainability of the photocatalytic technology we used energy-efficient light emitting diodes (LED) that completely removed bisphenol-A, an endocrine disruptor, from water.[11] We were also able to destroy microplastics by advanced oxidation technologies.[12, 13] We are currently working on developing efficient nature-based adsorbents to effectively remove microplastics and nanoplastics from water.

However, the lack of strict regulatory limits for releasing such persistent contaminants into the environment delays the upscaling of these technologies and their integration in existing water and wastewater treatment plants. While some countries have made concerted efforts, environmental policies must be strengthened worldwide to minimise the impact of persistent contaminants on the environment and on human health. Stricter policies, and their enforcement, will incentivise water industries to adopt advanced tertiary treatment technologies and accelerate the removal of these contaminants. Policymakers and water regulators have the power to control the amount of persistent contaminants in water, which will increase circularity in the water sector and create a healthier environment for people.

Green Healthcare Scotland: Advancing circular healthcare in Scotland



Steven Chawk

MSc student and Programme Manager of Green Healthcare Scotland, Centre for Sustainable Delivery, NHS Scotland



Jonathan Borba via Unsplash

The Global Action Agenda calls for resilient health systems that can respond to the climate and environmental crises while safeguarding population health. The Belém Health Action Plan supports this ambition by identifying capacity building, evidence-based policy implementation, innovation and sustainable production as key enablers of health system resilience. Circular economy approaches align closely with these priorities, offering opportunities to reduce waste, improve resource efficiency and maximise the value of existing products and infrastructure.

The need for this transition is clear. Healthcare exists to improve health and wellbeing while minimising harm. Yet the delivery of care consumes vast quantities of materials, energy and natural resources, contributing to carbon emissions, pollution and waste. For decades, healthcare systems have largely operated on a linear model of take, make, use and dispose. To build sustainable and resilient health systems for the future, this model must evolve towards a more circular economy.

A circular economy seeks to design waste out of a system rather than manage it after it has been created. In healthcare, this means rethinking how products, services and clinical pathways are designed and delivered to maximise value, minimise waste and reduce the consumption of finite resources. The Green Healthcare Scotland Programme within NHS Scotland works with clinicians, academics, policymakers, suppliers and regulators to accelerate the transition towards a circular healthcare system. Through collaboration and innovation, we are identifying practical opportunities to reduce resource consumption, extend the value of products and materials, and eliminate avoidable waste while maintaining high-quality patient care.

Beyond sustainable procurement

Sustainable procurement remains an important part of healthcare's environmental response. However, circular healthcare requires a broader perspective. Rather than focusing solely on what we buy, it asks how products are designed, maintained, reused, repaired and, where appropriate, remanufactured.

One of Green Healthcare Scotland's priorities is to embed circular economy principles within frontline healthcare services. Across the health service, we



AI generated

Ethyl chloride and cool stick

support the testing, evaluation and scaling of initiatives that reduce environmental impact while maintaining clinical effectiveness, from changes in clinical practice to innovations that influence product design, procurement approaches and regulatory frameworks.

A simple example is the replacement of single-use ethyl chloride spray with a reusable 'cool stick' for assessing the effectiveness of spinal anaesthesia. Ethyl chloride spray has traditionally been used to create a cold sensation that helps clinicians determine whether a spinal block is effective. However, the product is single-use and generates avoidable waste.

The cool stick provides the same clinical function through a reusable stainless steel device that can simply be cleaned between patients. By replacing thousands of disposable spray cans with a durable reusable alternative, this intervention reduces waste generation, lowers demand for single-use products and supports a more circular approach to care delivery.

Making better use of existing resources

Circularity is not only about replacing disposable products with reusable alternatives. It is also about ensuring that existing resources are used as efficiently as possible.

An example is the optimisation of surgical instrument trays used within operating theatres. Many trays contain instruments that are rarely or never used during procedures, yet every instrument must still be transported, cleaned, sterilised and repackaged after use.

Working with clinicians and sterile services teams, Green Healthcare Scotland supports tray rationalisation initiatives that remove unnecessary instruments while maintaining clinical safety and effectiveness. Reducing tray sizes decreases sterilisation demand, lowers water and energy consumption, reduces instrument wear and extends product lifespan. This approach demonstrates how circular economy principles can improve both environmental and operational performance by eliminating waste from healthcare processes.

Influencing the medical device market

We are also exploring opportunities to extend the life of medical devices through remanufacturing.

While countries such as the United States and Australia have established regulatory pathways that enable the safe remanufacture of certain medical devices under controlled conditions, current UK guidance does not permit the remanufacture of single-use Class I medical devices. These devices generally represent the lowest-risk category of medical device and are typically non-invasive products used routinely across healthcare settings

In collaboration with Scottish Government, NHS Scotland colleagues, industry partners and regulatory stakeholders, we are taking forward a pioneering pilot focused on a Class I medical device. The project aims to generate evidence on the environmental, economic and operational benefits that remanufacturing could deliver within a Scottish healthcare context.

By building the evidence base for remanufacturing within a healthcare setting, this initiative has the potential to inform future policy and regulatory development and create the conditions for wider adoption of circular economy approaches across healthcare. More broadly, it demonstrates how innovation and collaboration can help accelerate the transition towards a more resource-efficient, resilient and sustainable healthcare system.

Looking ahead

The transition to circular healthcare will not be achieved through a single innovation or policy change. It requires collaboration across governments, healthcare systems, industry and regulators to rethink how products and services are designed, procured, used and valued.

The examples emerging through Green Healthcare Scotland demonstrate that practical solutions already exist, from reusable clinical products and surgical tray optimisation through to pioneering work on medical device remanufacturing.

As healthcare systems respond to climate change, resource constraints and growing demand, circularity offers more than an environmental solution. It provides an opportunity to create systems that are more efficient, resilient and sustainable. In doing so, circular approaches can help deliver the ambitions of the Global Action Agenda and the Belém Health Action Plan by supporting innovation, building capacity and informing future policy and practice. If healthcare is to align its mission of protecting health with the realities of a changing planet, becoming circular is not simply an option; it is a necessity.

The double-edged sword of air pollution and climate change: Health is key



Chris Close

Professor Mark R Miller

Personal Chair of the Environment and Health, Institute of Neuroscience and Cardiovascular Research

Air pollution and climate change are both environmental stressors with significant impacts on environmental and human health. Previous COP conferences have traditionally focused predominantly on climate change, and arguably through an environmental lens rather than human health. However, perspectives are evolving, with sessions dedicated to air quality appearing in the COP fringe events, and with the theme of health gaining momentum. Indeed, promoting resilient healthcare systems is a key ambition of the COP Action Agenda, with both air quality and climate (in)stability being crucial to that resilience. Establishing a circular economy will be an important tool in realising those aims, by halting the production of both greenhouse gases and air pollutants.



Santiago, Chile, under a haze of pollution

Nikolai Kolosov via Unsplash

While climate change and air pollution are distinct, they can be viewed as two sides of the same coin. They interact in many ways, frequently exacerbating each other. However, the scientific distinction is important, especially in terms of interventions, where the nuances of each risk factor can become apparent. A good example of this was the push for diesel vehicles around the turn of the millennium. Diesel vehicles emit lower levels of carbon dioxide (a key driver of climate change) compared to petrol engines. However, this overlooked the greater numbers of nano-sized particles in diesel exhaust. Particulate matter is the key class of air pollutants responsible for the adverse effects on human health, especially nano-sized particles which can carry a cocktail of harmful chemicals into the blood to affect every organ system.

A prominent risk factor

Air pollution has been repositioned from a 'niche' research interest to a prominent risk factor for human health. Air pollution is ranked as the second highest risk factor for morbidity and mortality. Globally, around eight million premature deaths are attributed to air pollution every year.

Low- and middle-income countries in particular are at risk, tending to have higher levels of air pollution as well as higher rates of disease and a lack of access to adequate medical care. However, higher economic settings, should not be complacent. There does not appear to be a threshold level of air pollution below which no harm is caused. This has led the World Health Organization to propose highly stringent guidelines for air pollution, yet only a handful of countries worldwide meet these targets.

More than half of the mortality attributed to air pollution is due to cardiovascular causes, notably ischaemic heart disease and stroke, although there are links with all major cardiovascular diseases. Our own programme of research at the University has demonstrated that exposure to air pollution causes wide ranging effects across the cardiovascular system that promotes cardiovascular disease and increases the risk of heart attacks and stroke.[1] A large network of interacting biological pathways underlies these effects. Interestingly, many of these pathways overlap with those caused by extreme temperature, the cardiovascular effects of which account for a high proportion of hospital of admissions during heat episodes.

The rise of some air pollutants

While many of the established air pollutants have fallen, others have not. Ground-level ozone, for example, is predicted to rise in the future; a concern not only because this pollutant has adverse health effects, but also because the synergies with climate change. New pollutants of concern are also emerging, including brake and tyre wear particles[2] (which may increase due to the heavier weight of electric vehicles), indoor air pollution[3] (with some potential conflicts where building net-zero measures that reduce ventilation may encourage the build-up of indoor-derived pollutants), and airborne micro/nanoplastics (a pollutant of concern that is highly relevant to a circular economy).



Marc Szeglat via Unsplash

The increasing occurrence and severity of wildfires also leads to prominent episodes of air pollution, which can travel hundreds of miles beyond their source, leading to marked increases in hospital admissions in urban areas. Wildfires are a good example of the synergies with climate change. Higher temperatures, as well as poor land and vegetation management, and encroachment of urban areas into wildlands, is increasing the risk of wildfires. In turn, combustion-derived air pollutants from wildfires feedback into climate change through heat retention and disturbance of atmospheric precipitation.

An opportunity to find solutions

While it is important to appreciate the huge health burden of air pollution, an opportunity emerges: if we can effectively tackle air pollution, we could also improve cardiovascular health. Indeed, epidemiological studies have shown that relocation to areas of better air quality, or the gradual improvements in air quality over the last decade, is accompanied by reductions in cardiovascular risk. While the relationship between air pollution and climate change is complex, the solutions are already in our hands. Fossil fuels are major drivers of both, and their replacement with cleaner alternatives will, overall, lead to co-benefits for both air quality and slowing global warming.

The implementation of circular economies will reap benefits, not just financially, but also through reduction of (and exposure to) various pollutants. Better urban design with more local amenities, traffic control, public transport and greenspace, will reduce vehicle use and improve health and wellbeing through physical activity. Development of cost-benefit analyses that encompasses both the direct and indirect effects of climate change, and factor in interactions between environmental risk factors, are needed to convey the substantial cost savings from this improved health. Inclusion of health, thus, needs to be a central theme of the COP discussions: tackling air pollution and climate change is not just about the environment, it is about our health, and the health of future generations.

Universities as transdisciplinary network hubs for circular transitions



Dr Lucy Wishart

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Natalya Kosarevich v via Getty

By embedding transdisciplinarity in education, universities can contribute to circular economy networks that will help address the climate and environmental crises with expertise and learning opportunities to address the climate and environmental crises.

'How do you teach the circular economy?' is one of the most asked questions about our MSc in Circular Economy at the University's Edinburgh Futures Institute. And certainly, addressing the climate crisis by transitioning to a circular economy requires a complex blend of evidence to identify and support change, as well as individuals with the confidence and capabilities to navigate these multifaceted knowledge systems. A dual purpose that presents new challenges for education for circular futures.

The need for transdisciplinary knowledge systems

A circular transition requires understanding systems, identifying targets, and designing transitions across ecological, economic and socio-cultural realms. And the evidence base that supports circular policies, innovations, business models and behaviour change transcends traditional academic disciplines and sectoral expertise. Circular resource systems are place-based, so transitions require local understanding of environments, relations, cultures and infrastructures while circular targets involve confronting waste and wasting within a global system, in turn raising critical questions about what we value in life and how we might reorganise systems to reflect those values. Circular ideas that seem sensible on paper can often be more complex in practice. For example, in 2025, the Scottish Environmental Protection Agency announced a two-year delay to the planned ban on landfilling biodegradable waste in Scotland, when it emerged that lack of appropriate reprocessing centres in Scotland would mean that waste would have to be transported to other countries. The transport of waste elsewhere put a heavy economic burden on small rural waste management companies as well as negated any carbon savings

from removing the biodegradable waste from landfill. Although the ban would have helped Scotland reach domestic circular targets, the economic costs alongside the environmental repercussions, require more systemic change locally to contribute to climate change mitigation.

The realities of transdisciplinary research

Transdisciplinary networks support circular transitions by creating knowledge systems that are scientifically robust and socially accepted. Academics from diverse disciplines work alongside societal actors to understand the most pressing resource-management issues before collectively identifying well-evidenced context specific interventions.

While the importance of transdisciplinary knowledge networks to circular futures is rarely questioned, the actual work of transdisciplinary research and knowledge can, in practice, be challenging to implement. For example, knowledge exchange in the circular economy has predominantly focused on smaller scale interventions without much consideration given to macro-systems change. Universities have historically tended to contribute to circularity through research expertise in the applied fields of engineering and environmental science at the expense of more transformational change. And yet, universities arguably offer an ideal critical public space to explore challenging conversations around questions of growth, sufficiency and equitable systems of resource use.

Universities as transdisciplinary network hubs

Universities can act as a 'microcosm of circularity' where responsibilities for innovative research and future-focused learning sit alongside resource management in complex estates. As the university campus offers opportunity to test-bed circular interventions so it creates space for diverse communities to engage in the kind of transdisciplinary networks that explore technical solutions alongside more radical discussions about how circular futures can help address the climate and environmental crises. Interacting through living lab projects like the University's Forest and Peatlands Programme project CirHIVE – allows students and staff alike to build the confidence and capabilities required to engage in broader transdisciplinary networks for circularity.

Navigating transdisciplinary knowledge systems for circular futures does require technical and digital skills but they also need 'big picture' strategic and interpersonal skills including systems-thinking; knowledge facilitation and multistakeholder collaboration and communication. By creating opportunities to develop these key and adaptable skills, universities have a central role in achieving the education and capacity building objects of the Global Climate Action Agenda's pillar on fostering human and social development. The MSc in Circular Economy at the Edinburgh Futures Institute focuses on building these skills, by inviting students to participate in transdisciplinary networks for sustainability within the classroom and beyond.

Learning together in the circular economy

Students learn with experts from across academic disciplines and guest speakers from industry, government and civil society. Collaborative learning activities create space for students, academics and external experts to critically and collectively discuss circular futures. Assessments provide opportunity for students, academics and external partners to experience navigating transdisciplinary knowledge systems, actively developing the interpersonal and strategic skills needed for success both of individuals and more systemic circular transitions. Connections made through these knowledge exchange activities can spill out of the classroom into collaborations and funding bids but equally the classroom can provide the space to explore transformational questions about circular futures that more project-based collaborations lack. From this perspective the importance of the iterative relationship between research, education and impact becomes more acute in circular knowledge systems.

Universities can contribute to transdisciplinary networks for a circular future by providing the academic expertise to support well-evidenced interventions. But universities can also provide the opportunities for students, researchers and external stakeholders to collaborate and develop the necessary skills to navigate transdisciplinary networks to generate the knowledge needed to support circular futures that make a positive contribution to the climate crisis. So how do we teach the circular economy? The answer is that we don't do it alone.

Take, make, waste



Ian Hamilton

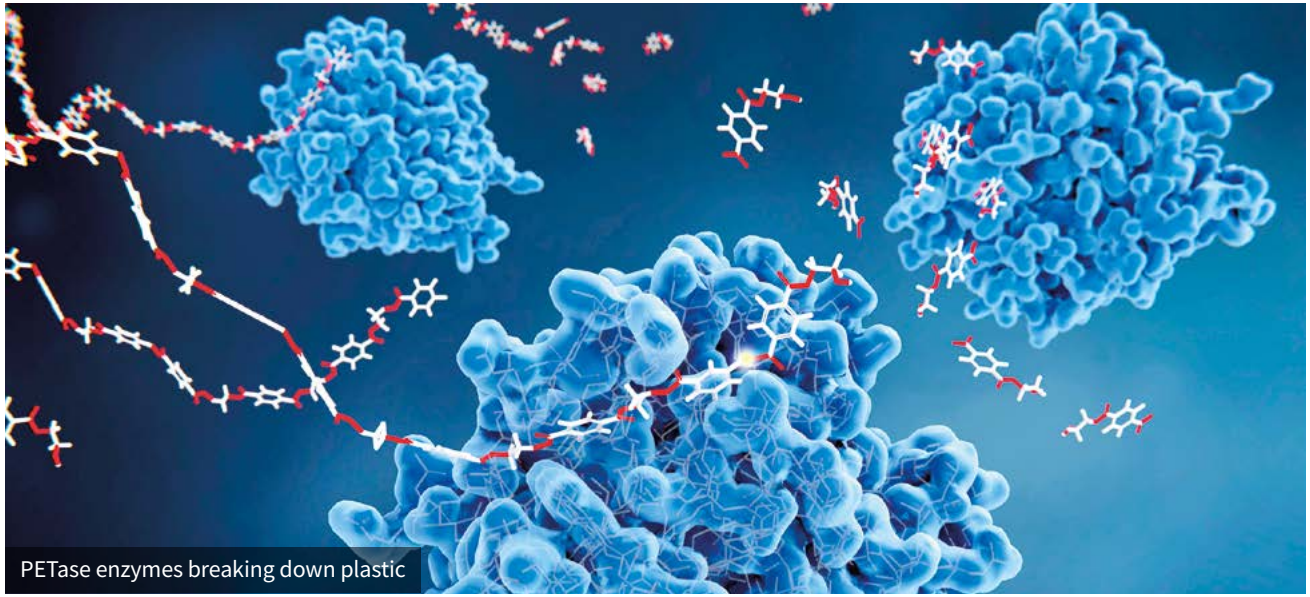
Professor Louise Horsfall

Chair of Sustainable Biotechnology, Head of the Institute of Quantitative Biology, Biochemistry and Biotechnology



Dr Joanna Sadler

Senior Lecturer, the Institute of Quantitative Biology, Biochemistry & Biotechnology



PETase enzymes breaking down plastic

Juan Gaertner/Science Photo Library via Getty

We have built an economy that digs up finite resources, uses them briefly, and buries or burns what is left.

Plastics and metals sit at the heart of that model. Each is an essential material for modern living and is a crucial enabling resource for a more sustainable and healthy future for people and planet. Yet more than 75 per cent of the plastic that has ever been made is now waste;[1,2] and global recycling of rare earth elements is just one per cent.[3] The circular economy, where 'waste' is repurposed as a resource, proposes a better way, yet so far has not been implemented at scale.

Engineering biology enables circularity by design

The road to Antalya is being framed around delivery: the COP 31 Presidency has set out to move from agreed ambition to practical results, guided by dialogue, consensus and action. Its Action Agenda places zero waste and green industrialisation alongside clean energy and electrification. This is a welcome opening for enabling technologies, such as engineering biology,[4] which to date has received far too little attention in climate discussions particularly in terms of the role it could play in addressing the climate and environmental crisis. Engineering biology is a set of tools capable of doing the hard molecular work under the traditionally 'mild' conditions needed to enable a circular economy.

Consider plastics first. Mechanical recycling, the shredding and remelting, works tolerably well for clean, single-polymer streams such as drinks bottles. It works badly for everything else. Mixed plastics, multilayer packaging, dyed and contaminated materials, and textiles blending several fibres, degrade with every cycle or simply cannot be processed. Much of what we put in the recycling bin is downcycled into lower-value products or quietly diverted to landfill and incineration. Metals present a different problem. Steel and aluminium recycle well, but the critical metals that power the energy transition, such as lithium, cobalt, nickel and the rare earth elements, are often present in tiny quantities, locked into complex electronics and batteries. Conventional recovery relies on energy-hungry smelting or on harsh chemical leaching, which generates hazardous waste. Meanwhile, demand for these materials is set to climb steeply as we electrify transport and decarbonise power. Both problems share a root cause: our existing processes are blunt instruments applied to intricate materials. Biology, by contrast, has spent billions of years perfecting precision chemistry at ambient temperature and pressure.

The most striking demonstration of what engineering biology can do for plastics is enzymatic recycling. In a global effort, researchers have discovered, and then engineered, enzymes capable of breaking down PET (polyethylene terephthalate), the polymer used in single-use drinks bottles, food packaging and polyester clothing, back into its chemical building blocks. Protein engineering, now turbocharged by AI-based structure prediction tools like AlphaFold, has made these enzymes faster, more stable and more tolerant to industrial conditions than anything found in nature. The significance is not merely that plastic can be degraded. It is that it can be rapidly depolymerised into pure monomers, which can then be used to make new plastic indistinguishable from virgin material. Further, enzymes or microbes can be designed to take these monomers and use them as a feedstock to make new, higher value chemicals like perfumes, flavouring and medicines. Because enzymes and microbes work at modest temperatures, the energy demand is lower than for thermal routes, and because they are selective, they can in principle tease apart the mixed and contaminated waste that defeats mechanical recycling.

Researchers at the University have shown that engineering biology also works at the other end of the lifecycle, and we can embed principles of the circular economy into this process by design. Carbon rich waste streams from industry, including plastic waste itself, can be fermented into building blocks for bio-based polymers such as polyhydroxyalkanoates (PHAs) and polylactic acid (PLA), which can then be safely depolymerised under industrial composting conditions. These bio-based plastics in themselves also pose an ideal feedstock for biological upcycling, pointing towards a future plastics economy, enabled by engineering biology, which operates independently of fossil-derived carbon.

For metals, the biological toolkit is just as compelling, if less widely appreciated. Microbes have been used in mining for decades: biomining, using bacteria to help extract copper and gold from low-grade ores, already accounts for a meaningful share of global production. What is new is the ability to engineer these organisms, and the proteins they produce, for greater selectivity and efficiency.

Engineered bacteria and designed proteins can bind specific metal ions with extraordinary selectivity. This allows rare earth elements with near-identical chemical properties to be separated from one another, a task that currently requires dozens of energy-intensive solvent extraction stages. Researchers at Edinburgh are showing microbes can transform low-concentration waste into valuable feedstock without the furnaces and mineral acids of conventional routes, when applied to electronic waste, spent lithium-ion batteries and industrial effluents. Those same approaches also apply to bioremediation, as the organisms that capture metals from waste can also clean contaminated soil and water.

Closing the materials loop

If we want a circular economy for plastics and metals rather than merely an aspiration for one, there are many gaps to close. That means public-private partnerships to create scale-up and follow-on facilities. It means non-dilutive proof of concept funding to support the transition from academic laboratory research to higher technology readiness levels where most commercialisation endeavours fail, thereby carrying promising science across the ‘valley of death’. And it means a skills pipeline, including retraining chemical and process engineers from the petrochemical sector, whose expertise in large-scale processing is exactly what biomanufacturing needs. There is a neat symmetry in workers who built the fossil economy being retrained to help replace it.

Engineering biology is not a magic wand, and advocates do themselves no favours by pretending otherwise. Technical challenges must still be addressed for biological recycling and upcycling to compete on cost with cheap virgin plastic and petrochemicals. Indeed, success here will underpin all subsequent attempts at scale-up and deployment. This must also be incentivised by policy that properly values recycled and non-fossil carbon derived content. Biological metal recovery is still maturing, and some processes are slow compared with smelting. Regulation of engineered organisms remains uncertain and differs globally, which matters for any company planning to deploy them. And the best circular economy is one that reduces consumption first; biology should complement reuse and reduction, not excuse us from them.

Public trust matters too. Genetic technologies provoke understandable questions, and the sector must be open about how engineered organisms are contained and governed. Dismissing those concerns would be both arrogant and strategically foolish.

Still, the direction of travel is clear. The linear economy is running into resource limits, climate targets and public impatience. The tools to replace it are emerging, and they are increasingly biological. Countries that build the skills, facilities and regulatory clarity to use them will capture the jobs and the value; those that hesitate will import the technology, and the benefits, from elsewhere. Plastics and metals are not going away. The question is whether we keep digging and dumping, or learn to grow, recover and reuse. Engineering biology offers a credible way to do the latter, and the time to act is now.

Towards regenerative sustainability

The University has published its sector-leading regenerative sustainability strategy, which seeks to go beyond minimising harm, to proactively restore natural systems to benefit both nature and people.

Created through substantial consultation and collaborative planning, the strategy outlines a science-based, achievable approach, that seeks to meaningfully address the challenge of the environmental polycrisis facing the planet.

Launched in March 2026, our regenerative sustainability strategy commits us to go:

- beyond a primarily operational focus, prioritising areas where the University has the greatest impact, such as its research and innovation and its learning and teaching;
- beyond net zero carbon targets, to a comprehensive and interconnected response to the environmental polycrisis of climate change, nature loss, water, chemical pollution, overuse of resources and;
- beyond sustainability as merely limiting environmental damage, for example, ecologically regenerating an area five times the size of our combined physical campuses, and targeting net negative carbon, following 1.5°C-aligned five-year carbon budgets.

Our net negative carbon commitment includes all emissions, including international student travel, investments and supply chains, with a decarbonisation pathway aligning with a 1.5°C warming scenario.

Read more: **www.ed.ac.uk/regenerative-sustainability**



Andrew Perry



Neil Hanna

Above: Undergraduate students on the ecological measurement course from the School of GeoSciences visit Barvick Burn Wood, a 431 hectare site in Perthshire. The students collected valuable baseline plant data from the area where woodland is being created whilst gaining valuable fieldwork experience. The data they collect will help assess how the site meets its carbon sequestration, ecological conservation and social impact objectives. The University has committed to sequestering over one million tonnes of CO_2 over a 50-year period through its Forest and Peatland Programme.

Left: PhD candidate Alice Barron-Eaves performed her poem 'Passing on the heft' at the launch of the University's regenerative sustainability strategy in McEwan Hall. The poem explored themes of nature, agriculture and the passing of knowledge from one generation to the next.

Advancing action at the University

Climate and environment research and innovation

The University is ranked globally for its excellence in research, teaching and innovation. Our academics are at the forefront of applying cutting edge research to help communities adapt and mitigate the effects of the climate emergency.

W: www.earth.ed.ac.uk/research-action-impact

Edinburgh Earth Initiative

The Edinburgh Earth Initiative is a strategic support unit that accelerates the University's interdisciplinary research, partnerships and innovation activities, addressing the climate and environmental crises.

E: earth@ed.ac.uk
W: www.earth.ed.ac.uk

Edinburgh Impact

Edinburgh Impact showcases the University's global research and innovation, including significant work on climate change, environmental sustainability, and ecosystem conservation.

W: impact.ed.ac.uk

Edinburgh Innovations

Edinburgh Innovations drives climate and environmental innovation at the University, connecting researchers with industry to tackle sustainability challenges through partnerships and cutting-edge facilities.

W: www.edinburgh-innovations.ed.ac.uk/expertise/sustainability

Forest and Peatland Programme

Our long-term, multi-million-pound project to restore peatland and expand forests in Scotland. This project will remove carbon from the atmosphere, increase biodiversity, connect woodlands, improve recreation and scenery for local communities, and preserve cultural heritage sites.

W: www.sustainability.ed.ac.uk/operations/forest-peatland

Regenerative sustainability strategy

The University is working to become an environmentally regenerative university. From the energy we use to the emissions from student travel to study here, we will be carbon net negative, nature net-positive and circular in our resource use.

W: www.ed.ac.uk/regenerative-sustainability

Circular economy

Award-winning circular fashion research

Pioneering research led by the University's Law School won a prestigious Business Law Prize. Their research on circular fashion investigated legal frameworks for sustainable and ethical industry practices.

W: www.law.ed.ac.uk/news-events/news/pioneering-research-circular-fashion-wins-prestigious-business-law-prize

Carbon-Loop Sustainable Biomanufacturing Hub

C-Loop is a sustainable manufacturing hub that uses microorganisms to transform carbon-based waste products into next generation materials such as pharmaceuticals. More than 40 industry partners from seven different sectors are involved in the hub, which will help integrate products manufactured using fossil fuels into a circular economy.

E: Stephen.Wallace@ed.ac.uk
W: www.ed.ac.uk/news/new-hub-uses-microbes-to-turn-trash-into-treasure

Responsible Electronics and Circular Technologies Centre (REACT)

The University is part of the REACT research centre: advancing sustainable electronics, reducing e-waste and emissions through circular technologies and cross-sector collaboration for a net-zero future.

W: www.react.ac.uk

The Horsfall Group

The Horsfall Group is interested in multidisciplinary challenges involving biotechnology and synthetic biology. It is especially interested in how these areas might make manufacturing more resource efficient and help move us towards a more sustainable, circular economy. The group is affiliated to the Institute of Quantitative Biology, Biochemistry and Biotechnology; the Centre for Engineering Biology; and the Centre for Science at Extreme Conditions, at the University.

W: www.biology.ed.ac.uk/horsfall/research

Endnotes

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Building resilience for cities, infrastructure and water

Look after the urban landscape and it will take care of you

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Unleashing enablers and accelerators

Take, make, waste

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