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URBAN SOLUTIONS

INTERVIEW

Shirley Rodriguez
Takeharu Yamanaka
Yvonne Aki-Sawyer

CITY FOCUS

Madrid

OPINION

Ravi Menon
Rahul Mehrotra

ESSAY

Winston Chow
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Nirmal Kishnani &
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CASE STUDY

Kotchakorn Voraakhom
Cristina Gamboa

Resilience and Regeneration II



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Resilience and Regeneration II

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From the Executive Director

A New Paradigm for Resilience: Regenerative Cities

With temperatures on the rise, more cities are trying to keep cool whilst adhering to net zero targets. Cities are also needing to house more people, amid greater resource constraints. Urban solutions need to address these intertwined issues, mitigating environmentally harmful activities as we build resilience against short-term shocks and long-term stressors.

The concept of regenerative cities proposes that urban development should lead to restorative relationships with nature, because it is from nature that the city draws resources. In this issue, I share CLC's working framework for regenerative cities, applying it across case studies from Singapore, London, and Bangkok.

The 27th issue, Resilience and Regeneration II, is a sequel to the 25th issue, where we started exploring how cities are building climate resilience in the face of multiple urban challenges. We continue that discussion by distilling regenerative cities into three key dimensions.

Systems thinking—Relationships across scale and disciplines

Shirley Rodrigues, former Deputy Mayor of London, shares the need for city governments to work with national and global governments to accelerate innovative policies for climate action. Ravi Menon, Singapore's Ambassador for Climate Action, underscores the need for regional coordination to build systemic resilience in the face of transboundary risks.

At the city-level, systems thinking acknowledges the interconnected nature of cities. Nirmal Kishnani and Wong Mun Summ, co-programme directors of MSc Integrated Sustainable Design at the National University of Singapore (NUS), posit that planning begins with analysing the exchanges and flows across urban systems.

Temporality—Harness circular flows through long-term planning

Time as a dimension suggests the need for a whole-of-lifecycle approach to harness circular flows. To enable this, Mayor Takeharu Yamanaka shares how the City of Yokohama embeds circularity principles into governance, effecting change from individual households to partnerships between cities.

Similarly, Rahul Mehrotra, the founder principal of RMA Architects, encourages us to think about transitional design, underpinned by the concept of a kinetic city.

People and the Environment—Interdependencies and mutual importance of social and ecological systems

Freetown, as Mayor Yvonne Aki-Sawyerr elucidates, is a testament to the positive impact of community partnerships and nature-based solutions. In Spain, Juan Azcárate and Antonio Morcillo from the Madrid City Council make a compelling case for how the thriving ecological systems of the Madrid Río enable local communities to flourish.

Likewise, Kotchakorn Voraakhom, founder of Landprocess, outlines how the prioritisation of human connectivity and biodiversity at Bangkok's Thailand Government Complex brought about inviting spaces for enhancing human-nature relationships.

I hope this issue of Urban Solutions will inspire truly resilient and regenerative cities, reconciling the tension between liveability and climate change.



Hugh Lim
Executive Director
Centre for Liveable Cities



IN CONVERSATION WITH
SHIRLEY RODRIGUES

Former London Deputy Mayor
for Environment and Energy
(2016-2024), Chair of the
Breathe Cities Advisory
Committee, Our Common Air
Commissioner, and member
of the Board of C40 Cities.

Advancing Climate Action through Global and Local Policies



Image: Daniel Hambury / @stellapicsltd



Cities can inspire others to go further and faster not just locally but globally in understanding emissions, setting targets and implementing climate action plans and initiatives to reduce emissions.



Rapid urbanisation is occurring globally, and by 2050, more than two-thirds of the world's population is projected to live in cities. Drawing from your experience as London's former Deputy Mayor, and as the current leader of various international organisations focused on cities, what do you think is the role of cities in advancing climate action?

Cities are absolutely critical to driving climate action. Most of the world's people, economic power, and investment are in cities and whilst they cover only 2% of the world's land surface, they use over 75% of the planet's material resources. They are also the places where we see the highest inequalities in society, and are often at the frontline of climate change and air pollution impacts. Over 2.6 billion people live in cities that do not meet the World Health Organization's guidelines for air quality.

But cities are also innovation and wealth creation hubs, with a strong civil society that can drive community-led action. They can play a leadership role by demonstrating local solutions which can then be replicated or scaled up to encourage sustainable behaviours.

This leadership is about inspiring others to go further and faster not just locally but globally too. C40's latest report demonstrates the huge progress cities have made in understanding their emissions, setting targets, and implementing climate action plans and initiatives to reduce emissions. These cities recognise that acting on climate change is not only a matter of self-preservation and protecting the vulnerable but also a huge economic opportunity. C40 Cities estimate that 50 million good green jobs can be created by climate action and building resilience, and recently reported that 16 million jobs are already supporting this transition.

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We engaged regularly with citizens and businesses to raise awareness of ULEZ’s benefits but also to understand their concerns. As a result, we amended the scheme to address perceived fairness issues whilst maintaining air pollution benefits.

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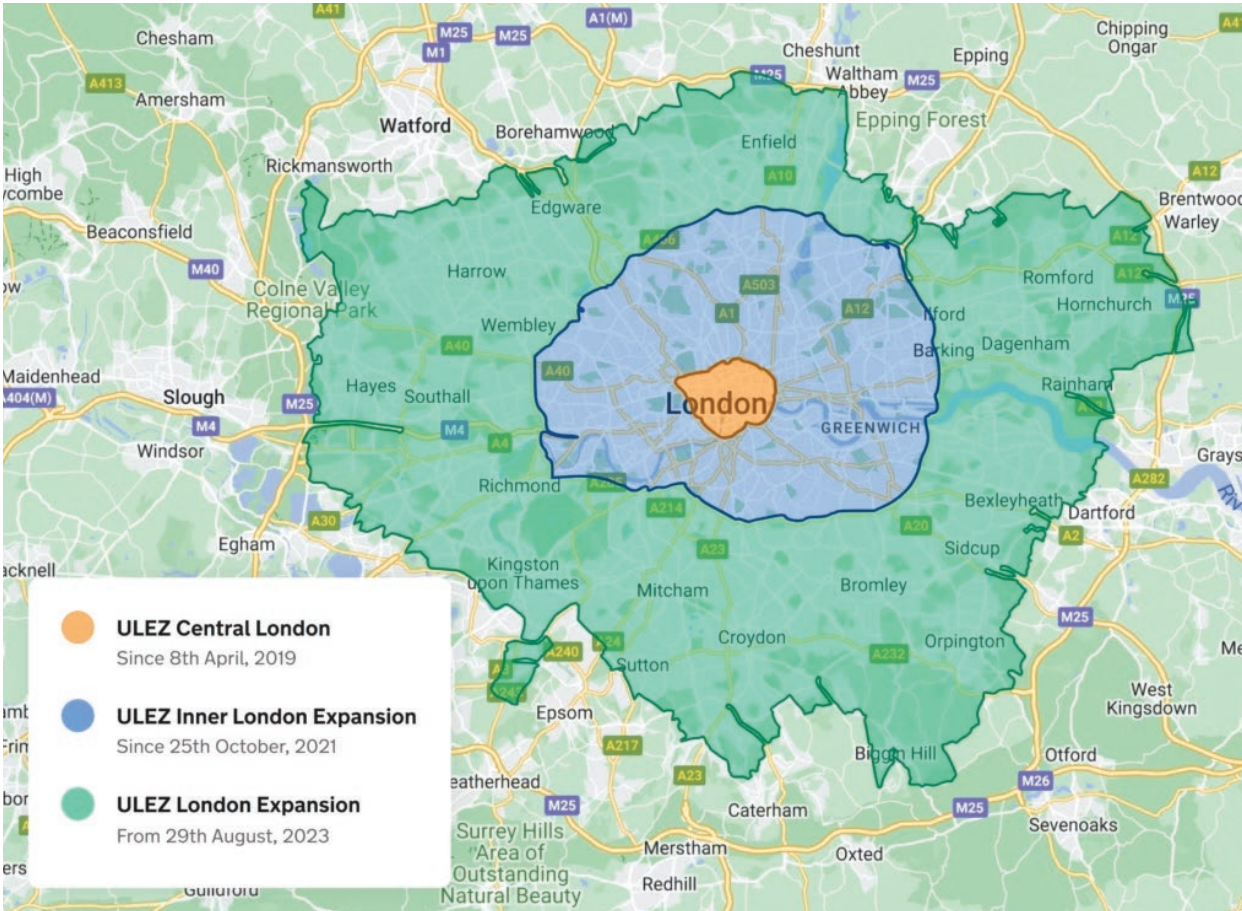
The Ultra-Low Emission Zone (ULEZ) was enacted during your time as deputy mayor to Mayor Sadiq Khan. It alleviated air pollution by creating chargeable zones that limited the use of polluting vehicles. The ULEZ was initially implemented only in Central London, then expanded to inner London in 2021. In 2023, the ULEZ was expanded a second time to all London boroughs—covering 9 million people across 1,500 km². What were the factors that enabled this scaling up to happen, and what are some of the learnings that other cities can take away from this initiative?

Poor air quality impacts everyone, everywhere. It is now the second leading risk factor for death, ahead of tobacco use—people are increasingly more likely to die from breathing toxic air than from smoking. Another is the issue of social and racial justice—the poorest are least likely to contribute to air pollution but are much more likely to live in the places with the worst air quality.

The situation in London was no different and ULEZ was successful because it was part of a larger set of policies that addressed this issue of poor air quality.

From the onset, we made sure that improving the environment whilst addressing inequality was core to the scheme. We focused on areas where we had the greatest power to act, such as transport. We built a robust case for action with strong evidence using independent research from many stakeholders, including universities and business organisations. This drew attention to a wide range of health, equity, and economic factors such as the economic cost of workers getting sick due to poor air quality.

We engaged regularly with citizens and businesses to raise awareness of ULEZ’s benefits but also to understand their concerns. As a result, we amended the scheme to address perceived fairness issues whilst maintaining air pollution benefits. For instance, we brought in discounts and exemptions from the charge for certain drivers, businesses, and charities and established scrappage schemes of more than £270 million. These initially supported the people who would most struggle to change their vehicles, and was later made accessible to all.



The Ultra Low Emission Zone was expanded in 2023.
Image: Motorway

We also provided alternative options of travel, and mitigations for drivers who would be affected by schemes like the Superloop (a network of 10 new express orbital bus routes in Outer London). The cycling network was quadrupled, the clean-up of buses and taxis was accelerated with more zero emission vehicles, and 18,000 electric vehicle charge points (making up a third of the UK’s infrastructure) were installed.

Any initiative seeking change has its detractors—but what has markedly increased over the last few years has been the level of misinformation and disinformation, and divisive political rhetoric. So, a key measure was building coalitions with those directly affected by air pollution—parents with children sick from air pollution, their doctors, business leaders, and faith groups. They were able to act as trusted messengers reminding people of the true cost of air pollution from people’s lived experience.

In London, these efforts have paid off with around 97% of all vehicles in London now ULEZ compliant, up from 39% when the scheme was first mooted. Harmful roadside nitrogen dioxide (NO₂) concentrations are estimated to be 27% lower across London. And, for some of the most deprived communities living near London’s busiest roads, there has been an estimated 80% reduction in exposure to illegal levels of pollution.

Another key priority during your term was rewilding London—bringing nature back into the city. According to the Final Report of the London Rewilding Taskforce (2023), London has invested more than £28 million in greening the city since 2016, and has over 1,600 sites covering 20% of Greater London protected for nature conservation. How does London balance human needs with ecological goals? Please share some of the strategies that London has adopted that you think can be replicated in other cities.

Ecological goals and human needs are not an either-or situation. We are dependent on our natural systems which help us to be more resilient to the impacts of extreme weather, as well as improve our health and wellbeing. Equally, the competition for land in urban spaces can lead to conflict as we seek to build more housing.

In London's example, Mayor Khan responded to this challenge by putting environmental and climate change at the heart of all his strategies, and making clear the need to balance these demands. The London Plan serves as a key vehicle, setting out the requirement to integrate nature into the built environment. Under the London Plan Guidance (LPG), the city has introduced an Urban Greening Factor tool to evaluate the quality and quantity of natural features proposed as part of development applications. Developers have to consider how they can install or retrofit more green infrastructure to enhance biodiversity and habitats, be it through sustainable urban drainage schemes, green roofs, or more accessible green spaces to act as places of respite from the heat or tackle flash-flooding. Often, such green-blue-grey infrastructures are more cost-effective than hard infrastructures.

Another area of opportunity that has been identified is integrating nature into our highways and streets. Transport for London and local boroughs have been installing rain gardens, and planting more trees and wildflower verges to attract bees and butterflies as well as provide shade for pedestrians. These actions help to make the highways more resilient to flash-flooding and improve overall air quality.



Two beavers were born in West London, an indication of the success of reintroduction through the rewilding of London.
Image: Londonist



An image of Waltham Forest rain garden.
Image: Liveable Neighbourhoods 2023, Transport for London



London Fire Brigade using the UK's first electric-hybrid fire engine.
Image: ITV

Local governments are asset owners and procurers of goods and services which are major levers for driving change.

As the former Deputy Mayor of London, you led programmes to tackle the impact of climate change in cities. Now, on the committees of international organisations, you advocate for the development of policies and initiatives at the local level. Can you share how local governments and international organisations can foster innovation to tackle climate change in cities? How are their approaches and strategies similar and/or different?

Local governments can pilot and fund innovative solutions to the problems their citizens face by using their areas as living laboratories. They are asset owners and procurers of goods and services which are major levers for driving change. The Greater London Authority and its agencies in London spend around £10 billion annually, and they set policy and regulation in many areas. London Fire Brigade's development of a first-of-its-kind electric-hybrid fire engine to reduce carbon emissions is just one instance of what local governments can do to drive innovation.

Their most powerful tool though is in welcoming and supporting innovation by facilitating and convening key actors in their cities, including business, universities, entrepreneurs, and community organisations. A brilliant example is Undaunted, a climate innovation hub consisting of Imperial College London, the Royal Institution, and the Grantham Institute—Climate Change and the Environment, and supported by the Greater London Authority. It has helped start-ups develop technology to tackle climate change and has secured over \$1.3 billion investment to scale their innovations whilst creating jobs.



This November, on the eve of COP30, the Mayors of London and Rio de Janeiro will bring together cities at the C40 World Mayors Summit, showing how cities can accelerate the global climate agenda. From left to right: Governor Sakaja Arthur Johnson of Nairobi, Mayor Giuseppe Sala of Milan, Mayor Anne Hidalgo of Paris, President of the C40 Board Michael Bloomberg, Mayor Sadiq Khan of London and Mayor Eduardo Paes of Rio de Janeiro
Image: C40

Whilst cities may have different politics, capacities, or governance systems, they all can benefit from participating in international networks like C40. These networks provide a platform for connecting with peers, sharing the problems and successes of different approaches, driving experimentation with technical support, and even getting funding. As a collective, they can raise ambition through friendly competition and drive progress, often faster than their national governments.

Having worked with many cities in your capacity as leader of international committees, can you share some memorable examples of innovative and impactful policies, or strategies that cities have adopted towards advancing climate action?

A couple spring to mind. The city of Oslo inspired the concept of climate budgeting to mainstream climate action and this is now being taken up by many other cities such as London, New York, and Mumbai. In London it is embedded in the financial budget process and this means that every budget decision of the city government is assessed with a climate lens. So, new projects like a new solar membrane for London's Olympic Stadium get higher priority, while decisions that are contrary to climate goals—like buying new fossil fuel vehicles—are replaced with more sustainable options.

The other is the Breathe Cities initiative. This partnership between Bloomberg Philanthropies, the Clean Air Fund, and C40 Cities is working for a 30% reduction in air pollution across participating cities by 2030 to save lives, improve health, and cut carbon emissions. This initiative demonstrates how data and technical capacity can be leveraged to invoke inclusive climate action. Using local knowledge to design solutions that are specific to their

Cities and their leaders play a pivotal role in influencing national level decisions. CHAMP now has 74 national governments committing to greater collaboration with their cities and regions on their national climate strategies, as well as nationally determined contributions for COP30.

city's needs, local communities are empowered to reduce their exposure to air pollution. This is driving the establishment of stronger policies that reduce air pollution, such as the first city-owned air quality monitoring network in Nairobi, or Warsaw's Clean Air Zone which could reduce traffic-related pollution by half within this decade.

Moving forward, how can we build a collaborative ecosystem where international organisations, local governments, and city leaders complement one another's efforts in advancing climate action?

It is key for all of us to work together to cut emissions and to stop further accelerating the impacts of climate change. Greater collaboration with businesses, for example, can cut emissions and climate risk, bringing about better outcomes that mutually benefit stakeholders. At the same time, we also need to work with informal communities to incorporate grassroots solutions. And of course, working with national governments too. On the eve of COP30, as part of the Local Leaders Forum co-hosted by Bloomberg Philanthropies and the COP30 Presidency of Brazil, the C40 World Mayors Summit will bring together mayors from around the world who are delivering urgent, fair and ambitious climate action.

At COP28, the Coalition for High Ambition Multilevel Partnerships (CHAMP) for Climate Action was established to enhance cooperation between national and subnational governments in the planning, financing, implementation, and monitoring of climate strategies. This is a reflection of national governments' growing recognition of the pivotal role that cities and their leaders play in influencing national level decisions. CHAMP now has 74 national governments committing to greater collaboration with their cities and regions on their national climate strategies, as well as nationally determined contributions (NDCs) for COP30, Belem. But more still need to come on board.

We all have to collaborate, whether formally or informally, and leverage our strengths to prevent the worsening impacts from climate change, and to protect our people and nature. 🌱



IN CONVERSATION WITH
TAKEHARU YAMANAKA

Since 2021, Mayor Takeharu Yamanaka has been leading Yokohama's ambitious initiatives, advancing Yokohama as a world-leading circular city.

Yokohama Leading the Global Shift to a Circular Economy



Image: © City of Yokohama

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In the face of climate change, the role and responsibility of cities are critical. Yokohama is working in close partnership with citizens and businesses to promote comprehensive efforts towards a sustainable circular society.

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Besides being a major international trading port, Yokohama is a renowned thriving economic hub, which attracts a diverse range of industries from information technology to advanced manufacturing. It is also Japan's largest city-level municipality, housing around 3.8 million residents. As a port city, what projected climate risks does the city face, and how do these risks affect Yokohama's economy and people?

In the face of climate change, the role and responsibility of cities are critical. Yokohama possesses a coastline extending approximately 140 kilometres, where around 3.8 million residents live and over 110,000 businesses operate. As climate-related disasters grow in frequency and intensity, they pose serious threats to both daily life and economic activity. To mitigate and adapt to these risks, Yokohama is strategically advancing infrastructure development, including coastal protection facilities. At the same time, the city is working in close partnership with citizens and businesses to promote comprehensive efforts towards a sustainable circular society—contributing to the global challenge of tackling climate change through local action.

Yokohama has set ambitious climate goals: to cut greenhouse gas emissions in half by 2030 and to reach net zero by 2050. In addition to decarbonisation, the city is prioritising the transition to a circular economy. What are some notable decarbonisation initiatives and programmes that the City of Yokohama has implemented to achieve this target?

Realising a decarbonised society requires broad-based participation by both citizens and businesses. Cities, being closest to them, play a vital role in raising environmental awareness and encouraging behavioural change. Yokohama promotes climate policy through four pillars:

1. Empowering citizens
2. Empowering businesses
3. Implementing innovative technology
4. Taking actions as a local government

II

Minato Mirai is a central business district where we have implemented ambitious climate actions, thus developing an urban model for a green future.

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Minato Mirai is a central business district where we have implemented ambitious climate actions, thus developing an urban model for a green future. This 2 km² hub, employing 140,000 people and accounting for 10% of the city's commercial energy consumption, has been designated as a "Leading Decarbonisation Area" by Japan's Ministry of the Environment. Through a combination of rooftop solar power, office energy efficiency, and renewable energy procurement from outside the district, it aims to achieve net-zero CO₂ emissions in the commercial sector by 2030. This public-private collaboration serves as a model for large cities.

Another example is our Carbon Neutral Port. Yokohama is advancing the "Port and Harbour Decarbonisation Plan for the Port of Yokohama", which aims for net-zero CO₂ emissions in Yokohama's waterfront area by 2050, formulated together with thermal power producers, oil refiners, shipping companies, and financial institutions. This plan includes three policies: decarbonisation of industries, decarbonisation at terminals, and creation of an abundant ocean. It identifies 121 port decarbonisation projects through public-private partnerships.

The project promoting this plan became the first in Japan to win the Climate and Energy category of the International Association of Ports and Harbors (IAPH) 2025 Sustainability Awards, contributing globally as knowledge that can be applied to ports worldwide.

In terms of citizen engagement, Yokohama has introduced a recycling system for plastics that were previously incinerated, reducing CO₂ emissions from waste disposal. To ensure success, the city has worked closely with neighbourhood voluntary clubs to promote public understanding and behavioural change. It has also expanded shared bicycle ports through deregulation, encouraging low-carbon mobility.



The Port of Yokohama: JAPAN's PORT, which has a variety of functions such as logistics, production and tourism.
Image: © City of Yokohama



In Yokohama, a profound culture of conscientious waste separation permeates among citizens. Even at music festivals held at serene seaside parks, meticulous segregation of refuse ensures its transformation into valuable resources.
Image: © City of Yokohama

Finally, to support SMEs, we allow Yokohama's 73,000 small and medium-sized enterprises to declare their decarbonisation efforts to access subsidies, loans, and technical assistance. The city provides tools for visualising emissions, supports planning, and offers funding for energy-efficient equipment and solar installations.

Why has Yokohama made the circular economy a central policy pillar?

The transition to a circular economy not only contributes to climate change mitigation but also represents a pursuit of a better society and enhanced urban sustainability.

Yokohama has already established a strong presence in the international community in the environmental field, and we aspire to take an even greater lead in shaping the global momentum towards solutions. To advance these efforts, Yokohama is pursuing the transition towards a circular city by interlinking six key drivers—termed the "Circular Link":

1. Strengthening Ties between Manufacturers and Recyclers
2. Applying Circular Design in Public Buildings
3. Measuring Circular Inflow and Outflow Rates (%) in the Central Business District
4. Promoting Civic Involvement through Circular Lifestyles
5. Circulating Food Loss as Compost in City Farms
6. Fostering SMEs' Shift to Circular Management



The "Food Loss Reduction Vending Machine" is an unmanned, locker-style vending machine that sells food at affordable prices to reduce food waste. It offers items that are still within their expiration dates but would otherwise be discarded due to factors such as store operating hours or product standards. Yokohama is also advancing the development and implementation of a system to collect used cooking oil from households and recycle it into sustainable aviation fuel (SAF).
Image: © City of Yokohama

What specific circular economy initiatives are being implemented?

With a rich ecosystem of manufacturing (arterial industries) and recycling (venous industries) businesses, Yokohama is cultivating synergies between these sectors to drive the emergence of new industries that support a circular economy and generate employment. Minato Mirai has begun a pioneering initiative to visualise the circulation of resources at the district level—quantifying both inflows and outflows to create Japan's first measurable model of resource circularity. The city is also advancing circular architecture. For example, temporary school buildings in central Yokohama are designed for disassembly and reuse, minimising waste and environmental impact. Students at the school are also engaged in experiential learning, using sorting bins made from upcycled marine plastics and creating crayons from food waste such as discarded vegetables.

Yokohama is also advancing horizontal recycling initiatives, such as the re-manufacturing of unwanted clothing into new products. To reduce food loss, the city is promoting a variety of innovative programs led by the municipality, including the "Food Loss Reduction Vending Machine" that sells food items that are safe for consumption, but at risk of being discarded due to factors such as store operating hours or stringent product standards, like breads approaching its expiration date, and a scheme to collect used cooking oil from households for the production of sustainable aviation fuel (SAF).

These sustainable initiatives and lifestyles adopted by citizens and businesses to advance the realisation of a circular society are brought together under the banner of "STYLE100". Through dissemination on websites and social media, as well as hands-on implementation at participatory events, Yokohama fosters public engagement and behavioural change, broadening the circle of action.

II

Yokohama is the first city in the world to be recognised by the OECD for its climate action.

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How is Yokohama engaging internationally to advance decarbonisation and circularity?

As Mayor, I serve as an OECD Champion Mayor for Inclusive Growth and as East Asia regional representative for the Global Covenant of Mayors for Climate & Energy. In May last year, I was the only Asian mayor invited to the Vatican Climate Summit, where I delivered a speech on Yokohama's initiatives and engaged with global city leaders to strengthen resilience against climate impacts. In March this year, Yokohama hosted a joint seminar with the Intergovernmental Panel for Climate Change (IPCC) to ensure Japanese local government perspectives are reflected in the forthcoming Special Report on Climate Change and Cities. I gave the keynote address, presenting Yokohama's decarbonisation and circular economy efforts, and emphasising on the critical role of cities.

Yokohama is also the first city in the world to be recognised by the OECD for its climate action. The OECD's 2024 review praised our wide-ranging public-private collaborations and our contributions to sustainable urban development in Asia.

At the 9th Tokyo International Conference on African Development (TICAD 9), held in Yokohama this August, I highlighted our green initiatives to African leaders and met with UN Secretary-General António Guterres, who described Yokohama as "one of the most cosmopolitan cities in the world". In September, I spoke at the EU's Circular Economy Days Programme at Expo 2025 in Osaka, engaging in dialogue with European policymakers and reinforcing Yokohama's leadership in advancing global environmental policy.



International Outreach—In May 2024, Yokohama's Mayor was the only city leader from Asia invited to the Climate Summit held at the Vatican, where he presented the city's initiatives for climate change mitigation.
Image: © City of Yokohama



At the forthcoming ASCC2025, I intend to spearhead a strategic initiative—jointly with Asian city leaders—to catalyse momentum for the advancement of circular cities across Asia.



Could you share examples of international cooperation with other cities and regions?

Since signing a memorandum with Bangkok in 2012, Yokohama has had over 20 exchanges with Bangkok, contributing expertise to Bangkok's Climate Change Master Plan and Energy Action Plan. Yokohama also hosts the annual Asia Smart City Conference (ASCC), which serves as a platform for knowledge sharing and project creation among cities, international organisations, governments, and businesses. Last year, it attracted over 2,000 participants from 39 cities and institutions. At the forthcoming ASCC2025, I intend to spearhead a strategic initiative—jointly with Asian city leaders—to catalyse momentum for the advancement of circular cities across Asia.

Looking ahead, Yokohama will co-host the Asia-Pacific Urban Forum (APUF) with the UN Economic and Social Commission for Asia and the Pacific (ESCAP) in 2027, bringing together diverse stakeholders to discuss sustainable urban futures.

Through these initiatives, Yokohama will continue to lead international dialogue and actions, aiming to inspire other cities to scale and speed up climate initiatives



Asia Smart City Conference—In October 2024, under the theme “Decarbonising Asia,” Yokohama hosted the Asia Smart City Conference, sharing insights on balancing economic growth with urban environmental sustainability. With the support of 39 overseas cities and government agencies, the Yokohama Declaration was issued to promote the realisation of green societies across Asia.
Image: © City of Yokohama



GREEN×EXPO, opening in March 2027, will serve as a global platform to showcase innovative technologies and initiatives aimed at building a sustainable and green society in harmony with nature. Yokohama will share its vision for a better future with the world, through the theme “Living in harmony with the environment, creating together with everyone”.
Image: Main Garden © Expo 2027



GREEN×EXPO 2027 will show how fostering a harmonious relationship with the environment can address global challenges.



Sincere congratulations on your recent re-election. As you begin your second term, what are your aspirations for Yokohama's sustainable future?

Thank you. I remain committed to advancing decarbonisation and the circular economy, ensuring safety and security for our citizens, and contributing globally through policies shaped with an international perspective.

An upcoming milestone will be GREEN×EXPO 2027, an A1-ranked world expo certified by the International Association of Horticultural Producers (AIPH). The event will show how fostering a harmonious relationship with the environment can address global challenges. Surrounded by 10 million flowers and plants, the venue will welcome visitors with opportunities for discovery and learning, both day and night.

At GREEN×EXPO, exhibitions and experiences will range from cutting-edge technologies contributing to the realisation of a green society, to interactive programmes on agriculture and food supported by biodiversity. These are offerings that people from around the world can enjoy.

Visitors will also be able to appreciate Japan's traditional aesthetics, including gardens, ikebana, and bonsai, crafted with the highest levels of expertise and artistry. Through this exhibition, we aim to inspire people everywhere to begin embracing lifestyles in harmony with the Earth, starting in Yokohama, and expanding across the globe.

We warmly invite all to join us in these efforts, as we work together towards realising sustainable circular society. 🌱



IN CONVERSATION WITH
YVONNE AKI-SAWYERR

Freetown's Innovative and Collaborative Climate Agenda

Yvonne Aki-Sawyerr OBE was Mayor of Freetown from May 2018 to February 2023 and was re-elected to serve for a second term in June 2023.



Image: © Freetown City Council | Capital of Sierra Leone

Freetown's first Climate Action Plan was developed in 2020 based on international standards such as C40 Cities' Climate Action Planning Framework, set to meet the goals of the Paris Agreement—to limit global warming to 1.5°C and strengthen climate resilience by 2050. It comes after the broader "Transform Freetown—Transforming Lives" agenda, in which climate action is one of four strategic clusters.

Apart from climate change, Freetown also faces several competing needs such as health and sanitation, economic growth, and air pollution. Nevertheless, you have championed the climate change agenda and prioritised it for the city. Please share with us what were the challenges of developing the first Freetown Climate Action Plan?

When I campaigned to be Mayor in 2018, I presented a platform that prioritised addressing the consequences of climate change, especially those that were already being experienced by residents of Freetown—flooding and landslides. As we subsequently developed the Transform Freetown agenda, resilience was elevated as one of the strategic clusters, with environmental management and climate action at its core.

The preparation of our strategy towards climate action, which ultimately informed the Climate Action Plan in 2020, required an institutionalised response to climate change. From a policy leadership standpoint, we first established a Climate Change and Disaster Response Committee and later created a dedicated Climate Change and Disaster Response Department within the Council.

Developing the Climate Action Plan itself was challenging. While we had a broad understanding of the climate issues, particularly from an adaptation perspective, there was a lack of detailed, evidence-based information. Much of the existing knowledge was anecdotal. For this reason, the formulation of the plan required robust research which was intense and time consuming. We were thrilled that at this stage, C40 Cities provided us with a technical expert who was able to dedicate time and expertise to support the research and analysis process.



The Climate Action Plan represents a refinement and expansion, a more detailed and data-driven articulation of interventions and areas of focus already established in the Transform Freetown Agenda.



How did the City of Freetown leverage existing key policies and frameworks, like the Transform Freetown Agenda and the #FreetownTheTreeTown community tree planting programme, to set the climate agenda and inspire change?

The Transform Freetown Agenda was published in 2019, a year prior to the launch of the Climate Action Plan. On 3 January 2020, the #FreetownTheTreeTown community tree planting programme was initiated. These interventions predated the Climate Action Plan but served as important foundations for its development.

The relationship between the Climate Action Plan, and the Transform Freetown Agenda is direct and evident. Most of the measures outlined in the plan originated from priorities set within the Transform Freetown Agenda, particularly in relation to resilience and environmental management. The overarching strategy for climate action is therefore built on both: the #FreetownTheTreeTown initiative as a core intervention, and the Transform Freetown Agenda as the structural framework.

Also incorporated within the framework were green urban mobility, and sanitation and waste management, which have since been embedded in Freetown's strategy for climate action. In this sense, the Climate Action Plan represents a refinement and expansion, a more detailed and data-driven articulation of interventions and areas of focus already established in the Transform Freetown Agenda.

It has been six years since the announcement of the Transform Freetown Agenda, and almost five years since the release of the Climate Action Plan. How is the progress of climate action in Freetown?

Implementation has been progressing, though not without challenges. For example, while the feasibility study for the proposed cable car system has been completed, we have yet to secure government support to mobilise



Mayor Yvonne Aki-Sawyer OBE planting a tree as part of Freetown's urban greening drive.
Source: © Freetown City Council | Capital of Sierra Leone

the necessary financing. Similarly, for our carbon credit accreditation process, which is a key component of our climate strategy, we have elected to take an important step forward even amidst ongoing financial constraints. Our progress is measured annually, with reports aligned to the Climate Action Plan, ensuring both transparency and accountability in Freetown's climate journey.

We are making notable progress along many fronts, including with our tree planting initiative. Among the more than 1.2 million trees planted, we have had an impressive 82% survival rate. In Kroo Bay, one of Freetown's most flood- and erosion-prone communities, residents have planted over 75,000 mangroves with the support of the World Bank and Bloomberg Philanthropies. This initiative is restoring vital natural buffers, enhancing community participation, raising awareness, and creating cooler, greener neighbourhoods, while also providing protection against mudslides and flooding.

Our flood mitigation programme continues to thrive through strong youth engagement, with community-led teams mobilised to clear and maintain drainage systems, thereby strengthening local resilience and reducing disaster risks in vulnerable areas.

In collaboration with C40 Cities' Breathe Cities and African Cities for Clean Air, we are advancing air quality management by establishing pollution baseline levels and deploying low-cost sensors across the city. This will help us identify pollution hotspots and better assess residents' exposure to harmful air pollutants. With support from the Rockefeller Foundation's "Enhancing Heat-Health Resilience" project, we are also integrating climate and health data collection, delivering community training, and fostering inter-agency collaboration to address the growing risks of extreme heat.



Mayor Yvonne Aki-Sawyer OBE visiting the Kingdom Faecal Sludge Treatment Plant in Freetown.
Source: © Freetown City Council | Capital of Sierra Leone

II

Strategic partnerships have enabled us to move beyond ambition to implementation and to demonstrate that with the right alliances, cities can deliver impactful and sustainable climate solutions.

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Furthermore, the introduction of the 2024 New Sanitation By-laws marks a landmark reform, modernising and formalising waste management in the city through Public-Private Partnerships. This is an essential part of our broader climate action interventions.

Finally, we continue to raise public awareness on the protection of water catchment areas and are implementing slope stabilisation measures to safeguard communities from flooding, landslides, and water insecurity.

#FreetownTheTreeTown adopted a first-of-its-kind "pay-to-grow" scheme where city residents partnered with private and carbon markets, which helped to fund the planting and monitoring of trees and mangroves. Similarly, the Freetown Heat Action Plan was launched in 2025, in conjunction with the first African Urban Heat Summit, to bring together city leaders and climate experts from African cities to collaborate on solutions to mitigate rising heat across African cities.

What is the role of stakeholder partnerships in advancing climate action for the City of Freetown? How has engagement with different stakeholders transformed Freetown's approach to climate change?

Freetown City Council remains severely under-resourced, reflecting broader economic constraints, limited local revenue mobilisation, and restrictions on borrowing or accessing capital markets. In this context, partnerships have been transformative.

For example, through the Bloomberg Philanthropies' Mayors Challenge, we were able to secure the funds required for accrediting the #FreetownTheTreeTown initiative. This was a prerequisite step for participating in the carbon market, and has subsequently paved the way for our long-term financial sustainability. And, with support from the UK Government's Foreign, Commonwealth and Development Office (FCDO), we constructed the city's first wastewater treatment plant, which enables the conversion of faecal sludge into briquettes, thereby reducing reliance on charcoal and firewood for cooking. Likewise, collaboration with the C40 Cities Finance Facility facilitated the completion of the cable car feasibility study.

Without these strategic partnerships, the scope and scale of our climate action efforts would have been significantly diminished. They have enabled us to move beyond ambition to implementation, and to demonstrate that with the right alliances, cities can deliver impactful and sustainable climate solutions.

Our heat action initiatives are primarily directed towards vulnerable groups, particularly residents of informal settlements.

Temperatures in informal settlements in Freetown can rise up to 6°C higher than surrounding regions. The City of Freetown's Heat Action Plan therefore sets out to equitably and sustainably combat heat risks, while bolstering urban resilience, particularly for the most vulnerable. How does the City of Freetown ensure that the Heat Action Plan enhances heat resilience for all of Freetown's urban population?

Our heat action initiatives are primarily directed towards vulnerable groups, particularly residents of informal settlements. As the area of urban heat adaptation is relatively new, our approach has necessarily involved testing and refining interventions. For instance, we introduced shade covers in markets to protect informal sector workers, especially women traders. The initial design proved effective during the dry season but was unable to withstand wind and rain during the rainy season. A redesigned model has since been developed and successfully tested, continuing to prioritise the protection of these workers.

We have also implemented measures related to roofing and the expansion of urban tree cover. Heat-mapping exercises identified the locations of urban heat islands and highlighted the heightened impact of corrugated iron roofing in informal settlements with minimal vegetation. These findings informed targeted investments in tree planting and greening in those areas. In addition, we set objectives for the creation of green corridors. While implementation has faced delays, other interventions have been successful. For example, the construction of a heat pavilion has provided both a place of respite from extreme heat and a visible demonstration of climate-responsive urban design. Furthermore, pilot tests of roof-cooling materials have shown promise and are now being evaluated for potential scale-up.

Collectively, these efforts represent an evolving, evidence-based approach to reducing heat risks and protecting vulnerable urban populations.



Freetown the Treetown was a 2023 Finalist for the Earthshot Prize.
Source: *The Earthshot Prize*

How do you hope to see Freetown transform in the next 5 to 10 years?

Looking ahead, gaining authority over land-use planning and building permitting will enable significant expansion of green spaces across the city. I also anticipate the Freetown Cable Car to become operational and two wastewater treatment plants to be constructed. In addition, the mechanisation of briquette production is expected to substantially reduce reliance on wood and charcoal for cooking—cutting pollution, lowering emissions, and preserving tree cover.

From a sanitation perspective, the new by-laws should, within the next five years, be firmly embedded in practice. Recycling plants currently under development are expected to become operational, supporting the conversion of the city's two existing dump sites into material recovery facilities complemented by sanitary landfills. Together, these developments would represent a profound transformation of Freetown's environmental and urban landscape. 🌱



MADRID

Returning Life to the City: Renaturalising the Manzanares River

The Madrid Río complex is today a verdant riverside park that spans 7.5 km. It sits atop the Spanish capital's former main ring road, the M-30, a six-lane thoroughfare which cuts off locals' access to the Manzanares River. This article bears witness to the remarkable transformation that the Madrid City Council undertook to return life to the heart of the city.



Juan Azcárate, Deputy Director-General of Energy and Climate Change, Madrid City Council
Juan has over 35 years of experience in management and urban environmental control in the Madrid City Council. He developed the Roadmap towards Climate Neutrality for Madrid.



Antonio Morcillo, Deputy Director-General of Parks and Nursery Gardens, Madrid City Council
Antonio has been the head of Green Area Conservation Service at the Madrid City Council for the past 10 years. He has authored numerous articles and books, the latest titled “Parks and Gardens of Madrid”.



Madrid Río Park.
Image: Madrid City Council

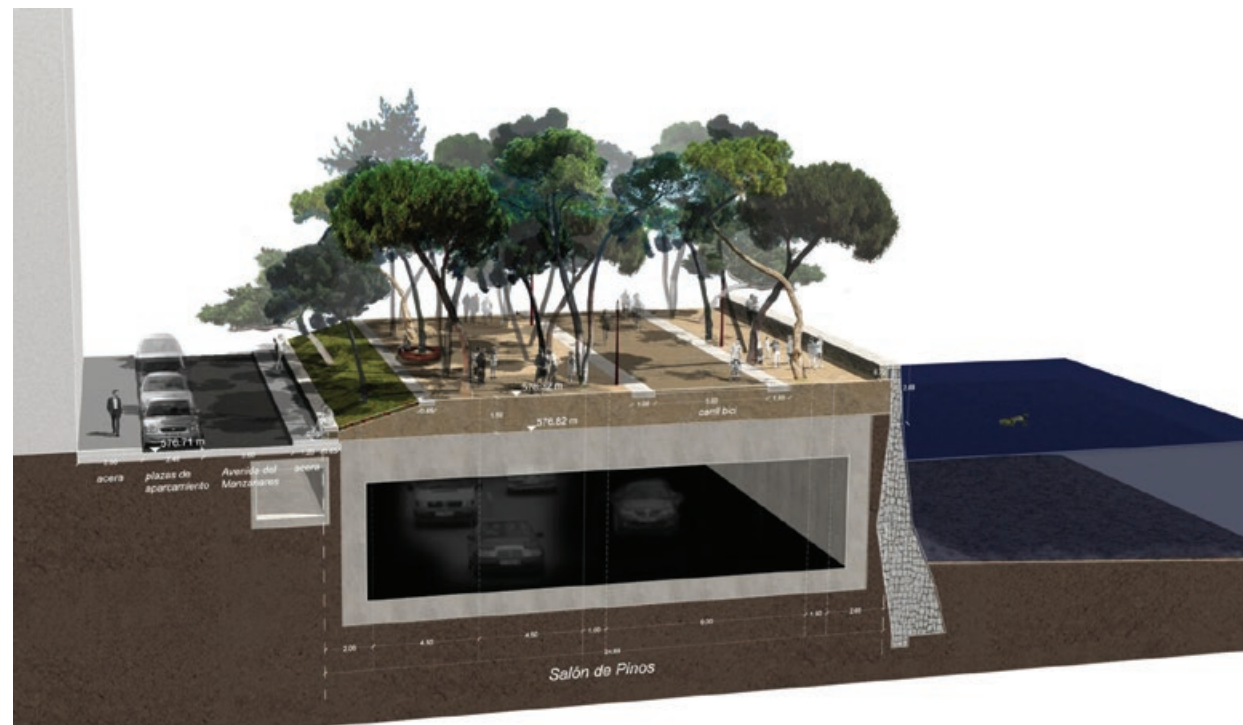
The renaturalisation of the urban section of the Manzanares River is part of Spain's municipal environmental strategy, alongside the Green Infrastructure and Biodiversity Plan and the Climate Change Adaptation Programme.

This initiative seeks to increase green infrastructure in the city of Madrid, bringing about environmental, social, and economic benefits. Examples of these infrastructural changes include improved connectivity between urban parks, the increased landscape quality of the urban section of the river, and the positive experience of applying nature-based solutions to increase Madrid's resilience to the effects of climate change.

The Manzanares is a humble river, with a small flow, but it plays an essential role in life, and its course is a vital ecological corridor for the conservation of biodiversity in its surroundings.

In the first half of the 20th century, the Manzanares was channelled along its 8-km urban stretch. Riparian vegetation was removed, high granite side walls were built, and the waters were dammed through nine dams, transforming the river into a succession of lifeless pools. In 1970, the M-30 urban ring road was built, occupying both banks of the river and isolating it from the city. As a result, the urban Manzanares, for decades, lost its ecological function.

This changed in 2004, when the Madrid City Council led the charge to move the M-30 underground, as part of a project called the Calle 30. Calle 30 began with a focus on reclaiming the Manzanares Riverbanks for citizens' use and enjoyment. In 2009, the addition of the Madrid Río Park followed, infilling the recovered spaces along the banks with greenery to enhance both biodiversity and liveability.



Cross-section of Madrid Río Park. With the M-30 shifted underground, surface streets are freed up for citizens' use and enjoyment.
Image: West 8



Avenida de Portugal, once a road, is today a park characterised by curved, landscaped areas with stone benches and decorative mosaics.
Image: Madrid City Council



Aerial view of the Madrid Río Park.
Image: Madrid City Council



The Perrault footbridge is an iconic landmark of the Madrid Río, linking the districts of Arganzuela and Carabanchel. It was inaugurated in March 2011.
Image: Madrid City Council

A central feature of the Madrid Río Park is the "Salón de Pinos", a green corridor that runs along the right bank of the river. It is a linear park comprising of more than 9,000 pine trees of different species, sizes, and shapes, that transform the former concrete banks into a forest-like setting. The transplanted pine trees, which have been specially chosen for their natural morphologies, enable the corridor to function as an extension of the pine forests in the mountains to the north of Madrid, providing ecological connectivity for biodiversity to thrive. At ground level, the corridor provides many landscaped areas for rest and public use, as well as pedestrian and cycling routes that weave through the pine trees.

To facilitate permeability between the districts located on both banks of the river, there are 33 crossings. These include newly built bridges that have become urban icons as well as the historic bridges of Rey, Segovia and Toledo, among others.

In 2016, the Madrid City Council launched a plan to renaturalise the urban stretch of the Manzanares River.

Even so, its waters remained stagnant and lifeless. In 2016, the Madrid City Council launched a plan to renaturalise the urban stretch of the Manzanares River. The aim of the Manzanares Renaturalisation Plan was to restore the natural flow of the river, revitalising the river's ecosystem and ecological function as a green corridor for biodiversity. The restoration also sought to allow the river to serve as a connector between the city of Madrid and surrounding natural areas of high ecological value.

In May 2016, the dam floodgates were opened, allowing the water to flow freely, thus promoting natural processes of sedimentation and the spontaneous growth of marsh vegetation and riparian trees. It took only a few months for the once-shallow river to sediment the materials it carried, recover its banks, and form small islands in its course. Carried by the water, seeds found ideal places in the sand and silt banks to

germinate, and river banks were soon covered with reeds, bulrushes, and rushes. Willows, white poplars, cottonwoods, and elms also grew spontaneously, transforming the 8-km channelled urban section of the Manzanares into a veritable green corridor, thus completing the transformation that Madrid Río represented.

Less than a year later, in the spring of 2017, mallards (*Asnas platyrhynchos*) and common moorhens (*Gallinula chloropus*) had islands of vegetation to nest and raise their broods, right in the heart of the city of Madrid. To date, seven dams have been rehabilitated.

The clearing of marsh vegetation and pruning of riverside trees remain an ongoing work till today. These initiatives persist to ensure compliance with the Tagus River's management requirements for the riverbed, which help to mitigate floods that can potentially arise from



Return of wild animals into the urban section of the Manzanares.
Image: Madrid City Council

Arganzuela garden.
Image: Madrid City Council



The Madrid Río Park provides cool spaces that help the city adapt to higher temperatures in summer.
Image: Madrid City Council

extraordinary episodes of torrential rain. At the same time, these measures also promote greater habitat diversity and increased biodiversity.

The influx of life that has emerged in the urban stretch of the Manzanares has exceeded all expectations. The diversity of habitats has enabled the presence of new bird species and the increase in the populations of existing ones. To date, more than 50 bird species have been counted in the urban stretch of the Manzanares.

The renaturalisation of the river allows Madrid residents to enjoy contact with nature in the city and has become a valuable tool for fostering environmental awareness. Collaboration with a non-governmental organisation, the Spanish

Ornithological Society (SEO), also known as BirdLife, has unleashed opportunities for citizen-led bird monitoring. This is enabled by environmental volunteering initiatives, and online bird-sighting recording platforms such as eBird.

The undergrounding of the M-30 urban motorway and the subsequent recovery of the city's most important park, Madrid Río, has been the greatest urban transformation to take place in Madrid since the dawn of the 21st century. The success of the project qualified by the enjoyment of the residents, and thriving biodiversity are testament to Madrid City Council's commitment towards urban restoration, conservation, and maintenance to the benefit of its people and ecological systems. 🌿

VIEWPOINT
RAVI MENON

Climate Resilience Through Regeneration



Mr Ravi Menon is Singapore's Ambassador for Climate Action and Senior Adviser to the National Climate Change Secretariat at the Prime Minister's Office. He is also Chairman of the Glasgow Financial Alliance for Net Zero (GFANZ) Asia-Pacific Advisory Board and a member of the GFANZ Principals Group.



Bishan-Ang Mo Kio Park in Singapore.
Image: AtelierDreiseitl (CC BY-SA3.0 / Wikimedia Commons)

When we think of resilience in the face of climate change, we typically think of strengthening our defences against floods, droughts, heat waves and other extreme weather events. But what if we can turn climate resilience from a defensive strategy into a pathway for new opportunities and shared co-benefits?

Achieving good, not just avoid the bad

Investing in climate mitigation and adaptation is often seen as a cost to pay today to reduce the probability of potentially catastrophic losses in the future. This is a sensible perspective, given the potential economic consequences associated with rising sea levels, extreme weather events, and supply chain collapses in the future. But focusing solely on reducing risks could potentially blind us to the possibilities for achieving good in addition to just avoiding the bad.

The idea of regeneration offers an important shift in perspective. It pushes us to think how climate solutions can go beyond minimising risks and

harm—to also holistically restore and enhance natural ecosystems, and generate co-benefits such as social wellbeing and economic vitality.

The power of regeneration is perhaps most evident in the use of *nature-based solutions*. Take for example Bishan-Ang Mo Kio Park in Singapore, which was once vulnerable to flood risk in the event of extreme rainfall. Rather than enlarging the existing concrete drain to accommodate the rare incidence of extreme precipitation, the canal was converted into a naturalised river system with vegetated riverbanks and wetland biotopes. This has created substantial economic and social co-benefits. Not only does the river system now act as a natural floodplain with increased stormwater capacity to reduce flood risks, its bioengineered river edges provide the community a recreational space to immerse in nature. Biodiversity has increased by 30% since the restoration.

Regenerative practices can also strengthen the viability of climate mitigation tools such as carbon credits. Projects to restore degraded lands

through the generation of *carbon credits* can be structured to bring in revenue streams, which provide local communities with an incentive to protect these ecosystems. Embedding these socioeconomic co-benefits alongside the preservation of nature provides potential buyers an added incentive to not only buy these credits, but to pay more for them.

The Mikoko Pamoja project in Kenya is a successful case study of the power of regenerative practices. Launched in 2010, it is the world's first community-based project to sell carbon credits from the conservation and restoration of mangrove forests. It now protects 117 hectares of mangroves annually. Revenue from the protection of these mangroves funds further protection and reforestation, providing a virtuous feedback loop. It also supports various community development projects, such as providing clean water for 3,500 people and educational materials for 700 schoolchildren. These socio-economic benefits provide long-term incentives for the protection of the mangroves.

A whole-of-society approach

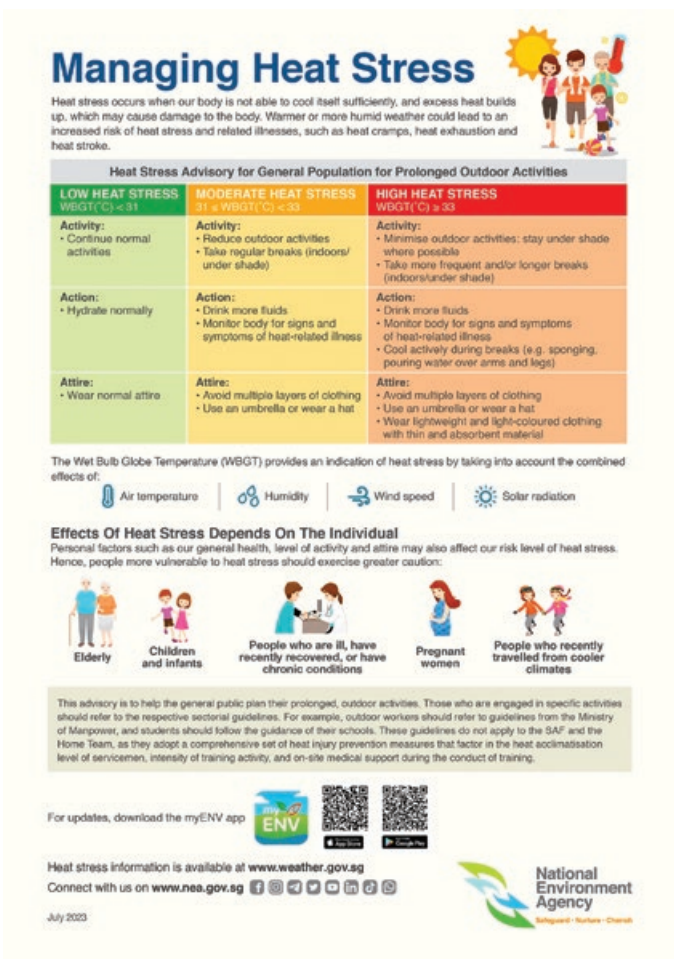
A key enabler of a regenerative approach is collective participation across all sectors and communities. Governments have a role in setting relevant regulations and investing in public infrastructure to strengthen resilience and reduce risks. Businesses have an interest in ensuring the resilience of their operations, assets and

supply chains. Academics and civic groups can complement these resilience measures through research and actions closer to the ground. Taking a whole-of-society approach fosters a sense of shared ownership and commitment and generates solutions that are better tailored to diverse needs.

In Singapore, we are beginning to see such collective action in heat adaptation efforts. As a tropical city, Singapore is particularly vulnerable to heat stress in the face of worsening climate change. A whole-of-society approach is necessary to protect the safety and livelihoods of workers, strengthen the long-term economic resilience of businesses, and develop solutions customised to the needs of individuals.

The *government* launched a three-tier Heat Stress Advisory in 2023 to guide the public on precautionary measures they can take to minimise heat stress. The government has also developed guidelines that address the unique needs of outdoor workers, athletes and students in schools. For example, the government introduced measures to reduce the risk of heat stress for outdoor workers, while allowing flexibility for employers to adjust and implement measures based on their localised conditions.

More *businesses* have started to take measures to protect their workers, such as redesigning workplaces for better ventilation, scheduling intense physical work to cooler parts of the day, and ensuring proper rest and hydration



In 2023, the Singapore government launched a three-tier Heat Stress Advisory to guide the public on precautionary measures they can take to minimise heat stress.
Image: National Environment Agency

for workers. For example, Grab and Deliveroo have begun issuing heat advisories to their riders,¹ while Changi Airport Group has started distributing protective sun wear and deploying water trucks during the hotter months.²

More *academics* are also conducting research to understand and address various heat adaptation needs in the community. Researchers from the Singapore University of Technology and Design are surveying residents on their heat adaptation behaviours and household features, to create a menu of low-cost, effective cooling options.³ Experts from the Heat Resilience and Performance Centre at the National University of Singapore have been developing solutions such as wearable devices and smart uniforms to monitor heat stress.^{4,5} They are now looking to investigate heat risks to more vulnerable groups, including outdoor workers and hospital patients.⁶ More ground-up participation from civic groups can complement such efforts to ensure that solutions are accessible to all.

Thinking resilience beyond borders

A regenerative approach requires us to consider the interconnectedness of ecosystems, economies, and communities.

Southeast Asia has highly inter-dependent food, energy and water systems, as well as shared trade and financial links. This means that climate impacts on any one sector or country can quickly

ripple across borders. For example, as the region’s largest waterway, the Mekong River is a primary source of freshwater for drinking, farming and industry, and supports tens of millions of livelihoods. However, droughts occurring upstream, such as in Laos, Thailand or Cambodia, can result in less water flowing downstream into regions such as the Mekong Delta in southern Vietnam, leading to large-scale crop failures and water shortages. Declining water levels in the river can also threaten hydropower power generation in countries across the Lower Mekong River Basin, reducing electricity supply.

A regenerative approach requires us to channel adaptation efforts beyond our borders and manage transboundary risks. This is increasingly being recognised around the world. IPCC AR6 recommends that national adaptation plans consider these transboundary risks and coordinate regionally to build systemic resilience.⁷ Research coalitions such as Adaptation Without Borders have emerged, bringing together research capacities to help identify, assess and manage these risks. Closer to home, the ASEAN Integrated River Management Project was launched in 2023 to establish functional management mechanisms for major transboundary rivers in the region.⁸

Singapore has started to contribute to regional adaptation, primarily through research. Singapore has been sharing the findings of its Third National Climate Change Study with other ASEAN members states, to enable them to better

understand and adapt to the impacts of climate change. Researchers at the National University of Singapore’s Tropical Marine Science Institute have been working closely with their counterparts in universities in the region, to study the impacts of climate change on the region’s agriculture sector and measures to enhance regional food security. The Nanyang Technological University’s Earth Observatory of Singapore has been advancing the scientific understanding of sea level rise and storms in the region. As climate change escalates, we must build on these efforts to address knowledge gaps, build capacity, and strengthen regional coordination to drive collective resilience.

Hope for climate action

Climate action is not easy. It demands trade-offs, sustained investments, and cooperation at every level. But regenerative principles and practices remind us that climate action is not just about surviving the challenges ahead, but also about creating new opportunities and shared benefits for communities and businesses. By embedding such principles into our plans and investments, we can move beyond a mindset of scarcity and loss, and build a future where both people and the planet can thrive. 🌱

[1] Source: “Mentally, you have to push through’: Delivery riders’ long hours, hot days”, Straits Times, 2024. <https://www.straitstimes.com/singapore/mentally-you-just-have-to-push-through-delivery-riders-endure-longer-hours-hotter-days>

[2] Source: “Enhancing Heat Resilience for Airside Personnel”, Changi Airport Group, 2025. <https://www.changiairport.com/en/corporate/our-sustainability-efforts/environment/enhancing-heat-resilience.html>

[3] Source: “Who bears the heat of climate change? Helping communities deal with rising temperatures”, Straits Times, 2025. <https://www.sutd.edu.sg/news-listing/who-bears-the-heat-of-climate-change-helping-communities-deal-with-rising-temperatures/>

[4] Source: “Why runners are swallowing electronic pills to help build next-generation wearables”, Straits Times, 2023. <https://www.straitstimes.com/tech/why-runners-are-swallowing-electronic-pills-to-help-build-next-generation-wearables>

[5] Source: “Smart uniform to monitor heat stress in soldiers among ideas mooted in new research centre”, Straits Times, 2023. <https://www.straitstimes.com/singapore/smart-uniform-to-monitor-heat-stress-in-soldiers-among-ideas-mooted-in-new-research-centre>

[6] Source: “NUS scientist wants to expand research to help vulnerable groups in S’pore, S-E Asia beat the heat”, Straits Times, 2025. <https://www.straitstimes.com/singapore/environment/nus-scientist-wants-to-expand-research-to-help-vulnerable-groups-in-spore-se-asia-beat-the-heat>

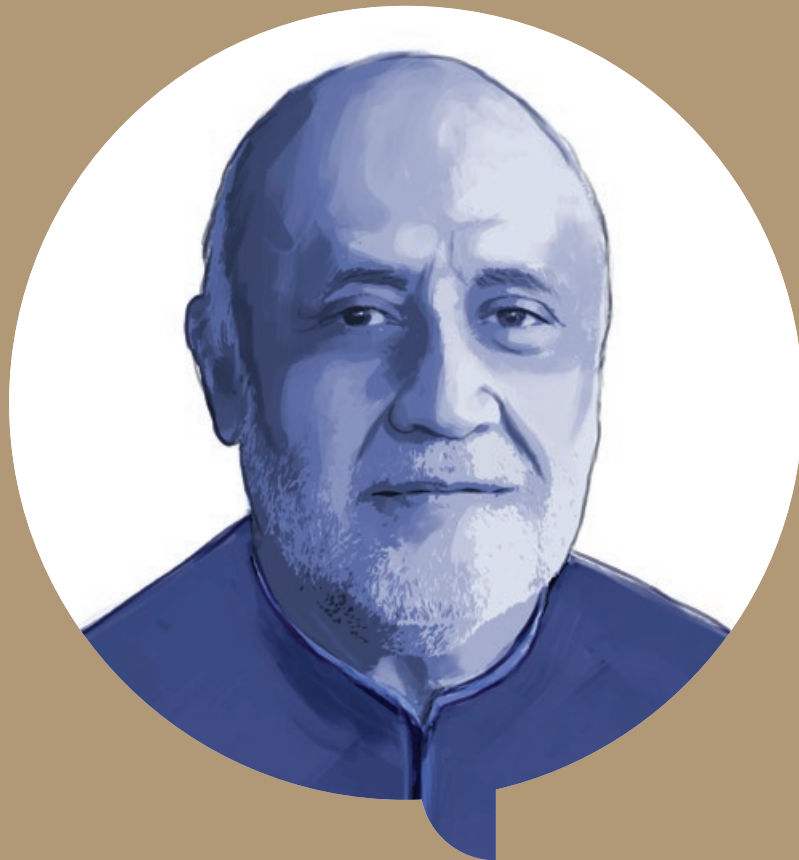
[7] Chapter 16 of IPCC AR6 discusses four inter-regional risk channels (trade, finance, food and ecosystems) and how adaptation can govern these risks (see Chapter 16.3: Cross-Chapter Box INTEREG | Inter-regional Flows of Risks and Responses to Risk). <https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-16/>

[8] Source: “State of River Basin Reporting to start in seven priority rivers in Southeast Asia”, Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), 2024. <https://www.pemsea.org/resources/news/state-river-basin-reporting-start-seven-priority-rivers-southeast-asia>

VIEWPOINT

RAHUL MEHROTRA

Temporality as a Strategy for Resilient and Regenerative Cities



Rahul Mehrotra is the founder principal of RMA Architects and the John T. Dunlop Professor in Housing and Urbanisation at the Harvard Graduate School of Design. Mehrotra's most recent books are titled *Working in Mumbai* (2020) and *The Kinetic City and other essays* (2021).

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The "kinetic city" understands the city as being in a state of constant flux.

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Today's urbanism seems to be suspended in a constant negotiation between two contrasting conditions. The first is based on the assumption that architecture and urban design is about accumulation. It exists as a material exercise, disconnected from social implication. In this first condition, the city is static and its architecture is a centralising spectacle driving the inherent impatience of capital.

The second condition is derived from the idea that there is a more elastic, and thus often perceived as weaker, expression of the city, which one could refer to as the "kinetic city".¹ This completely different observation of urbanity understands the city as being in a state of constant flux. This, kinetic quality challenges the notion of accumulation and its relationship to development. The kinetic city cannot be understood as a two-dimensional entity. Instead, it is multifaceted—a three-dimensional conglomeration of incremental development, perceived as ever-changing. In a way, the kinetic city is home to an emergent population who do not participate in traditional trade and social activities. This is not to say that the kinetic city

is merely for the impoverished. Rather, it is a temporal articulation and occupation of space that allows for formerly unimagined uses in the dense urban environment.

The proposed alternative conceptualisation of the kinetic city avoids describing a city as either formal or informal—since neither accurately captures the intertwined physical, economic, and cultural conditions on the ground. Such an approach provides an alternative to our business-as-usual response by imagining different uses of space in society. In planning, this leads us to make distinctions between space and time, and how space evolves over time.

The phenomenon of "Bazaars in Victorian Arcades" in the old Fort Area of Mumbai's Historic District is emblematic of this negotiation between the Static and Kinetic City. The original use of the arcades was two-fold. First, they provided spatial mediation between the building and street. Second, the arcades were a perfect response to Mumbai's climate. They served as a zone protecting pedestrians from both the harsh sun and lashing rains.



The spread of traditional Indian bazaars into the Victorian arcades of the Fort area transformed the intensity and patterns of use of public space and blurred the physical segregation of the formal and informal.
Image: Rahul Mehrotra

Today, with the informal bazaar occupying the arcade, its original intent has been challenged. This emergent relationship of the arcade and bazaar not only forces a re-examination of uses and interest groups but also demands new preservation approaches. For the average Mumbai resident, the hawker provides a wide range of goods at prices considerably lower than those found in local shops. Thus, the bazaars in the arcades that characterise the Fort Area are thriving businesses.

For the elite and for conservationists, however, the Victorian core represents the old city centre, complete with monumental icons. As the city sprawls, these images, places, and icons acquire even greater meaning as critical symbols of the city's historic image. Consequently, hawking has now been deemed illegal by the city authorities who are constantly attempting to relocate the bazaars.

The way forward for Mumbai to cope with the transformation is not by encouraging the dualism between the average Mumbai resident

and conservationists, but by attempting to reconcile their needs and desires as being simultaneously valid. The existence of two worlds in the same space suggests that there is a need to accommodate and overlap varying uses, perceptions, and physical forms.

The arcades in the Fort Area represent a special urban component with the potential for reinterpretation. As an architectural or urban design solution, the arcade's ability to accommodate new uses while keeping the illusion of its architecture intact, makes it incredibly resilient.

One design solution might, therefore, be to re-adapt the function of the arcades. They could be restructured to allow for easy pedestrian movement while accommodating hawkers at the same time. The amorphous bazaar could also be encased in the illusion of a Victorian arcade. With this sort of planning, components of the city would have a greater ability to survive by being more adaptable to changing economic and social conditions.



In Mumbai, during the Ganesh Festival, which occurs in August or September (based on the lunar calendar), new spaces are created to house the idol of Ganesh for 10 days. On the last day, a large part of the city's population carries the idol in long processions, ultimately to be immersed in the sea.
Image: Rahul Mehrotra

There are unfortunately no total solutions in an urban landscape that has to balance conservation with rapid transformation. At best, the city could constantly evolve and invent solutions for the present while safeguarding crucial historic components, like its urban hardware. Using such an approach, "Bazaars in Victorian Arcades" could become a symbol for resilience and regeneration through temporary adjustment.

In Mumbai's example, architecture is neither the only spectacle of the evolving city, nor the single dominant image of the city. It is perhaps for this reason that debates around conservation in Mumbai do not have the same currency as in other societies, where architecture is integral to how the city is remembered or perceived. Taking the place of architecture are festivals, such as Diwali, Dusshera, Navratri, Durga Puja, Ganesh Chaturthi, and Janmashtami.

Their presence on the everyday landscape pervades and dominates the popular visual culture of Indian cities. Festivals create an environment through which the fantasies of the

average citizen are articulated and momentarily executed into political action. For example, in Mumbai, the popularity and growth of the Ganesh festival has become a phenomenon. The grand immersion of the clay idol of the elephant god is a metaphor for the spectacle of the city. As the clay idol dissolves in the water of the bay, the spectacle comes to a close. There are no permanent mechanisms to encode this spectacle. Here the memory of the city is encapsulated by the process itself—captured in the moment as opposed to a building which contains the public memory as a static or permanent entity. The city and its architecture are not synonymous and cannot contain a single meaning. Within this urbanism, meanings are not stable, and spaces get consumed, reinterpreted, and recycled.

In India, the word for both tomorrow and yesterday in Hindi is the same—"kal". In this cultural context, one views the past and the future with simultaneous gestures. They are omnipresent in the current reality, or, as articulated by Stephen Hawking, "The past, like the future, is indefinite and exists only as

Cricket Ground and Weddings Along Marine Drive in Mumbai



Transformation of the cricket ground throughout the day.
Image: Rahul Mehrotra

A cricket ground by day and a wedding venue by night. The sacred space of the cricket pitch is untouched, but its perimeter is appropriated for wedding sets that are turned over in a 12-hour cycle. In the evening, the members of the cricket club take high tea provided by the temporary kitchen set up for the wedding. After the wedding at night, the wedding set is dismantled and the perimeter of the pitch is completely restored for the next scheduled cricket game in the morning.

Weddings are an example of how the affluent are also engaged in making the Kinetic City. The lack of formal spaces for weddings in Mumbai, have resulted in public open spaces being temporarily appropriated by the elite to hold elaborate Indian weddings. Often, very complex wedding sets are constructed and removed within 12 hours. This is a temporary spectacle set up by the affluent that results in functions of the city being altered momentarily.

a spectrum of possibilities.”² Contemporary education in urbanism engages with a compulsive obsession with the past which often detracts from our perspectives of the future or even our comprehension and acceptance of the present reality. Likewise, architects and urbanists tend to be inspired solely by the past, as compared to other patrons, such as real estate developers and governments, who are more concerned about the usefulness of their present investments for future returns.

Mumbai is not, as many images suggest, only a city of the poor. Rather, it is a showcase for how spaces in crowded cities can be dynamically reconfigured to serve new uses. It helps us to better understand the blurred lines of contemporary urbanism and the changing roles of people and spaces in urban society. Here, the idea of a city is an elastic urban condition—not a product of a stable grand vision, but instead one that might be characterised as a dynamic or kinetic adjustment that is constantly regenerating for contingent needs.

In emergent settlements around the world, transient landscapes of pop-up settlements are constantly increasing in scale and challenging the notion of a stable and permanent city. Resultantly, there is an emerging call to no longer treat the ephemeral and stable components in cities as binary states. For, when cities are analysed over large temporal-spans, ephemerality emerges as an important condition in the life cycle of every built environment. These parameters unlock our ability to not only rethink alternative uses within the boundaries of an ephemeral urbanism but also come up with softer and more robust systems that can be adapted over time.³

Ephemeral urbanism acknowledges the need for re-examining permanent solutions as the way forward for developing cities. It calls for new protocols that are constantly reformulated, re-adapted, and re-projected in an iterative search for a temporary equilibrium that reacts to a permanent state of crises.

Our transitional condition on this planet demands that cities consider “temporality” alongside notions of material life cycles and

circular economies, climate change, and pandemics. One way to frame this question of transience or flux is to think instrumentally as designers about the difference between transitional solutions and our design interventions being absolute in their proposition and approach. Transitional design acknowledges that we are living in transitional times, and premises the need for society to move towards more sustainable futures and for design to play a key role in these transitions.

Temporality is an important factor to consider, whether designing for everyday social practices at a community scale or at the level of global challenges. Mapping the path of the transition is a crucial consensus building process that will need new forms of representation, governance, and management. This would involve imagining governance hierarchies on a temporal scale, reconfiguring power structures to address different challenges at different moments in the process, and enacting nonlinear decision-making processes across physical scales of interventions. Considering the relationship between space and time in the built environment will allow for both temporal and permanent imaginaries to exist in various dimensions, and question permanence and stability as default conditions. More importantly, it will help us recognise the potential to construct a new imaginary for cities that are resilient and that can constantly regenerate to embrace the future. 

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REGENERATIVE CITIES

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Resilient and Regenerative Cities for a Climate-Changed World



Impacts of climate change such as extreme heat and sea-level rise will affect large metropolises in Southeast Asia.
Image: Andy Tan

Can Cities Be the Solution in a Climate-Changed World?

Climate change is happening rapidly. While we know that the causes of global warming mainly arise from accumulated global emissions of greenhouse gases, the impacts felt by cities around the world are local in nature. Cities are affected in different ways by the increased frequency and severity of climate impacts, such as heatwaves, droughts, floods, tropical storms, poor air quality and wildfires.¹ Simultaneously, we are living in a time where more than 55% of the global population are living in urban settlements. Current urbanisation rates will likely result in almost 70% of global population residing in cities by 2050. These cities will not only be hotspots for greenhouse gas emissions, but they will also be vulnerable to increased climate risks, *irrespective of location*.

Recent examples of urban impacts from anomalous weather impacts abound; from cities in East Africa, such as Nairobi, Kenya, being subject to flooding in May 2024 and resulting in close to 300 deaths and almost 280,000 people mostly from informal settlements being displaced, to record multi-day rainfall over Central Europe in September 2024.² The latter caused

Austrian cities such as Vienna to incur an estimated 1.3 Billion Euro in damages.³ Extreme heat caused by climate change has been estimated to reduce local GDP by 1.2–3.9% for large metropolitan areas in Southeast Asia, and 1.7–5.5% for other cities in East Asia with warm baseline climates. In Bangkok, without sufficient intervention, a 1°C rise in average temperature could result in more than 2,300 heat-related deaths and 44 billion baht in lost wages from reduced productivity.⁴

While cities are hotspots for emissions and climate risks, they also have tremendous potential to develop solutions for mitigating emissions and local climate risks. Cities can turn challenges into opportunities by optimising the co-benefits of climate strategies to ensure continued liveability and resiliency for people and the built environment, as well as flourishing natural ecosystems. To do so would require cities to plan and implement climate strategies in an integrated manner across urban systems, collaborate across sectors and cities, and tap on a suite of enablers such as technology and green financing.

Challenges Faced by Cities in a Climate-Changed World

First, cities are reaching the limits of sustainability as a model for urban development. Guided by the United Nations (UN) 2030 Agenda for Sustainability Development, sustainability focuses on the reduction and mitigation of environmental degradation for present and future generations. With greenhouse gas emissions projected to rise to 170 CtCO₂e by 2100 under a business-as-usual scenario, the sustainability approach is inadequate in the long term to limit emissions and meet the 1.5°C target set out in the Paris Agreement.⁵ As illustrated by *Doughnut Economics*, we need a developmental approach that can meet our livelihood needs without exceeding the thresholds of Earth's systems that support us.⁶

Second, while cities already experience direct impacts of climate-related hazards as illustrated above, there have been significant compounding and cascading risks that will arise as the world continues warming beyond the 1.5°C Paris Agreement limit. Extensive urban flooding can cause critical infrastructure—such as transport, power, water and information and communications—to fail and result in impacts being felt beyond the physical boundaries of a settlement.⁷

Third, rapid urbanisation is occurring globally. The world's urban floor area is growing by 2.3% annually and global building stock is expected to double by 2065.^{8,9} To limit the undesirable impact of urban sprawl, cities have to plan for higher density to accommodate the needs of

people while managing the pressure on existing urban systems. With higher population and infrastructure density, cities are faced with the challenge of maintaining liveability, or ensuring liveable densification and building resilience to climate risks, while facing land, carbon and other resource constraints.¹⁰

Fourth, cities, especially rapidly urbanising high-density cities, have to tackle the above challenges while facing three key resource constraints. First, land constraints within city boundaries and the need for urban infrastructure to accommodate spaces for living, working, leisure, transport and utilities. Next, carbon constraints which require lower emission footprint for urban activities to meet emission targets. Lastly, fiscal constraints posed by competing demands compounded by increased disaster risk, the need for climate adaptation, and green energy transition, among other factors in an evolving economic and geopolitical global environment.¹¹ Internationally, the resource challenge is compounded by the complexities and challenges in supply chains pertaining to raw materials and other essential goods, as evidenced from disrupted global flows during the COVID-19 pandemic.¹²

Addressing these challenges would require cities to plan and implement long-term integrated climate strategies that minimise emissions and reduce climate risks, enhance liveability and natural ecosystems, while ensuring sufficiency of resources for the present and future.

Charting the Way Forward with Nature, Carbon and Circularity

Leveraging Nature

Cities can embrace nature as a partner through nature-based and biomimetic solutions. Nature-based Solutions (NbS) are defined by the International Union for the Conservation of Nature (IUCN) as “actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits”.¹³ For example, Singapore taps on nature-based solutions such as greenery and naturalised streams and rivers for its cooling, stormwater retention and cleansing, and social benefits. Consistent cooling of 2°C from large and connected urban park spaces can, for instance, reduce risks from urban warmth for residents in Singapore.¹⁴ With a “City in Nature” vision, Singapore is aiming to have 200 hectares of skyrise greenery, green spaces such as parks within a 10-minute walk from every household, and recovery plans for 100 plant and 60 animal species to be carried out by 2030.¹⁵

Cities can also tap on the intelligence of nature and adopt biomimicry, the emulation of living organisms or ecosystems, in its design process.¹⁶ In the Canary Islands, Grimshaw Architects took inspiration from how Namib Desert beetles captured moisture from fog to create a seawater harvesting system in a building that produced sufficient freshwater to be shared with neighbouring buildings.¹⁷



With a City in Nature vision, Singapore weaves greenery into its urban fabric to tap on nature's ecosystem benefits.
Image: Chuttersnap, Unsplash (left); Gigi, Unsplash (right)

Carbon-sensitive developments not only reduce emissions, but also produce social, economic and environmental co-benefits for the city.

Reducing Carbon

Transitioning towards a low-carbon built environment can be achieved through carbon-sensitive developments. Carbon-sensitive developments not only reduce embodied and operational carbon emissions, but also produce social, economic and environmental co-benefits for the city. The Gare Maritime, formerly Europe's largest freight railway station in Brussels' Tours & Taxis district, was redeveloped into a carbon-neutral mixed-use hub comprising work, event, retail, food and public spaces.

The existing steel structure and original building envelope were restored through an adaptive reuse process. By constructing 12 modular pavilions out of

cross-laminated timber instead of traditional concrete, approximately 3,500 tonnes of CO₂ emissions were saved, and the construction process was expedited. Renewable energy sources such as solar panels on 17,000 m² of roof space were used to power the building, while geothermal technologies were employed for heating and cooling. The Central Hall was designed with wide pedestrian boulevards lined with greenery, consisting of over 100 large trees and seating areas for community use.

Accelerating Circularity in Resource Flows

Establishing circular resource flows that move away from linear consumption to closed resource



The Gare Maritime in Brussels—a carbon-neutral mixed-use hub, an adaptive reuse of Europe's largest freight railway station.
Image: Nanda Sluijsmans / Flickr

loops help to optimise use of raw materials, reduce and recapture waste for use as resource, and maximise the lifetime value of products. Seoul's resource recovery facilities convert approximately 2,850 metric tonnes of non-recyclable solid waste daily into heating for about 518,000 households, and turn bottom ash residue from incineration activities into construction materials.¹⁸ Similarly, Singapore is setting up an integrated waste management facility next to a water reclamation plant to harness the synergies of the water-energy-waste nexus from used water and solid waste, while

optimising land use and cost-savings for waste treatment. Called the Tuas Nexus, it will generate enough electricity to sustain its own operations, and export excess electricity back to the national grid. It is expected to achieve more than 200,000 tonnes of CO₂ savings annually.

An Integrative Approach and Systems View of the Key Enablers

Key Enabler #1—Long-Term Integrated Planning

In Singapore, a Long-Term Plan Review is carried out every 10 years, to plan holistically for its urban development over the next 50 years and beyond. By adopting a source-pathway-receptor approach that includes continued investments and improvements to drainage infrastructure, Singapore has successfully reduced its flood prone areas from 3,200 hectares in the 1970s to less than 25 hectares today. The government also works closely with building owners and the community to strengthen flood resilience and preparedness.

An iconic water management infrastructure is the Marina Barrage, first mooted by Singapore's Founding Prime Minister Lee Kuan Yew in 1987. Construction of Marina Barrage commenced in 2005 to dam the Marina Channel, simultaneously facilitating the creation of Marina Reservoir to augment Singapore's water supply. The tidal gates at Marina Barrage help to control flooding in low-lying areas of the city during heavy rainfall, and its iconic green rooftop serves as a popular recreational spot in the heart of the city.

Looking to the decades ahead, Singapore is planning for the "Long Island" project along its Southeastern coast as a coastal protection measure. "Long Island" will also strengthen the city-state's water supply resilience and create new spaces for housing, jobs and recreation for future generations.

Key Enabler #2—A Collaborative Ecosystem of Stakeholders

Another key enabler is to build partnerships across all sectors—public, private (businesses and industries), academia, people and community, and international organisations. As an example, the Greater London Authority and Cross River Partnership collaborated on a public-private partnership for central London's Business Improvement Districts (BIDs) to increase green cover in privately-owned land and buildings, while providing benefits for the public.¹⁹ Through coordination across the BIDs, incentives such as grants and financial support, retrofitting older buildings to maximise potential for green cover, and a best practice guide put out by the Victoria BID to assist other districts, the collaboration supported 19 green

infrastructure audits and 16 green infrastructure installations such as rain gardens, green walls and green roofs.²⁰

Having an inclusivity of views from the local community that are facing the brunt of climate impacts are important to sustain resilient and regenerative efforts for the long-term. Such inputs and insights also build community resilience that addresses both local challenges and national efforts, and reduce maladaptive practices due to poor, or misaligned planning.^{21,22} In Bangkok, social enterprise Porous City Network partnered with vulnerable communities, such as households along the Lat Prao Canal, to raise awareness of climate challenges, create site-specific design solutions, and lead workshops on site maintenance post-implementation.

Key Enabler #3—Technology and Data

Technology and data are crucial drivers for planning, as well as post-implementation monitoring and assessment. In the planning of Singapore's public housing towns, the Housing and Development Board uses computer simulation and data analytics to examine how environmental conditions interact with the layout and design of the town, precincts and buildings. Using computational fluid dynamics, housing blocks are positioned to capitalise on wind flows, thus increasing natural ventilation and providing a cooler environment. Solar irradiance simulations and shadow analysis also help to identify naturally shady areas, where common amenities such as playgrounds can be sited to optimise thermal comfort.

An analytical framework developed by WOHA and bioSEA in Singapore further enables the assessment and quantification of the social and ecological benefits of nature-centric design in completed developments, providing an evidence-based case for cities to have more of such regenerative-aligned developments.²³

Key Enabler #4—Sustainable Financing

The importance of ensuring sustainable finance for projects cannot be overstated. The business case for investments in local risk reduction is strong given the increases in exposure to climate hazards. One potential solution is that of blended finance (public-private), as seen in the example of Xi'Xian located in Northwest China.²⁴ Part of the Silk Road Economic Belt, the city has a green financial mechanism that creates a leverage effect for national funding including the first provincial Green Sponge Development Fund (RMB 1.2 billion) and the Shaanxi Urbanisation Development Fund (RMB 2.64 billion). The city also has a public-private partnership model with a whole-lifecycle-management approach, raising funding of RMB 1.24 billion with a packaged project that includes public pipelines and sewage water treatment facilities.

Together with institutional support coming from special fiscal policies like the national-level New Area and streamlined municipal administrative systems, Xi'Xian was able to build more than 50 km of sponge roads and 1.4 million m² of climate resilient parks. The city was also able to establish green coverage of more than 50% of the urban space, enabling everyone to "see green in 100 metres, and step into a garden every 300 metres".²⁵



Knowledge platforms such as Singapore's World Cities Summit and the UNFCCC COP Singapore Pavilion's Cities Thematic Day convene leaders and experts to share and exchange best practices and solutions for cities.

Image: Andy Tan

Beyond Sustainability— A Call to Action for Resilient and Regenerative Cities

The strategies and enablers outlined above point to how cities can undertake resilient and regenerative urban development to thrive in a climate-changed world. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report has highlighted how Climate Resilient Development can combine mitigation and adaptation actions to support sustainable development for humans, ecosystem and planetary health.²⁶ With a genesis in natural science and increasingly adopted in the built environment realm, regenerative approaches push cities to go beyond simply minimising harm to the environment in urban development, and strive to ensure that urban development also benefits the natural ecosystem.^{27,28,29,30,31} Regenerative urban development thus advances conventional sustainability by not just restoring or maintaining,

but actively growing social and ecological systems to achieve net-positive outcomes for both people and the natural environment. Taken together, resilient and regenerative approaches to urban development offer pathways for cities to remain highly liveable and resilient, enhance biodiversity, and ensure effective stewardship of resources for the present and future.

In the face of accelerating climate disruption, cities can effect resilient and regenerative urban development using the enabling tools we already have. To build mindshare and collective action, these tools can be shared at platforms such as the World Cities Summit held biennially in Singapore, the Singapore Pavilion's Cities Thematic Day at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties

(COP), and the forthcoming IPCC Special Report on Climate Change and Cities. Through self-assessment and city-to-city benchmarking, we can foster cross-exchanges, mutual learning and galvanise collective action for urban climate mitigation and adaptation.

More than just knowing what to do, action is required to reduce the severe risks that will manifest from continued inaction. A pathway towards resilience and regeneration has been put forth by this essay, and commitment for the next steps lie in the hands of all stakeholders—governments, industries, researchers, international and non-governmental organisations, and communities. Together, we can create resilient and regenerative cities for generations to come, in a climate-changed world. 🌱

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REGENERATIVE CITIES

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Charting Regenerative Urban Futures: A Working Regenerative City Framework



Bidadari Park is an ecologically-sensitive regional park within the Bidadari estate. The park design seeks to preserve Bidadari's rich history and enhance biodiversity.
Image: Stewart Tan

In a future where climate change is expected to put greater constraints on how we use resources, a regenerative approach to urban development offers a means for cities to restore natural ecosystems and improve liveability for their residents. The Centre for Liveable Cities (CLC) is thus developing a Regenerative City Framework and testing ideas through the Regenerative City Forum series. This essay unpacks regenerative development and the working Framework, summarises insights from the Regenerative City Forum series, and charts next steps forward.

From Sustainable to Regenerative

Sustainable development has thus far been seen as the solution to mitigate the impact of cities on climate change. Yet, insofar as it seeks to minimise negative impacts, sustainable development may not address the restoration of natural ecosystems or ways to enhance positive impacts.

Where sustainable development focuses on “doing less harm”, regenerative development aims to “do more good” by creating net-positive outcomes for people and the environment. With its origins in natural science, regenerative development is underpinned by systemic thinking that maximises co-benefits. This is defined by the Intergovernmental Panel on Climate Change (IPCC) as “the positive effects that a policy or measure aimed at one objective might have on other objectives”. A regenerative approach is thus interdisciplinary and considers how urban interventions can achieve co-benefits across social, economic, and environmental domains.

Such approaches can enable cities to adapt to climate change more effectively. Even as cities aim for net-zero, there are still activities that continue to have a carbon footprint. Taking a regenerative lens could help to offset some of these carbon emissions, while generating co-benefits for residents. For example, including more nature-based solutions like restoring wetlands, planting trees, and increasing green spaces could help reduce flood risks and urban heat island effects, while increasing health and wellbeing outcomes. Having such natural ecosystems within cities also enhances liveability and ensures that cities do not become concrete jungles. With increasing rural-urban migration, there could also be opportunities to reforest or rewild spaces just beyond city boundaries, contributing to lower carbon emissions.

A Proposed Regenerative City Framework

Acknowledging the complexity of adopting a regenerative approach, CLC is developing a Regenerative City Framework to guide the planning and execution of regenerative development. Conceptualised through literature reviews and engagements with experts across a range of disciplines, the working Framework comprises three key layers.

The first layer outlines liveability, resilience and resource outcomes for people and the environment that can be achieved through regenerative development. The second layer identifies

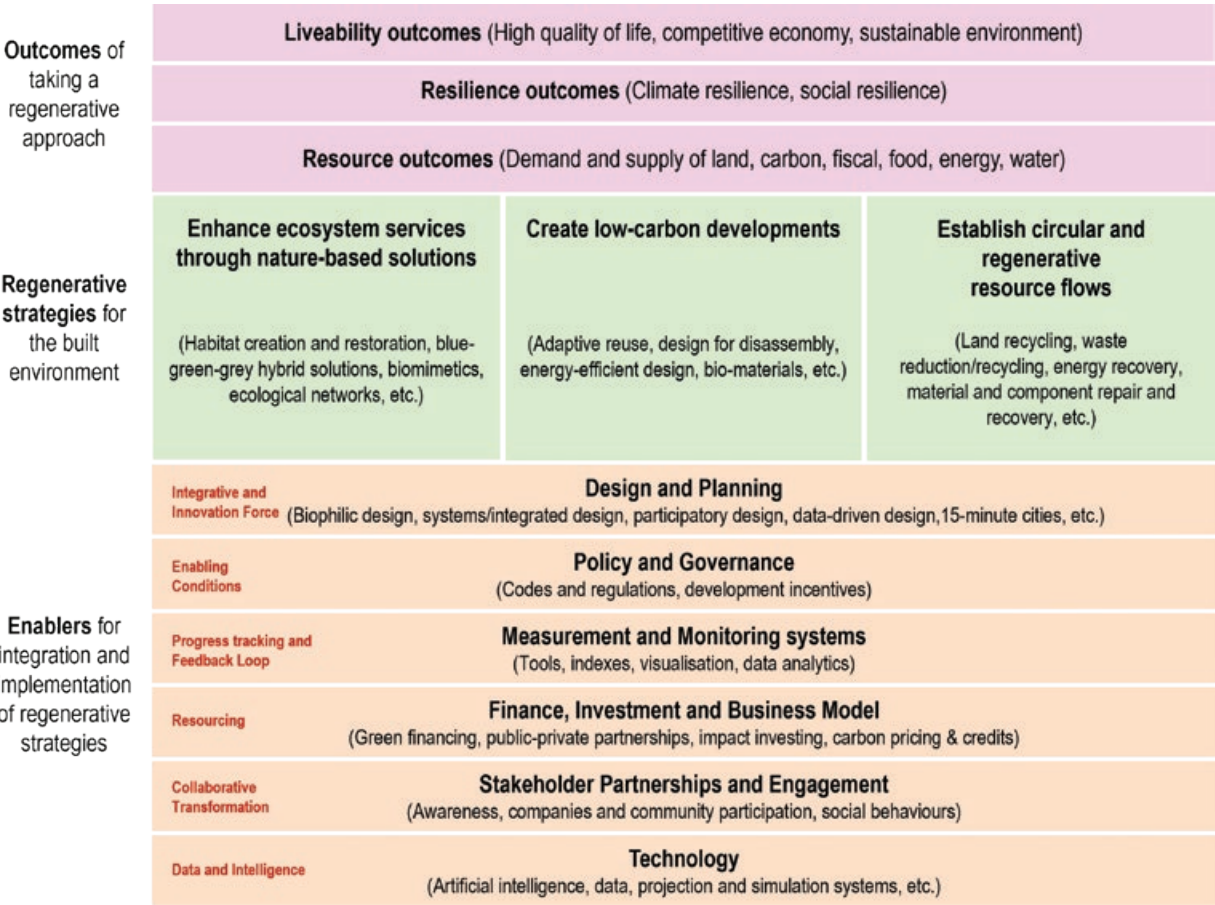
broad regenerative strategies that can be applied in the built environment to support these desired outcomes. These strategies refer to enhancing ecosystem services through nature-based solutions, creating low-carbon developments, and establishing circular and regenerative resource flows. The third layer proposes six key enablers that facilitate the implementation of regenerative strategies in integrated ways. They span across sectors and include design and planning interventions, policies and governance structures, measurement and monitoring systems, finance, investment and

business models, stakeholder partnerships and engagement, and the use of technology and AI.

By focusing on these three key layers, the Framework provides a structure for considering how different Enablers and Strategies of regenerative development can interact in creative ways to enhance net-positive outcomes, thereby maximising co-benefits in a specific context. It offers a systematic means to map and optimise synergies, correlations, and interdependencies across various components of a system.



Bidadari Park and surrounding housing estate.
Image: Stewart Tan



Working Regenerative City Framework.
Image: Centre for Liveable Cities

Illustrating the Framework: 3 Case Studies

The Regenerative City Framework aids in understanding how planning decisions interact to maximise co-benefits at existing sites. This is illustrated through three case studies in Singapore, London, and Bangkok.

BIDADARI, SINGAPORE

Located in Singapore’s central region and formerly home to a crematorium and cemetery, the Bidadari area had been left undeveloped since the 1970s. In 2013, the Government announced plans to redevelop Bidadari into a residential estate to provide about 10,000 new homes.

Guided by the vision of Bidadari as a “Community in a Garden”, planners adopted ecologically sensitive design to retain greenery and natural features including knolls and

hills. For example, multi-storey car parks were integrated into natural slopes, with their rooftops covered by gardens. This provided residents with both parking amenities and green spaces. Environmental modelling and simulation tools were also used to position residential blocks in ways that leverage wind flows and shade, resulting in energy-efficient design that maximises natural ventilation and optimises thermal comfort.

The planning team also engaged and worked closely with local conservation group Nature Society Singapore, as well as the National Parks Board to identify and safeguard existing migratory bird habitats. In addition, there were also extensive engagements with heritage-interest groups, the National Heritage Board, as well

Outcomes of taking a regenerative approach

Regenerative strategies for the built environment

Enablers for integration and implementation of regenerative strategies

Liveability outcomes High quality of life – amenities and green spaces; recreational spaces that preserve heritage		
Resilience outcomes Climate resilience – protecting biodiversity; mitigating flood risk		
Resource outcomes Optimising land as a resource through redevelopment		
Enhance ecosystem services through nature-based solutions Stormwater retention pond to mitigate flooding risk (Alkaff Lake)	Create low-carbon developments Energy-efficient design to leverage natural ventilation and optimise thermal comfort	Establish circular and regenerative resource flows Felled timber reused as park benches; excavated clay repurposed into natural pond liners
Integrative and Innovation Force Design and Planning Ecologically sensitive design retaining greenery and natural features		
Collaborative Transformation Stakeholder Partnerships and Engagement Engagements with Nature Society Singapore, National Parks Board, heritage-interest groups, National Heritage Board, and surrounding stakeholders		
Data and Intelligence Technology Environmental modelling and simulation tools to capitalise on wind flows and shade		

Illustrating the working Framework—Bidadari, Singapore.
Image: Centre for Liveable Cities

as surrounding stakeholders such as Maris Stella High School, Cedar Girls' Secondary School, Cedar Primary School, Gurkha Cantonment and private housing residents from Wan Tho Avenue Estate. Bidadari Park, located within the housing estate, now hosts more than half of the migratory dryland bird species in Singapore. The park also features Alkaff Lake, which can hold up to 40,000 m³ of water and serves as a stormwater retention pond that mitigates flood risk. The design of the park emphasises circular resource flows, by reusing felled timber as park benches and repurposing excavated clay for use as natural pond liners.

CANADA WATER, LONDON

The Canada Water Masterplan is a 53-acre rejuvenation project

that aims to revitalise the former docklands in the south-east of London. When completed, the Masterplan will provide up to 185,806 m² of workspace and up to 92,903 m² of retail and leisure space, as well as 3,000 new homes, 35% of which will be designated as affordable housing.

Developer British Land partnered with the London Wildlife Trust to restore Canada Water’s existing wetlands. This effort saw the creation of three new wetland habitats and seven wetland islands that support local biodiversity. According to British Land, Canada Water could create 28% biodiversity net gain for hedgerows and habitats when completed, exceeding the 10% statutory planning requirements. The development will also feature

open spaces including a 3.5-acre park and a new town square, alongside walking and cycling routes that enhance connectivity.

Another key priority at Canada Water is low-carbon development. Through the collective efforts of 3,000 volunteers including local students and residents, a former Daily Mail paper warehouse on site has been repurposed into a community and educational space known as The Paper Garden. The project retained the warehouse’s structural frame and used recycled materials, including materials reclaimed from the original site. Beyond adaptive reuse, Canada Water is also adopting heat-sharing technology that allows waste heat from workplaces to power homes, thus optimising energy flows.



View of Canada Water, with restored wetlands in the foreground.
Image: Alysia Wee

Outcomes of taking a regenerative approach

Regenerative strategies for the built environment

Enablers for integration and implementation of regenerative strategies

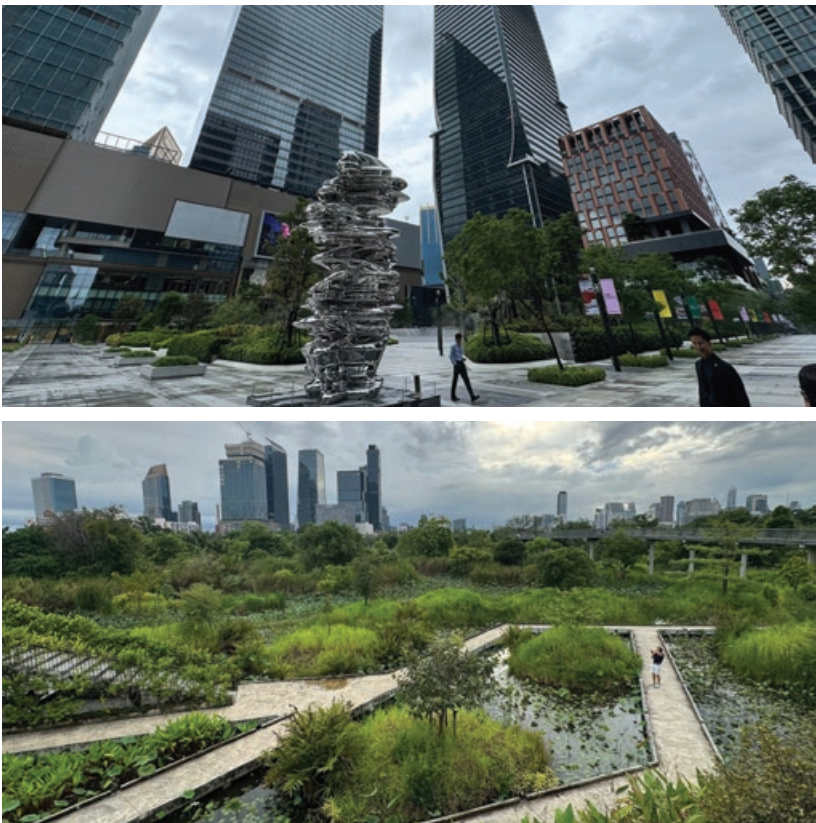
Liveability outcomes Affordable housing commitments; revitalised workspace, retail and leisure space; green public spaces, walking/cycling routes		
Resilience outcomes Climate resilience – protecting biodiversity; Social resilience – affordability and inclusivity		
Resource outcomes Optimising land as a resource through redevelopment; optimising carbon savings		
Enhance ecosystem services through nature-based solutions Wetland habitat restoration and creation	Create low-carbon developments Adaptive reuse; repurposing of sites; retaining structural frames (e.g., The Paper Garden)	Establish circular and regenerative resource flows Use of recycled and reclaimed materials; heat-sharing from workplaces to homes
Progress tracking and Feedback Loop Measurement and Monitoring systems Biodiversity net gain		
Collaborative Transformation Stakeholder Partnerships and Engagement Engagements with local community, London Wildlife Trust		
Data and Intelligence Technology Heat-sharing technology allowing waste heat from workplaces to power homes		

Illustrating the working Framework—Canada Water, London.
Image: Centre for Liveable Cities

ONE BANGKOK

Situated in central Bangkok, One Bangkok was opened in 2024 as a mixed-use district comprising retail, residential, and office spaces. It was developed by TCC Assets and Frasers Property based on a “15-minute city” concept, where homes, offices, shops, and green spaces are located within a 15-minute commute.

One Bangkok features more than 5 km of tree-shaded pedestrian walkways as well as the One Bangkok Urban Park, which provides about 80,000 m² of green and open space. The presence of shade trees and strategic landscaping has made the urban park approximately 2–3°C cooler than the surrounding city, offering an important



One Bangkok and Benjakitti Park.
Image: Andy Tan

ecosystem service in a tropical climate. One Bangkok is also connected to nearby Lumpini Park and Benjakitti Park, where native vegetation and urban wetlands help to filter polluted water from a neighbouring canal. The wetlands are also expected to retain up to 200,000 m³ of stormwater during the monsoon season, contributing to climate resilience.

Beyond ecosystem services, resource savings and circular waste management are other key features of One Bangkok. The development’s central district cooling system serves to reduce peak energy load, delivering up to 22% energy savings as compared to traditional HVAC systems, and reducing annual carbon emissions by 9,000 tonnes. More than 75% of the development’s construction waste was diverted from the landfill and recycled into components such as precast panels and sound barriers, while wastewater is treated and recycled for flushing fixtures and landscape irrigation systems. Leveraging its resource and energy efficiency, One Bangkok has secured a long-term green loan agreement with five of Thailand’s leading financial institutions to support its further development and operations.

These case studies illustrate how the Regenerative City Framework can be used to understand how existing sites support regenerative development and maximise co-benefits. Once fully validated, the Framework could be used to guide sites undergoing (re)development, by actively structuring and enabling the integrated planning of regenerative features.

Refining the Framework: Insights from the Regenerative City Forum Series

To sharpen the Framework’s efficacy as a guiding tool for regenerative development, there is value in refining and validating it with experts and practitioners. In 2025, the CLC’s Regenerative City Forum series was launched to enhance the Framework’s applicability in both local and international urban contexts.

The series comprised workshops with multi-sectoral stakeholders in Singapore (March 2025) and London (June 2025), engaging

about 100 participants from public agencies, industry partners, academia, and international organisations across both cities. Structured around hypothetical sites inspired by existing projects and indicative of urban typologies, workshop discussions explored how regenerative urban development could enhance, measure, and communicate various co-benefits to stakeholders, and how the Regenerative City Framework could support these efforts.



Workshops as part of the Regenerative City Forum series in Singapore (top) and London (bottom).
Image: Centre for Liveable Cities

Outcomes of taking a regenerative approach

Regenerative strategies for the built environment

Enablers for integration and implementation of regenerative strategies

Outcomes of taking a regenerative approach	Liveability outcomes Mixed-use district comprising retail, residential, office spaces, and green spaces within a 15-minute walk		
	Resilience outcomes Climate resilience – supporting native vegetation; regulating stormwater during monsoon season		
	Resource outcomes Optimising energy and carbon savings, use of water		
Regenerative strategies for the built environment	Enhance ecosystem services through nature-based solutions Cooling through urban greenery; stormwater regulation and filtration of polluted water (Benjakitti Park)	Create low-carbon developments Energy and carbon savings through central district cooling, waste diversion from landfill	Establish circular and regenerative resource flows Recycled construction waste; treating and recycling wastewater for flushing and irrigation systems
	Design and Planning '15-minute city' design concept		
	Finance, Investment and Business Model Long-term green loan agreement with financial institutions		
Enablers for integration and implementation of regenerative strategies	Integrative and Innovation Force		
	Resourcing		
	Technology District cooling system with greater energy savings, waste recycling capabilities		

Illustrating the working Framework—One Bangkok, Bangkok.
Image: Centre for Liveable Cities

Insights from the Regenerative City Forum series can be distilled into six key themes:



Six key themes from the Regenerative City Forum series.
Image: Centre for Liveable Cities

First, to maximise co-benefits and outcomes, the application of regenerative design must consider time as a core dimension. For instance, whole-life-cycle planning—which considers decisions from conceptualisation to completion and eventual demolition—would enable greater optimisation of outcomes including maintenance needs, operational costs and environmental impact. Taking a long-term view also enables feedback loops to be incorporated at each stage of the development process, to holistically measure and optimise co-benefits.

Second, district-scale interventions that are enabled by collaborative systems and partnerships offer key opportunities to maximise co-benefits. District-scale developments can tap on synergies across shared facilities such as district cooling, waste disposal systems, and material processing hubs. Such closed-looped systems can strengthen resource circularity for multiple tenants and users, offering an optimal scale to implement regenerative approaches and achieve co-benefits across entities.

Third, social and ecological systems are interdependent and equally important in realising potential co-benefits. Regenerative principles envision creating a conducive environment where humans and nature have a mutually dependent and beneficial relationship. For example, green spaces that are safeguarded for biodiversity can also support recreational activities among residents.

Fourth, measurement tools and frameworks that can track the integrated co-benefits of regenerative development are

instrumental, especially at a district scale. Holistically tracking social and environmental co-benefits and outcomes can allow regenerative interventions to be prioritised in decision-making. However, this would require addressing challenges around data ownership and sharing, as well as complexities around aggregating and interpreting data across both individual entities and the whole district.

Relatedly, measuring the performance of regenerative developments would require both place-based as well as more universal indicators. While regenerative thinking prioritises local contexts and place specificities, such place-based indicators are insufficient on their own. Broader standardised indicators are also needed to provide a common language that enables mutual learning and benchmarking across urban typologies and contexts. To scale the application of regenerative design, this tension between place-based and universal indicators must be navigated carefully.

Finally, the co-benefits of regenerative development must be communicated in targeted ways according to stakeholders' priorities. While developers may prioritise co-benefits that optimise existing systems in terms of water and energy usage, residents and the wider community would typically prioritise co-benefits that matter to and affect their lived experience more directly, such as access to green spaces or thermal comfort. To enable productive partnerships with diverse stakeholders, it will be necessary not only to measure co-benefits accurately, but also to communicate them effectively.

Conclusion

The Regenerative City Forum series has provided rich insights and a useful foundation for refining the working Regenerative City Framework. The Framework will continue to be enhanced through an ongoing collaboration between CLC and the Singapore University of Technology and Design. This work seeks to establish a scientifically validated definition of a regenerative city, which can help to anchor international discourse and application. Responding to the gap in measurement mechanisms, the enhanced Framework will also propose an integrated self-assessment tool to track and measure the co-benefits of regenerative approaches at the district scale.

With its emphasis on enhancing co-benefits and creating net-positive outcomes for people and the environment, regenerative development provides a viable urban development pathway for cities in a world increasingly affected by climate change and resource constraints. The development and adoption of practical tools like the Regenerative City Framework will go a long way towards creating regenerative cities that restore natural ecosystems and ensure liveability for all. 🌱



CROSS-SCALE RELATIONSHIPS

BREE TREVENA

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

Regenerative Design: Across Urban Scales



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

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

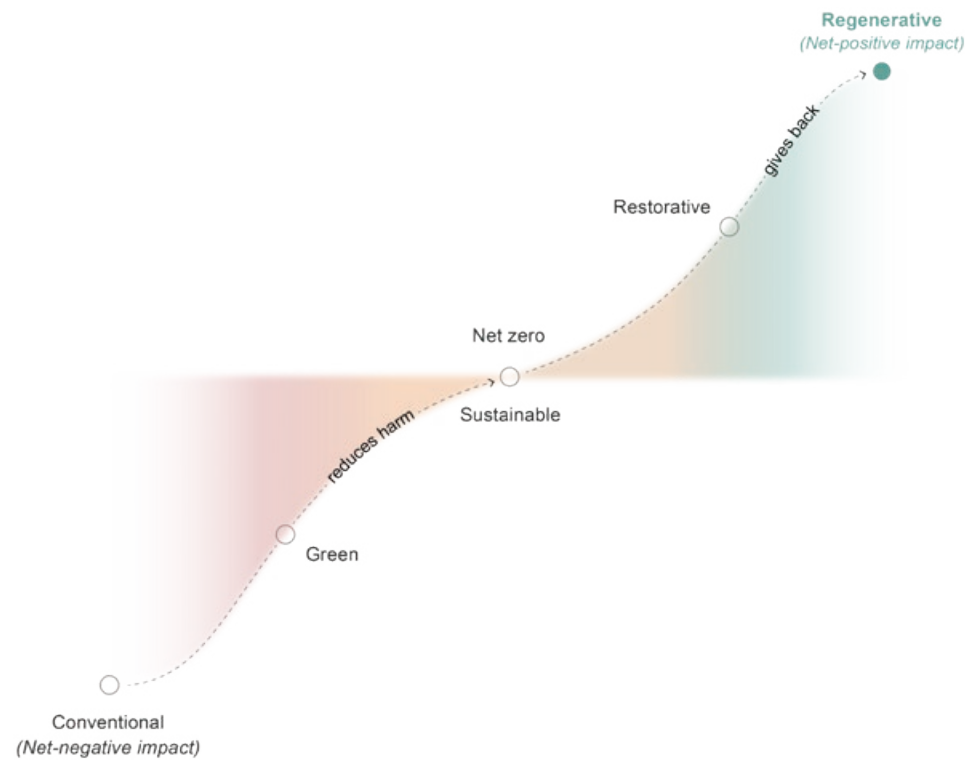
Beyond Sustainability

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

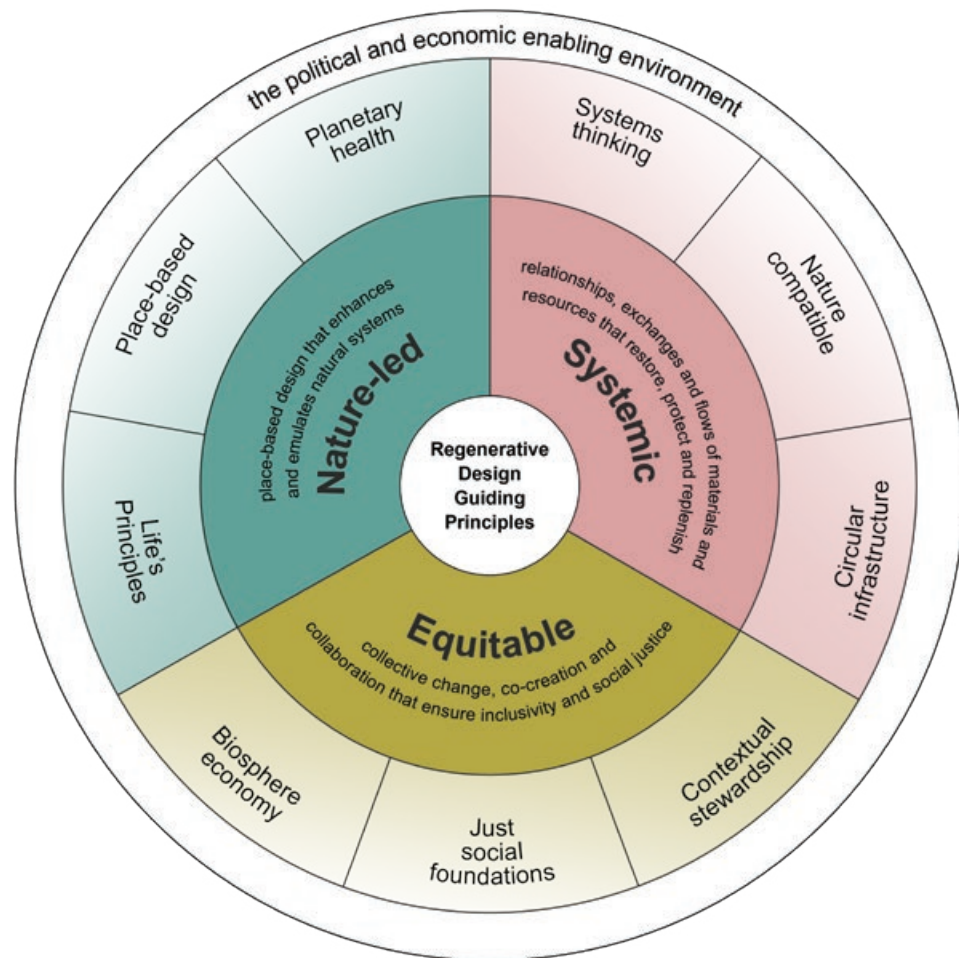
Every year, the World Economic Forum surveys experts for a sense of the biggest risks facing our shared economic, environmental, and social wellbeing. Looking ahead to the next decade, the 2025 Global Risks Report finds that four out of the top five critical challenges are environmental: extreme weather,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

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

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



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



Regenerative Design Guiding Principles.
Image: Arup



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

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

Towards Regenerative Design

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

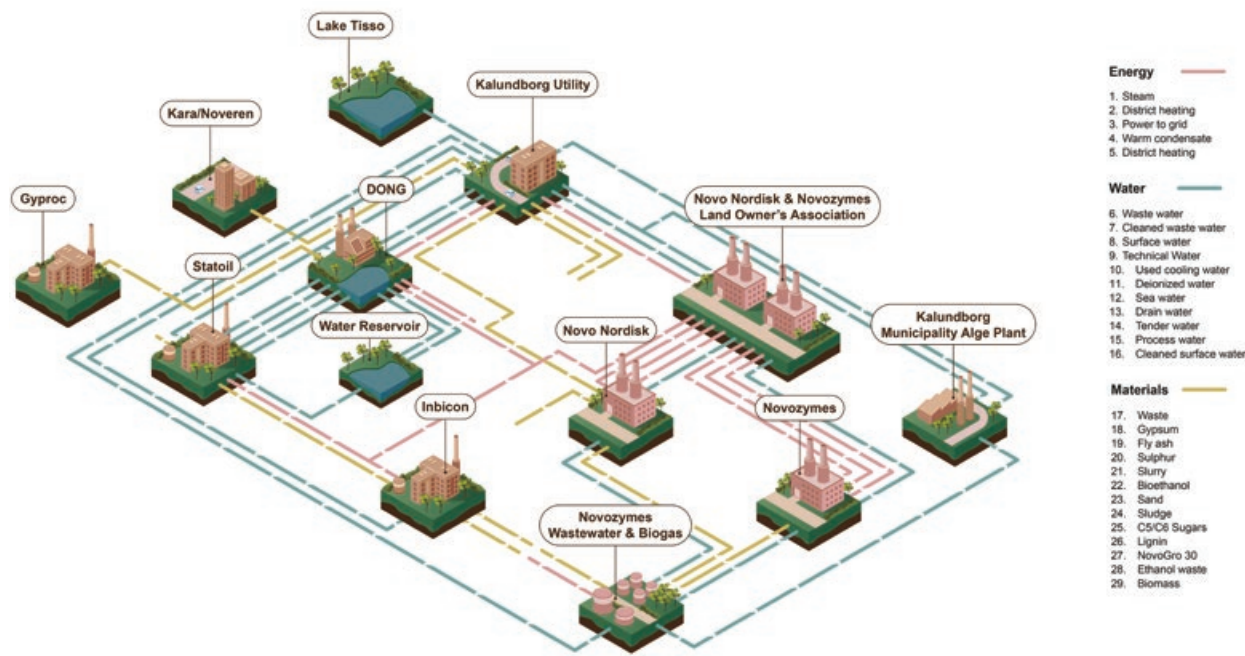
Yet a shift from sustainable to regenerative design is not straightforward. Among other things, it requires a fundamental shift in values, economics, and material practice. Fortunately, we have 3.8 billion years of data from nature to learn from.

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

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

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

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



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

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

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

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

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

substantial economic benefits and new value chains.

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

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

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

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

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

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

Working Across Scales

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

Material Scale

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

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

Building Scale

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

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

Neighbourhood Scale

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

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

City and Region Scale

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

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

Reflections from London Climate Action Week (LCAW) 2025

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

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



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

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



URBAN ACUPUNCTURE AT DISTRICT-SCALE
**NIRMAL KISHNANI
& WONG MUN SUMM**

Nirmal Kishnani and Wong Mun Summ are co-programme directors of MSc Integrated Sustainable Design at the National University of Singapore. Over the past six years, they have collaborated on developing a whole-systems approach to design and planning. Wong is also the co-founding director of Singapore-based design firm, WOHA Architects.

Systems, Patterns, Place: A Novel Framework for Urban Transformations



A mosaic of systems and patterns that represent place.
Image: Arthur Mazi, Wynn Loner U. Uy

|| The boundary condition within which this conversation must happen is not the building but rather the city. ||

Despite decades of green standards and sustainability practices, cities continue to struggle with mounting environmental pressures and declining quality of life. This deterioration reveals a gap between action and impact, pointing to a deeper systemic problem rooted in our approach to design and planning.

One reason for this gap is a persistent myth of greening: that improvements of parts aggregate into system-wide transformation. Despite the proliferation of green-certified buildings over the past two decades, cities have not been able to achieve meaningful change. This dichotomy between parts and wholes reveals the limitations of component-based approaches to complex urban challenges.

Another greening myth is that it suffices to simply do less harm. However, the time for incrementalism has passed. Climate change and ecosystem losses have accelerated to a point where small improvements within large, faltering systems serve as mere placebos. We must now find new ways to do good, and at the right scale, moving past mitigation towards regeneration.

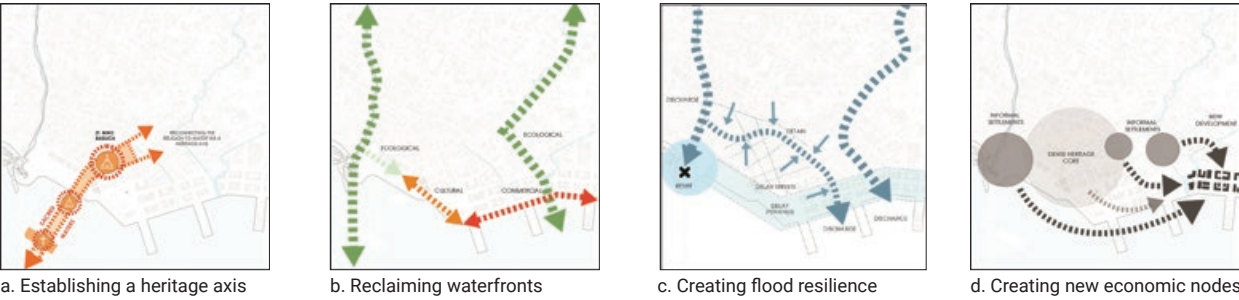
Redefining 'Good' in Urban Systems

But what constitutes 'good' in this new paradigm? Good is not merely the absence of harm but the active enabling of human and ecological systems to thrive together. It involves creating positive feedback loops that enhance the life-supporting capacity of urban environments whilst generating social, economic, and natural capitals. This understanding of good is inherently systemic—emerging from an understanding of the relationships and exchanges between parts rather than optimising their individual performance.

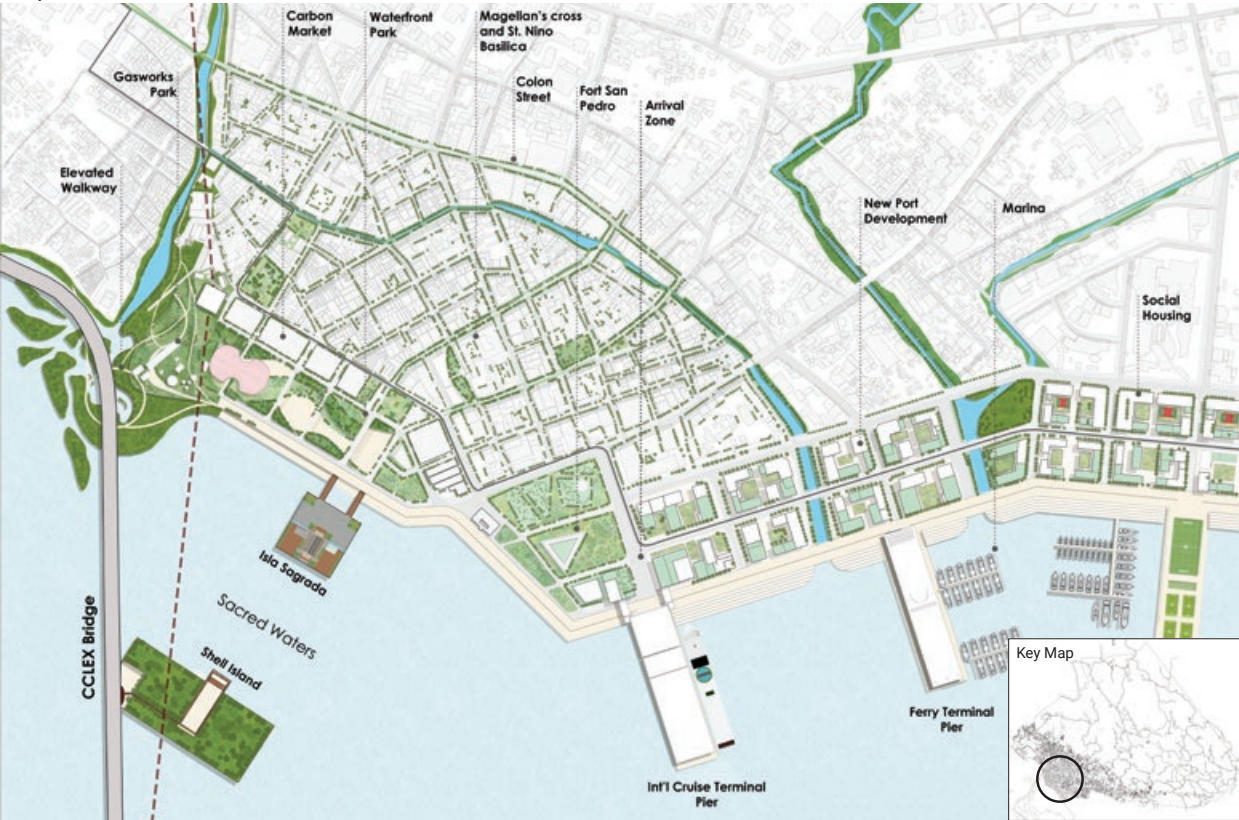
Good is also place-based. Unlike universal metrics or standardised solutions, good manifests differently across situations, responding to local ecologies, cultures, economies, and social structures. It is multivariate and dynamic, requiring continuous adaptation

Cebu City, Philippines

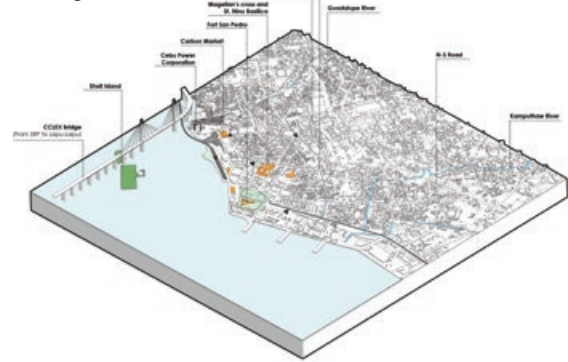
Future Patterns



Proposed Master Plan



Existing



Proposed



The potential of the historic-commercial district of Cebu City is presently constrained by traffic congestion, flood risk, water pollution and an inaccessible waterfront. The studio proposed alterations that were guided by two ideas of 'good': the restoration of ecosystems—addressing water quality, flood inundation and green social space—plus the augmentation and de-fragmentation of public space networks. Both actions elevate economic capital by enhancing the value of real estate and creating new jobs.

rather than fixed outcomes. Here, the goal of design is to foster systems that can learn, evolve, and respond to changing context and circumstance.

The boundary condition within which this conversation must happen is therefore not the building but rather the city, framed as a complex living system. From this understanding of a living whole, we determine what roles the parts must play and how they ought to interact.

Once we visualise cities through a systems lens, every act of design is an opportunity to alter flows and exchanges so that the system as a whole becomes balanced and deconflicted.

Beyond 20th Century Urbanism

Current conventions of urban design and city planning were forged in the 20th century around a particular vision of the future. The fragmentation of the city into pathways for automobiles, hard edges between building and street, discrete mono-functional precincts, etc., all reflect a machine-like view of the metropolis—robust, rational, enabled by technology, but soulless.

Author and theorist, Jane Jacobs, warned in 1961 that this approach constituted the de facto death of the city, arguing instead for a more organic, living systems understanding of urban environments. Over six decades later, her warning continues to be pressing and relevant.

Today, cities also face new imperatives: climate change, biodiversity loss, rapid urbanisation, and deepening social inequity. In this environment, good is often viewed as ad-hoc mitigation—actively countering the negatives where they occur or correcting situations that exacerbate these problems.

But good, at this moment in time, must transcend the cautionary and reactive. It must seek out the positive, cultivate new forms of life, beauty, and delight. This calls for a shift in how we see urban systems and act on them.

Cities as Complex Living Systems

Cities are complex organisms with emergent phenomena characterised by the collective behaviour of their deeply entwined human and natural systems. Understanding urban complexity begins with recognising that multiple systems are operating simultaneously: ecological systems (water cycles, energy flows, biodiversity networks), social systems (communities, economies, governance structures), and built systems (infrastructure, buildings, transportation networks)—each in perpetual dialogue with each other.

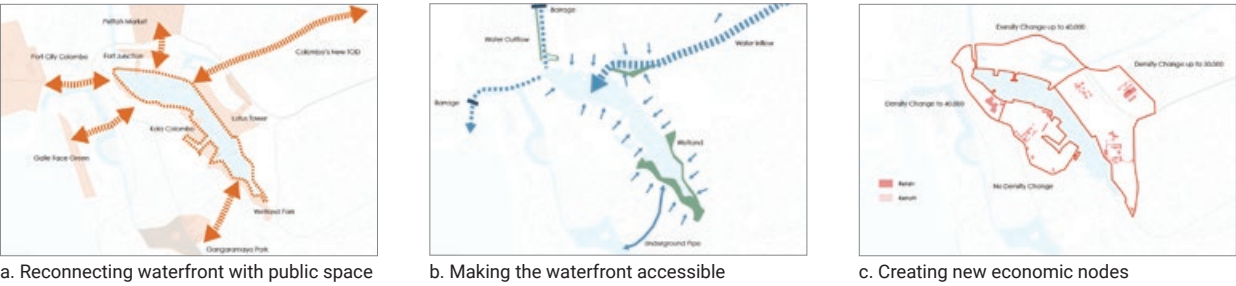
These systems manifest characteristics of complex adaptive systems: they are non-linear, exhibit emergent properties, demonstrate self-organisation, and display adaptive capacity. The key to understanding complexity is systems thinking. Once we visualise cities through a systems lens, every act of design is an opportunity to alter flows and exchanges so that the system as a whole becomes balanced and deconflicted.

This systems approach obliges us to start by taking stock of current conditions, including assets embedded in existing communities, ecological services provided by local ecosystems, cultural wealth accumulated through history, and economic relationships between traditional livelihoods and emerging opportunities.

Equally important are the invisible threads of urban systems: flows of energy, materials, information, and socio-economic relationships. Water cycles connecting watersheds to neighbourhoods, energy flows linking renewable generation to consumption patterns, economic exchanges creating livelihoods, and social networks building community resilience, all represent invisible but essential infrastructure.

Colombo, Sri Lanka

Future Patterns



Proposed Master Plan



Existing



Proposed



Beira Lake in central Colombo is inaccessible and considered the “backyard” of the city with abandoned warehouses and poor water quality. The proposal reimagines the lake as a vibrant urban commons that combines ecological restoration, social amenity, and economic revitalisation with new tourist attractions, social-cultural nodes and recreation spaces. This is carefully managed through strategic acts of urban densification and adaptive reuse.

Designing Systems: A Three-Step Methodology

A systems approach to design and planning has been developed at the Integrated Sustainable Design (ISD) studio at the National University of Singapore. The studios experiment with spatial visualisation and problem-solving, focusing on large urban precincts as microcosms of the city-at-large. These are approached with four ideas of ‘good’: autonomy (decoupling from extractive practices), ecology (protecting ecosystems as urban infrastructure), society (creating new nodes for interaction), and economy (protecting existing livelihoods whilst creating new opportunities).

Step 1: Cartography of Systems, Patterns, Place

“Systems” are mapped as discrete layers to reveal spatial contiguity or fragmentation. The studio prioritises systems with spatial attributes: mobility, buildings, green cover, public space, energy,

water, and food. Mapping is done at multiple scales—precinct, city, metropolitan region—to understand cross-scale connections and how system granularity changes with scale. Systems mapping also looks back to the recent history which, depending on the city, may be prior to periods of rapid economic growth or, further back, to pre-colonial times.

“Patterns” are relationships between systems—overlaps and synergies, flows and exchanges, edge conditions and buffers that occur within and between systems—resulting in specific behaviours. For instance, how people move through a city at different times of day or week depends on how mobility networks are designed (or not designed), and how land use and density are distributed. Understanding patterns opens up the possibility of small interventions for large impacts, for example, a

new cycling pathway that eliminates vehicular bottlenecks between two points in a city.

“Story of Place” is made up of the unique geographical, cultural, and historical characteristics that define a location’s identity and potential. Understanding this narrative enables design responses that honour local knowledge and strengthen community identity. Place-seeking also identifies stakeholder groups and areas of conflict or contestation, which aids in understanding how power dynamics and competing interests are manifest. Place mapping can be partly spatial, for instance, processional routes during festivals, networks of public gathering spaces, or commercial corridors. Place can also be ecologically informed by the role of geography or hydrology in shaping the life of a city.

Existing



Proposed



Blue Green Mobility Built form

The “system” diagrams show the mapping of four urban layers: blue (water), green, mobility and built form. Each is an implicit pattern of connectivity and flows. The proposal (bottom row) shows how these systems are altered, taking cues from each other, to create new patterns of movement and flux.

Step 2: Deficits and Surpluses of Capitals

The spatial mapping from Step 1 reveals elements and connections that make up the urban landscape. Step 2 unpacks the value of these structures by observing and understanding the economic, human, social, and natural capitals present in each city. Every city consists of a dynamic relationship between these capitals—some are deprioritised, others are unevenly distributed across the city or between groups.

Natural capital consists of ecological systems and ecosystem services that reduce flooding, mitigate urban heat island effects, and improve biodiversity. Social capital encompasses networks, relationships, and institutions enabling collective action. Human capital includes knowledge, skills, and capabilities of the local population. Economic capital consists of formal and informal economic systems that contribute to local resilience.

Step 3: Capital Creation through Spatial Planning

The ISD approach posits that: (a) spatial networks and land use can be seen as proxies for capitals, and (b) that the rise of one capital can increase or diminish another. A deficit or surplus of capitals can therefore be inferred from space. The growth of one space type, linked to a capital, can affect adjacent spaces and their capitals. A new park, for instance, can raise the rental value of nearby properties, while an ecologically vibrant park might improve ecosystem services in the neighbourhood.

Designing for good therefore requires understanding of how certain space types act as levers for capital gains.

Natural Capital can be gauged from the quantity and connectivity of green and blue spaces, size and shape of biodiversity habitats, contiguity of wildlife corridors, and presence of ecotones, wherein ecological functions and human activities overlap.

Social Capital arises in part from the availability and accessibility of public spaces, the diversity of amenities and social infrastructure, and the presence of cultural or economic nodes, such as churches or markets, that engage communities.

Economic Capital is enhanced when, in a precinct, there is a nexus of revenue-generating activities that attract a community of consumers, a presence of spaces that support formal and informal economies, close proximity to sourcing, manufacture, use, and reuse, and connectivity between residential areas and employment opportunities.

Integration is key. The most effective interventions create spaces that serve multiple capitals simultaneously. Economic targets for local autonomy in food, for example, can be coupled with creation of social capital, if the farms are also community-led. The same farm might also offer ecosystem services such as carbon sequestration, which improves natural capital.

Implementation: Tools, Metrics, and Assessment

The three-step methodology demonstrates systems thinking as a tool for design—allowing urban designers and planners to see the connection between spatial planning and capital gains. Moving forward, the implementation of masterplans will require complementary governance and finance metrics and tools that mayors, investors, and community stakeholders can use. These include "upstream" assessment tools that estimate return on investment, prior to implementation, as well as "downstream" management tools.

Starting with the upstream: traditional economic assessment focuses on single-benefit calculations. Emerging frameworks are attempting to expand on this approach by providing multi-capital accounting methods that value ecosystem services, social infrastructure benefits, and economic multiplier effects within integrated metrics. Tools like Integrated Return on Investment (IROI) quantify capital gains by type and beneficiary for every dollar invested, creating business cases for systems interventions that generate value across multiple domains.

For downstream management, digital technologies—including ecosystem services valuation software, AI-powered risk assessment platforms, digital twin technologies, and participatory mapping tools—enable real-time monitoring and adaptive management of complex urban systems. These technologies make visible the flows and relationships, providing feedback loops for continuous system optimisation.

The future of urbanism lies in combining the rigour of systems thinking and place-based design at the drawing board, and supporting upstream assessment and downstream management tools that make complex system behaviours visible, measurable, and actionable for diverse stakeholders operating at the intersection of public policy, private investment, and community development.

Conclusion

The persistent failure of component-based approaches to solve complex urban challenges necessitates a fundamental shift toward systems thinking. By understanding cities as complex living systems and employing integrated methodologies that map patterns, assess capitals, and design for multiple good outcomes simultaneously, we can move beyond incremental improvements toward regenerative transformation.

This approach requires new forms of collaboration between designers, planners, communities, and investors—supported by tools that recognise and value the interconnected nature of urban prosperity. The three-step systems methodology provides a design framework, combining spatial mapping and multi-capital analysis, which sets the stage for a 21st-century approach to urbanism. 📍

Future Patterns



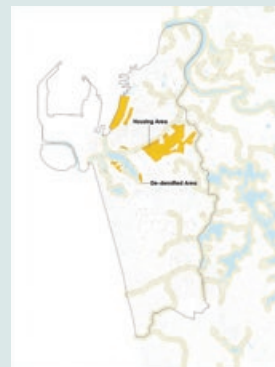
Restored blue-green networks



Increased & connected public spaces



De-fragmented land use



New residential & commercial nodes

"Pattern" maps show new capitals in metropolitan Colombo. The restoration of blue-green networks creates new public space that re-connects the city. Elevating the railway lines in the city centre—and freeing railway land for development—creates new possibilities for commercial and residential nodes, thereby generating social and economic capitals. A new transit node, east of city centre, de-congests the city and creates opportunity for high-value real estate.



The Cebu and Colombo studios, carried out between August 2024 and May 2025, were co-led by Dr Swinal Samant, and supported by Mr Alakesh Dutta. The Cebu studio was also facilitated by Ms Marianne Amores Dutta.

CROSS-SYSTEMS RELATIONSHIPS

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Rethinking Value Creation in Building Sustainable and Regenerative Cities



The NUS E7 facility, a green building which bridges research between the Engineering and Medical fields, the state-of-the-art Wet Science Building, as well as energy-related initiatives.

Image: National University of Singapore

II

Green buildings enhance economic resilience, strengthen natural capital resilience, forge a net-zero pathway, and create liveable cities.

II

Urban development is at an inflection point. As the climate crisis intensifies and cities swell under demographic, ecological, and economic pressures, planners, developers, and investors are re-evaluating what constitutes value.

Traditional financial metrics like internal rate of return (IRR) and net present value (NPV), while still relevant, no longer capture the full spectrum of impact generated by buildings and districts. To address this gap, the Sustainable and Green Finance Institute (SGFIN) at the National University of Singapore (NUS) has developed an Integrated Return on Investment (IROI) framework—a methodology that quantifies and monetises economic, environmental, social, and governance (EESG) outcomes of urban development.

The IROI framework offers a holistic valuation tool applicable at both the building and district levels. It enables stakeholders to answer a fundamental question: for every dollar spent on sustainability, what is the true value created for people, the planet, and investors?

Theory of Change

To answer the preceding question, we first asked ourselves why green buildings are needed and what value propositions they offer to society and the environment. A key method that we used to identify stakeholders and establish input-output causality was the Theory of Change (ToC). This helped us better understand the role of green buildings in contributing to a more sustainable future.

In developing the ToC, we identified four long-term impacts of green buildings for key stakeholders, society, and the environment:

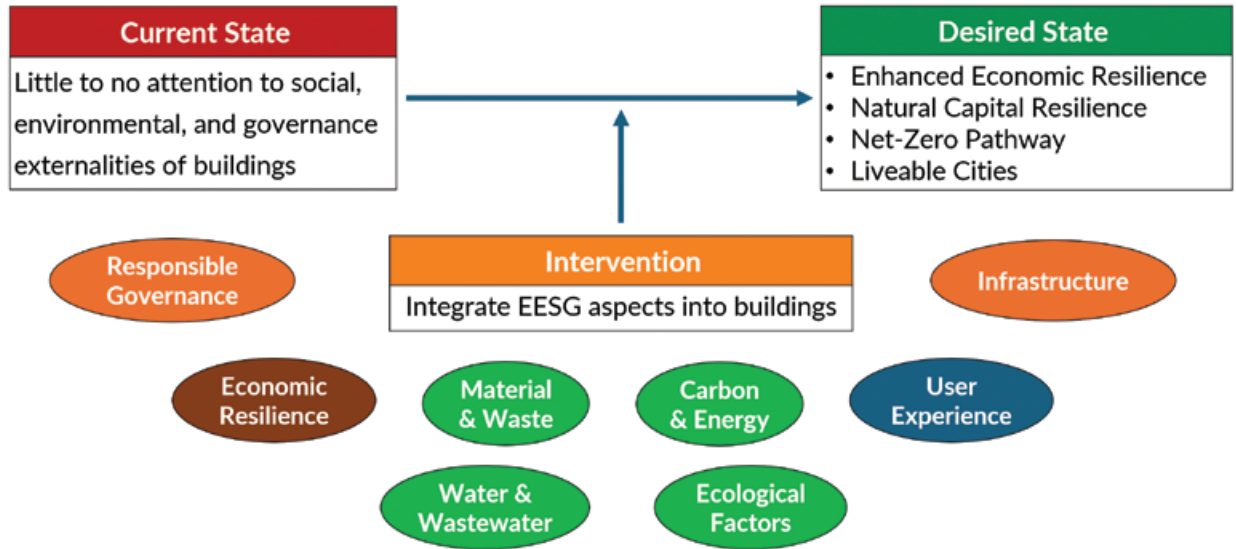
- Green buildings enhance **economic resilience** by reducing operational costs, attracting higher occupancy through green premiums, and creating jobs across the construction value chain.

Building projects can improve how they manage their assets and surroundings, such as by better integrating with transportation and infrastructure to meet future urban and climate goals.

- They strengthen **natural capital resilience** by minimising environmental footprint and supporting the regenerative capacity of essential natural resources.
- They are critical components for building a **net-zero pathway** through energy-efficient design, retrofitting, and adoption of zero-carbon technologies.
- They contribute to creating **liveable cities** by improving environmental quality, fostering social inclusion, and supporting urban biodiversity.

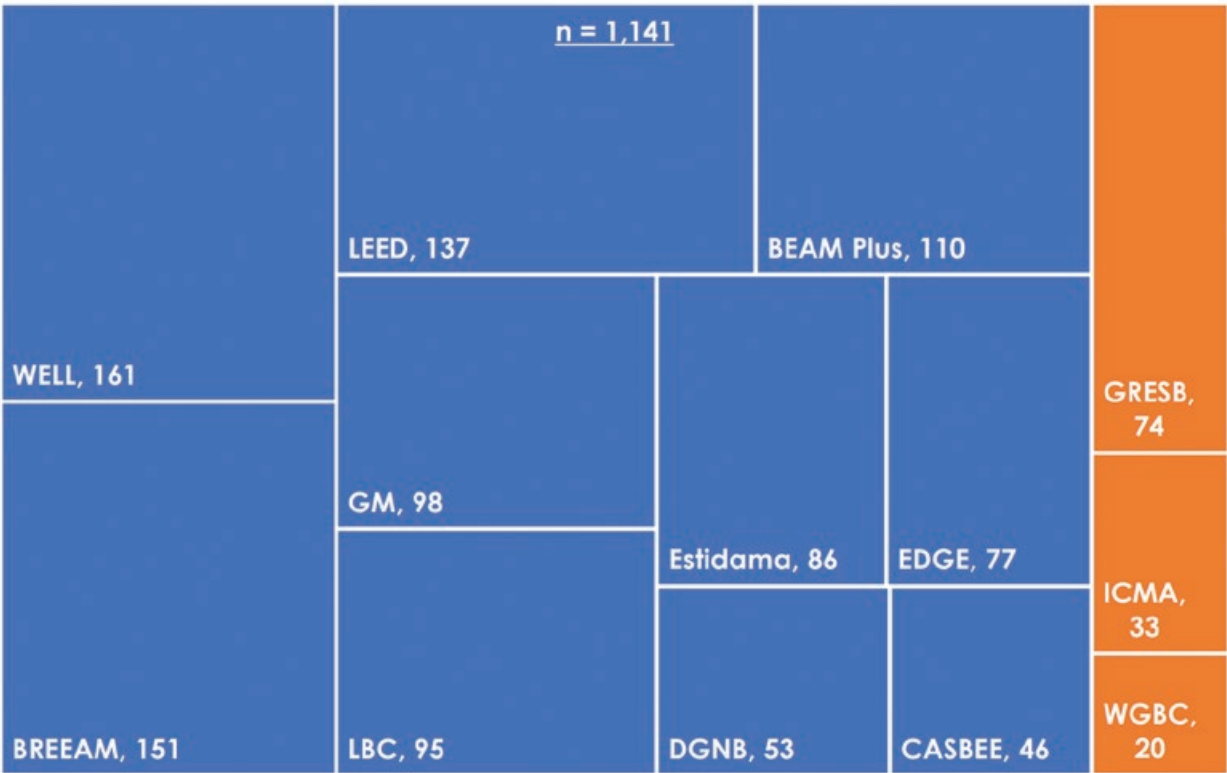
Currently, many buildings are constructed with little attention to their environmental, social, and governance externalities, exacerbating global challenges. **Economically**, buildings must justify their investment and reflect integrated costs and benefits. Yet, despite massive global investment, only a small share is allocated to green buildings. Future stakeholders

must move beyond traditional profit maximisation and account for ESG impacts. **Environmentally**, buildings often overlook their impact on surrounding ecosystems, with low energy efficiency, high GHG emissions, inadequate water management, and poor material and waste practices remaining widespread. **Socially**, developments often insufficiently consider their direct and indirect impacts, including indoor environmental quality and their role in promoting health and food resilience, which are critical to user experience. **Governance**-wise, building projects can improve how they manage their assets and surroundings, such as by better integrating with transportation and infrastructure to meet future urban and climate goals. These gaps substantiate the need for intervention—to integrate EESG aspects into buildings. We present the ToC below to illustrate the entire value chain.



Theory of Change for Green Buildings in Singapore.
Image: The Integrated Impact Valuation Framework for Green Buildings, 2024, SGFIN Whitepaper Series 04

■ Building certification standard ■ Impact measurement framework



Building Indicators under Different Standards and Frameworks.
Image: The Integrated Impact Valuation Framework for Green Buildings, 2024, SGFIN Whitepaper Series 04

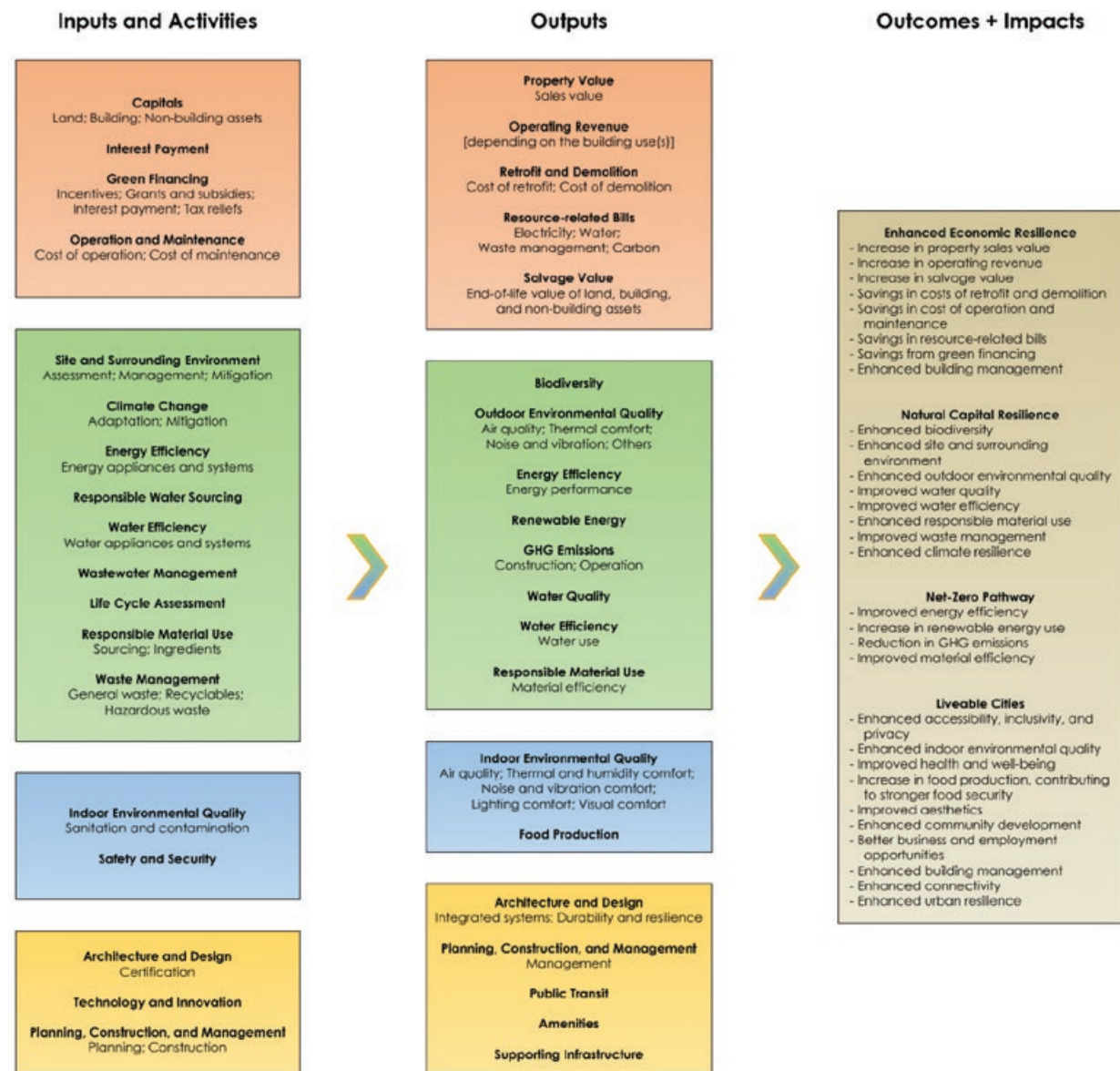
Logic Model

Working in tandem with the ToC is the Logic Model, which maps the pathway from resource inputs and intervention activities to outputs and short- to medium-term outcomes.

We developed the logic model by first harmonising 1,141 building indicators from established building certification standards and impact measurement frameworks, and then categorising them into inputs/activities, outputs, and outcomes/impacts to capture the multifaceted nature of a green building.

These components reconcile the objectives of achieving robust economic returns while maximising integrated impact across a building's lifecycle.

The logic model (shown on page 86) displays the key elements aligned with the EESG pillars and clear value chains. The outcomes/impacts are consistent with the desired state outlined in the earlier ToC, demonstrating that a sustainable future can be achieved through the intervention of green buildings and sustainable developments.



Logic Model for Green Buildings in Singapore.

Image: The Integrated Impact Valuation Framework for Green Buildings, 2024, SGFIN Whitepaper Series 04

Integrated Return on Investment (IROI): Building a Common Language

Traditional financial Return on Investment (ROI) considers only direct financial and economic results, often overlooking many intangible benefits and externalities, which can lead to incomplete decision-making. Although numerous sustainability design features can be proposed, a consistent and robust decision process is needed. Moreover, the

diversity of stakeholders—with different preferences, risk appetites, and decision-making criteria—makes it difficult to communicate these externalities in ways that resonate with everyone.

In our IROI framework, we identified five key stakeholder groups in the built environment: 1) building owners and developers; 2) building

occupants, tenants, and visitors; 3) investors and financial institutions; 4) governments, regulatory authorities, and certification bodies; and 5) local communities and non-governmental organisations. We assigned value creation to each of these stakeholders and standardised the externalities by monetising the outcomes and impacts most relevant to them. For example, we translated intangible benefits such as improved air quality, enhanced productivity, and healthier indoor

environments into monetary terms that directly benefit users. By employing the use of financial proxies, our IROI methodology converts intangible sustainability outcomes into monetary values that are clearly understandable and comparable, enabling informed decision-making across the stakeholder spectrum.

Another key strength of our IROI framework is its use as a forward-looking planning tool. It clearly shows who invests, what results

are generated, and how impact values are created and attributed to different stakeholders. By expressing integrated EESG returns as dollar value per unit of investment, IROI fosters alignment, transparency, and more strategic resource allocation—making the case for bolder sustainability investments that deliver lasting co-benefits for the entire ecosystem.

Case Study 1: NUS SDE4 Net-Zero Building

We applied our IROI framework to the SDE4 building at NUS, Singapore's first new-build net-zero energy building, to illustrate the distribution of co-benefits among key stakeholders, namely the building's owner, NUS, and its users. Our calculations accounted for benefits from many innovative features, such as solar panels, hybrid cooling, smart sensors, and water recycling, and produced an IROI of \$2.32 per dollar of investment. Interestingly, \$1.07 was accrued to NUS through direct utility savings, carbon tax savings, and knowledge sharing, while \$1.25 was attributed to SDE4 users. The user benefits primarily arose from improved water and air quality, which generated health benefits and enhanced well-being and productivity. Although SDE4 is well known as Singapore's first net-zero building and now even a positive energy building, our value computation shows that the additional environmental and social benefits are also substantial.



SDE4 Building in NUS.

Image: National University of Singapore

Sustainability is a Journey:
Why Time Matters

Resilience and regeneration are inherently temporal processes, yet time is often overlooked in urban valuation. Sustainability is not a one-time intervention but a long-term commitment, with the full value of regenerative design unfolding over years or even decades. Early investments in daylighting and ventilation, for example, can yield decades of improved learning outcomes, while biophilic features, which take time to mature, ultimately enhance biodiversity and flood resilience.

Improvement is also a continuous process. Sustainability efforts must be sustained and adaptive, starting with small steps that, when refined over time, generate significant long-term impact. Developers must assess which green features will continue to generate value in the long run. For instance, the effectiveness of green facades depends not only on installation, but also on ongoing maintenance and the selection of resilient, site-appropriate plant species.

This temporal lens is increasingly shaping both design and financing decisions. A notable example is the United World College of South East Asia (UWCSEA), which has embedded long-term thinking and commitment into its sustainability strategy since 2009.

Case Study 2: UWCSEA Dover Campus

For more than a decade, UWCSEA Dover Campus has progressively implemented a wide range of green features, including green walls and roofs, photovoltaic (PV) systems, daylighting strategies, and a self-developed Building Management System (BMS). The PV systems contribute the largest share—59% of the total net impact value—driven by ongoing dialogue between student-led advocacy and supportive school leadership.

In line with UWC’s mission to educate future sustainability experts, these green features are integrated into the curriculum to provide hands-on learning opportunities for students. The BMS not only reduces electricity and water costs, generating economic value, but also creates social value as an educational tool, accounting for 16% of the total impact value. Proper maintenance of the school’s chillers has extended the lifespan of the equipment, reducing the need for replacements, and significantly cutting embodied carbon emissions, contributing 12% towards value creation. Many of these features have long-term benefits, and the integrated value grows when designed for durability and maintained over time. Overall, our IROI assessment from 2015 to 2030 estimated an exceptional return of over \$5.21 per dollar of investment.



UWCSEA Dover Campus.
Image: United World College—South East Asia (UWCSEA)

By treating urban districts as interconnected living systems rather than isolated assets, planners can maximise synergies between ecological and human-centred infrastructure.

Scaling Building-Level Metrics to District Systems

Green buildings are typically evaluated using metrics such as energy efficiency (kWh/m²), water use intensity (L/m²), indoor air quality, occupant satisfaction, and avoided greenhouse gas (GHG) emissions. Beyond the building level, regenerative cities need to also aggregate and adapt these indicators at the district scale.

This is where the scalability of the IROI framework stands out. Within our framework, 82 out of 192 impact value metrics can be aggregated at the precinct or district level. For example:

- **Energy and carbon-related metrics** can be translated into district-wide savings by summing reductions across buildings and infrastructure. These are further enhanced by the synergy between energy-efficient building envelopes and integrated urban planning.
- **Social well-being indicators**, such as improvements in thermal comfort or mental health due to better access to green spaces, can be extrapolated using population-weighted benefits.
- **Resource circularity**, such as shared stormwater systems or waste-to-energy networks, becomes more measurable and impactful when modelled in a collective system.
- **Governance metrics**, such as stakeholder engagement or resilience to disruptions, gain complexity and salience when viewed through multi-building, multi-use, and multi-stakeholder systems.

District-level IROI assessments also account for shared infrastructure, such as mobility corridors, green buffers, distributed energy systems, and digital management platforms, enabling more systemic planning. By treating urban districts as interconnected living systems rather than isolated assets, planners can maximise synergies between ecological and human-centred infrastructure.



Depiction of Future Jurong East District.
Image: Urban Redevelopment Authority

Case Study 3: Urban Planning for Jurong East District (JED)

In our IROI study of JED, a transit-oriented mixed-use district, conducted in collaboration with researchers from the College of Design and Engineering, NUS, we assessed the potential impact of implementing multiple green features in alignment with national initiatives, such as green retrofitting, district cooling systems, and park connectors. Scaling up from the building level, our model incorporated district-level metrics such as estimated healthcare cost reductions from mitigating the urban heat island effect through collective greening efforts.

The uniqueness of our IROI model lies in its examination of the co-benefits generated by both mandatory measures and voluntary enhancements across stakeholders, including private developers, government, occupants, and the general public. Our hypothetical analysis revealed that if only mandatory measures aligned with national targets were to be implemented, the IROI would be \$3.37 per dollar invested. When voluntary enhancements, such as additional PV installations, are included, the IROI rises to \$3.46. Notably, electricity bill savings from PV systems alone accounted for 24% of total value creation. This comparison underscores the value creation of going beyond compliance to pursue higher sustainability ambitions in Singapore.

Our valuation exercise further revealed that integrated returns depend on collective investment and management by both the public and private sectors. While private developers could achieve an IROI of \$2.84 on their investments, the public sector also played a crucial enabling role by contributing to value creation through public greenery areas and infrastructure projects.

By translating EESG outcomes into a holistic and comparable term, IROI bridges the gap between technical interventions and financial decision-making, allowing developers, investors, users, and policymakers to speak a common language.

Conclusion: Toward a Valuation Paradigm Shift

In an era defined by the breach of planetary boundaries, rapid urbanisation, and climate volatility, sustainability must move from aspiration to accountability. Our IROI methodology offers a next-generation valuation language that captures sustained efforts, stakeholder value co-creation, and system-level interactions, enabling regenerative outcomes to be quantified and rewarded. If resilience is about surviving disruption and regeneration is about thriving beyond it, then our IROI approach can serve as a helpful blueprint for rethinking how we value impact, distribute benefits, and make decisions—not just for buildings, but across districts and urban systems.

This shift is especially timely as green finance instruments, such as green bonds and sustainability-linked loans, gain momentum across public and private sectors. The marketability of these financial instruments requires clear and credible narratives of value creation. By translating EESG outcomes into a holistic and comparable term, IROI bridges the gap between technical interventions and financial decision-making, allowing developers, investors, users, and policymakers to speak a common language grounded in cost, return, resilience, equity, and long-term value. 🌱

Note: All case studies are drawn from SGFIN's in-house IROI assessments, using our harmonised indicators across over 1,141 indicators from leading global green building certifications and standards.

BANGKOK | SOCIAL AND ECOLOGICAL SYSTEMS

Regenerating Nature, Transforming Governance: Redeveloping Thailand's Government Complex

Thailand's Government Complex (TGC) is a 178-acre site serving 29 government agencies. Prior to redevelopment, it faced issues of poor connectivity arising from car-centricity and traffic congestion. In 2024, following further development of the Bangkok Mass Transit System (BTS Skytrain), TGC was transformed into a sustainable and people-centric hub, aligned with broader national decarbonisation targets.



Kotchakorn Voraakhom is the founder of Landprocess, a Bangkok-based landscape architecture and urban design firm, and the Porous City Network, a social enterprise which co-designs water management solutions with vulnerable communities in Southeast Asia. Her works focus on tackling climate change in dense urban areas through landscape architecture and productive public spaces.

Every urban development project presents an opportunity to innovate and to redefine possibilities. This is especially true in climate-vulnerable cities like Bangkok. Addressing interconnected urban challenges—water stress, liveability, and climate adaptation—demands more than regenerative design principles, it requires regenerative governance and action. This shift goes beyond carbon metrics, recognising that the process—how we collaborate, adapt, and prioritise nature-positive outcomes—is critical to a regenerative future.

Every city may have to go through their own journey in addressing carbon sequestration and urban resilience, but the global transition will require collective action—a balance of top-down strategy and grassroots engagement. While regenerative principles provide a foundational framework, success depends on localised processes that combine top-down expertise with bottom-up community engagement. From Chulalongkorn Centenary Park (Bangkok's pioneering flood-mitigating green space) to Thammasat Urban



Built in 2017, Chulalongkorn University Centenary Park is a public park built to reduce urban flood risks.
Image: Andy Tan (top), Landprocess (bottom)



Repurposing 236,806 square feet of rooftop space, Thammasat University Rooftop is designed to mimic the structure of rice terraces for urban agriculture.
Image: Landprocess



Revitalised Chong Nonsi canal in the heart of Bangkok.
Image: Landprocess



Farm (Asia's largest rooftop farm), from the adaptive reuse of Chao Phraya Skypark to the revitalisation of Chong Nonsi Canal and Padung Krung Kasem canal, each project embodies a shared mission: reintegrating regenerative ecosystems into the urban fabric. These initiatives demonstrate that nature through landscape architecture is not just about aesthetics—it is a tool for building systemic resilience.

The Real Challenge: Shifting Systems, Not Just Solutions

For cities like Bangkok, already on the frontline of climate risk, the greatest barrier is not a lack of ideas, but whether we can move fast enough to meet all goals within our climate deadline. The question is about how to transform systems, processes, maintenance and operational structures to enable change at the speed and scale required.

The transformation of Thailand's largest government complex offers a pivotal opportunity. By embracing nature-based solutions, it serves as a model for how cities can merge liveability with ecological resilience—not through isolated benchmarks, but through integrated systems that bridge urban cores and surrounding natural ecosystems.

Making Thailand's Government Complex More Humane

Across the world, at eye level, buildings appear as giant concrete structures, densely packed in rigid symmetry. Specifically, the design of government buildings and complexes often lack fluidity, warmth, and human-centricity. Many tend to exude rigidity and hostility, evoking intimidation rather than creating a sense of arrival and welcoming to visitors. This begs the question—can civic architecture be designed at the human scale, creating spaces for human connection while embodying principles of sustainability and the preservation of tradition?

Thailand's Government Complex (TGC), the nation's largest administrative hub, provides a good case study. For over 20 years, this 178-acre campus has served nearly 40,000 users—government employees and civilians alike. Yet like many traditional civic centres, its design has struggled with inefficiency and poor connectivity: car-centric planning, traffic congestion, poor transit links, and siloed urban systems for water, waste, and food.

Bird's-eye view of Thailand's Government Complex. In the foreground, the Oval Lawn Plaza and the Urban Agriculture Rooftop atop the Semi-Outdoor Plaza is pictured.
Image: Landprocess

By employing nature-based solutions into landscape architecture, however, TGC can be redefined as a model of ecological and social resilience. By softening rigid geometries with diverse greenery and biodiversity, improving walkability, and creating inclusive public spaces, a climate-responsive environment that meets the needs of both human and natural ecosystems can be fostered. This shift is not just about aesthetics—it reclaims democracy through design, enabling spaces to enhance human well-being, encourage engagement, and thrive with nature.

The future of civic architecture lies in balance: where design meets accessibility, where concrete gives way to canopy, and where people—not just institutions—take centre stage.

The Oval Lawn Plaza is a multipurpose plaza that is surrounded by multiple pocket parks and entrances that connect people to the underground parking garage.
Image: Landprocess



An Ecosystem Design that Encapsulates Connectivity, Breathability and Flow

The city of Bangkok does not have many public open spaces due to its high population density. This government complex project therefore sets out to not only benefit the environment but also the people within it. With the opening of the new skytrain station in 2024, the government complex aims to be a resilient, people-centric hub that prioritises connectivity, low-carbon design, walkability, and nature-based infrastructure, in alignment with Thailand's net-zero goals.

In the original masterplan, ample parking spaces were provided to meet the needs of a car dependent

city. However, recognising that this would diminish connectivity and lead to the deprioritisation of sustainable mobility within the complex, Landprocess decided to reimagine Thailand's Government Complex, as a people-first hub. Their design sought to integrate low carbon solutions with walkability, as well as combine nature-based solutions with values of accessibility for all visitors.

The transformation of the complex begins with a 200-m elevated skywalk linking the skytrain station to TGC's open plaza. Public mass transit promises to not only achieve





Solar-urban farm.
Image: Landprocess

II
On the rooftop, a solar-urban farm meets 53.4% of the building's energy needs while providing a green space for employees to engage in urban agriculture.

the goals for net zero, but also improve liveability for the 37,500 workers working within the complex.

An unused parking garage rooftop has also been revamped into an open space plaza that breaks away from traditional, sterile government aesthetics. This versatile space hosts a wide range of events, from casual gatherings to formal occasions while also fostering connectivity, welcoming the community and public. The plaza blends green rooftops and runoff management systems with an organic design that mimics the fluidity and natural forms of nature, such as cascading rain chains and lush greenery. These features not only enhance aesthetics but also mitigate flooding, improve

air quality, and reduce the urban heat island effect.

Connected to the open plaza is a green park that seamlessly connects pedestrians to an EV bus station. The floors above this plaza not only provide parking for 1,500 cars, but also incorporate features of rainwater harvesting, urban farms, and vertical planters within the architectural facade. On the rooftop, a solar-urban farm meets 53.4% of the building's energy needs while providing a green space for employees to engage in urban agriculture. Rainwater is harvested and stored in tanks and a retention pond, achieving zero-runoff discharge and enhancing resilience during extreme weather events.



Covered walkways with rain chains and comprehensive drainage systems channel rainwater to rain tanks and a retention pond, achieving zero-runoff discharge.
Image: Landprocess



The Thailand Government Complex at dusk.
Image: Landprocess

To minimise waste and embodied carbon throughout the construction process, a third of construction materials are recycled while the other two-thirds are locally sourced. Solar panels meet more than half of the building's energy needs, while energy-efficient systems and passive design cut operational power usage by almost 90%. All these technical features incorporate traditional Thai motifs of water, blending innovative functionality with cultural ancestry.

The redesigned nature-based structures are built around a central axis that connects visitors to the rest of the complex. The low-carbon project promotes walkability by turning concrete roads into cooling corridors, ensuring thermal comfort. Furthermore, all road networks are

equipped with pedestrian-friendly pathways, an EV shuttle system that reduces emissions while also providing reliable transport, and multi-layered landscapes that maximise carbon sequestration and ecosystem services. By planting 3,500 trees and adding 30 acres of green space, scorching roads and pavements within the complex have been transformed into cooling corridors that mitigate urban heat, flooding, and pollution, supporting the urban climate resilience of the complex.

By harmonising nature-based solutions with cultural and functional design, TGC demonstrates stewardship of natural resources and sets a benchmark for sustainable governance. It fosters a stronger

connection between government, people, and nature while also ensuring long-term environmental, social, and economic resilience. TGC's holistic approach offers a model for government officials to integrate more nature-based solutions and green infrastructure to not just cities within Thailand, but around the globe.

The need to shift is urgent: from rigid buildings to adaptive architecture, from siloed projects to integrated urban systems. When government becomes an active participant, cities like Bangkok can move faster than the rising tides. The future belongs to those who do not just declare change but act on it. 🌱

GLOBAL | REGENERATIVE STRATEGIES IN ACTION

Circular Cities: Regenerative Practices for a Resilient Urban Future

This article explores real-world examples of regenerative urban development and highlights key enablers to scale regenerative urbanism.



Cristina Gamboa is the CEO of the World Green Building Council (WGBC), where she leads a network of more than 75 national Green Building Councils, representing 47,000 companies. She champions scalable solutions and effective local advocacy to secure the sustainable transformation of the built environment.

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The Urgent Need for Resilient Built Environments

The urgent need for resilient buildings and infrastructure is being driven by escalating climate risks, ageing systems, and growing social and economic vulnerabilities. While resilience can be enhanced by upgrades and retrofits, more long-lasting solutions are achieved by optimising resources through future condition analyses and adopting regenerative design practices.

Regenerative building design promotes nature restoration through a whole system thinking approach, creating a more sustainable balance between

communities, the environment, and urban infrastructure. Analysing future conditions enables cities to account for imminent, shifting climate patterns and the increasing probability of hazards occurring.

This article will explore real-world examples of regenerative urban development and highlight key enablers to drive city resilience.

The Case for Circularity and Resilience in the Built Environment

While the built environment is the foundation of modern society, it has also been disruptive and a significant contributor to environmental degradation and climate change. Globally, strategies to reduce externalities have been implemented and innovative solutions keep emerging to not only improve the equilibrium across the three pillars of sustainability—social, environmental, and economic—but to actively revive natural systems.

Such a regenerative approach focuses on the properties and cycles of natural resources, which enable the design of buildings and cities to be optimised in a holistic way. For example, the combination of green and blue infrastructure, at building and city level—such as

green spaces and roofs, ponds, and wetlands—can help collect and purify water, whilst significantly mitigating extreme conditions such as heat. This enhances the resilience of both communities and the built environment. Beyond the building level, such integrated systems can also contribute to actively restoring nature.

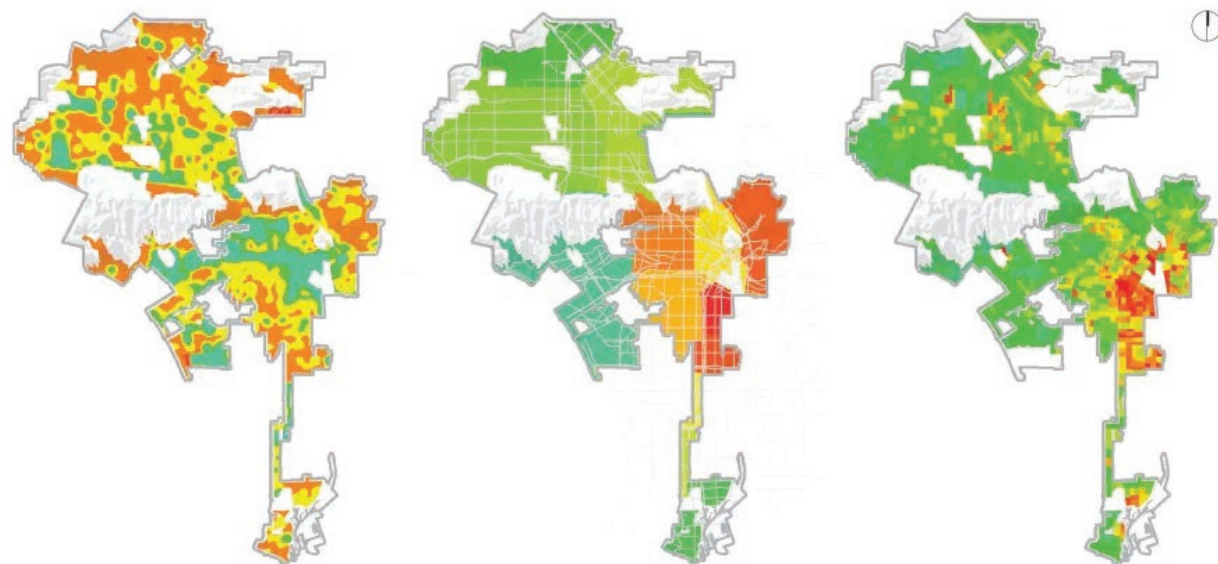
Circular economy practices also play a crucial role by promoting resource optimisation and value retention through closed-loop systems. The value and usability of construction products, including buildings, can be significantly increased by promoting circularity, mimicking naturally regenerative cycles in environmental ecosystems.

Global Case Studies: Regenerative Strategies in Action

There are numerous examples of regenerative practices being applied globally. Here are a few notable cases:

Design and Planning at City and Building Scales

- RegenCities, an initiative of Skidmore, Owings, and Merrill (SOM), uses a “systems-based” methodology that maps and analyses the data of five urban systems—built, natural, infrastructure, socioeconomic, and cultural—to present solutions that improve the balance among them. The City of Los Angeles uses this methodology to tackle challenges such as liveability, waste reduction, water and energy dependency, and transportation.



JOB DENSITY

CHRONIC DISEASES

POVERTY

SOM Los Angeles research project RegenCities collects data from open source portals, combining with census tract data, deploying a systems-based methodology to understand vulnerabilities and opportunities.
Image: Architectural Record



Lapalala Environmental Education Centre received its Net-Zero rating last year.
Image: Lapalala Wilderness School

- South Africa has shown exceptional leadership in resilient and regenerative built environments. For instance, the Lapalala Wilderness School in the Waterberg region of Limpopo is a net zero, off-grid school designed to be functional and repairable by school staff and members of the local community.
- Project Tempelas in Kalimantan, Borneo is a cutting-edge albumin production facility that was created to support sustainable

fish farming. It links a community with limited options to the global health market. This factory has sought to responsibly use the resources of the tropical peat swamp forest where it is located, and its included technologies such as solar energy to increase energy independency. By involving the community from conception, the design and construction was able to benefit from local knowledge, creating a building that responds to local climate conditions.



Beyond albumin production, other facilities like the function hall (pictured on the left) have been built to address the basic needs of the community.
Image: Project Tempelas



The Arezzo Condominium and surrounding sustainable drainage systems.
Image: Condominio Arezzo

- The Arezzo Condominium is much more than a housing development; it represents a transformative vision of comprehensive sustainability and increased quality of life. Spanning 18,900 m², this project located in the municipality of Neiva, Huila, features 159 two-story homes designed using bioclimatic architecture principles. Its approach optimises natural resources and integrates nature-based solutions, such as sustainable drainage systems (SuDS), to ensure energy efficiency, thermal comfort without air-conditioning, and reduction of flooding risks.

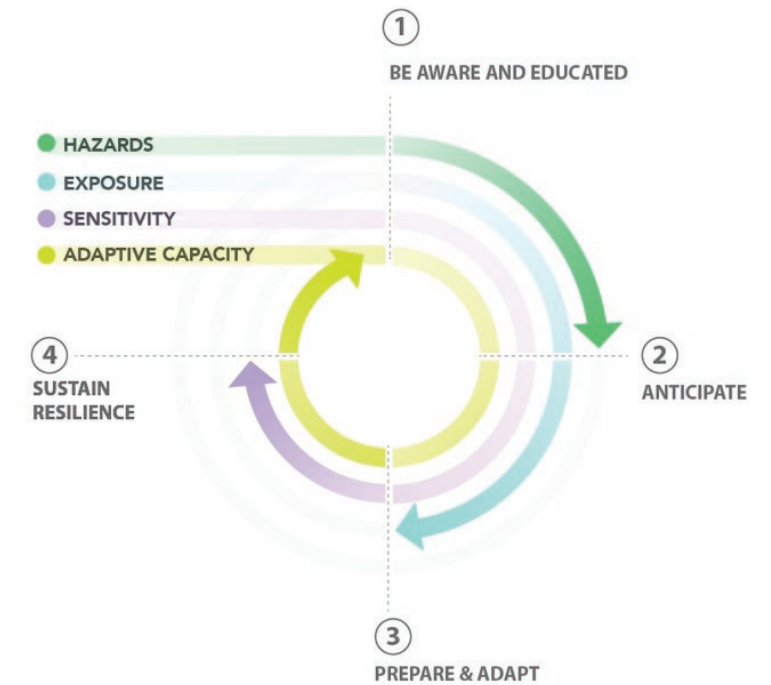
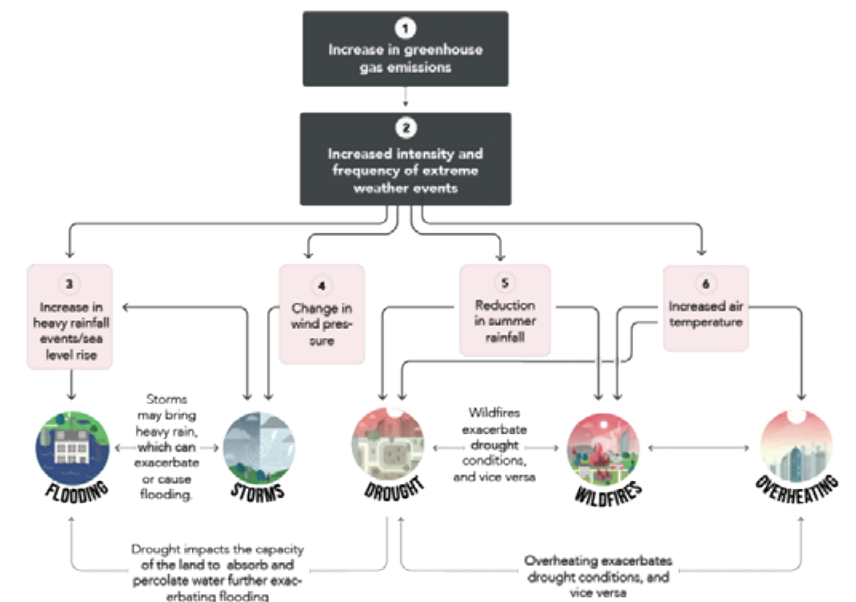
Establishing Guidelines

- The Green Building Council of Australia has published “Future in focus – Resilience in the built environment” as a set of guidelines for resilient buildings and neighbourhoods in Australia. A project that demonstrates resilience at the district-scale is the Resilient Communities in Residential and Mixed-use Development Action programme, led by Resilient Melbourne seated at the City of Melbourne. The programme oversees five pilot sites, each exploring innovative approaches to participatory planning and alternatives to conventional urban infill, greenfield planning, and housing models, with the goal of enhancing community-level resilience and cohesion.

- The UK Green Building Council recently launched the “Climate Resilience Roadmap”, setting out a vision for a climate resilient built environment for the UK, sharing clear recommendations for industry and policy with next steps needed to increase climate resilience. The roadmap details seven key principles towards building climate resilience: 1) Assessment and Planning, 2) Policy and Advocacy, 3) Designing and Adapting, 4) Energy, Materials and Resource Use, 5) Urban Planning and Transport, 6) Eco-centric Approach, and 7) Awareness and Collaboration.

Communication and Visualisation Tools

- The Dutch Green Building Council has developed a “Framework for Climate Adaptive Buildings” (FCAB), i.e. an open and transparent methodology for performing a building level Climate Vulnerability and Risk Analysis (CVRA). The methodology prescribes the use of publicly available geodata from the Dutch Climate Impact Atlas, “Klimaat-effectatlas”. The risk score is defined by combining exposure, using geodata, and vulnerability, determined by building characteristics. The FCAB framework is widely used by banks, investors and insurers in The Netherlands for reporting on climate risk and developing climate adaptation action plans.



The UK Climate Resilience Roadmap by the UK Green Building Council (UK GBC).
Image: UK GBC

The Zero Carbon and Climate Resilience Readiness Framework.
Image: WorldGBC

Looking Ahead: Scaling Regenerative Urbanism

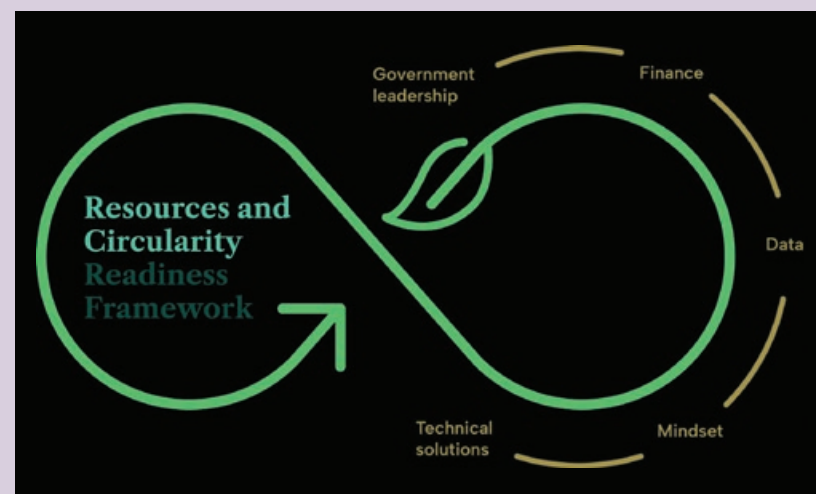
As we face intensifying climate risks and growing urban vulnerabilities, the need for resilient, regenerative built environments has never been more urgent.

To achieve World Green Building Council's (WorldGBC) mission of leading the built environment community in driving local action and strengthening global momentum for people and planet to thrive, we are prioritising

the development of national decarbonisation roadmaps and comprehensive zero carbon and resilience frameworks.

At WorldGBC, we believe that frameworks are an essential tool for turning ambition into action, and for providing structured guidance to align stakeholders at a regional and global level—from policymakers to developers, manufacturers, and building users.

Accordingly, we have developed the Zero Carbon and Climate Resilience Readiness Framework and the Resources and Circularity Readiness Framework—to help translate complex sustainability goals into actionable strategies, grounded in core principles such as energy and resource efficiency, enabling policies, and financial mechanisms and recommendations that increase transparency and accountability.



The Resources and Circularity Readiness Framework.
Image: WorldGBC

Both frameworks are underpinned by five categories... that are crucial for transition to a zero-carbon future and circular economy.

Both frameworks are underpinned by five categories, each with its own set of detailed goals that are crucial for transition to a zero-carbon future and circular economy. They are:

1. **Government leadership**—A commitment to the zero-carbon and circular economy target, setting out national roadmaps on clear policies and regulations that can guide supply chains and development projects.
2. **Technical solutions**—The adoption of new and innovative technologies in areas such as energy performance, construction techniques, and sustainable materials.
3. **Finance**—Optimising green financing and creating a sustainable business case through disclosure, incentives, investment instruments, and budgeting.
4. **Data**—Well-governed, transparent, and actionable for use in tracking, reporting, and benchmarking.
5. **Mindset**—Inspiring behavioural change for all stakeholders and decision-makers.

More recently, in August this year, WorldGBC also launched the Resilience Readiness Framework, showcasing essential strategies for ensuring that sustainable buildings are also climate resilient. This Framework provides key facets of a sustainable building that all built environment stakeholders should consider ensuring future ready built environments. They highlight the importance of CVRA, and of designing buildings and cities in accordance with future climate scenarios.

WorldGBC is committed to scaling actionable green building solutions. By working in collaboration with our global network of more than 85 Green Building Councils and their 48,000 members, we are delivering a regenerative, circular, and resilient urban future that enables both people and planet to thrive. 🌱

At the Centre for Liveable Cities,
we are committed to providing urban leaders
and practitioners with the knowledge and
support needed to make our cities better.

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