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 กสิณธร ราชโอรส, (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.

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

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

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

SYSTEMIC THINKING

The city is holistic, and decisions are made to achieve systemic outcomes for the whole ecosystem rather than to optimise individual components.

DYNAMISM

The city actively restores, revitalises and enhances its conditions to realise the full potential for thriving futures.

REFLEXIVITY

The city fosters continuous learning through experimentation and innovation. It also encourages attentive reflection on the interdependencies between the urban built and natural ecosystems.

ETHICAL STEWARDSHIP

The city regenerates with care, compassion and integrity, practicing active responsibility towards the urban built and natural ecosystems.

LONG-TERMISM

The city treats the past, present and future with equal importance, caring for both present and future generations.

RECIPROCITY

The city regenerates based on fair exchange and balanced interactions across all scales, domains and systems.

PLACE-BASED

The city engages deeply with its unique ecological and cultural identity.

INTERCONNECTEDNESS

The city operates across multiple scales: within itself, with its region and with other cities.

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.

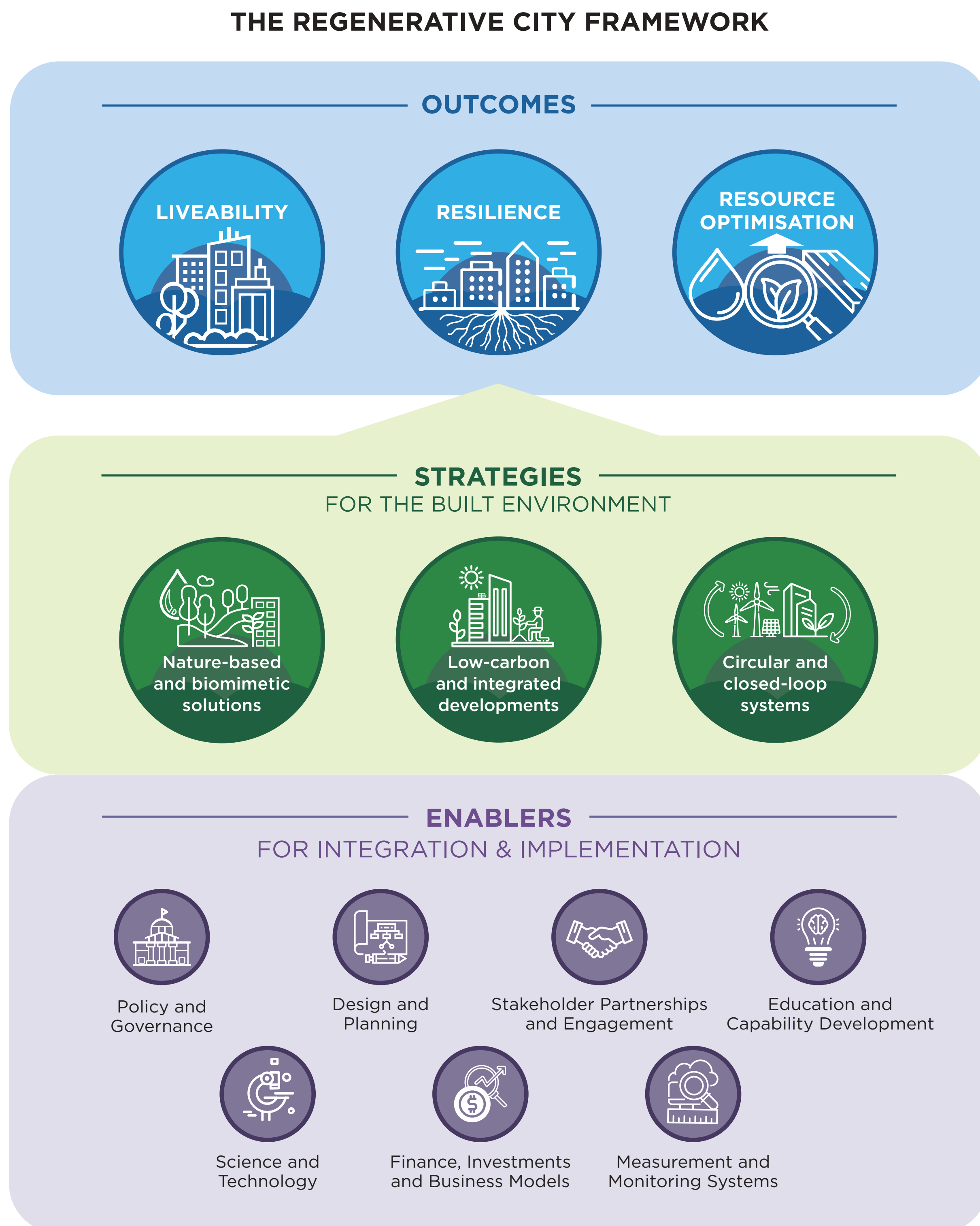
Co-benefits are often unevenly distributed, and the communities most in need of regenerative outcomes are not always the first to benefit from them. Governance and political economy constraints—from siloed institutional mandates to short electoral cycles—can prevent the kind of integrated, long-term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

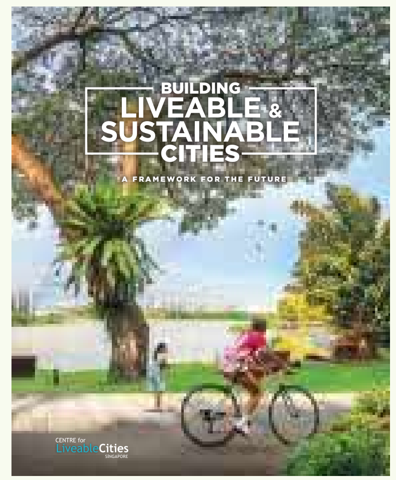


Image courtesy of Centre for Liveable Cities

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.

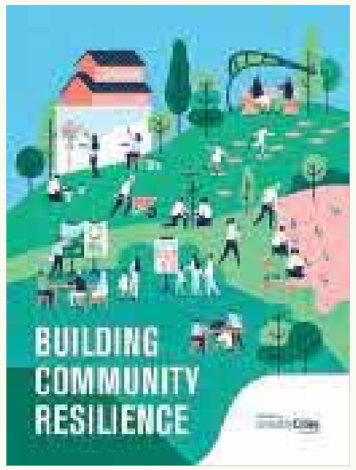


Image courtesy of Centre for Liveable Cities

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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

OP-ED

SINGAPORE'S WATER STORY FROM THE REGENERATIVE LENS

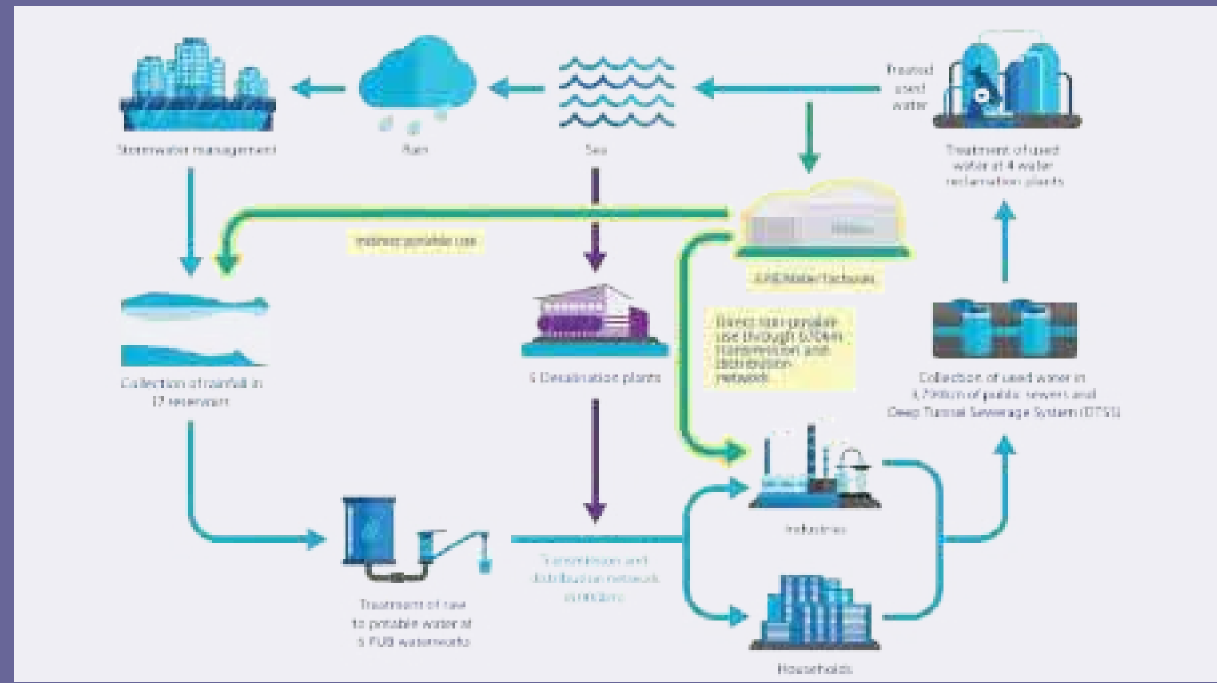
ONG TZE-CH'IN
Chief Executive Officer, PUB, Singapore's National Water Agency

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.

Singapore World Water Day 2026 campaign.
Images courtesy of PUB

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.

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 m^2 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.

PUBLISHED IN URBAN SOLUTIONS 27

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)

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

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.

OP-ED

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-m^2 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 km^2 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)

OP-ED

REGENERATIVE DESIGN: DELIVERING CO-BENEFITS THROUGH INTEGRATED DEVELOPMENT

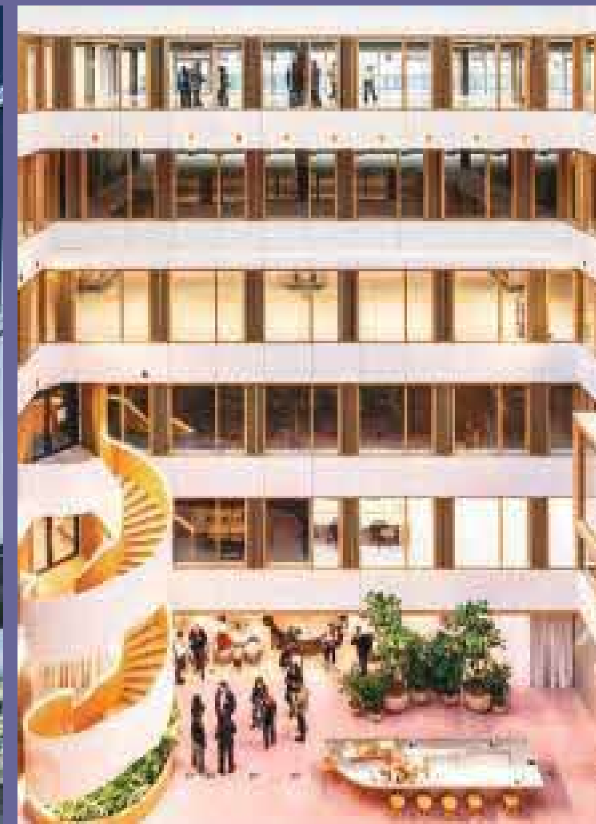
SOWMYA PARTHASARATHY
Fellow, Urban Design and Masterplanning, Arup

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 CO_2e 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

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.

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

Urban typology analysis using an AI tool called Terrain.
Image 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 CO_2e 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.

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

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.

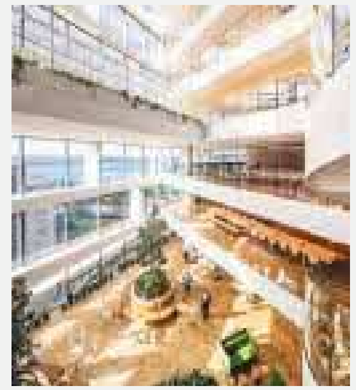
PUBLISHED IN URBAN SOLUTIONS 25

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

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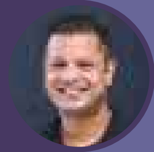

ADAPTIVE REUSE PLUS DENSIFICATION: A CARBON-ALIGNED GROWTH MODEL FOR CITIES

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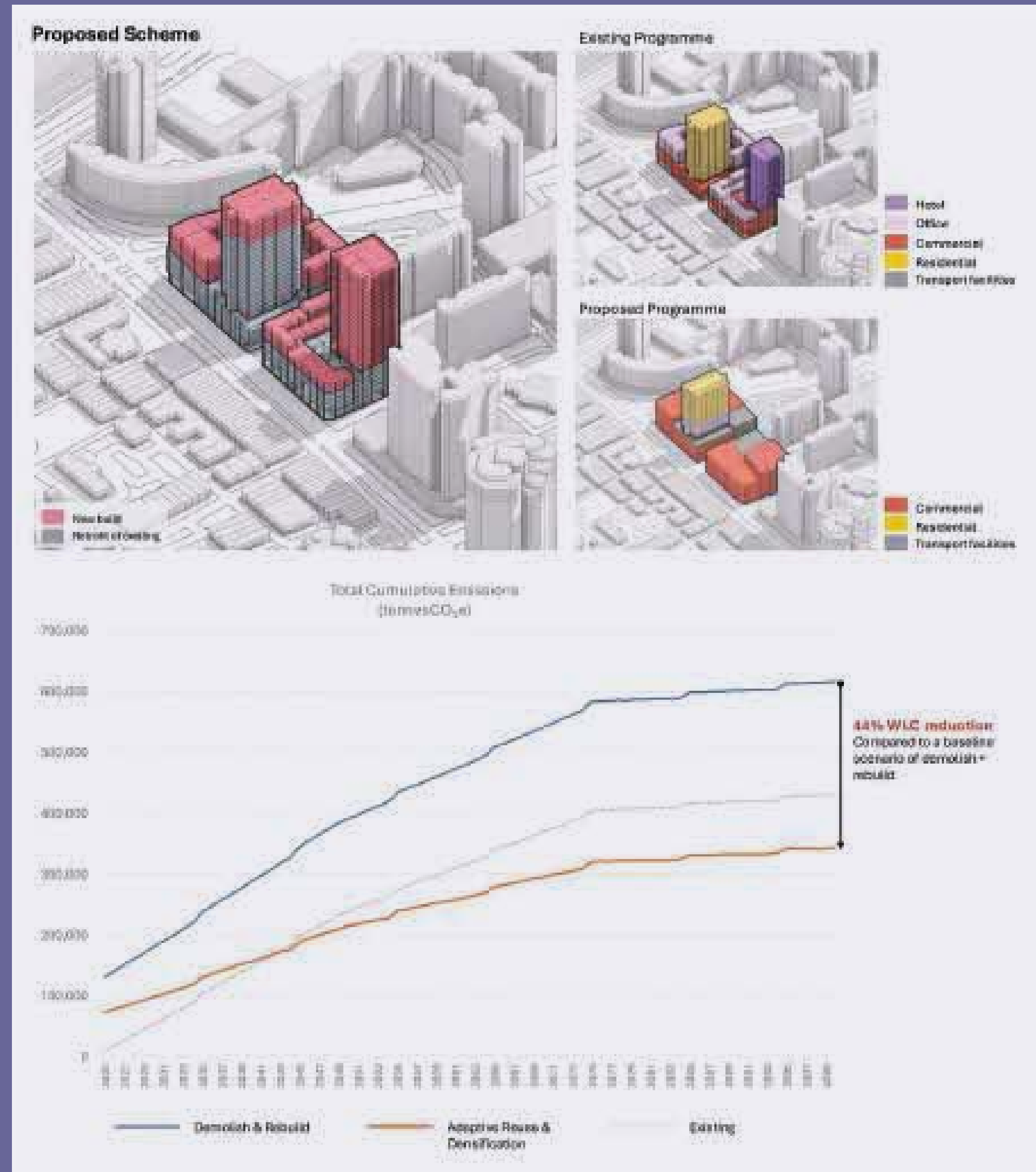
The built environment accounts for approximately 37% of global energy-related CO_2 emissions.[1] As electricity grids decarbonise and operational efficiencies improve, embodied carbon—the emissions associated with materials, construction, replacement and end-of-life processes—assumes a larger share of 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

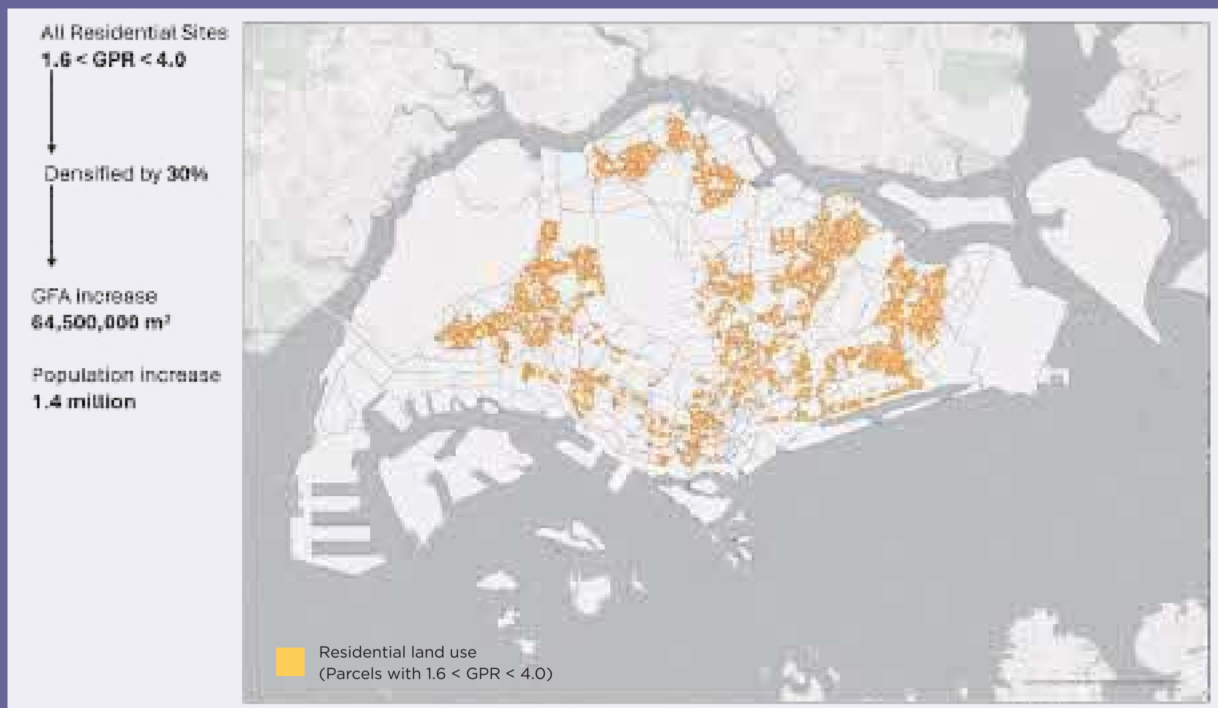
AR+Df responds to this situation with a set of design strategies. Envelope retrofits expand usable space while upgrading thermal performance. Vertical extensions add storeys to retained frames. Lateral extensions and strategic infill introduce new volumes alongside or between existing blocks. International 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.

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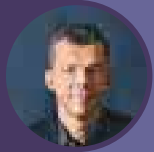

LEVERAGING THE CIRCULAR ECONOMY POTENTIAL OF EXISTING AND FUTURE BUILT ASSETS

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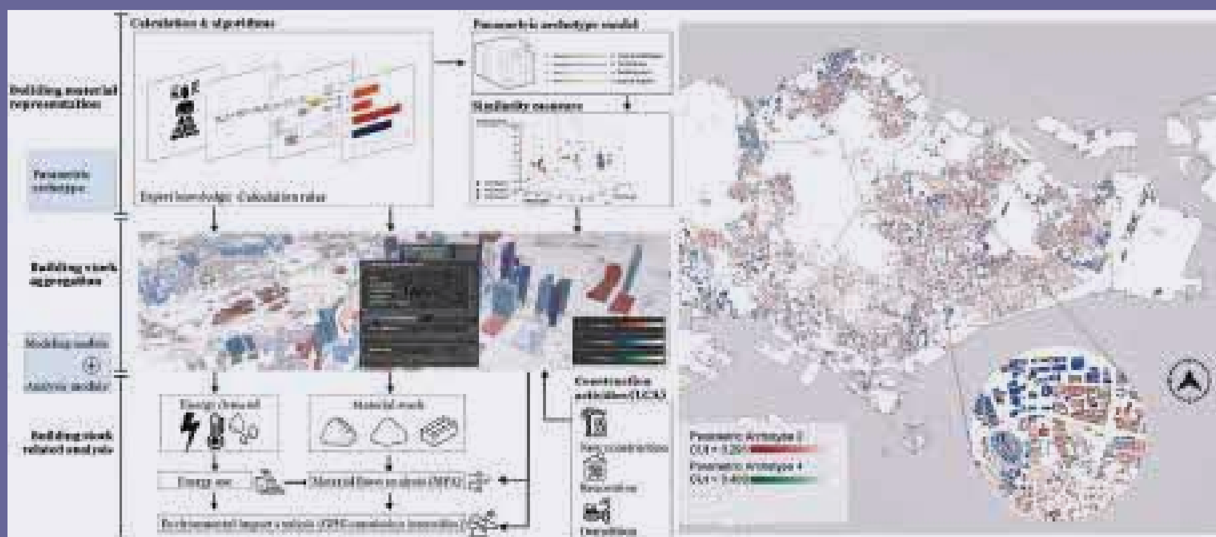
The construction industry is a major contributor to greenhouse gas emissions (GHG), with a significant portion of these emissions being embodied in construction components and materials. An opportunity to reduce these embodied emissions lies in the circular economy (CE). However, current practices rarely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

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.

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.

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)

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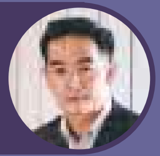


DRIVING REGENERATIVE URBAN DEVELOPMENT THROUGH GREEN MARK AND INNOVATION

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 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.

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

WHOLE LIFE CARBON BADGE	RESILIENCE BADGE
Cn	Re
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 $kgCO_2eq/m^2$ 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

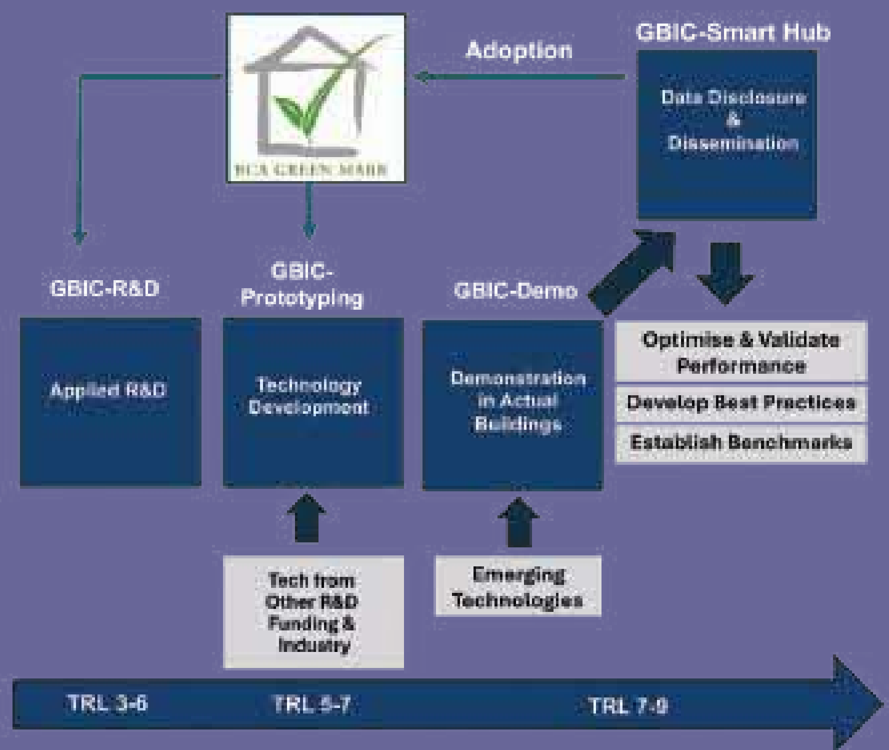
The 0.90-km^2 Jurong Lake Gardens Phase 2 Development exemplifies living with nature in a dense heartland, earning the BCA Green Mark Platinum Super Low Energy (SLE) rating with badges for Whole life Carbon, Resilience, and Health and Wellbeing. Under the Whole Life Carbon Badge, the project achieved a 55.48% reduction in embodied carbon, resulting in a low carbon intensity of 445.2 $kgCO_2eq/m^2$. 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 m^2 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

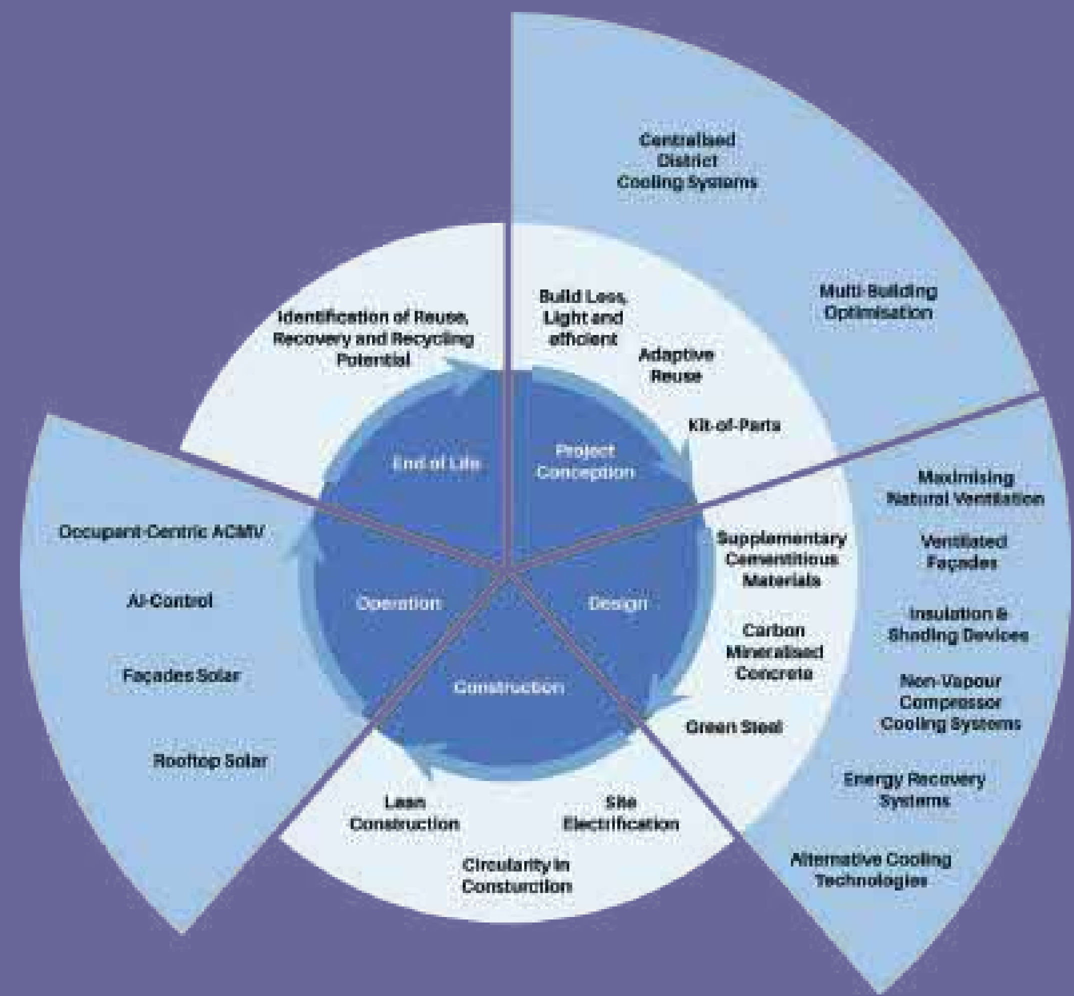
Powered by a robust innovation ecosystem, Singapore's building sector continues to push boundaries. Through the Green Buildings Innovation Cluster (GBIC)[3] Programme, the BCA partners with the industry to co-create next-generation research and development, prototyping, and demonstration solutions. To 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



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 geopolymer concrete with CO_2 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)	• CO_2 to aggregates • Geopolymer concrete with CO_2 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/.

GENERAL REFERENCES

Building and Construction Authority, "Green Mark 2021", last updated 25 March 2026, https://www1.bca.gov.sg/sustainability/greenmark/green-mark-2021/.

Centre for Liveable Cities, "USS R&I Congress 2026: Leveraging Science and Technology for Healthy and Regenerative Cities", 30 March 2026, https://knowledgehub.clc.gov.sg/publications/uss-r-i-congress-2026-leveraging-science-and-technology-for-heathy-and-regenerative-cities/.

Centre for Liveable Cities and Ramboll, *Creating a Regenerative City: Insights from the Centre for Liveable Cities-Ramboll Urban Lab* (Singapore: Centre for Liveable Cities, 2024).

National Climate Change Secretariat, *Charting Singapore's Low-Carbon and Climate Resilient Future* (Singapore: National Climate Change Secretariat, Strategy Group, Prime Minister's Office, 2020).

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)

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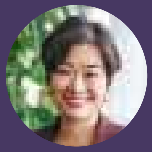

PUNGGOL DIGITAL DISTRICT: A BLUEPRINT FOR SUSTAINABLE MIXED-USE DEVELOPMENT

JACQUELINE POH
Chief Executive Officer, JTC, Singapore

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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 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.

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

"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.

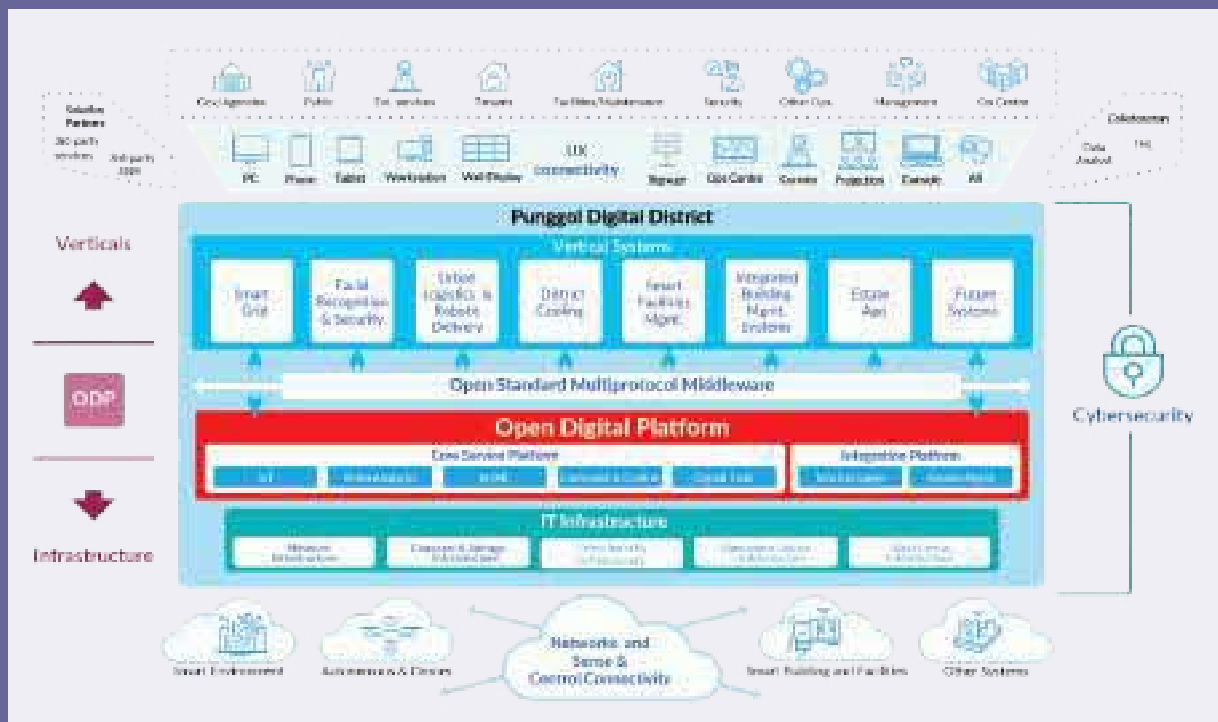
The mixed-use integration extends to comprehensive community infrastructure, with childcare facilities, healthcare services, recreational areas, the Punggol Coast Mall, and a hawker centre serving both the district's workforce and students alongside neighbouring Punggol residents. This creates a polycentric 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

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.

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

Smart Systems: Supporting a Greener District

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

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.

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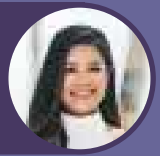


THE STORY OF PLACE: AN APPROACH TO PLACE-BASED REGENERATION

MARIANNE AMORES
Founder, The Regenesis 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?

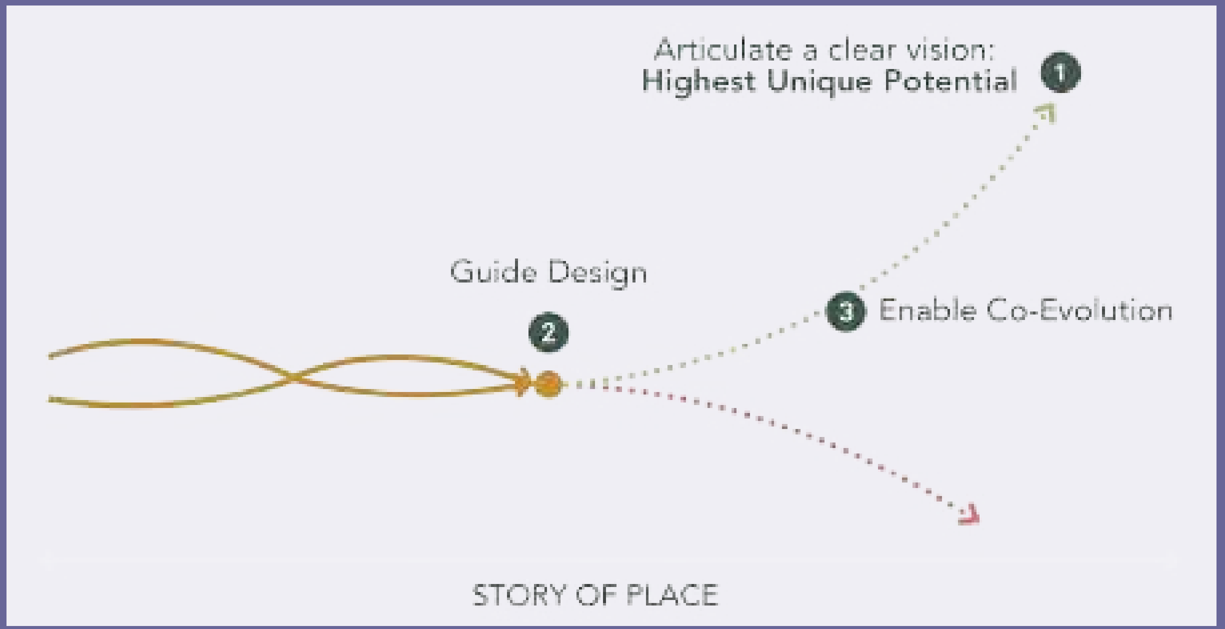
The Story of Place articulates a location's unique identity, essence, potential and role by tracing its evolution through interconnected ecological, socio-cultural, economic and infrastructural systems. It examines a city or site as a nested living system across space and time, revealing its trajectory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

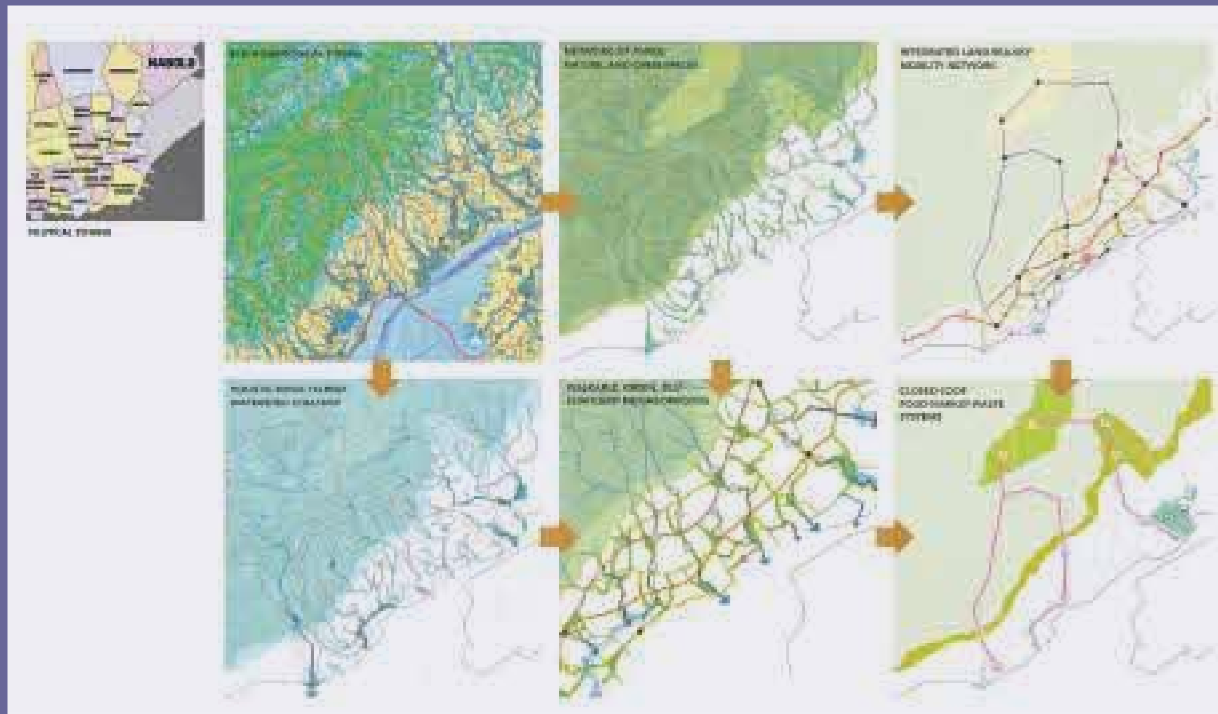
Pattern maps and design guide for Inabanga, Bohol.
Image courtesy of The Regenesis Project

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.



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 Regenesis 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.

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]

CASE STUDY

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

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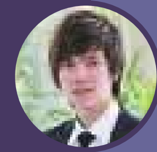

THE LIVING ALGORITHM: HOW ARTIFICIAL INTELLIGENCE SHAPES REGENERATIVE CITIES

ANG YU QIAN
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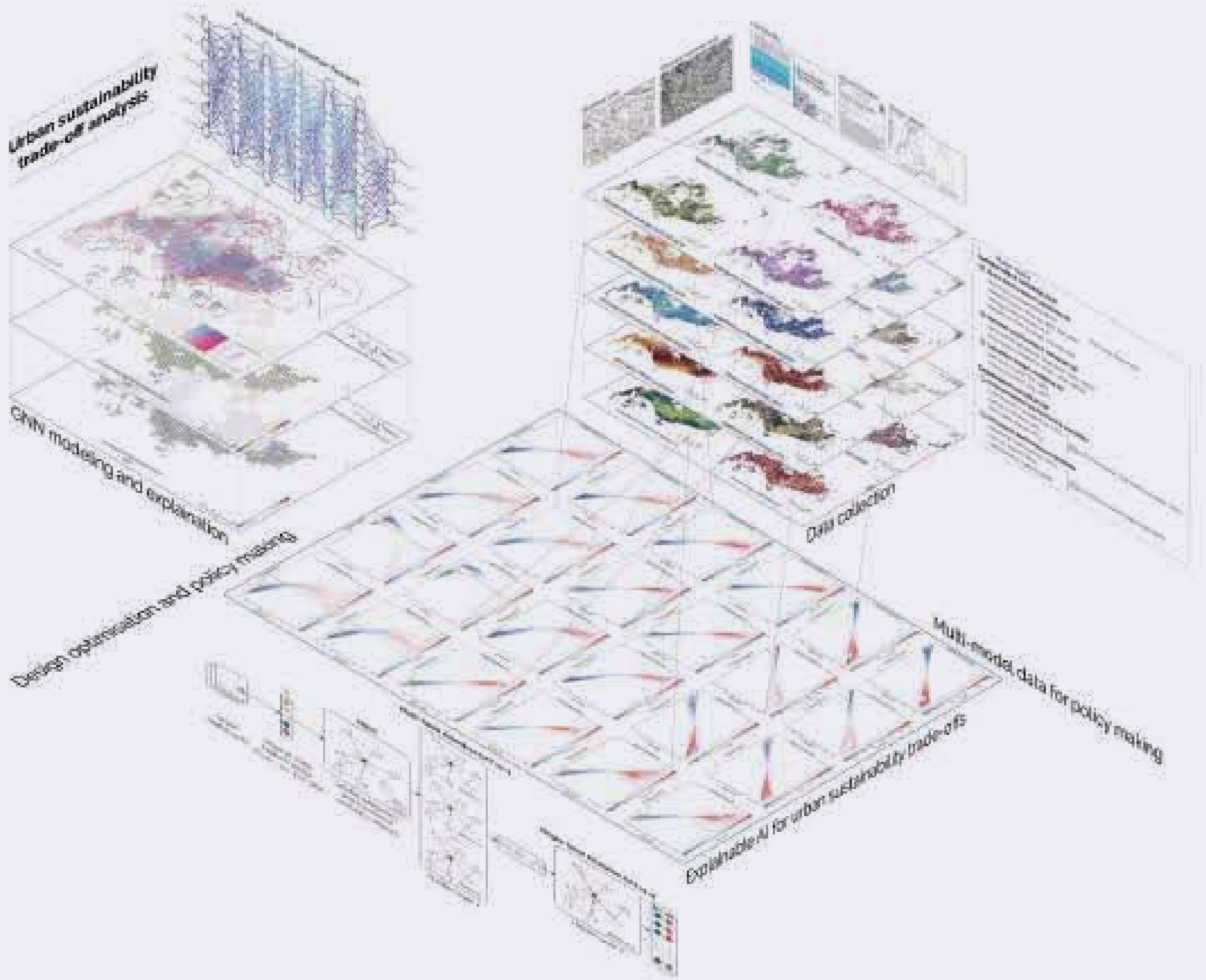
Department of the Built Environment, National University of Singapore

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.

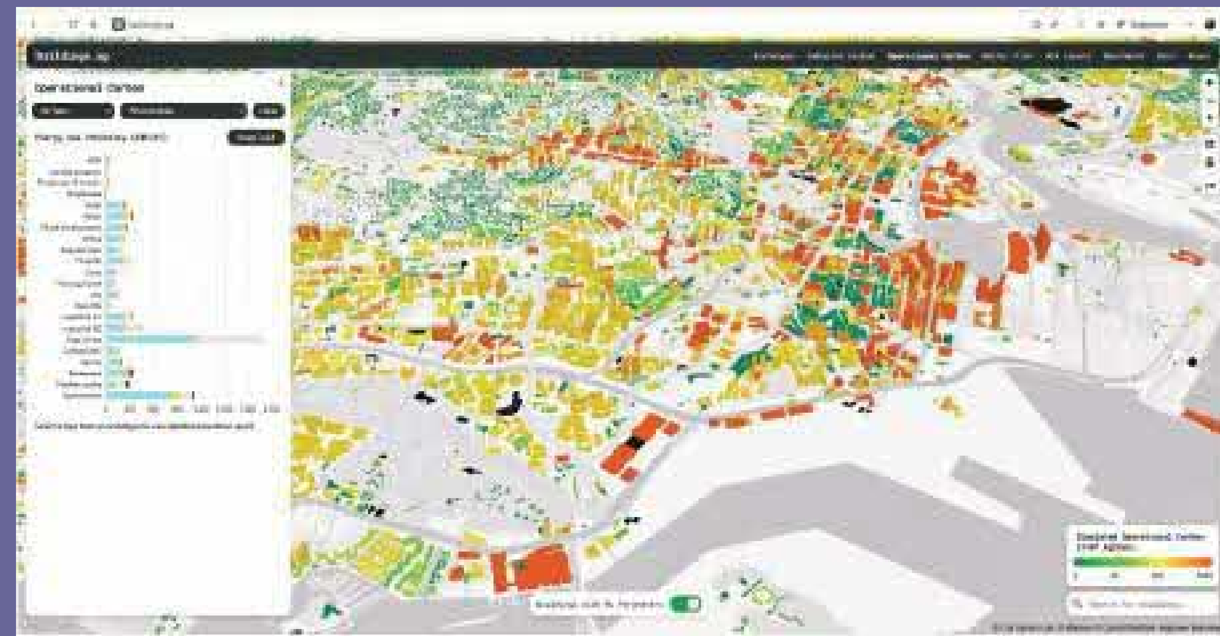
An overview of the CoolNUS-BEAM (Baseline, Evaluating, Action and Monitoring) Digital Twin and microclimate sensor network. Comprising 40 weather stations deployed at both ground and roof levels, 15-m-high meteorological towers, and rooftop infrared thermal cameras, this system forms one of the densest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

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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.

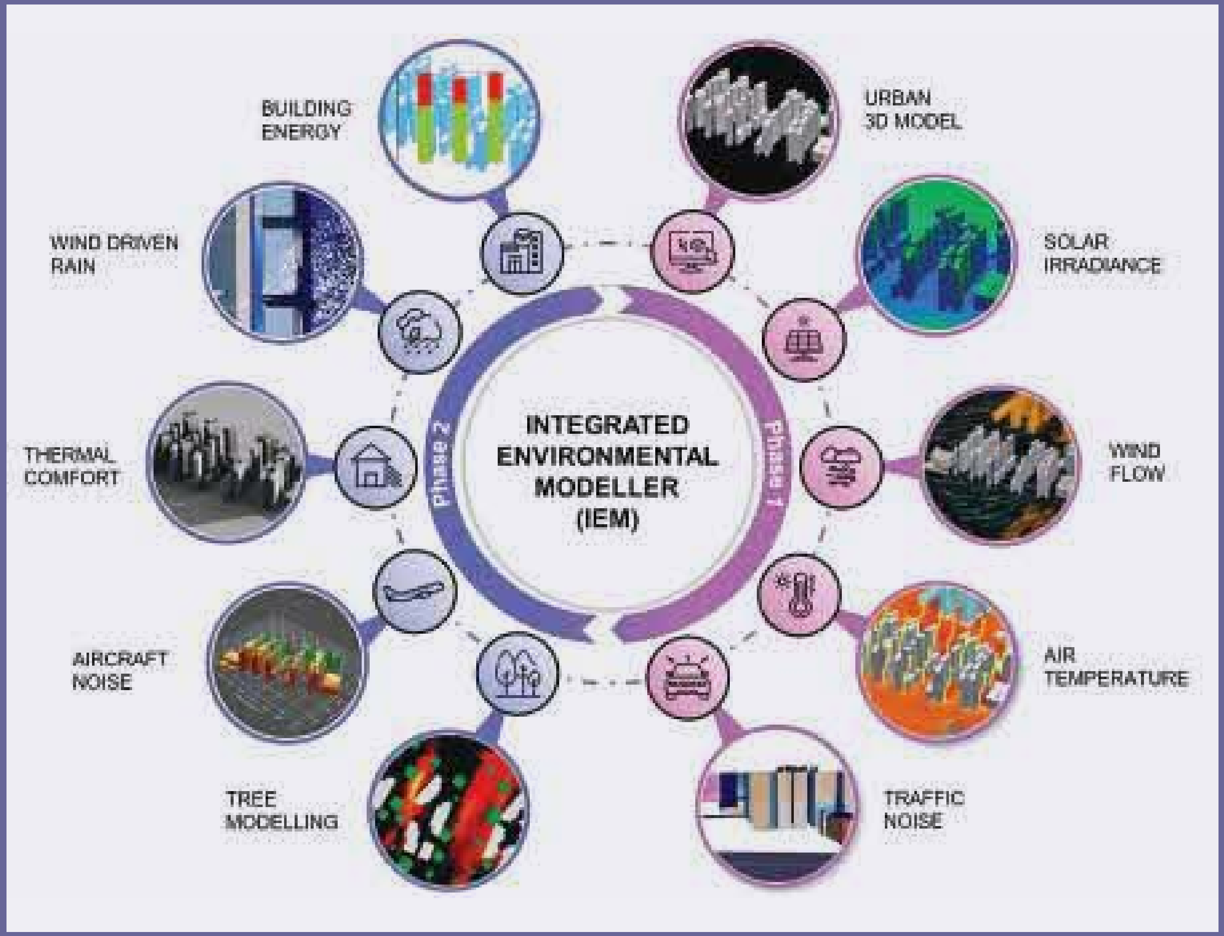
The HDB's first eco-town, Punggol, offers an ideal testing ground for implementing innovative sustainable housing solutions. At the same time, its waterfront location and undeveloped land provide opportunities to incorporate comprehensive environmental planning from the ground up. Punggol was therefore 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 S$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.

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

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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

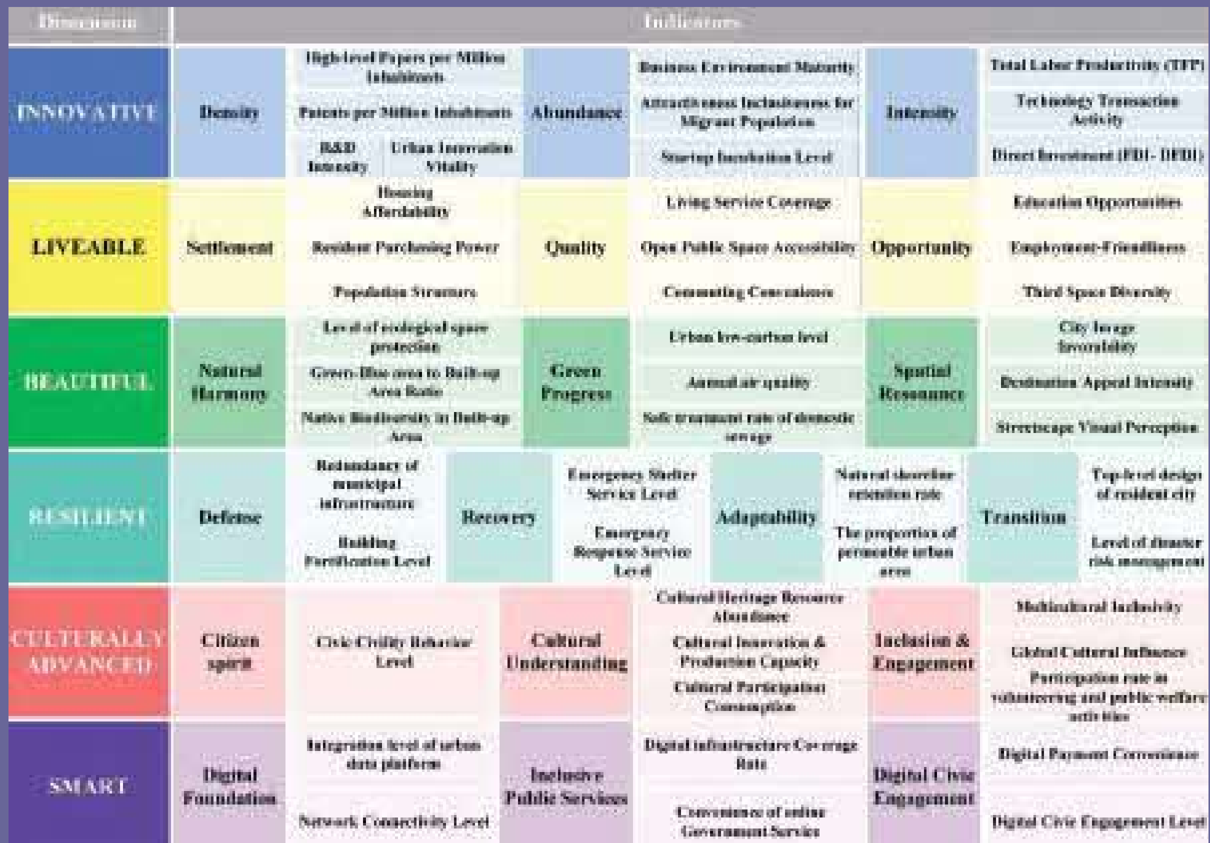
Shenzhen's local emissions trading scheme in operation, illustrating how carbon governance is embedded into everyday market mechanisms at the city scale.
Photo courtesy of Shenzhen Urban Planning and Land Resource Research Center

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.



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

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

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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 m^2 of green space and includes biodiversity nodes, dense native vegetation and family play areas.

Photo by DRONEIT, courtesy of Imágenes Barcelona