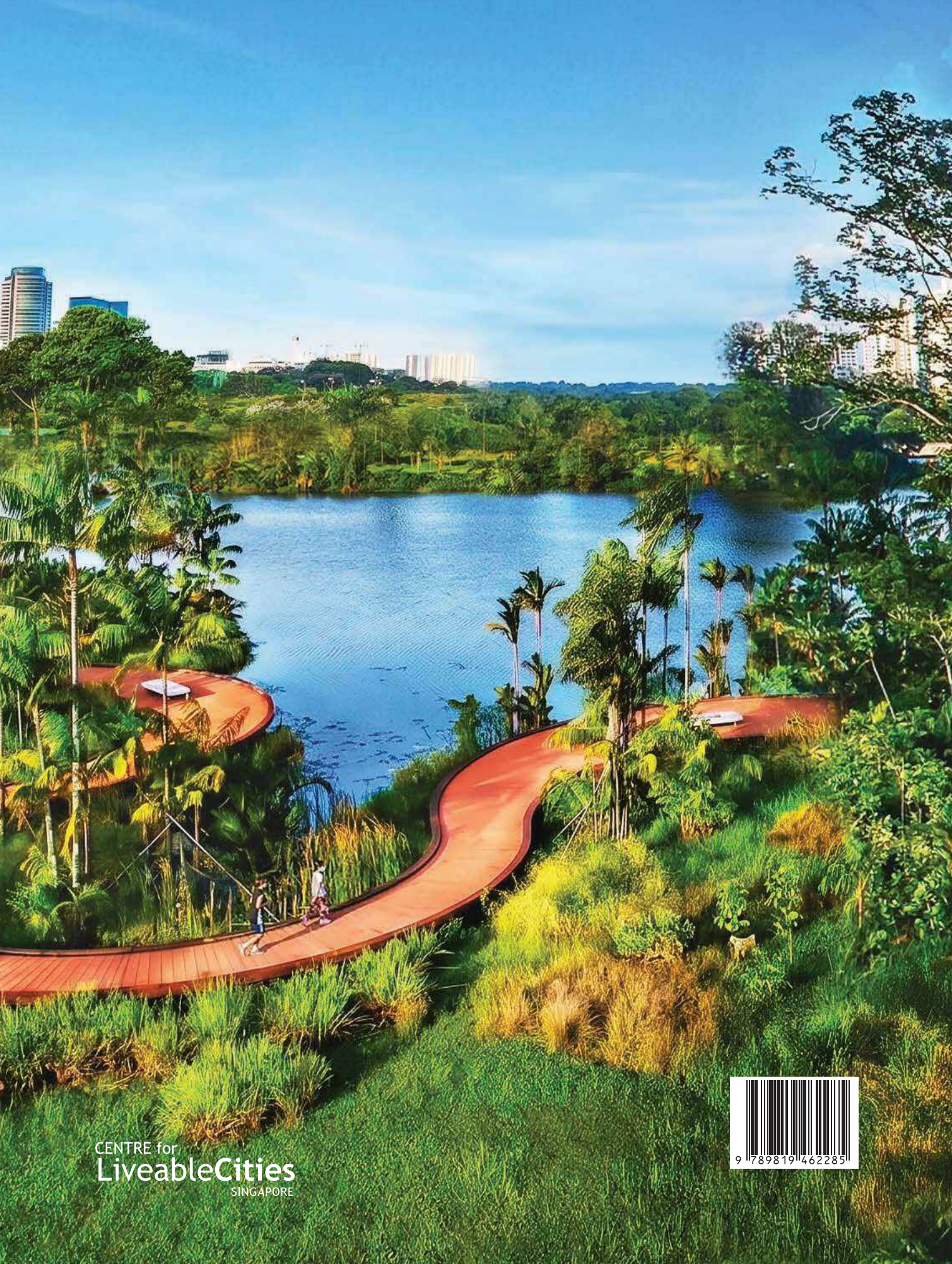




Beyond Sustainability: Building a Regenerative Future for Our Cities

CENTRE for
LiveableCities
SINGAPORE



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BEYOND SUSTAINABILITY
**Building a
REGENERATIVE
FUTURE
for Our Cities**

CENTRE for
LiveableCities
SINGAPORE

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Set up in 2008 by the Ministry of National Development and the then Ministry of the Environment and Water Resources, the Centre for Liveable Cities (CLC) has as its mission “to distil, create and share knowledge on liveable and sustainable cities”. The CLC’s work spans four main areas—Research, Capability Development, Knowledge Platforms, and Advisory. Through these activities, the CLC hopes to provide urban leaders and practitioners with the knowledge and support needed to make our cities better. For more information, please visit www.clc.gov.sg.

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Rasau Walk in Jurong Lake Gardens.
Photo courtesy of National Parks Board.

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FOREWORD

Mr CHEE Hong Tat

Minister for National Development, Singapore

Climate change is an existential challenge for cities worldwide. *Beyond Sustainability: Building a Regenerative Future for Our Cities* presents the Regenerative City as a pathway forward, through an urban development model that expands the boundaries of sustainable urban development. A city may be sustainable but not regenerative; but a regenerative city would certainly be more sustainable and resilient than one that is not.

Drawing from best practice examples in Singapore and cities around the world, this publication distils practical strategies, key enablers and assessment indicators to support cities to put regenerative urban development into action. This requires close integration across different urban systems, for cities to maximise the benefits for its residents across liveability, resilience and resource efficiency.

In Singapore, we will be embarking on an ambitious long-term reclamation project to develop “Long Island” along our Eastern coast. This project will achieve three goals—provide

coastal protection against sea level rise, enhance our water resilience, and create new land for future development such as housing and recreation. It is an example of our long-term, integrated planning approach to judiciously balance different land use requirements, navigate difficult trade-offs, and maximise every parcel of land as we develop our city-state.

To meet our climate goals, we rolled out the latest edition of the Singapore Green Building Masterplan (SGBMP) together with the industry in 2021. The SGBMP captures our collective commitment to pursue more ambitious sustainability standards in our built environment. A key initiative is the Green Mark certification scheme which encourages higher standards of environmental sustainability for developments in the tropical climate.

The latest version of the Green Mark scheme (GM: 2021) aims to raise our standards in building energy performance and place greater emphasis on other sustainability outcomes

such as designing for maintainability, reducing embodied carbon across a building’s life cycle and creating healthier environments for building users. There are now over 2,600 Green Mark-certified buildings in Singapore. Over the past 20 years since the inception of the Green Mark scheme, these buildings collectively save over 4.2 billion kilowatt-hours of energy annually and generate S\$1.3 billion in cost savings each year.

As we transform Singapore into a City in Nature, we will continue to leverage nature-based solutions for climate adaptation and to enhance liveability for residents. We will add more than 25 new parks and 50 kilometres of park connectors by 2030. We are strengthening ecological connectivity through Nature Ways, which mimic the multi-tiered structure of forests, to cool streets and support native biodiversity. We will also restore mangroves along Singapore’s coastlines to safeguard our coastal areas from storm surges and rising sea levels.

By addressing both the built and natural environments as key elements of our urban development, these efforts reflect a regenerative approach, which helps Singapore to achieve better sustainability and resilience outcomes over the longer term.

I hope that this publication will be a useful reference and a source of inspiration for city leaders and practitioners. By working together to share knowledge and develop capabilities, we can strengthen the collective efforts to build regenerative cities for our current and future generations.

FOREWORD

Ms Grace FU

Minister for Sustainability and the Environment, Singapore

We are living in a climate-impaired and resource-constrained world. Cities are not only emission hotspots, but are also vulnerable to climate risks, while at the same time facing mounting resource constraints and waste management challenges. Despite these, cities are uniquely positioned to develop innovative solutions to address these challenges.

Singapore will not be spared from the impacts of climate change. Our Third National Climate Change Study projected that, by 2100, Singapore could experience increases in annual mean temperatures of up to 5°C, mean sea levels of up to 1.15 m, and extreme weather events.

We have started making preparations to adapt to these impacts, in areas such as heat, coastal and flood resilience, and water and food resilience. Singapore is developing our first National Adaptation Plan, which will serve as our long-term, living strategy to continue thriving in the face of climate change. We have designated 2026 as the Year of Climate

Adaptation to raise awareness on the importance of adaptation, galvanise collective action, and co-create solutions with key public, private and people stakeholders.

Even as we adapt, we must also continue to stay the course on climate action—contributing to global mitigation efforts while securing Singapore’s long-term competitiveness and energy resilience. Singapore has committed to achieve net zero emissions by 2050, and submitted our 2035 Nationally Determined Contribution (NDC) to reduce our emissions to between 45 and 50 million tonnes of carbon dioxide equivalent (tCO₂e). We have pressed on with decarbonisation efforts, including raising our carbon tax in 2026 and 2027 to S\$45/tCO₂e, and expanding solar deployment.

Our Singapore Green Plan (SGP) 2030 is a whole-of-nation movement to rally collective action to build a liveable, resilient city while achieving our long-term net zero emissions goal. As part of the SGP, Singapore is shifting towards a

circular economy to reduce emissions, maximise resource efficiency and resilience, and conserve scarce landfill space. Launched in 2019, our Zero Waste Masterplan targets a 30% reduction in waste sent to landfill per capita each day by 2030. We have had successes with certain waste streams, such as metals and construction and demolition materials, with near 100% recycling rates. Along with our other National Taps, we have also created a sustainable, circular system through NEWater, which allows us to reuse every drop of water and strengthen our water resilience. Through integrated planning and design, technology, regulations, and cultivating a green citizenry, we are creating synergies across the water, energy, food and waste sectors, so that precious resources can be kept within closed-loop systems.

Beyond Sustainability: Building a Regenerative Future for Our Cities introduces the Regenerative City model, which supports cities in implementing climate adaptation and mitigation actions in ways that optimise resource use and strengthen

liveability and resilience. Featuring ideas and case studies from Singapore and cities worldwide, the publication challenges practitioners to think about how cities might consider the entire urban ecosystem, and design closed-loop systems suited to their own unique circumstances.

I hope that this publication will provide valuable insights as we strengthen our collective efforts to build climate-ready and resource-resilient cities.

EXECUTIVE SUMMARY

***Beyond Sustainability: Building a Regenerative Future for Our Cities** frames a central question: How can cities remain liveable and resilient in a climate-changed and resource-constrained world?*

Drawn from the Centre for Liveable Cities’ research and multisectoral engagements with over 100 experts across the globe, this publication captures insights, ideas and case studies to propose a way ahead for cities grounded in regenerative design principles.

To explain how the regenerative approach differs from existing thinking on sustainability, the publication introduces **FOUR PARADIGM SHIFTS** that collectively shape regenerative urban development:

- From “doing less bad” to “doing more good” (net-positive impact rather than harm reduction alone)
- From navigating trade-offs to optimising co-benefits (seeking greater overall wins from integration rather than accepting compromise as a default)
- From human-centric systems to urban ecosystems (where cities are understood as interdependent systems)
- From end-of-life to closed-loop planning (designing out waste and linear lifecycles)

Building on these paradigm shifts, **A DEFINITION FOR A REGENERATIVE CITY** is established:

A regenerative city goes beyond sustainability—which strives to reduce harm—to optimise co-benefits across liveability, resilience and resource optimisation outcomes.

In doing so, the intention of this publication is to provide a common understanding of what a regenerative city is while providing space for each city to develop its own context-specific pathway. To translate from theory to practice, the **REGENERATIVE CITY FRAMEWORK** offers city leaders and practitioners a structured, systems-based approach by outlining clear outcomes, strategies and enablers for integration and implementation in the built environment.

- There are **3 OUTCOMES**: liveability, resilience and resource optimisation.
- There are **3 STRATEGIES**: nature-based and biomimetic solutions, low-carbon and integrated developments, and circular and closed-loop systems.
- There are **7 ENABLERS**: policy and governance; design and planning; stakeholder partnerships and engagement; education and capability development; science and technology; finance, investments and business models; and measurement and monitoring systems.

To pair ambition with accountability, a set of assessment indicators will help to measure regenerative outcomes and capacity. This publication proffers **A LIST OF EXAMPLE ASSESSMENT INDICATORS**. While outcomes measure the progress of regenerative urban development over time, capacity tracks the readiness of the city for implementation.

At the core of this publication lies a recurring takeaway that the regenerative city requires a systems-thinking and long-term lens—particularly a co-benefits view to urban development that integrates mitigation and adaptation action to maximise impact. This serves as a starting point. Deepening our understanding of the complexities and synergies of the regenerative city also depends on building a collaborative ecosystem of stakeholders and sharpening assessment capabilities. Cities are actors that must lead the way in climate action, and we posit that regenerative urban development is a potential next course of action.



Scan to view
CLC’s Regenerative
Cities webpage.

An aerial photograph of the Parque Lineal Gran Canal in Mexico City. The park is a long, linear green space with a central canal, paved walkways, and various recreational areas. In the foreground, a group of people is playing a game on a large paved area. To the right, there is a skate park with ramps and graffiti. The background shows a dense urban area with colorful buildings and distant mountains under a clear sky.

Chapter 1

THE REGENERATIVE APPROACH AS THE NEXT BOUND OF URBAN DEVELOPMENT

Cities have the potential to achieve both liveability and resilience in a climate-changed and resource-constrained world. This chapter presents key paradigm shifts to creating a regenerative city.

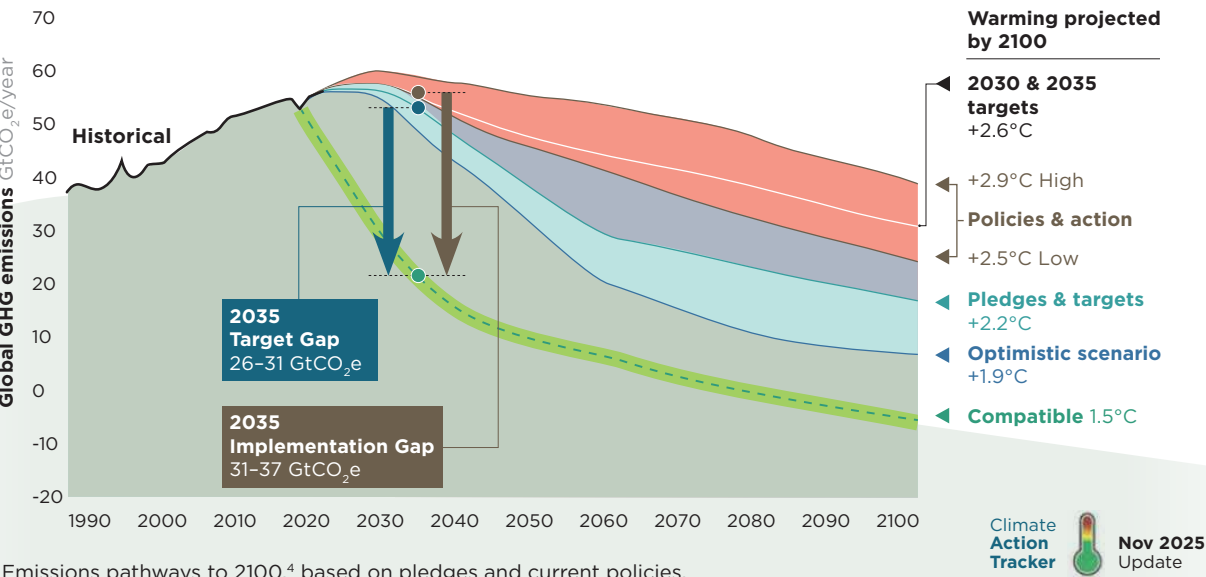
The Parque Lineal Gran Canal (Grand Canal Linear Park) in Mexico City, a once-abandoned sewerage drain that has been transformed into a well-utilised park, is testament to how the city is taking strides in engendering social resilience through environmental regeneration.

Photo courtesy of Onnis Luque

THE REALITY OF CLIMATE CHANGE FOR CITIES

Cities are at the forefront of climate innovation—the places where green technologies, smart systems and sustainable construction methods are actively being implemented. In 2023, the first Global Stocktake, a periodic assessment of the collective progress made towards achieving the goals of the Paris Agreement, recorded near-universal progress on steering climate action in this direction.¹

Yet, climate data indicates that more can be done. From 2015 to 2025, recorded temperatures continued to reach new highs. In 2025, the Earth’s average global surface temperature increased by 1.44°C above pre-industrial levels, while ocean temperatures also hit historic highs.² The declining health of our planet is additionally marked by the breach of seven out of nine critical planetary boundaries.³



Emissions pathways to 2100,⁴ based on pledges and current policies.
Image courtesy of ©2025 Climate Analytics and NewClimate Institute. All rights reserved.

PUBLISHED IN URBAN SOLUTIONS 27

Resilient and Regenerative Cities for a Climate-Changed World

by WINSTON CHOW, Co-Chair of the Intergovernmental Panel on Climate Change (IPCC) Working Group II, ELAINE TAN, Director of Research at the Centre for Liveable Cities (CLC), and ANDY TAN, Senior Assistant Director of Research at the CLC

In this essay, Winston, Elaine and Andy discuss how cities present unique opportunities for innovative climate solutions. Emerging regenerative strategies offer pathways beyond traditional sustainability approaches to actively remove atmospheric carbon through nature-based solutions, low-carbon developments, and circular systems that transform linear consumption into closed-loop processes.

Regenerative urban development transcends conventional sustainability measures by actively enhancing social and ecological systems, by creating pathways for cities to maintain high liveability while strengthening biodiversity, and by ensuring responsible resource stewardship for future generations.



Scan QR code to read the essay.



Cities face the three-pronged challenge of balancing liveability, biodiversity conservation and resource stewardship.
Photo courtesy of Singapore Tourism Board



London, a dense and complex historical city, has managed to continually reinvent itself and remain a highly liveable and integrated metropolis.

Photo courtesy of Colin and Kim Hansen (CC BY-SA 4.0 / Wikimedia Commons)

We are also living in a period of great urban transition. By 2050, nearly 70% of the world's population will live in urban areas.⁵

Considering that key urban functions in cities are responsible for 75% of global energy consumption, they are among the largest contributors to the emissions driving climate change.⁶ At the same time, cities are vulnerable to compounded and cascading climate impacts that transcend geographical, sectoral and temporal boundaries.⁷

However, challenges can also be opportunities. As compact urban agglomerations, density in cities allows for the optimisation of resources where urban systems can operate at economies of scale that support coordinated, shared services. When paired with well-integrated transportation systems, density facilitates connectivity. As concentrations of talent and innovation, cities can adopt and scale climate adaptation and mitigation strategies.⁸



The revitalised Chong Nonsi canal in Bangkok shows how green and blue spaces can be integrated into dense urban spaces.

Photo courtesy of Dharmadana (CC BY-SA 4.0 / Wikimedia Commons)

“

...to be less bad is to accept things as they are, to believe that poorly designed, dishonorable, destructive systems are the best humans can do. This is the ultimate failure of the ‘be less bad’ approach: a failure of the imagination.”

WILLIAM MCDONOUGH
*Author of Cradle to Cradle:
 Remaking the Way We Make Things*



The Gare Maritime in Brussels is a carbon neutral mixed-use hub repurposed from Europe's largest freight railway station.
Photo courtesy of Nanda Sluijsmans, Flickr



Khoo Teck Puat Hospital in Singapore integrates greenery within the compound, enabling patients and nearby residents to be in close proximity to local flora and fauna.
Photo courtesy of Munhuiyee (CC BY-SA 4.0 / Wikimedia Commons)



Urban farms are growing in popularity globally as a sustainability measure that can strengthen food security and enhance ecosystem services, including climate regulation and stormwater management.
Photo courtesy of Rhododendrites (CC BY-SA 4.0 / Wikimedia Commons)

In recent years, cities have been guided by sustainable development frameworks to address climate change, taking a net-zero approach while setting the path for continuity.⁹ Yet, sustainability approaches tend to focus on doing less harm rather than more good, and the current pace of urban development and accelerated growth have already pushed us beyond ecological limits and posed challenges to liveability in many cities. To address the climate crisis and achieve global climate targets, there is a clear need to advance beyond sustainability. Going forward, **how might cities achieve both liveability and resilience goals in a climate-changed and resource-constrained world?**

This publication puts forth a regenerative approach to urban development that combines mitigation and adaptation strategies, going beyond minimising harm to actively doing good.

The regenerative approach demands us to rethink the relationship between urban development and natural systems, where cities are not seen as separate from nature but as integral parts of living ecosystems that are capable of renewal and regeneration. It stresses both mitigation and adaptation, seeking to strengthen cities' resilience by leveraging the synergies between these strategies to take climate action and achieve liveability goals.



TOWARDS THE REGENERATIVE CITY: THE NEXT LEAP FOR URBAN DEVELOPMENT

CHRISNA DU PLESSIS

*Professor of Regenerative Futures at the Department of Architecture, University of Pretoria,
and co-author of Designing for Hope: Pathways to Regenerative Sustainability*

Cities today face a convergence of crises—from climate instability to social fragmentation and resource scarcity—revealing the limits of a sustainability paradigm too often reduced to doing less harm. In an era that has already pushed past several planetary boundaries, this approach is no longer enough. As these limits draw nearer, cities have both the incentive and the responsibility to move beyond neutral ambitions and take a brave leap towards a regenerative future.

The stories we tell about sustainability also shape what we believe is possible. While the dominant narrative that leans on guilt and scarcity imagines a future of inevitable collapse, living systems show that endings also create space for new life. A regenerative narrative reframes the present moment as an opening for deep transformation and it offers an active form of hope, recognising that humans can contribute to the flourishing of life and that cities can become catalysts for co-evolution rather than places of extraction.

Reframing the Story of the Future

At its heart, regenerative development marks a profound shift in worldview. Instead of seeing the city as a machine to be optimised, it invites us to understand urban environments as living systems that are continually adapting and unfolding. Working from this perspective means shifting attention away from merely maintaining existing structures and trying to solve intractable problems. Instead, the focus is on identifying and nurturing potential and cultivating new possibilities. This shift reframes urban development through four key transitions: from reducing harm to generating net-positive value, from negotiating trade-offs to co-creating co-benefits, from human-centred design to mutually supportive human-nature relationships, and from linear resource flows to circular metabolic patterns.



Regeneration emerging through the cracks at Moja Gabedi, a community garden in Hatfield, Pretoria, South Africa. This once-derelict urban wasteland was turned into a healing oasis for human and non-human inhabitants through community co-creation.

Photo courtesy of Chrisna du Plessis

Rethinking Humanity's Ecological Role

A crucial part of this shift involves rethinking humanity's place within the wider ecology. The move from an ego-centred stance, which emphasises dominion over nature, to an eco-centred perspective is already well recognised. Regenerative thinking goes further by embracing the idea of *seva*, or service, which suggests that human activity can actively enhance the capacity of ecosystems to thrive.

Ultimately, regenerative development is anchored in purpose. It is concerned less with meeting efficiency targets and more with nurturing the capacity of living systems to evolve in complexity, diversity and creativity. Regenerative cities are not simply more sustainable or resilient versions of what we already know. They represent a deeper transformation: urban places that heal relationships, nurture life, and unlock human and ecological potential. Just as a caterpillar must relinquish its old form to become a butterfly, cities too must be willing to shed outdated identities and open themselves to new possibilities.

Reconnection and Reciprocity as Catalysts for Transformation

This transformation begins with reconnecting people to place. Living systems offer powerful lessons for how cities can evolve. Regenerative cities pay close attention to the flows, forms and functions that characterise healthy ecosystems. They draw from the deep ecological and cultural identity of place, working with local soils, waters, seasons and communities. Regenerative design encourages people to attune to the local ecologies that sustain them and rediscover their role within the wider web of life. While biophilic design has shown that bringing nature into the built environment enhances human well-being, regeneration demands reciprocity. People must also contribute to the vitality of the ecosystems they inhabit. Many emerging projects already embody this principle by creating buildings and landscapes that enhance biodiversity, purify air and water, and strengthen social-ecological networks.

In time, regenerative cities behave like mature ecosystems. They are grounded in reciprocity and mutual support, and their economic and social systems prioritise net-positive contributions rather than individual gain. From this grounded understanding, it becomes possible to identify leverage points: small, strategic interventions that can set larger systems on a path of positive transformation.

New Life Grows from Broken Places

Embracing regeneration also requires accepting the role of creative destruction. Dysfunctional infrastructures and outdated paradigms must sometimes be allowed to collapse so that their latent potential can be reorganised into more resilient forms. In nature, collapse is not a failure. It is an essential step in renewal. Often, transformation begins at the edges where the old system is loosening—in the neglected spaces of failing infrastructure, storm-damaged neighbourhoods or decaying industrial landscapes. These liminal spaces can become fertile ground for regenerative possibilities to take root and reshape the city from within. With imagination and care, they can become the first places where regenerative possibilities set cities on a bold new path towards a more life-giving urban future.

Cities as Key Drivers of Global Regeneration

Cities are uniquely positioned to lead this shift in thinking. Although they occupy only a small portion of the Earth's surface, their concentration of creativity, resources and influence makes them powerful drivers of global change. Regenerative actions taken at the neighbourhood or district scale can ripple outward to influence regional and even global cycles. By moving beyond the limitations of sustainability and embracing the city as a thriving, living system, it is possible to create urban environments that contribute to the enduring health and well-being of the entire planet. The regenerative approach stands as an invitation to engage with urban spaces as vibrant, co-evolutionary participants in the web of life.

THE GENESIS AND EVOLUTION OF THE REGENERATIVE APPROACH IN URBAN DESIGN

In the 1970s, a new approach to design—one centred on ecological regeneration—emerged. Architects like John T. Lyle envisioned that the ecosystem should ground the relationship between humanity and nature, establishing an ecosystem-centric order to development.¹⁰ Traditionally, indigenous cultures have embraced regenerative agriculture to ensure resource resilience and protect local ecosystems.¹¹

The 1980s witnessed a quiet revolution in design thinking that reshaped our relationship with the natural world. Amid rapid industrialisation, architects and planners began synergising development with ecological flows, seeking to create durable and ecologically responsible sites. This led to the idea of biophilia and the proliferation of self-renewing

landscapes—concepts adjacent to the regenerative approach and aimed at the conscious design of ecosystems as a whole.¹²

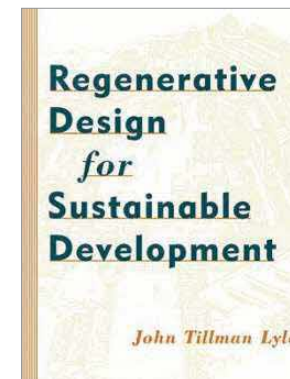
As the foundational principles of regeneration evolved, these theories translated into frameworks for practice. In 1995, theorists Bill Reed and Pamela Mang developed a theoretical foundation for regenerative development. Alongside scholars like Chrisna du Plessis, Herbert Girardet and John Robinson, they advocated for urban development that supports ecological health and continuous improvement of the surrounding environment. Since then, regenerative design has gained traction alongside complexity theories that emphasise interconnectedness across social, economic, environmental and political systems.

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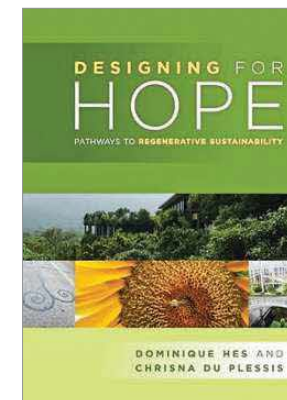
Regenerative development asks us to consider what does it mean to actually add value to life, ... and encourage or participate in evolutionary processes.”¹³

BILL REED
Principal of Regenesiis

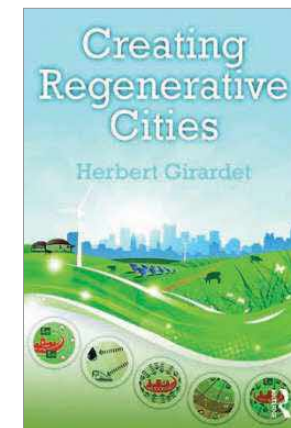
Early books on regenerative urban design



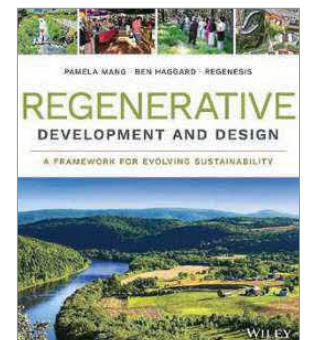
Regenerative Design for Sustainable Development by John T. Lyle, published in 1994



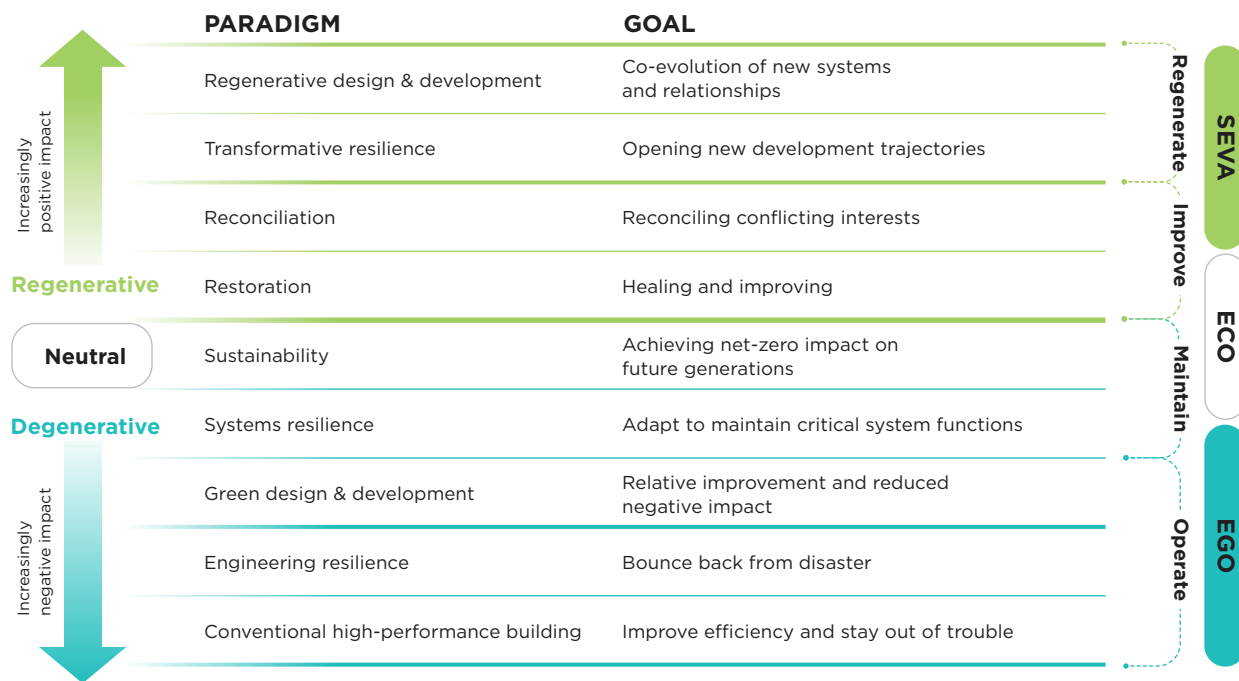
Designing for Hope: Pathways to Regenerative Sustainability by Dominique Hes and Chrisna du Plessis, published in 2014



Creating Regenerative Cities by Herbert Girardet, published in 2014



Regenerative Development and Design: A Framework for Evolving Sustainability by Pamela Mang and Ben Haggard, published in 2016



Shifts from sustainable approaches to regenerative ones.¹⁴
 Image courtesy of Chrisna du Plessis, adapted with permission

At its core, regenerative development seeks to foster co-evolutionary and positive interdependent relationships between human activities and ecological processes.¹⁵

To bring about meaningful change, regenerative design calls for engagement from all agents involved: designers, communities and the built environment itself. With this principle,

decision-makers are prompted to re-evaluate their approach to planning and designing cities. Practitioners in the infrastructure and environment sectors are increasingly incorporating nature into design practice, applying integrated systems thinking, and drawing connections across multiple spatial scales, all of which reflect regenerative-aligned principles.¹⁶

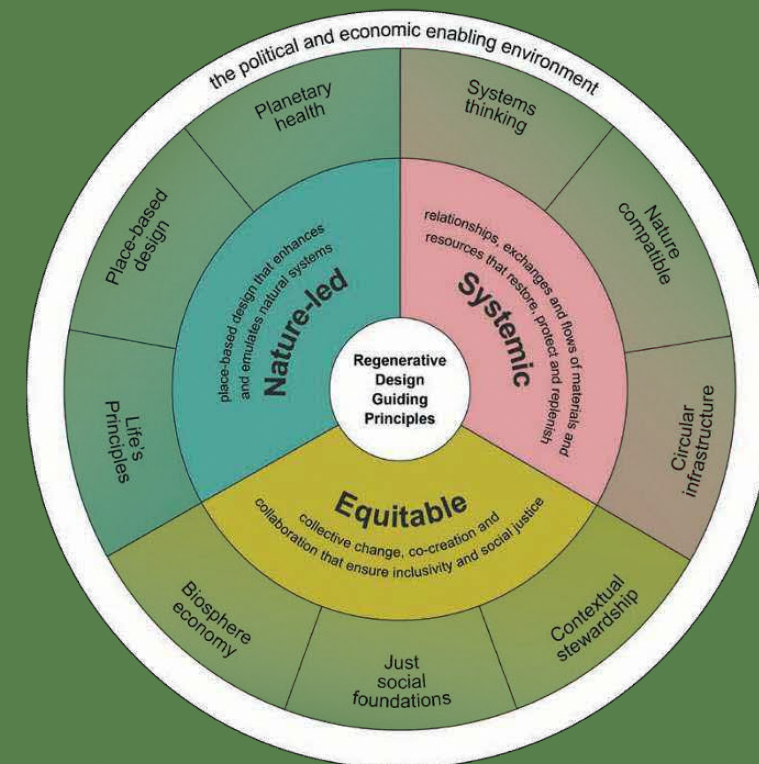
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REGENERATIVE DESIGN: ACROSS URBAN SCALES

adapted from an essay published in *Urban Solutions* 27

BREE TREVENA
 Australasia Foresight Team Lead, Arup



The Regenerative Design Guiding Principles.
 Image courtesy of Arup

Sustainability has shifted from a niche concern to a central priority in the built environment. The World Economic Forum's *Global Risks Report* shows why we need to keep pushing. Over the next decade, most of the top five long-term global risks will be environmental, including extreme weather, biodiversity loss and major disruptions to Earth's systems.

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. Three connected principles can act as a compass to guide this shift, with regenerative designs being 1) nature-led, 2) systemic and 3) equitable.

Nature-led designs are developed with local places and ecosystems in mind. Nature-based solutions often outperform engineered ones, with research showing an average of 50% in cost savings.

Systemic designs look at the relationships, flows and circular systems that can cut embodied emissions by up to 75% while generating economic value.

Equitable designs are created by working collaboratively with communities to ensure inclusive and just outcomes that are supported by clearer pathways for meaningful engagement.

Working Across Scales

Cities are important sites for regenerative ambitions. Operationalising these principles works by recognising how decisions at one urban scale ripple across others.

At the material scale, cement production accounts for around 8% of global CO₂ emissions, with the core ingredient, clinker, responsible for the majority of its impact. By replacing clinker with calcined clay, embodied carbon can be cut by up to 40% while maintaining performance.

At the building scale, workplaces can demonstrate regenerative principles by integrating features like biophilic design, natural ventilation and inclusive planning, which are already achieving notable yet practical regenerative outcomes.

At the neighbourhood scale, cities like Singapore, Mumbai and New York City proudly wear the mantle of “sponge cities”, where natural and naturalised areas help to reduce flooding by design.

As we scale to a city or region, aligning the incentives of stakeholders in the built environment matters. Market mechanisms like stormwater credit trading programmes show how policy and governance can accelerate investment in green infrastructure.

For anyone shaping the built environment—from policymakers and engineers to architects and community partners—by initiating each project with the question, “How can this advance regenerative design?”, we can help to cultivate a more resilient future.



Scan QR code to read the essay.



FROM SUSTAINABLE TO REGENERATIVE: BUILDINGS THAT GIVE BACK

ANGELENE CHAN
Executive Chairman, DP Architects

Rising temperatures, breached planetary boundaries and compounded urban risks demand a bold ambition: cities that actively give back. Regenerative urbanism asks not just how we reduce impact, but how we generate better benefits—for people, communities and ecosystems—through design.

Singapore’s dense urban fabric presents both constraints and opportunities. At DP Architects (DPA), we have embraced these opportunities

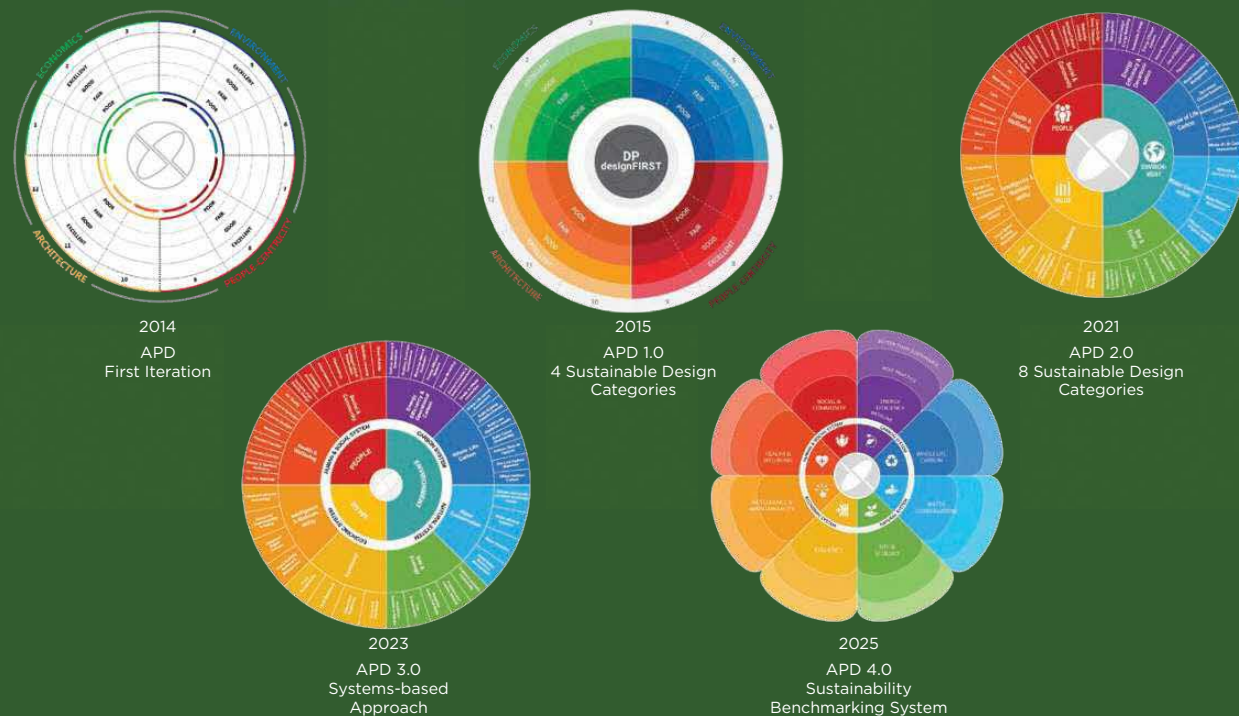
through projects that integrate ecology, community and infrastructure. Bukit Canberra is a case in point. Rather than treating public facilities as isolated components, the development unites sports, healthcare, green and blue spaces, and community programmes within a living, permeable ecosystem. Here, design delivers multiple benefits: supporting health and social well-being, enabling active mobility, enhancing biodiversity and strengthening the human-nature connection within an urban setting.



At Bukit Canberra, a porous and connected design engenders a sense of community.
Photo by Jerome Teo, courtesy of DP Architects

DPA:APD

Attributes of Purposeful Design – 12 Years of Sustainability in Practice



The evolution of DP's Attributes of Purposeful Design over the last 12 years.
Image courtesy of DP Architects

To translate regenerative ambition into tangible outcomes, DP has developed a structured approach that embeds sustainability across all projects and practices. At the heart of this is Green-Well-Tech (GWT), a core organisational thrust that operationalises sustainability through strategy, tools and people. Central to GWT is the Attributes of Purposeful Design (APD)—a design and assessment framework first introduced in 2015. The APD is used to evaluate performance across four systems—Human and Social, Carbon, Natural, and Economic—with clearly defined sustainability priorities that enable consistent assessment across project types and scales.

Institutionalised as groupwide key performance indicators and integrated into DP's ISO compliance, the APD requires all new projects to undergo assessments at multiple stages of development. This structured framework empowers project teams and clients to prioritise sustainability early, track progress systematically and identify patterns across typologies, ensuring that regenerative principles move from aspiration to actionable results.

Regeneration is not limited to new developments. In the case of the Golden Mile Complex, Singapore's first conserved post-independence building, which is privately owned, we prioritised adaptive reuse over replacement. This approach preserves embodied carbon and architectural heritage while keeping the building socially and economically relevant.



Spaces and amenities are integrated into the landscape at Bukit Canberra to foster a sense of cohesion and belonging.
Photo by Jerome Teo, courtesy of DP Architects



Community workout at Bukit Canberra.
Photo courtesy of DP Architects

The House of Tan Yeok Nee is the last remaining traditional Teochew style mansion in Singapore.

Photo by Darren Soh, courtesy of DP Architects



An artist's impression of the rejuvenated Golden Mile Complex from Nicoll Highway.
Image courtesy of Perennial Holdings and Far East Organization

Likewise, the restoration of the House of Tan Yeok Nee demonstrates that heritage buildings can actively enrich contemporary urban life. Through careful design and sensitive execution, conservation becomes regenerative: the past is preserved and communities gain spaces that foster cultural continuity and social cohesion.

What defines a regenerative approach is its mindset. Success is measured by what a project restores, enhances and amplifies, not just by what it avoids harming. Achieving this requires collaboration across disciplines, early engagement with communities, and systems that evolve with time rather than static solutions

designed to endure. This allows architecture to become proactive, contributing to social well-being, environmental health and economic vitality simultaneously.

Ultimately, regenerative urbanism is about giving back: designing cities that enrich human life while restoring the natural and cultural systems that support it. Through projects like Bukit Canberra, Golden Mile Complex and the House of Tan Yeok Nee, DP Architects is demonstrating that the built environment can do more than coexist with nature—it can actively enhance it. Our cities don't just have to endure; they can flourish.



THE CITY THAT KNOWS ITSELF: HOW INTELLIGENT CITIES CAN LEARN TO GIVE BACK

SEAN CHIAO
Group Chief Executive Officer, SJ Group

We are, by nature, a regenerative species. Like every living organism, we are built to participate in cycles of renewal, and contribute to the ecosystems that sustain us.

But somewhere along the way, we lost the thread.

We began to see the natural world as something separate from ourselves. We chased control, predictability, efficiency. In the pursuit of growth, we harnessed stored energy, altered entire landscapes and built cities that deplete the very systems we depend on.

The result? Ecological degradation. And a deepening disconnect between people and place.

Regeneration is how we find our way back. A return to how living systems actually work: through reciprocity, adaptation and interdependence. A regenerative city restores, renews and enhances the systems around it, creating the conditions for more life to thrive.

What needs to accompany aspiration is measurement. Without systematic assessment, regeneration cannot be operationalised, benchmarked or scaled, and the investment needed to make it last will not follow.

At SJ Group, our Regenerative Futures Framework is built for exactly this. Our premise is simple: cities must be assessed as complex socio-



Temasek Shophouse in Singapore.
Photo courtesy of Temasek Shophouse



New Lowell Vision Plan in Canada.
Image courtesy of SJ Group



Biomimicry Building in India.
Image courtesy of SJ Group

ecological systems. We evaluate performance across six interconnected impact areas—nature, life, society, knowledge, economy and built environment—each with clear action areas, delivery principles and performance outputs.

With a systemic lens, we examine how systems connect and depend on each other. We are building a continuum of performance, from business-as-usual to pioneering, that rewards continuous improvement over static compliance. And we integrate both quantitative and qualitative measures. After all, not everything that matters can be reduced to a number.

In Kaua'i, Hawai'i, the Economic Resilience Center is a real-world proof point. Its repurposed structure has a resilience understood as inseparable from the health of the surrounding coral reefs and wetlands. Indigenous knowledge is woven into the design. Ecological, social and economic performance are measured as one system, because they are one system.

Temasek Shophouse, a century-old conserved heritage building in Singapore, integrates real-time occupancy monitoring, solar panels, rainwater harvesting and native planting. Achieving up to 47% energy savings, it's on track to become Singapore's first heritage shophouse to achieve the Building and Construction Authority's Green Mark Platinum Zero Energy

certification. At larger scales, Singapore's Changi Airport shows how regenerative thinking enhances human experience through biophilic design and high-performance engineering.

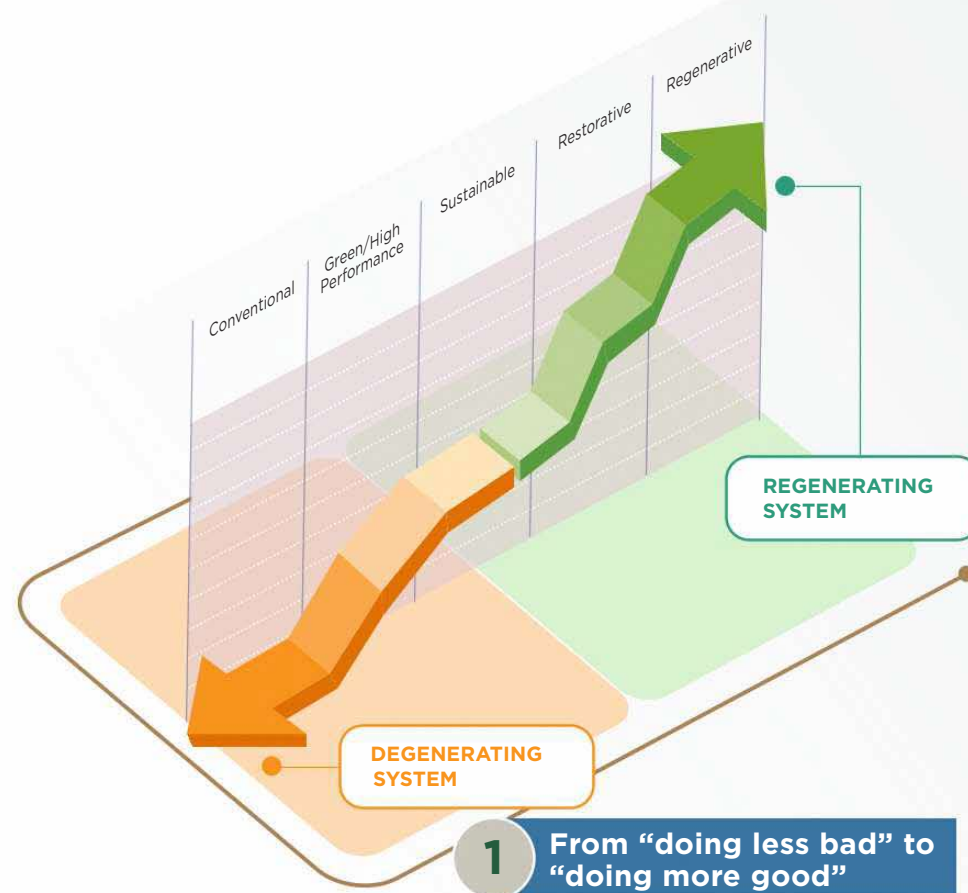
In Canada, the New Lowell masterplan, and in India, the Biomimicry Building, go further. These quantify CO₂ sequestration, oxygen production, stormwater retention, temperature regulation and air purification before and after design. These developments actively improve ecological performance by design.

To take this further, SJ Group has developed a Cognitive City framework, a dynamic digital layer that enables real-time monitoring and adaptive decision-making. AI can help cities learn from how their systems perform and accelerate their evolution. Regenerative design defines the direction that evolution should take: restoring ecosystems, strengthening communities, creating long-term value.

Together, they describe something genuinely new: a city that can measure, adapt and continuously improve, mirroring the behaviour of living systems.

The regenerative city is a living process. And a city that truly knows itself—one that measures, learns and adapts—will know how to give back. We have the frameworks, the tools and the knowledge. Now we build.

PARADIGM SHIFTS FOR THE REGENERATIVE CITY

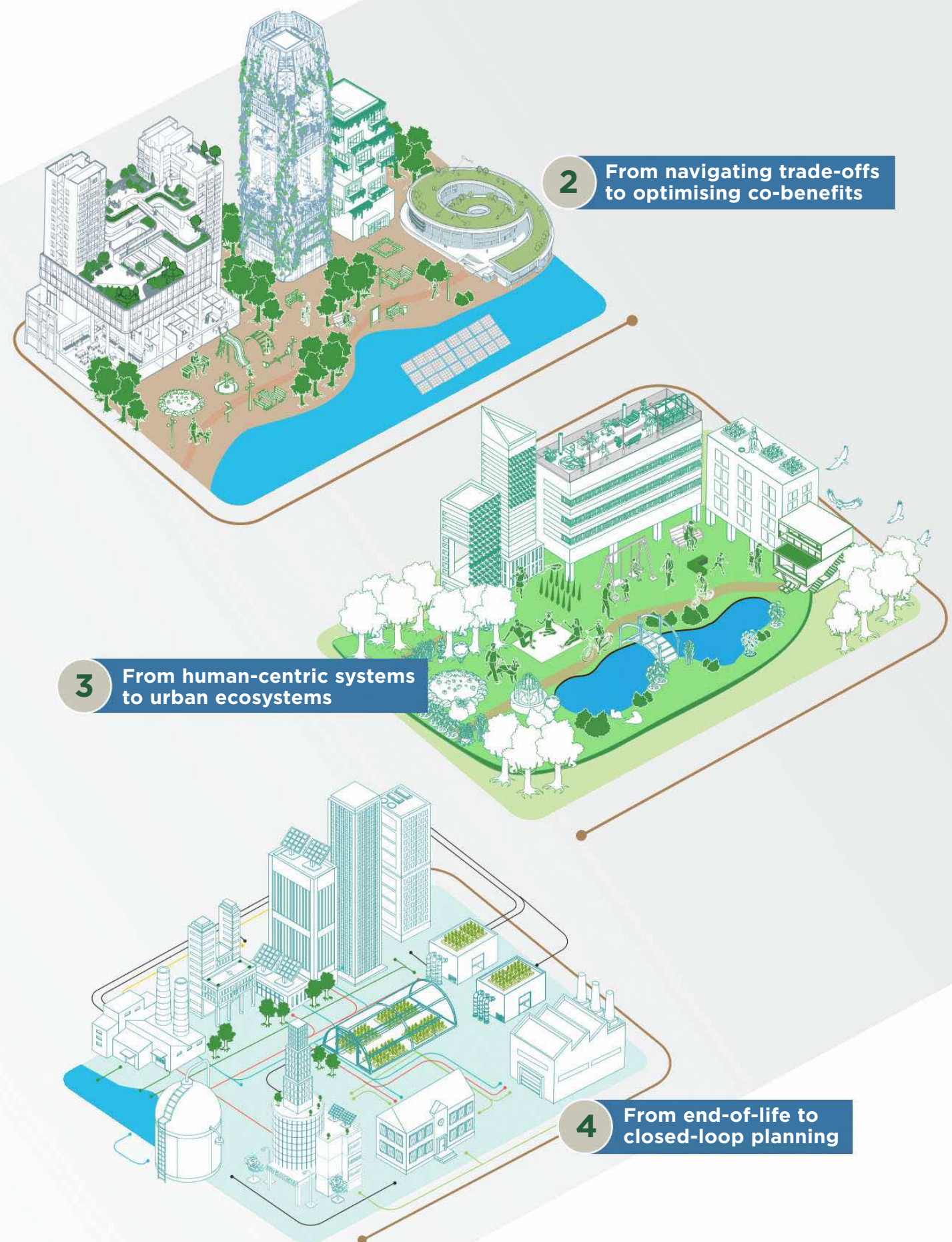


To engender a mindset shift, we must first answer the question, **how does a regenerative approach differ from sustainability?**

Both the regenerative approach and sustainability pursue ecologically responsible relationships between urban development and natural ecosystems.^{17,18} Both also seek to

preserve the planet’s capacity to support life. But there is a fundamental difference in their ambition and approach.

This evolution in ambition demands a reorientation in how we conceive, plan and build cities. There are four paradigm shifts that define the transition towards a regenerative approach.



1 From “doing less bad” to “doing more good”

The United Nations defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.¹⁹ It encompasses facets of environmental, economic, social and political conditions, reinforced by the need for intergenerational equity. Sustainability also extends to net zero goals and the green transition, as well as resource efficiency, while emphasising that the social needs of all must be met.²⁰

According to William McDonough, an expert in sustainable architecture and pioneer of cradle-to-cradle design, sustainability strives only to do “less bad”.^{21,22} But doing less bad is not enough; we need to do more good. As Singapore’s Ambassador for Climate Action, Ravi Menon, argues,

our fixation on risk reduction could make us overlook opportunities for achieving good. The regenerative approach sets us on a trajectory that moves through stages of restoring nature, harnessing socio-ecological co-benefits and building resilience and adaptive capacity in the face of change; in essence, designing cities where humans and the natural environment belong in one system.²³

The regenerative approach seeks to make positive change. It moves beyond simply managing the capacity of existing systems to absorb, recover from and adapt to disturbance. Instead of asking, “How can this project minimise environmental impact?”, the regenerative approach asks, “How can this project enhance the

local ecosystem?” Being regenerative means effectively engaging with our complex, dynamic environment in order to generate the co-benefits of healthy ecosystems, resilient communities and equitable economic progress.

Fundamentally, the regenerative approach is about balancing between competing environmental and socio-economic demands, and expanding our problem-solving capacity. For practitioners, this shift moves us from meeting minimum standards and minimising impact to seeking multiple positive outcomes simultaneously. It changes how we evaluate success: not by what we prevented, but by what was restored and enhanced.

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Climate Resilience Through Regeneration

by **RAVI MENON**, Singapore’s Ambassador for Climate Action, and Senior Advisor to the National Climate Change Secretariat at the Prime Minister’s Office

In this opinion piece, Ambassador Ravi posits that climate resilience can be turned from a defensive strategy into a pathway for new opportunities and co-benefits. Beyond minimising risks and harm, the idea of regeneration pushes us to consider how climate solutions can holistically restore and enhance natural ecosystems while also generating social well-being and economic vitality.

To achieve good, he prompts us to consider the interconnectedness of ecosystems, economies and communities, citing the Mekong River, Southeast Asia’s largest waterway, as an example of interdependencies between eco- and urban systems, and the ripple effects across borders. Regenerative practices remind us that climate action is not just about surviving the challenges ahead, but also about unlocking new opportunities and shared benefits for communities, businesses and ecosystems.



Scan QR code to read the opinion piece.

REGENERATING SYSTEM

DEGENERATING SYSTEM



2 From navigating trade-offs to optimising co-benefits

For cities, the “trade-offs” approach has conventionally guided us to assess the ability of actions to deliver outcomes.²⁴ It has enabled us to make value-based judgements about the cost of urban interventions against their expected outcomes. The regenerative approach, however, enlarges the space in which better outcomes can be pursued by looking beyond a narrow set of objectives and enabling synergistic solutions that deliver multiple benefits.

The “co-benefits” approach, first introduced in the Intergovernmental

Panel on Climate Change’s Third Assessment Report that was published in 2001, acknowledges that one policy or action can lead to multiple positive effects. Co-benefits lead us to consider how urban interventions can achieve mutualistic outcomes across social, economic and environmental domains, while also accounting for outcomes previously deemed ancillary to sustainability.²⁵ **Trade-offs must be accompanied by co-benefits to ensure that decisions are not only informed by a balance between risk and reward, but an optimisation of potential.**



Brooklyn Bridge Park generates co-benefits by mitigating floods and storm surges while simultaneously enhancing the local ecosystem and providing a place for New Yorkers to relax.

Photo courtesy of MusikAnimal (CC BY-SA 4.0 / Wikimedia Commons)

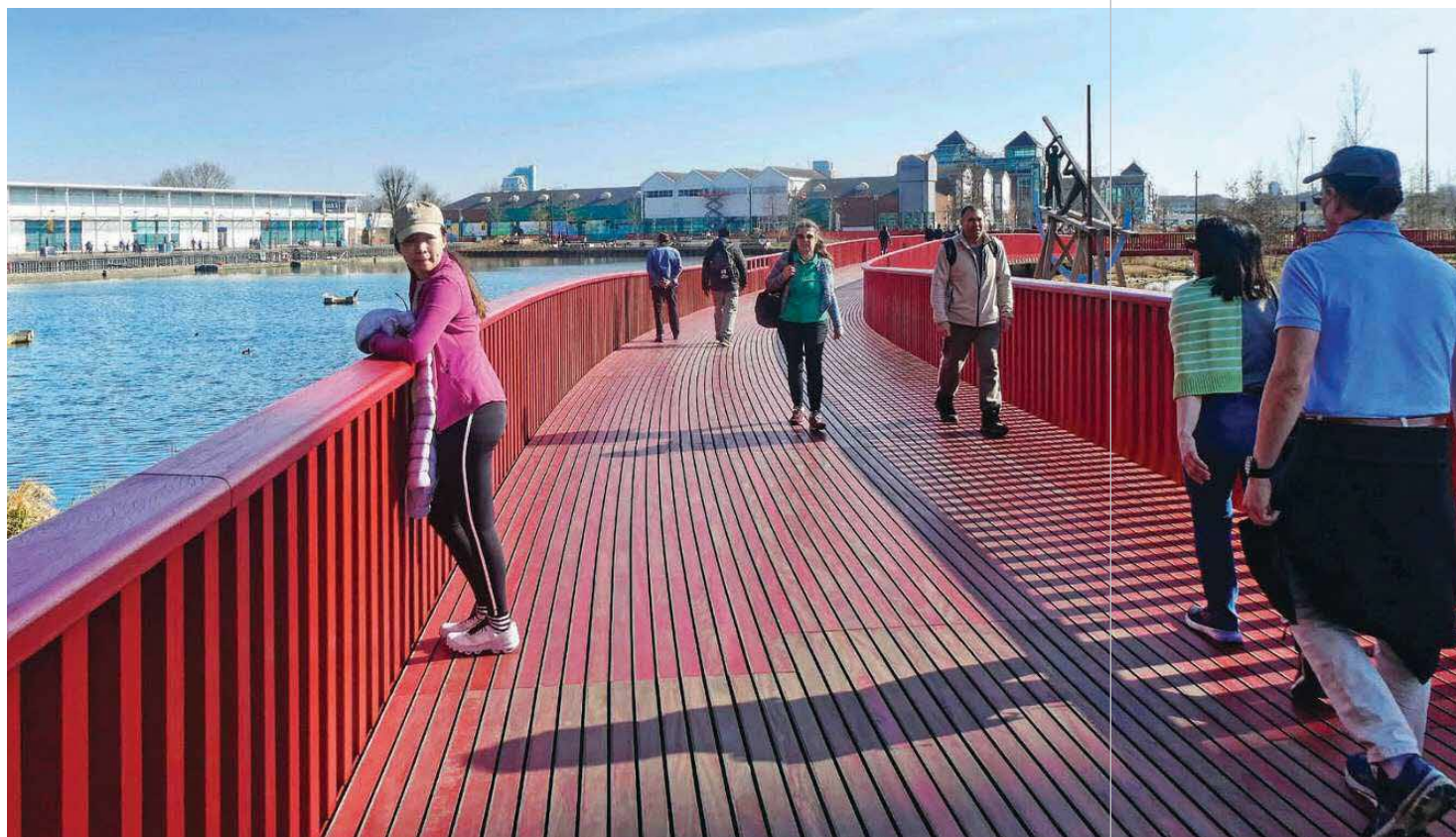


Cities in China have implemented sponge city initiatives, creating and restoring parks and wetlands to mitigate flooding instead of traditional flood-control measures. This has brought co-benefits to both local ecosystems and citizens.

Photo courtesy of Tomsyhaha (CC BY-SA 4.0 / Wikimedia Commons)



A view of Canada Water, with restored wetlands in the foreground.
Photo courtesy of Alysia Wee



Canada Water's Rafter Walk crosses over the revitalised wetland, allowing people to get closer to nature without disturbing it.
Photo courtesy of Acabashi (CC BY-SA 4.0 / Wikimedia Commons)

This shift fundamentally changes project design and evaluation. **It moves city-making solely from managing competing demands to also orchestrating synergies that reinforce liveability and resilience outcomes.** It enables cities to not only view natural systems for their ecosystem services or low-carbon developments for climate mitigation, but also to recognise their ability to achieve social and economic goals. In practice, co-benefits tend to favour environmental outcomes over socio-economic ones, and trade-offs around equity and displacement remain real and underexplored.²⁶ The co-benefits

approach does not dissolve these tensions, but equips decision-makers with a broader evaluative lens to navigate them more deliberately.

For example, Canada Water in London, a 0.21-km² mixed-use district, reflects synergies across low-carbon strategies, circularity and social outcomes. By repurposing the Daily Mail paper warehouse into a community and educational space using recycled materials, we observe how low-carbon strategies are not only fit for climate mitigation, but can also be optimised to tap on existing resources to provide more community-centred spaces.

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Charting Regenerative Urban Futures: A Working Regenerative City Framework

by HUGH LIM, *Executive Director of the Centre for Liveable Cities (CLC)*; and ALYSIA WEE, *Assistant Director of Research at the CLC*

In this essay, Hugh and Alysia discuss how the regenerative approach fills the gaps of sustainability, unpacking what constitutes a regenerative urban future through the co-benefits lens. They present three case studies across Singapore, London and Bangkok, applying a working regenerative framework from the CLC to map synergies, correlations and interdependencies across various components within the urban system.

They explore how nature-based solutions can achieve important co-benefits across social and ecological systems, including flood resilience, biodiversity conservation, and health and well-being.



Scan QR code to read the essay.

3 From human-centric systems to urban ecosystems

The lens of economic utility has conventionally framed our decisions for urban development.²⁷ For example, the worth of a forest is often measured by the amount of timber it produces, its ability to sequester carbon, or how well it serves human recreation. Nature has become a commodity we own, exploit and optimise for human benefit.

This mindset deems nature as separate from cities, rather than as living systems that, when integrated, can deliver multiple co-benefits. It limits our ability to work with natural processes and

overlooks the opportunity to work with and learn from ecological systems.

Echoing the early theorists of regenerative development, an urban ecosystems-led paradigm encourages the alignment of urban development with ecological processes.²⁸ It recognises that social and ecological systems are interdependent. The regenerative paradigm seeks to create conducive environments where humans and nature share mutually dependent and beneficial relationships rather than extractive ones.



Designed with social and ecological systems in mind, Boston's Emerald Necklace is a chain of nine parks linked by green corridors and waterways. It provides continuous green spaces for residents while tackling habitat fragmentation.

Photo courtesy of FASTILY (CC BY-SA 4.0 / Wikimedia Commons)



The Madrid-Río Park is a verdant riverside park that provides cool spaces that help the city adapt to higher temperatures in the summer.
Photo courtesy of Madrid City Council



Aside from its environmental benefits, the Cheonggyecheon stream has allowed new communal spaces to flourish and higher footfall for nearby businesses.
Photo courtesy of Philip Jang on Unsplash

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RETURNING LIFE TO THE CITY: RENATURALISING THE MANZANARES RIVER

by **JUAN AZCÁRATE**, Deputy Director-General of Energy and Climate Change; and **ANTONIO MORCILLO**, Deputy Director-General of Parks and Nursery Gardens, Madrid City Council

In this City Focus feature, Juan and Antonio share on behalf of the Madrid City Council on how Madrid undertook a remarkable transformation to return life to the city. Today, The Madrid-Río complex is a verdant riverside park that spans 7.5 km. It sits atop the Spanish capital’s former main ring road, the M-30, a six-lane thoroughfare which previously cut off locals’ access to the Manzanares River.



Scan QR code to read the feature.

Applied to dense urban environments, cities can be highly liveable and also possess social and ecological resilience, without losing economic viability. For instance, practitioners have demonstrated how to **design with natural processes such as water cycles and habitat networks, rather than against them.**

Notable examples around the world include Singapore’s Bishan-Ang Mo Kio Park, Seoul’s Cheonggyecheon

Stream and Madrid’s Madrid-Río Park. Each project treats the waterway not merely as infrastructure to control, but as a living system to work with and deliver multiple benefits to people while boosting economic vitality. This expands the city’s capacity to harness synergies across different urban systems. Realising this potential at scale remains contingent on governance capacity, resource availability, and the degree of climate stress a city faces.



THE PATHWAY TO CITIES THAT LEARN FROM NATURE

AMANDA STURGEON

Chief Executive Officer, Biomimicry Institute

We don't value what we don't love. To have any significant reduction on the impacts of climate change, it is critical to repair the relationship between humans and nature.

Designing our buildings and cities with respect for the resources that they depend on, and with a love of all life at the centre of decision-making, will require a complete systemic change. It necessitates an understanding that taking care of more than the human world will always result in the best outcome for people as well. It involves the need to move away from the prevalent human-centric (ego-centric) decision-making processes that rely on measurements, reporting, checklists and silos which are dominated by metrics that add up to a prescribed answer.

Instead, we must embrace eco-centric decision making, which focuses on understanding the impacts of a decision on the whole system. This will guide us in seeking intuitive answers based on long-term thinking, and valuing nature for its own sake rather than purely for its monetary benefits. However, an eco-centric approach can feel less certain, less defined and unpredictable—like nature, which is ever-changing, dynamic and adaptive.

Putting Learning from Nature into Practice

There are time-tested practices that light the path towards an eco-centric decision-making future. Nature itself adapts and designs solutions to challenging problems constantly, and much of the life on Earth has had 3.8 billion years to perfect adaptation. There is much to learn from Nature's brilliance, strategies and systems, which the practice of biomimicry brings to light.

The indigenous communities around the world that have been able to keep their knowledge, dignity and traditions intact demonstrate that it is possible for humanity to live with a different value system. Our current dominant societal and economic systems are set up to rely on the broken relationship between humans and the more-than-human world, even though these systems are driving humans and many other species to the brink of extinction, and the ecosystems that underpin them are collapsing.

The first step in moving towards an eco-centric decision-making approach is to reconnect people with nature. Cities can play a powerful role in that reconnection, and given that most of



The Bullitt Center in Seattle is a certified "Living Building" that generates its own electricity, collects its own rainwater, avoids the use of commonly hazardous materials during construction, and beautifies the surrounding neighbourhood with a pocket park.

Photos by Nic Lehoux, courtesy of Bullitt Center

the world's people live in cities, their potential for positive change is immense. The best cities to live in are consistently regarded as those with abundant open space, accessible rivers or waterfronts, clean air and frequent opportunities to spend time in nature. Cities can go beyond these basics to start integrating requirements for biodiversity net gain.

Biomimicry and Ecosystem Services

Once nature is vibrant in the city, and opportunities for reconnecting with nature are in place, utilising biomimicry can take the reconnection even deeper. Analysis and understanding of the ecosystem services that nature provides can teach us how to emulate those services in dense cities, where the addition of open space can be challenging, and in the process create a rich connection between the human and natural parts of a city.

Biomimicry can provide a functional view of how nature supports all of life to thrive. The adoption of this approach at the city scale is

limited, but one of the best examples that shows its potential is the Bullitt Center in Seattle. This project undertook an ecosystem services study that shows how the building continues to reap the benefits from an eco-centric approach. The Bullitt Center reuses 487 m³ of rainwater yearly. It also saves 323 metric tonnes of CO₂ each year through energy-efficient strategies, and a further 1,844 metric tonnes over its lifecycle through the use of responsibly managed wood in its construction.

Lastly, the reconnection between people and nature must be celebrated for eco-centric decision-making to take hold. If there is joy and play when we spend time in nature, then we can reawaken our profound relationship with the rest of life.

As we explore what a regenerative city could be, it is critical that we look at shifting our decision-making processes, that we analyse what we value and how we value it, and that we take accountability for challenging the dominant social structures that inherently do not value nature at their core.

4 From end-of-life to closed-loop planning

Conventional urban development operates on linear timescales and material flows. Buildings are designed for fixed lifespans and often demolished when deemed no longer viable or profitable. Planning often focuses on project completion, prioritising immediate outcomes rather than long-term system health.

With the greater push for urban renewal, changing social conditions and rapidly advancing technology, we are witnessing a rising trend of shrinking building lifespans. In Northern Europe, the lifespan for newer buildings tends to be 45% shorter than average,²⁹ while in China the average building lifespan is reportedly 25 to 35 years, which is significantly shorter

than designed lifespans.³⁰ Buildings must be designed and constructed with a longer-term view, incorporating regular and pre-emptive upgrading to meet evolving resilience needs.

Time is a core dimension in the regenerative approach. It demands that we choose long-term, holistic approaches aligned with closed-loop models over short-term, immediate priorities that drive linear extraction. The regenerative approach moves from models of linear extraction to creating closed-loop systems where resources are reused. This enables maximising co-benefits and outcomes throughout the entire lifecycle of a development.

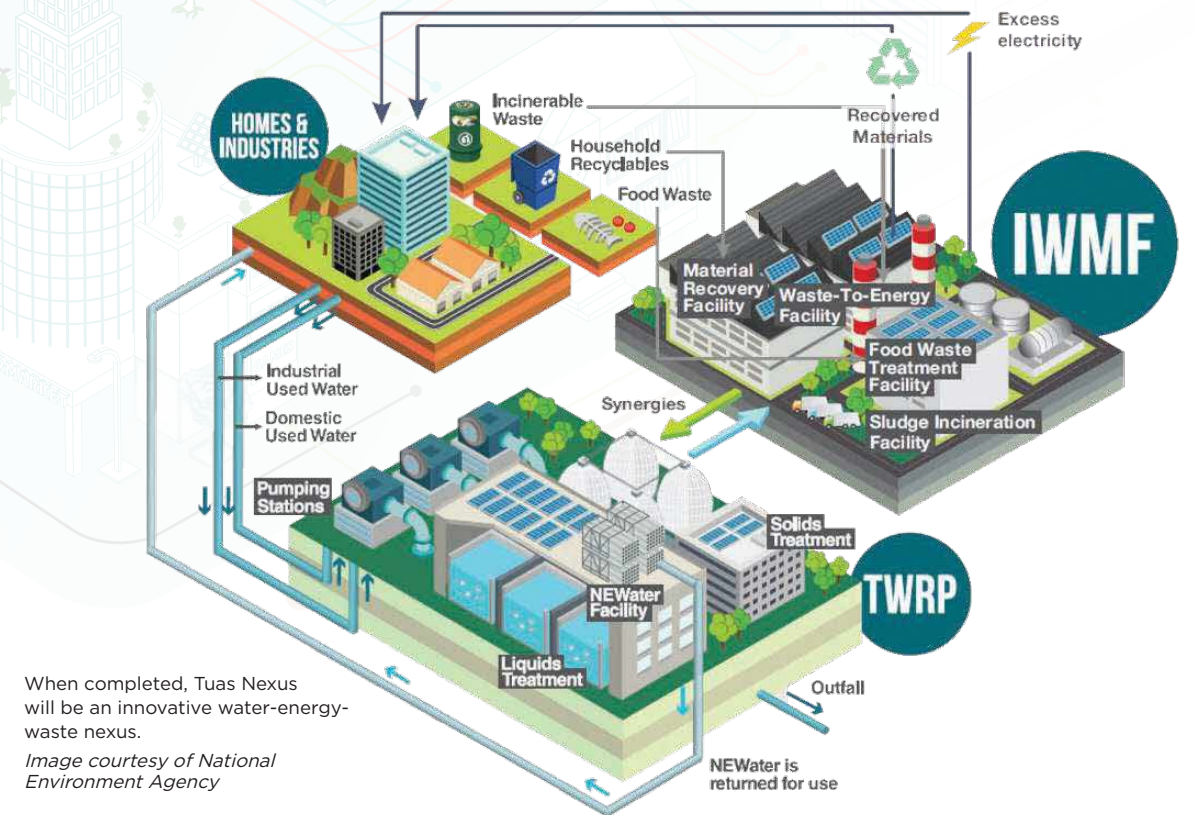


St Ann's Warehouse in New York City transformed a former tobacco warehouse into a performing arts venue with the addition of a new steel structural frame and a glass brick clerestory, prolonging the lifespan of the warehouse.

Photo courtesy of Wgreaves (CC BY-SA 4.0 / Wikimedia Commons)

AN INNOVATIVE WATER-ENERGY-WASTE NEXUS

FIRST OF ITS KIND, ENERGY SELF-SUFFICIENT GREENFIELD PROJECT PLANNED FROM THE GROUND UP



Planning and designing for the long term recognises that holistic outcomes take time to materialise, often beyond the immediate completion of a project. Social, economic and environmental investments are long-term commitments that require lifecycle planning. Early-stage investments in daylighting and ventilation, for instance, can yield decades of improved liveability outcomes, better health outcomes and long-term savings in energy cost.³¹ Biophilic features also take time to effectively support local biodiversity and ecological resilience. **In practice, this means practitioners do not merely design a building or infrastructure, but also design the feedback loops that allow urban systems to expand the capacity to adapt and optimise over time.** Practitioners must now create dynamic systems and not static solutions.

Singapore's upcoming Tuas Nexus co-locates an Integrated Waste Management Facility (IWMF) and the Tuas Water Reclamation Plant (TWRP), synergising the urban systems of water, energy and waste to optimise land use and reduce treatment costs. Once completed, Tuas Nexus will generate enough electricity to sustain its own operations and export excess electricity back to the national grid. This approach recognises that multiple urban systems operate simultaneously and require continuous feedback loops to harness their changing synergies. The potential of such integrated systems is significant, though circular systems can face rebound effects and operational difficulties in urban renewal contexts such as market barriers, lock-in from legacy infrastructure, and high coordination costs across fragmented utilities and agencies.



DESIGNING CITIES THAT GIVE BACK: A REGENERATIVE CO-BENEFITS AGENDA FOR URBAN DENSITY

CHEONG KOON HEAN

Chair, Lee Kuan Yew Centre for Innovative Cities at the Singapore University of Technology and Design, and Chair, World Cities Summit Knowledge Council 2026–2028

Cities sit at the front line of climate change. They concentrate people, assets, emissions and risks, while also holding the greatest potential to drive solutions at scale. Over the past two decades, urban climate action has focused primarily on mitigation targets, efficiency gains and risk management. These efforts remain essential. Yet as climate impacts intensify and resource constraints tighten, it is increasingly clear that incremental, siloed approaches are no longer sufficient.

What is now required is a shift in how cities conceive of climate action. Regenerative design offers a powerful and practical framework for this shift—one that enables cities to reduce emissions and climate risk while simultaneously enhancing ecosystems, liveability and resource efficiency.

Rather than treating these objectives as competing priorities, a regenerative approach reframes them as mutually reinforcing outcomes. This requires four shifts in current paradigms—towards net-positive value creation, designing for synergies, human-nature co-evolution and circular, regenerative lifecycles.

From Impact Reduction to Net-Positive Value Creation

Most urban climate strategies today are grounded in impact reduction. They operate within a logic of constraint, aiming to slow degradation rather than reverse it.

Regenerative design advances a more ambitious proposition: cities can become net contributors to ecological and social systems. This means that urban development should not only reduce emissions, but also restore ecosystem services, moderate climate impacts and strengthen long-term resilience. Through a regenerative approach, buildings, districts and infrastructure are designed to generate renewable energy, enhance biodiversity and improve microclimates—creating positive feedback loops over time.

From Managing Compromises to Designing for Synergies

Urban climate policy is often framed as a balancing act: decarbonisation versus growth; density versus liveability; resilience versus affordability. These perceived trade-offs are often tension points between the general populace, interest groups, industry and policymakers.

A regenerative, co-benefits approach replaces this logic with one that designs for synergies. By integrating climate action with urban development objectives, cities can unlock shared gains across four critical domains:

- ecosystem services and biodiversity,
- decarbonisation and climate mitigation,
- liveability and human well-being, and
- resource efficiency.

From Human Dominance to Human-Nature Co-Evolution

Conventional urban development has largely treated nature as an externality—something to be controlled, engineered around, or offset. This mindset has contributed to increased climate vulnerability, loss of biodiversity and reduced urban liveability.

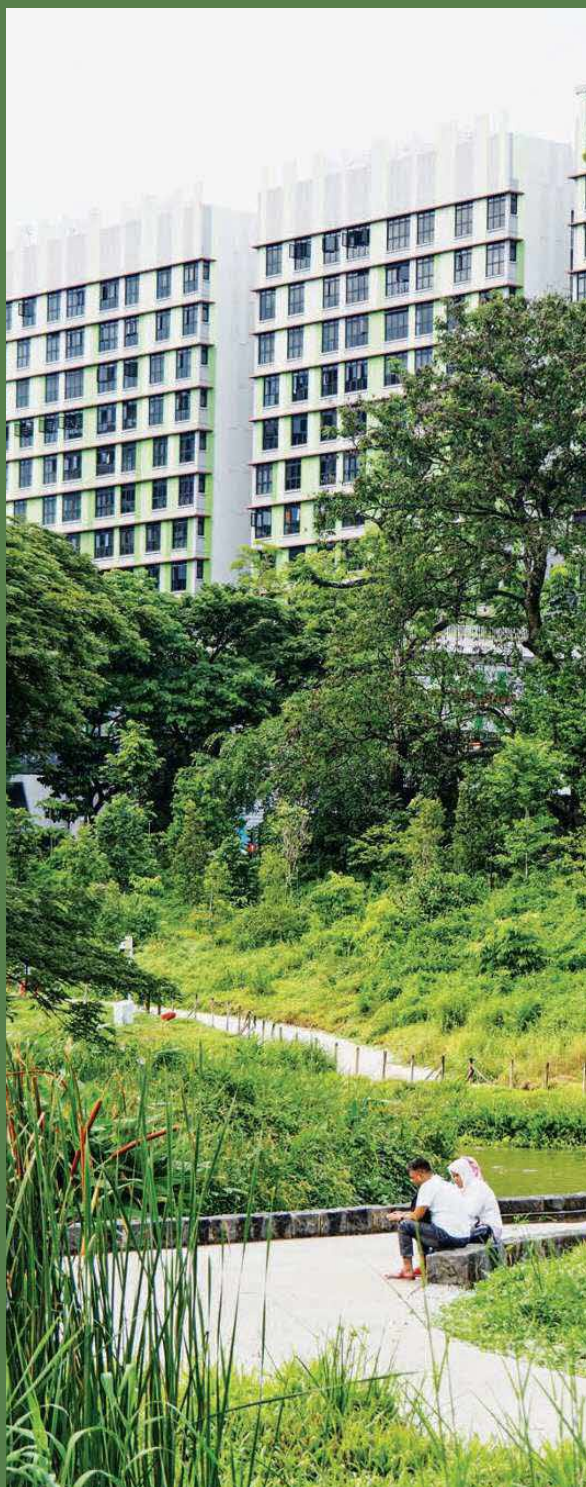
Regenerative cities are built on a different premise, that human and natural systems co-evolve. Nature-based solutions are not aesthetic add-ons but essential climate infrastructure. Urban trees, wetlands, green roofs and permeable

landscapes not only manage stormwater and sequester carbon, but reduce heat stress and support mental and physical health.

From Linear to Circular, Regenerative Lifecycles

Climate vulnerability is deeply tied to how cities use resources. Linear models of extraction, consumption and disposal increase emissions, expose cities to supply-chain shocks and lock in long-term environmental risk.

Regenerative design promotes circular, closed-loop systems across energy, water, materials and land. This includes designing buildings for adaptability and reuse, integrating district-scale energy and cooling systems, and treating waste streams as resources. Such approaches reduce emissions while strengthening resource security.



Bidadari Park's blue and green spaces not only provide areas for communal recreation and habitats for wildlife but also help absorb excess water in times of flooding.

Photo courtesy of Ng Sze Xuan

Regenerative Design in Singapore

Singapore provides a compelling illustration where land scarcity, competing urban demands and climate exposure intensify challenges such as urban heat, flooding and biodiversity loss. Density constrains the availability of large, contiguous areas for greenery, but it also creates powerful opportunities for innovation through compact, integrated systems.

Regenerative design allows ecological functions to be embedded vertically and systemically. Blue-green initiatives such as at Bishan-Ang Mo Kio Park and Bidadari Park demonstrate how naturalised waterways using a “sponge city” concept can simultaneously deliver climate resilience, recreational value and ecological restoration.

Deeper Science and Effective Governance for Climate Policy

Beyond aspirations and rhetoric, we need to develop the science behind regenerative thinking. The interactions between different elements of human interaction, nature, ecosystem services and resource chains, and the co-benefits generated by these interactions, need to be better understood before they are applied. Deeper transdisciplinary research with the involvement of academics, industry and policymakers is essential to contribute to such understanding.

The transition towards regenerative cities is not primarily a technical challenge, it is also a governance one. Delivering co-benefits at scale requires policy integration across climate, planning, health, housing and infrastructure dimensions. It also demands new decision-making tools that prioritise long-term system performance over short-term project optimisation.



The river channel that runs through Bishan-Ang Mo Kio Park, formerly a concrete canal, was redesigned to be a flood plain, incorporating plants, natural materials such as rocks, and civil engineering techniques to soften the edges of the waterway.

Photo courtesy of Wirbel1980 (CC BY-SA 3.0 / Wikimedia Commons)

Redefining Urban Climate Success

As climate risks intensify, cities can no longer afford fragmented solutions. Climate resilience and economic competitiveness increasingly depend on the ability of cities to create value across multiple systems, rather than optimising single variables in isolation.

Regenerative design offers a policy-relevant framework that aligns climate mitigation and adaptation with ecosystem restoration, liveability and resource efficiency. It enables cities to do more with every intervention, maximising shared value rather than managing competing demands.

The question facing urban leaders is no longer whether regenerative approaches are desirable, but whether climate action can succeed without them.

In our climate-changed and resource-constrained reality, the regenerative approach seeks to make positive change, harness co-benefits, steward urban ecosystems and design for circularity. It enables cities to achieve the outcomes of liveability and resilience, for people and the planet, by increasing the capacity for synergy, adaptation and optimisation. This is not to suggest that regeneration is a silver bullet. Some trade-offs around equity, affordability, land use and institutional capacity cannot be resolved through better design alone. They require sustained political will, governance capacity and long-term investment.

Our next question: How can we bridge regenerative outcomes with real-world operating capacities? In Chapter 2, we unpack the Regenerative City Framework to gear ourselves up for practical action.

Chapter 2

THE REGENERATIVE CITY FRAMEWORK

Composed of outcomes, strategies and enablers, the Regenerative City Framework presented in this chapter acts as a springboard that each city can adapt from and build upon.

Benjakitti Forest Park in Bangkok showcases how dense cities can build resilience through nature. The park acts as a green lung, providing ecosystem services to the city and recreational spaces for residents.

Photo courtesy of nāuss สุนโสภา, (CC BY-SA 4.0 / Wikimedia Commons)



DEVELOPING THE REGENERATIVE APPROACH FOR CITIES

Around the world, we have witnessed notable instances of low-carbon development, including promising projects and pilots that have taken on a regenerative design approach, particularly at the building scale. While initial progress has been encouraging, a fully realised, large-scale transition to low-carbon development has not been completed anywhere to date. As a result, there is significant opportunity to broaden and accelerate implementation at scale.

How can the regenerative approach be made practical and useful for urban leaders and practitioners seeking city-wide application?

Academics, urban practitioners and policymakers across disciplines and geographies were convened over multiple engagements to answer this question.³² While assessing institutional readiness, identifying barriers and uncovering opportunities, these engagements revealed several key obstacles.

First, there was a clear absence of shared metrics for measuring regenerative outcomes. Second, there was a knowledge gap on effective and impactful regenerative strategies to replace approaches that may no longer be fit to address contemporary urban challenges. And lastly, there was a sense that cities need better guidance to create an enabling environment for regenerative approaches, especially to scale this approach city-wide. It was evident that while the aspiration for creating the regenerative city resonated widely, the pathways to achieve it remained unclear.



Scan QR code to watch highlights of the 2025 kick-off edition of the Regenerative City Forum series.



The 2025 kick-off edition of the Regenerative City Forum series in Singapore featured speakers Wong Mun Summ, co-founder of WOHA, and Fred Holt, partner at 3XN, and moderator Chintan Raveshia, Director of Cities, Planning & Design Leader of the Asia Pacific Region at Arup.
Photos courtesy of Centre for Liveable Cities



The World Cities Summit Knowledge Council Members 2024–2026 partook in site visits and discussions to examine the topic of regenerative cities and what it means for cities around the world.
Photos courtesy of Centre for Liveable Cities



The Singapore Pavilion hosted the Cities Thematic Day at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP) 29.

Photo courtesy of Centre for Liveable Cities



(Left and above) The Singapore Pavilion's Cities Thematic Day at the UNFCCC COP30 focused on the theme of Resilient and Regenerative Cities for a Climate-changed World.

Photos courtesy of COP30 Singapore Pavilion



Panel discussion (left) and multisectoral workshop (above) at the Regenerative City Forum 2 held in conjunction with London Climate Action Week 2025.

Photos courtesy of Sarah Bastin (left) and Centre for Liveable Cities (above)

To move from aspiration to action, the Centre for Liveable Cities (CLC) began work on a Regenerative City Framework to support operationalising regenerative approaches in urban development. Equipped with rich insights collected from engagements with multi-sectoral stakeholders, the CLC partnered with the Singapore University of Technology and Design to conduct scientific studies and deep dives on the topic. This included employing the Delphi methodology and engaging with global experts from public, private, people and

academic sectors to uncover common aspirations, principles and perspectives.

Through the process of distilling and triangulating insights from the research, a shared foundation emerged: a consensus-based definition of regenerative cities, a set of guiding principles, and a validated compendium of strategies, enablers and outcomes. That foundation is the **Regenerative City Framework** presented in this chapter.

[To find out more about the research methodology, refer to Annex on page 198.](#)

WHAT IS A REGENERATIVE CITY?

A regenerative city goes beyond sustainability—which strives to reduce harm—to optimise co-benefits across liveability, resilience and resource optimisation outcomes.

It is a complex and dynamic urban-natural environment where human, ecological and technological systems co-evolve to generate multiple co-benefits. In a climate-changed and resource-constrained world, a regenerative city renews and adapts to turn interdependencies into opportunities.

This definition, validated through wide and deep engagements with global experts, presents the built environment as an engine for good. The city is recognised as a place where both the built and natural environments can be integrated, for the long-term well-being of the city’s inhabitants. It also acknowledges that cities need to redevelop and adapt to changing conditions, and that doing so in a regenerative manner can achieve positive outcomes across social, environmental and economic dimensions.

Recognising the contextual differences in cities across the world, the definition holds space for interpretation and adaptation. It offers a common understanding of what regenerative cities are and how they function, so that every city can develop its own context-specific path.

Animating this definition are eight key principles, which form the values that ground regenerative urban development and differentiate it from more conventional approaches. They are aimed at helping cities translate regenerative urbanism into actionable priorities.

THE REGENERATIVE CITY PRINCIPLES



Adapted from the findings of the Delphi study conducted by the Singapore University of Technology and Design, in collaboration with the Centre for Liveable Cities.

Co-benefits are often unevenly distributed, and the communities most in need of regenerative outcomes are not always the first to benefit from them. Governance and political economy constraints—from siloed institutional mandates to short

electoral cycles—can prevent the kind of integrated, long-term decision-making that regenerative urbanism demands. The principles are most useful when treated as a framework for structured judgement rather than a checklist of conditions to be met.

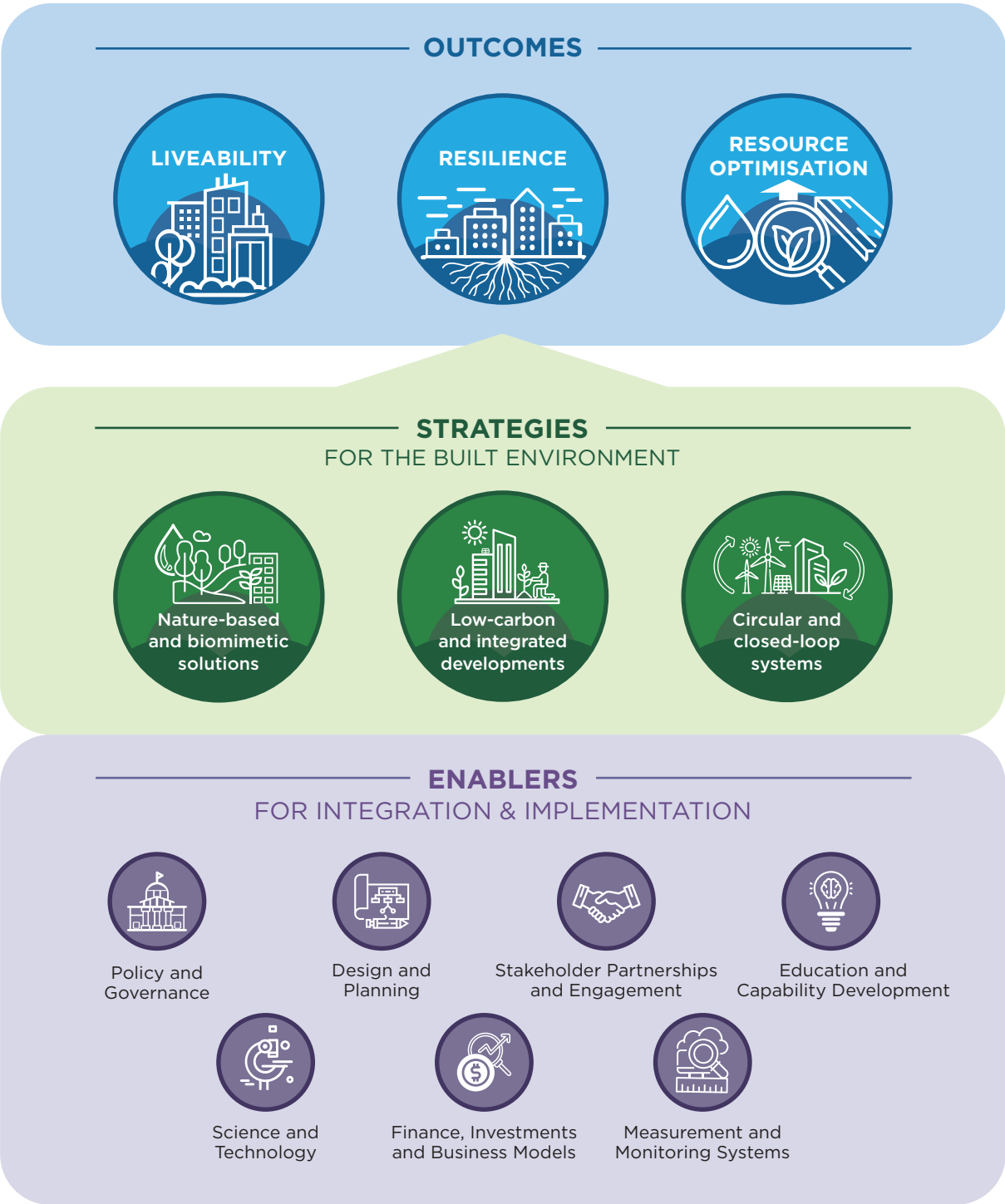
HOW CAN WE CREATE A REGENERATIVE CITY?

With the foundation of a shared definition and principles, the **Regenerative City Framework** offers a structure for action that city leaders can adopt, adapt and build upon.

The Framework has three components:

- **OUTCOMES** that form the “north star” for what regenerative cities hope to achieve
- **STRATEGIES** that leaders and practitioners can act on to pursue those outcomes
- **ENABLERS** that create supportive conditions for achieving those outcomes

THE REGENERATIVE CITY FRAMEWORK



The Regenerative City Framework.
Image courtesy of Centre for Liveable Cities

OUTCOMES

of Regenerative Cities



Vienna's New Danube not only provides habitats for wildlife and green-blue spaces for residents, but it also generates hydroelectric energy that is used to power household needs.⁴²
Photo courtesy of Gugerell (CC BY-SA 1.0 / Wikimedia Commons)

The Regenerative City Framework identifies three interdependent outcomes: **liveability**, **resilience** and **resource optimisation**. These are dimensions of the same ambition, where progress in one domain creates the conditions for progress in another. Interdependence is the defining characteristic of regenerative urban development so that co-benefits can be realised across all dimensions.



Liveability

Liveability is a measure of urban condition.

Outlined by the Centre for Liveable Cities' (CLC) Liveability Framework, liveability reflects the city's ability to balance and achieve a competitive economy, a high quality of life and a sustainable environment.

A regenerative city has a competitive economy that offers quality jobs for all in a dynamic and resilient business environment. The city is agile and adaptive to emerging growth sectors and evolving aspirations. It also achieves a high quality of life for its people. The city offers positive economic, social, environmental and physical aspects of urban living, where residents are safe and access to transport, food, housing and healthcare is secured. Importantly, a regenerative city strives to harness socio-ecological co-benefits, where people judiciously exercise stewardship of natural ecosystem services. It skilfully balances the demands of development with ecosystem health, sustaining the diversity, density and connectivity of the built and natural environments in the city.



PUBLISHED BY THE CLC

The Centre for Liveable Cities' Refreshed Liveability Framework

The CLC first introduced the Liveability Framework in 2014. With a recent refresh of the Framework in 2024, the Centre published **Building Liveable and Sustainable Cities: A Framework for the Future**, taking into account the challenges facing cities today and in the future. The refreshed edition of the Framework proposes an updated understanding of liveability outcomes for cities and the urban systems that support them.

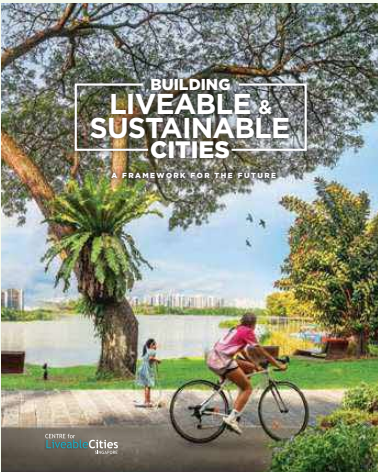


Image courtesy of Centre for Liveable Cities



Scan QR code to read the publication.



Resilience

Resilience is a measure of capacity.

It reflects the ability of a city's people, communities, institutions, businesses and systems to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events.

A regenerative city builds resilience across reinforcing dimensions: climate, social, environmental and resource. It pursues mitigation and adaptation simultaneously to address climate-induced risks. It cultivates strong inclusive collaborative ecosystems and establishes physical and social infrastructures that empower people to bounce back and participate in recovery. The regenerative city also nurtures the health and functionality of natural systems to remain diverse, adaptive and thus resilient. In addition, it secures long-term access to vital resources, safeguarding against disruptions and uncertainties. In a regenerative city, resilience is not merely a defensive strategy but also a pathway for unlocking co-benefits for the community and local ecosystems.

PUBLISHED BY THE CLC

Building Community Resilience

There can be no resilient city without a resilient community. This playbook documents the CLC's research on strengthening and measuring community resilience through co-creation. It showcases a multi-stakeholder framework that nurtures citizen-initiated projects that not only address local challenges but also support broader national efforts.



Image courtesy of
Centre for Liveable Cities



Scan QR code
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Resource Optimisation

Resource optimisation is a measure of process.

It shows the degree to which material, food, carbon, water and land are used and kept in continuous circulation to minimise extraction, waste and environmental degradation.

The regenerative city strives for efficiency, operating as an integrated metabolic system, where the lifespans of resources in circulation are prolonged, and more is created with

less. It aligns urban development with global carbon and ecological limits, and is mindful of the rate of resource replenishment and system processes to ensure resource security for its residents. It also champions land-sharing through compact, mixed-use and low-carbon developments to minimise land-take and resource use. Ultimately, a regenerative city stewards and responsibly uses its resources to ensure its long-term viability.



The Tampa Bay Estuary Program in Florida, the United States, engages the community in restoring natural habitats in the bay, which have been damaged by pollution and rising sea levels.

Photo courtesy of Joe Whalen on Unsplash



SINGAPORE'S WATER STORY FROM THE REGENERATIVE LENS

ONG TZE-CH'IN

Chief Executive Officer, PUB, Singapore's National Water Agency

Water as an Existential Issue for Singapore

Since independence, Singapore's water supply has been an existential issue. At that time, we lacked enough water resources of our own within Singapore to meet the demands of our growing population and economy. We remain dependent on imported water from Malaysia. For many,

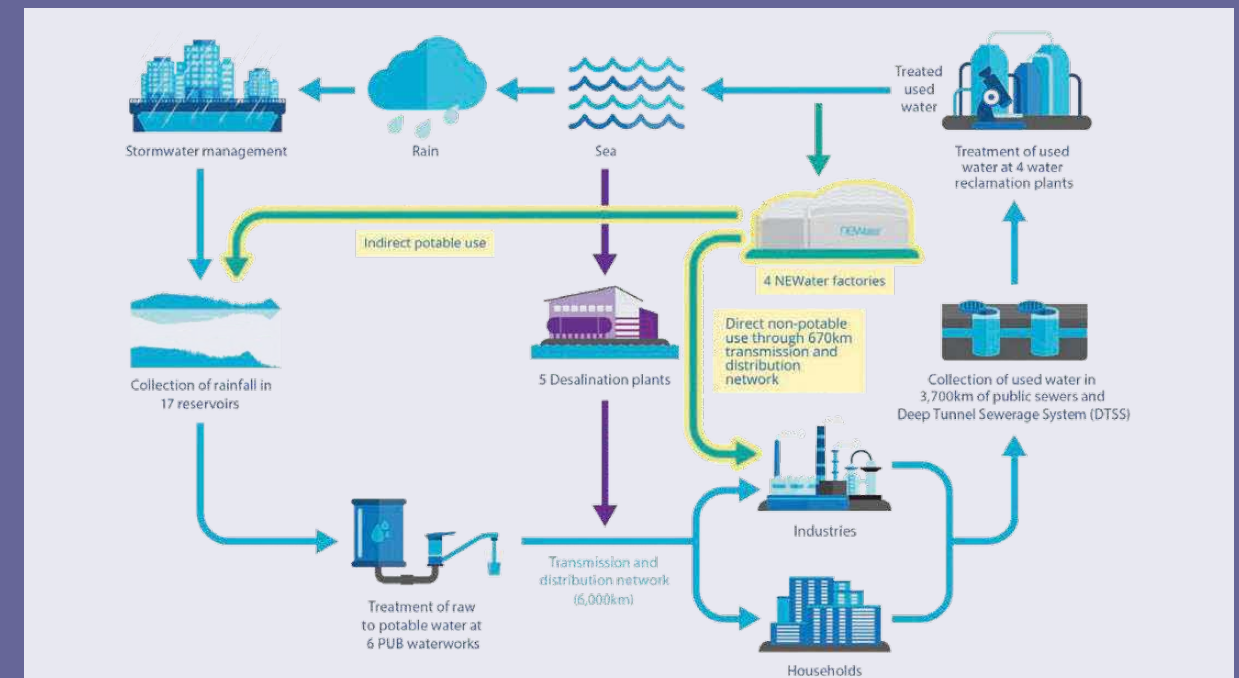
Singapore's water story is synonymous with our Four National Taps—our diversified water supply portfolio of local catchment water, imported water, NEWater and desalinated water—and how they have collectively transformed our water supply into one that is sustainable and resilient.



The Launch of NEWater at Singapore's 2002 National Day Parade.

Photo courtesy of PUB

Closing the Water Loop: NEWater



Singapore's water loop.

Image courtesy of PUB

PUB closed the water loop in Singapore with the introduction of NEWater—Singapore's brand of ultra-clean, high-grade recycled wastewater, which PUB produces from recycling both domestic and industrial wastewater. NEWater enabled PUB to reuse every drop of water endlessly, and through water recycling, to produce a multiplier effect on Singapore's finite water resources.

NEWater is designed to be potable, although today, most of it is sold to industrial customers who require high-purity water. Another major use of NEWater by PUB is to top up our impounding reservoirs scattered across Singapore. This then serves as indirect potable use of recycled water and strengthens the resilience of our water supply against climate risks.

Developing the NEWater tap has been a long journey for PUB and for Singapore—one that took decades and significant public buy-

in. Since the 1970s, PUB had been tracking water recycling technologies across the world, notably in the United States. Eventually, in 2000, this led to the construction of a dual-membrane demonstration plant in Bedok to get the NEWater project going. We undertook a comprehensive 2-year study, supported by an independent expert panel, to ensure that the technology worked and the recycled water was safe.

More importantly, we needed to convince the Singaporean public that NEWater was safe to drink. The use of recycled water for drinking purposes has long faced resistance all over the world, and Singapore was no exception. We put out the findings of our expert panel—that NEWater's quality was consistently safe. We convinced our politicians to publicly support NEWater. All of these public communications efforts culminated in a "mass toast" of NEWater at Singapore's National Day Parade in 2002, led no less than by the Prime Minister himself.

Managing Water Demand Through Conservation and Efficiency

Even as PUB grew our water supply and introduced new National Taps like NEWater, we were always clear that we needed to moderate the growth of water demand from both households and businesses. From the water resource perspective, Singapore’s development needs to be sustainable over the long term.

Starting with the “Save Water” campaigns of the 1970s, the same message of water conservation carries on today with our Singapore World Water Day campaigns. We work with schools to raise awareness of water conservation among students and bring many water saving tips to families and households. We also introduced the Water Efficiency Labelling Scheme to provide consumers with information on the water efficiency of appliances and water fixtures. These efforts are intended to empower every individual in Singapore to make more informed choices and choose water-efficient products for their homes.

PUB has also implemented measures and initiatives to drive water conservation in the non-domestic sector. The first is the right pricing of water. In Singapore, we price water at the marginal cost, i.e. the cost of producing and supplying the next drop of water. This ensures that companies take into account the true cost of water in their business decisions and work towards more water-efficient outcomes. The second is the use of grants under PUB’s Water Efficiency Fund to incentivise companies to introduce water recycling in their plants and businesses, and to apply more water-efficient processes into their operations. With the non-domestic sector driving much of the future growth in Singapore’s water demand, it is critical that our industries continue to prioritise water efficiency for long-term sustainable growth.

Conclusion

In an era of climate change, water becomes even more precious. Dry spells and droughts can easily disrupt the supply to homes and businesses. Everyone in Singapore continues to play an important role in Singapore’s water story, even as PUB builds on our past achievements and prepares to meet increased water demand. My colleagues and I continue to work hard on this important mission of supplying good water to Singapore and Singaporeans.

This op-ed takes reference from Tan Yong Soon, Lee Tung Jean and Karen Tan’s Clean, Green and Blue: Singapore’s Journey Towards Environmental and Water Sustainability (Singapore: Institute of Southeast Asian Studies, 2008).

These three outcomes of the regenerative city—liveability, resilience and resource optimisation—are interdependent. They are not separate end states to be achieved in sequence but are cultivated concurrently. The regenerative city is iterative, dynamic and place-based, and the strategies in the next section describe how cities can make meaningful progress toward all three.



Singapore World Water Day 2026 campaign.
Images courtesy of PUB

STRATEGIES

for Regenerative Cities

Actionable high-impact approaches help cities achieve the desired outcomes of a regenerative city. Yet, the diversity of urban contexts around the world means that strategies that work well in a high-density Asian metropolis might not work to the same effect in a post-industrial European city.

The Regenerative City Framework strikes a delicate balance. With the aim to set out broader directions for place-specific actions, the Framework introduces three key strategies.



STRATEGIES

FOR THE BUILT ENVIRONMENT



Adopt Nature-Based and Biomimetic Solutions

While nature is vital to sustaining the well-being of a city, only 37% of the most populous cities globally have a dedicated strategy to nature or biodiversity preservation.³³ Nature is often treated as an afterthought.

To harness the co-benefits of nature-based and biomimetic solutions—with the former working with natural systems and the latter drawing inspirations from or mimicking designs found in nature—policymakers, planners and designers must move beyond conventional thinking about the built environment to consider how it can support ecological health.

Rather than planning for grey infrastructure alone, cities can designate space for more green-blue-grey infrastructure. Green-blue-grey infrastructure ranges from soft ecological engineering, such as enhancing mangrove habitats for coastal protection, to ecosystem-based adaptation that involves hybridised solutions, such as creating rain gardens and green corridors that capture and retain stormwater. It gives cities an opportunity to balance the demands of urban development with ecosystem health, which is itself beneficial for human health.



In response to severe flooding in 2011, Copenhagen implemented several flood mitigation measures. It combines green-blue infrastructure such as parks and wetlands to drain and absorb water, along with grey infrastructure such as pipes and tunnels to store and remove any overflow.

Photo courtesy of Venus Major on Unsplash



The restoration of Te Auaunga added community amenities such as shared pathways and pedestrian bridges, community orchards, an outdoor classroom and natural play areas.

Photos courtesy of Auckland Council



TE AUAUNGA IN AUCKLAND, NEW ZEALAND

The restoration of Te Auaunga (Oakley Creek) from a concrete channel and culvert into a naturalised stream and wetland unlocked social, environmental and economic co-benefits. As a result, water quality improved, 80,000 m² of land was reclaimed for public use, and nearly 200 homes were protected from flooding.³⁴

The project was underpinned by the wider Auckland Water Strategy 2022–2050, an adaptive policy and planning approach that aims to drive the development of regenerative water infrastructure.³⁵ It mandates that all new and replaced existing infrastructure must be nature-based, resilient and generate low or zero emissions.

When deployed district-wide, nature-based and biomimetic solutions can help to alleviate the urban heat island effect, manage flooding and stormwater runoff, and strengthen connectivity for biodiversity. It can also reduce a city's vulnerability to cascading climate risks, making the city more resilient for both people and ecosystems.

Employing nature-based and biomimetic solutions can also be part of a strategy to create more equitable cities. Often, these solutions also secure socio-economic co-benefits for the broad populace, benefiting the most vulnerable in the city. This means that such solutions may not be just environmental imperatives, but social ones that embed resilience where it is needed most.

NATURE-BASED SOLUTIONS IN LONDON, UNITED KINGDOM, AND FREETOWN, SIERRA LEONE

Under city-wide mandates, rewilding and remediation of underutilised zones have helped London and Freetown bolster their resilience against flash floods and heat waves. In London, integrating nature into highways and streets has helped to improve flood resilience and the overall air quality. In Freetown, where temperatures can be as much as 6°C higher in informal settlements than surrounding regions, green corridors provide shade and cool vulnerable communities. This intervention protects informal sector workers, especially women traders who often have to work under harsh outdoor conditions.



London's Queen Elizabeth Olympic Park, once an industrial brownfield site, now contains close to 10,000 woodland shrubs and 120,000 flowers and plants, providing habitats for rare species of fauna while also providing flood protection for approximately 5,500 homes in the Lea Valley.⁴³

Photo courtesy of The Wub (CC BY-SA 4.0 / Wikimedia Commons)



Scan QR code to read an interview with Shirley Rodrigues, London's former Deputy for Environment and Energy.



Scan QR code to read an interview with Mayor Yvonne Aki-Sawyerr of Freetown.



Mayor Aki-Sawyerr planting a tree as part of Freetown's urban greening drive.

Photo courtesy of Freetown City Council



AN ISLAND THAT CAPTURES HEARTS FOR GENERATIONS: SENTOSA REDEFINES REGENERATIVE DESIGN PRACTICES

THIEN KWEE ENG

Chief Executive Officer, Sentosa Development Corporation, Singapore

There is something magical about stepping onto Sentosa, a premier island resort located just south of mainland Singapore. Whether it is families gathering at sunset along its golden sandy beaches, or leisure guests immersing themselves in its island rhythms, there is a palpable sense of escape—away from the “noise of machines”, as envisioned by former Prime Minister Mr Lee Kuan Yew half a century ago.

Sentosa is not just Asia's leading leisure destination for the 17 million who visit each year. For many Singaporeans, it is a repository of shared memories and joy experienced across generations. It is, in many ways, an island that captures hearts and the emotions it inspires.

The enduring affection that generations have for Sentosa has shaped our bold vision: To become the world's best loved leisure and lifestyle destination. To be “best loved” goes beyond scale or attractions. It is about creating a destination that continually delights, remains relevant, creates experiences that foster connection among communities, unlocks business opportunities and stewards our natural environment with care.

Our aspiration is not only to sustain what makes this island special, but to strengthen and restore the economic, social and environmental systems that support the island over time.



Generations have made treasured memories across Sentosa's well-loved spaces, such as Tanjong Beach.

Photo courtesy of Sentosa Development Corporation

From Sustainability to Regeneration

At Sentosa, we define regeneration as more than a design principle. It is about crafting experiences that are experientially exceptional, functionally effective and leave both our guests and our destination better off after every visit. Regenerative design, in this context, is not a standalone endeavour. It is a systems approach that thoughtfully integrates land use, guest experiences, infrastructure and nature not as separate elements, but as interconnected layers of one integrated destination. When these layers are planned and designed as a coherent whole, they create an island that is more resilient and enriching for all who experience it.

This philosophy is enabled by the integrated stewardship of Sentosa Development Corporation under the Sentosa Development Corporation Act.

Sensoryscape: A Living Demonstration of Regenerative Design

A compelling expression of the regenerative approach is Sentosa Sensoryscape, the first completed milestone of the Greater Sentosa Master Plan to reimagine the island over the next two decades.

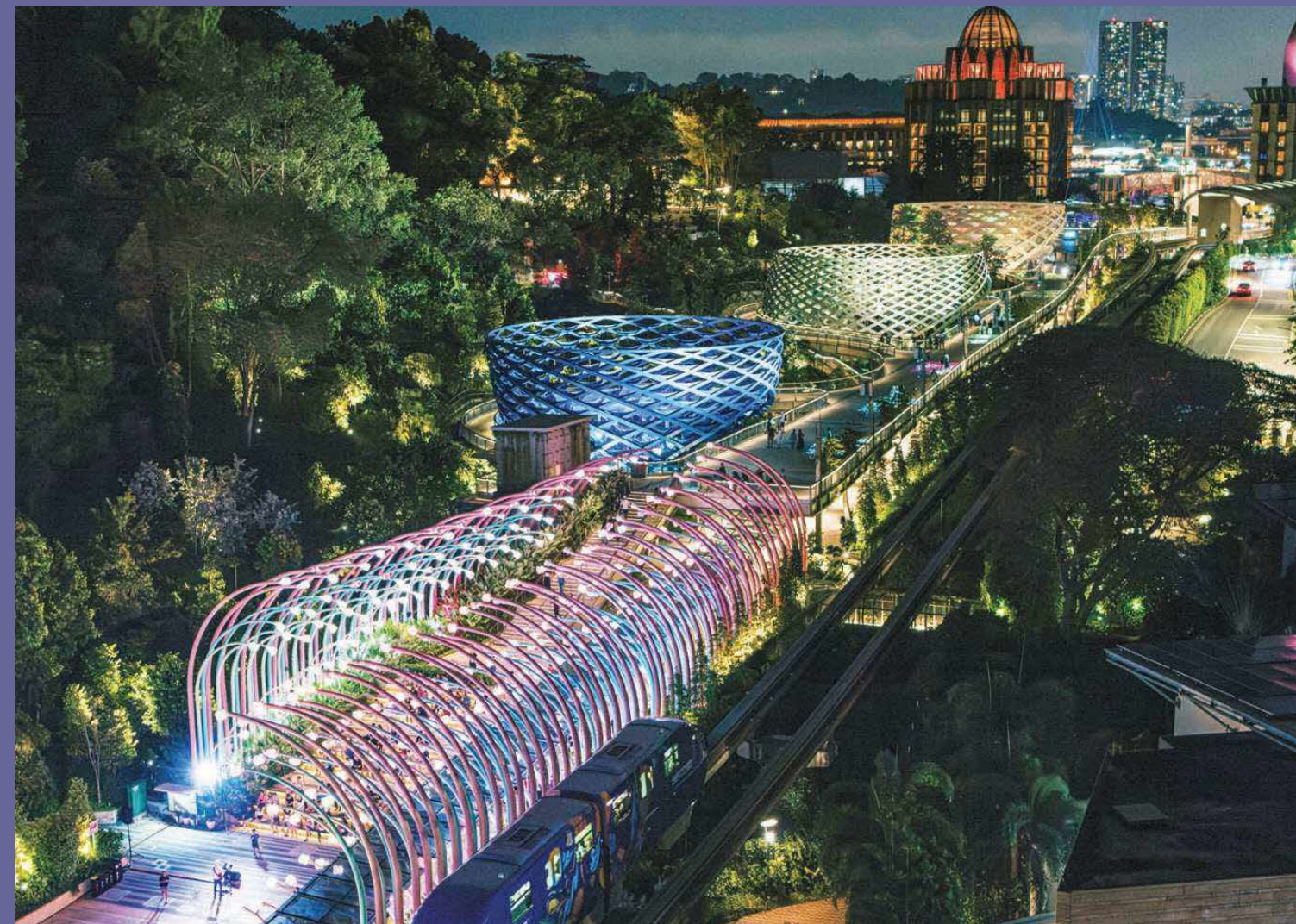
At its core, Sentosa Sensoryscape is a 350-m-long north-south green connector that links the Resorts World Sentosa integrated resort to the island's beaches. Yet it is far more than a thoroughfare. Designed as a day-to-night multi-sensory environment, it redefines the role of infrastructure. Through signature architecture, immersive gardens, interactive digital light art and augmented reality experiences, it transforms a functional connector into a space that creates value, inspires emotions and elevates the overall experience.

Built with universal design and all-weather features, Sentosa Sensoryscape improves accessibility and inclusivity while optimising visitor flow across the island—enhancing capacity and increasing dwell time.

It also demonstrates how regenerative design can strengthen Sentosa's ecological value through purposeful land use planning. Nature conservation is enabled by the incorporation of 38,000 plantings that include 116 native species. This is complemented by the adjacent 500-m² butterfly corridor that attracts pollinators and enhances biodiversity. Over time, such ecological connectors can extend beyond the island, linking to Singapore's mainland green networks and reinforcing Sentosa's role as a key node for biodiversity. This would allow Sentosa to play a meaningful role in supporting a wider ecological resilience, including facilitating migratory bird pathways at the southernmost edge of continental Asia.

Sentosa Sensoryscape is more than just a physical space. It is also a platform for community activation, shared experiences and meaningful partnerships. Creating impact requires collaboration across the entire island ecosystem. Sentosa's island partners—from attractions and hotels to F&B operators—are integral collaborators to amplify impact, generating broader value for guests, businesses and the community. A good example of a coordinated effort is the Peranakan Reimagined heritage celebration in 2025.

In this way, Sensoryscape demonstrates how infrastructure can simultaneously serve experiential, environmental and business goals—creating strong and positive feedback loops across the entire urban ecosystem.



Sentosa Sensoryscape at night.

Photo courtesy of Sentosa Development Corporation

Designing for Exceptional Experience and Climate Resilience

Beyond Sensoryscape, regenerative thinking shapes Sentosa's broader transformation under the Greater Sentosa Master Plan.

As an island destination, coastal protection is both an existential necessity and an opportunity. Measures such as raising ground levels and reconfiguring offshore islets are designed not only to build resilience against climate impacts, for instance, by mitigating erosion and the effects of sea level rise, but also to create new waterfront experiential coastal trails.

Furthermore, we are strengthening ecological connectivity across the island and with mainland Singapore. By linking 1.05 km² of forests across Pulau Brani, Serapong and Imbiah on Sentosa, we are creating a continuous green network that enhances biodiversity and improves habitat connectivity. The network is complemented by thematic wellness nodes that allow guests to immerse themselves in nature for restoration and to support well-being.



An artist's impression of the proposed Imbiah Canopy.
Image courtesy of Sentosa Development Corporation

Future developments will also embed regenerative thinking into the core of infrastructure design. A key example is the proposed Imbiah Canopy, where iconic architecture will be integrated with environmental performance, using renewable energy, rainwater harvesting and biophilic design to enhance the comfort and experience of guests.

Together, these efforts reflect a broader principle: that climate resilience and exceptional experiences are not competing priorities but can be mutually reinforcing when designed in harmony.

Rallying a Community for Change

Regenerative design cannot be achieved through physical infrastructure alone. It requires a community aligned around shared outcomes.

At Sentosa, this takes shape through “One Sentosa”—a coordinated public-private partnership that brings together island businesses, operators, residents, and stakeholders to drive sustainability and inclusivity.

The Sentosa Carbon Neutral Network exemplifies this approach. Since its inception, the network has grown to include partners that account for over 95% of the island's emissions. Through this collaboration, these partners are advancing renewable energy adoption, circular economy initiatives and more sustainable operations.

In addition, all hotels on Sentosa are now certified to internationally recognised sustainability standards. Solar capacity continues to expand across the island, and collective policies—such as reducing disposables—have significantly lowered waste.

Equally important is social inclusivity. Through initiatives like Sentosa Cares, the island has welcomed thousands of beneficiaries from diverse backgrounds, creating opportunities for shared experiences and inclusion. These efforts reinforce the idea that a regenerative destination must also strengthen its social fabric.

What is most striking is the shift in mindset. Competitors have become collaborators. Individual efforts have aligned towards collective purpose. Over time, this builds a culture of ownership where stakeholders see themselves not just as operators, but as co-stewards of a shared place.

A Living System, An Enduring Destination

Sentosa's journey towards regenerative design reflects a fundamental belief: with a clear purpose, the places that we love can continue to evolve without losing their soul. We believe that progress and preservation can be mutually reinforcing, allowing Sentosa as a destination to grow in relevance while deepening what makes it special. By weaving together exceptional guests' experiences, community partnerships and environmental stewardship, we are creating a coherent and enduring destination.

Sentosa must be more than a relevant destination. It should remain truly lived—a regenerative, evolving island playground and sanctuary that continues to capture hearts for generations to come.



Create Low-Carbon and Integrated Developments

Between 2000 and 2020, cities expanded up to 3.7 times faster than they densified,³⁶ and in 2024, urban sprawl accounted for up to one-third of global greenhouse gas emissions.³⁷ As cities race to accommodate growing urban populations, planning struggles to keep pace. This can give rise to informal settlements and urban sprawl, frequently at the expense of liveability and the environment.

The alternative lies in compactness as denser urban forms inherently produce lower emissions.

Integrated developments reimagine urban functions as interconnected parts of a living system, maximising co-benefits across functions, creating productive interdependence through proximity, and lowering carbon emissions.

At the building level, multiple urban functions can be co-located within a single complex. Mixed-use buildings can tap on shared, circular systems, like centrally managed cooling systems that redistribute energy throughout

the building, as well as vibrant, multi-purpose spaces designed to be adapted during different times of the day. By integrating multiple land uses, mixed-use buildings ensure energy and land efficiency. They also enhance liveability amid density by making common amenities closer to one another, improving accessibility.

Integrated approaches can also be applied at the district scale, with mixed-use and well-integrated districts offering high connectivity and access to all essential amenities. By prioritising sustainable mobility networks and transit-oriented developments, the carbon footprint from commuting is kept low. Through intentional design and planning, streets can be designed for multiple uses to maximise co-benefits, including the comfort and health of people and conditions to support biodiversity. At the same time, by creating compact and integrated districts, land use is minimised, freeing up space for social or green infrastructure.

CASE STUDY



OUR TAMPINES HUB IN SINGAPORE

Our Tampines Hub (OTH) is an example of an integrated, community-centred development under the People's Association. It co-locates a library, health centre, football pitch, theatre, community garden and an indoor sports hall that doubles as an auditorium. OTH brings together multiple government agencies, from the National Library Board to SportSG and the National Environment Agency, to offer a wide range of services, programmes and facilities under one roof. It also champions sustainability through eco-smart design, energy-efficient systems and community-driven green initiatives. OTH is built with residents, for residents—fostering a strong sense of community ownership and belonging in Tampines.

(Top) OTH is purposefully designed to include multiple community spaces where residents may gather and bond. It is home to facilities such as (middle right) a multi-purpose plaza and (bottom right) an eco-community garden.

Photos courtesy of DP Architects (top and middle right), and DP Green (bottom right)





REGENERATIVE DESIGN: DELIVERING CO-BENEFITS THROUGH INTEGRATED DEVELOPMENT

SOWMYA PARTHASARATHY

Fellow, Urban Design and Masterplanning, Arup

Regenerative design is reshaping the way cities think about their futures. For decades, sustainability has been framed through the language of limits: cutting emissions, reducing waste and minimising damage. Regenerative design demands a different approach. It challenges cities to give back more than they take—to restore ecosystems, enrich biodiversity

and create better places where human and natural systems thrive together.

At the heart of this perspective is a radical premise: take humans out of the centre of the equation, and design cities not merely as machines for human convenience but as living systems embedded within and dependent on wider ecological networks.



One Triton Square was renewed through a deep retrofit.
Photo courtesy of Arup



Old windows at One Triton Square were removed, repaired and refitted.
Photo courtesy of Arup



One Triton Square is an exemplar of high performance through the circular economy.
Photo courtesy of Arup

Building Scale: Regenerative Design Through Retrofit at One Triton Square

The refurbishment of One Triton Square in London, from office building to science lab, demonstrates how regenerative design translates into meaningful building-scale design decisions. Rather than demolish and rebuild, the Arup design team chose to reuse most of the existing structure, façade and core elements. This deep retrofit approach resulted in a dramatic reduction in carbon. A saving of 40,000 tonnes of CO₂e was achieved—more than what the building will emit in operation over 20 years—a clear demonstration of how

circular economy principles can transform the environmental impact of a building while still meeting contemporary performance standards.

One Triton Square also offers an important caution against “carbon tunnel vision”. While carbon reduction was one of the most compelling achievements of One Triton Square, the building also achieved multiple benefits through its focus on user well-being, air quality and landscape integration, thinking systemically to drive better, more resilient and more integrated design.



A blue-green system interconnected with engineered solutions.
Image courtesy of Arup



An urban square for everyday use can also serve to store stormwater during flooding.
Image courtesy of Arup



Shanghai—a city deeply connected to water—is located on the Yangtze River delta.
Photo courtesy of Arup

City Scale: A Nature-Led Urban Drainage Plan for Shanghai

At the urban scale, Shanghai’s Urban Drainage Plan shows how cities can adopt regenerative principles to tackle large city-scale challenges such as the growing impact of climate change-related flood risk.

Historically dependent on concrete channels and “grey” drainage infrastructure, the city shifted its emphasis in the new plan it developed with Arup to utilise nature-based solutions. “Blue-green” interventions such as wetlands, rain gardens, vegetated swales and naturalised waterways complemented, and in some cases replaced, engineered infrastructure. Beyond cutting carbon and cost, these investments also improved water quality, reduced urban heat, increased biodiversity and created green open spaces for the enjoyment of people. Grey infrastructure such as storage tanks, pumping stations and deep tunnels remained an important part of the solution and were able to be strategically resized and optimised in the new plan.



Urban typology analysis using an AI tool called Terrain.
Image courtesy of Arup

A Planetary Boundary for City Design

Regenerative design is **nature-led**, **systemic** and **equitable**. It strengthens the relationship between people and the natural world while ensuring benefits are shared fairly across society. Projects such as One Triton Square and Shanghai’s drainage plan point the way forward, but they are just the starting point. The real shift will come when cities and those who design and deliver projects adopt a systems approach—one where the boundary is not just a site or a district but as wide as possible. In doing so, this will ensure not just less harm but a planet that can sustain and generate life well into the future.



Creating more spongy landscapes.
Photo courtesy of Arup

A notable aspect of the project is the technical depth behind it. The team analysed 12 distinct urban typologies and used AI-driven tools to determine where nature-based solutions would have the most impact. This produced a blueprint that not only addressed infrastructure needs but also helped restore ecological function within the fast-urbanising metropolis.

At the district scale, sponge-city and nature-based drainage systems such as the one applied in Shanghai have been shown to reduce lifecycle carbon emissions by around 40 to 50%, delivering thousands of tonnes of CO₂e savings over 30 years, with several studies showing carbon neutrality within 2 to 3 decades.

But perhaps the biggest insight from the Shanghai urban drainage strategy is not technological but organisational. Regenerative design at the city scale demands wide collaboration across agencies, utilities, policymakers, communities and private developers. Aligning these interests is challenging, but the Shanghai project shows it is possible when they all share the same goal of long-term resilience and a regenerative outcome.



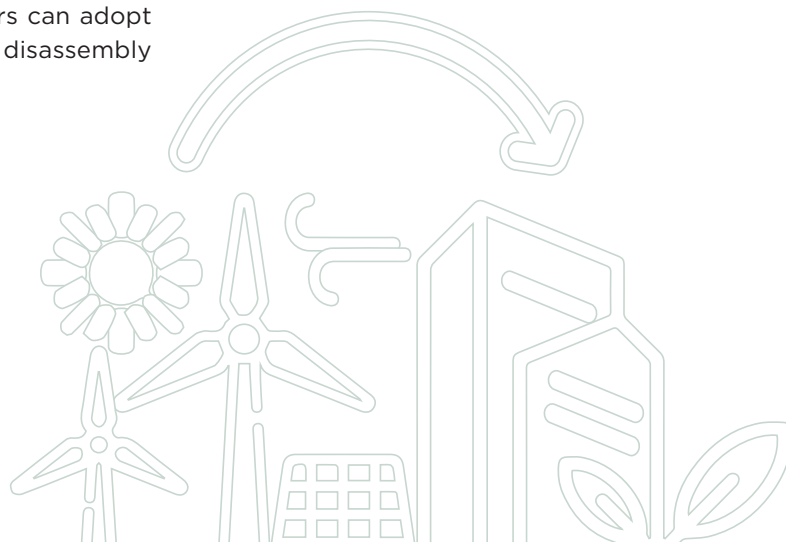
Establish Circular and Closed-Loop Systems

In 2025, the *Circularity Gap Report* shared that, globally, only 6.9% of materials are recovered and returned to the economy.³⁸ This means 93% of resources do not re-enter the economy. Circular and closed-loop systems activate the untapped potential of resources in circulation. They transform linear consumption into restorative flows, optimising resource use by restoring natural cycles and reducing extraction demand. In cities, the circular economy can be supported by whole-of-lifecycle planning, ensuring that resources are used to their full potential across their lifecycle.

Buildings can also be designed for flexibility and future reuse to extend their lifespans and usefulness. Rather than viewing buildings as resource consumers, they can be converted into resource banks. Circularity demands us to move beyond planned obsolescence towards charting out the use of resources from construction to disassembly. It requires a rethink of how buildings can be adapted, retrofitted and reused over time. To do so, planners and designers can adopt techniques of design for disassembly

to allow future adaptive reuse and flexibility, accommodating growth and changing requirements. In fact, with remote work shaping the demand for office spaces, cities like New York City and Boston are already considering how underused office buildings can be converted into residential use to alleviate the housing crisis.

Circular and closed-loop systems can also be accomplished by adapting the idea of “resource banks” to the wider city. At the municipal scale, resources can be coordinated and catalogued, systematically matching waste streams with material inputs to reduce the demand for new resources. When applied across urban systems, these synergies enable circularity, where waste from one industry can become inputs for another. To facilitate this, infrastructure for urban functions can be placed in deliberate proximity to one another, as seen in some cities which manage their food-energy-water nexus to optimise resource use across all three urban systems simultaneously.



PUBLISHED IN URBAN SOLUTIONS 25

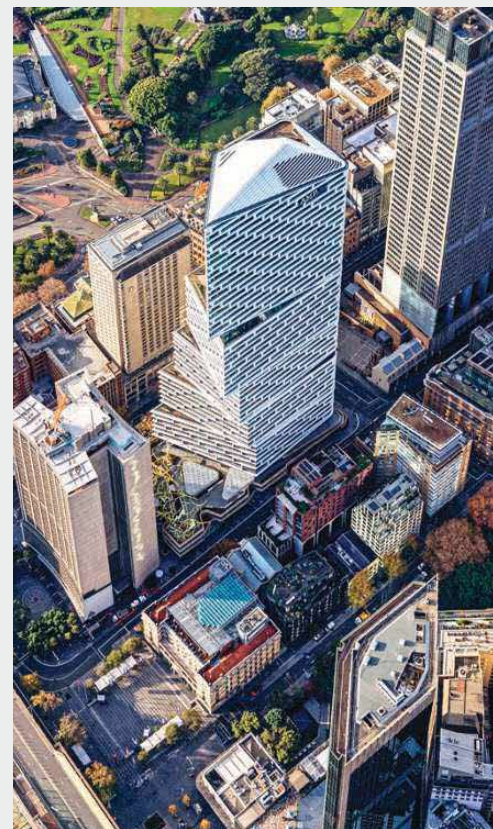
QUAY QUARTER TOWER IN SYDNEY, AUSTRALIA

FRED HOLT and DAN CRUDDACE
Partners, 3XN Australia

Sydney's Quay Quarter Tower (QQT) is an adaptive reuse project that transformed an underused 50-year-old high-rise into a regenerative asset. Originally completed in 1976 and retrofitted in 2022, QQT retains over 65% of the original structure and 95% of the concrete core. By avoiding demolition, the project saved approximately 12,000 metric tonnes of embodied carbon and achieved completion around 12 months early, thereby generating revenue ahead of time. The building was retrofitted to become a flexible, evolving system by reconfiguring floorplates, adding staggered volumes and placing cantilevers atop the preserved skeleton. On multiple fronts, QQT achieves resource outcomes by extending the lifecycles of materials and reducing long-term carbon costs.



Scan QR code
to read the
case study.



(Left) The cantilevered layout of QQT is designed around (top right) a social spine with floors built for disassembly. (Below) It is also designed to allow for multiple rooftop gardens, and maximising social spaces.

Photos by Adam Mørk, courtesy of 3XN





ADAPTIVE REUSE PLUS DENSIFICATION: A CARBON-ALIGNED GROWTH MODEL FOR CITIES

WONG MUN SUMM

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NIRMAL KISHNANI

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Practitioner and Researcher, Department of Architecture, NUS

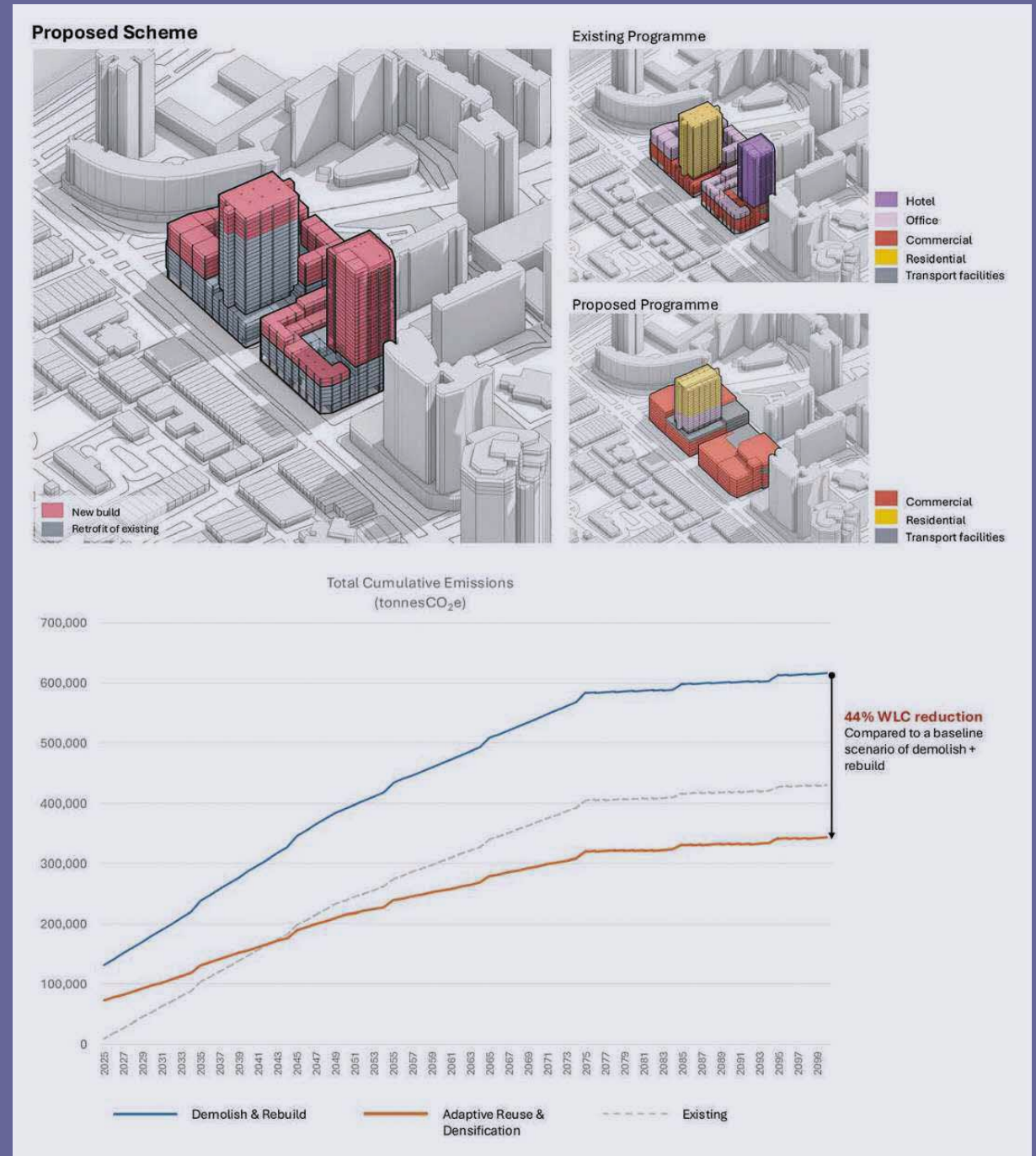
The built environment accounts for approximately 37% of global energy-related CO₂ emissions.¹ As electricity grids decarbonise and operational efficiencies improve, embodied carbon—the emissions associated with materials, construction, replacement and end-of-life processes—assumes a larger share of a building's whole-life impact.

In many fast-growing cities, however, redevelopment cycles remain short. Commercial and residential buildings are demolished well before the end of their structural life. This pattern, visible in Singapore, reflects powerful economic drivers: rising plot ratios, expiring leases and redevelopment incentives that prioritise financial yield. The carbon consequences of the build and demolish cycle are not discussed enough.

An alternative development model is emerging: adaptive reuse plus densification (AR+Df). Instead of treating retention and intensification as mutually exclusive options, it asks whether the most carbon-intensive elements of existing buildings—foundations, primary structure and cores—can be retained while land parcels are intensified to meet economic and demographic pressures. The city continues to grow but does so by building upon embodied capital.

European policies offer useful references. The Carbon Neutral Cities Alliance published a paper in 2023 advocating that whole-life carbon assessment, comparing retrofit and new-build scenarios, be a condition for granting demolition permits.² This follows the Greater London Authority's 2021 London Plan,³ which provided the first implemented example of carbon optioneering for redevelopment proposals. The English government has also been incentivising developers across the country to construct two additional storeys atop existing residential and commercial buildings without full planning permission, explicitly promoting AR+Df.⁴ These measures do not aim to prohibit redevelopment; rather, they recalibrate the baseline assumption that demolition is the default route to renewal.

Singapore presents a particular challenge. Approximately 90% of its land is state-owned and leased, often for 99 years in the residential and commercial sectors, and 20 to 30 years in the industrial sector. Periodic revisions to permitted plot ratios create gaps between what is built and what is permitted, reinforcing the financial logic to demolish and rebuild. While carbon is gaining traction in policy discourse, reporting remains largely voluntary. As a result, carbon rarely acts as a binding constraint in the moment when decisions about retention or demolition are made.



(Top) A design exploration study by NUS, showing the AR+Df capacity for the Sultan Plaza and Textile Centre located in Singapore's Central Area. The proposed design increases the overall gross plot ratio from 6.9 to 11.0—a 59% increase in gross floor area—while retaining almost all of the existing structures.

(Bottom) This strategy achieves densification while reducing whole-life carbon by 44% compared to a baseline scenario of demolish and rebuild.

Images courtesy of Department of Architecture, National University of Singapore

AR+Df responds to this situation with a set of design strategies. Envelope retrofits expand usable space while upgrading thermal performance. Vertical extensions add storeys to retained frames. Lateral extensions and strategic infill introduce new volumes alongside or between existing blocks. International precedents, such as the transformation of the Grand Parc housing estate in Bordeaux and the Hylo building in London, demonstrate that substantial increases in floor area can be achieved while retaining a significant proportion of existing structures and reducing embodied emissions relative to wholesale replacement.

To test the potential of AR+Df, a study at the National University of Singapore (NUS) focused on four sites in Singapore. In these high-density settings—residential, industrial and commercial—it was possible to substantially increase gross floor area without increasing whole-life carbon

emissions to the extent of demolish and rebuild projects. Most buildings were substantially retained; in some cases, selective demolition was a necessity.

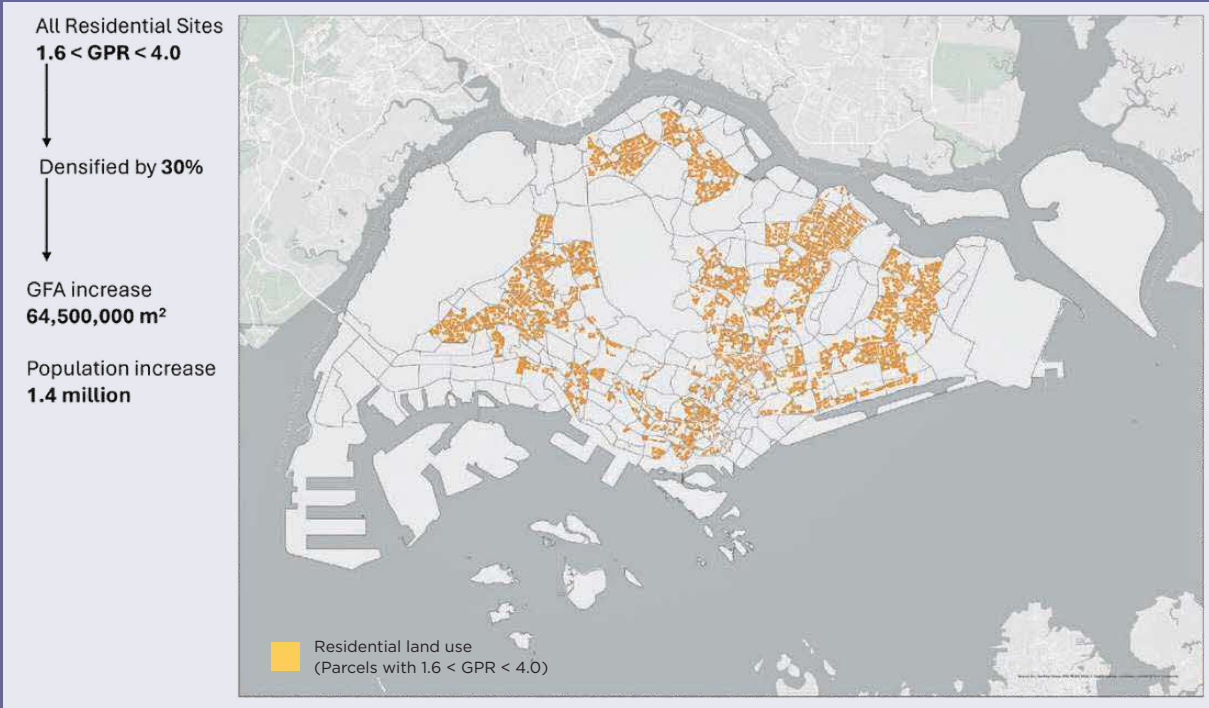
Scaling the results up to the metropolitan scale, even moderate uplifts in plot ratio across mid-density residential stock could generate substantial additional housing capacity, thereby reducing the pressure to extend urbanisation into reserve sites which, in Singapore, often have ecological value. AR+Df would also reduce the risk of dispersing communities and maintain continuity of older neighbourhoods.

Realising such a shift requires adjustments in governance. Mandatory whole-life carbon reporting and carbon optioneering, plus the deployment of early-stage carbon estimation tools, could align development economics with

climate commitments. As part of the research at NUS, a front-end carbon tool is being developed that gives reliable lifecycle estimates from simple massing and programme data, enabling carbon to inform decisions at the feasibility stage.

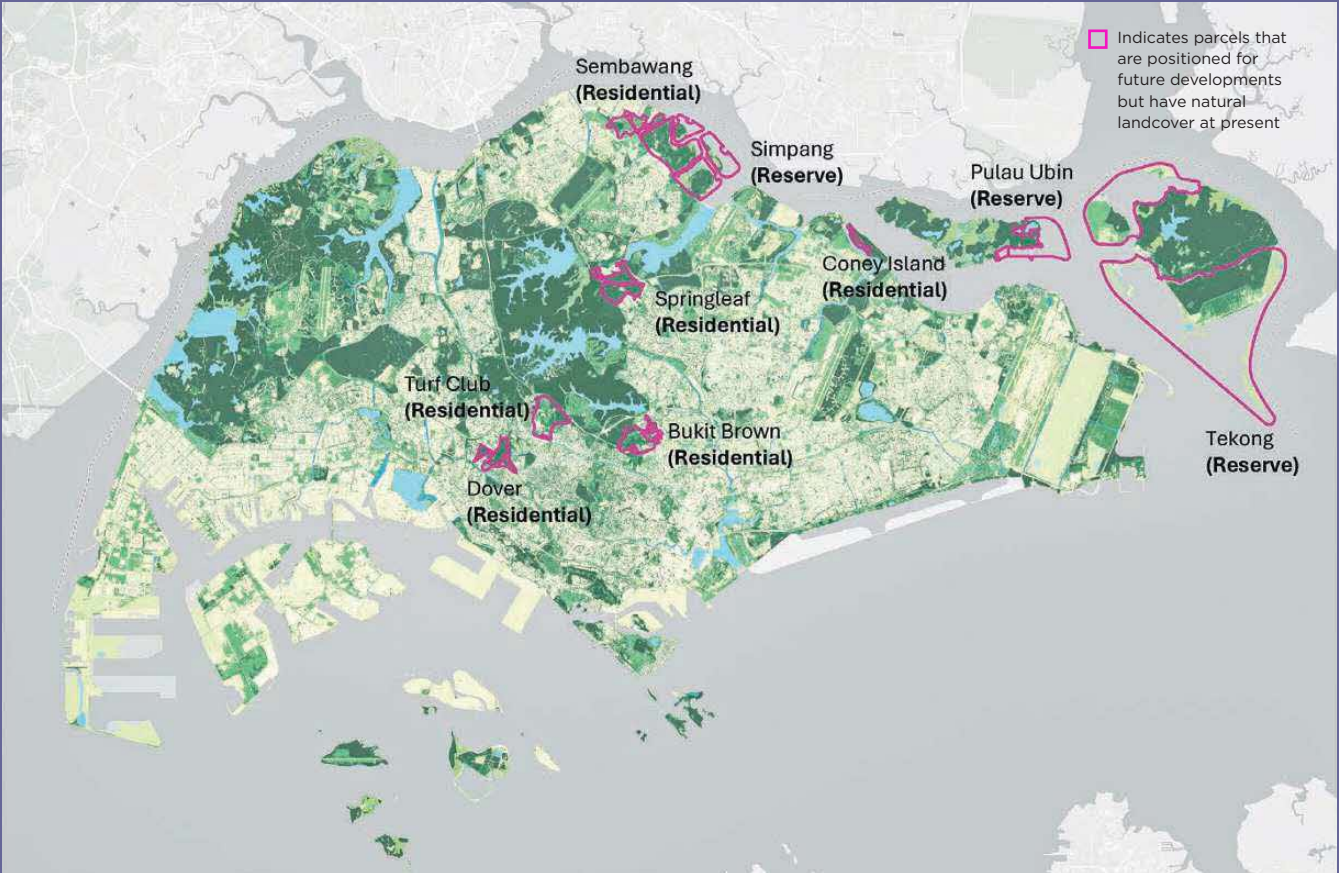
The central proposition of AR+Df is to alter urban metabolism. By coupling adaptive

reuse with densification, fast-growing cities can accommodate economic and population expansion while materially reducing the carbon burden associated with renewal. In an era defined by finite carbon budgets and persistent urban demand, this approach offers a pathway for growth that could be structurally, economically and climatically aligned.



Extrapolating a moderate AR+Df approach to existing residential land parcels across Singapore yields a substantial increase in gross floor area to cater to future housing needs.

Image courtesy of Department of Architecture, National University of Singapore



Creating capacity through AR+Df of existing residential land parcels can avert planned developments on reserved sites—many of which have important ecological value at present.

Image courtesy of Department of Architecture, National University of Singapore

ENDNOTES

- ¹ United Nations Environment Programme, *Global Status Report for Buildings and Construction 2022* (Nairobi: UNEP, 2022).
- ² Marios Tsikos and Leonardo Poli, *A Proposed Policy Outline for Cities: Refurbishment vs Demolition & New Build* (Carbon Neutral Cities Alliance, 2024).
- ³ Greater London Authority, *London Plan Guidance: Whole Life-Cycle Carbon Assessments* (London: GLA, 2022).
- ⁴ Jenny Pattison, “Vertical extensions: technical challenges and carbon impact”, *The Structural Engineer* 99.5 (2021): 12–15, <https://doi.org/10.56330/ERTS9701>.



LEVERAGING THE CIRCULAR ECONOMY POTENTIAL OF EXISTING AND FUTURE BUILT ASSETS

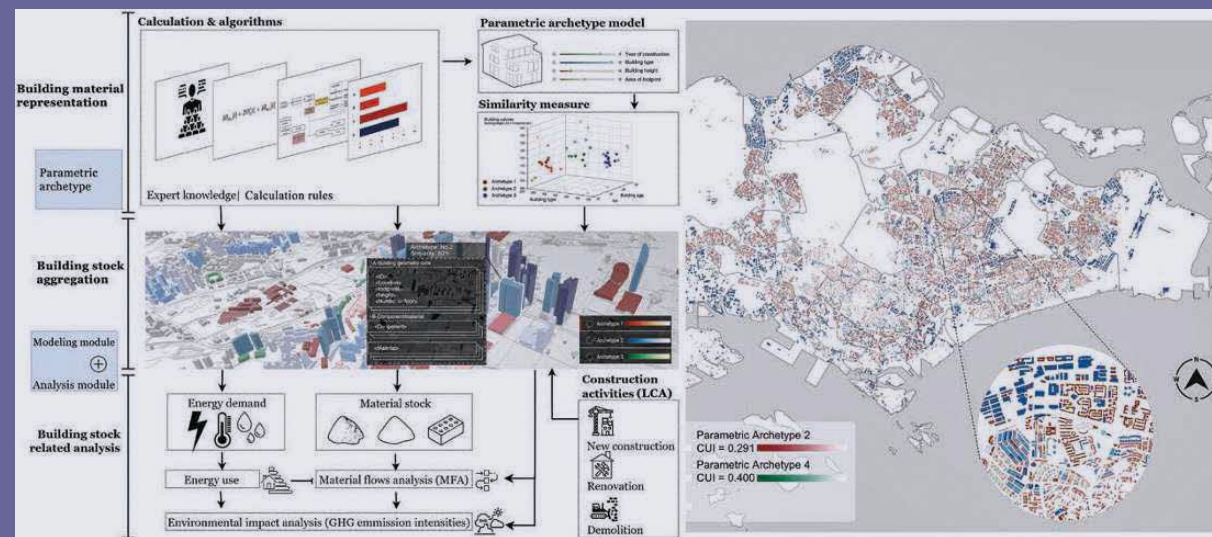
RUDI STOUFFS

Associate Professor and Assistant Dean (Research),
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The construction industry is a major contributor to greenhouse gas emissions (GHG), with a significant portion of these emissions being embodied in construction components and materials. An opportunity to reduce these embodied emissions lies in the circular economy (CE). However, current practices rarely fully leverage the circular economy potential (CEP)

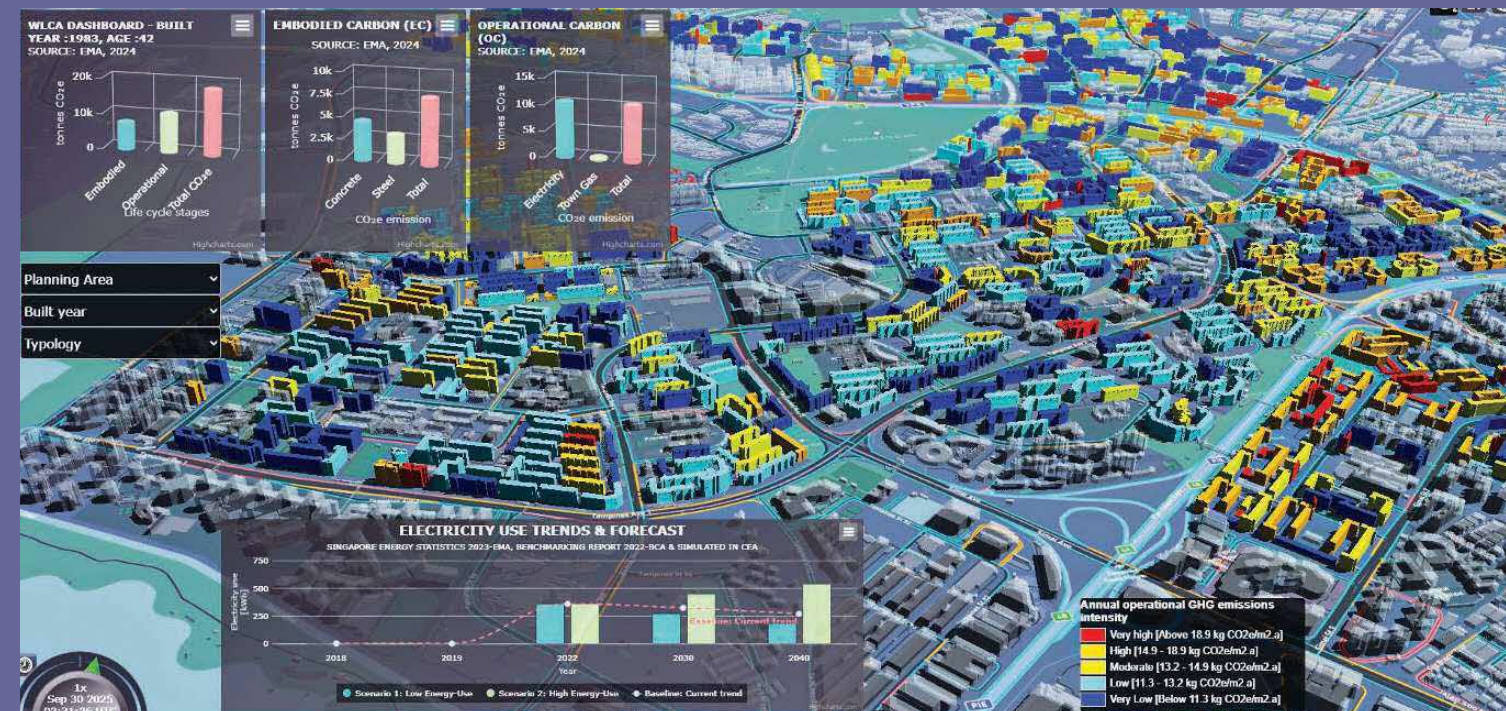
of existing and future built assets. We identify three key barriers.

One key barrier is the lack of material information about the current building stock. Studies modelling building material stocks (BMSs) have demonstrated the potential to reduce primary material consumption and environmental impacts



Application of the parametric archetype method to urban building material stock aggregation and analysis in a data-scarce environment.

Image courtesy of Rudi Stouffs and Wanyu Pei

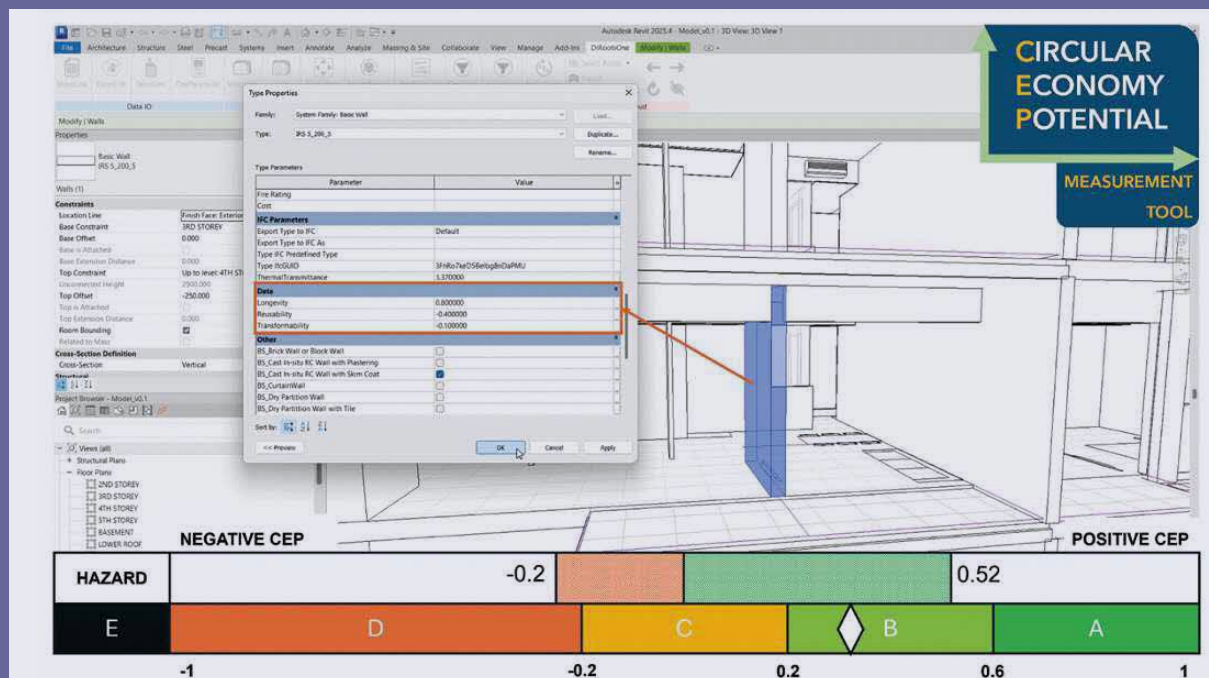


Screenshot from the GHG app, which provides whole-life cycle carbon assessments for buildings in Singapore, covering both operational and embodied carbon. The dashboard displays individual building electricity usage trends.

Image courtesy of Rudi Stouffs and Pradeep Alva

at a district scale (such as carbon emissions) by modelling the CE material flow of recycling. However, BMS modelling is data intensive, relying on complete material and component characteristics of various types of buildings. Data scarcity is a fundamental challenge many regions and districts face, especially material content data. Using AI-enabled methods that integrate building similarity measures may overcome these limitations, mapping material data to similar buildings, forming and enriching a cohesive dataset, and enabling incremental larger-scale BMS aggregation.

A second key barrier is the difficulty to access construction resource information and to conduct relevant analyses using this information. Embedding building material data with operational data about the built environment (including building energy use) into an urban digital twin (UDT) application enables the visualisation and analysis of outcomes related to whole life carbon assessment (WLCA). Such a platform facilitates data-driven decision-making for policymakers, urban planners and stakeholders in the building sector, focusing on whole-life carbon, material recycling, circularity and climate action.



Screenshot of the CEP measurement tool developed in the Revit environment, showing a component with assigned longevity, reusability and transformability parameters, and the resulting calculation of the built asset's CEP classification (class B), including indicated negative and positive CEP values.

Image courtesy of Rudi Stouffs and Goran Sibenik

A third key barrier is the lack of a holistic quantification method that can be applied to both existing and new designs. Current design quantification methods apply mostly for the modelling of the recovery potential of construction material. However, the value and recovery potential of resources depend on more than their mass alone and it is useful to consider CE strategies preserving higher embodied values. Such a method should consider multiple

CE objectives, such as keeping the constituents of a built structure in place (longevity), reusing them in a similar form (reusability), or changing their form through processes like recycling or decomposition (transformability). Although not all information required is available within Building Information Modelling (BIM) models, a BIM environment serves as an excellent base to extract relevant data or even embed such a holistic tool.¹

In the Circular Future Cities module of the Future Cities Laboratory (FCL) Global research programme at the Singapore-ETH Centre (SEC), we have explored and developed tools to address each of these three barriers, including a parametric archetype method for BMS modelling in urban districts with scarce material data, a GHG app implementing a UDT supporting WLCA and the analysis of potential recyclable materials in buildings, and a CEP measurement tool providing a practice-orientated approach to measuring circularity that can be applied to digital models of built assets. The work points to the significant gains that can be made in adopting computational technologies to operationalise CE strategies at the district-scale that are key to realising closed-loop systems.

In all, nature-based and biomimetic solutions, low-carbon and integrated developments, and circular and closed-loop systems enable the city to advance beyond sustainability. These three strategies approach urban development through systems-based thinking. The city becomes more than the sum of its parts and a living ecosystem that generates co-benefits for people and nature.

ENDNOTE

¹ BIM captures detailed material and component data for individual buildings, and can serve as a key data source for BMS modelling at the district or urban scale.

ENABLERS

for Regenerative Cities

Strategies alone cannot transform cities. Behind every successful regenerative project are the supportive conditions, resources and capacities that enable regenerative urban developments to take root. There are seven enablers in the Framework.



Policy and Governance



Design and Planning



Stakeholder Partnerships and Engagement



Education and Capability Development



Science and Technology



Finance, Investments and Business Models



Measurement and Monitoring Systems

ENABLERS

FOR INTEGRATION & IMPLEMENTATION



Policy and Governance

The right policies and governance systems in place create the institutional environment for regenerative strategies to flourish by levelling the playing field and encouraging innovation for decision-makers, asset owners and built environment professionals.

Enabling policy frameworks support collaboration across urban systems and stakeholders. In this respect, they play a key role in aligning goals and supporting coordination across various systems and operations. When crafted well, they can bridge separate mandates, budgets and metrics across different stakeholders to harness synergies and co-benefits.

The regenerative city benefits from a policy environment that is conducive to adaptation, experimentation and reflection. Space and opportunities for continuous learning, such as sandboxes and pilot projects, allow for experimentation of new processes with stakeholders while minimising risk. To institutionalise the regenerative principles of dynamism and reflexivity, cities can also move towards evidence-based policy making.

Policy can catalyse the scaling of regenerative approaches. For instance, it can set a city-wide agenda to rally and enable stakeholders such as architects, developers and engineers to implement regenerative strategies. Other than introducing new policy, city leaders can also look to remove barriers within existing policies and programmes to accelerate action. In these ways, a city can use policy to signal its commitment to regenerative urbanism.

CASE STUDY

THE RETROFIT FIRST POLICY IN LONDON, UNITED KINGDOM

London's Retrofit First Policy mandates that developers consider adaptive reuse before demolition during redevelopment. Camden was one of the first London boroughs to champion this.³⁹ A notable example is the old Camden Town Hall extension, whose brutalist exterior was retrofitted with three new stainless steel and glass storeys to become the Standard Hotel. This exemplifies how embedding retrofit principles into planning policy can drive the adoption of regenerative strategies at scale.



The Standard Hotel in Camden, London, previously the old Camden Town Hall.
Photo courtesy of Richard Kelly (CC BY-SA 4.0 / Wikimedia Commons)



DRIVING REGENERATIVE URBAN DEVELOPMENT THROUGH GREEN MARK AND INNOVATION

TAN CHEE KIAT
Deputy Chief Executive Officer (Industry Development), Building and Construction Authority, Singapore

Singapore is committed to achieving reduction in its national emissions as part of the country's Long-Term Low-Emissions Development Strategy (LEDS) to achieve net-zero emissions around 2050. With the building sector accounting for over 20% of Singapore's total carbon emissions, the Building and Construction Authority (BCA) is spearheading the mitigation strategy to drive energy efficiency and carbon reduction of the built environment. Globally, green building

rating tools are widely used by governments, organisations and cities as a policy to mitigate climate change. The BCA Green Mark (GM) scheme in Singapore is a good example.

Aligned with the United Nations (UN) Sustainable Development Goals (SDGs) and Sustainable Finance Taxonomies,¹ GM is a leading green building rating tool for tropical urban areas, transcending traditional efficiency metrics to position buildings as catalysts for ecological

Green Mark Sections



The BCA GM:2021 badge sections mapped to the UN SDGs. The UN SDGs are the blueprint to achieve a better and more sustainable future for all, addressing climate actions, health and well-being, and resources and circularity.
Image courtesy of Building and Construction Authority

regeneration. Since its launch, GM has seen over 230 projects attain higher standards of Super Low Energy (SLE), Zero Energy (ZE) and Positive Energy (PE).² Over 100 projects have attained Intelligence, Health & Wellbeing, Whole of Life Carbon, Maintainability or Resilience Badges.

Specifically, the GM Whole Life Carbon and Resilience badges support Singapore's transition to a regenerative city. They create value for building owners and investors through enhanced long-term asset value, operational resilience and risk mitigation.

WHOLE LIFE CARBON BADGE	RESILIENCE BADGE
 The Whole Life Carbon Badge scores buildings on their Whole Life Carbon performance based on international calculation methodologies, up-front (embodied) carbon (i.e., the carbon footprint of the construction materials), the use of sustainable construction methods, and the sustainable fitting-out of buildings.	 The Resilience Badge is evaluated based on a building's resilience and adaptation to climate change, as well as the use of nature-based or natural climate solutions, with actions to protect, sustainably manage and restore natural or modified ecosystems.

Whole Life Carbon and Resilience badges support the transition to regenerative cities.
Image courtesy of Building and Construction Authority

“As climate change intensifies, green buildings have become more critical than ever in achieving Singapore’s national climate goals. They help reduce embodied carbon through sustainable construction materials and lower operational carbon through energy-efficient designs.”

MR CHEE HONG TAT
Minister for National Development, Singapore
Extracted from the Minister's speech at the Singapore Green Building Council Gala Dinner, 11 July 2025



An artist's impression of One Comcentre.
Image courtesy of Singtel, Lendlease

One Comcentre, Singapore: Carbon Neutral Development

The Comcentre redevelopment is a carbon-neutral project in Orchard slated for completion in 2028. Designed as a Zero Energy (ZE) development, it has attained all five BCA GM: 2021 Sustainability Badges. Under the Whole Life Carbon Badge, the project attained a 55.4% reduction in embodied carbon, attaining a carbon intensity of 446.3 kgCO₂eq/m² by utilising carbon mineralised concrete and recycled steel. It also promotes circular construction by aiming to reuse 40% of the crushed concrete waste from the existing Comcentre structure.

Under the Resilience Badge, the development features a Green Plot Ratio of 5.9, providing 5.9 times more greenery than the site area to enhance urban biodiversity and thermal comfort. Additionally, the site is equipped with urban heat island (UHI) mitigation measures, including landscape greenery, solar PV panels, the application of cool paint on roofs and water features which comprise 57.3% of the site area.

Jurong Lake Gardens Phase 2 Development, Singapore: Living with Nature

The 0.90-km² Jurong Lake Gardens Phase 2 Development exemplifies living with nature in a dense heartland, earning the BCA Green Mark Platinum Super Low Energy (SLE) rating with badges for Whole life Carbon, Resilience, and Health and Wellbeing. Under the Whole Life Carbon Badge, the project achieved a 55.48% reduction in embodied carbon, resulting in a low carbon intensity of 445.2 kgCO₂eq/m². This was accomplished by maintaining a lean Concrete Usage Index (CUI) of 0.258 and utilising Mass

Engineered Timber for nearly 70% of the construction area. Furthermore, the development champions a circular economy by incorporating NEWSand and carbon-mineralisation technology across more than 9,300 m² of pathways. Under the Resilience Badge, the project features a Green Plot Ratio of 7.94, with extensive tree preservation and UHI mitigation measures, including ABC (Active, Beautiful, Clean) Waters features that cover 94% of the site.



At Jurong Lake Garden's Japanese Garden, advanced Mass Engineered Timber was used as a sustainable innovation for construction of the Water Lily Pavilion (above) and the Guesthouse (left).

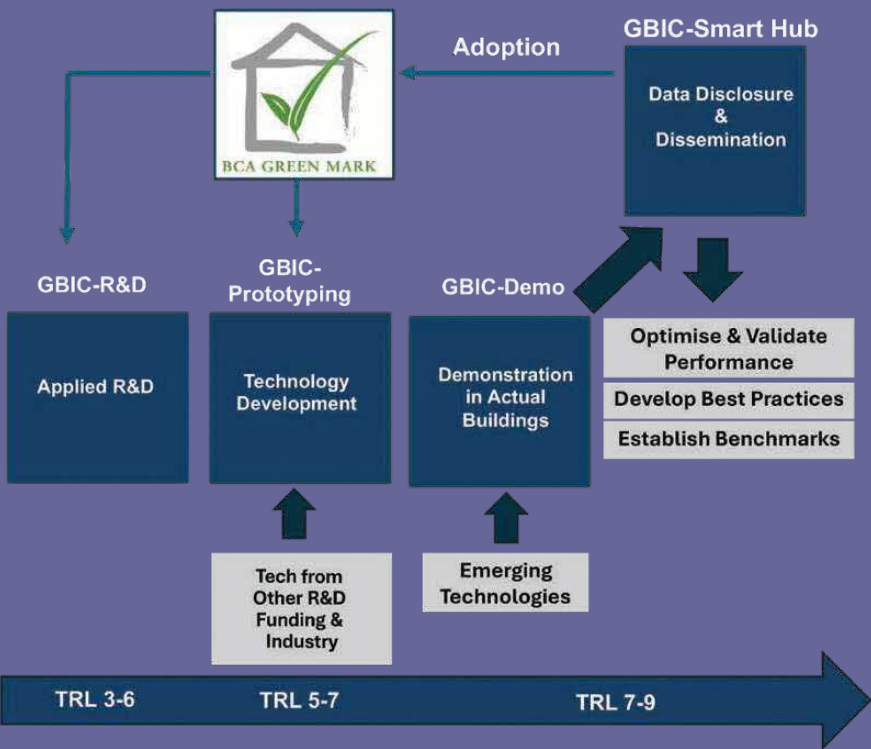
Photos courtesy of National Parks Board

Innovation as the Engine of Progress

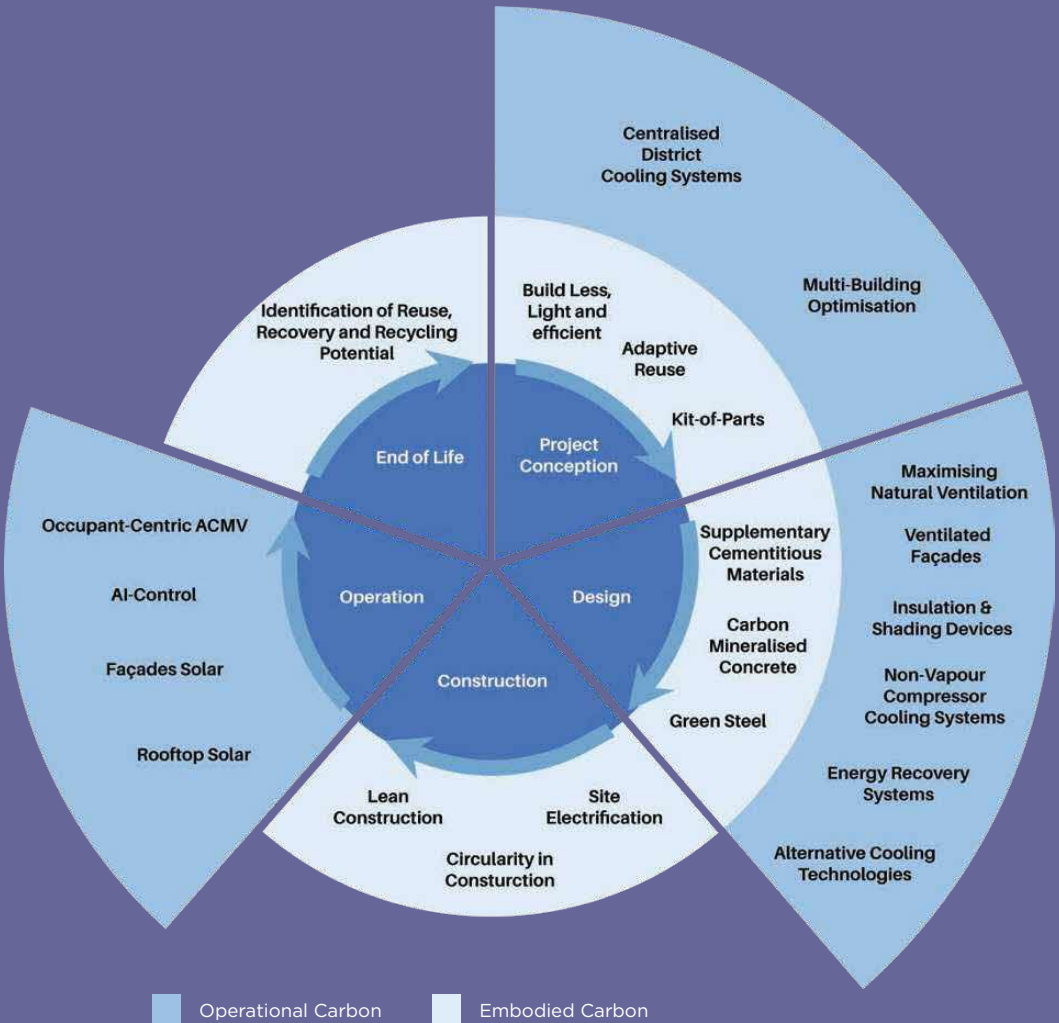
Powered by a robust innovation ecosystem, Singapore’s building sector continues to push boundaries. Through the Green Buildings Innovation Cluster (GBIC)³ Programme, the BCA partners with the industry to co-create next-generation research and development, prototyping, and demonstration solutions. To fast-track advancements in the BE sector, the BE Accelerate to Market Programme (BEAMP)⁴ provides an open innovation platform to address unmet sector needs and conduct commercial trials. Additionally, the BE Innovation Hub (BEIH) at the BCA’s Braddell Campus serves as a collaborative space where innovators can showcase their cutting-edge technologies, build

connections and use its facilities to demonstrate new solutions in real-world settings, further establishing Singapore as a global hub for ConTech (Construction Technology).

This innovation ecosystem operates as a continuous feedback loop where emerging technologies are first identified, tested and validated through innovation platforms. Strategic funding helps these solutions bridge the gap between technical viability and commercial scalability. Once proven, solutions may be integrated into the Green Mark framework through innovation bonus points to encourage early adoption and enhance industry performance.



The GBIC Continuous Feedback Loop and GM Standards. This cycle shows how the GBIC Programme bridges the gap between research and development (R&D), and commercial adoption. By moving innovations through prototyping and real-world demonstrations, from technology readiness levels 3 to 9 (TRL 3-9), the programme validates performance and establishes new benchmarks, ultimately raising the baseline standards for all GM buildings. Image courtesy of Building and Construction Authority

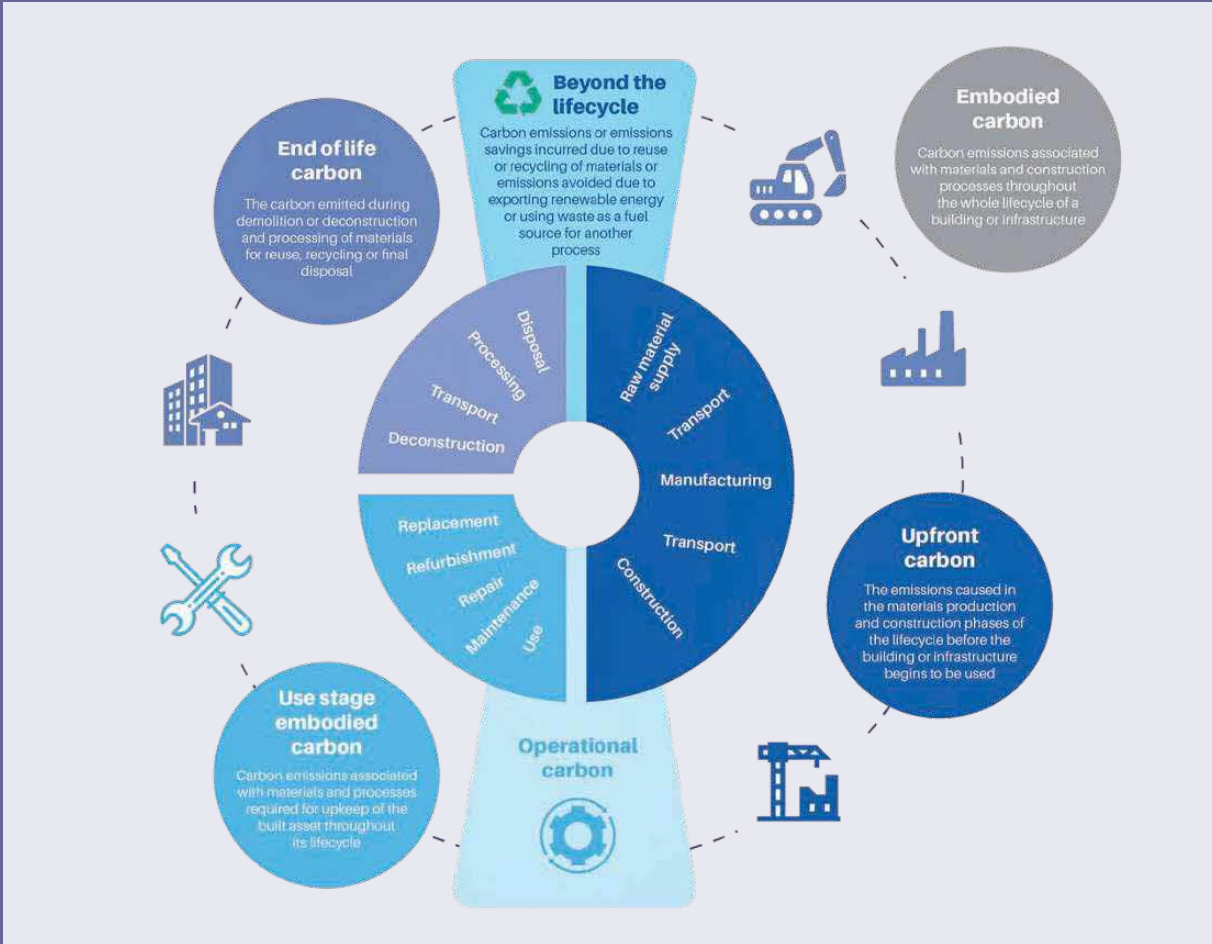


Operational Carbon Embodied Carbon
The BCA's updated reduction pathway reflects both operational carbon and embodied carbon strategies, in alignment with the whole life carbon approach. Image courtesy of Building and Construction Authority

BE Decarbonisation Technology Roadmap: A Blueprint for Innovation

The BE Decarbonisation Tech Roadmap, officially rolled out on 5 February 2026, is a forward-looking blueprint identifying future-ready solutions that reduce whole life carbon emissions, preparing Singapore firms for a low-carbon future.

The roadmap was jointly developed by the BCA and Singapore Green Building Council, with support from the Agency for Science, Technology and Research, and was shaped through extensive engagement with over 100 stakeholders, including building owners, consultants, institutes of higher learning, material suppliers and technology solution providers.



The whole life carbon approach is a comprehensive method for assessing a building's total carbon emissions across its entire life cycle, from construction through operations, to end of life.
Image courtesy of World Green Building Council

The next frontier involves transforming buildings into active carbon sinks by utilising innovative feedstock materials, such as carbon mineralised aggregates and geopolymers with CO₂ sequestration. Transcending individual building performance, we are championing a “systems” approach that replaces traditional building-

level silos with integrated district solutions. This strategy enhances energy independence and urban resilience by harnessing microgrids for peak shaving, and by fostering circular economy practices, including waste heat recovery and cross-facility material reuse.

Call for Action: Decarbonise Our Buildings Towards Net Zero in 2050

The BE Decarb Tech Roadmap is an evolving, “live” document. We invite the industry to partner with us through Deploy Now and Invest Now.

- Through **Deploy Now**, we encourage stakeholders to immediately leverage market-ready solutions and accelerate the reduction of whole life carbon emissions in their projects.

- Through **Invest Now**, we provide the research community with a clear directive on technology priorities to support Singapore’s Research, Innovation, and Enterprise (RIE) 2030 plan. We welcome industry collaborators to pilot the next generation of technologies to raise our collective industry baseline.

	Deploy Now (Quick Wins)	Invest Now (Research and Innovation)
	TRL 7-9	TRL 4-6
Operational Carbon	- Alternative cooling technologies (e.g., passive displacement cooling, hybrid cooling) - AI-driven optimisation for air conditioning and mechanical ventilation - Dedicated outdoor air systems	- Advanced cooling and ventilation technologies (e.g., magnetocaloric cooling, hybrid radiative cooling) - Advanced façade/envelope solutions that are retrofittable for existing buildings - District-level control algorithms for energy efficiency
Embodied Carbon	- Carbon mineralised fresh concrete - Replacement of ordinary Portland cement (e.g., with ground-granulated blast-furnace slag (GGBS), or a ternary blend of GGBS and fly ash) - Direct replacement of concrete (e.g., with Mass Engineered Timber)	- CO₂ to aggregates - Geopolymer concrete with CO₂ sequestration - Microgrid design for construction sites

A list of key technologies under Deploy Now and Invest Now.
Image courtesy of Building and Construction Authority

ENDNOTES

¹ Sustainable Finance Taxonomies include European Union taxonomy and requirements laid out by the Taskforce on Climate-Related Financial Disclosures.

² A Super Low Energy (SLE) building is defined as a best-in-class performing building that achieves at least 60% energy savings based on the code of 2025, or 40% energy savings based on prevailing code; a zero-energy (ZE) building is an SLE building with all energy consumption, including plug load, supplied from renewable energy sources; a positive energy (PE) building is an SLE building with 115% of all energy consumption, including plug load, supplied from onsite renewable energy sources.

³ The GBIC programme supports R&D and demonstration of energy-efficient solutions which are tracked under Singapore Green Building Masterplan targets.

⁴ For more information, see BEAMP, “Built Environment Accelerate to Market Programme”, n.d., <https://www.beamp.sg/>.

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Design and Planning

Regenerative outcomes are not achieved by chance, but by design. Through deliberate design and planning, the path to achieving regenerative outcomes can be established upstream.

A regenerative city is designed and planned with time in mind.

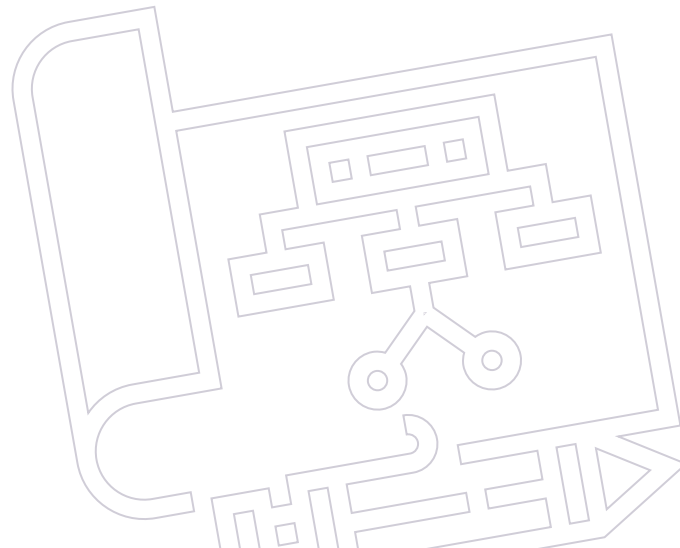
Where conventional practice focuses on delivery, regenerative thinking extends the frame to consider the full lifecycle. Approaches like design for manufacturing and assembly (DfMA) and design for disassembly improve construction and resource efficiencies, ensuring that the buildings remain adaptable and relevant long after completion. Thinking in extended timeframes also means accounting for and enabling outcomes that require time to materialise, such as the restoration of urban biodiversity in nature-based solutions and the forging of social cohesion at mixed-use developments.

Urban and building form are impactful passive decarbonisation strategies.

For example, the right urban form can facilitate wind flow and shade for

thermal comfort. Similarly, orientating buildings favourably for maximum shading in the tropics, or maximum sunlight in temperate countries, can significantly reduce operational energy demands compared to active decarbonisation tactics.

Developments that are intentionally planned and designed to be compact can achieve compounded benefits. Compact urban forms that are effectively co-located can harness synergies such as operational efficiencies arising from density, and also reduce distance for commutes. They also minimise land take, supporting the abatement of environmental impact while enabling other uses. Beyond planning purposes, zoning that encourages multiple uses and allows for densification has a direct impact on the capacity of a place to generate co-benefits. Ultimately, the planning of buildings and districts facilitates the achievement of co-benefits in a synergistic, and therein compounded fashion.



CASE STUDY

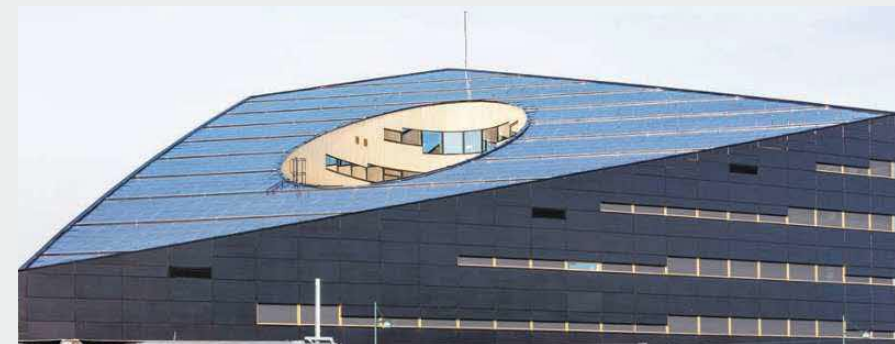
POWERHOUSE BRATTØRKAIA IN TRONDHEIM, NORWAY

Powerhouse Brattørkaia is an energy-positive building.⁴⁰ It is an office building designed to minimise operational energy, maximise the solar energy harnessed, and optimise the experience of both tenants and the public. Powerhouse Brattørkaia produces more energy over its lifetime than it uses, including in its construction phase. Surplus energy is shared with its neighbouring buildings as well as Trondheim's electric bus network through the local micro grid.



A view of the building's atrium and public garden; the space was designed to optimise daylighting and natural ventilation.

Photo courtesy of Lyndsayclose (CC BY-SA 4.0 / Wikimedia Commons)



The roof of Powerhouse Brattørkaia is clad in solar panels.

Photo courtesy of Diego Delso (CC BY-SA 4.0 / Wikimedia Commons)



Powerhouse Brattørkaia supplies surplus energy to its surrounding neighbourhood.

Photo courtesy of Diego Delso (CC SA 4.0 / Wikimedia Commons)



PUNGGOL DIGITAL DISTRICT: A BLUEPRINT FOR SUSTAINABLE MIXED-USE DEVELOPMENT

JACQUELINE POH

Chief Executive Officer, JTC, Singapore

DAVID TAN

Assistant Chief Executive Officer (Development Group), JTC, Singapore

Pioneering Singapore's First Smart and Sustainable District

Singapore's Punggol Digital District (PDD) represents a fundamental reimagining of urban development, demonstrating how cities can integrate design innovation, smart systems and collaborative ecosystems to address contemporary urban challenges. As spatial challenges rise in dense cities along with climate pressures, the PDD is a representative model for sustainable, connected and adaptive urban environments that prioritise both ecosystem building and environmental stewardship.

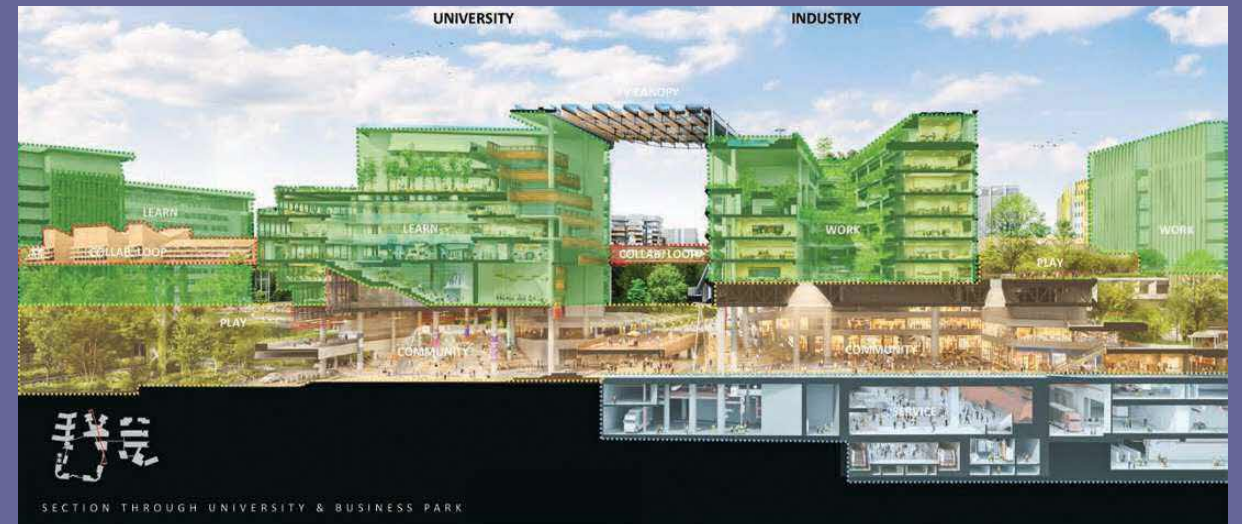
Reimagining Urban Form: Interconnectedness Below the Inverted Skyline

Most urban districts face a fundamental spatial challenge: how to accommodate dense built-up spaces while maintaining liveable environments and preserving nature. Traditional approaches often result in ground congestion where transportation networks and building services compete for limited space, creating fragmented urban environments that cannot address the interconnected challenges of climate change,

energy resilience and community integration. The PDD addresses this through innovative spatial organisation that treats the district as a 3-dimensional ecosystem rather than a conventional 2D master plan.

The district's most striking feature is its "inverted skyline" configuration, developed by WOHA Architects, which reverses the typical urban form. Rather than an upward "bar graph" skyline that limits solar renewable energy collection, the PDD's inverted massing approach introduces a broad rooftop canopy layer hovering above connected public spaces and preserved green spaces below. This design maximises usable roof area while creating sheltered ground level environments that emphasise human comfort and community interaction in a tropical environment.

Beneath the distinctive skyline, the PDD prioritises pedestrian connectivity through the strategic organisation of infrastructure. All heavy vehicle servicing, carparks, pneumatic waste bins and infrastructure such as a substation and district-cooling system are lowered into a

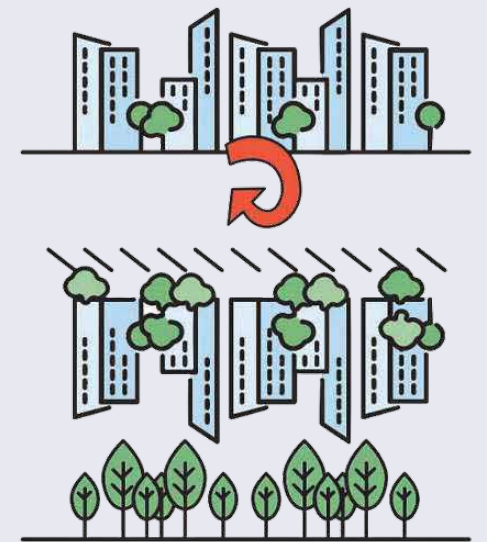


A section through the PDD's business park and university spaces, with seamless community spaces on the ground plane and services underground.

Image courtesy of WOHA

subterranean network, reserving the ground level for the people. The district creates a fully walkable and car-lite environment with the pedestrianised Campus Boulevard at its heart. This is seamlessly connected to the Punggol Coast MRT station, Punggol Coast bus interchange and cycling networks that provide links across Singapore. The 2-km Collaboration Loop at the 7th storey level further enhances connectivity by linking buildings through social nodes and indoor amphitheatres.

This interconnectedness enables a new model of nature-human cohabitation where additional lush green spaces and conserved trees create an urban park interwoven throughout the Business Park district, achieving a 100% landscape replacement area. The result is a district where the built and natural environments enhance rather than compete with each other, creating breathing spaces that serve both ecological and community functions and provide better stormwater management, urban heat island reduction, carbon sequestration and pollution mitigation.



"Inverted skyline" concept.

Image courtesy of WOHA



PDD Campus Boulevard with Collaboration Bridges connecting JTC Business Park spaces and SIT.
Photo courtesy of JTC Corporation

Collaborative Ecosystems: An Integrated Mixed-use District

The PDD redefines the relationship between education, industry and community through an integrated mixed-use model that responds to evolving patterns of work, live, learn and play. Accommodating 28,000 workers and 12,000 students, the development fosters continuous interaction between students, researchers, entrepreneurs and established businesses within a shared ecosystem.

At the heart of this approach lies the Enterprise District model, which introduces unprecedented development flexibility by allowing space

transfers between different land parcels, and even “space swaps” between the Singapore Institute of Technology’s campus and JTC’s business park facilities. The flexibility enables Gross Floor Area (GFA) transfers, allowing academic and business functions to adapt dynamically over time, with students accessing industry-standard laboratories while companies tap into talent and research capabilities. By eliminating institutional silos, this model creates direct collaboration opportunities in what would otherwise be physically separate zones.

The district strategically targets high-growth digital sectors including cybersecurity, artificial intelligence, robotics, FinTech and Smart City solutions. Beyond established industry players anchoring the business park, JTC will develop a new LaunchPad@PDD as a dedicated startup incubator, giving emerging companies access to both commercial partnerships and academic research capabilities. This creates pathways for startups to leverage the district’s ecosystem and resources while enabling established companies to tap into fresh innovations.

The mixed-use integration extends to comprehensive community infrastructure, with childcare facilities, healthcare services, recreational areas, the Punggol Coast Mall, and a hawker centre serving both the district’s workforce and students alongside neighbouring Punggol residents. This creates a polycentric district where educational, commercial and residential functions overlap naturally rather than operate in isolation. The result is a connected ecosystem that strengthens both professional networks and community ties.



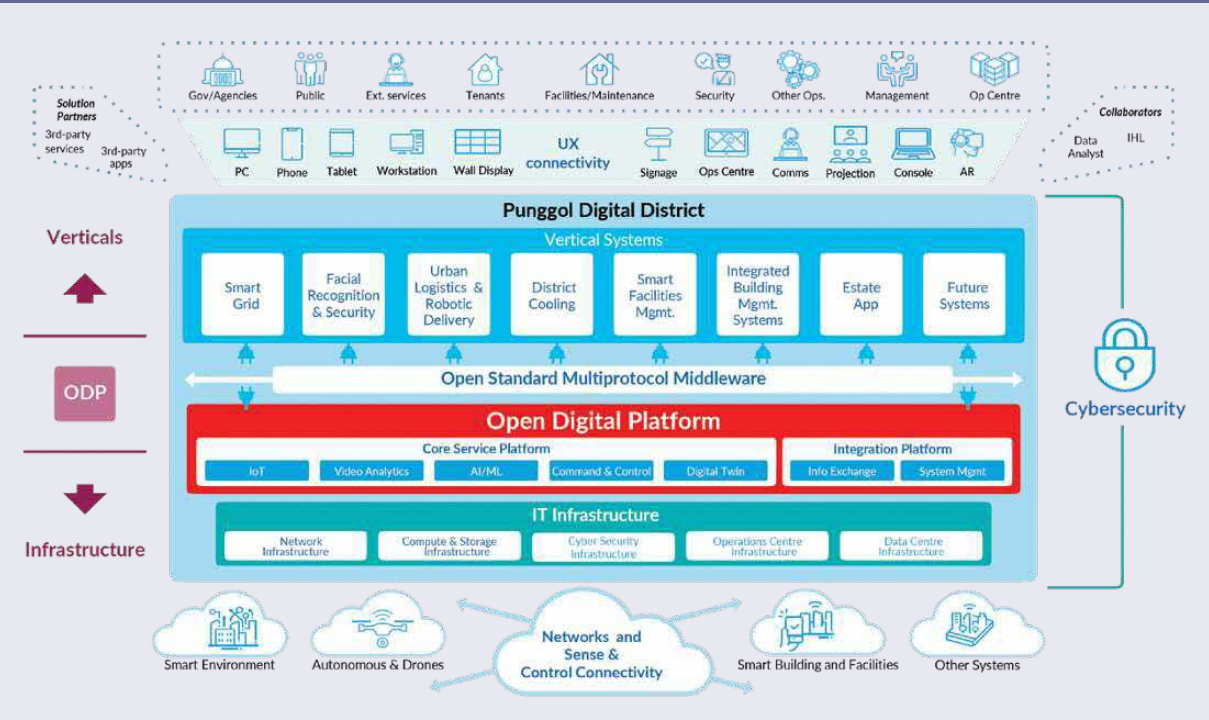
Nexus of Punggol Coast Mall.
Photo courtesy of JTC Corporation

Smart Systems: Digital Urban Operating System

The PDD’s comprehensive smart infrastructure transforms the district into an intelligent environment that operates as a living lab for smart city technologies. This digital foundation creates a responsive learning system where data-driven insights continuously optimise performance and enable real-world innovation, testing and deployment across all district functions.

Singapore’s first Open Digital Platform drives this transformation through a 3D digital twin that integrates smart city solutions across

the entire development. Over 20,000 sensors embedded throughout the district collect real-time data on building performance, occupancy patterns, environmental conditions and energy consumption. Artificial intelligence and machine learning algorithms can process this continuous data stream to achieve up to 20% energy savings, while predictive and preventive maintenance systems reduce operational downtime and repair costs, supporting rapid deployment and testing of smart solutions in live environments.



The PDD’s Open Digital Platform.
Image courtesy of JTC Corporation

Smart Systems: Supporting a Greener District

The digital twin also serves as a virtual testing ground where companies can simulate scenarios, optimise operations and validate innovations. This digital-first approach significantly accelerates the time to market for new technologies while supporting long-term planning and maintenance. The platform provides real-world sustainability data that deepens understanding of environmental stewardship and smart city principles while enabling continuous experimentation and refinement.

Integrated smart systems deliver substantial environmental benefits through Singapore’s first urban district-level smart grid that optimises energy distribution and storage within photovoltaic canopies. Through extensive rooftop solar installations, the district generates over 3,000 MWh annually—equivalent to powering 11,000 3-room HDB flats—while achieving a 35% reduction in annual carbon emissions, equivalent to removing 4,000 cars from Singapore’s roads.

Beyond the PDD: Scaling the Smart and Sustainable District Blueprint



Smart technology and robotics are deployed and testbedded at the PDD.
Photo courtesy of JTC Corporation

The PDD demonstrates that urban development can transcend traditional trade-offs between density and liveability, economic growth and environmental sustainability, innovation and community cohesion. Through its integration of spatial innovation, smart systems and collaborative ecosystems, the district establishes a replicable blueprint for cities worldwide that are seeking to address climate challenges while fostering human connection and economic dynamism. As urban environments continue to evolve under mounting pressures, the PDD’s holistic approach—where physical design, institutional flexibility and digital intelligence work in concert—offers valuable insights for creating resilient, adaptive and thriving urban communities that serve both present needs and future aspirations.



Stakeholder Partnerships and Engagement

Regenerative cities are built with people and for people. The quality and depth of stakeholder engagements determine whether regenerative intentions translate into sustained outcomes over time.

Not all engagements are equal. Some regenerative strategies and interventions require deep co-creation, some require sustained cross-agency partnership, and others need targeted industry consultation. Engaging different stakeholders can bring different capabilities to the table raising a diversity of values and concerns that may need addressing. Defaulting to one-way communication misses an opportunity to make engagements meaningful and impactful.

Transforming one-off engagements to lasting partnerships requires deep listening and action. Scientific, indigenous, local and creative knowledge all have a place in regenerative cities. Effort is needed to engage widely across diverse stakeholders to gather their inputs, arrive at insights, and close the loop after every stage. Through discussion and by taking action together, cities demonstrate to stakeholders how everyone has a role to play in shaping a regenerative city.

Co-benefits must be communicated in the language of what stakeholders value. Cities must translate technical details differently for residents who value their lived experiences than for industry players who look out for operational efficiencies and asset values. Communicating co-benefits according to the needs of each stakeholder can build broader coalitions.

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THE CLIMATE STRONG COMMUNITIES INITIATIVE IN NEW YORK CITY, UNITED STATES

The Climate Strong Communities (CSC) initiative in New York City offers a compelling model—one that bridges the gap between systemic climate goals and lived experiences through deeply relational, culturally grounded engagement. Rather than leading with technical risk maps or carbon metrics, the CSC centres residents' own stories, priorities and social networks as the starting point for co-creating resilience. It utilises engagement tools such as a multilingual card game to spark conversations around pairing climate hazards with actionable solutions. Such methods make complex risks comprehensible, especially for youth and non-English speakers.



As part of CSC, New York City's Department of Environmental Protection (NYC DEP) consulted with community members regarding the Kissena Cloudburst Hub, a district-scale stormwater management project. Through the community outreach process, NYC DEP was able to better understand the public's everyday lived experience with rainfall.

Photos courtesy of NYC DEP



Scan QR code to read an interview with Rohit Aggarwala, former Commissioner of NYC DEP.



Education and Capability Development

Regenerative urbanism demands that city leaders and practitioners think across sectors, disciplines, borders and even generations. Education and capability development that build capacity at every level—from communities to policymakers—make cities more equipped for a regenerative future.

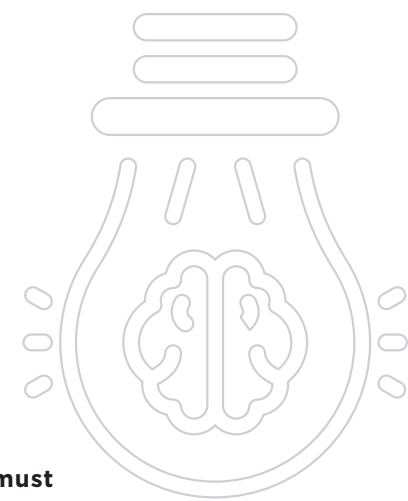
Regenerative literacy must be embedded as continuous practice.

Through continuous learning, knowledge can be layered across domains, and new knowledge can be integrated into practice. Sustained practice instead of one-off training also catalyses a broader cultural shift towards regenerative thinking.



Platforms such as the World Cities Summit—Mayors Forum (above) and Knowledge Council (right)—enable city leaders and practitioners to come together to learn and discuss new ideas and solutions.

Photos courtesy of Centre for Liveable Cities



At the global scale, inter-city networks are valuable learning infrastructure.

Collaborative networks such as C40 Cities and the City Network for the Lee Kuan Yew World City Prize facilitate peer learning, benchmarking and knowledge transfer across contexts. Through the exchange of insights and knowledge, adoption of solutions can be accelerated to meet the urgency of the climate crisis.

Capabilities and knowledge must be calibrated to place.

Knowledge creation and transfer must address context-specific needs, enabling capacities to be built up according to local ecologies, community realities and development contexts. Through place-based knowledge, cities can better apply, scale and sustain their unique regenerative pathways.





THE STORY OF PLACE: AN APPROACH TO PLACE-BASED REGENERATION

MARIANNE AMORES
Founder, The Regenes Project

The importance of “place” has long been acknowledged in regenerative design, yet it is often reduced to placemaking, honouring cultural heritage, or integrating local context. While valuable, these approaches miss a critical opportunity. When done well, understanding place becomes a complete framework for managing the complexity of regenerative design and development while simultaneously addressing place-specific challenges and crises.

What Is the Story of Place?

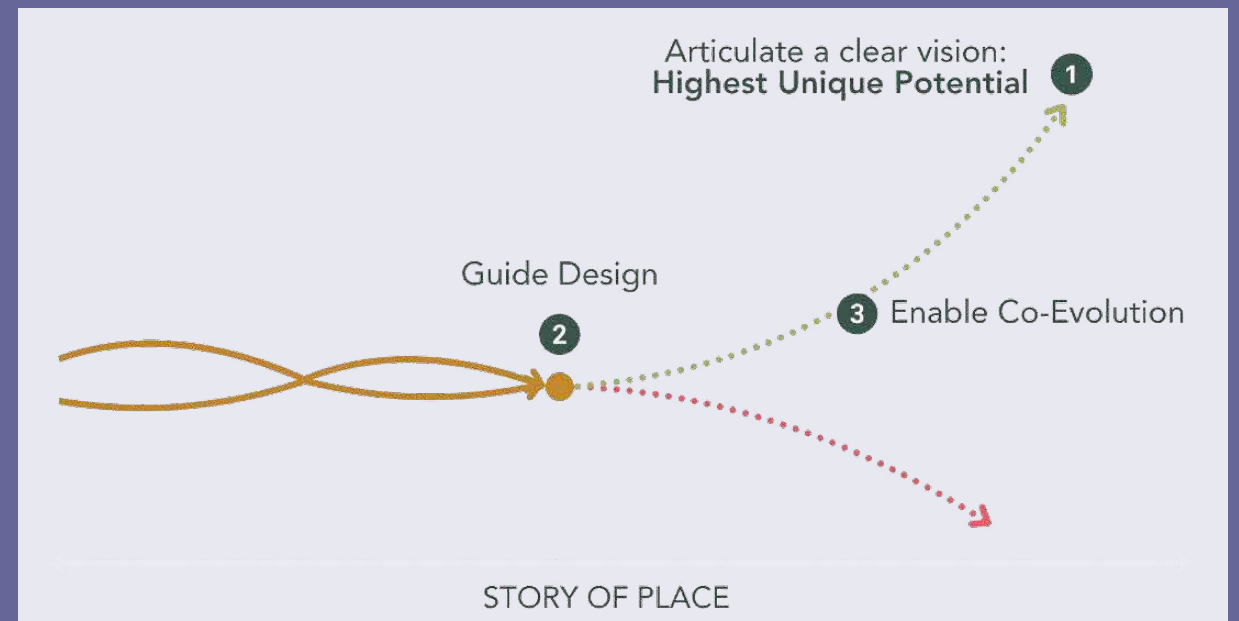
The Story of Place articulates a location’s unique identity, essence, potential and role by tracing its evolution through interconnected ecological, socio-cultural, economic and infrastructural systems. It examines a city or site as a nested living system across space and time, revealing its trajectory and potential evolution.

In essence, it applies nested systems-thinking to spatial and temporal reality, reorienting a place towards a trajectory that catalyses systemic regeneration at multiple scales.

How It Works: Three Levers of Change

1 ARTICULATE A CLEAR VISION: HIGHEST UNIQUE POTENTIAL

Rather than working from deficits or importing generic solutions, the Story of Place reveals what regeneration uniquely means for each location. It identifies specific drivers across design, physical systems, industry, economy and socio-culture, giving each place its own DNA for transformation. The result is a clear north star that defines exactly what regeneration looks like there, moving beyond vague aspirations of “doing more good” to articulating the specific good that only that place can achieve.



The story of place goes beyond mapping history. It allows practitioners to articulate a place’s highest trajectory, guide design in the present, and create the systems needed to ensure it continues on that path.

Image courtesy of The Regenes Project

2 GUIDE DESIGN: PATTERNS ALIGNED WITH LIFE

The framework exposes patterns that guide regenerative interventions, aligning new configurations with the life patterns already functioning in that place. It calibrates strategies across water, ecology, energy, mobility and other systems to harmonise with how the land actually operates. The mainframe design follows a clear logic: landform and geology determine water patterns; water patterns shape blue-green infrastructure (the resilience backbone); and infrastructure organises public space, mobility networks and neighbourhoods. Each layer builds on the previous, with natural systems considered first, creating integrated systems unique to that place. When executed well, the design emerges organically from the place’s own patterns.

3 ENABLE EVOLUTION: CREATING AN OPERATING SYSTEM FOR CO-EVOLUTION

Beyond physical design, the Story of Place creates an operating system that tips the scales and builds lasting capacity for regeneration. It identifies new economies and industries unique to that place and its patterns, where impact and regeneration literally become the reason for economic viability, not just a value-add. This extends to policy influence, particularly land use zoning and ordinances that support regenerative patterns. It also becomes the basis for education across all stakeholders—students, professionals, business people and residents—aligning everyone with the capacity to practice and live in accordance with their place’s patterns of life. The goal is a fundamental mindset shift enabling the system to organically evolve beyond the designer’s direct role.

Bohol's Story of Place

Home to iconic “chocolate” hills, ancient churches and a predominantly karst landscape, Bohol in the Philippines represents a rare convergence—a compact island where distinctive geology, hill-to-reef connectivity, syncretic culture and vibrant tourism operate as one integrated living system. Yet tourism, a key part of Bohol's economy and once an asset, has become extractive.

Mass tourism has driven up costs while degrading the very nature that draws visitors in the first place. Rather than abandoning tourism altogether, the story of place reframes it as a catalytic tool: a decentralised network of nodes across Bohol's towns that makes tourism an enabler of ecological and community regeneration, not a threat to it.

For instance, Inabanga, one of Bohol's towns known for its estuarine identity, has been progressively degraded through decades of extraction. Understanding Inabanga's natural landscape becomes the key to regenerating ecological and ecotone patterns across every estuarine zone, while reconnecting the diverse industries (fishing, aquaculture, fibre and bamboo weaving) that are both the product of a healthy estuary and the means of sustaining it. The result is a circular eco-economic model that restores livelihoods and builds resilience against climate change.



Pattern maps and design guide for Inabanga, Bohol.
Image courtesy of The Regensis Project



Science and Technology

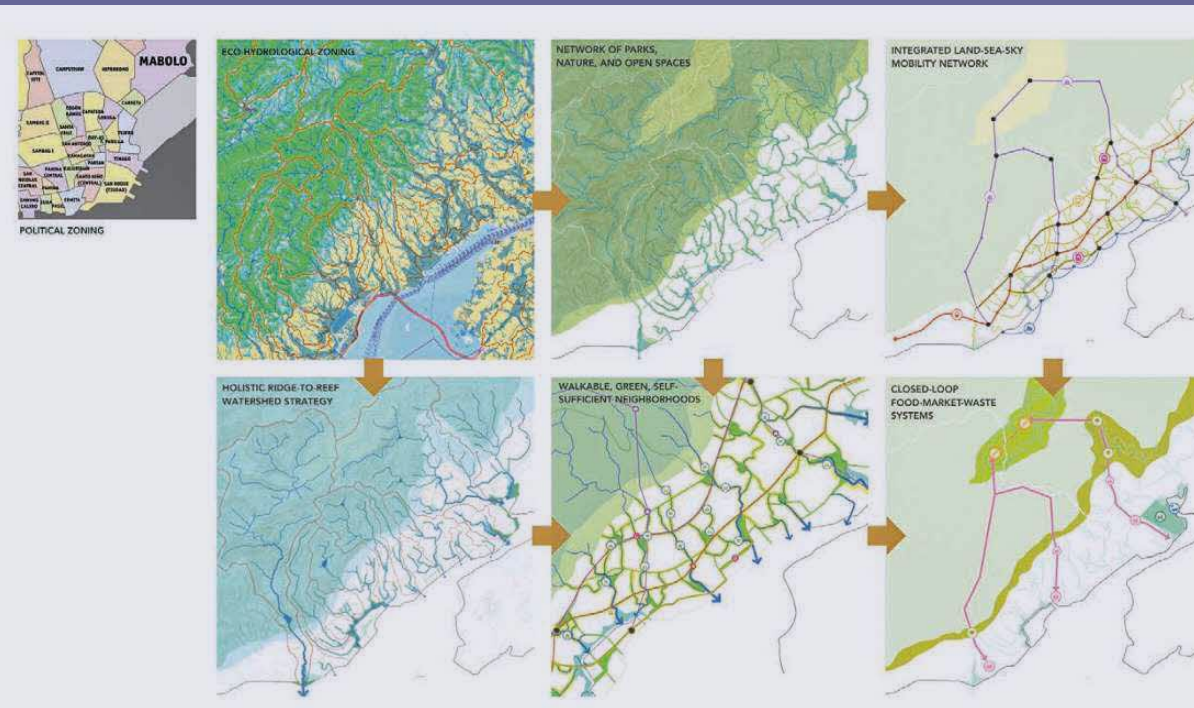
Science and technology expand what is possible and shift decision-making from convention towards evidence. They allow cities to understand the processes in play and the co-benefits they are generating.

Real-time technologies can support active optimisation of resource flows. Microclimate sensor networks, smart building energy systems, and integrated urban data platforms monitor across multiple systems and generate feedback loops to continuously optimise resource use. Beyond efficiencies, this can also meaningfully improve the lived experiences in cities.

Science and technology can support the shift towards decision-making that harnesses co-benefits. With the right tools, we can make visible what conventional metrics of urban development leave out. For example,

artificial intelligence (AI) that is supported by reliable and locally collected data can be leveraged to bridge the gap in our understanding of co-benefits for the entire urban ecosystem. Using their multi-modal computing ability, AI-powered tools can process and synthesise information across previously incompatible data formats and disciplinary boundaries.

Anticipating performance over decades can be made possible. At both building and district scales, computational modelling and lifecycle projections can advance how we think about and plan for the built environment. Such tools can make the regenerative principle of long-termism not just an idea but a practical capability. Cities can plan for reuse and material recovery over the entire lifecycle of buildings and districts, navigating obsolescence and minimising the need for demolition.⁴¹



Cebu City's Story of Place exposes a disconnect between its natural eco-hydrological patterns (such as parallel rivers that run from a mountain range to the coast) and its current urban reality. Designing from this story involves upward layering—from an eco-hydrological zoning underlay as its resiliency backbone, to integrated blue-green riverine systems, to walkable self-sufficient riverine neighborhoods supported by multi-modal transport, and to a closed-loop urban to peri-urban food system.

Image courtesy of The Regensis Project

Place as Source

Applying the three levers of change shifts regeneration from “doing more good” to creating the highest good unique to each place. It reveals a blueprint sourced entirely from within—demonstrating that each place already holds what it needs to regenerate; we need to only learn its language.

THE SMU CONNEXION BUILDING IN SINGAPORE

The Singapore Management University (SMU) Connexion building is a net-zero energy building designed with smart energy management features. These include an operations-centric smart controls system, which integrates building services with networked sensors to minimise energy consumption and maintain indoor comfort, as well as a plug load management system.



The SMU Connexion building (bottom) adopts Mass Engineered Timber (MET) construction technology (top).

Photos courtesy of Singapore Management University



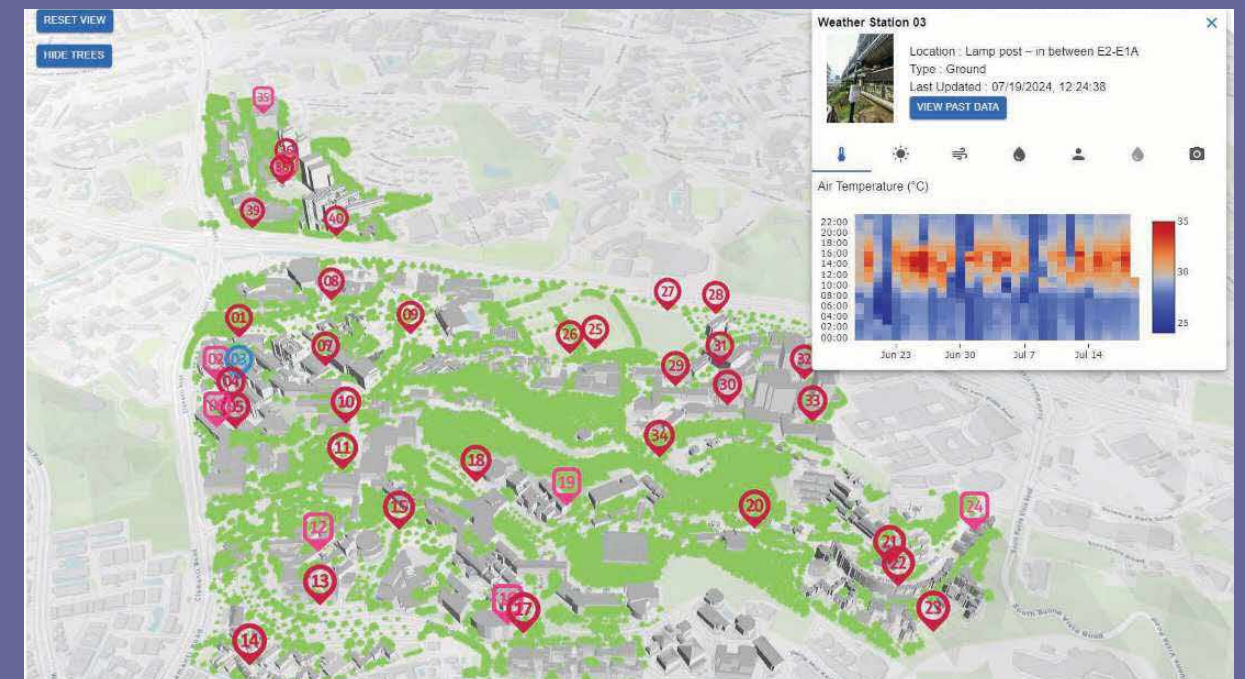
THE LIVING ALGORITHM: HOW ARTIFICIAL INTELLIGENCE SHAPES REGENERATIVE CITIES

ANG YU QIAN

*Assistant Professor (Presidential Young Professor),
Department of the Built Environment, National University of Singapore*

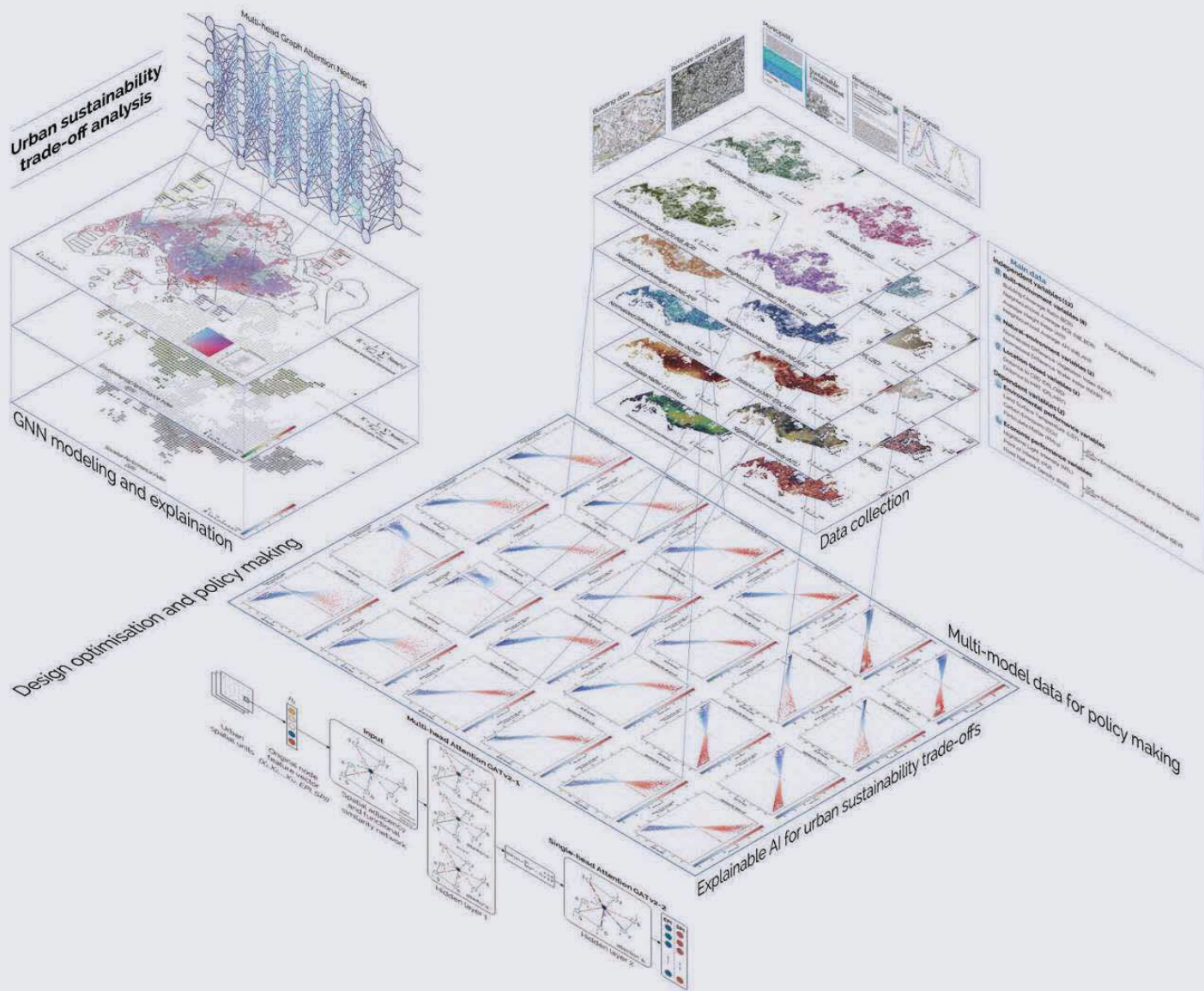
A static city measures its footprint; a living algorithm measures its pulse. At dawn, Singapore's built environment is already actively adapting. Behind this seamless orchestration, urban planners meticulously navigate complex sustainability trade-offs, guided by graph neural networks and explainable artificial intelligence (AI). Before the first commuters step onto the pavement, a highly localised network of microclimate sensors feeds real-time temperature, humidity and wind speed data into

a hybrid physics-based and machine learning model. Anticipating the morning's specific thermal load and hot spots, buildings then autonomously adjust their cooling parameters, drawing on live urban building energy models. At the human scale, experience is subtly but profoundly shaped by visual perception models. Streetscapes are calibrated using AI-informed perception studies, aligning visual determinants with thermal comfort and psychological well-being.



An overview of the CoolINUS-BEAM (Baseline, Evaluating, Action and Monitoring) Digital Twin and microclimate sensor network. Comprising 40 weather stations deployed at both ground and roof levels, 15-m-high meteorological towers, and rooftop infrared thermal cameras, this system forms one of the densest microclimate monitoring networks in the world.

Image courtesy of Joie Lim, National University of Singapore

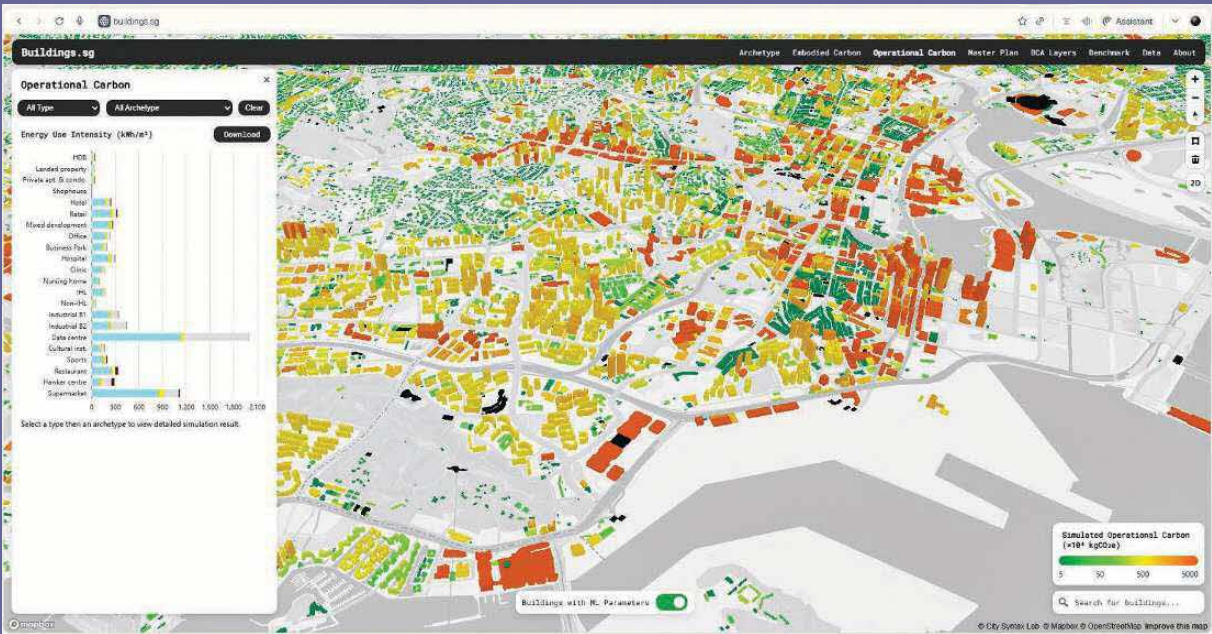


An AI framework that helps planners understand and balance sustainability trade-offs across the city. Urban data—from building form and land use to connectivity—are represented as an interconnected network in graph neural networks. The model reveals how specific design features influence environmental impact and socio-economic vitality, enabling more informed planning decisions.

Image courtesy of Xia Ye, National University of Singapore

This is the regenerative city in motion: an ecosystem that does not merely sustain itself but actively harmonises with its physical environment, generating net-positive benefits. By leveraging AI at multiple scales, the city transcends (basic) sustainability. These continuous micro-decisions seamlessly weave the Regenerative City Framework directly into the living algorithm of daily life.

For decades, urban sustainability was defined by mitigation—a concept focused strictly on doing less harm. However, as global environments confront the escalating realities of a climate-changed future, the strict limitations of traditional sustainable development have become starkly apparent. To thrive, cities and municipalities are embracing regenerative design, a paradigm that shifts the goalpost from net-zero carbon



An interface view of Buildings.sg, an interactive urban energy and carbon map of Singapore. By integrating data across the built environment, it visualises building energy use, operational and embodied carbon, and Green Mark performance—supporting scenario planning and energy optimisation from the district to city scale.

Image courtesy of Buildings.sg

emissions to net-positive outcomes. The new approach demands that urban spaces actively “heal” ecosystems and maximise co-benefits across environmental, social and economic domains.

Translating regenerative principles into built reality demands navigating thousands of interdependent variables (data)—from energy demand and thermal comfort to biodiversity, social equity and population health—within finite spatial and resource constraints. Managing these trade-offs exceeds the capacity of the human mind alone. AI provides the predictive and inferential foresight required to anticipate cascading effects across environmental, social and economic systems before any ground is broken.

To achieve the vision laid out in the Regenerative City Framework, research (academia), government (policy) and industry (technology) must operate in close collaboration. AI functions not merely as an optimisation tool, but as the analytical backbone required to synthesise complex ecosystems, built environments and human behaviours into a cohesive whole. To build the city, we drafted blueprints; to regenerate it, we must decode its syntax. The cities that thrive in a climate-changed century will not be those that optimise once—but those that learn, adapt and evolve in real time.



URBAN ENVIRONMENTAL MODELLING FOR SUSTAINABLE TOWN DESIGN

TAN SZE TIONG

Chief Sustainability Officer and Group Director of the Building and Research Institute, Housing and Development Board, Singapore

The Housing and Development Board (HDB) has long integrated climate-sensitive design in Singapore's public housing projects. In recent years, the HDB has intensified efforts to mitigate climate change effects and create more comfortable environments through various strategies and initiatives.

In 2018, the HDB partnered with the Agency for Science, Technology and Research (A*STAR) to jointly develop the Integrated Environmental Modeller (IEM). The IEM is an advanced modelling tool which uses high-resolution 3D city models that enable our planners, architects and engineers to simulate the interaction of environmental factors such as solar irradiance, wind flow, air temperature and noise levels, as well as their combined effects, on our urban setting.

The IEM was developed to improve town planning methodologies by providing data-driven insights for environmental optimisation. The primary objective is to support informed decisions that will enhance thermal comfort, reduce urban heat island effects, and create more liveable public housing environments through passive cooling strategies.

With the IEM, we can simulate how the placement and configuration of HDB blocks would affect wind flow, and where amenities

such as playgrounds and childcare centres should be located so they are comfortable for their users. Similarly, we can identify potential hotspots and implement mitigation measures, such as the planting of greenery or application of cooling materials, to reduce the build-up of heat, even before construction starts.

The HDB's first eco-town, Punggol, offers an ideal testing ground for implementing innovative sustainable housing solutions. At the same time, its waterfront location and undeveloped land provide opportunities to incorporate comprehensive environmental planning from the ground up. Punggol was therefore selected as a test case to validate the results generated by the IEM.

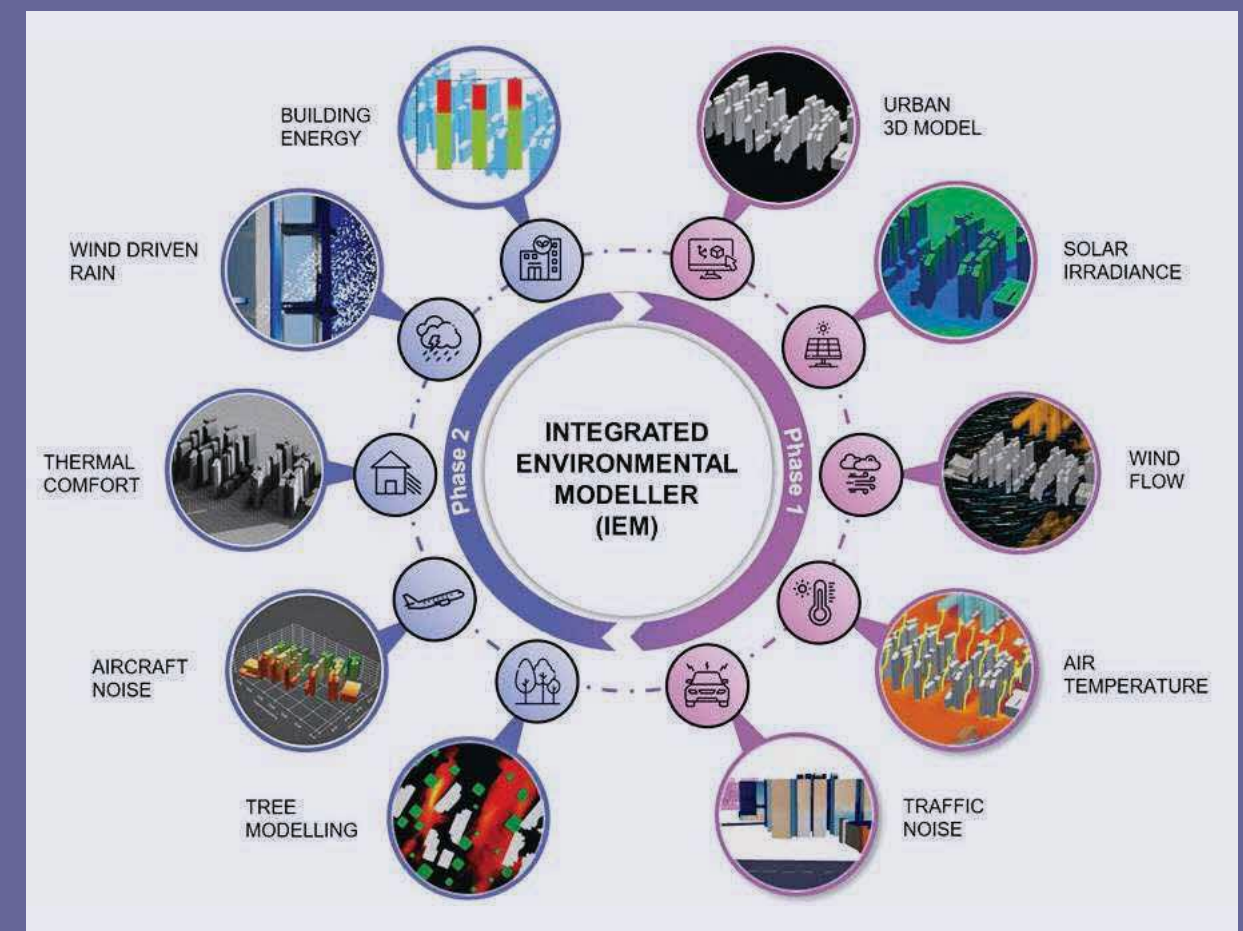
Simulation results were compared with comprehensive data collected over a two-month period from sensors strategically positioned across different locations within the town to represent various urban microclimates. The data included wind speed and direction, ambient temperature, solar irradiation levels, relative humidity, mean radiant temperature and surface temperature. The comparison demonstrated that the IEM accurately simulated the diurnal behaviour of these environmental factors and predicted both daily temperature cycles and wind patterns, confirming the model's reliability for future applications.

At the precinct level, the IEM enables the identification of hotspots for implementation of mitigation measures to reduce heat build-up and channel wind flow. In Punggol Northshore, this method has enabled planners to set aside shaded green spaces for outdoor activities. One example is the Community Wave feature found in Northshore Residences, where children of all ages can play in a shaded and breezy area near the childcare centre.

Following this, the IEM was adopted in the planning and urban design of Tengah, including mapping of town-wide wind flow and solar heat gain. The IEM was adopted to design several

Build-To-Order projects in Tengah, such as Parc Residences @ Tengah and Parc Clover @ Tengah. Their precinct amenities, such as a rooftop sky community park featuring playgrounds, fitness corners and a brisk-walking track, will be located in areas largely shaded by buildings, so that residents can comfortably enjoy them during the day.

Through these comprehensive measures, the IEM initiative demonstrates Singapore's commitment to creating inclusive, sustainable and comfortable living environments for all residents while helping to mitigate environmental challenges.



Overview of the IEM.

Image courtesy of Housing and Development Board



Finance, Investments and Business Models

Regenerative urbanism is a long-term investment. By ensuring sound financial logic behind the strategies employed, financing can be unlocked and the efforts sustained over time.

Financial frameworks must recognise the value that regenerative development generates. Reduced flood risk, improved public health, enhanced biodiversity and stronger social cohesion are not soft co-benefits but risk reduction and value creation at scale. Financial systems that recognise the value of ecological and social co-benefits can direct capital more effectively to regenerative projects. Matching investment timelines and taking a long-term view of capital returns will unlock financing for regenerative cities.

Legal and regulatory frameworks must align. Taxonomies related to resilience, liveability and resource optimisation outcomes must be updated. This will enable a supportive economic environment, where procurement, policy, regulatory codes and financial incentives can evolve in tandem.

Transition financing creates pathways to regenerative cities. Just as green transition finance supports projects in moving away from carbon-intensive models, regenerative transition finance can enable projects to do more good, maximise co-benefits, adopt an environment-centric approach and establish circular resource flows. Blended financing from governments, development banks and the private sector can enable this pathway.

CASE STUDY

THE FINANCING ASIA'S TRANSITION PARTNERSHIP BY THE MONETARY AUTHORITY OF SINGAPORE

The Financing Asia's Transition Partnership (FAST-P) is a Singapore-led blended finance initiative that aims to mobilise up to US\$5 billion in collaboration with public, private and philanthropic sector partners to de-risk and finance green and transition projects in Asia. The Singapore Government has pledged up to US\$500 million as concessional capital, to match dollar-for-dollar, other concessional capital from partners. This combined pool of concessional capital will be used to crowd in commercial capital and other sources of finance to accelerate capital flows to support Asia's green transition.



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THE INTEGRATED RETURN ON INVESTMENT FRAMEWORK BY THE NATIONAL UNIVERSITY OF SINGAPORE'S SUSTAINABLE AND GREEN FINANCE INSTITUTE

by **ZHANG WEINA**, Associate Professor, National University of Singapore

The Sustainable and Green Finance Institute (SGFIN) at the National University of Singapore (NUS) developed the Integrated Return on Investment (IROI) Framework. It offers holistic valuation of economic, environmental, social and governance outcomes, going beyond traditional financial and economic results to capture intangible benefits and externalities.



Scan QR code to read the case study.



Applying the framework, the SDE4 net-zero building at NUS produced an IROI of \$2.32 per dollar of investment.

Photo courtesy of National University of Singapore



Measurement and Monitoring Systems

What gets measured gets managed, and in the regenerative city, this covers a range of desired co-benefits. Good tracking systems allow cities to see the benefits they are generating, enable accountability for interventions made and generate feedback loops.

Integrated data systems can give planners a holistic view of the city. Such systems should bring together resilience, liveability and resource optimisation outcomes via shared platforms and common indicators. With good data governance through a collaborative and coordinated approach, cities can benefit from a fuller assessment of co-benefits, capture harnessed synergies and strengthen accountability. These systems can also accelerate learning and knowledge transfer across projects.

Regenerative measurement is key for feedback. Through longitudinal tracking, progress and performance in generating co-benefits can be quantified with actual rather than modelled data. Tracking is how the regenerative city learns what is working, corrects what is wrong and builds evidence for future investment. It also improves the science of regenerative cities, leading to more accurate understanding of employed strategies and urban-natural processes.

Good measurement systems give contextual meaning. By balancing place-based and universal indicators, cities can understand how they are performing against others, while also being rooted in local considerations. Through common indicators, a shared language emerges to enable benchmarking, peer learning and knowledge transfer. Place-based indicators then reflect local urban, ecological and social conditions that affect the regenerative capacity of the city.



OP-ED



SHENZHEN AS A TEST-BEDDING CITY: HOW LOW-CARBON INNOVATION GENERATES URBAN CO-BENEFITS

SHAN LIANG

Director, Shenzhen Urban Planning and Land Resource Research Center

As cities push ahead with low-carbon transitions, a familiar tension keeps resurfacing. Cutting emissions is still widely seen as something that competes with economic growth or everyday urban vitality. In many cases, this perception—not technology—has been the real brake on action. That is why “test-bedding cities” matter. They are places where climate policies and technologies are not discussed in the abstract, but tested in daily urban life and adjusted as cities learn what actually works.

Shenzhen is one such place. Over time, the city has moved away from treating innovation as a collection of stand-alone pilots. Instead, experimentation has become part of how the city plans, governs and operates. What has emerged is not a single showcase project, but a pattern of learning through practice—trying

things early, refining them and scaling them once they prove viable.

This approach can be traced back to one of Shenzhen’s earliest low-carbon initiatives: the Shenzhen International Low Carbon City. Launched in 2012 under the China-EU cooperation on sustainable urbanisation, it was never intended as a technology display zone. From the outset, it was conceived as a city-scale exploration of how planning, infrastructure and urban systems could work together to reduce emissions. At a time when low-carbon urbanism was still largely theoretical, Shenzhen chose to experiment in real space, under real constraints. That willingness to move early—and accept uncertainty—later drew international attention, including recognition from the Paulson Institute for its contribution to low-carbon urban planning.



The Shenzhen International Low Carbon City is a city-scale exploration of low-carbon development, from planning innovation to international recognition.

Photos courtesy of Shenzhen Urban Planning and Land Resource Research Center

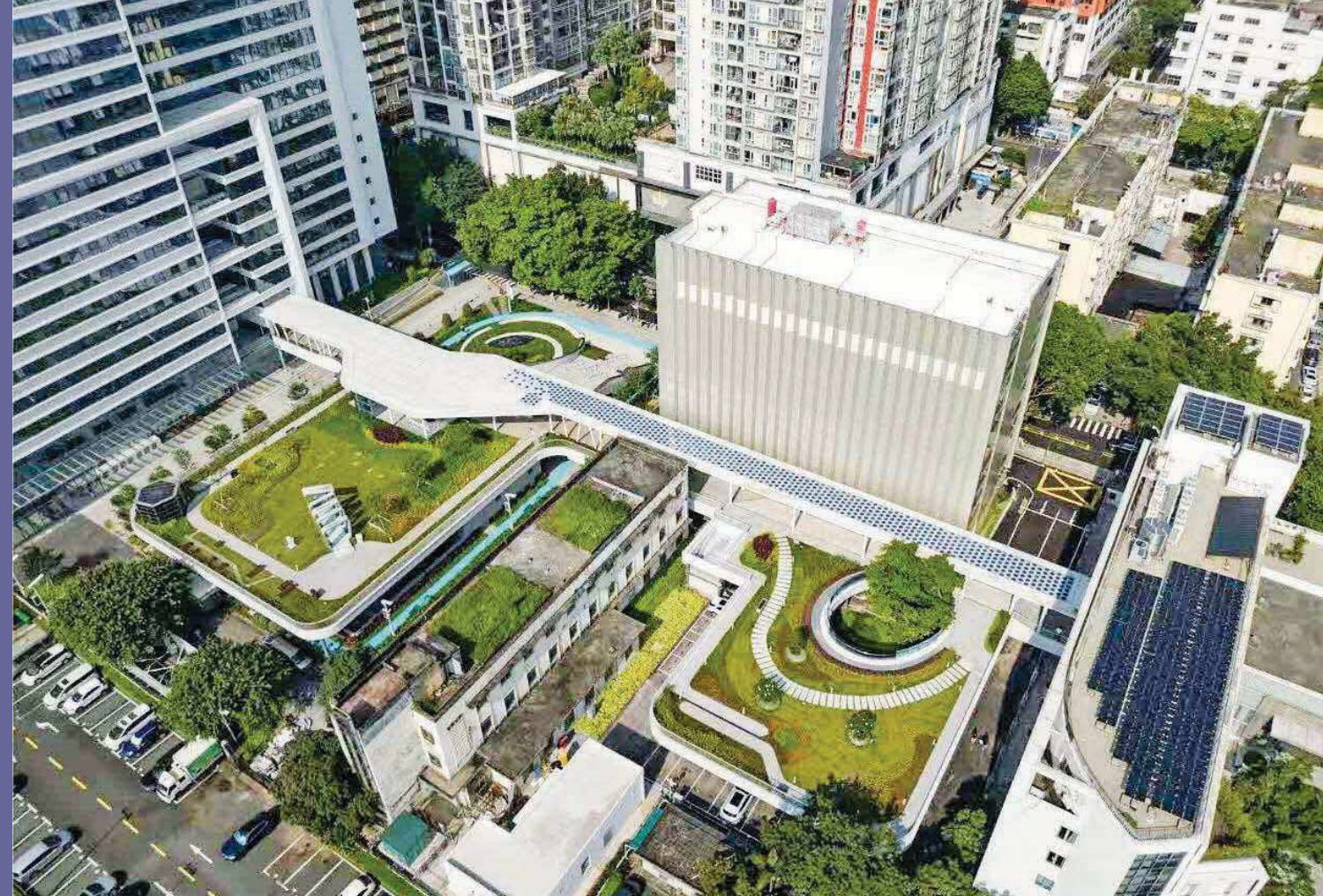


Shenzhen's local emissions trading scheme in operation, illustrating how carbon governance is embedded into everyday market mechanisms at the city scale.
Photo courtesy of Shenzhen Urban Planning and Land Resource Research Center

From there, experimentation extended into institutions. Shenzhen's local emissions trading scheme, launched in 2013, was among China's earliest carbon-market pilots. What made it notable was not just its timing, but its scope. By bringing buildings and transport into carbon governance, the scheme turned emissions reduction into a practical, city-wide concern. More importantly, it allowed rules to evolve through use, showing how climate policy can function as a learning system rather than a fixed regulatory package.

The city's test-bedding character is perhaps most visible in its transport transition. Shenzhen became the first major metropolis to fully electrify

its public bus fleet. The immediate benefits—cleaner air and lower emissions—were clear. Over time, however, the deeper impact was economic: as a stable urban application scenario, it helped to anchor a competitive electric-vehicle and clean-technology ecosystem. Similar dynamics can be seen in near-zero carbon communities (like the Huaqiangbei Ganquan Road Near-Zero Carbon Community), industrial parks and public facilities, where emissions reduction has gone hand in hand with lower energy costs and improved liveability. Investments in sponge-city infrastructure and circular systems, including waste-to-energy facilities, have further strengthened resilience in a dense urban context.



Shenzhen advances a low-carbon transition through coordinated urban systems—integrating emissions reduction into everyday operations while strengthening resilience and circular infrastructure—at the Huaqiangbei Ganquan Road Near-Zero Carbon Community (top) and other industrial parks and public facilities (bottom).
Photo and image courtesy of Shenzhen Urban Planning and Land Resource Research Center

Taken together, these experiences have shaped how Shenzhen understands urban transformation. Rather than isolated measures, they form an interconnected way of governing change. Out of this accumulated practice, the city has articulated the Urban Index of Shenzhen (UIS). The UIS is not simply an indicator set. It is an attempt to turn lived experience into a usable governance tool—one that helps make

sense of how policy experimentation, system performance and everyday urban outcomes interact. In that sense, the UIS represents a contribution from Shenzhen to the wider urban community: a framework grounded in practice, and intended to be shared, adapted and learned from by other cities navigating low-carbon transitions.

Dimension	Indicators											
INNOVATIVE	Density	High-level Papers per Million Inhabitants		Abundance	Business Environment Maturity		Intensity	Total Labor Productivity (TFP)				
		Patents per Million Inhabitants			Attractiveness Inclusiveness for Migrant Population			Technology Transaction Activity				
		R&D Intensity	Urban Innovation Vitality		Startup Incubation Level			Direct Investment (FDI- DFDI)				
LIVEABLE	Settlement	Housing Affordability		Quality	Living Service Coverage		Opportunity	Education Opportunities				
		Resident Purchasing Power			Open Public Space Accessibility			Employment-Friendliness				
		Population Structure			Commuting Convenience			Third Space Diversity				
BEAUTIFUL	Natural Harmony	Level of ecological space protection		Green Progress	Urban low-carbon level		Spatial Resonance	City Image favorability				
		Green-Blue area to Built-up Area Ratio			Annual air quality			Destination Appeal Intensity				
		Native Biodiversity in Built-up Area			Safe treatment rate of domestic sewage			Streetscape Visual Perception				
RESILIENT	Defense	Redundancy of municipal infrastructure		Recovery	Emergency Shelter Service Level		Adaptability	Natural shoreline retention rate		Transition	Top-level design of resident city	
		Building Fortification Level			Emergency Response Service Level			The proportion of permeable urban area			Level of disaster risk management	
CULTURALLY ADVANCED	Citizen spirit	Civic Civility Behavior Level		Cultural Understanding	Cultural Heritage Resource Abundance		Inclusion & Engagement	Multicultural Inclusivity				
					Cultural Innovation & Production Capacity			Global Cultural Influence				
					Cultural Participation Consumption			Participation rate in volunteering and public welfare activities				
SMART	Digital Foundation	Integration level of urban data platform		Inclusive Public Services	Digital infrastructure Coverage Rate		Digital Civic Engagement	Digital Payment Convenience				
		Network Connectivity Level			Convenience of online Government Service			Digital Civic Engagement Level				

The UIS as a practical governance interface. The framework organises complex urban practice into six interrelated dimensions, supporting interpretation, dialogue and communication across diverse urban stakeholders.

Image courtesy of Shenzhen Urban Planning and Land Resource Research Center



CITIES CAN LEAD THE CLIMATE FIGHT—BUT ONLY IF THEY MEASURE, PLAN AND BUILD REGENERATIVELY

MARK WATTS
Executive Director, C40 Cities

Cities are on the front lines of the climate crisis. Heatwaves, floods and extreme weather are increasingly disrupting lives and livelihoods. At the same time, city leaders hold the solutions to this existential threat: cutting emissions, reducing reliance on fossil fuels, regreening our urban centres and cutting waste while empowering residents to improve and protect the places they love.

But ambition alone is not enough; city climate action can only succeed when coupled with robust measurement tools, science-based standards, and regenerative planning frameworks that translate pledges into action and ensure progress is measurable, accountable and demonstrable to those living in the city.

C40’s model is built on municipal multilateralism. Unlike most intergovernmental institutions, membership of the C40 Cities group is earned through action, not by right or fee. Our cities demonstrate climate leadership through measurable, science-based action, a willingness to collaborate, and a readiness to share their solutions and learn from one another. There are no negotiations or requirements for consensus; individual cities set the pace where they are best suited to lead and C40 helps everyone else follow them to the top together. This model has produced tangible results: cleaner air, safer streets, more green jobs, and millions of residents living in healthier, more resilient communities. To take just one example: the emissions of 72% of our cities are on a downward trend, so even as global emissions continue to grow, C40 cities’ collective emissions are decreasing.



School street in Milan.
Photo courtesy of C40 Cities

At the heart of this action-oriented approach are the C40 Leadership Standards and Accelerators. The Leadership Standards set a global benchmark for climate governance, requiring cities to integrate climate action into decision-making, cut emissions in line with the Paris Agreement, and report progress transparently. Many cities complement this with reporting their emissions, ensuring data is globally comparable, credible and actionable. Together, these tools allow mayors to measure what matters, track outcomes and scale solutions.

Central to effective urban climate action is regenerative planning. Cities must make the most of existing land and infrastructure, prioritise adaptive reuse, integrate circular approaches to materials, and bring nature back into urban environments. The C40 × UN-Habitat Urban Planning Accelerator leads this agenda, helping cities adopt compact, connected, mixed-use and transit-oriented development. By embedding measurable objectives into

planning—such as adopting a polycentric model and prioritising density over urban sprawl—the Accelerator enables cities to cut emissions at source while delivering equitable, resilient and thriving communities.

Regenerative principles also drive C40’s Clean Construction and Urban Nature Accelerators. Clean Construction reduces embodied carbon through adaptive reuse and circular construction, while Urban Nature restores green space, mitigates urban heat and enhances well-being. All of these measures can be tracked through quantifiable targets that are then transparently reported so that leaders can be held to account on their promises. For example, we can see that three quarters of cities that publicly committed to ensuring that 70% of their population has access to green or blue space within a 15-minute walk have now done so. Together, these programmes demonstrate that climate action can be regenerative, equitable and economically transformative.



The Campus for Living Cities in the South Campus of Madrid’s Polytechnic University was set to be Spain’s largest cross-laminated timber building in 2025.
Photo courtesy of ©UNEXUM



Tactical urbanism in Rio de Janeiro.
Photo courtesy of João Salomonde

C40’s model of collaboration—sharing, adapting and scaling successful interventions—shows that cities can lead globally even amid political and economic uncertainty. By combining leadership standards, accelerators and robust reporting through the CDP-ICLEI Track, a city climate reporting platform by the Carbon Disclosure Project and the Local Government for Sustainability, cities demonstrate that measurable, science-based action is possible and popular with voters. They show that urban climate leadership can be politically bold, globally coordinated and locally transformative, delivering emissions reductions, resilient infrastructure and a better quality of life for millions.

The message is clear: cities are doing more than ever, but the climate crisis still demands urgency. With the right frameworks, measurement tools and regenerative approaches, mayors can turn ambition into action, and action into real, measurable change. Cities are leading—the question now is whether the world will follow.

The Regenerative City Framework acts as a guide for cities to chart intention and scale implementation towards regenerative urban development. At its core, it is a roadmap to show how cities can begin approaching urban development in a way that balances the demands of urban growth against the need to secure healthy ecosystems. It guides us to harness co-benefits for the entire urban ecosystem, achieving more than the sum of their parts through integrated and long-term planning.

Applying the Framework will involve trade-offs and difficult choices. Competing priorities, resource constraints, and governance realities shape what is possible at any given moment, and the outcomes, strategies, and enablers described here interact dynamically rather than in sequence. The Framework is also not a universal prescription—a high-density Asian

metropolis and a mid-sized post-industrial European city will draw on the same principles but arrive at very different applications. Used well, it is a tool for structured prioritisation that helps city leaders ask better questions: which **outcomes** matter most in this context, which **strategies** are most viable given current conditions, and which **enablers** need to be strengthened before others can take effect. Equipped with this understanding, the Framework invites cities to develop place-specific solutions.

Action must be matched with accountability. Regenerative urban development requires tracking progress to ensure that ambition translates to results over time. In Chapter 3, we introduce an approach to *Measuring the Regenerative City* to help cities evaluate progress and measure effectiveness.

The transformation of Parc de les Glòries (Glòries Park) in Barcelona, from a heavily trafficked road, has helped to regulate the local climate and add comfort in the summer. The reclaimed space now offers 30,000 m² of green space and includes biodiversity nodes, dense native vegetation and family play areas.

*Photo by DRONEIT,
courtesy of Imágenes Barcelona*



Chapter 3

MEASURING THE REGENERATIVE CITY

The regenerative city can measure progress by its ability to achieve regenerative outcomes and build capacity over time. This chapter delves into example indicators that can be used as a starting point for evidence-based planning.

Stockholm Royal Seaport, also known as Norra Djurgårdsstaden, is a former industrial land turned mixed-used district. It is a test-bed district for developing new solutions and processes for a more liveable and resilient future.

Photo courtesy of Ng Sze Xuan



MOVING THE NEEDLE: INSPIRING AND MEASURING PROGRESS

A regenerative city cannot be built by intention alone. Rather, progress can be achieved by strategically harnessing co-benefits, and further accelerated through the systematic application of metrics, indicators and measurements that enable us to monitor, evaluate and refine our actions.

The Regenerative City Framework in Chapter 2 answered the questions of what a regenerative city is and how to create a regenerative city. This chapter builds on that and turns to the more complex question of **how to assess the regenerative city**.

We present two sets of assessment indicators—outcomes and capacities. Regenerative outcomes, based on the Regenerative City Framework, measure progress in implementing regenerative urban development. Regenerative capacities assess existing conditions and how well the city can harness co-benefits.

When outcomes and capacities are assessed together, a city can measure the extent to which investments in capacity are associated with desired outcomes across the development lifecycle.

Outcomes of the Regenerative City

Tracking outcomes helps cities to understand change. Beyond that, it accounts for the impacts of interventions as well as progress in achieving various goals.

The Regenerative City Framework highlights three key outcomes to track: **liveability**, **resilience** and **resource optimisation**.

To find out more about the outcomes of a regenerative city, refer to page 64 of Chapter 2.



Liveability indicators show the city's ability to achieve a competitive economy, a high quality of life and a sustainable environment. They reflect the underlying systems of planning, governance and collaboration, which create the enabling conditions for urban liveability.



Resilience indicators reflect the ability of a city's people, communities, institutions, businesses and systems to prepare and plan for, absorb, recover from and more successfully adapt to adverse events.



Resource optimisation indicators point to the degree to which material, carbon, water and land are used and kept in continuous circulation to minimise extraction, waste and environmental degradation, while allowing for growth.

To advance local food production and optimise limited land space, urban farms utilise vacant space on top of multistorey carparks and in housing estates in Singapore.

Photo courtesy of Singapore Tourism Board



Altogether, the outcomes indicators provide us with a holistic view into how truly regenerative the city is. They can also act as a guide by articulating the range of co-benefits that the city can unlock, in turn orienting it towards a broader goal: urban development that pursues co-benefits for the entire urban ecosystem.

Over time, tracking these outcomes can also help cities gain a better understanding of regenerative interventions by comparing their before and after impacts. Time enables progressive comparison, allowing cities to understand the effectiveness of their actions and determine where course correction is needed. This is further amplified by a clear understanding of the city's regenerative capacity.



Yokohama's Minato Mirai achieves liveability through integrated planning, where office, commercial and recreational facilities are placed together with green spaces and historical sites. Minato Mirai has also pioneered several circular initiatives in Japan in line with Yokohama's goal of becoming a circular economy.

Photo courtesy of Pmlydon (CC BY-SA 3.0 / Wikimedia Commons)

Hamburg's HafenCity is a mixed-use district that transforms the city's former industrial port. The district is estimated to create 45,000 new jobs while also providing subsidised housing for low and middle-income households.

Photo courtesy of Gunnar Ridderström on Unsplash

Capacities of the Regenerative City

The regenerative city requires an understanding of outcomes and capacity. Guided by regenerative outcomes, capacity indicators support planners and policymakers in creating conditions fit to harness the interdependencies between the urban built and natural environments.



Marina One is a high density complex, integrating 175,000 m² of office space and 1,042 apartments together with a 37,000-m² green space that is home to over 350 different species of trees and other plants.

Photo courtesy of Singapore Tourism Board



Tokyo's Azabudai Hills is a development that leverages density and diversity by integrating multiple uses over 81,000 m² of land area: office, residential, retail and green spaces.

Photo courtesy of William L. McGough (CC BY-SA 4.0 / Wikimedia Commons)

Regenerative capacity is also informed by the concept of “adaptive capacity”, established by the Intergovernmental Panel on Climate Change (IPCC) in their Third Assessment Report.⁴⁵ Adaptive capacity refers to the capability of the ecosystem or community to adjust to potential damage or impact caused by climate change. It measures the ability of urban ecosystems in the city to take advantage of opportunities and respond to consequences.

Assessing adaptive capacity would therefore help cities to take action to reduce vulnerability and risks. Cities can understand trade-offs through five types of capital: natural, physical, financial, social and human.⁴⁶ Natural capital refers to resources such as vegetation, land and water; physical capital includes roads and reservoirs; financial capital is funding that supports adaptation; social capital is the community's capacity to adapt to changing conditions; and human capital points to people as resource. These types of capital outline how capacity is currently measured, serving as a springboard for the development of regenerative capacity.

To find out more about adaptive capacity, refer to Glossary on page 196.

Understanding Regenerative Capacity

In essence, while adaptive capacity measures the latent capability of a city to respond to climate change and inform action to reduce risks, regenerative capacity extends this idea by distilling co-benefits.

Regenerative capacity aims to encourage synergies between the city's urban built and natural environments, advancing a balanced assessment of the urban ecosystem's ability to bring holistic benefits. It comprises three fundamental tenets: **density**, **diversity** and **connectivity**. Each of these represents a systems-

based approach to holistic planning for the urban ecosystem. Collectively, they measure how well both the urban built and natural environments can facilitate future regenerative urban development.

Yet, regenerative capacity does not necessarily lead to regeneration. Regenerative capacity, more accurately, provides a preview of how the regenerative city might develop. It must be complemented by an assessment of regenerative outcomes that provide a measure of the actual progress of regeneration.



Vancouver, Canada is working towards building a series of greenways throughout the city, with the goal of ensuring that they can be accessed via a 10-minute cycle or 25-minute walk by every household.

Photo courtesy of Andrew Raun (CC BY-SA 2.0 / Wikimedia Commons)



To facilitate connectivity, Singapore transformed a former railway line into a rail corridor that integrates walking trails and community nodes into an ecological pathway that enables wildlife movement between major green spaces.

Photo courtesy of Singapore Tourism Board

Density measures the concentration of human and ecological activity at a given site or district. It promotes the co-location of land uses in ways that generate shared benefits across liveability, ecosystem health and urban resource efficiency. It also embodies the principles of multi-functionality and integration that underpin low-carbon developments.

Diversity captures the range of human and ecological activities across a site or district. For people, it reflects the vitality and economic competitiveness of the city. For nature, it encompasses biodiversity which signals ecosystem health and the city's capacity to support interspecies interactions. Together, these diversity indicators offer a cross-sectional view of the city's social, economic and ecological conditions that point towards resilience.

Connectivity measures the accessibility of amenities and resources in a site or district, for both people and natural ecosystems. A regenerative city requires urban functions and landscapes to be in productive proximity to facilitate movement and exchange. While mobility for people is enabled by roads, cycling paths, walkways and a public transport network, the natural environment is enabled through ecological corridors and contiguous green infrastructure.

Measuring capacity gives city leaders a point-in-time read of how well-configured the city is to support regenerative processes. It informs where deliberate action is needed to increase the city's regenerative capacity—whether by refining proposed regenerative policies to ensure alignment with existing capabilities or by adjusting planning parameters.

For city leaders and planners, capacity indicators do not just describe the city as it is; they actively shape what the city chooses to do next.

INDICATORS TO MEASURE THE REGENERATIVE CITY

Knowing what to measure is only half the challenge. With a vast landscape of existing frameworks and metrics to choose from, cities must know which indicators are most useful in assessing a regenerative city.

Methodology

Guided by the Regenerative City Framework, the Centre for Liveable Cities and Singapore University of Technology and Design conducted a review of indicators, benchmarking them against industry standards and capabilities.

Drawing from leading assessment tools and metrics, including the World Bank Group’s One Health Framework, Singapore Index on Cities’ Biodiversity and CityLoops Urban Circularity Assessment Method, the review prioritised indicators that reflect up-to-date scientific findings, that have garnered international acceptance and are relatively easy to use. This process was guided by five key principles.

Principles for selecting indicators



LEVERAGE WELL-ESTABLISHED FRAMEWORKS AND EXISTING DATA

To minimise the need for additional data collection and analysis.



MINIMISE THE NUMBER OF METRICS USED

To ensure that the outcomes and capacity of the regenerative city are adequately measured, without causing reporting fatigue.



ARTICULATE CLEAR GOALS FOR EACH METRIC

To ensure deliberate and meaningful assessments that can inform decision-making.

OVERVIEW OF REFERENCED ASSESSMENT FRAMEWORKS AND INDICES

Frameworks	• One Health Framework by the World Health Organization⁴⁷ • Climate Guidance for Cities by the Science Based Targets Network⁴⁸ • Planetary Boundaries Framework by Rockström et al.⁴⁹ • The Liveability Framework by the Centre for Liveable Cities⁵⁰ • The HDB Biophilic Town Framework by the Housing and Development Board⁵¹
Indices	• Kunming-Montreal Global Biodiversity Framework by the United Nations⁵² • Global Protocol for Community-Scale Greenhouse Gas Emission Inventories by the World Resources Institute, C40 Cities and ICLEI—Local Governments for Sustainability⁵³ • The Singapore Index on Cities’ Biodiversity by the Secretariat of the Convention on Biological Diversity and the National Parks Board⁵⁴ • City Resilience Index by Arup and the Rockefeller Foundation⁵⁵ • Global Biodiversity Metric by Ramboll⁵⁶ • Guide to Inclusion and Health in Public Spaces by the Gehl Institute⁵⁷ • Urban Circularity Assessment Method by CityLoops⁵⁸ • City Water Circularity Assessment by Arora et al.⁵⁹ • Baseline Indicators for Community Resilience by Cutter et al.⁶⁰ • Socioeconomic and Built Environment Indicators of Liveability by Martino et al.⁶¹ • Sprawl Indices by Ewing,⁶² and Frenkel and Ashkenazi ⁶³



ENABLE PHASED AND PROGRESSIVE ACHIEVEMENT OF THE REGENERATIVE CITY

To provide adequate guidance for all cities, regardless of whether they are in the early or advanced phases of regenerative urban development.



ALIGN WITH BROADER REGENERATIVE STRATEGIES, WHILE LEAVING ROOM FOR CITIES TO DRIVE PLACE-SPECIFIC INTERVENTIONS

To encourage cities to measure progress in their own trajectories of regenerative urban development.

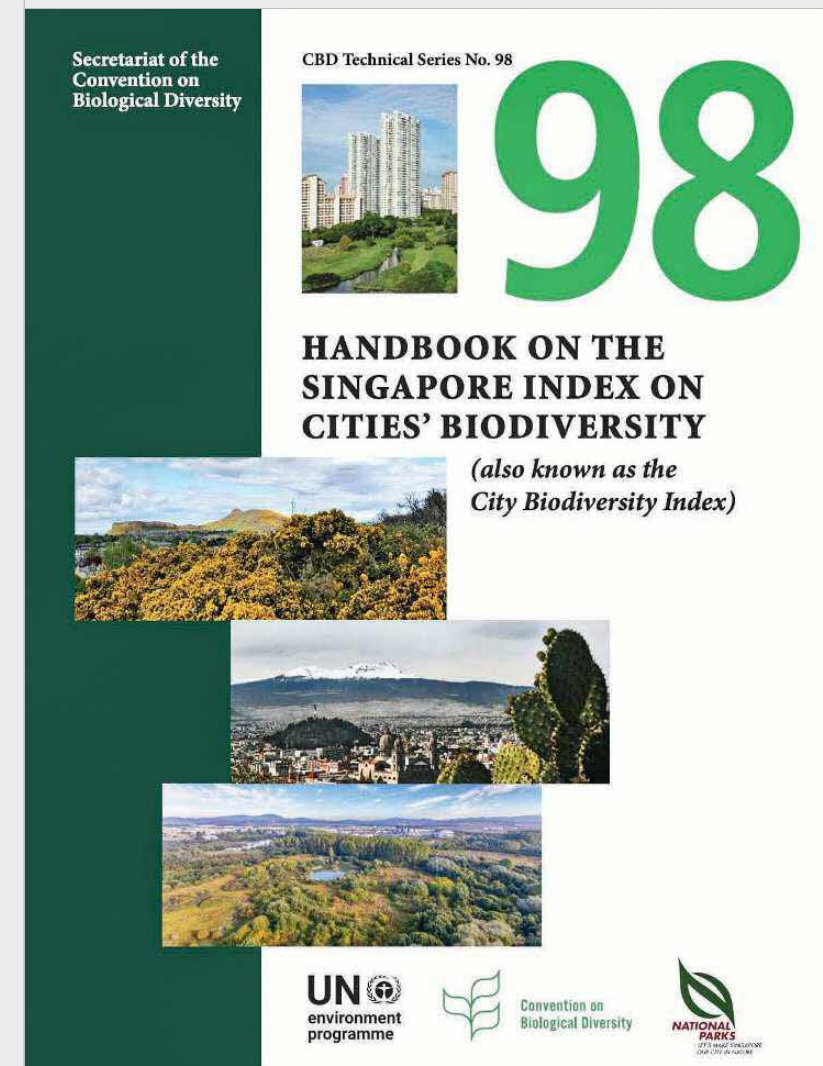
THE SINGAPORE INDEX ON CITIES' BIODIVERSITY

by National Parks Board

Developed by Singapore in collaboration with the Secretariat of the Convention on Biological Diversity and the Global Partnership for Local and Subnational Action for Biodiversity, the Singapore Index on Cities' Biodiversity (SI, also known as the City Biodiversity Index) provides cities with a robust framework to assess their nature conservation efforts.

Through workshops held with international experts, the SI was designed as a self-assessment tool with two parts: the profile of the city as well as 28 indicators spanning the 3 core components on native biodiversity, ecosystem services and governance. Examples of indicators include an assessment of the city's richness of bird diversity in built up areas, the area of habitats undergoing restoration efforts, the ecosystem services (such as recreation and climate regulation) provided by the city's natural assets, as well as the city's budget allocated to biodiversity conservation. Cities score themselves based on the *Handbook on the Singapore Index on Cities' Biodiversity* guidelines published in 2021.

The SI helps cities demonstrate that urban nature can help to achieve the co-beneficial outcomes needed in a regenerative city. Today, 40 city governments, such as Helsinki, Abu Dhabi and Los Angeles, have applied the SI, and academics have applied it to a further 16 cities.



Handbook on the Singapore Index on Cities' Biodiversity.
Image courtesy of National Parks Board

With the aim of deriving a set of example indicators grounded in both evidence and practice, we also looked to the work of industry players. Learning from industry reporting, insights were gained into the plethora of evidence that could be collected to inform decision-making. From utilising data for research-driven innovation to setting targets for leading-edge regenerative developments, the industry offers a pragmatic view of effective reporting that complements the rigour of scientific assessments.

Through this process, a list of example indicators that could be used for assessing regenerative outcomes and regenerative capacity indicators was identified. The list is not exhaustive, but rather a preliminary one intended to be used as a starting point to move towards evidence-based planning that explicitly addresses interdependencies within the urban environment.

By establishing a clear method of assessing indicators across the three regenerative outcomes and three pillars of regenerative capacity, cities gain a framework for understanding co-benefits over time.



A REGENERATIVE TROPICAL MICROFOREST IN THE BUILT ENVIRONMENT: A PATHWAY TO URBAN BIODIVERSITY AND ECOSYSTEM RESTORATION AT CITY SQUARE MALL

ESTHER AN

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VEERA SEKARAN

Professor, Engineered Nature-Based Solutions, NUS President's Office

In tropical cities, urbanisation is intensifying environmental pressures, particularly the urban heat island effect, biodiversity loss and ecosystem fragmentation. Conventional urban greening, often reliant on sparse planting and non-native species, has limited effectiveness in delivering meaningful cooling or ecological restoration. In response, regenerative tropical microforests (RTMFs) have emerged as a nature-based solution that integrates dense, biodiverse forest systems into highly urbanised environments.

The CDL MicroForest at City Square Mall in Singapore exemplifies this approach. This pilot project was developed in collaboration with City Developments Limited (CDL), the National University of Singapore (NUS) and the National Parks Board (NParks), and is aimed to serve as a living laboratory to assess how regenerative forests can deliver both environmental and social co-benefits.



The CDL MicroForest at City Square Mall is Singapore's first research-driven regenerative tropical microforest in a retail mall, designed to mitigate urban heat, enhance climate resilience and boost biodiversity.

Photo courtesy of City Developments Limited



In just one year, the forest has grown rapidly, both in density and ecological function.

Photo courtesy of City Developments Limited



Professor Veera Sekaran and Associate Professor Adrian Loo, whose guidance has brought the CDL MicroForest to life.

Photo courtesy of City Developments Limited

RTMFs are designed as dense, multi-layered ecosystems composed primarily of native tropical species. Typically incorporating as many diverse native species where possible across plant habitats like canopy trees, saplings, shrubs and ground cover, they mimic natural forest succession. Their layered structure also enhances ecological resilience, disease resistance and habitat complexity. With planting densities of 6-8 mixed saplings, ground covers and mature trees per 2 square metres, arranged in naturalistic patterns, RTMFs enable rapid canopy formation within three to five years, significantly faster than conventional tree planting systems.

The Forestscapes methodology developed by Professor Veera Sekaran at NUS underpins the RTMF framework. The methodology emphasises rigorous site assessment, including soil composition, drainage, fertility and microclimate conditions, and actively regenerates degraded urban soils using compost, organic amendments and beneficial microbial inoculation.



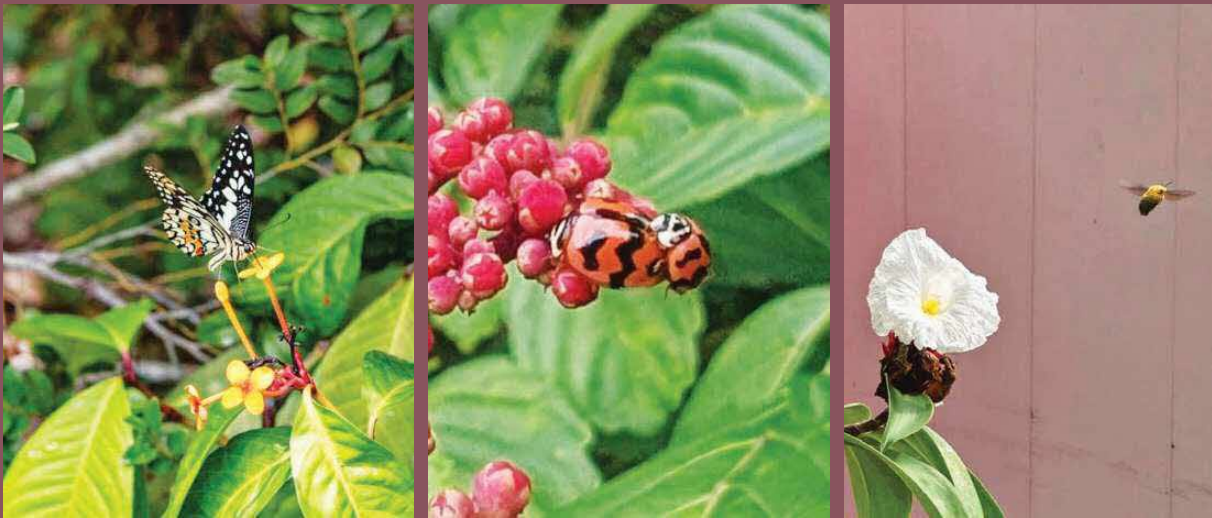
Unveiled on 10 March 2025 by President Tharman Shanmugaratnam, the CDL MicroForest is Singapore's first research-driven regenerative tropical microforest piloted within a retail mall in the high-density city centre.
Photo courtesy of City Developments Limited



Group photo at the MicroForest (from left to right): Associate Professor Jason Lee, Professor Veera Sekaran, Ms Esther An, Mr Lim Tuang Liang, Ms Kong Manjing, Associate Professor Adrian Loo. First-year findings from the CDL MicroForest underscore the growing interest in "cooling through greening" as a viable approach to enhancing urban resilience.
Photo courtesy of City Developments Limited

Mycorrhizal fungi and nitrogen-fixing bacteria improve nutrient cycling and plant resilience, establishing a strong soil microbiome that supports long-term forest health. Additionally, site design considers sun orientation, canopy light penetration and understorey viability to ensure successful stratified growth.

Ecologically, RTMFs accelerate biodiversity recovery by creating layered habitats that support birds, pollinators and small urban fauna. Over time, natural regeneration through wind and animal seed dispersal increases species diversity and strengthens ecosystem adaptability. Maintenance is minimal after establishment, requiring only early-stage watering, mulching and limited weed control, after which the system becomes largely self-sustaining.



Biodiversity spotted at the CDL MicroForest (from left to right): the Lime Butterfly (*Papilio demoleus*), Six-spotted Zigzag Ladybird (*Cheilomenes sexmaculata*) and Yellow-and-black Carpenter Bee (*Xylocopa flavonigrescens*).
Photos courtesy of City Developments Limited

Early monitoring of the CDL MicroForest demonstrates measurable environmental benefits. Studies indicate localised temperature reductions of up to 5°C compared to surrounding urban areas, with adjacent areas also experiencing cooling effects of 1° to 4°C. Environmental DNA analysis shows approximately 70% higher species richness compared to nearby grass areas, alongside increased bird activity, confirming improved urban biodiversity and ecological function.

Beyond environmental outcomes, RTMFs offer high urban and economic value. By reducing heat stress and improving microclimates, they enhance pedestrian comfort, increase dwell time, and strengthen placemaking in retail and mixed-use developments. They also contribute to

climate resilience strategies, support biodiversity targets and align with emerging frameworks such as the Taskforce on Nature-related Financial Disclosures (TNFD). For CDL, the MicroForest strengthens City Square Mall's identity as Singapore's first eco-mall and complements its broader asset enhancement strategy, reinforcing long-term asset value and tenant attractiveness.

Overall, RTMFs represent a scalable and evidence-based model for integrating ecological restoration into dense tropical urban environments. The CDL MicroForest demonstrates that even small urban sites can function as high-impact ecological infrastructure, contributing to climate mitigation, biodiversity recovery and improved human well-being.

Examples of Outcomes Indicators

Spanning across the three key outcomes of liveability, resilience and resource optimisation, the examples of indicators offer the groundwork for an approach towards harnessing co-benefits across urban systems.

Liveability indicators can be categorised into three sub-categories: high quality of life, competitive economy and sustainable environment. Collectively, these indicators give a holistic view of the urban condition.

The list of example indicators links the three sub-categories with patterns of compact urban environments and highlights the importance of integrated, multi-functional developments in enabling liveability. This includes ensuring a diversity of businesses in individual districts and providing quality transport options. These example indicators were also selected to capture the interdependencies of liveability and ecosystem health, like quantifying the physical and mental health benefits that people gain from proximity to green spaces.

CASE STUDY

THE SUPERBLOCK PROGRAMME IN BARCELONA, SPAIN



The improved walkability of the superblocks has revitalised neighbourhoods and imbued them with new life.

Photo courtesy of Cataleirxs (CC BY-SA 4.0 / Wikimedia Commons)

Barcelona piloted its Superblock programme in the neighbourhood of Poblenou in 2016. For Poblenou, the Superblock programme resulted in positive social, economic and environmental outcomes. The reconfigured streets not only diversified mobility options and improved walkability, but have also increased commercial activity by more than 30%.⁶⁴ Beyond the neighbourhood, the Superblock programme also catalysed the transformation of an adjacent road, where one of the city’s busiest and most dangerous traffic intersections used to be. Known as Glòries Park, the reclaimed space now offers 30,000 m² of green space and includes biodiversity nodes, dense native vegetation and family play areas.⁶⁵

EXAMPLES OF LIVEABILITY INDICATORS

Subcategory	Indicator	Metric
High Quality of Life	Life Expectancy	Average life expectancy for inhabitants <i>From the indicators for life expectancy and healthy life expectancy by the World Health Organization (2021)</i>
	Resident Retention	Duration of residence in the neighbourhood district <i>From the Inclusive Healthy Places Framework by the Gehl Institute (2018)</i>
	Resident Satisfaction	Mean score from standardised resident satisfaction survey <i>From the Inclusive Healthy Places Framework by the Gehl Institute (2018)</i>
	Modal Share	Ratio of residents who take public transport, walk or bike to work <i>From “Urban form and livability: socioeconomic and built environment indicators” by Martino, N. et al. (2021)</i>
Sustainable Environment	Air Quality	Annual average air quality index <i>From the Global Air Quality Guidelines by the World Health Organization (2021)</i>
	Surface Water Quality	Proportion of wastewater generated on-site that is treated before release <i>From the Urban Environment and Social Inclusion Index by the Data-driven EnviroLab (2024)</i>
	Safe Drinking Water	Average life years lost due to waterborne diseases from exposure to unsafe drinking water <i>From the Environmental Performance Index by the Yale Center for Environmental Law & Policy (2024)</i>
	Ambient Noise	Proportion of residential area exceeding long-term, unhealthy noise level threshold <i>From an assessment of Environmental Noise in Europe by the European Environment Agency (2020)</i>
	Green Amenity Access	Proportion of population living within a 400-m walking distance of a park or green space <i>From the Singapore Index on Cities’ Biodiversity by Chan, L. et al. (2021), and A Green & Liveable City: Singapore Urban Design Guidebook by the Urban Redevelopment Authority (2015)</i>
Competitive Economy	Income Equity	Distribution of household income within the district <i>From the Urban Indicators Guidelines by the UN-Habitat (2024)</i>
	Employment Rate	Proportion of working-age population within the district who are employed <i>From the Principles on Urban Policy Implementation Toolkit by the Organisation for Economic Co-operation and Development (OECD) (2024), and the Inclusive Healthy Places Framework by the Gehl Institute (2018)</i>
	Local Business	Diversity of business establishment types per district <i>From “Urban form and livability: socioeconomic and built environment indicators” by Martino, N. et al. (2021)</i>
	Ground Floor Activation	Proportion of ground floor frontage in active use <i>From the Inclusive Healthy Places Framework by the Gehl Institute (2018)</i>

➡ For full elaboration, refer to liveability indicators in the Annex on page 200.

Resilience indicators can be broadly grouped into three sub-categories: climate, environmental and social resilience. These indicators aim to give decision-makers a better sense of the city’s ability to recover and adapt from shocks and stressors.

Indicators for climate resilience measure the effectiveness of climate change mitigation and adaptation efforts, and reflect the adaptive capacity of the city in the face of

climate impacts. Environmental resilience can be assessed by the health of ecosystems; its indicators reflect the cumulative quantity, diversity and quality of non-human life within the urban area and its hinterland. Lastly, social resilience can be assessed through a community-centric lens. Commonly represented by the social cohesion index and civic participation rate, these measurements can provide an indication of people’s capacity to deal with potential disruptions.

CASE STUDY

KRANJI COASTAL NATURE PARK IN SINGAPORE

by National Parks Board



Before



After

A low rock revetment at Kranji Coastal Nature Park installed in 2019 slows wave energy and allows sediments to settle, facilitating the natural regeneration of mangroves and coastal vegetation. By 2025, mangroves have naturally recruited without planting, while a coastal vegetation belt had regenerated landward of the revetment.

Photos courtesy of National Parks Board

Kranji Coastal Nature Park is a buffer park abutting the Sungei Buloh Wetland Reserve, where natural regeneration of mangroves was employed for coastal resilience.

As part of coastal protection efforts, a 400-m-long low rock barrier was implemented to slow down wave energy for sediments to settle and mangroves to recruit naturally along the coast. Landward of the barrier, a 4,900-m² coastal vegetation belt was established through a specially curated planting palette to mirror the natural transition from inland forest to coastal and mangrove ones. Over 70 species of plant were selected and planted on site with 1,600 community participants.

The site now buffers against rising sea levels and storm surges, mitigates erosion and expands habitat connectivity within the Sungei Buloh Nature Park Network, demonstrating how nature-based solutions can provide multiple co-benefits in a regenerative city.

EXAMPLES OF RESILIENCE INDICATORS

Subcategory	Indicator	Metric
Climate Resilience	Urban Heat Reduction	Change in mean land surface temperature <i>From “Landscape configuration and urban heat island effects: Assessing the relationship between landscape characteristics and land surface temperature in Phoenix, Arizona” by Connors, J.P., Galletti, C.S. & Chow, W.T.L. (2013)</i>
	Flood Risk Exposure	Proportion of area in the district at risk of flooding in 100 years <i>From Chapter 15 of Climate Change: Impacts, Adaptation and Vulnerability under IPCC AR6 (2022)</i>
	Runoff Volume Control	Proportion of rainfall retained and reused on-site <i>From “Evaluating Sponge City volume capture ratio at the catchment scale using SWMM” by Randall, M. et al. (2019)</i>
	Water Stress	Ratio of freshwater reserves to population size <i>From “Macro-scale water scarcity requires micro-scale approaches” by Falkenmark, M., Lundqvist, J., & Widstrand, C. (1989)</i>
Environmental Resilience	Urban Greenness	Area of healthy vegetation cover using the normalised difference vegetation index <i>From the “Development of a global urban greenness indicator dataset for 1,000+ cities” by Stowell, J.D., et al. (2023)</i>
	Plant Species Richness	Number of native plant species per survey area <i>From the Singapore Index on Cities’ Biodiversity by Chan, L., et al. (2021)</i>
	Bird Species Richness	Number of native bird species per survey period <i>From the Singapore Index on Cities’ Biodiversity by Chan, L. et al. (2021)</i>
	Soil Health	Amount of soil lost through water erosion per year <i>From “How the EU Soil Observatory is providing solid science for healthy soils” by Pangoes, P., et al. (2024)</i>
	Habitat Restoration	Proportion of area of restored habitat measured against area of degraded habitat <i>From the Singapore Index on Cities’ Biodiversity by Chan, L. et al. (2021)</i>
Social Resilience	Civic Participation	Number of urban community resident associations <i>From the “Critical review of urban community resilience indicators” by Osei-Kyei, R., et al. (2023)</i>
	Social Cohesion	Extent of the local community’s interpersonal trust and institutional trust <i>From the Guidelines on Measuring Trust by the OECD (2017)</i>
	Local Environmental Stewardship	Extent of the local community’s involvement in the stewardship of the environment <i>From “LESI: A quantitative indicator to measure local environmental stewardship” by Turnbull, J.W., Johnston, E.L., & Clark, G.F. (2020)</i>

📌 For full elaboration, refer to resilience indicators in the Annex on page 203.

Resource optimisation indicators can be divided into various groups: land, water, carbon, material and food. Altogether, these indicators measure the extent to which the city is consuming and extracting resources even as it moves towards circularity.

Land indicators favour integrated developments with co-located amenities. Food, water and material

indicators—largely characterised as resources that continuously flow throughout the city—draw upon the concept of urban metabolism to provide a scientific basis for the measurement and analysis of urban resource use. Meanwhile, carbon indicators are premised on scientific consensus on carbon accounting methodologies.

CASE STUDY

THE KALUNDBORG SYMBIOSIS IN KALUNDBORG, DENMARK

Developed in 1972, the Kalundborg Symbiosis is the world’s first industrial symbiosis, involving 17 public and private partners. The network connects resource and waste streams, creating a circular ecosystem that synergistically leverages residual and surplus by-products across organisations. The co-benefits are multiple. The Kalundborg Symbiosis optimises resources and generates economic growth. It saves 4 million m³ of groundwater and 62,000 tonnes of residual materials annually, and employs approximately 6,500 people—all while driving the industrial transition towards net zero.⁶⁶



The Asnæs Power Plant forms a key part of the Kalundborg Symbiosis. By-products and waste from the power plant are used by other manufacturers in their own production lines. Photos courtesy of (top) Johan Wessman / News Øresund (CC BY-SA 2.0 / Wikimedia Commons) and (bottom) Bob Collowan (CC BY-SA 3.0 / Wikimedia Commons)

EXAMPLES OF RESOURCE OPTIMISATION INDICATORS

Subcategory	Indicator	Metric
Carbon	Greenhouse Gas Emissions Intensity	Total amount of CO ₂ e per resident per year <i>From the Global Protocol for Community Scale GHG Emission Inventories (GPC) by the World Resources Institute, C40 Cities and ICLEI (2021)</i>
	Stationary Combustion	Amount of CO ₂ e from stationary fuel combustion within the district boundary per year <i>From the Global Protocol for Community Scale GHG Emission Inventories (GPC) by the World Resources Institute, C40 Cities and ICLEI (2021)</i>
	Transport	Amount of CO ₂ e from transportation within the district boundary per year <i>From the Global Protocol for Community Scale GHG Emission Inventories (GPC) by the World Resources Institute, C40 Cities and ICLEI (2021)</i>
	Agriculture, Forestry and Other Land Use Changes	Amount of CO ₂ e from agriculture, forestry and other land use change within the district boundary per year <i>From the Global Protocol for Community Scale GHG Emission Inventories (GPC) by the World Resources Institute, C40 Cities and ICLEI (2021)</i>
	Industrial Processes	Amount of CO ₂ e from industrial processes and product use within the district boundary per year <i>From the Global Protocol for Community Scale GHG Emission Inventories (GPC) by the World Resources Institute, C40 Cities and ICLEI (2021)</i>
	Waste and Wastewater Emissions	Amount of CO ₂ e from waste and wastewater treatment within the district boundary per year <i>From the Global Protocol for Community Scale GHG Emission Inventories (GPC) by the World Resources Institute, C40 Cities and ICLEI (2021)</i>
	Grid-supplied Energy	Amount of CO ₂ e from purchased grid electricity and heat per year <i>From the Global Protocol for Community Scale GHG Emission Inventories (GPC) by the World Resources Institute, C40 Cities and ICLEI (2021)</i>
Land	Land Use Compactness	Spatial autocorrelation index of built-up density <i>From “Measuring urban sprawl” by Frenkel, A. & Ashkenazi, M. (2008)</i>
Water	Water Consumption Intensity	Daily average of potable water consumption per resident <i>From “Assessing water circularity in cities: methodological framework with a case study” by Arora, M., et al. (2022)</i>
Materials	Waste Recycling	Proportion of total municipal solid waste diverted from landfills through recycling or reuse per year <i>From the “CityLoops urban circularity assessment method” by Bellstedt, C. et al. (2022)</i>
	Building Reuse Rate	Proportion of construction permits for renovation or adaptive reuse per year <i>From Regenerative by Design: Creating Living Buildings and Cities by Cheshire, D. (2024)</i>
Food	Local Food Production	Proportion of total consumed food sourced from within the city or peri-urban region <i>From the Singapore Index on Cities’ Biodiversity by Chan, L. et al. (2021)</i>

➦ For full elaboration, refer to resource optimisation indicators in the Annex on page 206.

Examples of Capacity Indicators

In a regenerative city, density, diversity and connectivity indicators measure the capacity of the built and natural environments to support regenerative processes. The list includes examples of indicators that are specific to the urban built and natural environments, and reflective of cross-system integration.

Density indicators assess how well the city utilises its land. They look at how the city is able to extract the benefits of urban density, such as supporting efficient information exchange, increasing economic productivity

and improving social cohesion. They also reflect a city’s stewardship of land to support human and natural ecosystems.

Multiple density indicators have been selected based on their ability to assess individual and combined aspects of the built and natural environments. There are also density indicators that reflect cross-system integration across the two to show how the city is operating as an integrated urban environment. These include measuring shared green spaces, as well as green plot ratios.

CASE STUDY

SKYVILLE @ DAWSON IN SINGAPORE

When planned thoughtfully, densification can generate a range of co-benefits for the entire urban ecosystem. SkyVille @ Dawson, a 47-storey public housing complex in Singapore, showcases how density can enable liveability through the thoughtful integration of nature into housing. Adopting the use of skyrise greenery, the complex incorporates 3 community terraces, each placed at 11-storey intervals, and a sky garden. In a dense environment, these areas are designed to provide community spaces for residents and while accommodating skyrise greenery.

(Top left) SkyVille @ Dawson is designed with (top right) stacked sky gardens connecting the three residential blocks of the complex and (bottom) a commercial plaza that also serves the neighbouring communities.

Photos courtesy of (top left and right) Patrick Bingham-Hall and (bottom) Albert Lim K.S.



EXAMPLES OF DENSITY INDICATORS

Subcategory	Indicator	Metric	Mapping to Outcomes
Built Environment	Gross Plot Ratio	Total gross floor area per site area <i>From “Urban form and livability: socioeconomic and built environment indicators” by Martino, N. et al. (2021)</i>	Liveability Resource Optimisation
	Population Density	Total resident population per site area <i>From Denser and greener cities: Green interventions to achieve both urban density and nature” by McDonald, R.I. et al. (2023)</i>	Liveability Resource Optimisation
	Impervious Surface Coverage	Proportion of the site area covered by impervious surfaces <i>From “Denser and greener cities: Green interventions to achieve both urban density and nature” by McDonald, R.I. et al. (2023), the Singapore Index on Cities’ Biodiversity by Chan, L. et al. (2021), and Urban Flood Risk Mitigation, InVEST User Guide by Stanford University</i>	Liveability Resilience Resource Optimisation
	Skyview Factor	Proportion of the visible sky area from a specific point on the ground to the total sky area <i>From the “Review of methods used to estimate the sky view factor in urban street canyons” by Miao, C. et al. (2020)</i>	Liveability Resilience
	Frontal Area Density	Proportion of a building’s windward façade area to the total site area <i>From the “Aerodynamic properties of urban areas derived from analysis of surface form” by Grimmond, C.S.B. & Oke, T.R. (1999)</i>	Liveability Resilience Resource Optimisation
Natural Environment	Natural Areas in the City	Proportion of the total natural, restored and naturalised areas in the city <i>From the Singapore Index on Cities’ Biodiversity by Chan, L. et al. (2021), and the Kunming-Montreal Global Biodiversity Framework (GBF), “2030 Targets (with Guidance Notes)” by the Convention on Biological Diversity</i>	Liveability Resilience
	Protected Natural Area in the City	Proportion of protected or secured natural areas in the city <i>From the Singapore Index on Cities’ Biodiversity by Chan, L. et al., (2021), the Kunming-Montreal Global Biodiversity Framework (GBF), “2030 Targets (with Guidance Notes)” by the Convention on Biological Diversity, and “Biodiversity needs both land sharing and land sparing” by Selinske, M. et al., (2023)</i>	Liveability Resilience
	Tree Coverage	Proportion of the district area covered by tree canopy <i>From “Denser and greener cities: Green interventions to achieve both urban density and nature” by McDonald, R.I. et al. (2023)</i>	Liveability Resilience
Cross System Integration	Shared Green Space Ratio	Proportion of the site area for shared use (parks, gardens, green roofs, etc.) <i>From Dense + Green Cities by Schröpfer, T. (2019), and Designing for Biodiversity: The Value of Nature Centric Design by WOHA & bioSEA (2024)</i>	Liveability Resilience Resource Optimisation
	Green Plot Ratio	Average leaf area index (total leaf area) per unit area <i>From “Green plot ratio: an ecological measure for architecture and urban planning” by Ong, B.L. (2003)</i>	Liveability Resilience Resource Optimisation

➡ For full elaboration, refer to density indicators in the Annex on page 208.

Diversity indicators measure the variety and distribution of activities and species found in the district. Diversity brings many co-benefits to the regenerative city—enabling interspecies interaction like pollination and nutrient cycling for nature, and improving social, economic and ecological resilience by reducing reliance on a single system.

This list of example diversity indicators for the built environment includes assessing land use types, mix of housing typologies and range of ground floor uses. These are complemented by assessing the diversity of the natural environment through indicators such as habitat biodiversity and tree species diversity. Cross-system integration can be tracked through indicators that count the number of distinct landscape elements.

EXAMPLES OF DIVERSITY INDICATORS

Subcategory	Indicator	Metric	Mapping to Outcomes
Built Environment	Land Use Diversity	Count and distribution of land use types within the site boundary <i>From “Urban form and livability: socioeconomic and built environment indicators” by Martino, N. et al. (2021)</i>	Liveability Resilience
	Housing Typology Mix	Count and distribution of dwelling unit types within the district <i>From “Urban form and livability: socioeconomic and built environment indicators” by Martino, N. et al. (2021)</i>	Liveability Resilience
	Ground Floor Use Mix	Count of distinct ground floor use categories per 100 m of street frontage <i>From the Inclusive Healthy Places Framework by the Gehl Institute (2018)</i>	Liveability Resilience
Natural Environment	Habitat Biodiversity Value	Biodiversity value scored based on the habitat size, condition, conservation priority and strategic significance <i>From the Global Biodiversity Metric (GBM) by Ramboll (2024)</i>	Liveability Resilience
	Tree Species Diversity	Count and distribution of tree species within the site boundary <i>From the Singapore Index on Cities’ Biodiversity by Chan, L. et al. (2021)</i>	Liveability Resilience
Cross System Integration	Landscape Element Diversity	Count of distinct landscape elements (planter, green wall, pond, etc.) per unit area <i>From Designing for Biodiversity: The Value of Nature Centric Design by WOHA & bioSEA (2024)</i>	Liveability

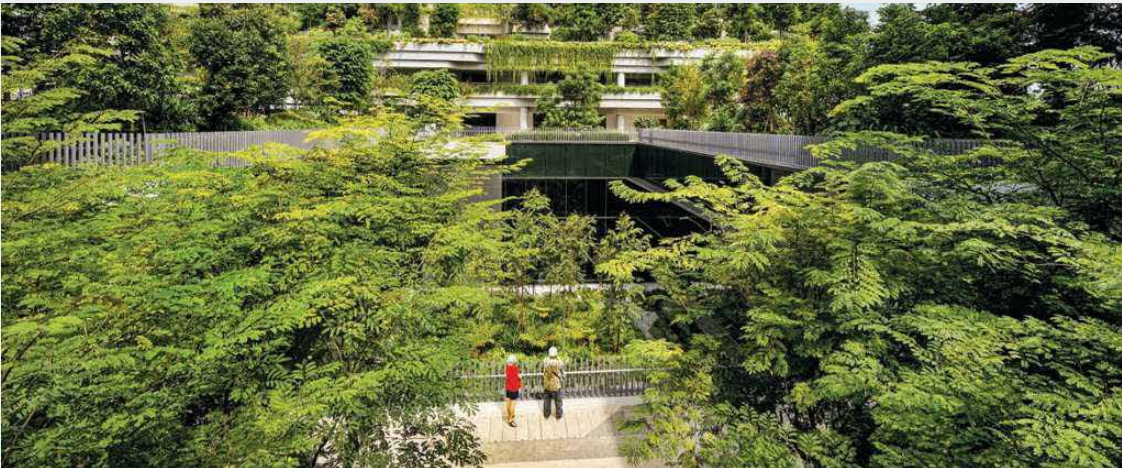
➔ For full elaboration, refer to diversity indicators in the Annex on page 210.

CASE STUDY

KAMPUNG ADMIRALTY IN SINGAPORE

The co-benefits of diversity are evident at Kampung Admiralty, a mixed-use development that brings together multiple users and supports rich biodiversity.⁶⁷ It co-locates multiple public amenities and services for the old and young, such as senior living apartments and active ageing hubs, a childcare centre, and dining and retail outlets. This enables intergenerational

engagements and cross-programming which can contribute to social resilience. Its terraced building form incorporates over 100 different plant species, with the intention to replicate a small, dense tropical rainforest. In a series of biodiversity surveys conducted in 2024, 218 unique species of fauna were recorded at the site.



Visible from its façade, Kampung Admiralty has a terraced layout that supports biodiversity. Photos courtesy of (top) Patrick Bingham-Hall and (bottom) Housing and Development Board

Connectivity indicators measure the accessibility of resources for people and animals and contiguity of habitats for flora and fauna. The regenerative city is achieved through productive proximities and connected corridors—mobility networks enable the urban economy to function and people to move seamlessly within the city, while ecological corridors provide vital links for biodiversity and bring people to nature.

Examples of connectivity indicators for the built environment include access to public transport, and availability of key social services and green spaces. The corresponding indicators for the natural environment include fragmentation of landscapes and prevalence of ecological corridors. An example of an indicator that measures cross-system integration is the proportion of active mobility networks that are co-located with green corridors.

CASE STUDY

ONE BANGKOK URBAN PARK IN BANGKOK, THAILAND



A regenerative city accounts for varying degrees of mobility, and integrates nature into the urban environment to connect both humans and nature. The One Bangkok Urban Park in central Bangkok connects the One Bangkok mixed-used district to the nearby Lumpini and Benjakitti parks. The 80,000-m² urban park also functions as an ecological bridge that connects the urban built environment with the urban natural environment. Such connectivity allows the One Bangkok district to leverage local ecosystem services that the neighbouring parks afford, such as alleviating urban heat, filtering polluted water and managing stormwater.⁶⁸



(Top) The One Bangkok Urban Park is connected to (bottom) Benjakitti Park. Photos courtesy of Andy Tan

EXAMPLES OF CONNECTIVITY INDICATORS

Subcategory	Indicator	Metric	Mapping of Outcomes
Built Environment	Key Services Access	Average network distance to schools, clinics and retail centres <i>From “Urban form and livability: socioeconomic and built environment indicators” by Martino, N. et al. (2021), and Building Liveable and Sustainable Cities: A Framework for the Future by the Centre for Liveable Cities (2025)</i>	Liveability Resource Optimisation
	Walkability	Composite of intersection density, average block length, and land-use mix within a 400-m buffer <i>From “The development of a walkability index: application to the neighborhood quality of life study” by Frank, L.D. et al. (2009)</i>	Liveability
	Train Network Access	Network distance to the nearest train station <i>From “Urban form and livability: socioeconomic and built environment indicators” by Martino, N. et al. (2021), and Building Liveable and Sustainable Cities: A Framework for the Future by the Centre for Liveable Cities (2025)</i>	Liveability Resource Optimisation
	Bus Network Access	Network distance to the nearest bus stop <i>From “Urban form and livability: socioeconomic and built environment indicators” by Martino, N. et al. (2021), and Building Liveable and Sustainable Cities: A Framework for the Future by the Centre for Liveable Cities (2025)</i>	Liveability Resource Optimisation
	Cycling Infrastructure Access	Network distance to the nearest dedicated cycling path <i>From “Urban form and livability: socioeconomic and built environment indicators” by Martino, N. et al. (2021), and Building Liveable and Sustainable Cities: A Framework for the Future by the Centre for Liveable Cities (2025)</i>	Liveability Resource Optimisation
Natural Environment	Ecosystem Connectivity	Spatial network analysis of the nearest landscape patch <i>From “Ecological connectivity in fragmented agricultural landscapes and the importance of scattered trees and small patches” by Tiang, D.C.F. et al. (2021)</i>	Liveability Resilience
	Effective Mesh Size	Area-weighted mean of unfragmented landscape patch sizes <i>From the Singapore Index on Cities’ Biodiversity by Chan, L. et al. (2021), and “Implementing the connectivity of natural areas in cities as an indicator in the City Biodiversity Index (CBI)” by Deslauriers, M.R. et al. (2018)</i>	Liveability Resilience
	Access to Nature	Network distance from residential parcels to the nearest park or nature area <i>From the Singapore Index on Cities’ Biodiversity by Chan, L. et al. (2021), and A Green & Liveable City: Singapore Urban Design Guidebook by the Urban Redevelopment Authority (2015)</i>	Liveability Resource Optimisation
	Ecological Corridor Length	Total length of dedicated ecological corridors <i>From Land Mosaics: The ecology of landscapes and regions by Forman, R.T.T. (1995)</i>	Liveability Resilience
Cross System Integration	Green Mobility Co-location	Proportion of active mobility networks (walking/cycling) that are co-located with a green corridor or park connector <i>From “A greenway network for Singapore” by Tan, K.W. (2006)</i>	Liveability Resource Optimisation

For full elaboration, refer to connectivity indicators in the Annex on page 212.



FROM GARDEN CITY TO CITY IN NATURE: HOW SINGAPORE'S GREEN-BLUE NETWORKS EMBODY REGENERATIVE URBAN LIVING

HWANG YU-NING

Chief Executive Officer, National Parks Board, Singapore

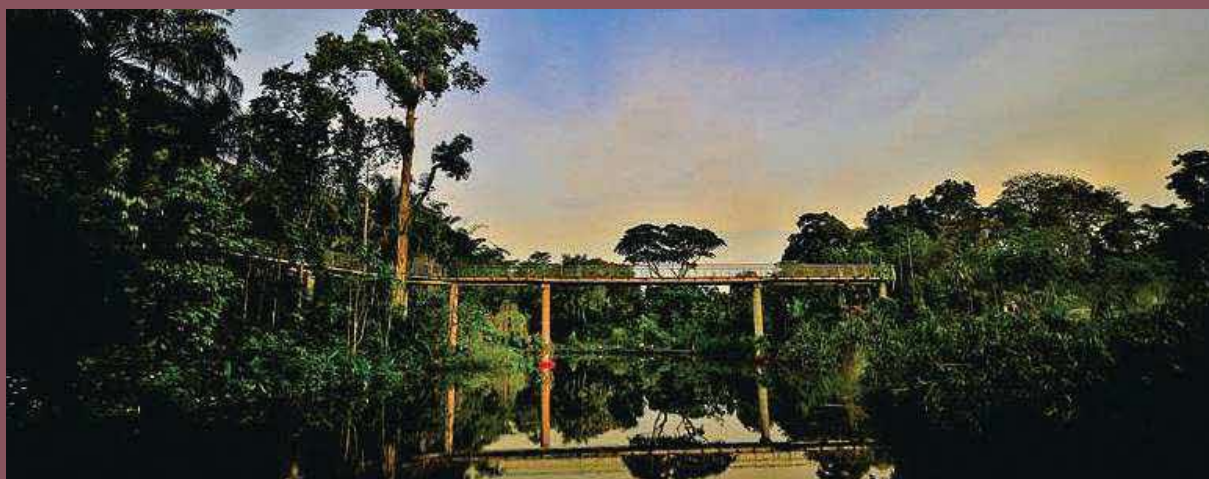
With CHARLENE NG

Director, Science & Tech planning, National Parks Board, Singapore

Singapore's transformation from a nation that had lost 95% of its original forest cover by 1930 to the thriving City in Nature that it is today exemplifies the four key paradigm shifts of the regenerative approach: from avoiding bad to doing good, from trade-offs to co-benefits, from human-centric thinking to fostering human-nature relationships, and from end-of-life to closed-loop planning. Our journey demonstrates that even the most urbanised environments can become net positive for both human communities and natural ecosystems.

Regenerative Principles in Practice

The Nature Conservation Masterplan¹ and City in Nature² strategies embody regenerative city principles of systemic thinking, dynamism and ethical stewardship. Rather than viewing green spaces as isolated amenities, we approach our island holistically as an interconnected ecosystem where nature-based solutions create multiple co-benefits across urban systems.



A lowland rainforest and freshwater wetland restoration project on a 10-hectare site led to the delivery of multiple regenerative outcomes—the delivery of clean water to the Swan Lake, refuge for threatened freshwater flora and fauna, as well as an educational site for visitors to enjoy.

Photo courtesy of National Parks Board



(Left) At Pulau Ubin, the restoration of an abandoned prawning pond through assisted natural regeneration has demonstrated that (right) mangroves can recover rapidly when tidal processes are allowed to resume.

Photos courtesy of National Parks Board

Density: Maximising Regenerative Capacity

Within our extreme land constraints, Singapore demonstrates how concentrated restoration interventions can yield disproportionate benefits. Our four nature reserves and expanding nature park networks exemplify the use of nature-based solutions in the city.

The Framework Species Method, where 20 to 40 native plant species are selected to rapidly accelerate biodiversity recovery, has been used to support the creation of integrated, multifunctional developments that serve both ecological and human needs.

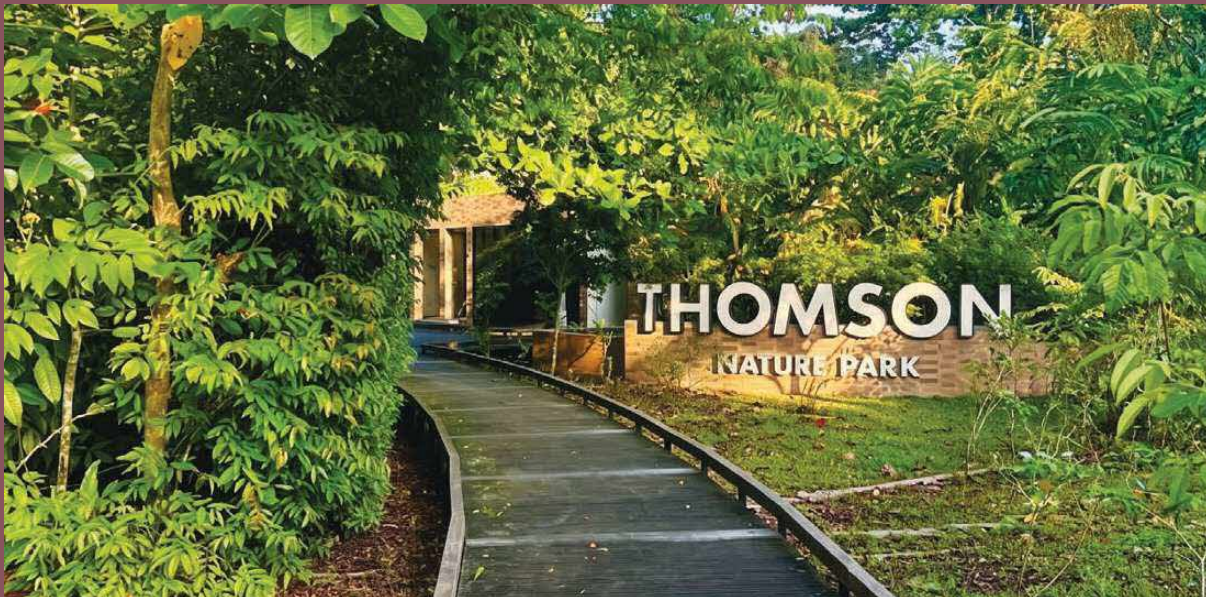
The Singapore Botanic Gardens Learning Forest's freshwater wetland restoration showcases this approach well. This single site has created multiple regenerative outcomes: restoring hydrological processes and delivering clean water to the Swan Lake, regenerating lowland rainforest, creating refuge for threatened freshwater flora and fauna, and providing educational and recreational opportunities for visitors to enjoy. By 2026, over 300 hectares of such naturalised gardens and parks will demonstrate how strategic density can optimise co-benefits across liveability, resilience and resource domains.

Diversity: Ecosystem Richness as a Climate Foundation

Singapore's habitat diversity—from lowland dipterocarp forests to mangroves, and from freshwater swamps to coral reefs—forms the foundation for ecological, climate and social resilience.

Our restoration methods demonstrate regenerative dynamism, ranging from assisted natural regeneration like the successful Pulau Ubin mangrove recovery to active maximum diversity approaches for isolated urban sites.³

We prioritise keystone species like native figs (*Ficus* spp.), which create circular, closed-loop ecological systems that support diverse fauna year-round. Crucially, we restore all successional stages of the ecosystem rather than focusing solely on climax ecosystems.⁴ This approach builds regenerative capacity for unknown climate futures. It recognises that ecological resilience requires complete ecosystem representation, not merely individual species conservation.



Thomson Nature Park.
Photo courtesy of National Parks Board

Connectivity: Living Networks Through Systemic Thinking

Our ecological corridor network, which links Singapore’s nature reserves to heartland parks, embodies regenerative infrastructure that operates across multiple scales. Projects like Thomson Nature Park incorporate connectivity planning for species like the critically endangered Raffles’ Banded Langur, demonstrating ethical stewardship where both humans and nature act as co-creators.

The vision of every road as a nature way creates integrated developments serving both human mobility and wildlife movement.⁵ Taking such a systemic approach, guided by adaptive management principles, enables continuous learning through experimentation and reflection on how urban development affects nature.

Measuring Regenerative Outcomes

Singapore pioneered systematic measurement of urban regenerative capacity through the Singapore Index on Cities’ Biodiversity (SI), developed in 2008 with the Convention on Biological Diversity Secretariat. This 28-indicator framework measures native biodiversity, ecosystem services and governance—aligning with regenerative principles of tracking co-benefits for people and nature. 📍 *To find out more about the SI, refer to page 156 of Chapter 3.*

Our long-term socio-ecological research programmes, including long-term forest ecology monitoring, provide measurement systems that track regenerative outcomes across decades. This enables true adaptive management, validating strategies through evidence-based assessment. Sites like Bishan-Ang Mo Kio Park, Kranji Marshes and Kent Ridge Park demonstrate measurable regenerative outcomes: microclimate regulation, water management, pollution reduction, biodiversity enhancement and cultural services.

Community as a Regenerative Enabler

Regenerative cities depend on collective agency and whole-of-society involvement. Community participation in our Forest Restoration Action Plan and One Million Trees Movement embodies stakeholder partnerships that create collective shifts in values and trust. From the Raffles’ Banded Langur Working Group to volunteers supporting invasive species clearance, early stakeholder engagement demonstrates regenerative reciprocity—recognising that long-term ecosystem health requires active community stewardship.

Science as a Regenerative Foundation

Our restoration efforts integrate ecology, conservation biology, hydrology, engineering and social sciences, embodying holistic planning approaches. Collaboration with institutions like the Singapore University of Technology and Design has demonstrated how smart systems and modelling support future-proofing and adaptability. Tools like the “5-star system” and “recovery wheel” enable data-driven design and holistic tracking of co-benefits, while long-term monitoring infrastructure enables the regenerative principle of long-termism.



(Left) The critically endangered Raffles’ Banded Langur, one of only three non-human primate species native to Singapore, finds refuge in Thomson Nature Park. Rope bridges across Old Upper Thomson Road allow these langurs to move safely between the nature park and Central Catchment Nature Reserve. (Right) Thomson Nature Park also served as the site of a Hainanese Village in the 1930s to 1980s. Parts of the old road network and remnants of homes have been preserved in the park as well.

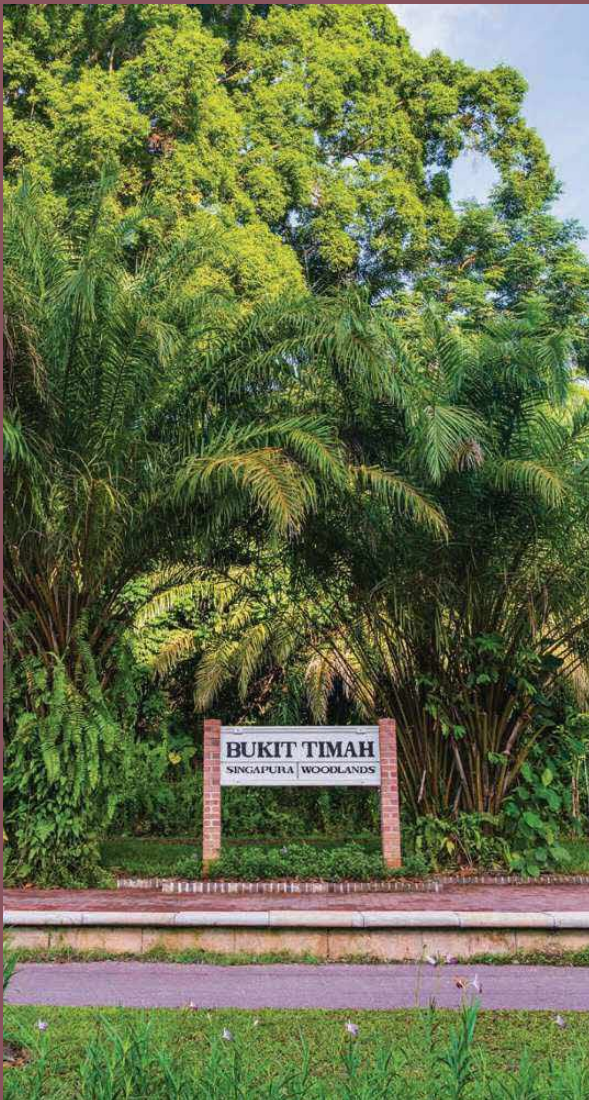
Photos courtesy of National Parks Board

A Possible Model for Regenerative Development

Singapore’s systematic approach to habitat restoration provides a replicable model for high-density cities pursuing regenerative development. Our contribution to the United Nations Decade on Ecosystem Restoration 2021–2030, and to platforms like the World Cities Summit, position Singapore as a living lab for regenerative approaches.

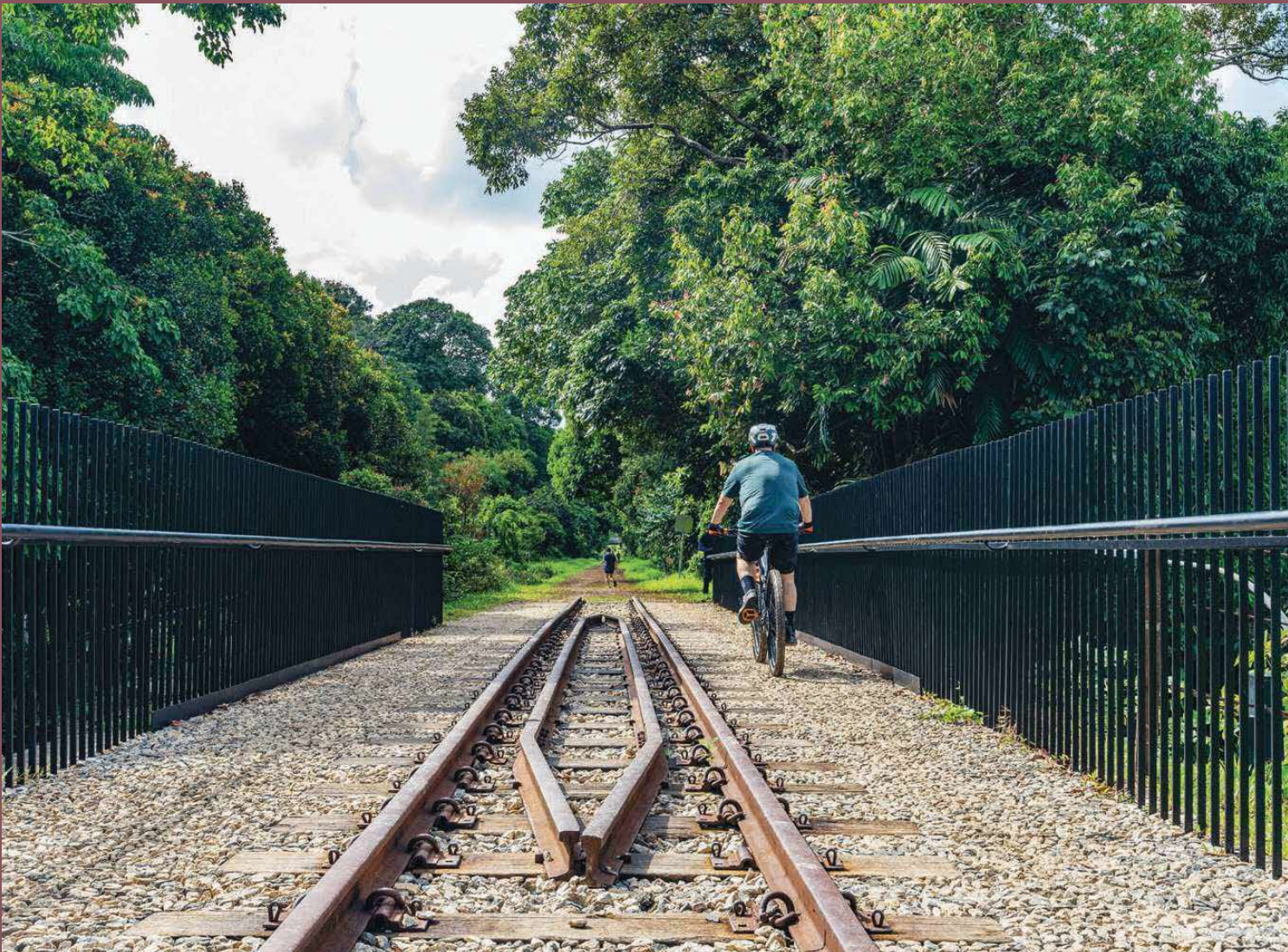
We have shifted from restoring to former ecological states to building climate-resilient ecosystems that leverage interdependencies, flows and loops to adapt to evolving challenges. This paradigm shift recognises that regenerative cities are complex, dynamic systems capable of thriving in climate-changed and resource-constrained futures.

Singapore’s City in Nature vision proves that urban development can be optimised for co-benefits, to create more good for both people and the environment. Through systematic habitat restoration, pioneering assessment tools and long-term research validation, we have created living infrastructure that enables true regenerative urban development—providing a scientifically-grounded model for cities worldwide seeking to become net positive forces for both human communities and natural ecosystems.



Once a working railway line connecting Singapore to Malaysia, the 24-km Rail Corridor has been rewilded into a living ecological thread through the heart of Singapore. Stretching from Woodlands in the north to Tanjong Pagar in the south, its rewilded stretches link green spaces across the island.

Photo courtesy of National Parks Board



The Rail Corridor has also become one of Singapore’s most cherished green passages: a place where joggers, cyclists and families share the trail with native wildlife.

Photo courtesy of National Parks Board

ENDNOTES

- ¹ National Parks Board, *Nature Conservation Masterplan* (Singapore: National Parks Board, 2015), <https://www.nparks.gov.sg/docs/default-source/resources/2015/nature-conservation-masterplan.pdf>.
- ² National Parks Board, “City in Nature: key strategies”, last updated 11 February 2025, <https://www.nparks.gov.sg/who-we-are/city-in-nature-key-strategies>.
- ³ Robert Teo, “Chapter 20: Mangrove Restoration in Pulau Ubin”, in *Handbook on Habitat Restoration: General Principles and Case Studies in Singapore*, ed. Lena Chan, Daniel Ng and Lim Liang Jim (Singapore: National Parks Board, 2023), 249–253.
- ⁴ Successional stages refer to the sequential phases through which an ecosystem develops over time, from bare or disturbed ground through the establishment of progressively more complex plant communities. In contrast, a climax ecosystem refers to the stable, self-sustaining community that represents the endpoint of ecological succession; for example, a primary tropical rainforest.
- ⁵ Lee Jia Hwa, Jason Yong Wai Weng and Oh Cheow Sheng, “Chapter 7: Nature Ways—Habitat Enhancement in Streetscape for Biodiversity”, in *Handbook on Habitat Restoration: General Principles and Case Studies in Singapore* (Singapore: National Parks Board, 2023), 76–89.



DENSITY, DIVERSITY, CONNECTIVITY: PLANNING SINGAPORE AS A REGENERATIVE CITY

LIM ENG HWEЕ

Chief Executive Officer, Urban Redevelopment Authority, Singapore

When Singapore's pioneering urban planner Dr Liu Thai Ker passed on recently, many of us paused to reflect on his enduring wisdom. He often said that to build a city, one must have the heart of a humanist, the mind of a scientist and the eye of an artist.

Cities are living organisms that outlast their planners. Our responsibility is to design systems that continue working decades after we are gone—especially in a future when populations age, economies restructure and climate conditions shift unpredictably.

In Singapore, the principles of regenerative urbanism have long guided our planning practice. Over decades, we have consciously applied the concepts of density, diversity and connectivity to plan and shape how our city functions socially, economically and ecologically.

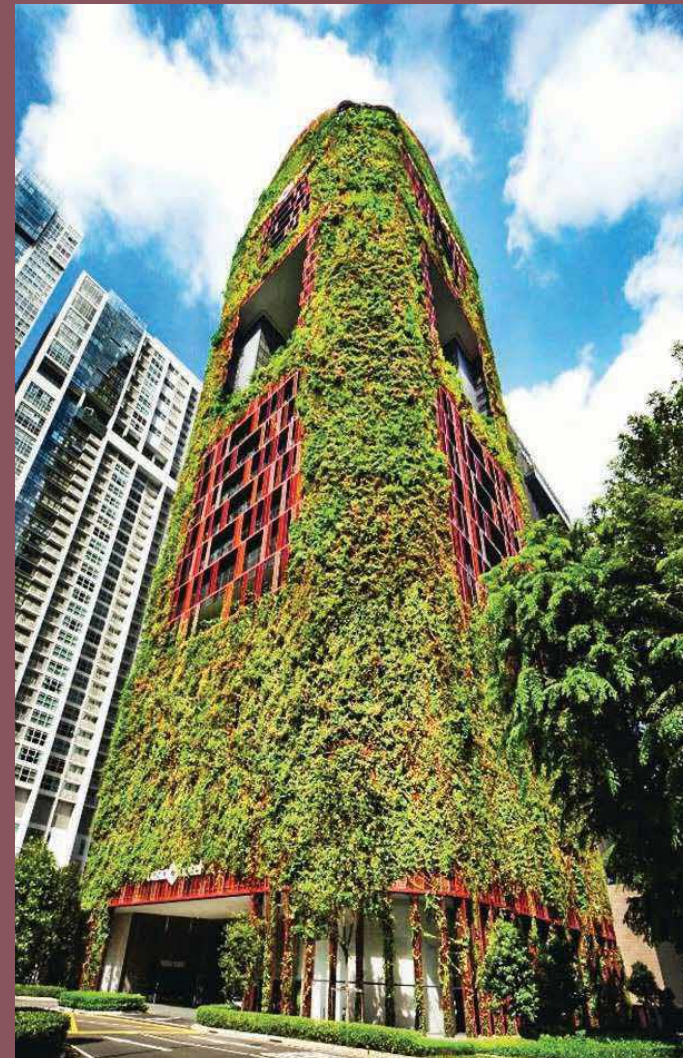
Density: Intensification Without Compromising Liveability

Density is often (wrongly) associated with dystopian skyscrapers and congested living environments. But when it is thoughtfully applied by planners, density means co-location

and convenience, bringing homes, jobs, services and amenities closer together so that more people can benefit from them efficiently. In Singapore, intensification through progressive redevelopment allows our limited land to support a growing population, more jobs and better amenities.

Urban infrastructure, such as rail lines, drainage systems and digital networks requires large upfront investments. Singapore's compact form has allowed us to build a comprehensive Mass Rapid Transit network and district systems such as **Marina Bay's district cooling**, serving a much larger population with a smaller footprint and in a more cost-effective manner.

Density also creates space for nature. By building up strategically at selected locations (e.g. near transport nodes), we can set aside land elsewhere for nature reserves, parks, waterways and ecological corridors which are essential for biodiversity and climate adaptation. Through the Landscaping for Urban Spaces and High-Rises (LUSH) programme, we also embed greenery into buildings to cool the city and enhance well-being.



The Oasia Hotel Downtown features sky terraces and cascading lush planting integrated into the building form, providing green visual relief for guests and employees.

Photo courtesy of Patrick Bingham-Hall

Diversity: Designing for Change

Cities go through cycles. Economies rise and fall. Technologies disrupt industries. Diversity in urban form helps cities stay resilient through these changes.

In practice, this often takes the form of mixed-use neighbourhoods. Singapore's **Jurong Lake District** (JLD) exemplifies this approach, where commercial, residential and recreational spaces are being developed around a major transport hub. JLD will be a model sustainable mixed-use district, aiming to achieve net zero emissions for all new developments by 2045. Smart infrastructure initiatives such as district cooling, solar power deployment and super low-energy buildings can help to optimise resources, reduce the district's carbon footprint, and improve health and well-being.

Integrated developments illustrate another aspect of diversity. For example, the new Bukit Canberra integrates sports facilities, healthcare and greenery within a single precinct. These uses are deliberately arranged to complement one another. For instance, sports and eldercare facilities sit side by side, creating opportunities for shared activities and intergenerational interaction. Such planning strengthens social bonds while supporting physical and mental well-being.

In newer neighbourhoods like Springleaf and Lentor, we are shaping development around nature from the outset. Urban design is guided by natural topography, existing greenery and ecological corridors that are linked to the Central Catchment Nature Reserve. These neighbourhoods also provide shaded streets, permeable surfaces and water-sensitive landscapes to create cooler environments.



Interrelated uses in Bukit Canberra are organised based on four key areas: greenery, water, food and health.
Image courtesy of DP Architects

Connectivity: Binding the City Together

Connectivity is more than roads and rails. It structures how people, goods, energy, information and nature flow through a city.

At the macro scale, innovation districts anchor Singapore in flows of trade, talent and knowledge. Clustering universities, research institutions and firms in areas such as one-north, the Jurong Innovation District and Punggol Digital District generates knowledge spillovers that support emerging sectors like clean technologies, advanced manufacturing and artificial intelligence.

Within the city, rail expansion and transit-oriented development concentrate growth

around public transport nodes, reducing private vehicle dependence and carbon emissions. The Rail Corridor, once a freight line, has been transformed into a continuous green spine for walking, cycling and biodiversity—demonstrating how connectivity can restore ecological and social value.

At the neighbourhood level, pedestrian networks, cycling paths and park connectors encourage low-carbon mobility while improving well-being. We also carry out environmental studies to identify ecological corridors and guide the development of eco-links which allow wildlife to move between habitats, integrating nature into our urban fabric even as we develop.



The 24-km Rail Corridor repurposes an old freight line into a continuous green and mobility spine, linking neighbourhoods while restoring ecological and social connectivity.
Photos courtesy of Urban Redevelopment Authority



From Sustainable to Regenerative City

For cities, being regenerative means moving beyond sustaining what we have today to restoring ecological, social and economic capacity. Density allows infrastructure to be used more efficiently while setting aside land for nature. Diversity creates neighbourhoods where different activities and communities can co-exist and evolve. Connectivity supports low-carbon mobility, knowledge exchange and ecological

networks that allow people and biodiversity to move through the city.

Dr Liu reminded us that planners must be humanists, scientists and artists. I would add that we must also be gardeners—cultivating conditions for growth, resilience and renewal. If we do this well, the seeds we plant today will shade many generations to come.

DEVELOPING A REGENERATIVE CITY SELF-ASSESSMENT TOOL

The value of the indicators outlined in this chapter can only be realised when they are applied together and operationalised as part of urban development processes. The desired regenerative outcomes of liveability, resilience and resource optimisation are too often treated as separate goals handled by separate agencies, measured by separate protocols and funded through separate budgets. However, the regenerative approach is a systems approach. The planning and

design of urban interventions must be done in an integrated manner to maximise co-benefits across all three regenerative outcomes while building a city's regenerative capacity in a resource-constrained environment. Here, we present the outline of a Regenerative City Self-Assessment Tool (RCSAT) that when fully developed can make this integration possible by giving practitioners a shared tool and framework to measure and track action.



Dar Ramani Huria gathers community members to create maps of Dar Es Salaam. By mapping relevant features, the project aims to help previously neglected areas better prevent and respond to the city's yearly floods.

Photo courtesy of Ramani Huria, Flickr

What the RCSAT Does

The RCSAT can serve practitioners by making regenerative outcomes and capacity visible, measurable and actionable through three key functions.

The RCSAT creates a common language across sectors. Urban planners, ecologists and financiers each bring rigorous methods to their domains but they measure and prioritise different things. By offering a unified set of indicators across the key outcomes of a regenerative city, the tool bridges fragmentations in the reporting landscape and enables all to have a shared understanding of the city's overall regenerative performance and capacity. This enables more holistic assessment and decision-making, and gives diverse stakeholders a common goal and basis for prioritising action.

The RCSAT enables longitudinal tracking. Regenerative developments unfold over time and their impacts are not always immediately visible. Outcome indicators that are assessed over time reveal whether regenerative interventions are really achieving their intended effects and how long meaningful change takes to emerge. Capacity indicators, when tracked

over time, reveal how well the city is building its ability to facilitate and sustain regenerative processes over time. Such longitudinal data offers cities an evidence-based feedback loop for them to iterate and evolve. At the same time, such measurements give decision-makers an empirical foundation to value and justify long-term regenerative investments.

The RCSAT supports better decisions. Beyond tracking what has happened, the tool can inform what should happen next. Enabled by science and technology, simulation, modelling, and analysis can be built off the RCSAT to assess the performance of proposed interventions before they are implemented. This enables city leaders to conduct options analysis, stress-test interventions, and direct resources towards interventions that generate the broadest regenerative returns. The RCSAT can also expand conventional cost-benefit analysis approaches by making the range of co-benefits legible and comparable. This operationalises the integrated decision-making needed to maximise the co-benefits that a city can achieve.

Who the RCSAT Is For

The RCSAT is primarily targeted at city leaders, urban planners and policymakers making decisions at the district scale. Its value lies in the holistic view achieved through aggregating key indicators across urban functions. In doing so, it aims to support strategic and long-term decision-making.

The tool is also equally designed for the domain experts that city leaders,

urban planners and policymakers work with: urban designers, ecologists, civil engineers, architects, and social and behavioural scientists. All of these stakeholders contribute to the whole from within their respective areas of expertise. By bringing decision-makers and domain experts into a shared assessment framework, the RCSAT creates the conditions for a collaborative ecosystem that enables regenerative urban development.

Where the RCSAT Works Best

The RCSAT is best optimised at the district scale. This is the scale at which urban systems intersect, and co-benefits become visible and attributable. Nature-based and biomimetic solutions amplify resilience across a district in ways that building-level solutions cannot achieve. Low-carbon, integrated developments support connectivity and enable liveability when integrated at the neighbourhood level. Circular flows become viable when the loop is closed across shared infrastructure. These synergies are difficult to capture at the building scale, while they become too diffused and difficult to attribute at the city scale. Therefore, the district is where regenerative strategies produce their most legible returns.



Citizens can contribute to measuring environmental outcomes. This can involve counting animal species and tracking their changes over time, contributing to how conservation efforts are carried out.
Photo courtesy of National Parks Board

The RCSAT is a work-in-progress but this outline aims to establish the framework for an integrated evidence-based regenerative practice. The indicators discussed in this chapter provide a rigorous and informed starting point: a clear articulation of what to measure, distinguishing between regenerative outcomes tracked longitudinally to reveal the impacts of interventions, and regenerative capacity assessed cross-sectionally to reveal a city’s readiness to support regenerative processes.

While preliminary, the sketch of the tool aims to inspire cities to apply a common basis for understanding and improving their regenerative performance. While the tool is imagined to be as broadly applicable as possible, it must also be grounded in the climate, culture, governance and urban context of where the tool

is applied. Getting this right will depend on extensive collaboration among city planners, ecologists, urban designers and local communities, as well as the availability of transparent and comprehensive datasets. We continue to work towards an initial release of the RCSAT. As the tool is applied across case studies and refined through use, the relationships between regenerative capacity and outcomes will become clearer, the understanding of the social and ecological processes that link them will be better understood, and the evidence base will become deeper. As the science of regenerative cities advances, the case for regenerative approaches to urban development will also become harder to ignore.

Chapter 4

WORKING TOWARDS REGENERATIVE CITIES

As cities continue to make progress in regenerative urban development, this chapter shares how scaling action involves building a collaborative ecosystem and sharpening assessment capabilities.

The Punggol Digital District in Singapore redefines the relationship between education, industry, and community through an integrated mixed-use model that responds to the evolving patterns of how people work, live, learn and play.

Photo courtesy of Ng Sze Xuan

IMPLEMENTING REGENERATIVE URBAN DEVELOPMENT

Cities today stand at a pivotal inflection point in addressing climate change. On one hand, cities can continue to respond reactively to climate impacts as they occur through emergency measures, short-term fixes and incremental adaptations. On the other hand, cities can turn climate challenges into opportunities to create a liveable and resilient future by taking a long-term, integrated approach to mitigation and adaptation actions, and by identifying co-benefits in what we do to maximise the impact of our actions. This is the pathway offered by regenerative urban development.

This approach guides cities to move beyond just reducing harm in the course of urban (re)development, to doing more good for a city's residents. By addressing both the built and natural environments, regenerative

urban development can support cities to decarbonise and reduce climate risks and vulnerabilities in ways that optimise resource use and create communities that thrive alongside nature.

Distilling insights from the Centre for Liveable Cities' (CLC) research and engagements with leading experts across diverse sectors around the world, this publication offers evidence-based ideas and guidance for city leaders and practitioners to implement regenerative urban development, primarily at the district-scale and wider. Acting at this scale is crucial, because when every district implements regenerative strategies, the cumulative effect multiplies across the city, creating an exponential impact that transforms urban environments into thriving socio-ecological systems.

To help shape the thinking for regenerative projects, this publication presents a set of conceptual ideas that are foundational to the regenerative city—**paradigm shifts** for development to build onto sustainability efforts and pivot towards regenerative approaches, **a definition** for the regenerative city, which provides a common understanding of how regenerative cities function, and **principles** of the regenerative city that clarify values and form pathways for implementation.

To support the operationalisation of regenerative developments, we provide a **Regenerative City Framework** which outlines outcomes, strategies and enablers, and **examples of assessment indicators** to measure regenerative outcomes (progress in implementation) and capacities (existing conditions of the site). While a fully regenerative city remains aspirational, this publication documents many regenerative-aligned projects at different scales around the world that provide inspiration for action.

To find out more about the:

- *Paradigm shifts, refer to page 34 of Chapter 1.*
- *Definition, refer to page 60 of Chapter 2.*
- *Principles, refer to page 61 of Chapter 2.*
- *Regenerative City Framework, refer to page 63 of Chapter 2.*
- *Assessment indicators, refer to page 154 of Chapter 3.*

SCALING REGENERATIVE CITIES

While these ideas and guidance provide a consolidated starting point for implementation, there are also avenues for further work to strengthen the application of the regenerative approach.

The cross-system, multi-faceted and place-based nature of the regenerative city requires a deeper understanding of the city to strengthen and scale its implementation through the following avenues.

Building a Regenerative City Through a Collaborative Ecosystem of Stakeholders

Ideas and strategies of the regenerative city work when they are tailored to the local climatic, socio-cultural, governance and urban context, as exemplified by the case studies in this publication. The Regenerative City Framework and assessment indicators invite cities to develop place-specific solutions by considering how different strategies and enablers can interact to maximise co-benefits for the local urban ecosystem.

The key to successful implementation of regenerative urban development is having a strong collaborative ecosystem of stakeholders across sectors who are able to maximise the potential of each regenerative strategy and enabler. The public sector plays a crucial role in long-term planning, public communication and creating frameworks that catalyse collaboration,

integration, experimentation and learning, while the private sector plays a partnership role by piloting new technologies, designs and financing mechanisms that enable scalable and replicable approaches. Research and academic institutions help ensure that innovations are evidence-based and provide capacity building for implementation. Local communities and citizen groups contribute ground-up insights and initiatives that help to mobilise city-wide implementation. Beyond the city's localised ecosystems, international organisations facilitate knowledge exchange, reporting, benchmarking and access to best practices between cities and regions. Together, these sectors form an interconnected collaborative ecosystem that accelerates the adoption and scaling up of regenerative urban development.

Sharpening the Assessment Capabilities of the Regenerative City

The examples of assessment indicators introduced in this book articulate what to measure. Three areas for further development will sharpen assessment capabilities for scaling up.

First, advancing cities' understanding of correlational and/or causal relationships between regenerative strategies and their respective co-benefits can improve the precision of regenerative action and enable calibration for greater impact. As regenerative urban development requires practitioners to plan across numerous urban systems and possibly administrative or organisational boundaries, being able to identify and measure the social, economic and environmental co-benefits at a district level or beyond can refine the application of approaches like nature-based solutions and design-for-disassembly.

Second, in order to enhance strategic planning and efficient resourcing for implementation, cities need to deepen our understanding of the relationship between regenerative outcomes and capacities, and assessment of the socio-ecological processes that connect them. This can build on existing research on interactions between people and nature, such as ecosystem services provision and stewardship.⁶⁹

For instance, conducting financial valuation of the ecosystem services provided by nature-based solutions that go beyond conventional economic metrics to include environmental, social and governance outcomes will more holistically capture the cost and benefits associated with implementing nature-based solutions at particular sites.

Third, there needs to be more robust validation and tracking of regenerative outcome and capacity indicators across timescales and district typologies. For a brownfield redevelopment project, measuring the existing site using outcome indicators provides a baseline to track the effectiveness of implementation, and measuring capacity guides and calibrates the application of regenerative strategies and enablers. Tracking outcomes and capacities post-implementation over time assesses the effectiveness of interventions, and informs the extent to which investments in capacity are associated with desired outcomes across the development lifecycle. Once validated, the indicators can be applied to guide greenfield development projects.

These areas of enquiry will be developed as the CLC works towards building up the Regenerative City Self-Assessment Tool.

 *To find out more about the Regenerative City Self-Assessment Tool, refer to page 184 of Chapter 3.*

A COLLECTIVE COMMITMENT

The United Nations Sustainable Development Goals are targeted to be achieved by 2030. The post-2030 era will not mark the end of global sustainability efforts but rather a pivot to a new, more integrated framework. In early 2027, the Intergovernmental Panel on Climate Change (IPCC) will release its Special Report on Climate Change and Cities. This is a significant report, being the first IPCC report to spotlight cities both as sources of climate risks and engines of climate solutions and innovation.

Against this backdrop, regenerative urban development offers a pathway for cities to not only respond, but to lead the way in climate action. The Regenerative City Framework, developed by the CLC with support from the Singapore University of Technology and Design, allows for different cities to tailor their solutions to the scale, complexity and conditions of their own contexts.

To be clear, embracing regenerative urban development does not require cities to dismantle existing sustainability efforts, nor does it eliminate all trade-offs inherent in planning and development choices.

Instead, it guides cities to build on existing initiatives, integrating more closely across urban systems to maximise co-benefits across liveability, resilience and resource outcomes for people and the built and natural environments. By tightening connections across communities, infrastructure and nature, regenerative approaches can amplify the impact of existing strategies.

This moment requires collective commitment and action. Scaling regenerative urban development requires stakeholders across sectors and cities to collaborate as an ecosystem. Platforms such as the United Nations Framework Convention on Climate Change's Conference of the Parties (COP), World Cities Summit and the City Network for the Lee Kuan Yew World City Prize (LKYWCP Network) provide avenues for cities to learn from one another, validate what works, and build the momentum to make regenerative approaches commonplace. Even in a climate-changed and resource-constrained world, we can build a liveable, resilient and regenerative future for our cities together.

Secondary rainforests, like the Southern Ridges in Singapore, are regenerated forest patches that can help cities adapt to intensifying heat stress and flooding.

Photo courtesy of Chuttersnap on Unsplash



GLOSSARY

1. **Adaptive capacity:** Adaptive capacity refers to the capability of a system, institution, person or other organism to adjust to potential damage, effect or impact caused by climate change, to take advantage of opportunities, or to respond to consequences.⁷⁰

2. **Adaptive reuse:** Adaptive reuse is the transformation of ageing or underutilised assets for reuse or new uses.⁷¹ In addition to preserving heritage, adaptive reuse can help cities cut carbon emissions, achieve cost savings and retain the identity of spaces while sensitively accommodating to changing uses.

3. **Biomimicry:** Biomimicry is the emulation of nature to solve human problems.⁷² It argues that nature’s evolution has created time-tested solutions that can inspire sustainable design solutions.⁷³

4. **Biophilia:** Biophilia refers to the principle of natural affinity between humans and nature.⁷⁴ Biophilic design in the built environment fosters this relationship by integrating natural elements and processes into urban spaces.⁷⁵ It is associated with benefits such as improved human health, well-being and productivity.

5. **Climate mitigation and adaptation:** Climate mitigation seeks to limit greenhouse gas emissions and reduce current levels by improving greenhouse gas sinks,⁷⁶ while climate adaptation aims to enhance adaptive capacity to respond to the consequences of climate change or to take advantage of potential opportunities.⁷⁷

6. **Co-benefits:** Popularised by the International Panel on Climate Change’s AR3, co-benefits refer to the planned non-climate benefits arising from greenhouse gas mitigation efforts.⁷⁸ A co-benefits approach to planning, recognising that mutualistic relationships exist between various domains, utilises these synergies such that a single policy or action maximises shared benefits across these domains.

7. **Ecosystem services:** Ecosystem services refer to the benefits or functions that the natural environment provides to people. In cities, ecosystem services are key to designing nature-based solutions that can complement and enhance the resilience of traditional grey infrastructure. They bring about ecological, social and economic benefits. For example, urban vegetation can lower surface air temperatures through shading and evapotranspiration. Likewise, green walls and trees that shade buildings can reduce building heat loads and energy consumption from cooling.⁷⁹
8. **Liveability:** Liveability reflects the city’s ability to balance and achieve a competitive economy, high quality of life and sustainable environment at the same time.⁸⁰ Ensuring liveability in the regenerative city requires balancing the demands of development with ecosystem health, sustaining the diversity, density and connectivity of both the built and natural environments. Liveability is one of the three outcomes of the regenerative city.

9. **Living systems:** Drawing from the term’s origins in biology, living systems are characterised by three core properties: metabolism (the ability to process energy and resources), self-reproduction and mutability. Likewise, cities can be understood as complex living systems composed of interdependent ecological, social and built subsystems. These urban systems interact to produce desirable outcomes, dynamically reorganising and adapting over time.⁸¹

10. **Planetary boundaries:** Planetary boundaries elucidate the limits for human pressure on nine earth processes that are critical to maintaining a “safe operating space for humanity”. These earth processes are climate change, biosphere integrity, land-system change, freshwater change, biogeochemical flows, ocean acidification, atmospheric aerosol loading, stratospheric ozone depletion and novel entities (human-made chemicals, plastics, etc.). The Planetary Health Check 2025 reported that seven out of the nine planetary boundaries have been breached; only aerosol loading and stratospheric ozone depletion remain within safe levels.⁸²

11. **Regenerative capacity:** Taking inspiration from Pamela Mang and Bill Reed’s concept of “operational capacity” for regenerative development, which refers to the ability of a system to self-organise, adapt and evolve,⁸³ regenerative capacity measures the synergies between the city’s urban built and natural environments, advancing a balanced assessment of the urban ecosystem’s ability to bring holistic benefits. It comprises three fundamental tenets: density, diversity and connectivity, with each representing a systems-based approach to holistic planning for the urban ecosystem.
12. **Regenerative city:** The regenerative city is one that goes beyond sustainability—which strives to reduce harm—to optimise co-benefits across liveability, resilience and resource optimisation outcomes. It refers to the city as a complex and dynamic urban–natural environment where human, ecological and technological systems co-evolve to generate multiple co-benefits. In a climate-changed and resource-constrained world, a regenerative city renews and adapts to turn interdependencies into opportunities.

13. **Resilience:** Resilience refers to the ability of a city’s people, communities, institutions, businesses and systems to prepare and plan for, absorb, recover from and more successfully adapt to adverse events. A regenerative city builds resilience across reinforcing dimensions: climate, social, environmental and resource, forming one of the three outcomes of the regenerative city.

14. **Resource optimisation:** Resource optimisation shows the degree to which material, food, carbon, water and land are used and kept in continuous circulation to minimise extraction, waste and environmental degradation. For the regenerative city, resource optimisation strives for efficiency and the creation of an integrated metabolic system, where the lifespans of resources in circulation are prolonged, and more is created with less.

15. **Sponge city:** Sponge city is a concept frequently used in planning to describe the adoption of blue-green infrastructure and nature-based drainage systems to tackle urban stormwater. In addition to reducing flood risk, this can generate co-benefits of improved water quality, reduced urban heat and enhanced biodiversity, contributing to greater liveability and resilience.⁸⁴

16. **Sustainable development:** Sustainable development broadly refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs.⁸⁵ In particular, sustainable urban development seeks to further progress while minimising activities that are harmful to residents and the environment, thereby mitigating the climate and environmental damage caused by development.⁸⁶
17. **Systems-based approach:** A systems-based approach examines how components within a system interact and influence one another to produce emergent behaviours and outcomes.⁸⁷ In urban systems, it examines how subsystems interact through feedback loops and identifies leverage points where integrated interventions can restore ecological functions, strengthen resilience and improve long-term urban well-being.^{88,89}

18. **Trade-offs:** Trade-offs refer to situations where pursuing one option or outcome comes at the cost of another, requiring decision-makers to forgo or even accept the deterioration of alternative options.⁹⁰ While trade-offs have conventionally been used as an approach to assess the ability of actions to deliver outcomes, regenerative urban development argues that they must be accompanied by co-benefits to ensure that decisions are not only informed by a balance between risk and reward, but an optimisation of potential.

19. **Urban heat island effect:** The urban heat island effect is a phenomenon where densely built areas experience higher air temperatures than less developed rural areas.⁹¹ The additional warming caused by urbanisation is more palpable at night when urban structures release the solar radiation that is trapped in the day. The urban heat island effect is exacerbated by a lack of vegetated surfaces which reduce heat absorption in the day.

20. **Urban metabolism:** With metabolism referred to as the set of chemical processes which convert food into energy required for growth, maintenance and survival for living organisms, urban metabolism is the set of processes and factors that influence cities’ evolving structure and function. Specifically, it analyses cities’ flow of resources (materials, water, and energy) and emissions, explicating varied socio-technical and socio-ecological relationships in the urban environment.⁹²

21. **Urban-natural environment:** An urban–natural environment refers to an ecosystem where urban and natural environments are deeply integrated with each other such that there are mutualistic relationships between the two environments.⁹³ In such an ecosystem, urban environments benefit from ecosystem services from the natural environment, while natural environments benefit from human stewardship.⁹⁴

ANNEX

Methodology for the Regenerative City Framework

The Regenerative City Framework was developed through two complementary research approaches. Expert engagements gathered broad, open-ended insights from stakeholders across diverse sectors and international platforms. The Delphi survey then brought scientific rigour to the process, involving iterative rounds of expert consultation to refine and validate the framework. Together, these findings were triangulated⁹⁵ to produce a framework that is both practically applicable across diverse urban conditions and scientifically grounded in expert consensus.

Expert Engagements

Expert engagements were conducted with more than 100 multi-sectoral stakeholders over a 2-year period. The Centre for Liveable Cities (CLC) leveraged international platforms such as the World Cities Summit and the Conference of the Parties to the United Nations Framework Convention on Climate Change, consulted expert panels like the World Cities Summit Knowledge Council, and organised forums and workshops, most notably the CLC’s Regenerative City Forum Series held in Singapore and at London Climate Action Week in 2025. Knowledge partners spanned the public, industry, people and international organisations, and academic sectors (see Table 1).

TABLE 1: SECTORAL SPREAD OF ENGAGED STAKEHOLDERS

Public	Industry	People/International Organisations	Academics	Total
35	40	20	32	127

Delphi Survey

Three rounds of the Delphi survey⁹⁶ were conducted online by the Singapore University of Technology and Design, in collaboration with the CLC, from September 2025 to January 2026. Round 1 consisted of unstructured questions, while rounds 2 and 3 employed semi-structured formats combining rating scales and optional qualitative feedback (see Table 2). Each round remained open for approximately three to four weeks and was closed once a minimum response rate of 70% was achieved, which is consistent with recommendations for Delphi studies.

TABLE 2: OVERVIEW OF THE THREE DELPHI SURVEY ROUNDS

Round 1	To establish an understanding of the regenerative city, the round 1 survey sought experts’ inputs on: • A definition • Key principles • Strategies • Enablers • How a regenerative city differs from a sustainable city, and the additional value that the regenerative city might bring to urban development
Round 2	Building on round 1, experts were asked to: • Share their level of agreement with the draft definition • Rank the importance of the seven identified principles and share their level of agreement • Rank the importance of identified strategies and enablers • Provide any additional comments or revisions
Round 3	Validating findings from round 2, experts were asked to: • Re-evaluate the definition, principles, strategies and enablers using the same scales as round 2 • Select the top five strategies and top five enablers to prioritise for implementation • Provide any additional qualitative comments

Participants were selected based on their expertise in urban sustainability, regenerative design, urban regeneration and related fields, with evidence of expertise assessed through indicators such as publication records, leadership positions or involvement in major projects characterised by regenerative features.

Among 143 invited global experts, 43 agreed to participate, falling within the recommended Delphi panel size of 10 to 50.

The process identified a definition for the regenerative city which received 91% agreement in the final round. Alongside this, 8 core principles, 21 strategies and 17 enabling conditions met the consensus criteria, indicating strong collective alignment around a broad set of actions and conditions.

Data Triangulation

The Regenerative City Framework was produced from a triangulation of findings from both the expert engagements and Delphi survey. Pertinently, data triangulation was used to find patterns across expert domains around the central question: How can the Framework support city leaders and practitioners in applying the regenerative approach? These findings culminated in the three outcomes, three strategies, and seven enablers of the Regenerative City Framework.

 To find out more about our research journey, refer to page 56 of Chapter 2.

Detailed List of Example Indicators

The example indicators were identified by the Singapore University of Technology and Design.

Indicators for Regenerative Outcomes

LIVEABILITY			
Subcategory	Indicator	Method of Calculation	Key Reference
High Quality of Life	Life Expectancy	Average life expectancy for inhabitants	World Health Organization, <i>World Health Statistics 2024: Monitoring Health for the SDGs</i> (Geneva: World Health Organization, 2024).
	Resident Retention Rate	Duration of residence in district	Gehl Institute, <i>Inclusive Healthy Places: A Guide to Inclusion and Health in Public Spaces</i> (Copenhagen: Gehl Institute, 2018).
	Resident Satisfaction	Resident satisfaction survey	Gehl Institute, <i>Inclusive Healthy Places</i> .
	Modal Split of Journey to Work	Ratio of residents who take public transport, walk or bike to work	Nicholas Martino, Cynthia Girling and Yuhao Lu, "Urban form and livability: Socioeconomic and built environment indicators", <i>Buildings and Cities</i> 2.1 (2021): 220–243.

LIVEABILITY			
Subcategory	Indicator	Method of Calculation	Key Reference
Sustainable Environment	Air Quality	Annual average air quality index	World Health Organization, <i>WHO Global Air Quality Guidelines</i> (Geneva: World Health Organization, 2021).
	Surface Water Quality	Proportion of wastewater generated on-site that is treated before release	Data-Driven EnviroLab, "Urban Environment and Social Inclusion Index" (UESI), n.d.
	Safe Drinking Water	Age-standardised disability-adjusted life-years (DALYs) lost per 100,000 persons due to exposure to unsafe drinking water	Environmental Performance Index, "Unsafe drinking water" data, available at https://epi.yale.edu/measure/2024/UWD .
	Ambient Noise Level	% of residential area exceeding 55 dB(A) Lden threshold	European Environment Agency, <i>Environmental Noise in Europe—2020</i> , EEA Report No. 22/2019 (Luxembourg: Publications Office of the European Union, 2020).
	Green Amenity Access	Year on year change in % of population living within 400 m walking distance of a park or green space	Lena Chan et al., <i>Handbook on the Singapore Index on Cities' Biodiversity (also known as the City Biodiversity Index) (CBI)</i> (Montreal: Secretariat of the Convention on Biological Diversity and Singapore: National Parks Board, Singapore, 2021), Indicator 13, 26. Urban Redevelopment Authority, <i>A Green & Liveable City: Singapore Urban Design Guidebook</i> (Singapore: Urban Redevelopment Authority, 2015), 1.1.2. 32–50.

LIVEABILITY			
Subcategory	Indicator	Method of Calculation	Key Reference
Competitive Economy	Income Equity (Gini)	Gini coefficient of household income distribution within district (0–1)	United Nations Human Settlements Programme (UN-Habitat), <i>Guidelines for Reporting on the Implementation of the New Urban Agenda</i> , revised ed. (Nairobi: UN-Habitat, 2024).
	Employment Rate	% of working-age population (15–64) in employment within the district	Organisation for Economic Co-operation and Development (OECD), <i>Implementation toolkit of the OECD Principles on urban policy</i> , OECD Regional Development Papers, 31 (Paris: OECD Publishing, 2022). Gehl Institute, <i>Inclusive Healthy Places</i> .
	Local Business Diversity	Shannon entropy index of business establishment types per district	Martino, Girling and Lu, “Urban form and liveability”.
	Ground Floor Activation	% of ground floor frontage in active use (retail, F&B, community)	Gehl Institute, <i>Inclusive Healthy Places</i> .

RESILIENCE			
Subcategory	Indicator	Method of Calculation	Key Reference
Climate Resilience	Urban Heat Reduction	Year-on-year change in mean land surface temperature (°C)	John Patrick Connors, Christopher S. Galleti and Winston T.L. Chow, “Landscape configuration and urban heat island effects: Assessing the relationship between landscape characteristics and land surface temperature in Phoenix, Arizona”, <i>Landscape Ecology</i> 28 (2013): 271-283.
	Flood Risk Exposure	% of district area within modelled 1-in-100-year flood zone according to local flood risk map	Intergovernmental Panel on Climate Change (IPCC), “Small Islands” in <i>Climate Change 2022 — Impacts, Adaptation and Vulnerability</i> , Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge: Cambridge University Press 2022), 2043-2121.
	Annual Runoff Volume Control Rate	The percentage of rainfall retained and reused on-site.	Mark Randall et al., “Evaluating Sponge City volume capture ratio at the catchment scale using SWMM”, <i>Journal of Environmental Management</i> 246 (2019): 745-757.
	Water Stress Indicator	Ratio of freshwater reserves to population size.	Malin Falkenmark, Jan Lundqvist and Carl Widstrand, “Macro-scale water scarcity requires micro-scale approaches”, <i>Natural Resources Forum</i> 13.4 (1989): 258-267.

RESILIENCE			
Subcategory	Indicator	Method of Calculation	Key Reference
Environmental Resilience	Urban Greenness Indicator	Area-averaged (mean) NDVI [may also include peak NDVI, annual mean NDVI, population-weighted peak NDVI, and population-weight annual mean NDVI]	Jennifer D. Stowell et al., “Development of a global urban greenness indicator dataset for 1,000+ cities”, <i>Data in Brief</i> 48 (2023): 109140.
	Plant Species Richness	Count of native vascular plant species per standard survey area	Chan et al., CBI, Indicator 4.
	Bird Species Richness	Count of native bird species recorded per standard survey period	Chan et al., CBI, Indicator 5.
	Soil Retention	Water erosion of soil in tonnes/ha/year	Panos Panagos et al., (2024) “How the EU Soil Observatory is providing solid science for healthy soils”, <i>European Journal of Soil Science</i> 75.3 (2024): e13507.
	Habitat Restoration	(Area of habitat restored in year) / (area of degraded habitat) × 100%	Chan et al., CBI, Indicator 7. United Nations Environment Programme, Convention on Biological Diversity, “Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity: 15/4. Kunming-Montreal Global Biodiversity Framework”, 19 December 2022.

RESILIENCE			
Subcategory	Indicator	Method of Calculation	Key Reference
Social Resilience	Civic Participation Rate	Number of urban community resident associations	Robert Osei-Kyei et al., “Critical review of urban community resilience indicators”, <i>Smart and Sustainable Built Environment</i> 13.6 (2024): 1511–1537.
	Social Cohesion Index	Standardised survey questions for measuring interpersonal trust and institutional trust, with a core module of five questions using 0–10 scales.	OECD, <i>OECD Guidelines on Measuring Trust</i> (Paris: OECD Publishing, 2017), Annex 2, 196–211.
	Local Environmental Stewardship Indicator	Survey across seven action categories, quantifies stewardship of the environment by members of the local community.	John W. Turnbull, Emma L. Johnston and Graeme F. Clark, “LESI: A quantitative indicator to measure local environmental stewardship”, <i>MethodsX</i> 7 (2020): 101141.

Resource Optimisation			
Subcategory	Indicator	Method of Calculation	Key Reference
Carbon	Total GHG Intensity	Total tCO ₂ e (Scope 1+2) / resident population per year	World Resources Institute, C40 Cities and ICLEI, <i>Global Protocol for Community-Scale Greenhouse Gas Inventories: An Accounting and Reporting Standard for Cities</i> , Version 1.1 (Washington, DC: World Resources Institute, 2021).
	Scope 1: Stationary Combustion	tCO ₂ e from stationary fuel combustion within district boundary per year	Ibid.
	Scope 1: In-boundary Transport	tCO ₂ e from in-boundary transportation per year	Ibid.
	Scope 1: Agriculture Forestry and Other Land Use Change	tCO ₂ e from AFOLU in boundary per year	Ibid.
	Scope 1: Industrial Processes	tCO ₂ e from IPPU in boundary per year	Ibid.
	Scope 1: In Boundary Waste and Wastewater Emissions	tCO ₂ e from in-boundary Waste and Wastewater treatment per year	Ibid.
	Scope 2: Grid-supplied Energy	tCO ₂ e from purchased grid electricity and heat per year	Ibid.

Resource Optimisation			
Subcategory	Indicator	Method of Calculation	Key Reference
Land	Land Use Compactness	Moran's I spatial autocorrelation index of built-up density across the district	Amnon Frenkel and Maya Ashkenazi, "Measuring Urban Sprawl: How Can We Deal with It?", <i>Environment and Planning B: Urban Analytics and City Science</i> , 35.1 (2008): 56–79.
			Miriam Steurer and Caroline Bayr, "Measuring urban sprawl using land use data", <i>Land Use Policy</i> 97, (2020): 104799.
Water	Water Consumption Intensity	Annual daily average of potable water consumption / resident population (litres/capita/day)	Mohit Arora et al., "Assessing water circularity in cities: Methodological framework with a case study", <i>Resources, Conservation and Recycling</i> 178 (2022): 106042.
Materials	Waste Recycling Rate	% of total municipal solid waste diverted through recycling or reuse per year	Carolyn Bellstedt et al., <i>CityLoops: Urban Circularity Assessment Method</i> , Deliverable 4.4, 1 (CityLoops, 2022).
	Building Reuse Rate	% of construction permits for renovation/adaptive reuse vs. new construction per year	David Cheshire, <i>Regenerative by Design: Creating Living Buildings and Cities</i> (London: RIBA Publishing, 2024).
Food	Local Food Production	% of total food consumption (by weight) sourced from within the city or peri-urban region	Chan et al., CBI, Indicator 14.

Indicators for Regenerative Capacity

DENSITY			
Subcategory	Indicator	Method of Calculation	Key Reference
Built Environment	Gross Plot Ratio	Total gross floor area / site area	Martino, Girling and Lu, "Urban form and liveability".
	Population Density	Resident population / site area	Robert I. McDonald et al., "Denser and greener cities: Green interventions to achieve both urban density and nature", <i>People and Nature</i> 5.1 (2023): 84–102.
	Impervious Surface Coverage	% of site area covered by impervious surfaces	McDonald, "Denser and greener cities". Chan et al., CBI, Indicator 10. Stanford University, <i>Urban Flood Risk Mitigation</i> , InVEST User Guide.
	Skyview Factor (SVF)	Average SVF for 10m samples across the district. (Sky view factor (SVF) is the ratio of the visible sky area of a point in space to the total sky area.)	Chunping Miao et al. "Review of methods used to estimate the sky view factor in urban street canyons", <i>Building and Environment</i> 168 (2020): 106497.
	Frontal Area Density (FAD)	Average FAD for the district across 200x200m samples. See references for methodology.	C.S.B. Grimmond and T.R. Oke, "Aerodynamic properties of urban areas derived from analysis of surface form", <i>Journal of Applied Meteorology</i> , 38.9 (1999): 1262–1292.

DENSITY			
Subcategory	Indicator	Method of Calculation	Key Reference
Natural Environment	Proportion of Natural Areas in the City	(Total area of natural, restored and naturalised areas) ÷ (Area of city) × 100%	Chan et al., CBI, Indicator 1. Convention on Biological Diversity, Kunming-Montreal Global Biodiversity Framework (GBF), "2030 Targets (with Guidance Notes)", n.d., Targets 2, 3.
	Protected Natural Area	(Area of protected or secured natural areas) / (total district area) × 100%	Chan et al., CBI, Indicator 8. GBF, "2030 Targets", Target 3. Matthew Selinske et al., "Biodiversity needs both land sharing and land sparing", <i>Nature</i> 620 (2023): 727.
	Tree Canopy Coverage	% of site area covered by tree canopy (from NDVI satellite data)	McDonald, "Denser and greener cities".

Density			
Subcategory	Indicator	Method of Calculation	Key Reference
Cross System Integration	Shared Green Space Ratio	% of site area in shared human-nature use (parks, gardens, green roofs)	Thomas Schröpfer, <i>Dense + Green Cities</i> (Basel: Birkhäuser, 2020). WOHA and bioSEA, <i>Designing for Biodiversity: The Value of Nature Centric Design</i> (Singapore: WOHA, 2024).
	Green Plot Ratio (GnPR)	Weighted Leaf Area Index total / site area (unitless)	Boon Lay Ong, "Green plot ratio: an ecological measure for architecture and urban planning", <i>Landscape & Urban Planning</i> , 63.4 (2003): 197–211.

Diversity			
Subcategory	Indicator	Method of Calculation	Key Reference
Built Environment	Land Use Diversity	Shannon entropy index of land use types within site boundary	Martino, Girling and Lu, "Urban form and liveability".
	Housing Typology Mix	Shannon entropy of dwelling unit types (by size/tenure) within district	Ibid.

Diversity			
Subcategory	Indicator	Method of Calculation	Key Reference
Natural Environment	Habitat Biodiversity Value	Biodiversity value score calculated as the product of habitat size, condition, conservation priority and strategic significance, expressed in biodiversity units. Habitat types classified using the IUCN Global Ecosystem Typology.	Ramboll, <i>Global Biodiversity Metric (GBM): Launched at UN COP16, Cali, 2024</i> , adapted from Natural England Biodiversity Metric 4.0.
	Tree Species Diversity	Shannon entropy index of tree species from municipal tree inventory	Chan et al., CBI.
Cross System Integration	Landscape Element Diversity	Count of distinct landscape elements (planter, green wall, pond, etc.) / site area	WOHA and bioSEA, <i>Designing for Biodiversity</i> .

CONNECTIVITY			
Subcategory	Indicator	Method of Calculation	Key Reference
Built Environment	Key Services Access	Average network distance to school, clinic, and retail centre (m)	Centre for Liveable Cities, <i>Building Liveable and Sustainable Cities: A Framework for the Future</i> (Singapore: Centre for Liveable Cities, 2025). Martino, Girling and Lu, "Urban form and liveability".
	Walkability Index	Composite of intersection density, average block length, and land-use entropy within 400m buffer	Lawrence D. Frank et al., "The development of a walkability index: application to the Neighborhood Quality of Life Study", <i>British Journal of Sports Medicine</i> , 44.13 (2009): 924–933.
	Rail Transit Access	Network distance to nearest rail/MRT station (m)	Martino, Girling and Lu, "Urban form and liveability" CLC. <i>Building Liveable and Sustainable Cities</i> .
	Bus Network Access	Network distance to nearest bus stop (m)	Martino, Girling and Lu, "Urban form and liveability". CLC. <i>Building Liveable and Sustainable Cities</i> .
	Cycling Infrastructure Access	Network distance to nearest dedicated cycling path (m)	Martino, Girling and Lu, "Urban form and liveability". CLC. <i>Building Liveable and Sustainable Cities</i> .

CONNECTIVITY			
Subcategory	Indicator	Method of Calculation	Key Reference
Natural Environment	Ecosystem Connectivity	Betweenness centrality of nearest landscape patch (spatial network analysis)	Darrel Chin Fung Tiang et al., "Ecological connectivity in fragmented agricultural landscapes and the importance of scattered trees and small patches", <i>Ecological Process</i> 10, 20 (2021).
	Effective Mesh Size	Area-weighted mean of unfragmented landscape patch sizes (ha)	Megan R. Deslauriers et al., "Implementing the connectivity of natural areas in cities as an indicator in the City Biodiversity Index (CBI)", <i>Ecological Indicators</i> 94.2 (2018): 99–113. Chan et al., CBI, Indicator 2.
	Access to Nature	Network distance from residential parcel to nearest park or nature area (m)	Chan et al., CBI, Indicator 13. URA, <i>A Green & Liveable City</i> .
	Ecological Corridor Length	Total length of dedicated ecological corridors (km)	Richard T.T. Forman, <i>Land Mosaics: The ecology of landscapes and regions</i> . (Cambridge: Cambridge University Press, 1995)
Cross System Integration	Green Mobility Co-location	% of active mobility network (walking/cycling) co-located with green corridor or park connector	Kiat W. Tan, "A greenway network for Singapore", <i>Landscape and Urban Planning</i> 76 (2006): 45–66.

ENDNOTES

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² World Meteorological Organization, “WMO Confirms 2025 was one of warmest years on record”, 14 January 2026, <https://wmo.int/news/media-centre/wmo-confirms-2025-was-one-of-warmest-years-record>.

³ The seven boundaries that have been crossed are Climate Change, Biosphere Integrity, Land System Change, Freshwater Use, Biogeochemical Flows, Novel Entities and Ocean Acidification, leaving only Ozone Depletion and Aerosol Loading in the safe zone.

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⁵ United Nations Department of Economic and Social Affairs, *World Urbanization Prospects: The 2018 Revision* (New York: United Nations, 2019), <https://doi.org/10.18356/b9e995fe-en>.

⁶ International Energy Agency (IEA), *Empowering Urban Energy Transitions* (Paris: IEA, 2024).

⁷ Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2023: Synthesis Report* (AR6) (Geneva: IPCC, 2023).

⁸ United Nations Human Settlements Programme (UN-Habitat), *World Cities Report 2024: Cities and Climate Action* (UN-Habitat, 2024).

⁹ This has been guided by the UN's *2030 Agenda for Sustainable Development*, which focuses on the reduction and mitigation of environmental degradation for present and future generations.

¹⁰ John Tillman Lyle, *Regenerative Design for Sustainable Development* (Hoboken: John Wiley & Sons, 1994).

¹¹ Regenerative agriculture is common among indigenous communities, including those in the Pacific Islands and Southeast Asia. Known for building healthy soils, ensuring drought resilience and reducing erosion, it is recognised by state governments, like the Australian government, and offers crucial lessons for place-based climate resilience efforts.

¹² Pamela Mang and Bill Reed, “Regenerative Development and Design”, in *Encyclopedia of Sustainability Science and Technology*, ed. Robert A Meyers (New York: Springer, 2012), 8855-8879, 10.1007/978-1-4614-5828-9_303.

¹³ Chrisna du Plessis and Bill Reed, “Chrisna du Plessis and Bill Reed: Regenerating life by design”, interview by Nirmal Kishnani, Ecogradia, 28 February 2023, audio, 58:37, <https://www.ecogradia.com/podcast/chrisna-du-plessis-and-bill-reed-regenerating-life-by-design/>.

¹⁴ Adapted from Chrisna du Plessis, “The City Sustainable, Resilient, Regenerative – A Rose by Any Other Name?”, in *Design for Regenerative Cities and Landscapes*, ed. Rob Roggema (Cham: Springer, 2022), 33.

¹⁵ Pamela Mang and Bill Reed, “Regenerative Development and Design”, in *Encyclopedia of Sustainability Science and Technology*, ed. Robert A Meyers (New York: Springer, 2012), 8855-8879, 10.1007/978-1-4614-5828-9_303.

¹⁶ Arup, *Regenerative Design: towards living in harmony with nature*, (London: Arup and the Rockefeller Foundation, 2024).

¹⁷ Chrisna du Plessis, “The City Sustainable, Resilient, Regenerative – A Rose by Any Other Name?”, in *Design for Regenerative Cities and Landscapes*, ed. Rob Roggema (Cham: Springer, 2022), 23-48.

¹⁸ Carlos Alberto Ruggerio, “Sustainability and sustainable development: A review of principles and definitions”, *Science of The Total Environment* 786 (2021): 147481, <https://doi.org/10.1016/j.scitotenv.2021.147481>.

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²³ du Plessis, “The City Sustainable, Resilient, Regenerative”, 23-48.

²⁴ Mikaël J.A. Maes et al., “Mapping synergies and trade-offs between urban ecosystems and the sustainable development goals”, *Environmental Science & Policy* 93 (2019): 181-188, <https://doi.org/10.1016/j.envsci.2018.12.010>.

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