



CROSS-SCALE RELATIONSHIPS

BREE TREVENA

Dr Bree Trevena currently leads Arup's Australasia Foresight team, where she brings a future-focused lens to place-based policy and strategic design, and infrastructure delivery.

Regenerative Design: Across Urban Scales



Regenerative design is living in harmony with nature. As the most influential species, we have an ethical and ecological responsibility to participate in the natural system in a positive, reinforcing way.

Image: Arup

“Historically, the evolution of human consciousness has expanded through various stages: from individualistic to tribal to national and international perspectives. Now, we must extend that further to a planetary perspective that sees all life on Earth as connected.”
- Michael Pawlyn, architect and systems thinker

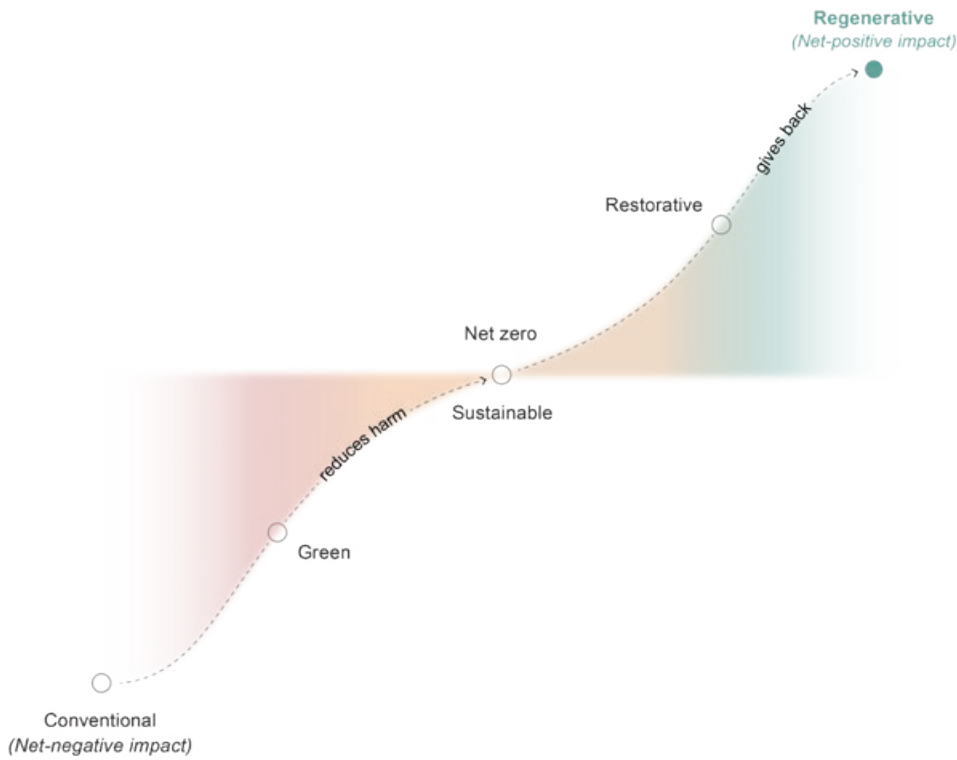
Beyond Sustainability

Sustainability has moved from the periphery to the heart of built environment practice. No longer an afterthought, environmental goals have become central focus points for everything from conference agendas to policymaking. But is sustainability enough to save our planet, or is more required?

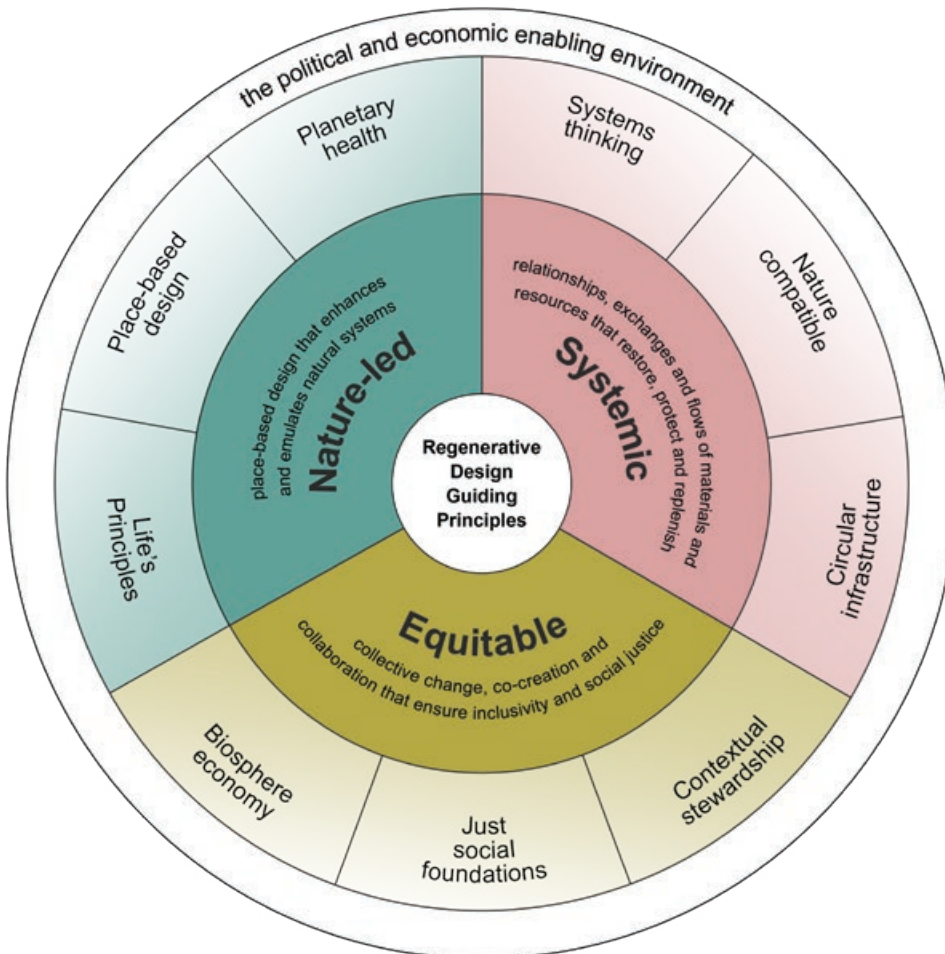
Every year, the World Economic Forum surveys experts for a sense of the biggest risks facing our shared economic, environmental, and social wellbeing. Looking ahead to the next decade, the 2025 Global Risks Report finds that four out of the top five critical challenges are environmental: extreme weather, biodiversity loss, shortages of natural resources, and major shifts in Earth's systems.

The science and economics behind these warnings are clear. For example, the Stockholm Resilience Centre's “planetary boundaries” framework quantifies the limits within which humanity can safely operate. When the framework was first introduced in 2009, three boundaries had been crossed. Today, the number is seven. This includes those relating to fresh water, climate change and ecosystem health.

Scientists argue that human activity has changed the planet to the extent we are in a new geological era—the Anthropocene. In cities, this influence is clear. Urban growth shapes our air, water, and green space. Despite recent sustainability achievements, more is needed to help cities and nature recover together. That's where regenerative design comes in.



Transitioning towards regenerative outcomes.
Adapted from Reed and Mang (2007)



Regenerative Design Guiding Principles.
Image: Arup



The bioremediation facility relies on a food-chain-based approach in which primary producers (algae and higher-order plants) and consumer organisms (fish, birds, and insects) break down urban wastewater components.
Image: Riyadh Bioremediation Facility

A circular approach has the potential to reduce up to 75% of embodied emissions in the built environment while unlocking substantial economic benefits and new value chains.

Towards Regenerative Design

Where sustainable or green design aims to reduce harm, regenerative design challenges us to do better by actively improving social and planetary health. Of course, regenerative practices are not new. The approach is foundational to many world views which have long understood our place within nature's cycles as one of stewardship and of ensuring abundance for future generations.

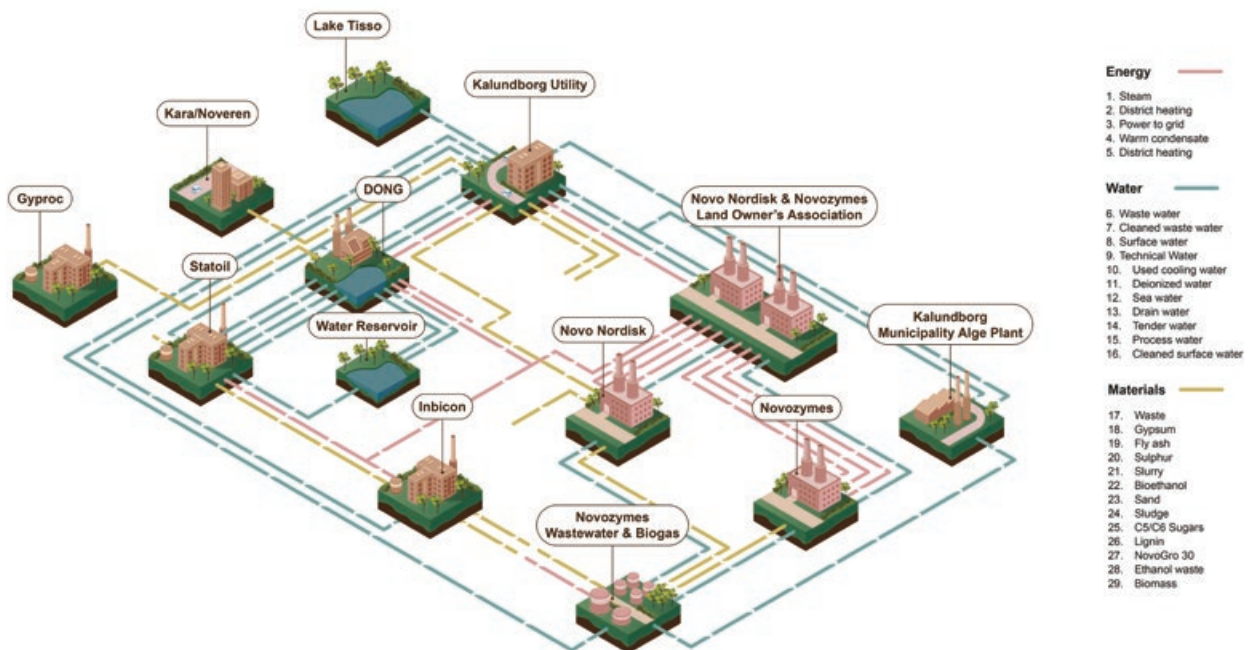
Yet a shift from sustainable to regenerative design is not straightforward. Among other things, it requires a fundamental shift in values, economics, and material practice. Fortunately, we have 3.8 billion years of data from nature to learn from.

While we may not have all the answers, there are practical avenues to test and embed regenerative design principles while delivering positive real-world outcomes. Taking a cue from the principles of

life itself, the following regenerative principles form a compass, anchoring urban projects into the local context, while enabling meaningful contributions to people, place and planet.

Nature-led: place-based design that enhances and emulates natural systems. Design and engineering using nature as a model is gaining traction, from the permeable pavements of sponge cities like Auckland and Nairobi to natural habitat restoration and rewilding at Shenzhen's Qianwan Park. Research shows nature-based solutions are, on average, 50% more cost-effective than human-made alternatives and deliver 28% added value.

There are tried and tested examples of nature-led approaches working in practice and at scale. Developed in 2009, Riyadh's Wadi Hanifa Wetland has a nature-led approach at the heart of its bioremediation facility.



Kalundborg Symbiosis is a partnership built around sharing surpluses within the system. The industries located on the campus operate as circular approaches both within their own operations as well as across industries.

Image: Arup

With a technical design inspired by a rocky river, stone barriers alter flows to oxygenate water. Each day more than 350 million litres of wastewater are treated using natural processes and ecological 'partners' like algae, birds, insects and fish.

Before reaching the restored wetland, naturally treated water flows into a city-wide river park system, borrowing a trick from nature to create a reprieve in the desert heat. Riyadh also reports saving millions by reducing potable water used for irrigation, preservation of agricultural land and tourism.

Systemic: attending to the relationships, exchanges, and flows of material and resources that restore and replenish.

In an age of resource shortage and supply chain fragility, a systemic approach keeping materials in circulation makes increasing sense. A circular approach has the potential to reduce up to 75% of embodied emissions in the built environment while unlocking

substantial economic benefits and new value chains.

Kalundborg Symbiosis in Denmark is a compelling example of a partnership built with the purpose of sharing surpluses in a system. The industries located at this eco-industry campus operate according to circular approaches, both within individual operations and across organisations.

Participants coordinate energy, water, material and waste loops to reduce resource use and waste generation using on-campus closed loop systems. Across the partnership, 87,000 tonnes of materials are circulated, saving 3.6 million m³ of ground water; 635,000 tonnes of CO₂; 100 GWh of energy; and S\$24 million in socio-economic savings.

Equitable: collective change, co-creation and collaboration to ensure inclusivity and social justice. A truly successful transition will be one with equitable social foundations at

its core. Formalised pathways for community voices already show the value of inclusive decision-making. Increasingly, "expert communities" and "community experts" are working across silos to integrate place-making and land stewardship in driving more equitable futures forward.

For example, the *Yarra River Protection (Wilip-gin Birrarung murrn) Act 2017* in Victoria, Australia, recognises the Birrarung/Yarra River and its surrounding lands as one living and integrated natural entity.

An independent body enshrined as the "voice of the Birrarung" empowers Traditional Owners, environmental, agriculture and planning experts, and skilled community representatives to advise on the protection and management of the river system from a cross-stakeholder, intergenerational and multi-species perspective.

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Working Across Scales

Our cities cover 2% of the world's land area, generate 85% of global GDP and consume over 75% of the planet's material resources. Cities, then, are potent sites for regenerative ambitions. Operationalising these principles means understanding cities as layered, interconnected systems with actions at one scale supporting and amplifying those at another.

Material Scale

Concrete, which shapes much of the world we live in, comes with a significant environmental cost. Cement production contributes to around 8% of global CO₂ emissions, with the core ingredient, clinker, responsible for the majority impact. By replacing clinker with calcined clay, a low-grade material transformed into a reactive binder, embodied carbon can be cut by up to 40% while maintaining performance. It is also more economical, with production costs up to 25% lower due to lower energy requirements and its use of abundant raw materials like clay.

This shift reflects a broader move towards low-carbon innovation and circular design in the built environment. Platforms like Materiom, an open-data library for biomaterial innovation, are further moving the dial from more sustainable towards truly regenerative. Materiom leverages AI and data to quickly develop and share bio-based materials, providing recipes for creating materials from locally abundant, renewable ingredients such as seaweed, agricultural waste, and food by-products that are compostable and non-toxic by design.

Building Scale

Arup's new workplace in Brisbane, Australia exemplifies how buildings can start moving towards a regenerative aspiration. Designed to meet the rigorous Living Building Challenge standards, the project involved retrofitting two floors of an inner-city tall building, integrating biophilic design, natural ventilation, and inclusive spatial planning more than 20 storeys above the ground.

In partnership with Five Mile Radius and Buildcorp, over 100 salvaged materials were incorporated into the design. Reclaimed timber offcuts, granite from a demolished building façade, and oyster shells collected from local restaurants to create render-forum columns were used to shape the office environment. Adopting this approach allowed the team to meet ambitious sustainability goals—while keeping construction costs lower than traditional fitouts.

Neighbourhood Scale

"Sponginess" as an urban resilience metric may have raised eyebrows just decades ago. Yet today cities like Singapore, Mumbai and New York proudly wear the mantle of "sponge cities". Shanghai's urban drainage masterplan combines machine learning with remote sensing data from satellites for detailed analysis. Sites of intervention and connection are pinpointed, allowing engineers to reconnect water cycles that have been disrupted by urban hardscapes like roads and footpaths.

Neighbourhood scale also often involves the neighbourhood itself in the form of those communities who make the space a place. Uganda's Nakivale Refugee Settlement is thinking regeneratively at the most basic unit of the city—its streets and those who live there. The Youth Initiative for Community Empowerment (YICE) is partnering to co-design a participatory framework includes residents mapping, visioning, and designing workshops at hyper local scale to shape a connected built environment while building local resilience and self-sufficiency.

City and Region Scale

As we scale to a city or region, aligning the incentives of stakeholders in the built environment is key. For example, Washington D.C.'s Stormwater Retention Credit (SRC) trading programme has created a market mechanism to incentivise green infrastructure. Developers who cannot meet stormwater requirements on-site can purchase credits from property owners who voluntarily install green infrastructure elsewhere in the city. In the 10 years between 2014 and 2024, more than 1.7 million credits coming from the capture and processing of over 151 million litres of runoff water annually have been sold for such purposes.

Elsewhere, in drought-prone Maharashtra, India, the Paani Foundation's Water Cup has mobilised thousands of villages to voluntarily implement soil and water conservation techniques, incentivised by collective benefit and local pride.

Reflections from London Climate Action Week (LCAW) 2025

The question of how to shift from sustainable to regenerative was a persistent hum under the many events, forums and hallway conversations at LCAW. Three common reflections surfaced:

- **Speaking a common language.** Clarifying the difference in practice, outcomes and impact between "sustainable" and "regenerative" is a non-negotiable step. This means communicating with different stakeholders in ways that reflect their everyday lives and concerns.
- **Capturing insights and case studies.** It is crucial not only to learn from what already works but from what does not. While technical solutions will be part of the puzzle, it will be perhaps more important to understand how incentives, governance, economics and finance can be assembled in service of regenerative design.
- **Measuring what matters.** Moving towards regenerative outcomes means building on our evidence base and showing progress. Climate impacts are often most felt as shocks over long-term stress. Metrics that focus on outcomes rather than outputs will serve as an effective bridge between personal experience and broad, longer-term social, economic and financial impacts.



Sowing the seeds of a resilient future starts with asking how each policy, project and conversation can take that practical step from sustainability towards regeneration. The regenerative mind shift asks us to reimagine our relationship with not just nature but the future context we will operate within—a climate context that is no longer decades away but already in effect. For policymakers, engineers, community organisers, architects, developers, and all who shape our urban environments, initiating each project with the question, "How can this advance regenerative design?" can help us cultivate a more resilient future. 🗨️



Alongside the Centre for Liveable Cities and C40 Cities, Arup hosted a mayoral panel titled "Urban Futures Reimagined: A Mayoral Exchange on Regenerative Cities" during LCAW 2025.
Image: © Sarah Bastin (top), Centre for Liveable Cities (bottom)