UN HABITAT
FOR A BETTER URBAN FUTURE

White Paper

Cities and Nature: Planning for the Future

Published in December 2022 as an information document for the 15th Conference of Parties of the Convention on Biological Diversity (CBD COP15).

Keywords: biodiversity, city, climate change, conservation, density, ecosystem services, expansion, mapping, multidisciplinarity, nature-based solutions, planning, prediction, preservation, prevention, projection, spatial planning, urban, vulnerability.

Coordinated by Andrew Rudd and drafted by Srilakshmi Menon, Cristina Pastore, and Karunya Subramanian, with contributions from Oliver Atwood, Matthijs Bouw, Kavya Kalyan, Laura Petrella, Robert McInnes, Ce Mo, Rafael Tuts, and Richard Weller. Edited by David Maddox. Reviewed by Bernhard Barth, Diana Carrillo-Silva, José Chong, Filiep Decorte, Thomas Forster, Seetha Gopalakrishnan, Julie Greenwalt, Naomi Hoogervorst, Joy Mutai, and Blake Robinson.

Executive Summary

The 2022 Global Biodiversity Framework shows the importance of the area, quality, and connectivity of green and blue spaces within urban areas but does not recognize the **role of urban land expansion as a driver of habitat loss**.

Over 90% of the cities in the world's 36 biodiversity hotspots are expanding in direct conflict with biodiversity and climate risk. The conversion of natural habitat for human habitation is accelerating, with **290,000 sq km of natural habitat likely to be lost to urban growth** between 2000 and 2030.

These trends are further compounded by the **'land greedy' nature of contemporary urban expansion patterns**, yielding a land consumption growth rate (4.84% per year) double that of urban population growth (2.18% per year); land continues to be consumed even in countries where the urban population is not increasing at all.

Yet action to prevent or even mitigate this loss remains elusive. **Restoration cannot keep up with the pace of land degradation**, so we need more preservation and conservation at the interface between cities and nature; particularly in biodiversity hotspots (Figure 1).

Cities are recognizing the need to protect landscapes in their vicinity, with approaches such as **extending ecological corridors and connecting green patches for** biodiversity protection and climate resilience, and the knock-on benefits of ecotourism, air purification, etc.

However, we need to shift to systematic, effective and properly **targeted interventions of biodiversity preservation and conservation** in the face of urban expansion, both present and future.

Most existing spatial planning processes **treat built and natural habitats as binary and static, while they are both in constant flux**. The two also have complex interactions, exacerbated by climate change, with either negative or positive feedback loops that affect cities.

Caring for nature would not only prevent the sixth extinction of non-human species but also **prevent the collapse of human settlements whose infrastructure fundamentally depends on the ecosystem services** that biodiversity provides.

The United Nations system has adopted a common approach to biodiversity that includes a joint commitment to **improve the quality of urbanization and limit encroachment**, recognizing the importance of nature in cities and the protective role of spatial planning.

Pro-biodiversity interventions within and beyond cities include **not only direct nature-based solutions but also indirect land-sparing measures that prevent the destruction of natural habitat** in the first place (Figure 1).

Many high-profile nature-based solutions have been applied at limited site-based scales, as retrofits to relatively wealthy, mature urban environments. This leaves a **gap in preservation-related efforts, particularly in fast-growing, resource-constrained contexts**.

Several **critical challenges remain**:

- A dichotomic conception of the natural and built
- Lack of clarity on where degradation is occurring
- Inability to predict future conversion

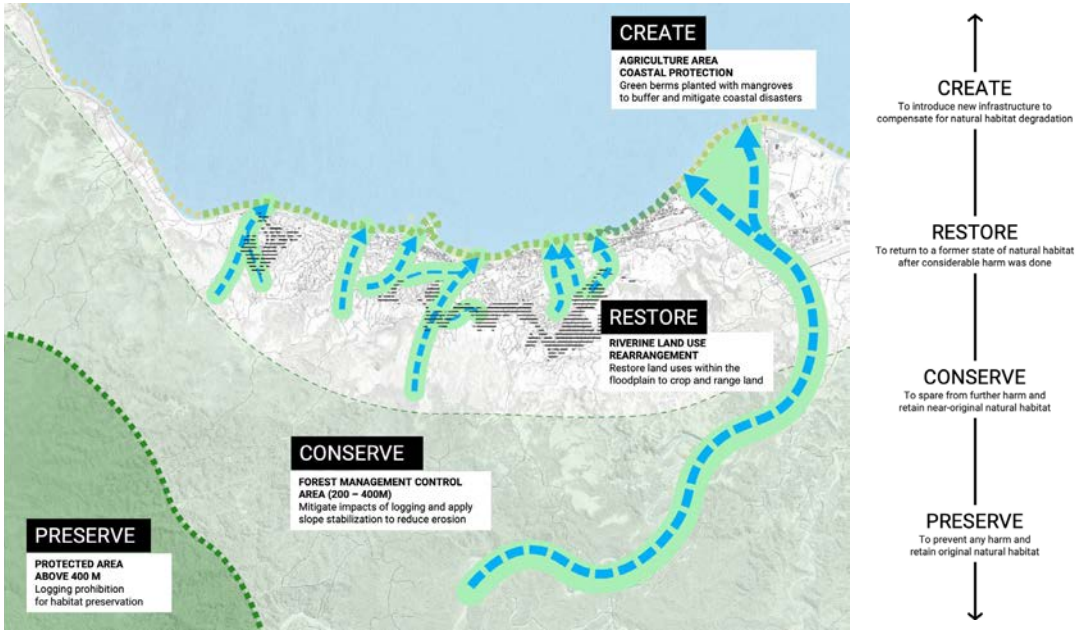


Figure 1 Pro-biodiversity interventions exist along a preserve-conserve-restore-create spectrum that responds to varying states of natural habitat around and within cities.

- Difficulty of assigning the full value of biodiversity
- Resistance to cooperating across jurisdictions
- Failure to slow degradation at the peri-urban edge

We need these overarching shifts in our work as urban and ecological policymakers and practitioners:

- **Spatializing challenges** to understand where change occurs and how urban systems interact
- **Working telescopically** between all relevant scales, acting at the most appropriate and linking to others
- **Working transversally** across silos, sectors, disciplines, jurisdictions, and stakeholders
- **Anticipating and guiding change** through informed decisions on where and how to develop

UN-Habitat proposes four spatial actions to support the preservation of biodiversity in and around cities:

- **Project spatial growth** over a specific timeframe to proactively guide urban expansion
- **Predict land use conflict zones** where urbanization and climate change are at odds with biodiversity in real space to pre-emptively intervene
- **Prioritize areas of most suitability/least harm** by preserving natural areas of highest value and directing compact growth to areas of less harm
- **Prevent wasteful and dangerous land conversion** that degrades natural habitat at the peri-urban edge

Sustainable development that proactively looks at safeguarding biodiversity hotspots is critical. Local officials need to be empowered with **decision-making tools that make these benefits explicit** and easier to implement.

Multidisciplinary mapping is a cost-effective means of equipping governments to make educated decisions about where to conserve or convert habitat. Here it has been conceived with light data requirements, for nimble deployment in data-scarce cities and modular pairing with other planning tools.

Potential benefits include assessment of broad environmental impact, catalyzing or revising master plans, studying land use conflict zones, promoting successful metropolitan planning models, developing a 'stoplight raster', and studying the trade-offs and co-benefits of nature-based vs form-based solutions for biodiversity.

Preventing mistakes before they are visible and too expensive to correct will require unprecedented effort. **44% of the global gross domestic product in cities is at risk due to the loss of nature**, so biodiversity preservation at the peri-urban edge must be incentivized and accelerated.

Spatial planning and design also require adequate regulations and financing to deliver the change we need. Taken together, they can help preserve biodiversity in and around cities, with transferability hinging on region, scale, timeframe, and champion (Annex 2).

Cities have enormous potential for biodiversity. Often, they are in important biodiversity hotspots near waterways, ecozone transitions, and migration paths. While we have collectively done little to strengthen the interface between cities and nature, **applying proactive effort now would be extraordinarily productive**.

Table of Contents

Page **List of Figures**

0. Introduction

Cities and nature have many interlinkages. This paper focuses on what the evidence suggests are the biggest addressable gaps for delivering global-scale impact on biodiversity, i.e., evolving urban form. Industrial agriculture is the biggest driver by area of habitat loss (Ritchie and Roser, 2021). However, the changes wrought by urban development have greater fixity that are more difficult and expensive to change. According to the old Roman axiom, a street lasts 1,000 years. Direct land consumption is not the only negative impact of cities—the International Panel on Biodiversity and Ecosystem Services (IPBES) reminds us that '[p]redicting the distant effects of local human-nature interactions and actions, i.e., telecoupling...is critical' (IPBES, 2019). Recent workstreams are elaborating on these ideas (UN-Habitat, 2022). 'However, planetary scale scenarios and models that assess complex local and regional scale tele-interactions do not exist yet' (IPBES, 2019).

Meanwhile, the mistakes of wasteful and dangerous land conversion near cities continue to be replicated at ever greater scales. Sawyer et al (2021) frame this as 'bypass urbanism' that 'usually does not emanate from a coherent planning initiative...but...emerges through a convergence of interests over large areas of land at the geographical periphery of urban regions'. '[H]ighways, gated communities, condominium towers, luxury residences and other real estate projects...have been rapidly built in the past decades over huge areas that once were sparsely settled agricultural lands, wetlands, nature reserves, *terrains vagues* or even contaminated areas.' Improving the impact of cities on biodiversity will require shaping the constantly shifting peri-urban frontier, especially in developing countries (ibid).

As cities grow, it is critical to preserve and conserve natural habitat at both local (within the city) and peri-urban (just outside the city) scales before expensive if not irreversible damage is done. This paper focuses on the direct impact of urban form on land-use change and habitat loss, which is a significant gap that demands early, coordinated action. It underscores the importance of both location and quality, i.e. avoiding expansion into areas of highest ecological value and vulnerability while still building in a compact, connected manner in areas of least harm including on smaller sites within the city.

There have been several inspiring examples of nature-based solutions in resourced, slow-growing cities. For example, the moss swales in the UK (Mohamed, 2022a), pollinating roofs in the Netherlands (Weston, 2022), highway underpasses in Australia (Goldingay, 2022), and harbour reoystering (Mindock, 2022) in the USA. However, most have been applied as site-based retrofits in relatively mature, wealthy, slow-growing urban environments. Uncritical application in inappropriate contexts can create expensive lock-in and other suboptimal outcomes (Simon 2022). Very few of them have been catalogued to facilitate appropriateness in other contexts or towards prevention in areas of rapid change. They evidence the biggest gap in the practice of preservation-related efforts at city and regional scales. In response, this paper begins to catalogue pro-biodiversity interventions by context, focusing on a narrower band of activity i.e., preservation at the smaller contextual scales.

Given the scope, the paper is directed towards urbanists and ecologists in policy and practice who work at the subnational scale. For policymakers, the narrative outlines six challenges and four principles for overcoming them to curtail biodiversity loss in and around cities. For practitioners, the paper concretizes those principles into four action-based approaches, supplemented by a global catalogue of preventative measures undertaken. For those interested in catalyzing positive change, the paper offers a new mapping methodology that can help cities—even data-scarce ones—make educated decisions about where and how to develop with minimal impact on nature and people. Lastly, the paper provides a catalogue of contextualized pro-biodiversity interventions that focus on preservation near cities.

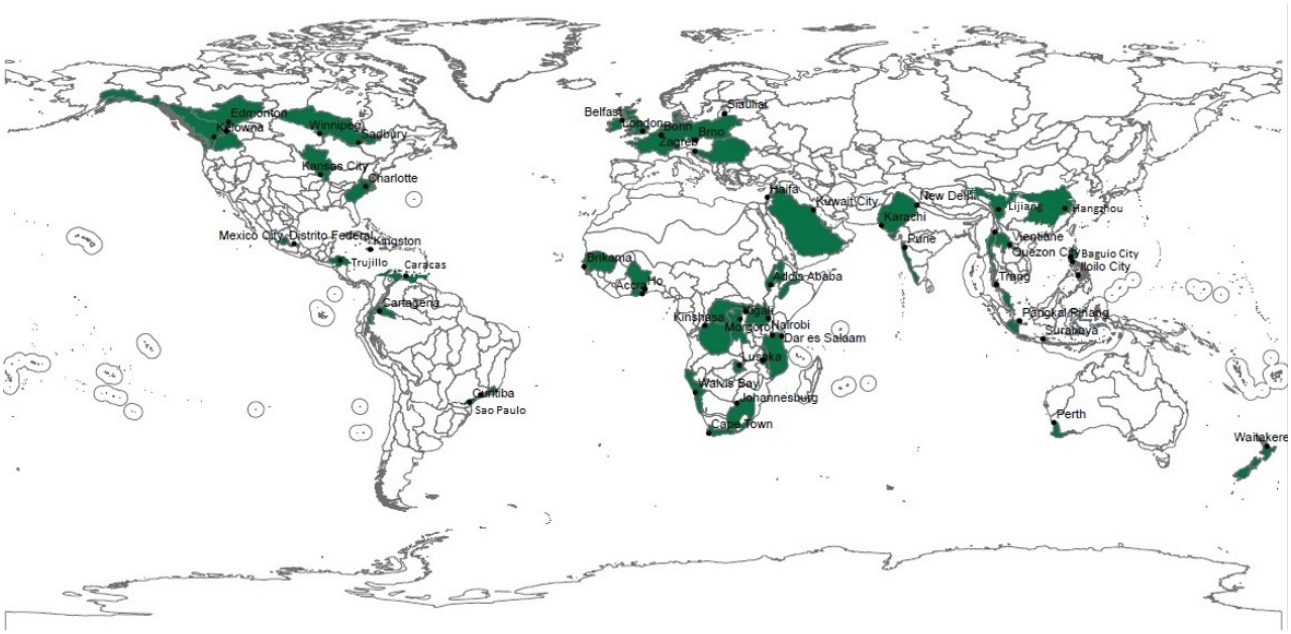


Figure 2 50 cities with pro-biodiversity interventions in different freshwater ecoregions of the world, studied by UN-Habitat (McInnes, 2013).

Ranking	North America	South America and Caribbean	Asia and Middle East	Europe	Africa	Oceania
HIGH	Habitat loss / urban expansion	Pollution	Habitat loss / urban expansion	Habitat loss / urban expansion	Pollution	Habitat loss / urban expansion
	Pollution	Infilling / draining wetlands	Pollution	Pollution	Habitat loss / urban expansion	Loss of biodiversity
	Loss of biodiversity	Deforestation	Loss of biodiversity	Loss of biodiversity	Unplanned/ informal settlements	Water demand
	Infilling / draining wetlands	Unplanned/ informal settlements	Deforestation	Climate change	Deforestation	Infilling / draining wetlands
	Agricultural intensification	Habitat loss / urban expansion	Infilling / draining wetlands	Alien / invasive species	Loss of biodiversity	Alien / invasive species
		Loss of biodiversity	Poor air quality			Habitat fragmentation
						Fire
LOW						Climate change

Figure 3 Ranked environmental pressures in the 50 cities with pro-biodiversity interventions studied by UN-Habitat, showing that habitat loss due to urban expansion on top in four out of six regional groupings of those cities (McInnes, 2013).

1. Challenges

Planet Earth is approaching a sixth wave of extinction as the conversion of natural habitats is accelerating (Ceballos, Ehrlich, and Dirzo, 2017). Ten years ago, in 2012, the Cities and Biodiversity Outlook projected that 60% of the area expected to be urban by 2030 had not yet been built (CBD Secretariat, 2012). This implied that the human spatial footprint would more than double, much faster than human population, with natural habitat the size of South Africa newly transformed for permanent human habitation. A current-day assessment is pending, though the projection has since been extended to 2050: the urban footprint will increase by 78%–171% over 2015 (Huang et al, 2019). The change of land to urban use is relatively permanent, with streets and other urban infrastructure having great fixity. Retrofitting them is difficult and expensive. Habitat restoration is possible and desirable, but at a global scale it cannot keep up with destruction. Furthermore, restoration will be too expensive when damage is extensive and entrenched, and too late after species go extinct. Preservation is critical, but it remains elusive (Swilling, 2016).

To date, the literature mostly pays insufficient attention to the quality of urbanization driving growth, as opposed to merely the quantity. Most characterizes urbanization uniformly, with little to no regard for the configuration of streets, density of residents or buildings, predominant modes of transportation, or distribution of land uses. And the CBD's Aichi Targets did not directly recognize urban land expansion as a driver of habitat loss (Simkin et al, 2022). Unfortunately, too often expansion replicates the low-density, land-hungry, use-segregated suburban model of 20th century North America (Güneralp et al., 2020; UN-Habitat, 2020). The relationship between land use change and biodiversity is complex (IPBES, 2019). The diversity of humans and human preferences in cities results in a correspondingly diverse patchwork of parks and gardens do often support increased biodiversity, though usually with less abundance and more richness of certain species (e.g., urban adapters over urban avoiders.

Fortunately, funding for the preservation and conservation (The Nature Conservancy, 2022) of natural habitat appears to be accelerating (World Climate Foundation, 2022). So far, much of this funding focuses on 'high value' forest habitat (e.g., the Congo basin, the last rainforest that absorbs more carbon than it releases), which is more susceptible to agriculture and extraction than urban expansion. Still, commendable efforts to preserve urban stepping stones and other remnant patches are creating ecological corridors that connect with larger, intact forest habitat are increasing (Spotswood et al. 2019). Such projects offer the twin benefits of protecting biodiversity against encroachment and protecting humans against the effects of climate change.

A parallel analysis by UN-Habitat in 2012 analyzed 50 case studies, all in different watersheds, of local-scale, urban-led strategies, policies, and plans intended to improve the city-biodiversity interface (Figure 2). It concluded that habitat loss due to land-use change for human settlement was the most significant direct environmental pressure at the interface between cities and natural systems for cities in four of the six major world regions (Figure 3) (McInnes, 2013). It is not only the increasing conversion of swathes of land for human purposes but also the forms that such expansions take that are having far-reaching impacts across sectors. Much of this conversion is unplanned; where has been planned, much has been badly planned yielding both unnecessary sprawl and inappropriate segregation.

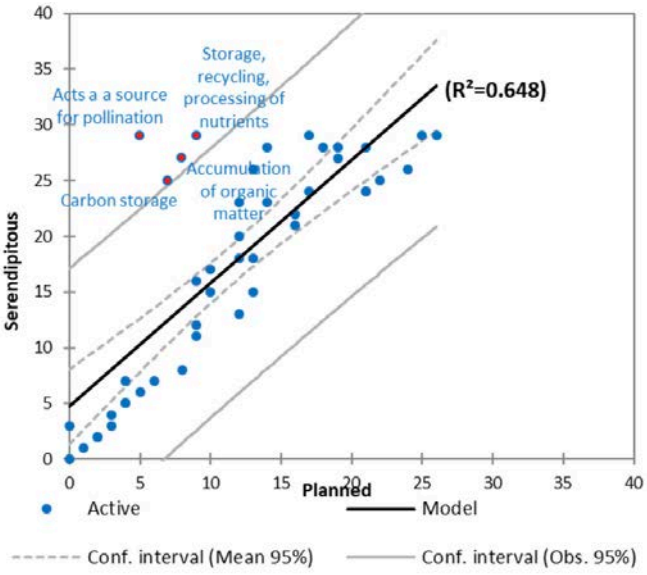


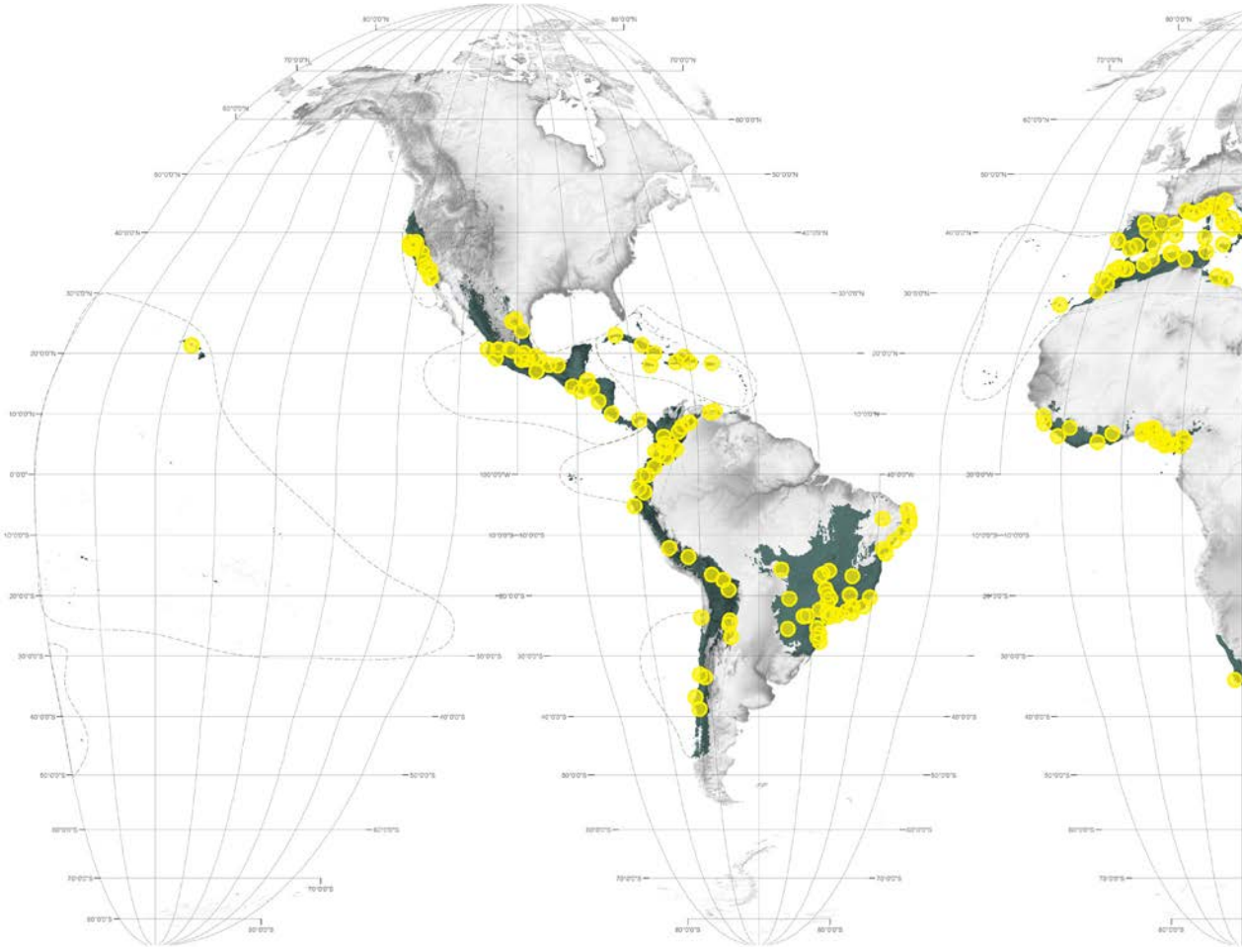
Figure 4 Linear regression analysis of planned and serendipitous ecosystem services through pro-biodiversity interventions in 50 cities revealed four outliers (i.e. pollination; nutrient storage, recycling, and processing; carbon storage; and accumulation of organic matter) that were least frequently acknowledged despite being delivered 'for free' (McInnes, 2013).

The land-wasteful models of the 20th century developed world are being replicated in the 21st century developing world. Conversion of natural habitat for human settlements is not a direct function of population growth, but rather lack of planning and/or unsustainable planning. Urban expansion is accelerating even where population growth is decelerating, meaning that per capita consumption of land is increasing and the average density of cities is decreasing. Unless we are able to reverse this trend with more sensitively-located, appropriately-compact development, new urban areas will be locked into highly resource-inefficient, emissions-intensive patterns.

The Hotspot Cities project (Figure 5) by the McHarg Center for Urbanism and Ecology at the University of Pennsylvania studied 463 cities with populations of 300,000 or more in the world's 36 biodiversity hotspots (Weller et al., 2021). Though the intact natural habitats of these hotspots cover only 2.5% of the earth's surface, it supports approximately half of its endemic plant and animal species ("Biodiversity Hotspots", 2006). Cities cover a similar area and accommodate more than half of the world's human species, but they are expanding at the expense of hotspots' decline. By superimposing their 2030 spatial growth projections onto mappings of endangered species' habitat ranges, the project identified that over 90% of the cities studied put biodiversity and urbanization in direct conflict. Cities are sprawling directly into biodiverse habitats and climate risk zones.

As UN-Habitat argued at the Stockholm+50 conference, most existing spatial planning processes treat built and natural habitats as binary and static (UN Web TV, 2022 & 2022a). By ignoring the accelerating replacement of the natural by the built, sprawl is accelerating along with unsustainable feedback loops. It is critical that we change this trajectory and embrace development models that spare land for nature and nature-based solutions. To phrase it crassly in the most anthropocentric terms, failure to do so will put 44% of the global GDP in cities at risk (Mejía and Amaya-Espinel, 2022).

As a community of living organisms (e.g., plants and animals) interacting with the non-living components of their environment (e.g., water and soil), the ecosystem is the broadest scale of biodiversity. The services it provides underlie all human life, from the provision of food to the regulation of air and water to culture and recreation to support of the soil. The ecosystem is the leverage point that simultaneously connects biodiversity, climate impacts, and urbanization. Depending on its health, it can result in either positive or negative feedback loops. For human communities, particularly vulnerable ones who may lack adaptive capacity, nature-based solutions and ecosystem-based adaptation can ease these intertwined issues. Yet many of the 'co-benefits' provided by nature-positive interventions are unacknowledged or 'serendipitous' by planners, decision makers, and residents. The UN-Habitat study (Figure 4)



also showed that the ecosystem services least likely to be acknowledged (but that nature was already providing 'for free' were (1) pollination, (2) nutrient recycling, (3) carbon storage, and (4) organic accumulation (McInnes, 2013). This fuller anthropocentric view still falls short of the ethical imperative of caring for nature for its own sake (Vucetich et al, 2015).

Since 2010, the Convention on Biological Diversity (CBD) has provided essential recognition of the role of subnational governments (CBD, 2010) and of peri-urban land use planning (CBD, 2014). The UN system has also adopted a common approach to biodiversity that includes a joint commitment to, inter alia, improve the quality of urbanization and limit encroachment (UNEP, UNDP and HLCP Biodiversity Task Team, 2021). As the Aichi Targets expired in 2020, the 2022 Global Biodiversity Framework brings welcome focus to urban space and multidisciplinary action (CBD, 2021). At the time of writing, one of the Framework's targets (currently #12) underlines the importance of the total area, quality, and connectivity of green and blue spaces in urban areas, such as pocket parks, roadside verges, street trees, or other elements whose contributions to biodiversity are small but potentially 'add up'. However, neither this target nor the Framework address 'in-between' spaces or their rapid conversion, essentially ignoring (as the Aichi Targets did) the role of urban land expansion as a driver of habitat loss (Simkin et al, 2022). Still, there is some indirect attention through other targets that prioritize restoration and conservation (currently #2 and 3), respectively, and incentivize interlinkages with climate (#8), developing with nature-based solutions (#11), and policies based on multi-level governance (#14).

Avoiding a sixth extinction requires preventing making the mistakes of the 20th century, which are now being replicated at a much bigger scale in the context of more severely depleted biodiversity. There will not be a second chance to get things right. In many low-density places, particularly where population growth is relatively slow, this will mean sparing and preserving natural habitat through compact urban development. This could involve the contextually appropriate densification and/or infill of underutilized land fragments of relatively low ecological value. Where densities are too high for infrastructural carrying capacity, cities will still need to expand. In such places it is essential that policymakers and planners understand the inherent risks and vulnerabilities of biodiversity to people and of people to climate so they can choose locations of the least potential damage. Complicating this is that--for historical and administrative reasons--the urban fringe is often outside the jurisdictional boundary of the city where development is usually managed by smaller, less-equipped local authorities. We must act now to recraft urban planning philosophies, practices, and tools so that biodiversity loss is curtailed. Several critical challenges urgently require solutions.

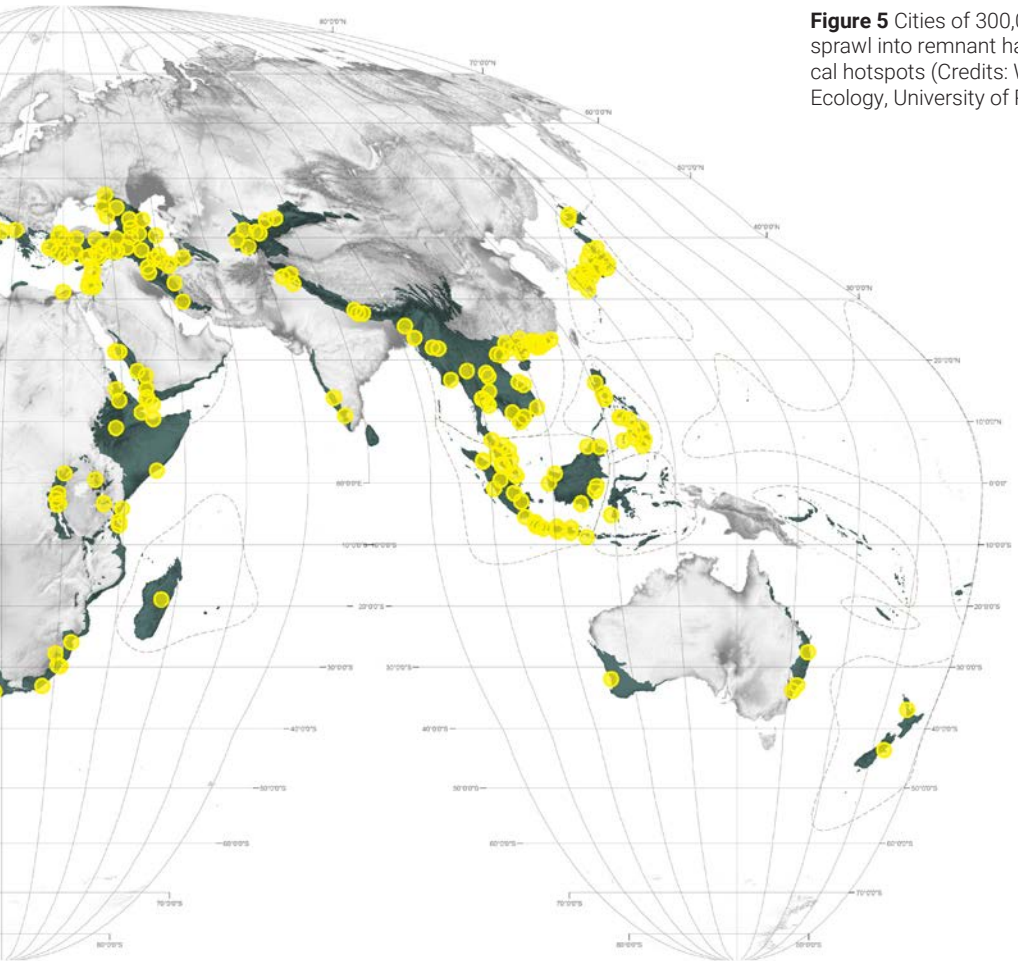
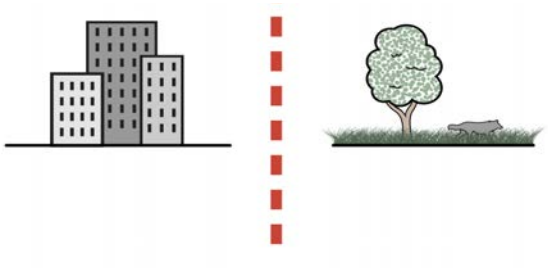
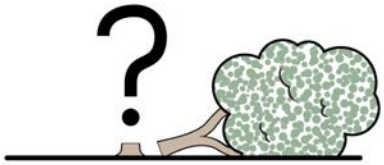


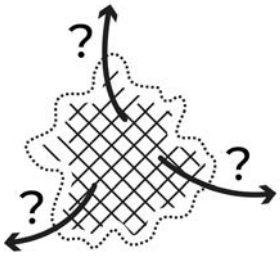
Figure 5 Cities of 300,000 or more people (in yellow) projected to sprawl into remnant habitats (in dark green) in the world's biological hotspots (Credits: Weller. R, McHarg Center for Urbanism and Ecology, University of Pennsylvania).



Unhelpful, **often inaccurate dichotomies** between natural and built (Matheswaran, Winowiecki, and Park, 2015), and rural and urban (Doernberg and Weith, 2021), fail to get to grips with the rapid and/or subtle transitions between the two.

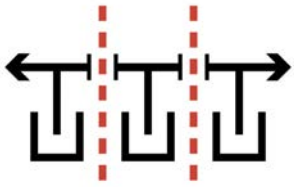


Lack of clarity about where at the local scale habitat degradation and destruction are occurring—particularly at the less-regulated peri-urban edge—makes them difficult to mitigate concretely (McDonald et al. 2018).

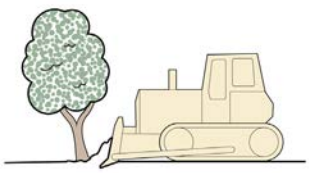


The widespread **inability to predict** where and when land-use change is most likely to happen makes anticipating risk difficult (McDonald et al., 2018).

The **difficulty of assigning the full economic and cultural value** of biodiversity and lack of awareness of more "'mundane"' ecosystem services privileges iconic species over habitat extent and quality and creates data gaps in places of relatively low institutional capacity (Seto, Parnell and Elmqvist, 2013).



The **resistance to cooperating** across jurisdictional boundaries and disciplinary silos impedes the wider-scale action required for ecosystem health (Rudd, 2012; Scarlett and McKinney, 2016).



The lack of and/or **limited application of sound planning options** for accommodating population growth, often at the 'no-man's-land' frontier just beyond a city's administrative boundaries, that would otherwise slow habitat degradation and local extirpations that undermine both ecosystem integrity and human livability (Bókony et al, 2018).

2. Principles

Overcoming the previous six challenges requires a shift in thinking. Several targets of the Sustainable Development Goals (SDGs) situate biodiversity and urbanization in the same frame of reference. Target 11.3 aims to mitigate urban sprawl, target 11.7 to increase green public space, and target 11.a to support regional development planning. Target 15.9 calls for integrating ecosystem and biodiversity values into national and local planning and development processes (UN, 2015). *Urban-Rural Linkages: Guiding Principles and Framework for Action* recommend a multi-sectoral, multi-level and multi-stakeholder governance framework and state that 'integrated territorial development along the urban-rural continuum should prioritize protecting, sustaining and expanding areas that are important to biodiversity and ecosystem services' (UN-Habitat, 2019). *Managing Urban-Rural Linkages for Biodiversity: an Integrated Territorial Approach* (UN-Habitat, 2022) calls on policymakers to consider the effects of their decisions on both distant and proximate territories. As methodologies are currently only available for assessing the latter (IPBES 2019), this paper focuses on proximate effects.

Getting to grips with the rapid eclipse of the natural by the built requires incorporating the following overarching shifts in our work as policymakers:

- Spatializing challenges
- Working telescopically (i.e. between scales)
- Working transversally (i.e. across silos)
- Anticipating and guiding change

2.1 Spatializing Challenges

In a physical world, it is only through mapping where challenges exist that we can ascertain how to address them, by whom, and with what measures. Very often the impacts of a decision or policy are hypothetical until they are spatialized. Humans shape physical places, and at the same time, physical places reinforce human behaviour because of their fixity, or relative permanence. This also helps to identify the interaction within city layers, neglecting any single one of which often leads to problems in other layers (ISO, 2019; WEF, 2022). For example, a lack of green space can not only degrade the environmental layer (e.g., a city's air quality), but also a city's societal layer (e.g., public safety). Similarly, a lack of natural, permeable surfaces can exacerbate flooding that environmental layers are less equipped to mitigate, leading to a snowball effect. Understanding where these occur is critical for understanding how they interact and impact one another. A 2007 study of the impact of transport infrastructure and urbanization on landscape fragmentation in the German state of Baden-Württemberg mapped its remaining green patches and calculated their effective mesh size (Figure 6), revealing development impact and providing a baseline for monitoring (Jaeger et al. 2007). In 2021, UNDP and the UNEP World Conservation Monitoring Centre launched the UN Biodiversity Lab 2.0 and Maps of Hope Project; together, they aim to build the capacity of national governments to use spatial data and explore where the protection, management, and restoration of nature are needed (UNDP, 2022).

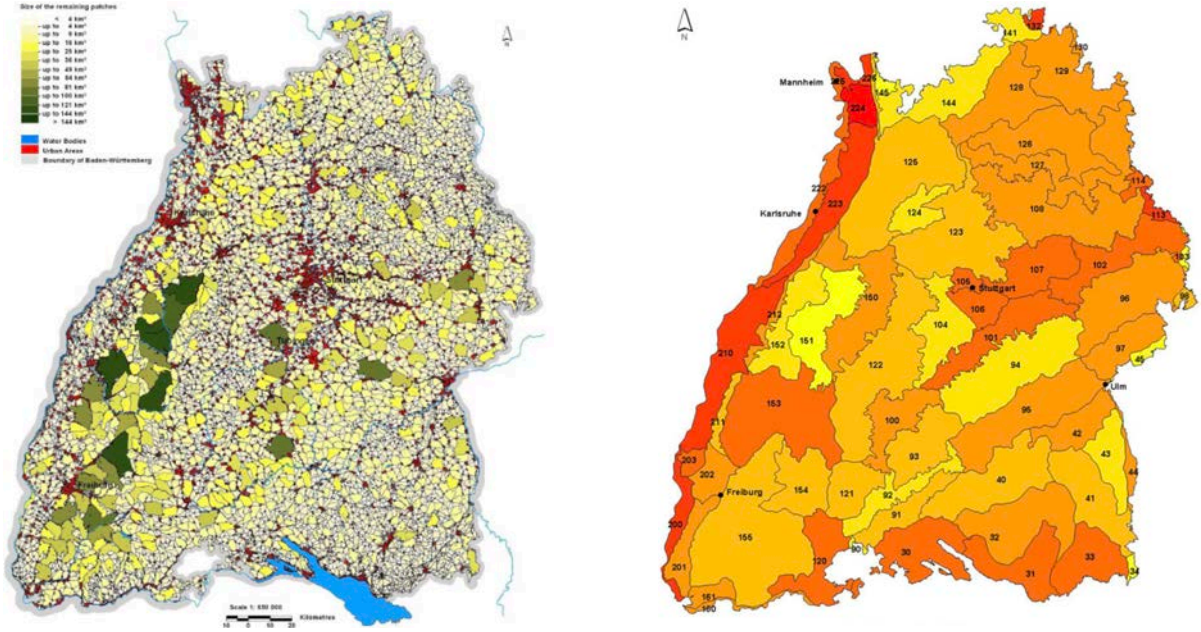


Figure 6 Jaeger et. al (2007) studied the impact of transport infrastructure and urbanization on landscape fragmentation in Baden-Württemberg, Germany. Credits: Institute of Landscape Planning & Ecology, University of Stuttgart.

2.2 Working Telescopically (i.e. between scales)

Many planning and development decisions take place at the site or, at best, neighbourhood scale, while the actual functioning of city-regions for humans takes place across the metropolitan scale. Ecosystems (e.g., watersheds) function and are impacted at an even wider regional scale. Similarly, decisions affecting transportation and conservation often take place at higher scales of government, i.e., provincial, or national. Effective action for biodiversity needs to 'telescope' across all these scales, acting at the most appropriate one and linking back to all the others (WEF, 2022). It may also need to account for and reconcile political motivations that diverge between scales. Likewise, political self-interest and competition often impede this. One bright exception is the Greater Sydney Region which requires of its constituent local authorities district plans that align with the priorities of the higher scale of government (Figure 7). They ensure alignment across scales in aspects such as open space proximity and connectivity measures that ultimately contribute to landscape protection (Greater Sydney Commission, 2018). Successful implementation of biodiversity and conservation plans often needs to span even wider scales. For example, National Biodiversity Strategies and Action Plans (NBSAPs) and only occasionally in Local Biodiversity Strategies and Action Plans (LBSAPs)--require synchronized coordination of planning, implementation, and regular monitoring and reporting across all levels of government (CBD, 2017).

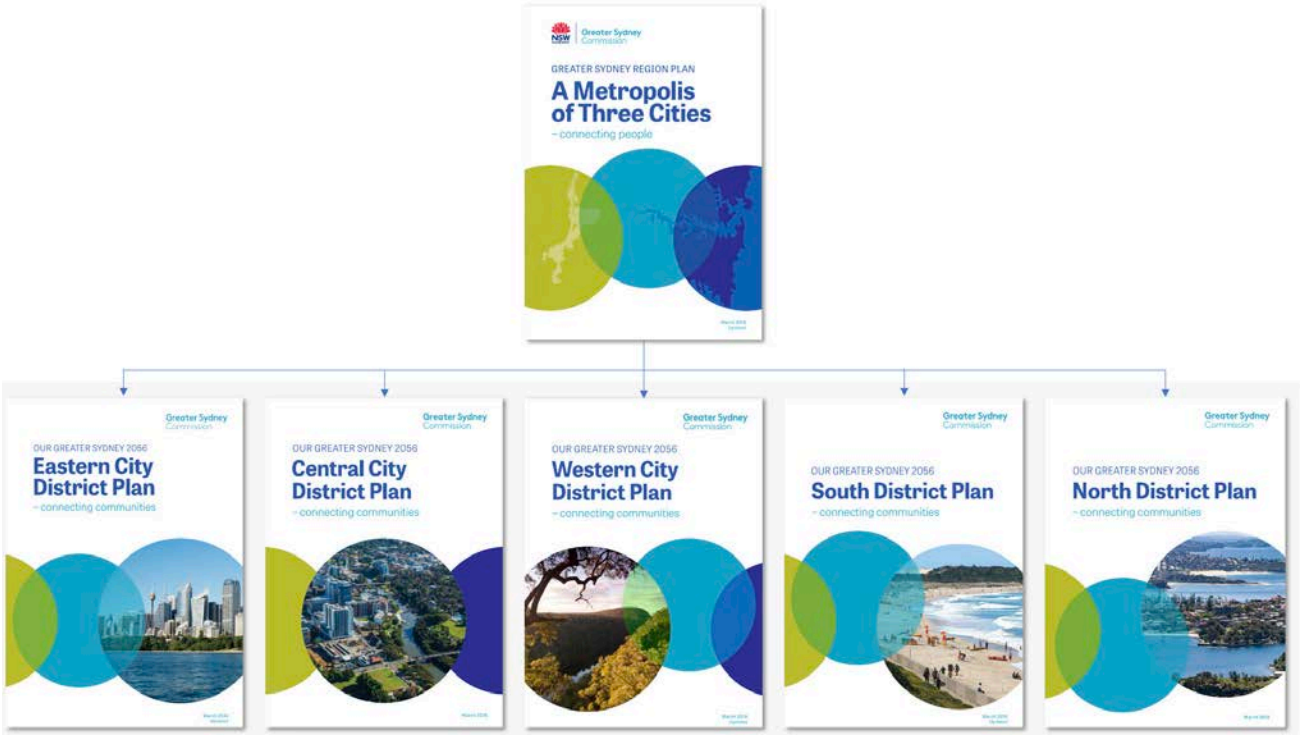
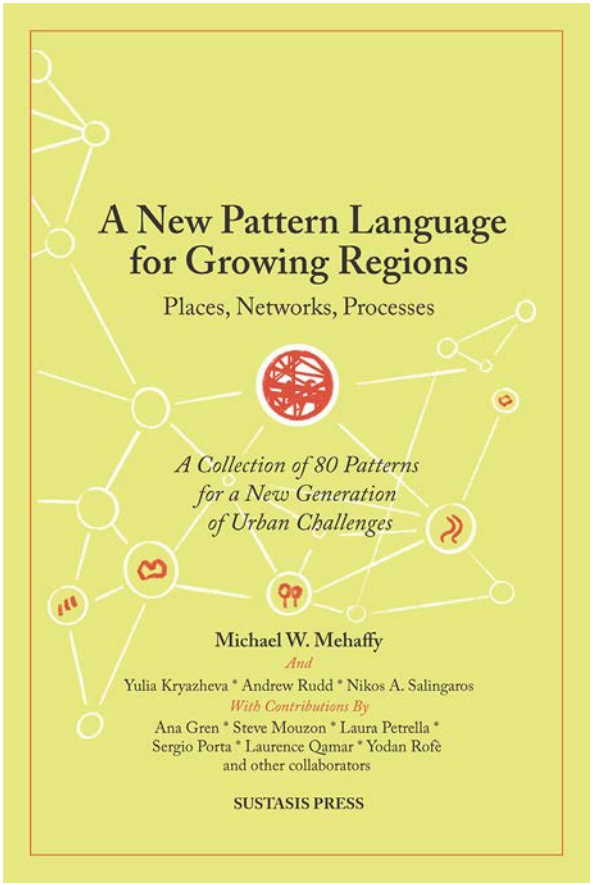


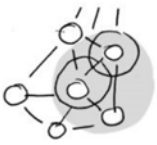
Figure 7 The Greater Sydney Commission requires its five district-scale master plans including their several landscape management strategies to align with the Greater Sydney Region Plan. Credits: Greater Sydney Commission (2018).

2.3 Working Transversally (i.e. across silos)

Alignment across governmental sectors, contiguous municipalities, professional disciplines, and diverse stakeholders is critical for nature-positive outcomes. Competing human interests—whether sectoral or territorial—can jeopardize the continuity and function of ecosystems. BiodiverCities 2030[1] provides a collaborative framework for subnational actors to achieve people-centric, science-based, actionable targets in Colombia (whose government has championed it). Its activities have inspired pro-nature urban management, governance for nature-based solutions, enhanced urban-rural linkages, biodiversity conservation, and, with potential application in rapidly densifying contexts outside of Colombia (Mejía and Amaya-Espinel, 2022). Local Action for Biodiversity (LAB)[2] works with local and regional authorities around the world to improve and enhance ecosystem management at the local level, facilitating networking and lesson sharing between them. By ensuring this alignment, the interaction between the systems (i.e., environment, agriculture, urban development, healthcare) can optimize achievement of the broader plan and avoid phenomena such as landscape fragmentation (WEF, 2022). A New Pattern Language for Growing Regions, the first update of the 1973 original outlines a collection of modular, replicable patterns, whether place-, network-, or process-oriented (Mehaffy et al, 2020). Each pattern links explicitly to other patterns in the collection, demonstrating how better landscape design can forge transversal connections (Figure 8).



Structure the governance of place in your city, town or neighborhood as a series of many overlapping formal and informal institutions, a system of "polycentric governance." Various institutions will have formal control over specific defined parts of a structure, but many other institutions will have overlapping and informal controls. Work to cooperate with these various entities from your own position or, very often, multiple positions.



❖ ❖ ❖

Recognize and support the least structured forms of place governance, including INFORMAL STEWARDSHIP (18.4). Assure that PUBLIC-PRIVATE PLACE MANAGEMENT (18.3) is balanced, and does not serve the interest of private over public interests.

Figure 8 Excerpts from *A New Pattern Language for Growing Regions: Places, Networks, Processes* underline the need for polycentric governance that offers linkages across seemingly disconnected silos

2.4 Anticipating and Guiding Change

The mapping of urban expansion alone is not enough to fully account for the indirect effects of development, particularly on distant areas, but it is a critical first step, particularly on land near protected areas. The spatial form adopted in a plan (i.e., street patterns, lot sizes, land use zoning) is highly predicative of the amount of space people consume, the distances they travel, and emissions they produce. Land-use change models can illustrate complexity and inform policymakers' decisions about where and how to develop. More than ever before, urbanization strategies must prioritize the protection of biodiversity. They may also need to backcast from desired states (e.g., landscape connectivity), particularly where large, expensive, and enduring infrastructure will be built. Having already predicted where the destruction of biodiversity will likely occur, cities can assess the sensitivity of proposed plans, explore costs and mitigation measures, and consider alternatives, and shift plans based on a more holistic understanding of the inherent incentives. With most future urban expansion taking place in developing countries, research on the relationship between urbanization and biodiversity needs to be readily accessible to them (Elmqvist et al. 2013).

Following proposals to drain and develop the Nakivubo Swamp in Kampala, Uganda, a study estimated that it was providing USD 1 million per year in 'avoided costs' of replacing natural functions with manmade alternatives (e.g., a sewerage treatment plant) and USD 1.75 million per year in terms of the expenditures that would be required to mitigate the effects of wetland loss. As a result, municipal decision makers reversed course and designated Nakivubo as part of the city's greenbelt zone (Figure 9) (IUCN, 2003). In India, the state of Kerala mandates and incentivizes the coordination of environmental planning between different levels of government for biodiversity management. This approach has resulted in the prioritization of nature-vulnerable areas. In Brazil, the Atlantic Forest biome cuts across multiple states but benefits from a federal-level designation. That designation establishes conservation frameworks that vertically align territorial and strategic development planning with national conservation efforts. Natural habitat loss has been stemmed, though lack of enforcement capacity and upstream challenges from an undesignated biome are undercutting this. See Annex 1 for more detail on Kerala and the Atlantic Forest.

Together, the examples of the Nakivubo Swamp, Kerala state, and the Atlantic Forest biome constitute multiple facets of integrating cities and biodiversity. Each contains elements of inspiration, though none are entirely complete. The implementation of a plan always requires complementary legislation and adequate finance. Any can serve as an entry point, though all are necessary in varying degrees. See Annex 2 for a contextualized catalogue of preservation-oriented projects and their regulatory, design-, and finance-related components.

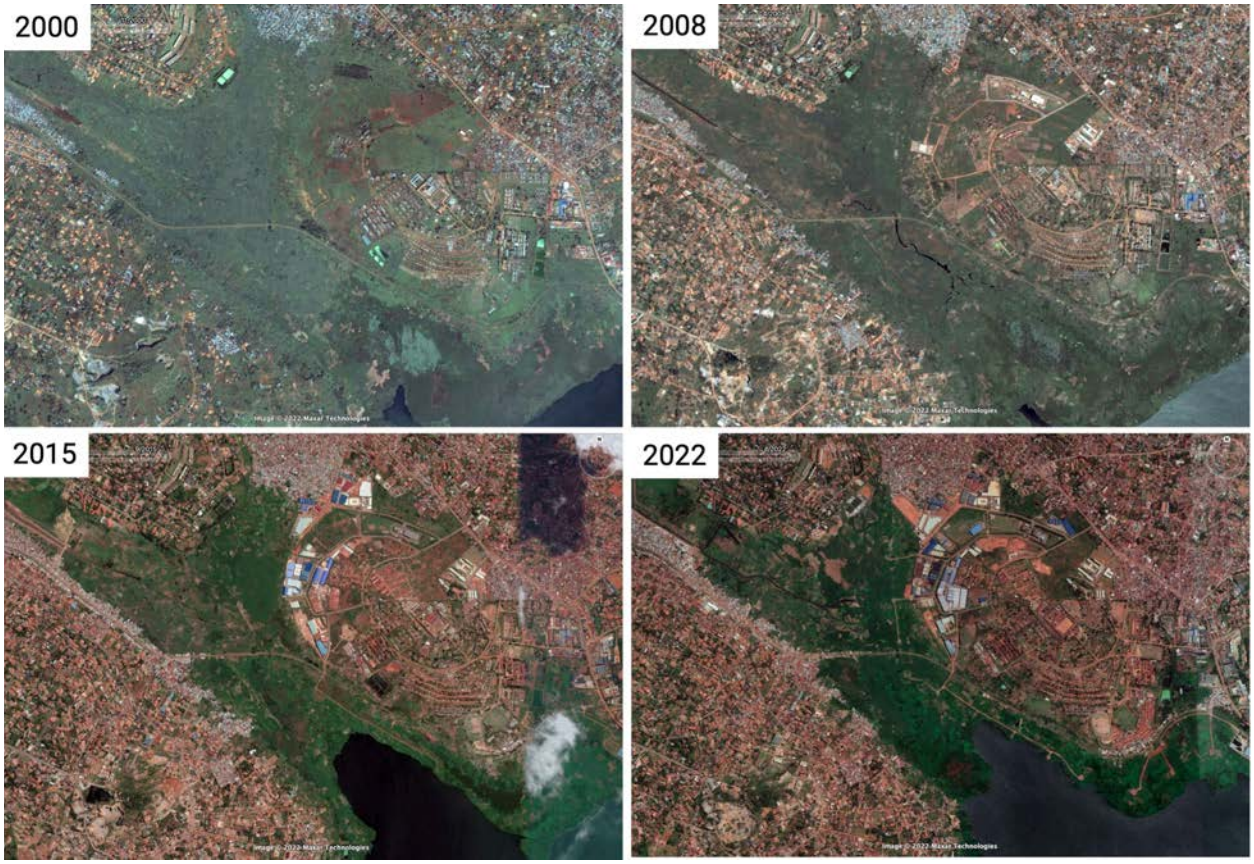


Figure 9 Designated greenbelt along Nakivubo Channel, Uganda and land-sparing urban development over 22 years (Source: Google Earth).

3. Actions

Achieving impact requires putting principles into action. Pro-biodiversity actions within and beyond cities include not only direct nature-based solutions such as green infrastructure, but also indirect 'nature-sparing' or form-based solutions within and at the fringe of the city that prevent the degradation and destruction of nearby natural habitat in the first place.

UN-Habitat reviewed widely-available compendia of nature-based and form-based solutions published by intergovernmental organizations and NGOs. From these it compiled more than 100 case studies from more than 50 countries and distilled them into 35 unique intervention typologies. Each has its merits but may not always be optimal or even feasible in any given context, whether because of physical or temporal constraints.

For that reason, five overlapping parameters were used to filter and classify the interventions (Figure 10):

- Spatial scale, along a continuum of neighbourhood-city-region
- Time frame for implementation, whether less or more than two years
- Frequency of intervention, whether one-off or sustained
- Type of action, whether preserve, conserve, restore, or create
- Density of urban environment, along a continuum of high-medium-low

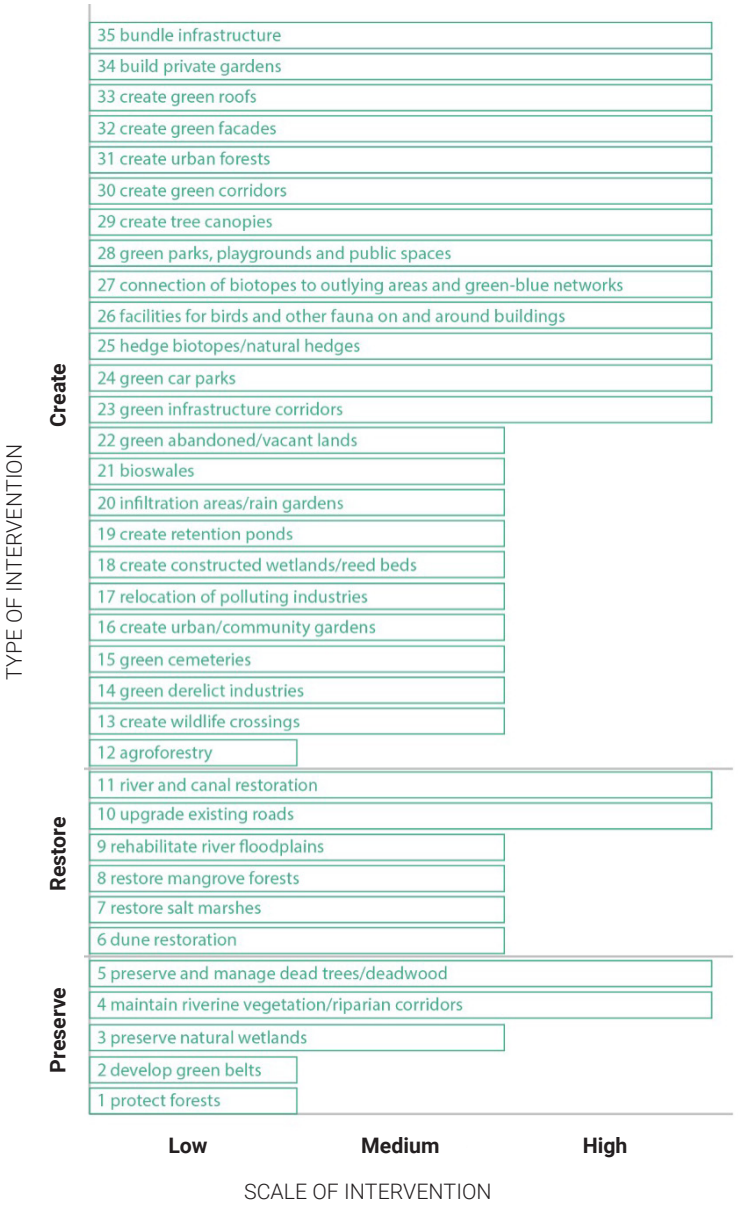


Figure 10 UN-Habitat compiled more than 100 nature-based and form-based solutions and distilled them into 35 unique intervention typologies and then categorized them roughly into types (vertical axis) and spatial scale (horizontal axis).

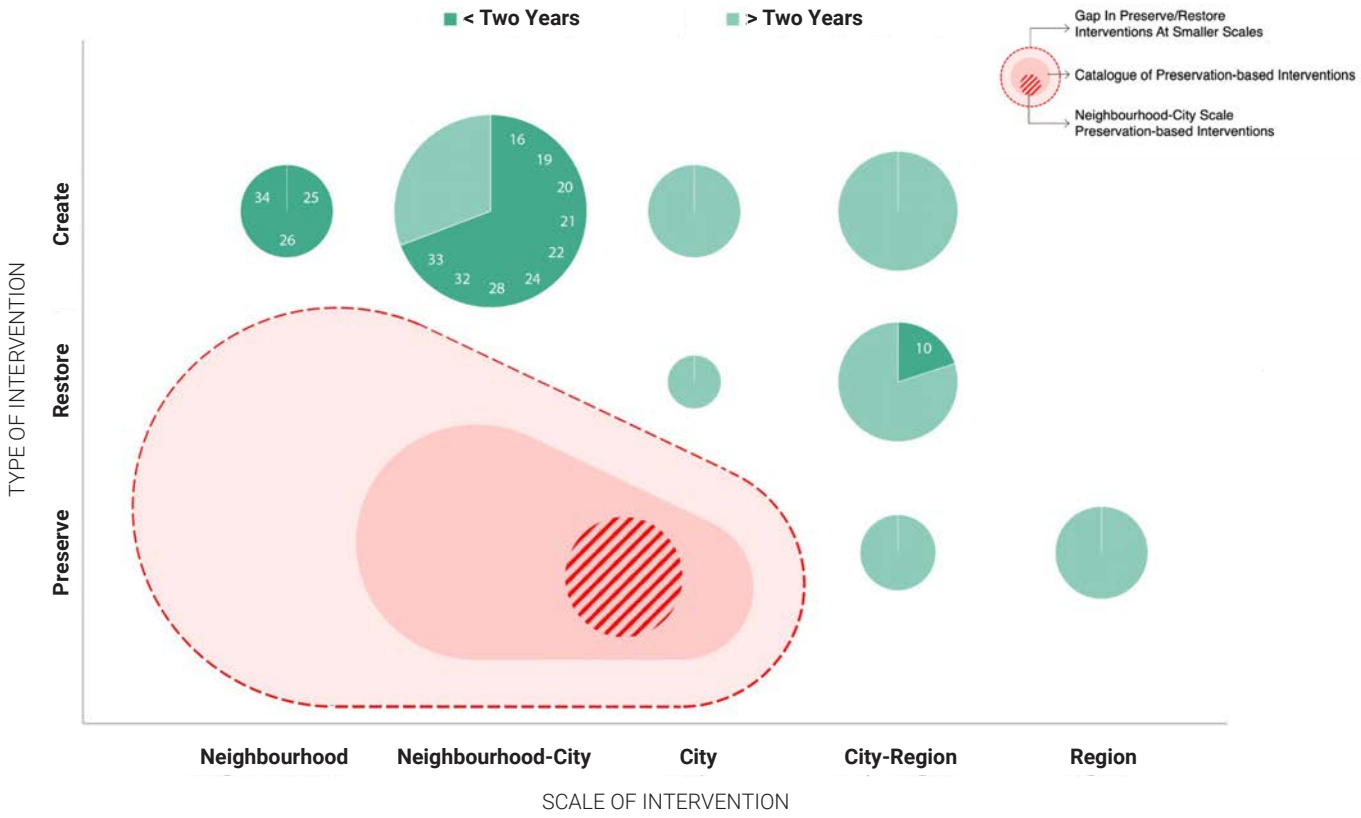


Figure 11 UN-Habitat plotted 35 unique intervention typologies (both nature-based and form-based) along a spectrum of preserve-restore-create (vertical axis) and nuanced spatial scale (horizontal axis) and categorized them further by temporal scale. What emerges is a gap in preservation and restoration interventions, especially at neighbourhood and city scales.

Having plotted the interventions with more nuance, according to type, spatial scale, and timeframe (Figure 11), several patterns are noticeable:

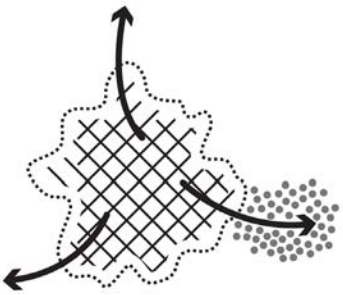
- Development/creation interventions proliferate at the smaller neighbourhood-to-city scale, while preservation and restoration interventions are mostly applicable at the larger city-to-regional scale.
- The frequency of intervention also changes between spatial scales, with more one-off interventions at the neighbourhood-city scale and more 'sustained' interventions at the city-region scale.
- A similar pattern is visible in the temporal dimension; development/creation interventions are short term actions, while most restoration and preservation interventions are long term.
- There are more creation-oriented interventions than those aimed at preservation and restoration, particularly in high-density environments.

One clear gap is the absence of long-term preservation interventions at the neighbourhood and city scales, especially in high density environments. This can stem from any of the challenges mentioned earlier in this paper, ranging from a failure to acknowledge the complex interactions between urban and natural systems to the lack of prior planning for growth within and adjacent to existing urban areas. It calls for taking a strategic approach in planning urban expansion that recognizes the importance of green infrastructure across the scales in contributing to urban biodiversity.

Sustainable development that proactively looks at preserving / protecting / safeguarding biodiversity hotspots that provide valuable ecosystem services whilst also increasing resilience to natural disasters is more critical now and going ahead than it ever was in the past. Local officials need to be empowered with decision-making tools that make these benefits explicit, making decision-makers understand why and where to prioritize preservation. Accordingly, UN-Habitat and partners are proposing the following actions:

- Project spatial growth
- Predict land use conflict zones
- Prioritize areas of least harm
- Prevent replication of mistakes

3.1 Project Spatial Growth



We must project future growth according to various possible scenarios to be able to proactively guide it. This will help the international development community catch up with the scale and speed at which private developers are already operating. Such development also often excludes populations of lesser means, who may have little choice but to settle informally in areas of high vulnerability to themselves and non-human species. Research suggests that more than 70% of the forecasted loss of the range of suitable habitat for heavily impacted species will be driven by one-third of the total forecasted new urban land that extends from a limited number of urban clusters (Simkin et al., 2022). In other words, we can locate the parts of cities whose expansion will be most damaging to non-human species and thus target urban preservation and conservation efforts accordingly.

In Figure 12, the first cartogram adjusts the size of the eight world regions according to how much they are currently sprawling (i.e., per capita land consumption of the entire urban population), indicating the ongoing tendency of land-rich regions to convert more natural habitat than necessary for human settlements. The second adjusts size for projected urban population growth, highlighting regions that are at high risk of replicating the wasteful urban patterns of the land-rich ones (UN-Habitat, 2018). The example in 3.2 shows how urban expansion can be projected for individual cities at the local scale.

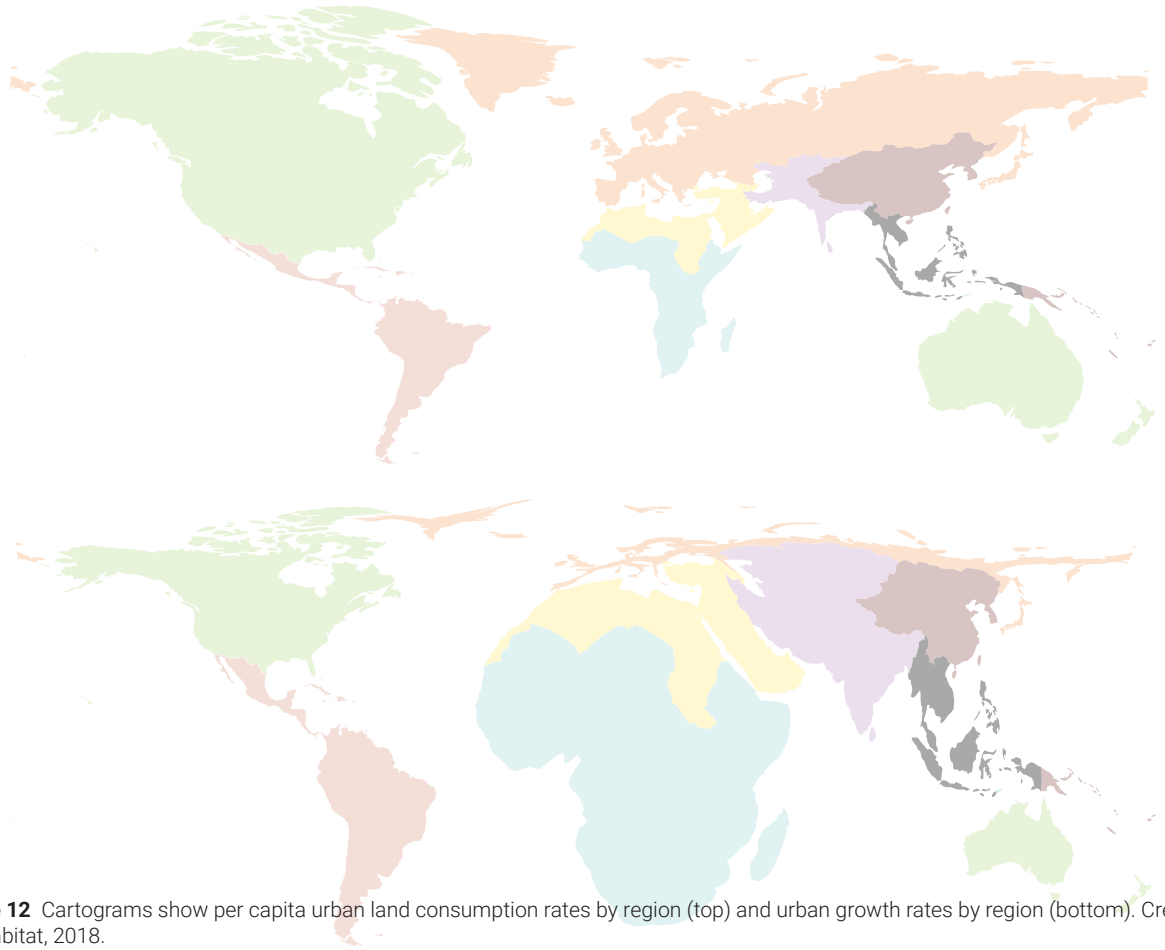
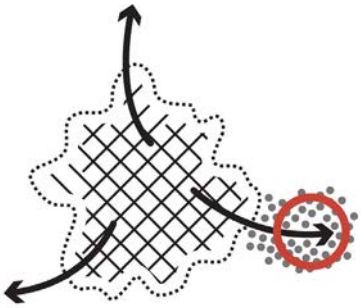
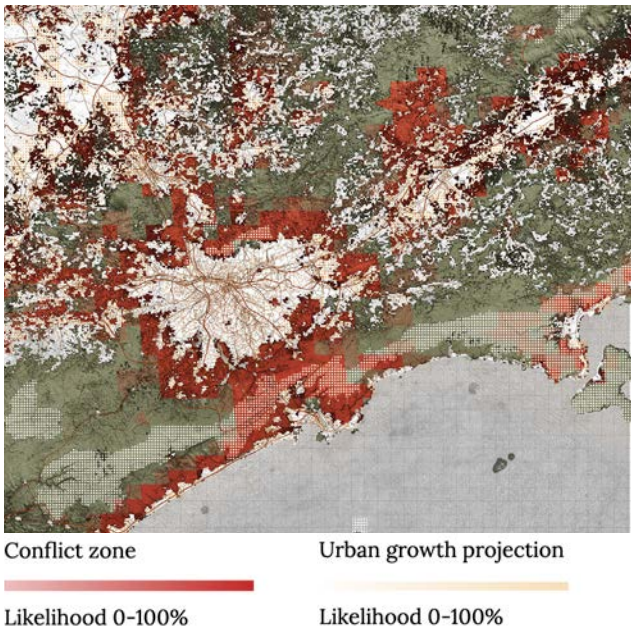


Figure 12 Cartograms show per capita urban land consumption rates by region (top) and urban growth rates by region (bottom). Credits: UN-Habitat, 2018.

3.2 Predicting Land Use Conflict Zones



We must be able to predict how business-as-usual development and climate change will impact biodiversity in real space. Only then can we intervene to avoid land use conflict before it occurs, either by making alternative or corrective choices about where and how to develop. The most immediate impact of urban expansion on biodiversity is often at the peri-urban frontier, whereas the impact of climate on urban is often along coastlines and rivers. At a global level, the McHarg Center for Urbanism and Ecology at the University of Pennsylvania superimposed 2030 spatial growth projections for the largest cities in each of the world's 33 most biodiversity-rich hotspots onto mappings of endangered species (Figure 13). It then identified and graded land use conflict zones at the peri-urban edges of those cities (Figure 14) (Weller et al. 2021).



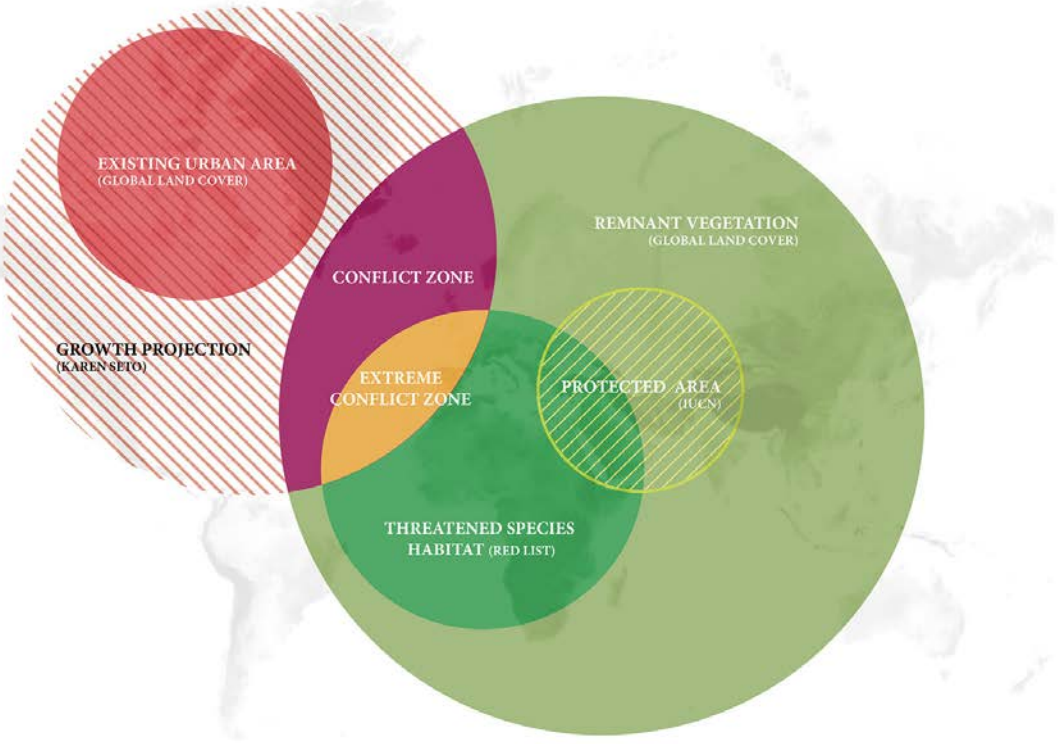
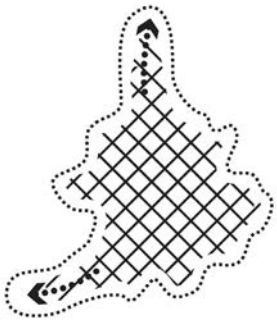


Figure 13 (lower) Venn representation of the overlapping conflict zones between urban growth and remnant vegetation. Credits: Weller. R, McHarg Center for Urbanism and Ecology, University of Pennsylvania.

Figure 14 (upper) Mapped projection of the extents of overlap between urban expansion and threatened species' habitat at the metropolitan scale for Sao Paulo. Credits: Weller. R, McHarg Center for Urbanism and Ecology, University of Pennsylvania.

3.3 Prioritize Areas of Least Harm/Most Suitability



Local budgets are often constrained, and political bandwidth is limited. Comprehensive studies—where they have been undertaken—can thus be overwhelming. In UN-Habitat's experience, governments—particularly local—wish to prioritize interventions in a 'sequence-able' manner that allows them to deploy resources as they come online. Municipal governments need to know the trade-offs between different developmental options and to have alternatives that balance a minimization of ecological harm with a maximization of growth. The Royal Melbourne Institute of Technology (RMIT) undertook such a study of the metropolitan area of Melbourne, aggregating the natural habitat of potential value to a selected group of key species. Their resulting plan rated the peri-urban areas outside the urban growth boundary and indicated which land should and should not be developed (Figure 15) (Gordon et al. 2009).

Combined with more traditional planning mapping, which tends to focus on land accessibility and connectivity as well as infrastructure proximity, this type of mapping adds the dimension of biodiversity preservation for more holistically informed decision making. Future iterations of this methodology might incorporate quantified economic value of biodiversity, though with the possible trade off of diminished replicability in resource- and data-scarce environments.

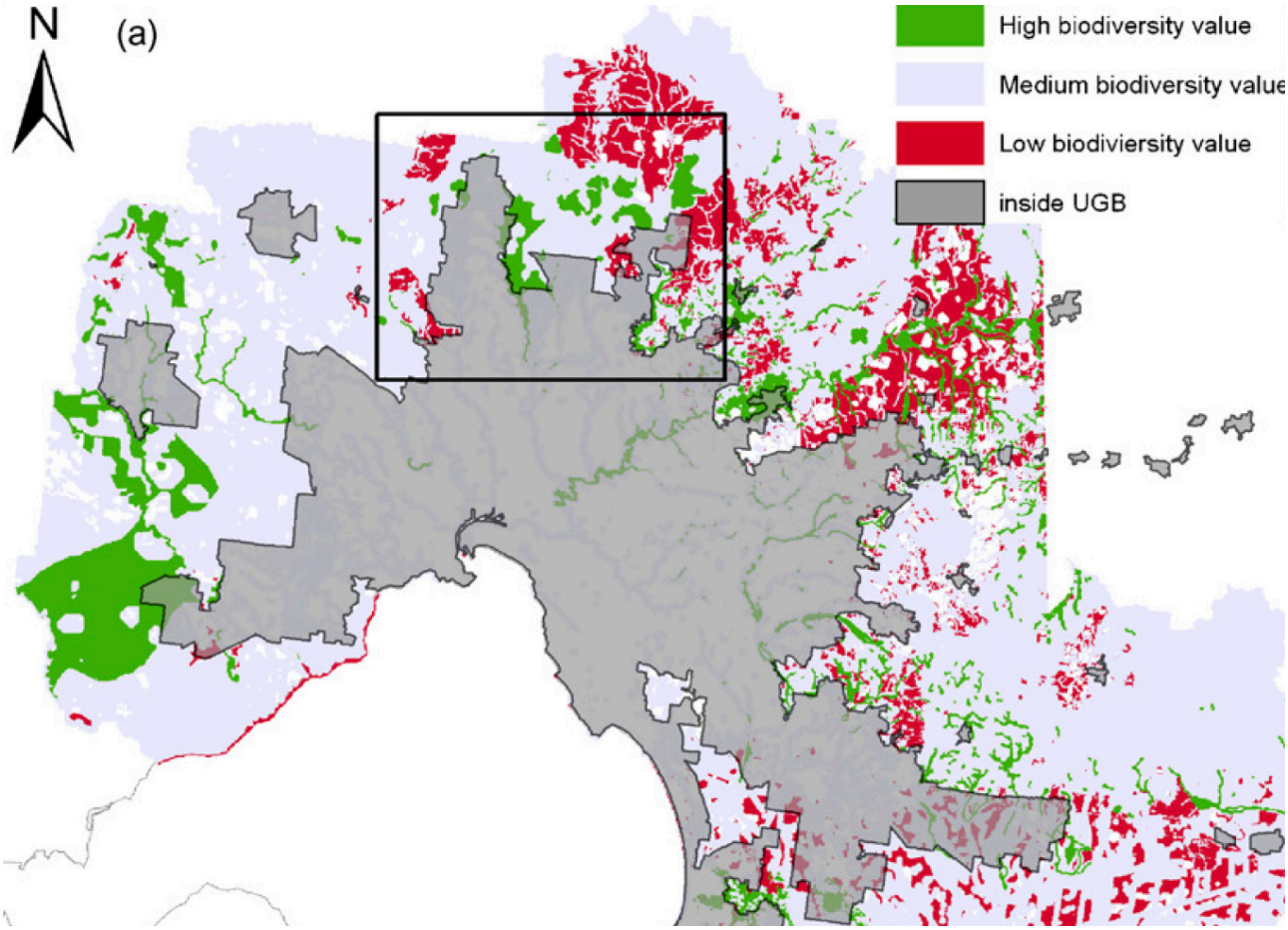
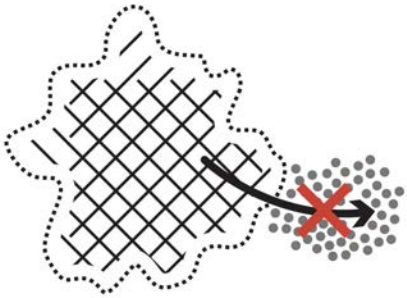


Figure 15 RMIT Study assigns spatial development options for Melbourne based on biodiversity value (Gordon et.al, 2009).

3.4 Prevent Replication of Mistakes



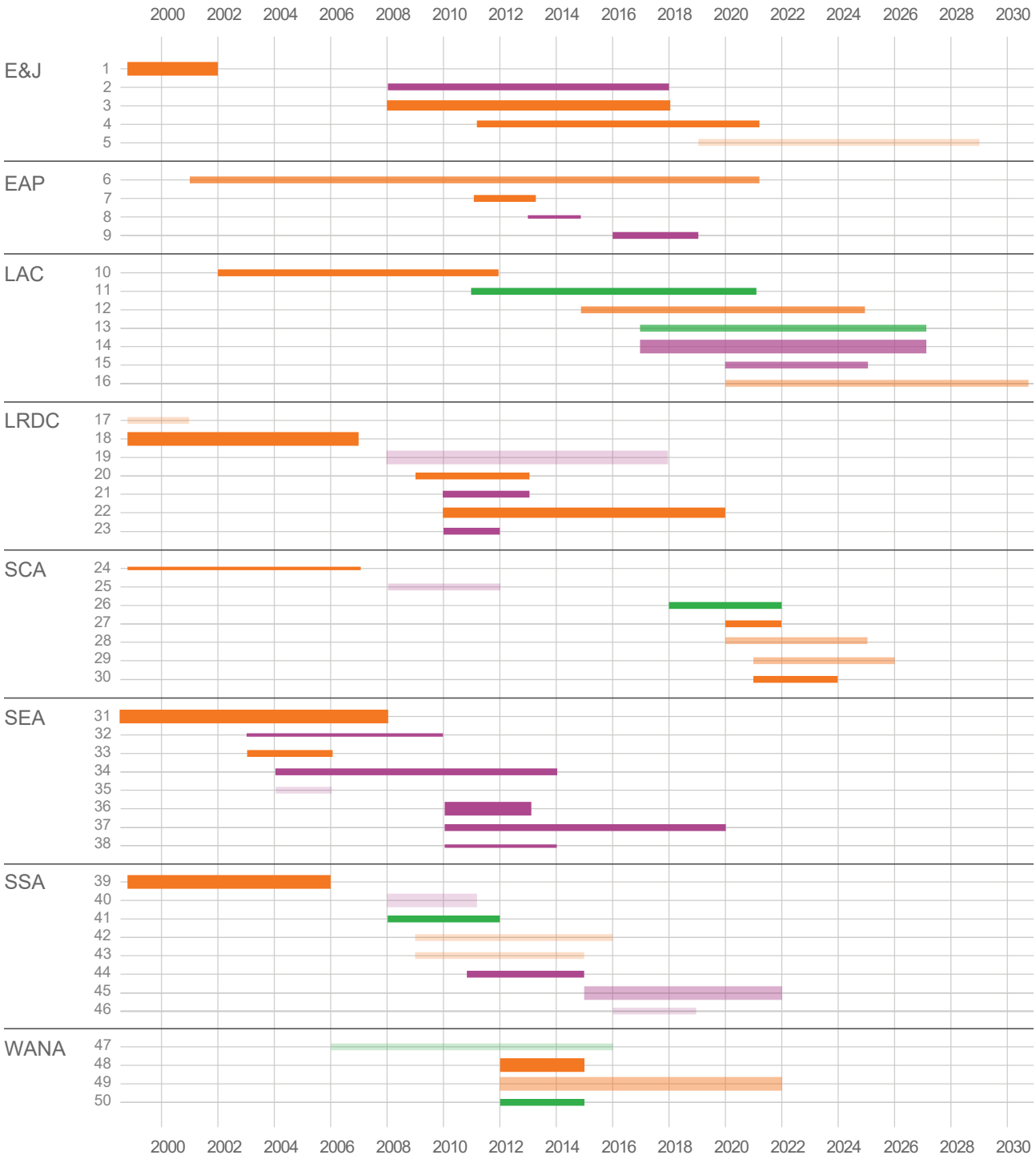
To date, much of the literature and investment around cities and biodiversity has been on restoring degraded ecosystems in and around mature, well-resourced urban areas. Simon (2022) warns against the uncritical application of urban sustainability solutions in contexts that may be inappropriate[3]. We currently lack concrete, transferable methods for preventing further degradation and destruction of natural habitat at the peri-urban edge where change is happening fastest (while retrofitting where needed inside cities). More importantly, many cities and other levels of subnational government need to be able to act immediately based on limited data to hand. Following its identification of a gap around preservation efforts at the local scale (Figure 11), UN-Habitat compiled a catalogue of 50 prevention-oriented interventions and analyzed them according to the following factors:

- Spatial scale, along a continuum of neighbourhood-city-region
- Region, according to eight groupings[4]
- Timeframe for implementation, between 2000-2032
- Status, whether proposed, adopted, in progress, or fully implemented
- Implementing agency, whether local government, non-governmental organization (NGO), or United Nations (UN) agency

Despite their relative scarcity in the literature, there is inspiring evidence of prevention-oriented interventions at the scale of the city (and smaller) that have been attempted in a variety of contexts. Figure 16 highlights several findings:

- Spatial scale runs the gamut from metropolitan down to neighbourhood, despite their relative scarcity in high-profile compendiums,
- Subnational governments (especially municipalities) were the most prevalent implementers, followed by NGOs.
- Duration and progress status varies widely.
- Regionally, southeast Asia has the 'oldest', most completed initiatives, though with nothing recent of note. Europe has the highest proportion of recent initiatives as well as most led by municipalities. Sub-Saharan Africa has the highest proportion of proposed initiatives, as well as those led by NGOs.
- In general, larger-scale initiatives tend to be more municipality-led and less fully implemented, while smaller-scale are more NGO-led and more fully implemented.

The 167 national governments that signed the New Urban Agenda, which guides sustainable urban development through 2036, 'commit[ed them]selves to promoting sustainable land use, combining urban extensions with adequate densities and compactness to prevent and contain urban sprawl, as well as preventing unnecessary land-use change and the loss of productive land and fragile and important ecosystems (United Nations 2017). McDonald et al (in press) argue that compact urban development spares habitat conversion at the periphery of cities while offering liveability and climate benefits (i.e. walkability) within cities. Though this density often comes with the tradeoff of less green space within the city, the paper highlights several 'brightspot' neighbourhoods that manage to balance both density and green space, along with a table of green urban interventions appropriate for different urban formal typologies.



Region

E&J Europe and Japan
EAP East Asia and Pacific
LAC Latin America and Caribbean
LRDC Land-Rich Developed Countries
SCA South and Central Asia
SEA Southeast Asia
SSA Sub-Saharan Africa
WANA West Asia and North Africa

Implementing Agency (by colour)

Municipality/Council
NGO
UN Agency

Intervention Status (by transparency)

Proposed
Adopted
In Progress
Implemented

Spatial Scale (by lineweight)

Neighbourhood
City
City-Region
Region

How to Read This Graph

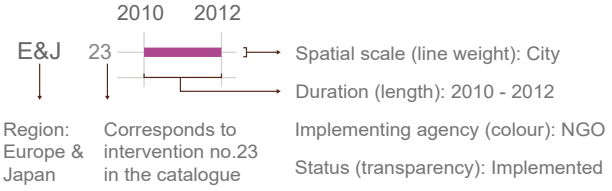


Figure 16 UN-Habitat compiled 50 examples of prevention-oriented interventions, with particular focus on city and neighbourhood scales. (See Annex 2 for details on all 50 examples.)

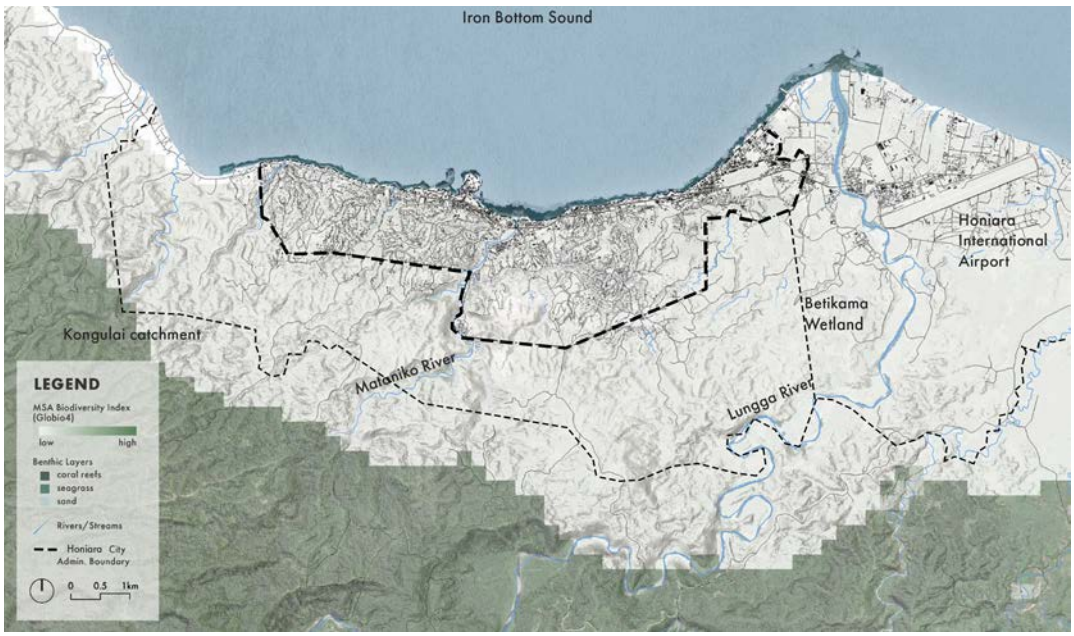
4. Tools

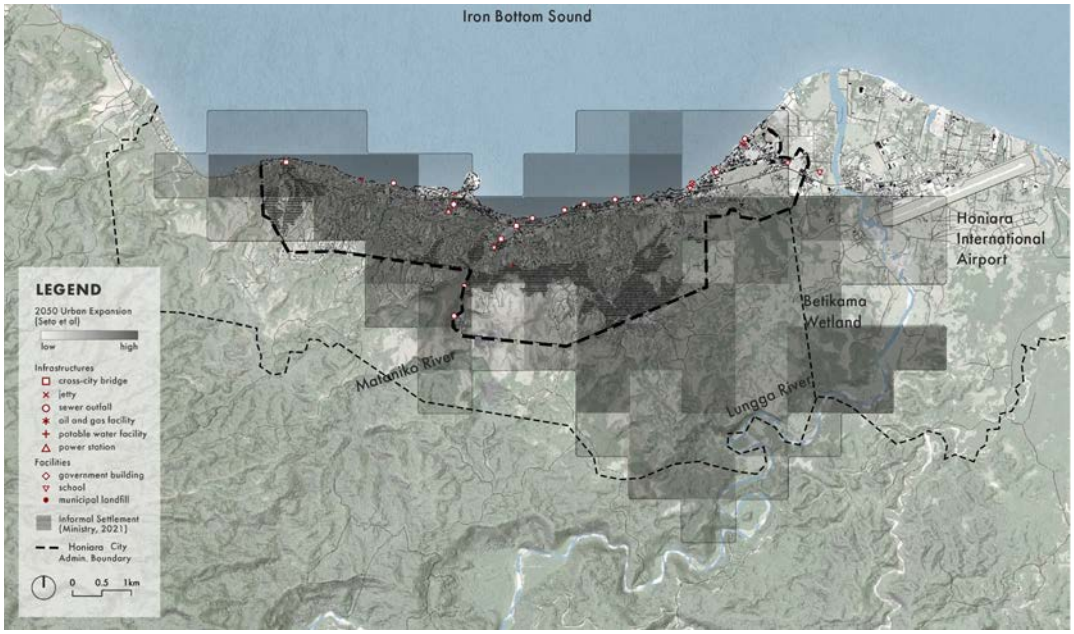
Based on the evidence and identified gaps, UN-Habitat with the McHarg Center at the University of Pennsylvania, and One Architecture and Urbanism have worked to develop a methodology of analysis and intervention across the urban development, biodiversity, and climate fields (working transversally as described in 2.3). At its core is a multi-disciplinary mapping methodology. Tested in three cities over five months[5], it sequences the previously discussed actions (i.e. project, predict, prioritize, and prevent) into an iterative and replicable methodology that simultaneously analyzes biodiversity loss, climate risks and urban expansion. By anticipating and guiding change (described in 2.4) the methodology enhances urban development planning to deliver stronger outcomes in terms of biodiversity protection and climate adaptation. Here we elaborate on the methodology as applied in one of the cities, Honiara, Solomon Islands.

4.1 Projection through Multidisciplinary Mapping

We investigated each context via desktop research, stakeholder workshops and on-site data collection to identify key physical features, climate change risks, natural habitats at both local and regional scales, urban land-use types and jurisdictional boundaries (Figure 17). Open-source global and regional data sets were compiled into high-resolution maps which characterize land based on present quality of biodiversity[6], climate risk[7], and urban expansion[8]. Sourcing of data sets was standardized across the cities to ensure replicability of the methodology in other data-scarce places. The team then projected urban expansion, biodiversity loss, and climate risk to 2050, using a 'business as usual' growth scenario[9] based on high population growth, resource-intensive consumption, and limited regulation of land-use change (Figure 18) (Seto, Güneralp, and Hutyra, 2012).

Figure 17 The peri-urban map of Honiara, Solomon Islands identifies key geographical features, the municipal boundary (thick dashed line), the non-administrative Greater Honiara Area comprising the city and two adjacent wards (thin dashed line), and significant infrastructure.





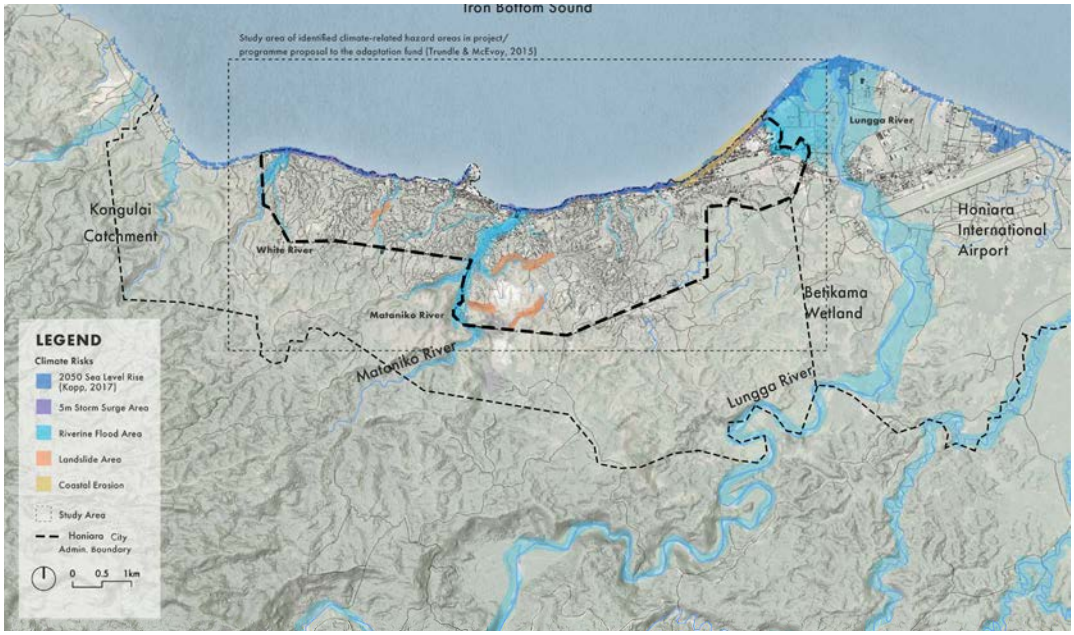
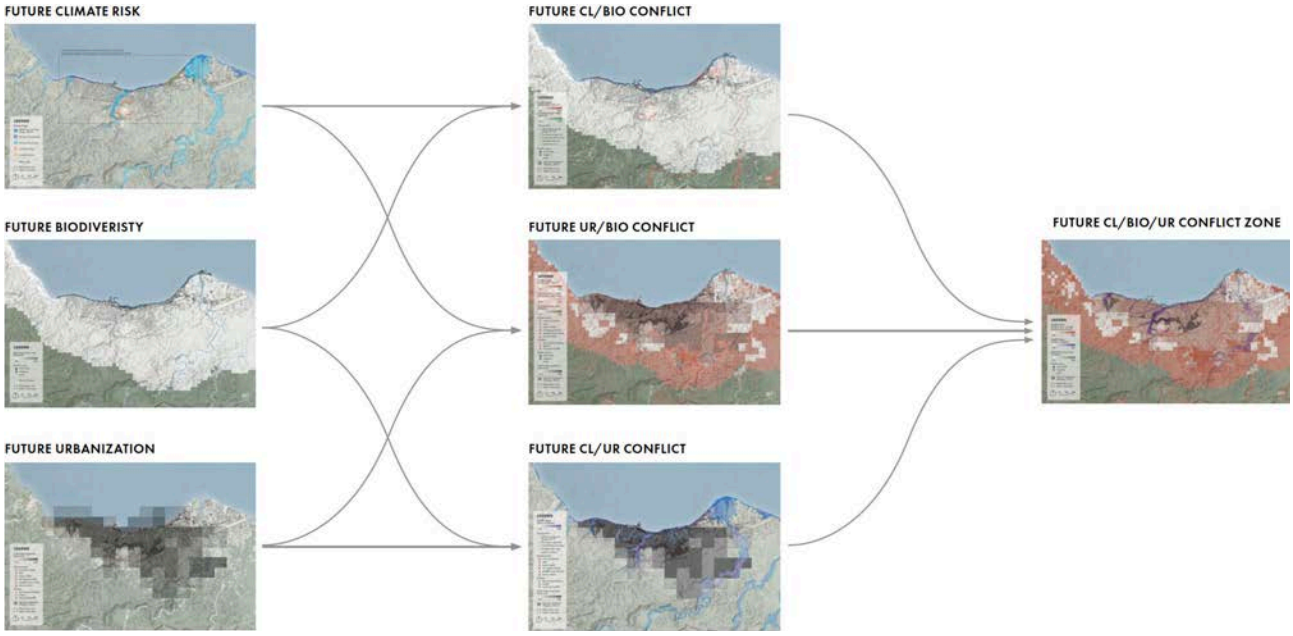


Figure 18 (from top to bottom) Maps of biodiversity loss, urbanization, and climate risks projected to 2050.

4.2 Prediction through Multidisciplinary Mapping

A spatial overlap-based workflow was used to generate an integrated vulnerability hotspots map that predicts overlapping regions of highest risk (Figure 19). Working transversally in anticipation of change, this workflow integrated information across silos to predict the future intersectional impacts of climate risk, biodiversity loss, and urban expansion. The maps produced therefrom were then discussed with local stakeholders to troubleshoot and verify the accuracy of the findings with on-the-ground reality.



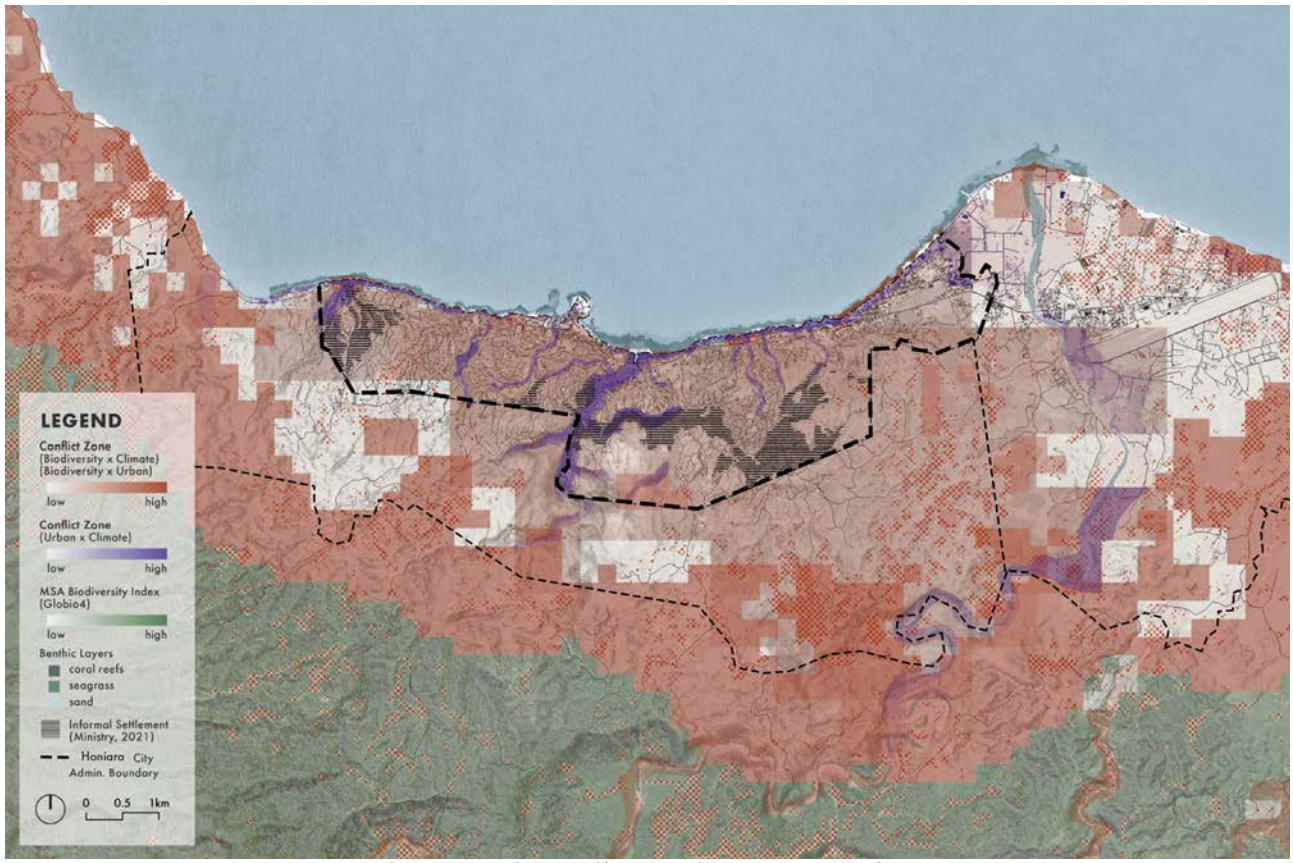
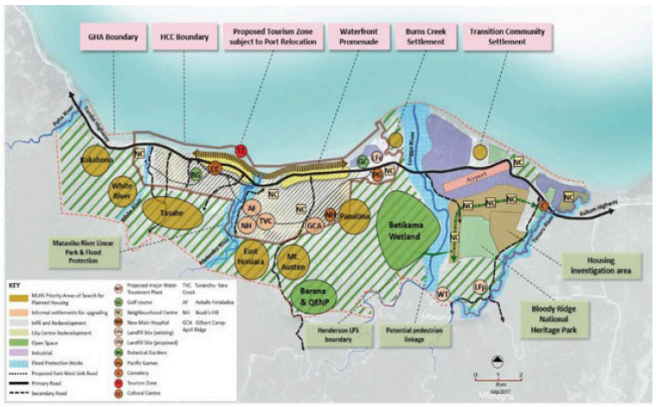


Figure 19 The spatial overlap-based workflow diagram (upper left) collects future projections of climate risks, biodiversity loss and urbanization, combines them in pairs to highlight zones of overlap (upper centre), and then hybridizes these three pairs into an integrated vulnerability hotspots map that highlights regions of highest threat to urban areas and high-biodiversity areas in red and purple, respectively (upper right and enlarged lower).

4.3 Prioritization through Multidisciplinary Mapping

In each context, the city's strategic development plan was combined with findings from the integrated vulnerability hotspots maps to produce strategic intervention maps (Figure 20). Given the inter-scalar nature of the issues considered—see 'working telescopically' in 2.2—these maps focused on (1) the resource-shed or regional scale (Figure 21), (2) the peri-urban scale (Figure 22), and (3) the city scale (Figure 23). Their proposals are both 'nature-based' and 'form-based' and have been recommended to each of the cities for consideration and prioritization based on land ownership, jurisdictional control, available resources, and other factors.

Honiara's 2018 urban development strategy promotes densification, infill, and mixed use within the city and designation of riverine areas as floodplains[10]. It also establishes the Greater Honiara Area (GHA), a non-administrative entity comprising the city and two adjacent peri-urban wards of Guadalcanal Province. The GHA aims to integrate planning, and the peri-urban areas its strategy has identified for residential expansion avoid existing nature parks. However, there is little mention of the 'no-man's-land' in between them, and none of biodiversity preservation or conservation. The following proposals for strategic interventions aim to compliment this.

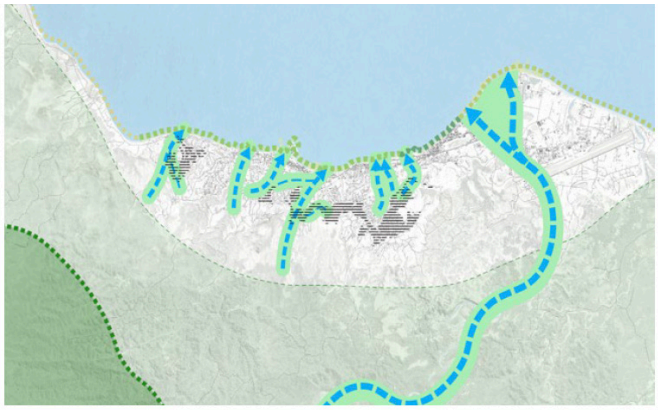


Existing Planning Document

+

Integrated Conflict Map

=



Intervention Map

Figure 20 Existing planning documents were combined with findings from the multidisciplinary mapping to inform the strategic proposals.

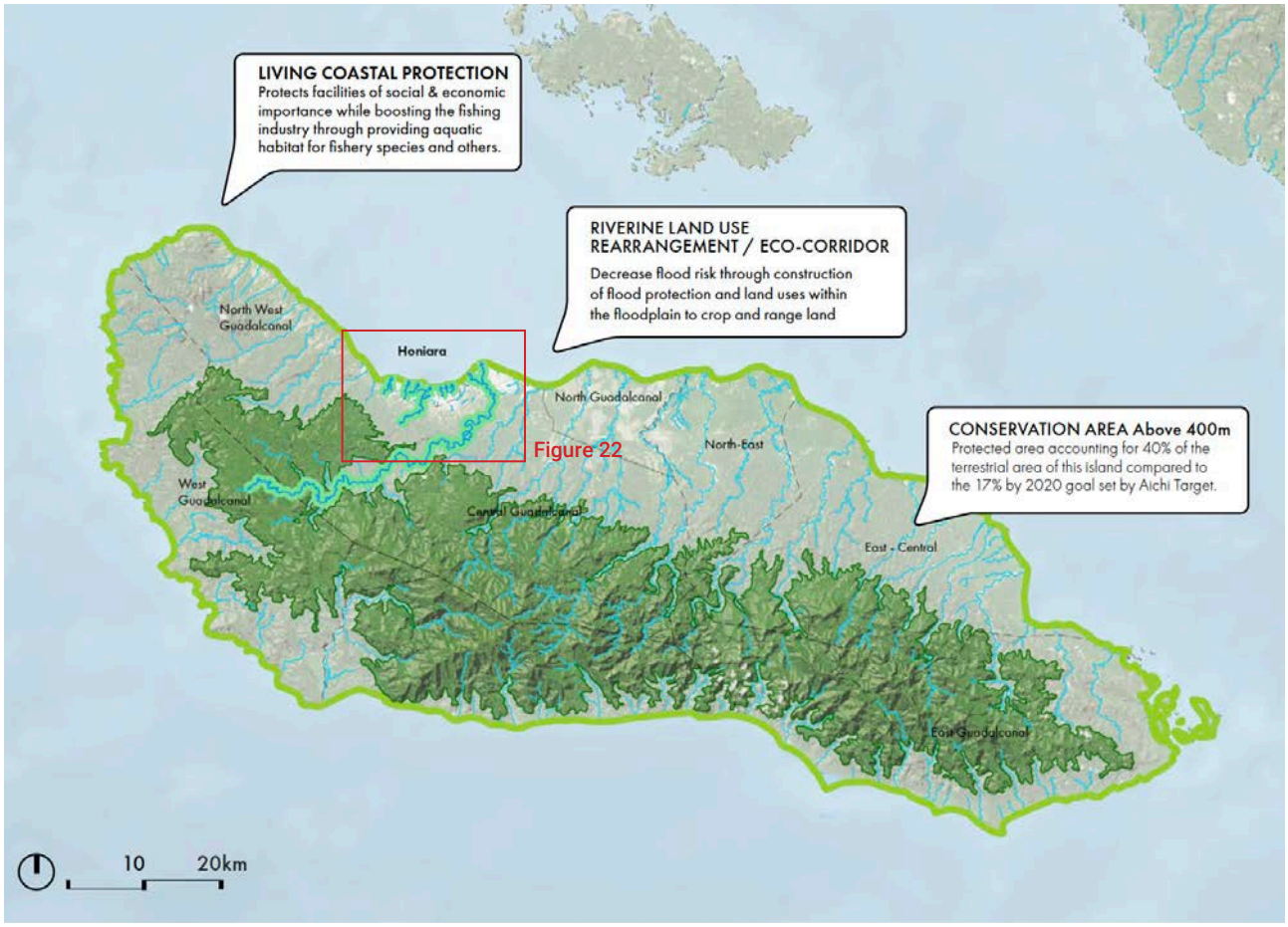


Figure 21 Proposals for regional-scale strategic interventions on Guadalcanal Island, Solomon Islands.

The Forest Act of the Solomon Islands designates all land above 400m as protected, though demand for timber exports have provoked logging there regardless. The country's National Biodiversity Strategy and Action Plan sought to reverse this trend and adopted a 'ridge-to-reef' concept of integrated forest, water, and coastal management[11]. Accordingly, our proposals for regional-scale strategic interventions on Guadalcanal Island would require national, provincial, and municipal government involvement in the following:

Protecting the forest:

- Consider more effective means of enforcing the protected area above 400m that prohibits logging (e.g. community conservation on customary land) and would effectively conserve 40% of the terrestrial area of the island
- Designate and incentivize forest management control areas between 200 and 400 metres that require the use of sustainable logging methods

Strengthening riverine corridors:

- Construct flood protection and limit uses within floodplains to crop and range land
- Manage waste and pollution more proactively, particularly in upstream informal settlements
- Make better, more flexible use of existing water bodies as buffers against flooding and drought

Reconfiguring urban areas:

- Designate areas of higher biodiversity near cities for preservation
- Prioritize urban expansion across the island into areas of lower biodiversity to limit impact on ecosystems
- Bundle new infrastructure such as roads to limit fragmentation of natural habitat

Protecting the coast:

- Construct a layered living flood protection system in all urban areas (e.g. offshore constructed reefs and aquaculture, seagrass restoration, mangrove conservation and restoration, protected fishing areas)
- Plant a green berm of mangroves in all peri-urban agricultural areas to buffer and mitigate coastal disasters

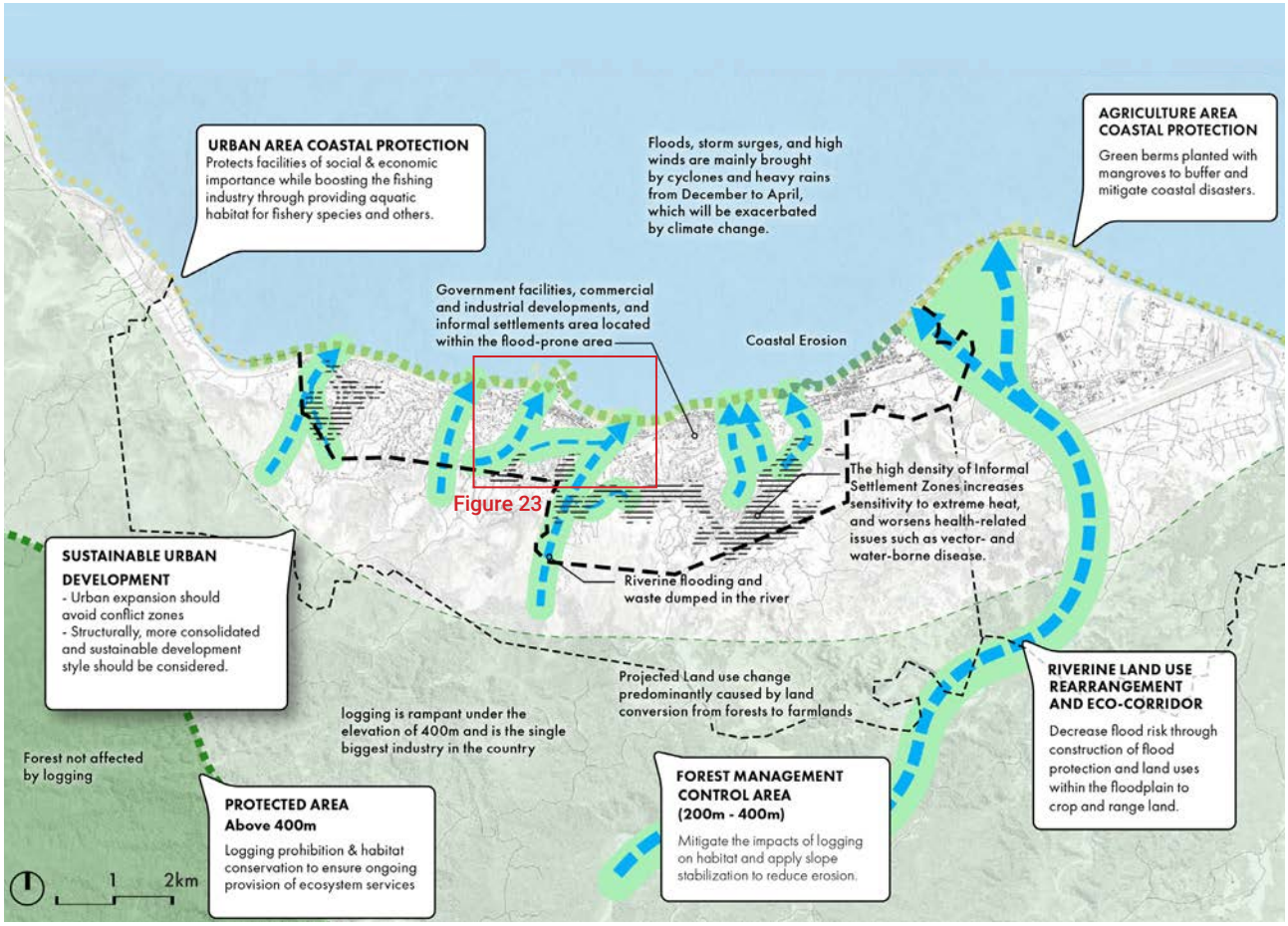


Figure 22 Proposals for peri-urban scale strategic interventions in and around Honiara, Solomon Islands.

In the periphery of Honiara, the threats to biodiversity in terms of land use conflict appeared the sharpest (Figure 19), due both to logging of land and urban expansion (formal and informal) on the south side of the city. Speculative, sprawling, often gated residential development is converting large swathes of land within and beyond the municipal boundary. Proposals for peri-urban scale strategic interventions in the Greater Honiara Area (Honiara and two adjacent wards in Guadalcanal Province) include:

Protecting the forest:

- Coordinate with national government on a potential forest management control area between 200 and 400 metres requiring sustainable logging

Strengthening riverine corridors:

- Decrease flood risk along the Lungga River to the east of the city through construction of flood protection and limiting of and uses within the floodplain to crop and range land
- Manage waste and pollution, particularly in peripheral informal settlements
- Make better use of existing or new water bodies as buffers against flooding and drought

Reconfiguring urban areas:

- Designate areas of higher biodiversity for preservation priority, e.g. to the south of the city, where biodiversity is relatively high (dark red areas on Figure 19) to discourage speculative residential development
- Prioritize and incentivize consolidated urban expansion into areas of lower biodiversity, e.g. to the far west of the city and east of the airport, in non-city peri-urban wards of the Greater Honiara Area (light areas on Figure 19)
- Assess the quantity and quality of open public spaces in the city (e.g. with UN-Habitat's City-Wide Public Space Assessment[12]) and explore previously-unconsidered conservation and restoration options
- Stabilize slopes in and around the city through reforestation and terraced agriculture

Protecting the coast:

- Construct a layered living flood protection system on the coast to the west of Honiara, including offshore reefs and a protected fishing area
- Plant a green berm of mangroves along the coastal agricultural area to the east of Honiara

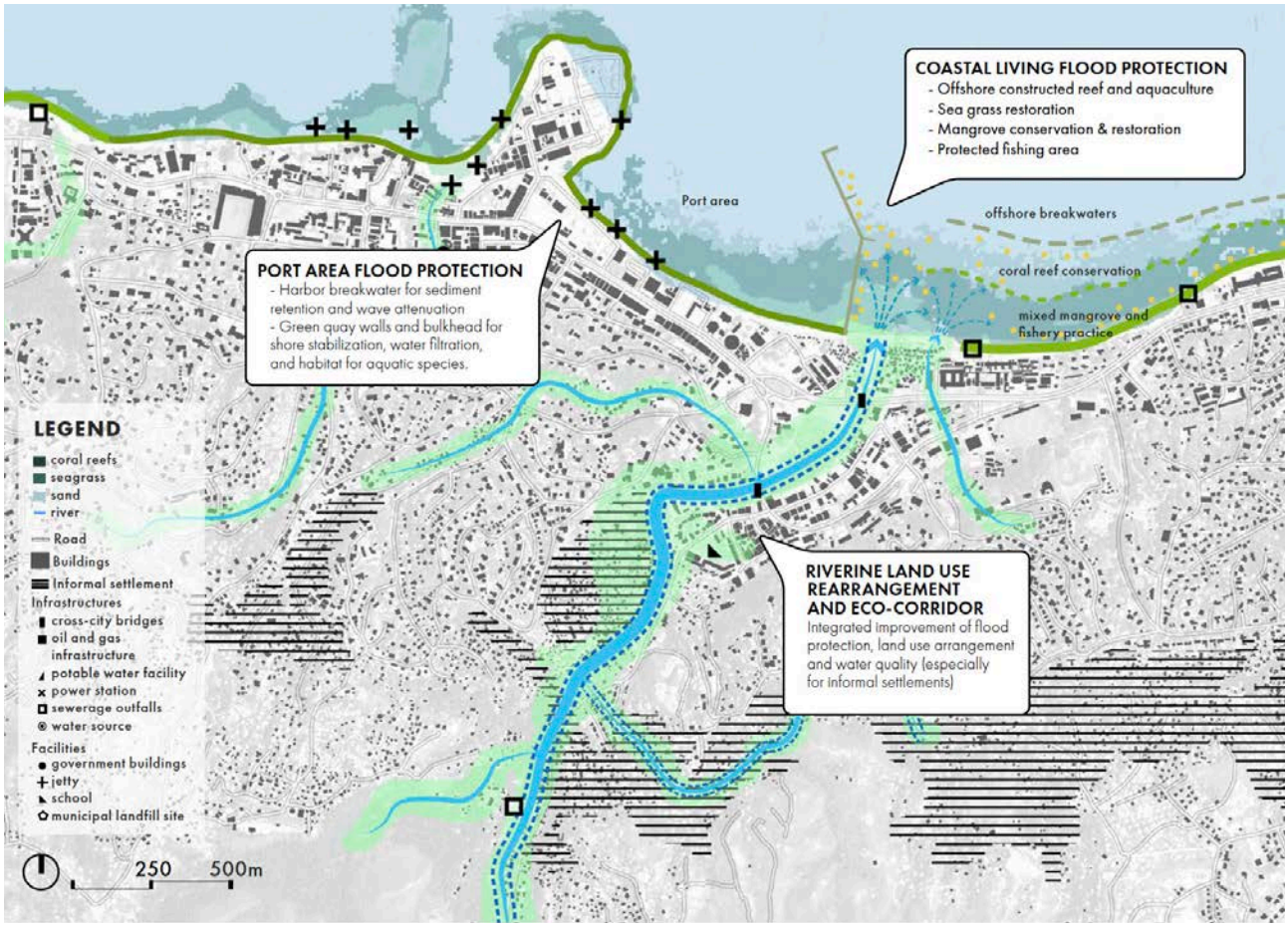


Figure 23 Proposals for city-scale strategic interventions in Honiara, Solomon Islands.

In the centre of Honiara threats to human residents from climate change appeared most acute (Figure 19), especially in the land use conflict zone along the Matanik River. This is a floodplain with high population density, much of it informal, and increasing water pollution issues. Additionally, most coastal areas along the northern edge of the city lack natural or artificial defenses from storm surges and tropical cyclones. Proposals for city-scale strategic interventions within the municipality of Honiara include:

Strengthening Riverine Corridors:

- Rearrange land uses and employ nature-based solutions along the Matanik River floodplain to mitigate flood risk and water pollution
- Establish a multifunctional blue- and green-way that provides stepping stones for biodiversity traveling between ridge and reef
- Generate a baseline of the quantity and quality of biodiversity (e.g. with the Singapore Index on Cities' Biodiversity[13]) and monitor change over time

Reconfiguring the city centre:

- Protect and invest in publicly-owned green patches of higher biodiversity value
- Rehabilitate degraded open spaces into parks, community gardens, or recreation space
- Consider 'leapfrogged' open space of lower biodiversity value for infill development as preventative of expansion at the peri-urban edge
- Guide the development of new settlements (particularly informal ones) into less risk-prone areas

Protecting the coast:

- Implement localized nature-based solutions such as seagrass, mangrove, and reef restoration
- Build a hard, engineered waterfront in the port area, including harbour breakwaters, area to block the flow of sediment, filter water, reduce wave action, and stabilize the shore
- Plant soft and layered vegetated barriers along the commercial coast of the city centre to mitigate the effects of extreme weather, provide breeding grounds and habitats for fishery species, and facilitate tourism

4.4 Prevention with the Multidisciplinary Mapping Methodology and Other Tools

Having implemented their respective plans of action, the cities will then be able to effectively prevent the projected risks from materializing. Additionally, catalogues of pro-biodiversity interventions (Figure 8 and Figure 13) provided an inexhaustive list of precedents based on scale and time frame of action among others to enable city leaders to make better-informed decisions.

The aim of this methodology is to equip cities with an evidence base to make better decisions about how and where to develop; fundamental decisions that collectively constitute the fate of nature. As its data requirements are light, it has the potential to serve as a troubleshooting guide, a precursor or revision to a city plan, or pre-investment suitability screening aid. Actors in any urban planning process can conduct the scenario building (i.e. projection and prediction) and prioritization steps and benefit from their insights. Future iterations will test the addition of economic valuation of biodiversity to the mean species analysis employed in this initial phase. However, the relative difficulty of such valuations may compromise the replicability of this methodology in data-scarce, low-resource urban environments.

Because it is modular, this methodology can also plug into existing tools and benchmarks for better integration with local environmental planning processes or other municipal agendas. For example, it can help characterize the presence and quality of biodiverse habitats identified using the Singapore Index on Cities' Biodiversity (Chan et al., 2021). This pioneering set of 28 indicators covers native biodiversity, ecosystem services, and the governance and management of biodiversity. It serves as a baseline against which progress can be measured and helps cities build their capabilities in biodiversity conservation. The mapping methodology described above can catalyze the findings from this baseline by helping set preservation/conservation priorities and allocate more strategic budgets (Secretariat of the Convention on Biological Diversity, 2021).

UN-Habitat's City-wide and Green Public Space Assessment is a well-tested spatial asset inventory that would strongly benefit the methodology by ground-truthing its recommendations and suggesting where a city might most feasibly take action. Its survey uses open-source technology and has been tested in more than 30 cities; covering open space ownership, use, conditions, and public perception, and it can be customized thematically to include biodiversity-relevant layers including vegetative characteristics, perviousness, and presence of key species. A primary advantage of the tool is its ability to help cities prioritize where they can intervene based on an accurate understanding of the places over which they have jurisdiction. One serendipitous advantage is the galvanizing effect it can have on residents (often students) whose deployment to spaces often generates momentum for action once a public space strategy is developed and adopted.

Thre are also synergies with UN-Habitat's Our City Plans Toolbox. The toolbox uses a participatory and incremental methodology that is adaptable to local contexts and guides and supports local governments and urban actors to better understand, customize, and undertake inclusive and integrated urban planning processes. The mapping methodology described in this paper could significantly enrich plan formulation steps during the initial assessment phase of the toolbox. Transdisciplinary co-production is another promising methodology for mobilizing stakeholders early in the planning process and testing innovative solutions in diverse contexts (Simon 2022). Beyond avoiding expensive lock-ins and path dependencies, it can also help prevent the dispossession of indigenous people and other local populations of land and livelihoods (Counsell 2022). As local needs often include persistent or escalating environmental problems, informed indications about how and where to develop and prevent further biodiversity loss are critical.

Once policymakers or practitioners in a city have used these tools to map and highlight potential land use conflicts and options, they need to decide on the location and quality of development they will pursue. Several different paths are possible, including (1) retrofitting existing plans to reduce the need for expansion (e.g. through densification, regeneration, and infill), (2) deliberate location of unavoidable expansion away from high-value biodiversity areas and protection of those areas (e.g. through regulations and incentives), and (3) sensitive design of the expansion itself to integrate and support biodiversity within those converted areas (e.g. through compact urban form, greening, and the incorporation of other nature-based solutions). Many local contexts will optimize sustainable outcomes with some combination of the three.

5. Next Steps

Additional funding for and partnership around this workstream should prioritize the following activities:

- Testing multidisciplinary mapping as a potential screening methodology for a diversity of urban projects and investments—and in particular for banks, lenders, and other funders—for early rapid assessment of broad environmental impact for large scale proposals and/or smaller ones beyond the scale of the site; under this stream, the full range of economic benefits and financial analysis could be further developed as well

- Catalyzing new master plans and development strategies and revising existing ones on the basis of multidisciplinary mapping that reconciles areas of imminent land use conflict, and supporting planning and environment professionals in the implementation of improved development and land use and controls including ecological corridors and networks

- Studying land use conflict zones in depth to jointly identify and troubleshoot specific environmental challenges (e.g., intensified effects of climate change), design and implement demonstration projects with key stakeholders, and link local solutions to national priorities and global funding

- Analyzing further prevention-oriented interventions (e.g. the 50 catalogued in Annex 2) to identify and promote successful planning models and multilevel governance arrangements that guide development within priority corridors, incentivize collaborative watershed management, and facilitate inter-municipal and other multilevel cooperation on ecosystems

- Liaising with state-of-the-art technicians measuring built and natural habitats at higher resolutions to advance the development of a 'stoplight raster' that reconciles/synthesizes all spatialized data points into a unified map of locations of most and least environmental harm and guides, inter alia, appropriate areas for new housing

- Researching further the trade-offs and co-benefits of different nature-based and form-based urban solutions (e.g., compact development, mixed-use configurations) for biodiversity, including balancing density (e.g., for increased housing provision) and greening (e.g., for increased climate resilience and other SDG-related benefits)

It is usually more politically attractive and often less expensive--in the short term--to solve obvious problems than prevent ones from happening in the first place. This is largely the case because there is more visibility and profit in correcting mistakes. One famous commercial example is a bio-based odour-neutralizing product that never found mass appeal until the problem being solved ('disappearing' the unwanted scent) was 'marked' with an additional perceived benefit (an added scent) (Duhigg, 2014). Preventing mistakes before they are visible (i.e., habitat loss before it is too late for a sixth mass extinction) will require unprecedented will and effort. Biodiversity preservation and conservation within and at the edge of cities must be incentivized and accelerated.

Cities have enormous potential for biodiversity. Often, they are in important biodiversity hotspots near waterways, ecozone transitions, and migration paths. The operating space within which humanity can safely live is defined by nine planetary boundaries, four of which—including land use change and biodiversity loss—have already been exceeded (United Nations Convention to Combat Desertification 2022). While we have collectively done little to strengthen the interface between cities and nature, applying proactive effort now would be extraordinarily productive.

Endnotes

1. BiodiverCities 2030, convened by the Government of Colombia with the Alexander von Humboldt Biological Resources Research Institute and the World Economic Forum was established to inspire, motivate, and assist city governments, businesses, and people in cities to thrive in harmony with nature by 2030.

2. Local Action for Biodiversity is run by ICLEI-Local Governments for Sustainability and the International Union for Conservation of Nature (IUCN).

3. Consequences include, inter alia, expensive technological lock-ins and path dependencies. Simon (2022) proceeds to recommend transdisciplinary co-production, which is mentioned in this paper at the end of Section 4.

4. The eight world regions used in this paper are: Europe & Japan (E&J), East Asia and Pacific (EAP), Latin America and Caribbean (LAC), Land-Rich Developed Countries (LRDC), South and Central Asia (SCA), South East Asia (SEA), Sub-Saharan Africa (SSA), West and North Africa (WANA).

5. To date, this multidimensional mapping methodology has been tested in Honiara, Solomon Islands; Lilongwe, Malawi; and Morondava, Madagascar.

6. Quality of biodiversity habitat is measured using Mean Species Abundance (MSA) which covers land use change, road disturbance, habitat fragmentation, hunting, and nitrogen deposition.

7. Climate risks include regional trends of temperature and precipitation; local patterns of sea level rise, riverine flood risk zones, extreme heat, cyclone paths and desertification.

8. The aggregate amount of urban expansion, calculated through GDP and population growth, was applied spatially based on a suitability analysis that considered population density, slope, distance to roads and land cover.

9. Biodiversity, Climate Risk & Urban Expansion 2022-2050, Shared Socio-Economic Pathway 3 (SSP3) and Representative Concentration Pathway 6.0 (RCP6.0). SSP3, 'regional rivalry', is characterized by high population growth, resource-intensive consumption, low agricultural productivity, and limited regulation of land-use change, leading to continued deforestation; arguably 'business as usual' in relation to prevailing urbanization trends. RCP6.0 is one of the two intermediate scenarios (along with RCP4.5) described by the IPCC.

10. Greater Honiara Urban Development Strategy and Action Plan, led by the Asian Development Bank, available at https://www.adb.org/sites/default/files/project-documents/49460/49460-001-dpta-en.pdf

11. The National Strategic Biodiversity Action Plan of Solomon Islands, 2016-2020, available at https://www.cbd.int/doc/world/sb/sb-nbsap-v2-en.pdf.

12. The City-Wide Public Space Assessment provides an inventory of spatial assets and helps cities understand the network, distribution, accessibility, and quality of those spaces. It also supports the development of a comprehensive evidence-based public space strategy. Available at https://unhabitat.org/city-wide-public-space-assessment-toolkit-a-guide-to-community-led-digital-inventory-and-assessment.

13. The Singapore Index on Cities' Biodiversity serves as a baseline against which progress can be measured and helps cities build their capabilities in biodiversity conservation. Available at https://www.cbd.int/doc/publications/cbd-ts-98-en.pdf.

References

"Biodiversity Hotspots." 2006. *Conservation International*. 2006. https://doi.org/10.5860/choice.43sup-0251

Bókony, Veronika et al (2018). "Endocrine Disruptors in Breeding Ponds and Reproductive Health of Toads in Agricultural, Urban and Natural Landscapes." *The Science of the Total Environment* 634: 1335–45. https://doi.org/10.1016/j.scitotenv.2018.03.363.

Ceballos, Gerardo, Paul Ehrlich, and Rodolfo Dirzo (2017). "Biological Annihilation via the Ongoing Sixth Mass Extinction Signaled by Vertebrate Population Losses and Declines." *Proceedings of the National Academy of Sciences of the United States of America* 114 (30): E6089–96. https://doi.org/10.1073/pnas.1704949114.

Chan, Lena et al (2021). *Handbook on the Singapore Index on Cities' Biodiversity*. Montréal & Singapore: Secretariat of the Convention on Biological Diversity; National Parks Board, Singapore. https://www.cbd.int/doc/publications/cbd-ts-98-en.pdf.

Convention on Biological Diversity (2010). "Plan of Action on Subnational Governments, Cities and Other Local Authorities for Biodiversity." Conference Of the Parties to the Convention on Biological Diversity, Tenth meeting: Nagoya, Japan. https://www.cbd.int/doc/decisions/cop-10/cop-10-dec-22-en.pdf.

——— (2014). "Engagement with Subnational and Local Governments." Conference Of the Parties to the Convention on Biological Diversity Twelfth meeting Pyeongchang, Republic of Korea. https://www.cbd.int/doc/decisions/cop-12/cop-12-dec-09-en.pdf.

——— (2021). "First Draft of The Post-2020 Global Biodiversity Framework." https://www.cbd.int/doc/c/abb5/591f/2e46096d3f0330b08ce87a45/wg2020-03-03-en.pdf.

Coscieme, L et al (2020). "Multiple conceptualizations of nature are key to inclusivity and legitimacy in global environmental governance." *Environmental Science & Policy*, 104, 36–42. https://doi.org/10.1016/j.envsci.2019.10.018

Counsell, Simon (2022). "Will Global Spatial Planning Save the World's Biodiversity? (No, It Won't.) For Those Engaged in Developing the New Global Biodiversity Framework: Four Lessons From the Past, and a Warning for the Future." https://redd-monitor.org/2022/02/11/will-global-spatial-planning-save-the-worlds-biodiversity-no-it-wont-for-those-engaged-in-developing-the-new-global-biodiversity-framework-four-lessons-from-the-past-and-a-war/.

Díaz, S., Demissew, S., Carabias, et al (2015). "The IPBES Conceptual Framework — connecting nature and people.". *Current Opinion in Environmental Sustainability,* 14, 1–16. https://doi.org/10.1016/j.cosust.2014.11.002

Doernberg, Alexandra, and Thomas Weith (2021). "Urban-Rural Interrelations—A Challenge for Sustainable Land Management." In *Human-Environment Interactions*, 101–24. Cham: Springer International Publishing.

Duhigg, Charles (2014). *The Power of Habit: Why We Do What We Do in Life and Business*. Canada, Australia: Doubleday.

Elmqvist, Thomas et al, eds (2013). *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment*. Dordrecht, Netherlands: Springer. https://link.springer.com/book/10.1007/978-94-007-7088-1.

Goldingay, Ross (2022). "Good News: Highway Underpasses for Wildlife Actually Work." *The Conversation*, 1 August 2022. http://theconversation.com/good-news-highway-underpasses-for-wildlife-actually-work-187434.

Gordon, Ascelin et al (2009). "Integrating Conservation Planning and Land use Planning in Urban Landscapes." *Landscape and Urban Planning* 91: 183–94.

Greater Sydney Commission (2018). "Greater Sydney Region Plan: A Metropolis of Three Cities." https://gsc-public-1.s3.amazonaws.com/s3fs-public/greater-sydney-region-plan-0318.pdf.

Güneralp, Burak et al (2020). "Trends in Urban Land Expansion, Density, and Land Transitions from 1970 to 2010: A Global Synthesis." *Environmental Research Letters* 15 (4): 044015. https://doi.org/10.1088/1748-9326/ab6669.

Habitat Encroachment. (2008). Reference Encyclopedia. https://reference.jrank.org/environmental-health/Habitat_Encroachment.html

Huang, Kangning et al (2019). "Projecting global urban land expansion and heat island intensification through 2050." *Environmental Research Letters* 14 (11): 114037 DOI 10.1088/1748-9326/ab4b71.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019). *Global Assessment Report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Edited by E. S. Brondízio, J. Settele, S. Díaz, and H. T. Ngo. Bonn, Germany: IPBES secretariat. https://ipbes.net/sites/default/files/inline/files/ipbes_global_assessment_report_summary_for_policymakers.pdf.

——— (2018). The IPBES Assessment Report on Land Degradation and Restoration. Edited by L. Montanarella, R. Scholes, and A. Brainich. Bonn, Germany: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. https://doi.org/10.5281/zenodo.3237392.

International Organization for Standardization (2019). "ISO 37105:2019 - Sustainable Cities and Communities: Descriptive Framework for Cities and Communities." https://www.iso.org/standard/62064.html.

International Union for Conservation of Nature (2003). "Case Studies in Wetland Valuation #7: Nakivubo Swamp, Uganda: Managing Natural Wetlands for Their Ecosystem Services." https://www.cbd.int/financial/values/uganda-valuenakivubo.pdf.

Jaeger, Jochen et al (2007). "Time Series of Landscape Fragmentation Caused by Transportation Infrastructure and Urban Development: A Case Study from Baden-Württemberg, Germany." *Ecology and Society: A Journal of Integrative Science for Resilience and Sustainability* 12 (1). https://doi.org/10.5751/es-01983-120122.

Marshall, F and P Randhawa (2017). *India's peri-urban frontier: rural-urban transformations and food security*. IIED. http:// pubs.iied.org/10794IIED

Matheswaran, Karthikeyan, Leigh Ann Winowiecki, and Sarah Park (2015). "Built or Natural Infrastructure: A False Dichotomy." *Water, Land and Ecosystems*. 5 March 2015. https://wle.cgiar.org/thrive/2015/03/05/built-or-natural-infrastructure-false-dichotomy.

McDonald, Robert et al (2018). "Nature in the Urban Century." Nature.org. Washington, DC: The Nature Conservancy. https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_NatureintheUrbanCentury_FullReport.pdf.

McDonald, Robert et al (in press). "Denser and Greener Cities: The Pathways to Achieve Both Urban Density and Nature." *People and Nature*.

McInnes, Robert (2013). "Cities and Ecosystem Services, Functionalities, Susceptibilities and Priorities."

McKinney, Michael (2002). "Urbanization, Biodiversity, and Conservation." *Bioscience* 52 (10): 883. https://doi.org/10.1641/0006-3568(2002)052[0883:ubac]2.0.co;2.

Mehaffy, Michael et al (2020). *A New Pattern Language for Growing Regions: Places, Networks, Processes*. Sweden: Sustasis Foundation.

Mejía, M. A., and J. D. Amaya-Espinel, eds. (2022). *BiodiverCities by 2030: Transforming Cities with Biodiversity*. Bogotá: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. http://repository.humboldt.org.co/handle/20.500.11761/36048.

Mindock, Clark (2022). 'Can Oysters Save New York City from the next Big Storm?' *The Guardian*, 17 March 2022. https://www.theguardian.com/environment/2022/mar/17/can-oysters-save-new-york-city-from-next-big-storm.

Mohamed, Waseem (2022a). "Urban Greening Can Reduce Impact of Global Heating in Cities, Finds Study." *The Guardian*, 29 September 2022.

https://amp.theguardian.com/environment/2022/sep/29/urban-greening-reduce-impact-global-heating-cities-study.

——— (2022b). "'Superhero' Moss Can Save Communities from Flooding, Say Scientists." *The Guardian*, 30 September 2022. https://www.theguardian.com/environment/2022/sep/30/superhero-sphagnum-moss-save-communities-flooding.

Parayil, Govindan (1996). "The 'Kerala Model' of Development: Development and Sustainability in the Third World." *Third World Quarterly* 17 (5): 941–57. http://www.jstor.org/stable/3993238 .

Ritchie, Hannah, and Max Roser (2021). "Biodiversity." Ourworldindata.org. https://ourworldindata.org/habitat-loss.

Rudd, Andrew (2012). "Landscape Connectivity and City-Region Planning." *Journal of Landscape Architecture*. 7(2): 90–90. https://doi.org/10.1080/18626033.2012.746099.

Sawyer, Lindsay et al (2021). "Bypass Urbanism: Re-Ordering Center-Periphery Relations in Kolkata, Lagos and Mexico City." *Environment & Planning A* 53 (4): 675–703. https://doi.org/10.1177/0308518x20983818.

Scarlett, Lynn, and Matthew McKinney (2016) "Connecting People and Places: The Emerging Role of Network Governance in Large Landscape Conservation." *Frontiers in Ecology and the Environment* 14 (3): 116–25. https://doi.org/10.1002/fee.1247.

Secretariat of the Convention on Biological Diversity (2012). *Cities and Biodiversity Outlook*. Montréal, QC, Canada: Secretariat of the Convention on Biological Diversity, Implementation and Outreach Division. https://www.cbd.int/doc/health/cbo-action-policy-en.pdf.

——— (2017). "Guidelines for an Integrated Approach in the Development and Implementation of National, Subnational and Local Biodiversity Strategies and Action Plans." http://cbc.iclei.org/wp-content/uploads/2017/12/NBSAP_WEB_SINGLE_PAGES-2.pdf.

Seto, Karen, Burak Güneralp, and Lucy Hutyra (2012). "Global Forecasts of Urban Expansion to 2030 and Direct Impacts on Biodiversity and Carbon Pools." *Proceedings of the National Academy of Sciences of the United States of America* 109 (40): 16083–88. https://doi.org/10.1073/pnas.1211658109.

Seto, Karen, Susan Parnell, and Thomas Elmqvist (2013). "A Global Outlook on Urbanization." In *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*, edited by Thomas Elmqvist, and others, 1–12. Dordrecht, Netherlands: Springer. https://doi.org/10.1007/978-94-007-7088-1.

Simkin, Rohan et al (2022). "Biodiversity Impacts and Conservation Implications of Urban Land Expansion Projected to 2050." *Proceedings of the National Academy of Sciences of the United States of America* 119 (12): e2117297119. https://doi.org/10.1073/pnas.2117297119.

Simon, David (2022). "From the What to the How of Keeping 1.5°C Alive: Methodological Innovations." *Journal of City Climate Policy and Economy* 1 (1). https://doi.org/10.3138/jccpe-2022.1.1.0006

Spotswood, Erica et al (2019). *Making Nature's City: A Science-Based Framework for Building Urban Biodiversity*. Richmond, CA: San Francisco Estuary Institute. https://www.sfei.org/projects/making-natures-city.

Swilling, Mark (2016). "The Curse of Urban Sprawl: How Cities Grow, and Why This Has to Change." *The Guardian*, 12 July 2016. https://www.theguardian.com/cities/2016/jul/12/urban-sprawl-how-cities-grow-change-sustainability-urban-age.

The Nature Conservancy (2022). "New Biodiversity Commitments Announced as World Leaders Declare Nature Summit COP15 a Priority." *The Nature Conservancy*. 20 September 2022. https://www.nature.org/en-us/newsroom/new-biodiversity-commitments-world-leaders-declare-un-biodiversity-summit-priority/.

UN Web TV (2022a). "Statement by Executive Director, UN-Habitat (@52:00) at the Stockholm+50 Leadership Dialogue 1: Reflecting on the Urgent Need for Actions to Achieve a Healthy Planet and Prosperity of All." 2 June 2022. https://media.un.org/en/asset/k1a/k1aagq29uz.

——— (2022b). "Statement by Andrew Rudd, on Behalf of the Executive Director, UNHabitat @45:40 Stockholm+50 Fourth Plenary Meeting." 3 June 2022. https://media.un.org/en/asset/k14/k14hohbm0f.

United Nations Development Programme (2022). "The Power of Maps to Inform Action for Nature and Development." Undp.org. 16 March 2022. https://www.undp.org/blog/power-maps-inform-action-nature-and-development.

UNEP, UNDP and HLCP Biodiversity Task Team (2021). "50+ Ways to Integrating Biodiversity and Nature-Based Solutions – a UN System Commitment to Collective Action for People and Planet." https://unemg.org/wp-content/uploads/2021/04/HLCP41-CRP.2-Biodiversity-and-Nature-based-Solutions-Annex-IV_Rev-12-Apr-2021.pdf.

UNEP World Conservation Monitoring Centre (2017). "Western Ghats." World Heritage Datasheet. 22 May 2017. http://www.yichuans.me/datasheet/output/site/western-ghats/.

UN-Habitat (2018). *The Quito Papers and the New Urban Agenda*. London, England: Routledge.

UN-Habitat (2019). *Urban-Rural Linkages: Guiding Principles Framework for Action to Advance Integrated Territorial Development*. https://unhabitat.org/sites/default/files/2020/03/url-gp-1.pdf.

UN-Habitat (2020). *World Cities Report 2020: The Value of Sustainable Urbanization*. New York: United Nations.

UN-Habitat (2022). *Managing Urban-Rural Linkages for Biodiversity: an Integrated Territorial Approach*. Nairobi: United Nations.

United Nations (2015). *Transforming Our World: The 2030 Agenda For Sustainable Development*. https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf.

United Nations (2017). *The New Urban Agenda*. https://habitat3.org/wp-content/uploads/NUA-English.pdf

United Nations Convention to Combat Desertification (2022). *Global Land Outlook, Second Edition.* https://www.unccd.int/sites/default/files/2022-04/UNCCD_GLO2_low-res_2.pdf

Vucetich, John, Jeremy Bruskotter, and Michael Nelson (2015). "Evaluating Whether Nature's Intrinsic Value Is an Axiom of or Anathema to Conservation." *Conservation Biology: Journal of the Society for Conservation Biology* 29 (2): 321–32. https://doi.org/10.1111/cobi.12464.

Wealth, Linus (2018). "Conservation & Preservation." *Sustainable Environment Online | Environment Resources and Sustainable Development*. 9 June 2018. https://www.sustainable-environment.org.uk/Earth/Conservation_and_Preservation.php

Weller, Richard, David Gouverneur, Zuzanna Drozdz, and Boya Ye (2021). "The Hotspot Cities Project: The Case Study of Bogotá 2050." *Journal of Landscape Architecture* 16 (1): 76–89. https://doi.org/10.1080/18626033.2021.1948198.

World Climate Foundation (2022). "Partnering for Nature - Calling for a Paris Moment in Biodiversity." WCF. 22 September 2022. https://www.worldclimatefoundation.org/post/partnering-for-nature-calling-for-a-paris-moment-in-biodiversity.

World Economic Forum (2022). "BiodiverCities by 2030: Transforming Cities' Relationship with Nature." https://www3.weforum.org/docs/WEF_BiodiverCities_by_2030_2022.pdf.

World Wildlife Fund (2022). *Living Planet Report 2022–Building a Nature Positive Society*. Edited by Almond R.E.A et al. Gland: WWF International.

Glossary

Conservation – Actions to manage human interactions with ecosystems to provide maximum benefits to the present generation while maintaining their potential to meet the needs of future generations (WRI, 1992)

Ecosystem - A community of living organisms (plants, animals, fungi and various microbes) in conjunction with the non-living components of their environment (such as energy, air, water and mineral soil), all interacting as a system.

Encroachment - Encroachment is the spread of humans, transportation systems, utilities, buildings, and other development into natural areas. Encroachment leads to loss of habitat or changes in the natural ecology for plants, animals, fish, and other living organisms that live in the area (Habitat Encroachment, 2008).

Full Value of Biodiversity - The values of nature encompass the different layers of the values typology, including worldviews, underpinning knowledge systems, languages and cultures, indicators, and preferences. In addition to instrumental values, the values of nature include reciprocal values and perspectives of nature where nature and people are not seen as separate, and where intrinsic values are acknowledged on a par with values of nature's benefits to people (Coscieme et al., 2020, Díaz et al., 2015)

Land Degradation – The many processes that drive the decline or loss in biodiversity, ecosystem functions or their benefits to people and includes the degradation of all terrestrial ecosystems.

Land-Use Change / Conversion - The modification or management of natural environments into human dominated environments, such as settlements, semi-natural and agricultural areas.

Multidisciplinary Mapping Methodology – The paper introduces a novel methodology that maps current and future biodiversity loss, climate risks and urbanization using open-source data in any given context. It measures and spatializes the interlinkages between the three disciplines comprehensively to provide a near-reality scenario that can benefit local partners in future-proofing urban master plans.

Natural Habitat - Areas composed of viable assemblages of plant and/or animal species of largely native origin and/or where human activity had not essentially modified an area's primary ecological functions and species composition (UNEP-WCMC, 2014).

Peri-Urban – The often neglected, ever-expanding regions that arise upon reclassification of rural villages to statutory towns. The region is characterized by a juxtaposition of rural and urban activities along with institutional ambiguity, unplanned growth, environmental degradation, with formal schemes aimed at improving aspects of the environment being exclusionary (Marshall & Randhawa, 2017).

Preservation - Actions undertaken to maintain areas that are so far untouched by humans in their pristine, existing condition. Often regarded as a deeper form of environmentalism, or ecocentrism, preservation supports the worldview that ecosystems should be preserved regardless of their benefits (Wealth, 2018)

Restoration - Any intentional activity that initiates or accelerates the recovery of an ecosystem from a degraded state.

Telescopic - Zooming across multiple scales, acting at the most appropriate one, and linking back to all the others

Urban Growth / Urbanization - The increase in the proportion of a population living in urban areas; the process by which a large number of people becomes permanently concentrated in relatively small areas, forming cities (IPBES, 2019)

Abbreviations

CBD - Convention on Biological Diversity
E&J - Europe & Japan
EAP - East Asia and Pacific
GBF – Global Biodiversity Framework
GDP - Gross Domestic Product
HLCP – High-level Committee on Programmes
IPBES - International Panel on Biodiversity and Ecosystem Services
ISO – International Organisation of Standardization
LAC - Latin America and Caribbean
LBSAP – Local Biodiversity Strategies and Action Plan
LRDC - Land-Rich Developed Countries
NBSAP – National Biodiversity Strategies and Action Plan
NGO – Non-governmental Organisation
RMIT - Royal Melbourne Institute of Technology
SCA - South and Central Asia
SDG - Sustainable Development Goals
SEA - South East Asia
SSA - Sub-Saharan Africa
UN – United Nations
UN-Habitat - United Nations Human Settlements Programme
UNDP – United Nations Development Programme
UNEP – United Nations Environment Programme
USD – United States Dollars
WANA - West and North Africa
WCF - World Climate Foundation
WEF – World Economic Forum

Annex 1: Case Studies

Case Study 1: Kerala, India

The Western Ghats (Montane Rain Forest ecoregion), older than the great Himalayan Mountain chain, is a global biodiversity hotspot covers 140,000 sq km and traverses the Indian states of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, and Gujarat (Mittermeier et al., 2005). Kerala alone manages 9,400 sq km of effective forest area (Forest Statistics, 2008). The state's protected area constitutes a wide range of biomes, extending from the salt marshes, mangroves and beaches of the Arabian Sea to the moist deciduous and montane rain forests of the Western Ghats (Kerala Forest and Wildlife Department, 2008). However, Kerala's biodiversity is threatened by improper land use, an expanding transport network and unplanned tourism development (Kerala Forest Research Institute, 2003). Additionally, Kerala's population density of 859 persons per sq km, more than twice the Indian average of 382 (Kerala State Planning Board), may be challenging conservation and restoration efforts (Chaudhary et al, 2022).

The state aims to better integrate sustainable development goals into policymaking, and to catalyze community-oriented strategies for biodiversity protection. In practice this means decentralized administration, collaboration and alignment between the state, NGOs and civic movements. Kerala was the first state in India to set up a Biodiversity Management Committees (BMCs) in all local bodies (Suchitra, 2012) with specific duties to document local biodiversity and traditional knowledge.

The State Biodiversity Strategy and Action plan developed by Kerala State Biodiversity Board[i] outlines the strategies relating to conservation, sustainable use, equitable access, and shared benefits of biodiversity[ii]. As the largest and most populous metropolitan in Kerala14, Kochi is the first Indian city to have developed a scientifically informed and participatory Local Biodiversity Strategy and Action Plan[iii]. The state announced plans to extend the biodiversity action plan to panchayats16 i.e., peri-urban and rural context in the next financial year with the pilot project already implemented in Athirappilly, a panchayat 70 km northeast of Kochi17.

People's Biodiversity Register (PBR) is a community-involved, participatory exercise implemented by the local BMCs under state's mandate as an effort to shift from welfare to participatory growth, and from top-down intervention to bottom-up planning. The register documents the community's traditional knowledge and insight of the status, history, uses and forces driving changes on the biodiversity resources and further provides information on its economic benefits to the local communities (Kerala State Biodiversity Board, 2017).

To protect the mangrove forests situated on about 1,000 acres of private land, the state has introduced a scheme to award monetary incentives to landowners, while assessing how much of the land can be acquired (G, Sajith Kumar 2021).

Kerala and its constituent municipalities are partially aligned with the principles of this paper, particularly telescopic coordination between levels of government and transversal coordination between constituent jurisdictions. However, the administrative boundaries of multiple Indian states cut across the Western Ghats hotspot, threatening the continuity of this ecoregion. Though Kerala has offered conservation incentives to many municipalities and landowners, spatial coordination is lacking, and increasingly non-contiguous land uses are exacerbating landscape functionality.

The state is anticipating sea level rise and the flooding of the coastal cities of Kochi and Thiruvananthapuram18, and beginning to explore various mitigation strategies19. However, its attempt to improve environmental awareness and the accountability of communities, local bodies and NGOs in biodiversity preservation falls short in addressing climate change risks through an integrated approach (Balan and M. D, 2022). Kerala would benefit from investigating the interlinkages between biodiversity, climate change, and urbanization. Local governments—particularly those affected by climate change risks—could use the multidisciplinary mapping tool described in this paper to identify land use conflict zones. The integrated analysis it yields would help to formulate development and land use management strategies for holistic biodiversity preservation and climate change adaptation.

Endnotes

i. Kerala State Biodiversity Board (KSBB) is a statutory regulatory body under the State's Department of Environment.

ii. In collaboration with ICLEI, South Asia and supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Germany.

iii. Various mitigation strategies in the pipeline in Kerala State include the "Flood Mitigation Cluster Initiative" by the International Urban and Regional Cooperation, European Union

References:

"Biodiversity Action Plan for More Local Bodies in Kerala: CM" (2021). thehindu.com. November 25, 2021. https://www.thehindu.com/news/national/kerala/biodiversity-action-plan-for-more-local-bodies-in-kerala-cm/article37688970.ece.

Balan, Pradeep, and Jessy M. D (2022). "Climate Crisis in Kerala: An Integrated Approach Is Needed to Mitigate Impact." Downtoearth.org.In. January 4, 2022. https://www.downtoearth.org.in/blog/climate-change/climate-crisis-in-kerala-an-integrated-approach-is-needed-to-mitigate-impact-80962.

Chaudhary, A., Mair, L., Strassburg, B. B. N., Brooks, T. M., Menon, V., & McGowan, P. J. K. (2022). Subnational assessment of threats to Indian biodiversity and habitat restoration opportunities. Environmental Research Letters, 17(5), 054022. https://doi.org/10.1088/1748-9326/ac5d99

G, Sajith Kumar (2021). "Govt to Take over Mangrove Forests in Private Lands." Mathrubhumi. January 6, 2021. https://english.mathrubhumi.com/news/kerala/govt-to-take-over-mangrove-forests-in-private-lands-1.5335945.

Kallungal, D. (2022, April 20). Coastline of Kochi, Thiruvananthapuram may be under water by 2050.Thehindu.com. https://www.thehindu.com/news/national/kerala/coastline-of-kochi-capital-may-be-underwater-by2050/article65338989.ece

Kerala Forest and Wildlife Department. 2008. "Statistics 2008." Forest.kerala.gov.In. 2008. https://forest.kerala.gov.in/index.php/topmenu/downloads/statistics-2008.

Kerala Forest Research Institute (2003). "Biodiversity Strategy and Action Plan For Kerala." Kalpavriksh.org. 2003. https://kalpavriksh.org/wp-content/uploads/2019/05/Kerala-BSAP-Final-April-2003.pdf.

Kerala State Biodiversity Board (2017). "People's Biodiversity Register (Manual)." Edited by Oommen V. Oommen, Cheruvat Dinesan, J. Jayalekhadevi, N. P. Suresh Babu, and N. B. Mithrambika. https://www.keralabiodiversity.org/images/2021/pbr.pdf.

Kerala State Planning Board. (2017). Economic Review. Spb.gov.In. https://spb.kerala.gov.in/economic-review/ER2017/web_e/ch11.php?id=1&ch=11

Mittermeier, Russell A., and others (2005). Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. Agrupacion Sierra Madre.

Suchitra, M (2012). "Kerala Becomes First State in Country to Complete Formation of Biodiversity Management Committees." Downtoearth.org.In. October 12, 2012. https://www.downtoearth.org.in/news/kerala-becomes-first-state-in-country-to-complete-formation-of-biodiversity-management-committees-39335.

Case Study 2: Atlantic Forest Biome, Brazil

The Atlantic Forest biome is a global biodiversity hotspot (Mittermeier et al., 2005). Located along the coastline of Brazil, it crosses 17 states and houses 70% of the country's population over 3,000 municipalities, including the major metropolitan areas of São Paulo, Rio de Janeiro, and Belo Horizonte. These dense conurbations and their industrial base generate 60% of Brazilian GDP (Fundação SOS Mata Atlântica, 2021). Largely as a result of urban expansion, this biome has suffered a high degree of degradation (70%) and its native vegetation coverage has been reduced by more than 92% from its original extent (Mittermeier et al., 2005).

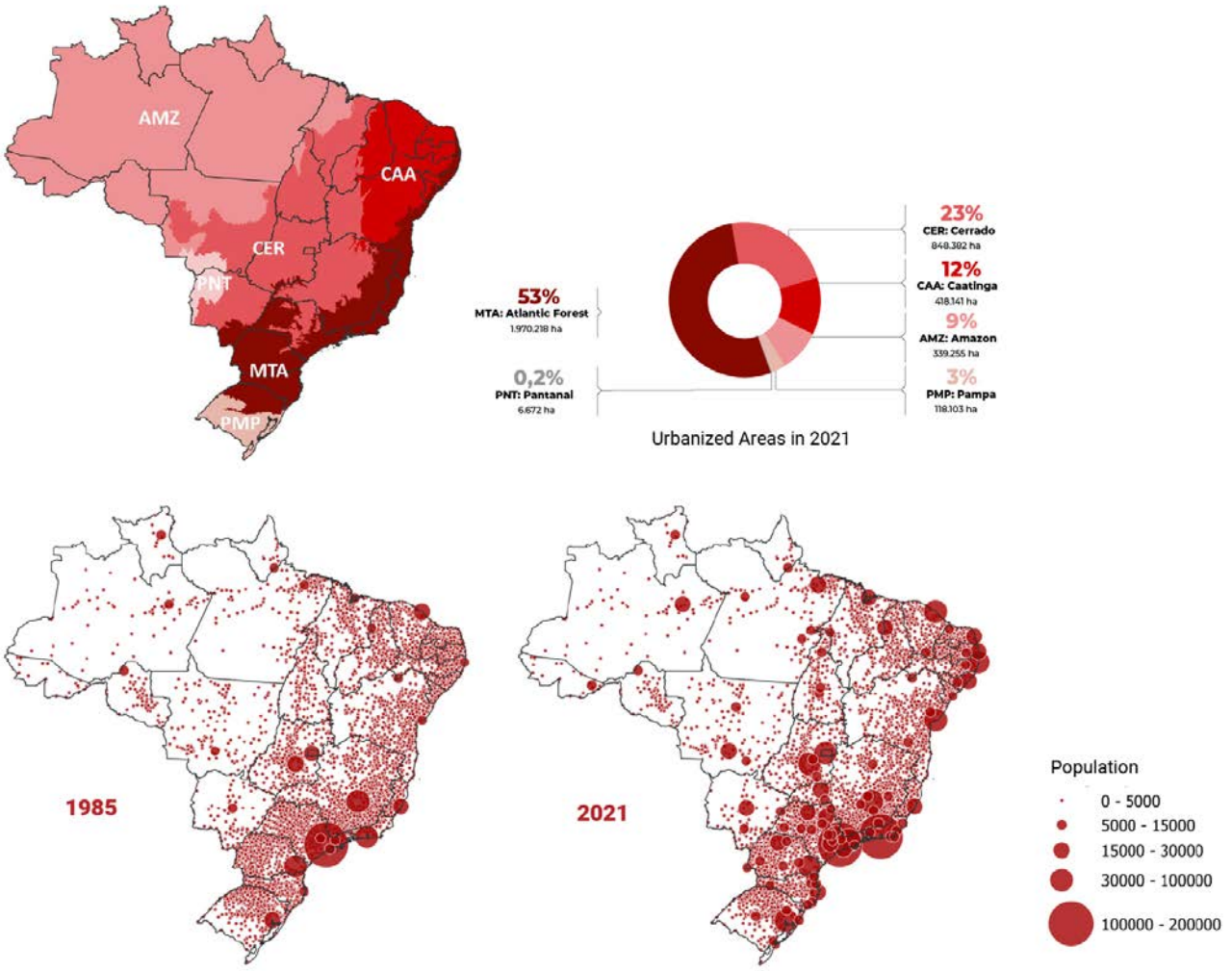
Fortunately, in 1988 the new Brazilian Constitution designated this biome as national heritage, and in 2006 the federal government adopted legislation protecting it. This legislation encourages municipalities fully or partially inside the biome to proactively protect, preserve, and restore native vegetation. It also established the creation of the Atlantic Forest Municipal Conservation and Recovery Plans (PMMAs) which, depending on the participating municipalities, and through both regulations and incentives, have preserved remnant habitat, expanded recovery zones, and mitigated growing pressures, including from climate change. The current guidelines call for these plans to align with local socioeconomic development strategies and territorial plans, along with existing governing bodies' capacities (Ribeiro et al. 2013).

Complementing this, the National System of Nature's Protected Areas (PAs) along with the ecological fiscal transfers mechanisms (ICMS Ecológico), facilitate the creation and management of such zones at all levels. Incentives for securing accreditation to the system have especially mobilized municipal governments. The PA designations are aligned with the Brazilian Forestry Code, and though compliance has been slowed by the lack of capacity and enforcement, PMMAs have partly helped overcome this lack (de Oliveira e Aguiar and Steinmetz, 2013). Alignment with existing local strategies and plans has been an additional enabler, guiding public and private actions for conservation even when political will at other spheres of government was lacking (Brazil, Ministério do Meio Ambiente, 2017).

Over one decade, 40% of coastal municipalities in the biome created PAs (128 in total) and 12% developed PMMAs. Promisingly, this increased the marine protection area from 1.5% to 26%. Now there is a public-private initiative to develop PMMAs in another 35 municipalities by 2023 (Steinmetz 2022). Building on previous lessons (de Oliveira e Aguiar and Steinmetz, 2013), this initiative groups municipalities to partner with non-governmental organizations and state government bodies to build capacity and reach out to the public. In any case, federal-level legislation at the biome scale is achieving cross-state and cross-municipal coordination that likely would not otherwise happen, providing a check against uncontrolled peri-urban expansion.

The federal government of Brazil has spatialized the challenges and opportunities within the Atlantic Forest biome and prompted vertical ('telescopic' as described above) coordination. These have had the knock-on effect of both regulating and incentivizing horizontal coordination between policymakers within the constituent states. In other words, the principles described in this paper are all evident in the biome. However, the lack of federal designation or protective legislation in neighbouring biomes is resulting in negative spillover effects.

Of particular interest is Cerrado, another global biodiversity hotspot that has been experiencing a rapid acceleration of human development in the last decades. (Mittermeier et al., 2005). Cerrado's groundwater supply is critical for water levels downstream, and rising levels of deforestation and land conversion have hindered the functioning of hydropower plants in states in the Atlantic Forest (Fellet, 2021). In this sense, policymakers have begun to anticipate change. In terms of the actions described in this paper, they have also begun to predict some of the spatial conflicts that may arise from that change. Short of expanded federal intervention, municipal governments in both biomes could strengthen and accelerate their spatial planning with the multidisciplinary mapping methodology presented in this paper. The prevention of zones of conflicting land use may constitute a particularly appealing medium incentive for governments that are experiencing intensified droughts, wildfire, and flooding first hand.



Urbanized Areas in the Brazilian Biomes

References:

Brasil Ministério do Meio Ambiente (2017). Roadmap for the Elaboration and Implementation of Municipal Conservation Plans and Recovery of the Atlantic Forest (Original: Roteiro Para a Elaboração e Implementação Dos Planos Municipais de Conservação e Recuperação Da Mata Atlântica). Brasília, DF: MMA. https://cms.sosma.org.br/wp-content/uploads/2021/01/roteiro-pmma-publicado.pdf. Mittermeier, Russell A., and others (2005). Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. Agrupacion Sierra Madre.

Fellet, João (2021). "Deforestation advances in the Cerrado and increases the risk of electric blackout in Brazil (Original: Desmatamento avança no Cerrado e faz crescer risco de apagão elétrico no Brasil)." British Broadcast Corporation, June 21, 2021. https://www.bbc.com/portuguese/brasil-57507268.

Fundação SOS Mata Atlântica (2021). "Áreas Protegidas e Municípios Costeiros Da Mata Atlântica (Protected Areas and Coastal Municipalities of the Atlantic Forest)." https://cms.sosma.org.br/wp-content/uploads/2021/11/SOS_A%CC%81reas_Protegidas-1.pdf.

de Oliveira e Aguiar, Alexandre de, and Sandra Steinmetz (2013). "Municipal Plans for the Conservation and Recovery of the Atlantic Forest: Lessons Learned in a Mobilization and Training Project (Original: Planos Municipais de Conservação e Recuperação Da Mata Atlântica: Lições Aprendidas Num Projeto de Mobilização e Capacitação)." In XXXVII EnANPAD. Rio de Janeiro, Brazil.

Ribeiro, Milton Cezar and others (2013). "Strategies for the Conservation of Biodiversity in the Atlantic Forest Incorporating Multiple Initiatives and Scales (Original: Estratégias Para a Conservação Da Biodiversidade Na Mata Atlântica Incorporando Múltiplas Iniciativas e Escalas)." In Mappings for Conservation and Recovery of Biodiversity in the Atlantic Forest: In Search of an Integrative Spatial Strategy to Guide Applied Actions (Original:Mapeamentos Para Conservação e Recuperação Da Biodiversidade Na Mata Atlântica: Em Busca de Uma Estratégia Espacial Integradora Para Orientar Ações Aplicadas), edited by A. A. Cunha and F. B. Guedes, 137–64. Brasília, DF: Ministério do Meio Ambiente (MMA), Secretaria de Biodiversidade e Florestas.

Steinmetz, Sandra (2022). "Planos da Mata." PMMA. February 12, 2022. https://pmma.etc.br/planos-da-mata/.

Annex 2: Catalogue of Prevention-Oriented Interventions

Number	Project	Location	Region	Status	Spatial scale	Time-fra (years)
1	Conversion of pine monocultures to mixed deciduous forests	Podyjí National Park, Czech Republic	E&J	Implemented	Regional	10
2	Nagoya Biodiversity Report	Nagoya, Japan	E&J	Implemented	City	10
3	Commitment to Biodiversity and Ecosystem Habitats	Zagreb, Croatia	E&J	Implemented	City & Regional	10
4	StEPKlima - The ecological utility of green spaces in the context of climate change	Berlin, Germany	E&J	Implemented	City	10
5	The London National Park city	London, UK	E&J	Proposed	City	10
6	Striving towards sustainable development through a mosaic of land use patches and corridors	Hangzhou, China	EAP	In-progress	City	20
7	Qunli National Urban Wetland	Qunli New Town, China	EAP	Implemented	City	2
8	EbA in Lami Town	Lami Town, Fiji	EAP	Implemented	Neighbourhood	2
9	Donghu Greenway	Wuhan, China	EAP	Implemented	City	3
10	Sinu river ecological corridor	Monteria, Colombia	LAC	Implemented	City	10
11	Action plan of the State of Sao Paulo	Sao Paolo, Brazil	LAC	Implemented	City	10
12	Sweet city program	Curridabat, Costa Rica	LAC	In-progress	City	10
13	Siuna Agroforestry	Siuna, Nicaragua	LAC	In-progress	Regional	10
14	Belmopan Blue-Green Master Plan	Belmopan, Belize	LAC	In-progress	City	10

me	Year	Implementing Agency	Tools and mechanisms	Regulation, design and finance		
	1992	Municipality/ Council	Classification of the biodiversity, repeated assessment of changes and economic evaluation of the conversion measures		●	●
	2008	NGO	Framework that helps researchers access genetic resources for biotechnology research, development and other activities, in return for a fair share of any benefits from their use. This provides the research & development sector with the certainty they need to invest in biodiversity-based research.	●		●
	2008	Municipality/Council	Research and inventory, monitoring, mainstreaming biodiversity within city policies, awareness building, participatory approach, financial support and incentives		●	●
	2011	Municipality/Council	Evidence based demonstration of the significance of existing urban biodiversity pockets for the improvement of climactic conditions		●	
	2019	Municipality/Council	Lateral coordination across local governments for a city-wide biodiversity management plan	●		
	2001	Municipality/Council	Using the green open system to support disaster prevention system for example flood control, protection against earthquake		●	
	2011	Municipality/Council	Landscape architecture used as a tool to address climate change risks. Preserved green area equipped to act as a green sponge, cleansing and storing urban stormwater and integrated with other ecosystem services including the protection of native habitats, aquifer recharge and recreational use		●	
	2013	NGO	Carried out cost-benefit analysis for climate change adaptation			●
	2016	NGO	Working at various scales effectively - setting strategic goals to achieve and extensive community engagement through an innovative participatory approach	●		
	2002	Municipality/ Council	Defining the spatial management and control scope of the river ecological corridor		●	
	2011	UN Agency	Incorporation of concepts of sustainability in other areas of the municipal public administration, considering that the actions related to the direct protection of biodiversity are still promoted, almost exclusively, by the environmental agency	●		
	2015	Municipality/Council	Mainstreaming conservation into urban planning, green spaces treated as infrastructure with accompanying ecosystem services that can be harnessed by local government and offered to residents	●	●	
	2017	NGO	Practice intercultural social responsibility with the indigenous communities neighboring preservation operation, through investment in the region's social capital			●
	2017	UN Agency	Recognizing biodiversity fragmentation and networking green space, vegetation restoration for flood resistance		●	

Number	Project	Location	Region	Status	Spatial scale	Time-fra (years)
15	Equity Park	Cancun, Mexico	LAC	In-progress	City	5
16	The mountain ecosystem of Chile's central Mediterranean region	Chile	LAC	Adopted	City	11
17	Natural Area Management Plan	Calgary, Canada	LRDC	Proposed	City	2
18	Watershed management	New York City, USA	LRDC	Implemented	Regional	10
19	LAB Biodiversity Action Plan	Waitakere, New Zealand	LRDC	Proposed	Regional	10
20	Collective Local Biodiversity Strategy	Bassendean, Australia	LRDC	Implemented	City	4
21	Sensitive Ecosystem Inventory (SEI), Sensitive Habitat Inventory and Mapping (SHIM)	Kelowna, Canada	LRDC	Implemented	City	3
22	Portland's Climate Action Plan, United States (US)	Portland, USA	LRDC	Implemented	City & Regional	10
23	Water Smart Parks: Efficiently irrigating parks and gardens - Water Smart Parks strategy	Stirling, Australia	LRDC	Implemented	City	2
24	The Najvan & Sofeh Parks Project in Isfahan, Iran	Isfahan, Iran	SCA	Implemented	Neighbourhood	10
25	Carbon Sequestration Potential of Trees in and around Pune City	Pune, India	SCA	Proposed	City	4
26	Anchunad UNDP Project	Kerala, India	SCA	Implemented	City	4
27	People's Biodiversity Register	Kerala, India	SCA	Implemented	City	2
28	Kochi LBSAP	Kerala, India	SCA	Adopted	City	5

me	Year	Implementing Agency	Tools and mechanisms	Regulation, design and finance		
	2020	NGO	Cross-sectoral lens applied to green space management - vegetation preservation and restoration for flood resistance		●	
	2020	Municipality/Council	Research to improve Biosystematic and biogeographic knowledge through several regional studies that evaluate patterns of alpha, beta, and gamma diversity in relation to environmental gradients.		●	
	1994	Municipality/Council	Developed natural environment assessment, inventory, classification of habitat types, natural systems, areas and parks, guidelines based on park type, category of natural park, habitat type		●	
	1997	Municipality/Council	Comprehensive watershed protection strategy, land conversion, land-use managament, monitoring, remediation		●	
	2008	NGO	Capacity building, research and monitoring, inventory of threatened species		●	
	2009	Municipality/Council	Increase the protection status of reserves , develop Local Planning Policy for biodiversity conservation	●	●	
	2010	NGO	Inventory for scientific information on ecosystem, inventory and tracking of creeks within city limits, identification, inventory and mapping of wetlands and their habitat features		●	
	2010	Municipality/Council	Land-use management through vulnerability assessment, monitoring and reporting framework for climate action plan		●	
	2010	NGO	Categorisation/zoning of parks and reserves - 'ecozones' or 'hydrozones', appropriate watering techniques, prioritising irrigation, integration with city's plan for central irrigation management system		●	
	1997	Municipality/Council	Successfully addresses the land use conflict on the city's fringe by curbing the often illegally built urban sprawl through the establishment of a green corridor that links the city with its periphery	●	●	
	2008	Municipality/Council	Assessment of standing biomass, carbon sequestration potential of trees, inventories of indigenous and exotic tree species		●	
	2018	UN Agency	Mainstreaming of ecology and biodiversity considerations in plantations management and tourism operation	●	●	
	2020	Municipality/Council	Community involvement through innovative participatory approach to evaluate economic benefits to community through local knowledge	●	●	
	2020	Municipality/Council	Developed scientifically informed and participatory LBSAP	●	●	

Number	Project	Location	Region	Status	Spatial scale	Time-fra (years)
29	East Kolkata Wetlands	Kerala, India	SCA	Adopted	City	5
30	Preserving mangrove on private land	Kerala, India	SCA	Implemented	City	3
31	Magat watershed	Nueva Vizcaya, Philippines	SEA	Implemented	Regional	10
32	Park development: Open spaces	Quezon City, Philippines	SEA	Implemented	Neighbourhood	7
33	Cheonggyecheon river restoration	Seoul, South Korea	SEA	Implemented	City	3
34	Mangrove conservation through partnership for multiple co-benefits	Surabaya, Indonesia	SEA	Implemented	City	10
35	Integrating Wetland Ecosystem Values into Urban Planning	Vientiane, Laos	SEA	Proposed	City	2
36	Urban Biodiversity towards Sustainable City and Climate Change Resilience project (UBD-SCCCR)	Chiang Rai, Thailand	SEA	Implemented	Regional	3
37	Urban development and biodiversity conservation in Trang - Klong Nam Jed Conservation (canal)	Trang, Thailand	SEA	Implemented	City	10
38	Community driven initiatives on urban biodiversity: Adopt-a-park, EcoWalk, Clean and Green program	Baguio, Philippines	SEA	Implemented	Neighbourhood	4
39	Durban's closed-loop landfill site	Durban, South Africa	SSA	Implemented	Regional	10
40	LAB Walvis Bay Biodiversity Report	Walvis Bay, Namibia	SSA	Proposed	Regional	3
41	Sustainable use of River and Riverbanks	Addis Ababa, Ethiopia	SSA	Implemented	City	4
42	An urban Biodiversity Network - The BioNet, 'Local Biodiversity Strategic Action Plan'	Cape Town, South Africa	SSA	Proposed	City	7

me	Year	Implementing Agency	Tools and mechanisms	Regulation, design and finance
	2021	Municipality/Council	Continous evaluation of wetand quality and including indigenous knowledge of the fish-farmers on management of wetlands	
	2021	Municipality/Council	Economic incentive to private landowners to preserve mangroves	
	1998	Municipality/ Council	Mobilisation of local government units for conservation efforts, initiatives to encourage private sector participation, capacity building, enabling policy and institutional support	
	2003	NGO	Park development program, network of open spaces, multi-stakeholder park management, rehabilitation of open space, ecological corridors, awareness building	
	2003	Municipality/Council	Removing manmade infrastructure to make room for ecological cooridor	
	2004	NGO	Multi-stakeholder approach, awareness building, empowerment program, special zoning for conservation, support eco-tourism and develop research facilities	
	2004	NGO	Economic assessment of goods and services, measurement of direct and indirect use values of wetland goods and services, measures for wetland and water resource management	
	2010	NGO	Integrated approach of developing the city in a sustainable way by conserving its natural areas while using them as a carbon sink; understand the role biodiversity plays in the community by collecting local knowledge	
	2010	NGO	Identifying cobenefits through sustainable tourism promotion, awareness building, capacity building, biodiversity assessment and data collection	
	2010	NGO	Advocacy, awareness building and capacity building participatory approach	
	1996	Municipality/Council	Environmental Impact Assessment, containment, treatment and reuse of leachate - geomembranes, constructed wetlands, protection and restoration of indigenous vegetation - on-site nursery, removal of alien plants, education and awareness building	
	2008	NGO	Developed Integrated Environmental Policy, Data Sharing Policy, Environmental Impact Assessment Guideline	
	2008	UN Agency	River restoration design, awareness building, capacity building, soil and water conservation structures	
	2009	Municipality/Council	Landscape-based approach, assessment, integration into policy and planning frameworks, promotion, awareness building and communication	

Number	Project	Location	Region	Status	Spatial scale	Time-fra (years)
43	Local Biodiversity Strategy and Action Plan	Johanessburg, South Africa	SSA	Proposed	City	6
44	Valuation of ecosystem services	Cape Town, South Africa	SSA	Implemented	City	4
45	Zambia Wetland preservation Efforts	Zambia	SSA	Adopted	Regional	5
46	Nairobi River Restoration Initiative	Nairobi, Kenya	SSA	Proposed	City	3
47	Policy, institutional and legal framework of UPFG (urban and peri-urban forestry and greening) in Yerevan	Yerevan, Armenia	WANA	Proposed	City	10
48	Oroklini Wetland Management	Larnaca, Cyprus	WANA	Implemented	Regional	3
49	Integrated Coastal Zone Management	Moulaya, Morocco	WANA	Adopted	Regional	10
50	Translocation of coral communities during land reclamation for urban developement	Jordan, EgyptTown, South Africa	WANA	Implemented	City	6

me	Year	Implementing Agency	Tools and mechanisms	Regulation, design and finance		
	2009	Municipality/Council	Assessment of urban ecological network, species conservation measures, awareness building, conducting education programs, coordinated governance systems and database creation	●	●	
	2011	NGO	Business case for increased budget allocations in natural assets, inventory and valuation of ecosystem goods and services, funding sources, knowledge dissemination			●
	2015	NGO	Marrying of public and business interests for the protection of groundwater in the collective stewardship of natural resources	●		
	2016	NGO	Incentives awarded aimed at mobilizing youth teams to take responsibility for managing biodiversity			●
	2006	UN Agency	Flexible but long-term policy planning, multi-level registers and policies, clarification of functions of management bodies and communities, cross-sectoral implementation, multi-level monitoring, UPFG guidelines, zoning, master plans, regulation on municipal forests, tree by-laws, park regulations, legal mechanisms for non-state stakeholder involvement, elimination of contradictions in acts, harmonisation of legal terminology	●		
	2012	Municipality/Council	Proper water management with small-scale measures to manage wetlands within urban areas for furthering nature conservation objectives such as wet grassland conditions for rare breeding birds; also offered minor flood protection.		●	
	2012	Municipality/Council	Capacity building to enable the undertaking of technical activities, creation of Three Specific permanent Coastal Commissions at provincial levels acquire the knowledge needed to become effective and to conduct regular bi-annual meetings. Six communal development plans (including one spatial plan) incorporating local ICZM activities are prepared and/or revised. Public education material is prepared and distributed for use in the project area		●	
	2012	UN Agency	Scientific assessment of the donor site (to define the coral priority species to be relocated) and the receiving sites (to verify suitable environmental conditions); and identifying cobenefits of recreational activities like diving in the Aqaba Special Economic Zone (ASEZA)	●		

UN HABITAT
FOR A BETTER URBAN FUTURE