Briefing note

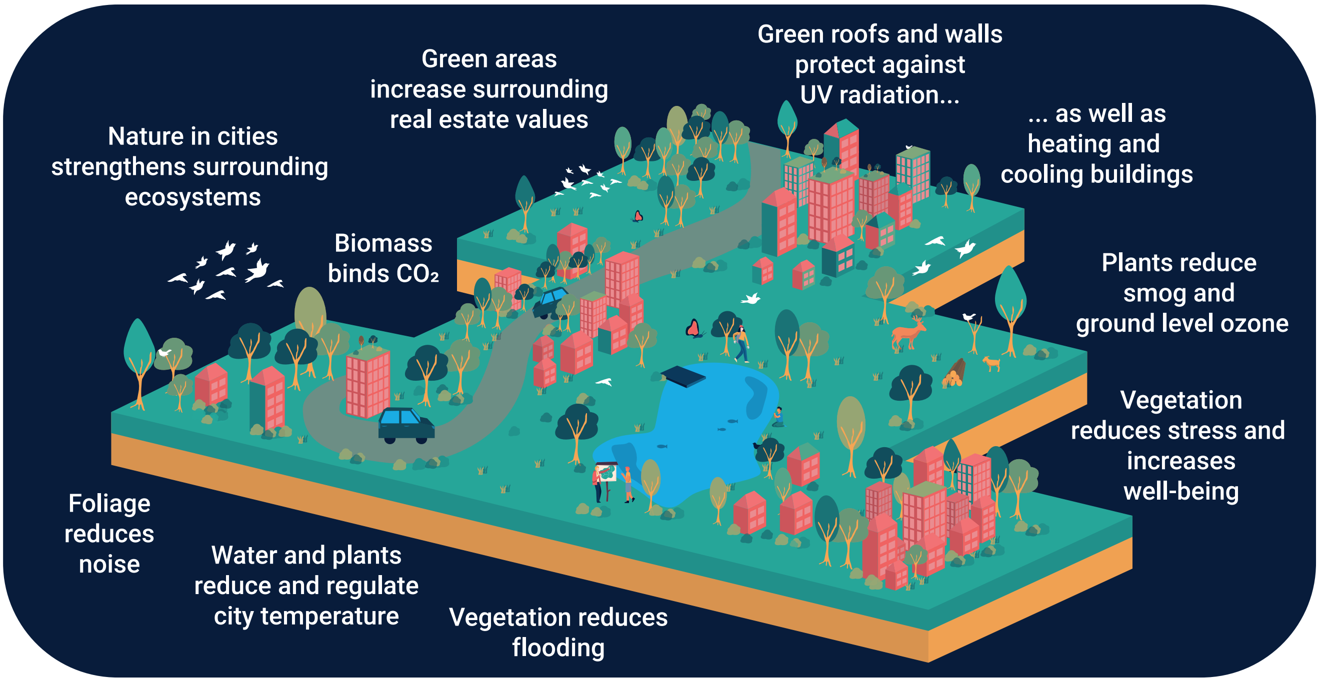
8

Urban Ecosystem-based Adaptation: Regreening Cities to Tackle Climate Change

Ecosystem-based Adaptation (EbA) is the utilization of biodiversity and ecosystem services as part of a strategy to aid people in adapting to the adverse effects of climate change. The approach is crucial for building climate resilience in cities and peri-urban areas, threatened by a multitude of climate hazards and home to more than half the human population as of 2018 (Melchiorri *et al.* 2018).

Despite some outmigration from the largest cities during the COVID-19 pandemic, urbanization will continue, and by 2035, 62.5 per cent of the world's population is expected to reside in urban areas (United Nations Human Settlements Programme [UN-Habitat] 2020). However, given the need to retrofit, replace and upgrade deteriorating urban infrastructure, and to meet the challenges of climate change - including the urban heat island effect, droughts and more intense flooding - many experts and policymakers see an opportunity to reinvent cities as greener, less prone to pandemics, and more liveable and equitable (Chaudhary and Bibhudatta 2020; Lim, 2020; Ong 2020; Xu 2020).

Figure1: Urban ecosystem services



Adapted from C/O City (2020)

Urban Ecosystem-based Adaptation Practices

The need to build, retrofit or renew existing infrastructure gives rise to the opportunity to utilize urban EbA practices to meet important human needs and provide ecosystem services (Figure 1), such as cleaner air and water, recreation areas, reliable sources of food, and economic opportunities in urban green areas. Urban parks, living walls, green roofs, rain gardens and street trees offer documented environmental benefits. They can ameliorate the 'urban heat island effect' and reduce air temperatures through shade, thereby reducing energy required for cooling.

Ecosystem services within and around cities can also help to buffer many extreme weather events, such as flooding and storms. For example, urban wetland ecosystems filter and capture floodwater, decreasing pollution while simultaneously absorbing rainwater to reduce flooding (United Nations Water [UN-Water] 2018). Additionally, forested areas reduce soil erosion and protect riverbanks, as well as help manage water quality and quantity by reducing untreated run-off before it enters bodies of water. Finally, as cities consume over 70 per cent of agricultural goods worldwide, and around 40 per cent of the world's croplands are located within a 20km radius of urban areas, urban food production will be crucial to ensuring liveable green cities that are less prone to supply chain disruptions and commodity price fluctuations.

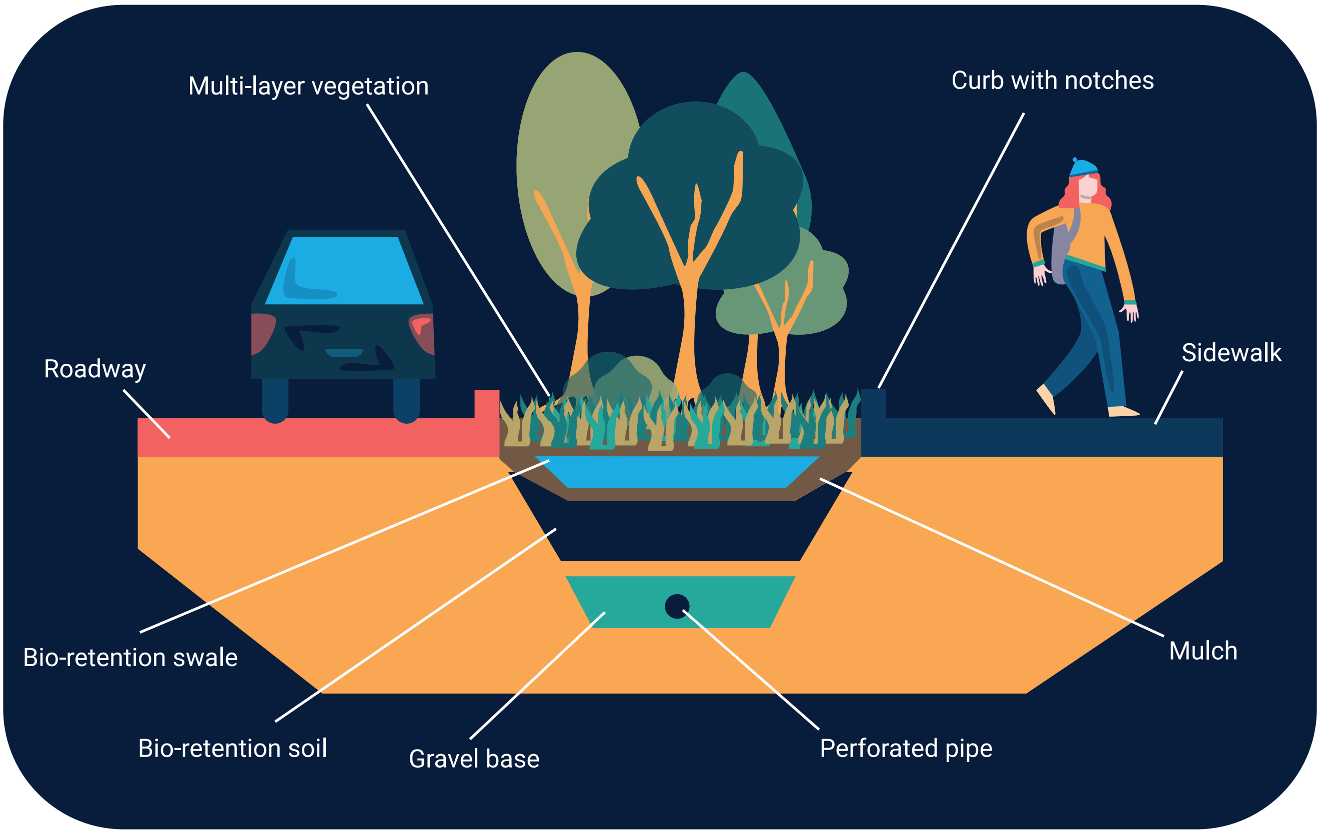
At the same time, green spaces and natural corridors encourage biodiversity to thrive, providing city dwellers contact with nature, resulting in perceived and actual physical and mental health benefits (Amano *et al*. 2018). For example, urban vegetation helps to significantly reduce air and noise pollution. In addition, natural spaces provide an excellent opportunity for education and citizens' involvement in their communities, promote a sense of ownership and stewardship of green spaces, and create opportunities for residents to be meaningfully engaged in planning processes.

Finally, the economic case for EbA in cities has been clearly established. Examining 25 case studies of projects in urban regions, a notable 2015 analysis estimated the monetary value of ecosystem services, quantified in terms of biophysical units such as carbon storage, stormwater reduction and pollution removal (Elmqvist *et al*. 2015). The analysis shows that the ecosystems provided between US$ 3,000 and US$ 18,000 in benefits per hectare of urban green area every year. EbA solutions are also job creators, requiring large amounts of manual labour to restore and manage ecosystems (World Wildlife Fund [WWF] and International Labour Organization [ILO] 2020).

Table 1: Urban EbA practices for environmental, economic and social impacts of climate change

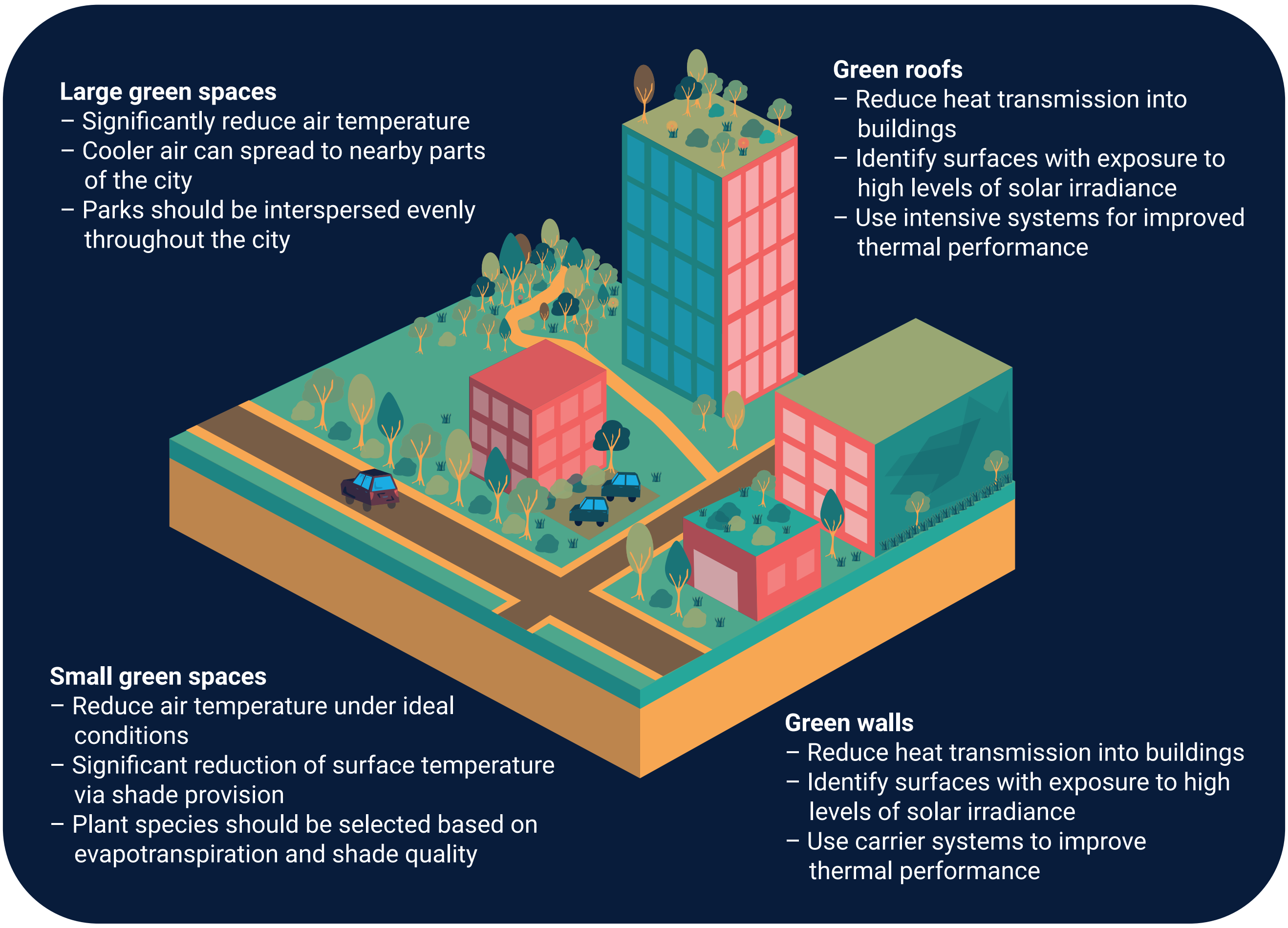
Environmental Impacts (direct hazards)
Heavy rains, flooding, erosion and landslides
Increase urban green and blue spaces (e.g., boulevards, greenbelts, arboretums, urban gardens, wetlands, ponds, living walkways, etc.) to absorb rainwater and reduce flooding, exemplified by "sponge cities" (see Case Study I on page 8 and Case Study II on page 9).
Construct urban bio-retention swales (Figure 2) and improve rainwater drainage systems and flood risk management, including early warning systems (see Case Study II on page 9).
Use porous concrete or permeable pavement that allows water to pass through, preventing flooding (see Case Study II on page 9).
Zone areas based on flood risk and prohibit building in vulnerable areas.
Construct infiltration ditches on hills to trap water into soil and aquifers, reducing flooding, erosion and landslide risk (see Case Study II on page 9).

Figure 2: Urban bio-retention swale



Drought, water scarcity and poor water quality
Increase urban green and blue spaces that capture and retain rainwater in dry periods and boost water quality (see Case Study I on page 8 and Case Study II on page 9).
Incorporate water-sensitive urban design approaches, such as rainwater harvesting techniques for businesses, public buildings and residences, 'grey water' supply, and artificial wetlands (see Case Study II on page 9).
Ensure water supply recharge by preserving natural land and forests through sustainable management of aquifers (see Case Study I on page 8 and Case Study II on page 9).
Implement water-sensitive practices for urban farming systems (e.g. hydroponics, aeroponics, vertical farming).
Higher temperatures, inversion layer formation, urban canyons, heat islands, heat stress/waves exacerbating poor air quality
Create green and blue spaces for shade, or reflective surfaces to lower temperatures (Figure 3).
Design green ventilaton corridors for cooling.

Figure 3: Urban design to reduce heat island effect



Source: Wong *et al*. (2021)

Integrate passive cooling approaches into urban structures (e.g., white surfaces or green roofs) (UNEP 2021).

Limit building density in urban areas, and plan and create multi-centric urban structures to reduce urban heat island effect.

Increase green spaces, structures and plant species that can absorb pollution and improve air quality (see Case Study I on page 8 and Case Study II on page 9).

Explore options to make city centres human-friendly environments by reducing driving and the consequent pollution. For instance, the promotion of car-free areas (e.g. Barcelona's "superblocks") and the use of bikes, e-vehicles and improved mass transit systems.

Biodiversity loss impacting ecosystem services

Reduce drivers of biodiversity loss (such as inadequate urban planning and development)

Increase urban green spaces, such as ecological corridors, pollinator habitats, parks and (semi-)urban conservation areas (see Case Study I on page 8 and Case Study II on page 9).

Establish urban community gardens to provide food security and additional sources of income (see Case Study II on page 9).

Economic Impacts

Increasing economic losses due to lost days of work and damage to infrastructure and agriculture from climate impacts

Explore payments for ecosystems services (PES), in addition to catastrophe or resilience bonds.

Explore water funds, tiered water-use fees and water markets for reliable urban water supplies while generating savings from avoiding grey water reservoirs and treatment systems (Hanlon 2017).

To reduce damage from flooding and heatwaves, encourage wetland and forest conservation and restoration with stormwater credits, conservation banking, pollution trading schemes, etc.

Promote a diverse economy with climate-resilient livelihoods in urban green spaces, such as beekeeping and ecotourism (see Case Study II on page 9).

The greater a country's dependence on food imports, the more susceptible it is to price fluctuations from climate impacts

Embrace urban farming (such as reusing organic waste as compost, vertical farming, aquaponics, hydroponics and community gardens) to decrease vulnerability to prices (see Case Study II on page 9).

Social Impacts
Climate impacts are contributing to rural-to-urban migration by reducing the reliability of farming, fishing and grazing livelihoods, while concentrating more people in vulnerable areas, which stresses basic services, infrastructure and labour markets
Promote agricultural EbA for climate-resilient rural jobs (see *Ecosystem-based Adaptation and Agriculture Briefing Note*)
Select urban EbA solutions with a focus on job creation to reduce labour-market pressures
Encourage adequate city planning and development to provide affordable housing options and appropriate basic services, and to prevent the creation of informal settlements in risk-prone areas.
Climate impacts on urban low-income or marginalized populations will be more severe, particularly as they lack assets to fall back on during climate shocks
Use the EbA Social Principles for the creation of solutions to ensure greater support of ecosystem protection and zoning rules in vulnerable areas (see Case Study II on page 9).
Strengthen community self-help groups to monitor EbA projects and respond to shocks.

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Case Studies

Case Study I: Making Cities and Towns Liveable – Lessons From Bangkok's Centenary Park

Bangkok, the capital and most populous city of Thailand, experiences frequent flooding due to its low-lying terrain, rapid expansion of grey infrastructure, inadequate drainage systems and extreme weather events that are linked to climate change. The city is also impacted by the urban heat island effect, which is expected to increase due to rising temperatures and urbanization (Arifwidodo and Tanaka 2015).

Chulalongkorn University's Centenary Park, which opened in 2017, was designed to address frequent flooding by using EbA. The system consists of three major components: a green roof, rainwater tanks, and the combination of a detention lawn, constructed wetland and a retention pond. The green roof is planted with native grasses and weeds for minimal maintenance and water absorption from their roots. Run-off is stored in rainwater tanks beneath the green roof, and because the park sits at a 3° angle, any overflow drains to the constructed wetlands and the retention pond. The park can store up to one million gallons of water during the rainy season that can then be used for irrigation during the dry season. Many of the installations – the green roof, wetlands, lawns and groves – help to sequester carbon. At the same time, these green spaces reduce urban air temperatures (Wong *et al*. 2021), while supporting the ecological connectivity crucial for animals and plants to survive (Tabor 2018). In addition to the ecosystem-based water management system, the Centenary Park also features a learning centre, museum, parking space and a range of multipurpose green spaces, including a herb and bamboo garden, meditation area, playgrounds and earth amphitheatre offering Bangkok citizens an opportunity to reconnect with nature (Landezine International Landscape Award no date).

During the planning phase, the project faced challenges in convincing the city authorities to see the overall benefits of establishing the 5-hectare park on land worth an estimated US$ 700 million in a rapidly developing and urbanizing city such as Bangkok. However, various studies helped to demonstrate the importance of increasing green spaces in cities to mitigate urban heat and other climate change impacts (Aram 2020; Khamchiangta and Dhakal 2020), while delivering co-benefits to residents (Houghton and Castillo-Salgado 2017; Yigitcanlar *et al*. 2020).

Chulalongkorn University Centenary Park green roof ©*Unsplash/Sudatip T*

Case Study II: CityAdapt in Latin America and the Caribbean – Reconnecting Cities With Nature

As the changing climate results in more frequent and intense storms, worsening droughts and increasingly volatile rainfall patterns, UNEP's CityAdapt initiative, an urban EbA project in the Latin American and Caribbean cities of Xalapa (Mexico), Kingston (Jamaica), and San Salvador (El Salvador), is building the capacity of more than 200 local decision makers and planning officials to better understand and identify opportunities for EbA solutions. This includes the initial development of a participatory and gender-differentiated climate vulnerability assessment.

In Xalapa, these EbA opportunities include the restoration of riparian areas totalling 3.46 km^2 of creeks and gullies, rainwater harvesting from public buildings and school roofs to enhance local water supplies, and ecological corridors for wildlife and pollination. Additionally, hillsides have been stabilized by planting trees, which reduces erosion and landslides. The creation of alternative livelihoods (such as edible mushroom cultivation) are also taking place in the city's surrounding market gardens and smallholder farming areas, in addition to a kilometre-long park that runs through a particularly flood-prone neighbourhood.

In San Salvador, CityAdapt is helping implement sustainable agriculture practices on over 5.91 km^2 of land including 5 km of riparian areas. The programme also supp,orts communities with rainwater harvesting and school gardening efforts within the city, while planting over 3,500 fruit trees to supplement community resources. Due to increasing flooding and destructive landslides resulting from intense storms, CityAdapt has also installed over 34 km of infiltration trenches to capture run-off and prevent landslides while recharging aquifers.

CityAdapt is also working in Kingston, where it has begun to reforest the Hope River watershed and rehabilitate a crucial wetland. Planting fruit trees supports local communities, as does the harvesting of rainwater that feeds into school gardens. Water and flood management work focuses on clearing drainage channels and installing holding tanks.

The project has faced challenges, including the lack of local adaptation capacity, the impact of COVID-19 on project participation, and the sparsity of local climate data. To mitigate these challenges, the project has stressed local capacity-building, adopted virtual outreach methods, and strengthened its participatory climate vulnerability assessment methodology to make up for a lack of data.

Learning from these EbA solutions and related challenges, the project has created an online educational platform, held a virtual course with participants from across 14 Latin American and Caribbean countries, and developed a wide variety of tools and learning materials, including a nature-based solutions manual to help share knowledge about the practice within the project countries and beyond.

A coffee farmer on the outskirts of San Salvador city points to a landslide that devastated his farm after a major storm hit in 2020. *©UNEP/CityAdapt*

Conclusion

Cities are key contributors to climate change, producing around 70 per cent of energy-related greenhouse gas emissions. A large proportion of the human population are living in cities, and losses and damages from climate change are already mounting. Cities can and should be environments that support resilient livelihoods and physical and mental health, while protecting communities against climate effects. Helping communities develop urban EbA solutions to adapt and to make their neighbourhoods more liveable and climate resilient is vital for a sustainable future.

Finally, in line with UNEP's project and programme guidelines, gender equality concerns were taken into account in both case studies of this briefing note. As articulated during a CityAdapt webinar: "Integrating gender criteria in urban development plans and linking them with nature-based solutions for adaptation to climate change is key to strengthening urban resilience."

Further resources

- Ecosystem-based Adaptation Briefing Note Series
- Climate adaptation resources and multimedia
- Beating the Heat: A Sustainable Cooling Handbook for Cities
- CityAdapt: Reconnecting Cities With Nature For Adaptation
- A Practical Guide to Climate-resilient Buildings & Communities

For more information about UNEP's work on Ecosystem-based Adaptation, contact Jessica.Troni@un.org

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