土木工程拓展署
Civil Engineering and
Development Department

漁農自然護理署
Agriculture, Fisheries and
Conservation Department

Hong Kong Nature-based Solutions Design Guidelines

A Framework for Practitioners

First published, March 2026

Jointly Prepared and Published by:
Civil Engineering and Development Department
Agriculture, Fisheries and Conservation Department

Contents

Foreword

IUCN's 20-year Strategic Vision calls on the global community to unite for a just world that values and conserves nature. As we enter implementation of the IUCN Programme 2026–2029, our collective mandate is to catalyse transformative change at the critical nexus between biodiversity, climate, and sustainable development. Nature-based Solutions (NbS) are central to this ambition, providing an integrated pathway to strengthen ecosystem integrity, enhance societal resilience, and deliver measurable benefits for people, nature, and the economy.

I am therefore delighted to welcome the Hong Kong Nature-based Solutions Design Guidelines, jointly developed by the Civil Engineering and Development Department and the Agriculture, Fisheries and Conservation Department of the Hong Kong Special Administrative Region. This important initiative directly advances the global effort to mainstream biodiversity across infrastructure, planning, and urban development sectors.

By translating the IUCN Global Standard for Nature-based Solutions into practical, city-scale guidance for a high-density metropolitan context, Hong Kong is demonstrating forward-looking leadership in operationalising nature as essential infrastructure. The Guidelines illustrate how NbS can be embedded within policy, design, engineering, and investment decisions, strengthening urban resilience while enhancing biodiversity, ecosystem services, and quality of life.

Hong Kong is uniquely positioned to serve as a regional catalyst. Through these Guidelines, the city can help shape a new generation of nature-positive urban development across the Greater Bay Area and the wider Asia-Pacific region, mobilising sustainable finance, accelerating innovation, and ensuring that biodiversity enhancement becomes a core outcome of development rather than an external consideration.

It is our hope that this pioneering resource will inspire cities worldwide to translate global NbS principles into actionable practice, scale credible and high-integrity implementation, and contribute meaningfully to a nature-positive, climate-resilient, and sustainable future for all.

Charles KARANGWA
Global Head, Nature-based Solutions
Director, Nature-based Solution Management Hub
International Union for Conservation of Nature

Preface

Civil Engineering and Development Department

Hong Kong is striving towards its ambitious goals of becoming a world-class, sustainable, and resilient city. As we navigate the evolving challenges of climate change and rapid urbanization, the role of our infrastructure has never been more critical. The Civil Engineering and Development Department (CEDD) is at the forefront of this evolution, defining success not merely by concrete and steel, but by how seamlessly our projects integrate with the natural environment to protect and nurture our community.

Nature-based Solutions (NbS) are not entirely new to us. We have actively incorporated these elements into our past works, ranging from our soil erosion control planting programme on natural hill slopes that utilize vegetation for slope stability and our "urban mini-forests" pilot project in Fanling North New Development Area (NDA) that build functional habitats within urban pockets; to Long Valley Nature Park that demonstrates harmonious co-existence of nature and human activities and eco-shorelines in Tung Chung New Town Extension (East) that enhance coastal resilience and biodiversity at the same time. These projects have been selected for the International Union for Conservation of Nature (IUCN)'s review as NbS case studies in Hong Kong. These initiatives underscore our understanding that nature is not for the sole purpose of aesthetic appeal; rather, it is a functional, critical component of our infrastructure that delivers tangible ecosystem services.

With the extensive development planned for the NDAs and the Northern Metropolis, we have a tremendous potential to deploy these solutions systematically, weaving them into the very fabric of our urban planning from the ground up. To fully seize this opportunity, we have recognized a genuine need to transition from individual applications to a structured and systematic approach that enables clarity and consistency to all practitioners in the field. These Hong Kong Nature-based Solutions Design Guidelines serve as a pioneering milestone to fill this information gap. Tailor-made for Hong Kong's unique high-density urban context, it offers practical insights and localized case studies, ensuring that engineers, architects, landscape architects, and planners can mainstream these practices into their daily workflows.

This publication is the result of hand-in-hand collaboration with the Agriculture, Fisheries and Conservation Department (AFCD), and engagement with key stakeholders including the IUCN, academia, professional institutions, and green groups. It stands as one of the first comprehensive NbS design guidelines developed specifically for the Greater Bay Area and the wider Asian region, signaling Hong Kong's determination to lead by example in the realm of sustainable urban development.

Looking ahead, I see the launch of these Guidelines as just the beginning of our NbS journey. I encourage all stakeholders, both locally and internationally, to utilize NbS to their fullest potential, innovating to create a city that is safe, functional, and in harmony with nature. By understanding and harnessing these capabilities, we hope to meet our common goal of engineering not just infrastructure, but a sustainable future for generations, consolidating Hong Kong's position as an international infrastructure centre and a global leader in sustainable development.

FONG Hok Shing, Michael, JP
Director of Civil Engineering and Development

Preface

Agriculture, Fisheries and Conservation Department

As Hong Kong enters a defining era in its pursuit of sustainable development, together with the Civil Engineering and Development Department, we are pleased to present the Hong Kong Nature-based Solutions Design Guidelines (HKNbSDG). This publication consolidates knowledge and best practices tailored to Hong Kong's context, offering pathways both progressive and achievable to guide stakeholders in adopting nature-based solutions (NbS). It marks a critical step forward in the Government's commitment to enhancing quality of life for all residents and conserving biodiversity.

The release of this publication is particularly timely. The Hong Kong Biodiversity Strategy and Action Plan 2035 (BSAP), updated in December 2025, has established a clear target: to widely adopt NbS and upgrade blue-green spaces throughout the city by 2035. This represents a fundamental rethinking of how we plan, design, build, and inhabit our city. Indeed, by harnessing the power of healthy and diversified ecosystems, NbS is a promising and practical approach to addressing complex societal challenges.

Hong Kong, with its blend of diverse natural resources and dynamic urban landscape, stands in the best position to champion NbS. Years of strategic investment in blue-green infrastructure have created a solid foundation, while our city's convergence of professional talents, world-class research institutions, pioneering enterprises, and sophisticated financial markets creates an ecosystem capable of developing NbS that can serve as a model for cities worldwide.

We have already demonstrated our commitment through pioneering projects in Hong Kong's Northern Metropolis. At Long Valley, we have established the Long Valley Nature Park to achieve long-term wetland conservation while supporting farming, education, and green spaces for surrounding communities. Building on the experience gained, we are now advancing the Wetland Conservation Park at Sam Po Shue, integrating ecological enhancement with eco-tourism experiences and modernised aquaculture. These projects exemplify how NbS delivers multiple benefits simultaneously for different stakeholders.

The widespread adoption of NbS will yield profound benefits spanning environmental health, economic vitality, and social equity. These solutions work simultaneously across scales—improving our well-being, strengthening urban resilience, and creating opportunities for sustainable growth. Most fundamentally, they represent a revolutionary step of introducing nature as an essential element in infrastructure, which yields invaluable natural benefits to every neighbourhood. Realising this vision requires genuine partnership across all sectors, recognising NbS as opportunities for innovation, embracing transdisciplinary approaches, and call for action from government to citizens. The opportunity hinges on moving from parallel to integrated thinking, from compliance to commitment, from short-term constraints to long-term transformation.

On behalf of the Agriculture, Fisheries and Conservation Department, I extend my sincere appreciation to all who contributed to the publication of the HKNbSDG. Looking forward, I hold deep confidence in our city's capacity to harmonizing urban development with natural systems. Together, let us shape a future where ecological health and economic vitality are mutually reinforcing, where innovation serves sustainability, and where every citizen can experience nature as an integral part of life in Hong Kong.

LAI Kin-ming, Mickey, JP
Director of Agriculture, Fisheries and Conservation

Acknowledgements

We would like to express our sincere gratitude to the government bureau/departments, international organisation, NGOs, professional bodies, private sector representatives and academics for their valuable contributions and insights to this NbS Design Guidelines, including but not limited to and in alphabetical order:

Government Bureau/Departments

Northern Metropolis Co-ordination Office (NMCO) of Development Bureau
Drainage Services Department (DSD)
Environmental Protection Department (EPD)
Lands Department (LandsD)
Leisure and Cultural Services Department (LCSD)
Planning Department (PlanD)
Water Supplies Department (WSD)

International Organisation

International Union for Conservation of Nature (IUCN)

NGOs

Civic Exchange
Hong Kong Wetlands Conservation Association (HKWCA)
Hong Kong Green Building Council (HKGBC)
Kadoorie Farm and Botanic Garden (KFBG)
The Nature Conservancy (TNC)
World Wide Fund for Nature Hong Kong (WWF HK)

Professional Organisations

Hong Kong Institute of Environmental Impact Assessment (HKIEIA)
Hong Kong Institute of Qualified Environmental Professionals (HKIQEP)
Hong Kong Institute of Urban Design (HKIUD)
The Hong Kong Institute of Architects (HKIA)
The Hong Kong Institution of Engineers (HKIE)
The Hong Kong Institute of Landscape Architects (HKILA)

Private Sector Representative(s)

The Real Estate Developers Association of Hong Kong (REDA)

Academics

Prof. Kenneth M. Y. LEUNG, City University of Hong Kong
Ms. Mengru LI, Hong Kong University of Science and Technology
Dr. Zhongming LU, Hong Kong University of Science and Technology
Dr. Majid NAZEER, The Hong Kong Polytechnic University
Prof. Yuhong WANG, The Hong Kong Polytechnic University
Sr Prof. Charles Man Sing WONG, The Hong Kong Polytechnic University

We also extend our appreciation to the appointed consultant, **AECOM – Halcrow Joint Venture,** for their professional input and effort. Their expertise has been instrumental in shaping the content and structure of this NbS Design Guidelines.

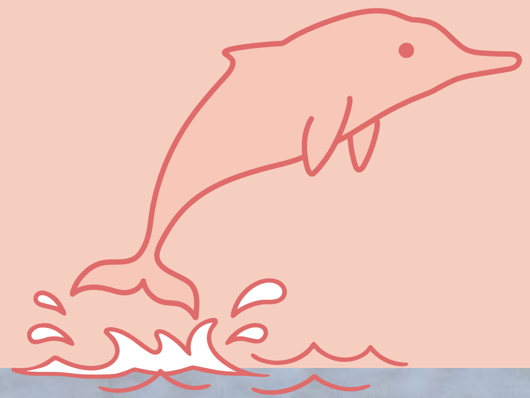
1. Introduction

1.1 Background

The climate crisis and biodiversity loss are two of the biggest global threats we are facing today. Moreover, these two issues are related: rising global temperatures and the associated impacts of the climate crisis are threatening biodiversity resources and the stability of ecosystems. As ecosystems are increasingly affected by the changing climate, their ability to sequester carbon and provide resilience is also under pressure. This will in turn weaken the planet's climate regulation, leading to even greater instability, further accelerating the climate crisis and hindering our planet's ability to regulate temperature.

The Kunming-Montreal Global Biodiversity Framework (GBF), agreed by 196 Parties to the Convention on Biological Diversity in 2022 during the COP15 meeting, sets out an ambitious pathway to reach the global vision of a world living in harmony with nature by 2050. Target 8 of the GBF creates direct linkages between climate action and biodiversity conservation through a multi-faceted approach, including using **nature and ecosystem-based approaches** to help address the climate crisis through mitigation, adaptation, and disaster risk reduction actions; as well as contribute to other societal needs such as regulation of air, water and climate, soil health, pollination and reduction of disease risk (UNEP, 2022).

Locally, while highly urbanised, Hong Kong sustains rich biodiversity, with 40% of its land protected as country parks and special areas. In addition, urban habitats are important in maintaining overall biodiversity as well as habitat connectivity, and should not be overlooked. As a coastal city in a sub-tropical and typhoon-prone area, Hong Kong's coastal and low-lying areas are prone to flooding and require greater coastal resilience. Climate change is intensifying the frequency and severity of extreme weather events. Hong Kong is also facing increasingly severe hot weather episodes as a consequence of urban heat island effect and climate change. Implementing Nature-based Solutions (NbS) across different environments in Hong Kong can help manage the climate crisis and contribute to biodiversity conservation. Moreover, NbS bring other benefits, such as improved air quality, food security, job creation and enhanced urban environments. In this way, multiple societal challenges can be addressed with simple ecosystem interventions.



Despite growing global recognition of NbS, Hong Kong currently lacks a dedicated, comprehensive set of design guidelines tailored to its unique urban and ecological context. To bridge this gap and support the mainstreaming of NbS in public works and infrastructure projects, the Civil Engineering and Development Department (CEDD) and the Agriculture, Fisheries and Conservation Department (AFCD) have jointly developed this NbS Design Guidelines (hereafter referred to as HKNbSDG). It provides a localised, context-sensitive framework for designing NbS for implementation in Hong Kong's urban and natural environments.

We aim to inspire and empower government departments, planners, engineers, landscape architects, and other stakeholders to adopt NbS, supporting Hong Kong's transition towards a more sustainable, climate-resilient, and nature-positive future.

> **"Provides a localised, context-sensitive framework for designing and implementing NbS"**

1.2 Nature-based Solutions

> **IUCN (2016) defines NbS as "...actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits""**

In this context, NbS is an umbrella concept covering a wide range of ecosystem interventions of different scales (i.e. from watershed reforestation projects to parks in urban areas), contexts (i.e. from natural woodlands to urban streetscapes) and types (i.e. from green building design to river restoration). NbS in development projects and built environments, as well as protection and sustainable management of more natural and rural landscapes or in the coastal and marine environments.

While addressing the climate crisis and biodiversity loss are key focuses for NbS, they can address a much wider range of societal issues through the provision of multiple ecosystem services. This is reflected in the IUCN (2016) definition of the overarching objective of NbS: "to support the achievement of society's development goals and safeguard human well-being in ways that reflect cultural and societal values and enhance the resilience of ecosystems, their capacity for renewal and the provision of services; NbS are designed to address major societal challenges, such as food security, climate change, water security, human health, disaster risk, social and economic development". Based on this definition, seven major societal challenges to be addressed by NbS were further established under the IUCN Global Standard for Nature-based Solutions (IUCN, 2020), including climate

> **While addressing the climate crisis and biodiversity loss are key focuses for NbS, they can address a much wider range of societal issues through the provision of multiple ecosystem services"**

Climate change mitigation and adaptation | Disaster risk reduction | Economic and social development | Human health | Food security | Water security | Environmental degradation and biodiversity loss

Source: IUCN (2020). Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS. First edition. Gland, Switzerland: IUCN. https://doi.org/10.2305/IUCN.CH.2020.08.en

change mitigation and adaptation, disaster risk reduction, economic and social development, human health, food security, water security and environmental degradation and biodiversity loss.

Many aspects of NbS planning, design and management are derived from more traditional approaches to ecosystem stewardship; such as biodiversity conservation, watershed management, and blue-green infrastructure planning. However, NbS differ from these more traditional approaches in several ways (IUCN, 2016; IUCN, 2020), such as:

- NbS must identify and address one or multiple societal challenges;
- NbS can be implemented in various contexts, from natural ecosystems to full integration with built environments;
- NbS are determined by site-specific natural and cultural contexts that capture traditional, local and scientific knowledge;
- NbS maximise the long-term production of multiple ecosystem services that deliver the broadest societal benefits;
- NbS should be mainstreamed into the overall design of plans and policies.

There are three main types of conservation actions that can be used (either alone or in combination) to address societal challenges - protection, restoration and restorative activities, and sustainable use. While addressing societal challenges, NbS should also deliver ecological benefits and a net positive impact on biodiversity. This can be achieved through the conservation, maintenance, and enhancement of biodiversity, and avoid further simplifying of ecosystems.

Functioning ecosystems provide essential processes and services that underpin the success of NbS. Maintaining functioning ecosystems will ensure that NbS can effectively deliver the intended objectives.

1.3 Purpose of the HKNbSDG

The HKNbSDG demonstrates how NbS global principles and best practices can be applied in a local context, incorporating geographical, environmental, cultural and socio-economic considerations.

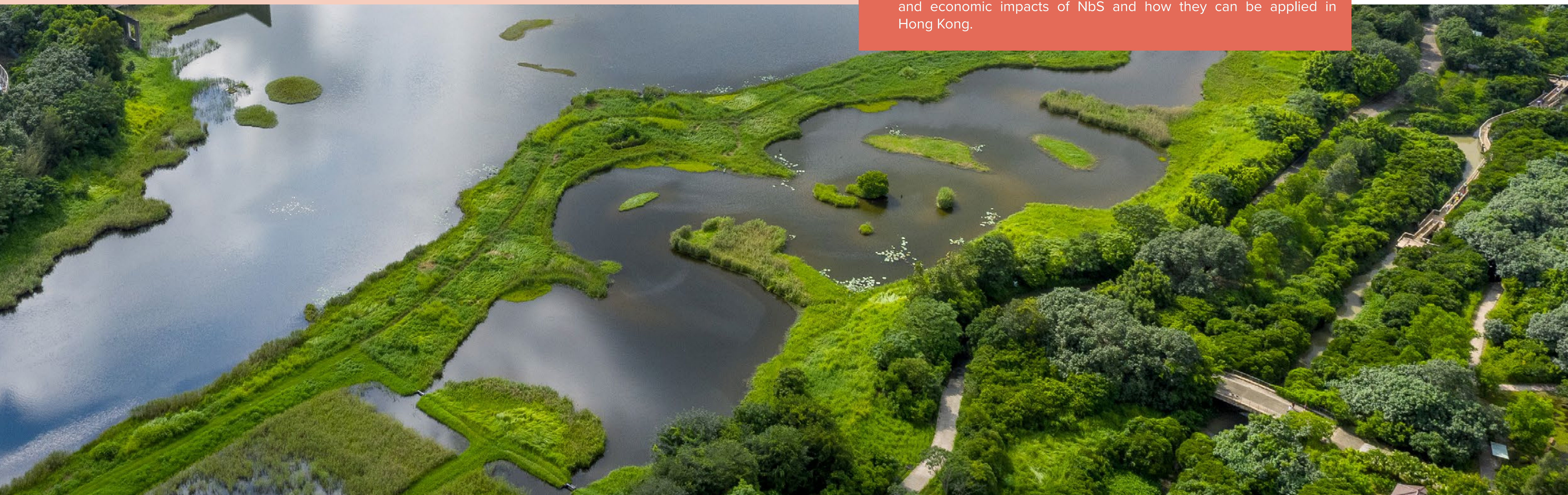
Key objectives of the HKNbSDG include:

- Illustrating the biodiversity enhancement and societal benefits that NbS can provide;
- Identifying the key design characteristics of NbS that help to deliver biodiversity enhancement and societal benefits; and
- Guiding users in the application of key design principles in a local context.

As NbS projects require input from numerous stakeholders and technical experts in different fields, the HKNbSDG aims to provide accessible background information on NbS design, and demonstrate how different types of NbS can be used to address key societal challenges in Hong Kong, benefitting both humans and biodiversity.

The HKNbSDG is intended for:

- **Government staff and associated professionals** involved in planning, infrastructure development, urban renewal, environmental management, and nature conservation.
- **Private developers** involved in the design and construction of residential, commercial and other types of development in Hong Kong.
- **Researchers and scientists** working in NbS and related disciplines can refer to the HKNbSDG to understand more practical aspects of NbS design and implementation in a local context.
- **Non-governmental organisations and members of the public** who are interested in understanding the environmental, social, and economic impacts of NbS and how they can be applied in Hong Kong.



1.4 Review of International and Local Publications

Numerous international NbS guidelines and publications as well as some existing local publications serve as useful references in developing this Hong Kong specific NbS guidelines. A review of these documents was conducted to identify those of most relevance to Hong Kong. From the long-list, 16 guidelines were selected for more detailed review:

Global

- IUCN Global Standard for Nature-based Solutions (IUCN, 2020)
- A Catalogue for Nature-based Solutions for Urban Resilience (World Bank, 2021)
- A Playbook for Nature-positive Infrastructure Development (AECOM & Camphora, 2024)
- ThinkNature Nature-based Solutions Handbook (Somarakis et al., 2019)
- Active, Beautiful, Clean Waters Design Guidelines (PUB, 2024)

National

- Towards Nature-based Solutions at scale - 10 case studies from China (Luo et al., 2023)
- Technical Guide for Ecological Design of Sea Dike (Chinese Hydraulic Engineering Society, n.d.)
- Technical Guidelines for Marine Ecological Restoration (Third Institute of Oceanography, Ministry of Natural Resources, Island Research Center, Ministry of Natural Resources, Second Institute of Oceanography, Ministry of Natural Resources, Ocean University of China, 2021)
- Technical Guideline for the Evaluation of Ecological and Environmental Impact of Human Activities within the Ecological Conservation Redline (Ministry of Ecology and Environment, n.d.a)
- Code for the Evaluation of Territorial Ecological Restoration Plan Implementation (Beijing Municipal Administration for Market Regulation, n.d.)
- Technical Guidelines for Eco-environmental Performance Assessment of Ecological Conservation and restoration projects (on trial) (Ministry of Ecology and Environment, n.d.b)
- Masterplan for Conservation and Restoration of Nationally Important Ecosystems (2021-2035) (National Development and Reform Commission Ministry of Natural Resources, 2020)

Local

- Adopting Nature-based Solutions for a better Hong Kong (WWF Hong Kong, 2024)
- Drainage Services Department Practice Note No. 3/2021 Guidelines on Design for Revitalisation of River Channel (DSD, 2021)
- Drainage Services Department Practice Note No. 3/2022 Guidelines on Bioretention System (DSD, 2022a)
- Drainage Services Department Practice Note No. 4/2022 Guidelines on Water Harvesting (DSD, 2022b)

The review uncovered common elements of effective NbS design, and highlighted the need for NbS design to be tailored for specific localities and environments. Key findings included:

Global Standard / Principles: The IUCN Global Standard is the most commonly adopted definition of NbS. Design principles like considering benefits of NbS, design of NbS informed by scale, balancing trade-offs between primary goal(s) and co-benefits, adaptive management, adopting an integrated system approach for better resilience, considering multiple designs, and taking into account the dynamic nature of ecosystem functions are highly relevant to Hong Kong context.

Local Context: Understanding Hong Kong's unique environment (i.e. a sub-tropical, highly urbanised coastal setting), the relationship of NbS to relevant local legislation and engineering standards, as well as urban design considerations, are important factors in the development of local guidelines.

Site Assessment and Compliance: Detailed site assessments should be conducted in the project planning stage to obtain a full picture of the site condition. The need for compliance of NbS with existing laws and regulations of Hong Kong should be emphasised.

Stakeholder Engagement: Presenting the range of benefits delivered by NbS can facilitate stakeholder understanding and support for NbS Projects, and inform the design of NbS to maximise its function. The emphasis of multiple and multi-scale benefits, as well as discussion of benefits from nature and society perspectives which cover biodiversity, carbon, resilience, social, economic and environmental benefits are highly relevant to Hong Kong.

These findings, along with consultations with stakeholders and academic experts, served as a basis for developing design guidelines tailored for Hong Kong.

1.5 Positioning of the HKNbSDG

The HKNbSDG assists users in improving the planning and design of NbS projects, particularly in works projects and new development areas. While users are encouraged to adopt as many of the proposed Design Guidelines as appropriate, it should be noted that these Design Guidelines do not serve as criteria for assessing whether a project qualifies as an NbS. Furthermore, key elements of NbS outside of the planning and design process (e.g. funding and economics, management and mainstreaming, and stakeholder engagement) are not covered in this edition. Advice on these aspects will be considered in subsequent versions.

To help readers better understand how NbS can be applied in Hong Kong, the HKNbSDG showcases NbS examples across different environments where nature conservation or landscaping works are typically undertaken, as shown in **Figure 1**. These include:

1. **Countryside and Rural Environments** – refers to more natural terrestrial habitats/landscapes.
    - Examples of NbS: woodland protection, reforestation, wetland restoration and creation.
2. **Rivers and Drainage Systems** – refers to natural and man-made watercourses.
    - Examples of NbS: revitalisation of drainage channels, sustainable urban drainage systems (SuDS) and riparian buffers.
3. **Marine Environments and Coastlines** – refers to marine and intertidal habitats/landscapes.
    - Examples of NbS: mangrove and coral restoration, eco-shorelines and artificial reefs.
4. **Man-made and Natural Terrains** – refers to slopes, retaining walls and natural terrain mitigation measures formed by human activities and natural ground, respectively.
    - Example of NbS: bioengineering and slope greening with native plants.

> **“The document is intended to assist users in improving the planning and design of NbS projects”**

5. **Urban Open Spaces** – refers to parks and open spaces within urban settings, as well as spaces around built structures.
    - Examples of NbS: biodiversity-friendly urban parks and urban farming.
6. **Built Environments** – refers specifically to buildings.
    - Examples of NbS: blue-green infrastructure, green roofs, wildlife gardens.

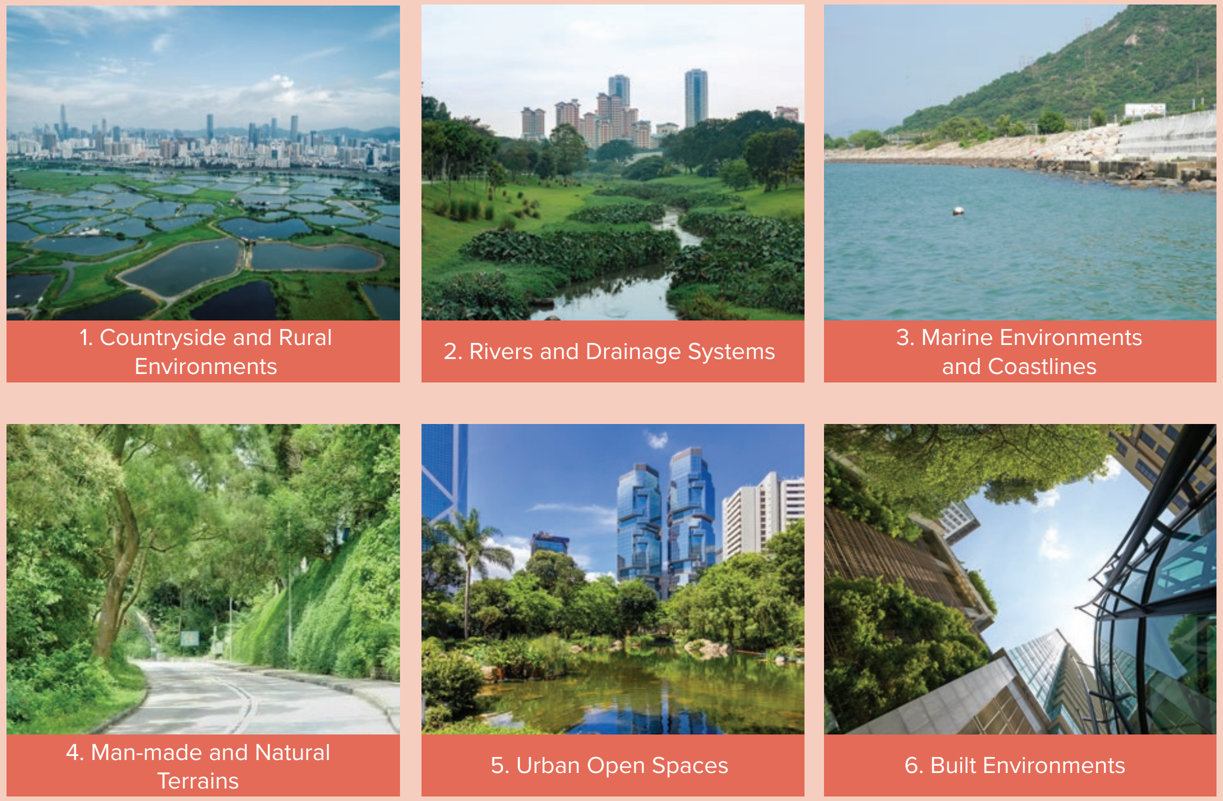


Figure 1 | Typical Environmental Types in Hong Kong

Guidelines, practice notes and other standards are already in place for the design of these environments. The Design Guidelines do not replace or supersede these existing materials, but rather provide a complementary reference for NbS best practices tailored to Hong Kong. These Design Guidelines can serve as a reference for environmental impact assessments, where NbS design may contribute to effective mitigation strategies to minimise environmental impacts of project. They are also relevant to green building schemes such as BEAM Plus, where the Design Guidelines may support planning and design works to attain credits under assessment aspects such as “Sustainable Site/Site Aspects” or “Innovations and Additions”.

1.6 Overview and How to Use the HKNbSDG

Rooted in science and best practices, this HKNbSDG presents nine Design Guidelines across three Core Principles, establishing a strong foundation for NbS Design. They advocate for a design approach that nurtures biodiversity, creates a harmonious coexistence between people and nature, and promotes resilience and sustainability.

Figure 2 | NbS Core Principles and Design Guidelines

Core Principle I: Promoting Ecosystem Diversity at Multiple Scales

Guideline 1: Enhancing Habitat and Spatial Diversity at Macro Scale

Guideline 2: Diversifying Habitat Components at Intermediate Scale

Guideline 3: Creating Complex Micro-habitats

Core Principle II: Embracing Human-Nature Coexistence for Mutual Benefits

Guideline 4: Addressing Societal Challenges through Nature-based Solutions

Guideline 5: Designing Human-Nature Composition in Context

Guideline 6: Harmonising Urban-Nature Transitions

Core Principle III: Improving Resilience through Nature-based Solutions

Guideline 7: Addressing Climate Challenges

Guideline 8: Building Ecological Resilience

Guideline 9: Promoting Socio-economic Sustainability

The nine Design Guidelines are relevant to various types of NbS across Hong Kong's different landscapes and environments. Practitioners are encouraged to adapt and follow the Design Guidelines that are relevant to their specific projects; however, it should be noted that not all Design Guidelines may be applicable in every instance, depending on site constraints and project objectives.

The Project Development Lifecycle

The Project Development Lifecycle Flowchart (Figure 3) below illustrates how each of the nine Design Guidelines can be applied through a typical project development cycle in Hong Kong. A detailed description of the Core Principles and Design Guidelines is provided in Chapter 2. Additionally, to help readers understand their application in the local context, several case studies of local projects that demonstrate these principles and guidelines in action are presented in Appendix A.

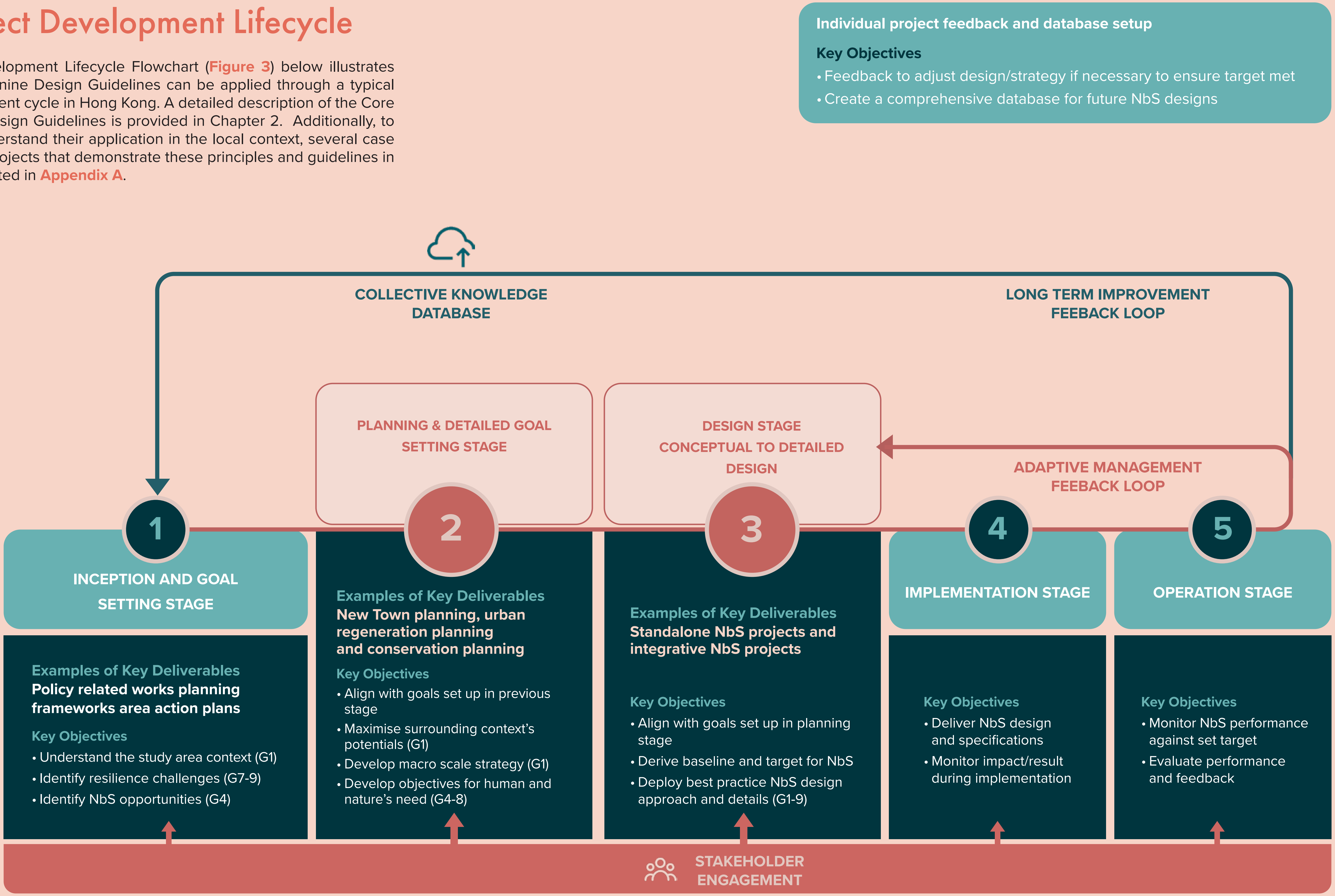


Figure 3 | Project Development Lifecycle Flowchart

2. The NbS Design Guidelines

2.1 Core Principles

Core Principle I:
Promoting Ecosystem Diversity at Multiple Scales
Guideline 1: Enhancing Habitat and Spatial Diversity at Macro Scale
Guideline 2: Diversifying Habitat Components at Intermediate Scale
Guideline 3: Creating Complex Micro-habitats

Core Principle II:
Embracing Human-Nature Coexistence for Mutual Benefits
Guideline 4: Addressing Societal Challenges through Nature-based Solutions
Guideline 5: Designing Human-Nature Composition in Context
Guideline 6: Harmonising Urban-Nature Transitions

Core Principle III:
Improving Resilience through Nature-based Solutions
Guideline 7: Addressing Climate Challenges
Guideline 8: Building Ecological Resilience
Guideline 9: Promoting Socio-economic Sustainability

2.2 Mock-up designs

2.1 CorePrinciples

Core Principle I:

Promoting Ecosystem Diversity at Multiple Scales

Structural diversity refers to the variety and complexity of physical features in the environment. Landscapes with greater physical complexity typically support more diverse ecological communities, as they offer a wider range of niches and microhabitats for different species (Kovalenko et al., 2012). Structurally diverse ecosystems can also be more stable and resilient to disturbance when compared to simpler ecosystems (Graham & Nash, 2013). Core Principle 1 therefore promotes structural diversity as a foundation for NbS design. This in turn will promote biodiversity, which ultimately translates into the ecosystem services provided by the NbS.

To fully leverage the potential of ecosystems to address societal challenges, Principle I considers structural diversity at different scales, providing a comprehensive framework for holistic ecosystem design. **Guideline 1** addresses complexity at the macro scale of habitats and landscapes; **Guideline 2** explores the diversity of components that make up a functioning ecosystem; and **Guideline 3** examines how surface treatments and small scale interventions can promote structural diversity at the micro scale.

Guideline 1 Enhancing Habitat and Spatial Diversity at Macro Scale

Guideline 2 Diversifying Habitat Components at Intermediate Scale

Guideline 3 Creating Complex Micro-habitats

Figure 4 | Core Principle I: Promoting Ecosystem Diversity at Multiple Scales

Guideline 1

Enhancing Habitat and Spatial Diversity at Macro Scale

At a macro scale, a fundamental step in designing NbS is to understand the larger contextual setting in which the solution is placed, such that smaller scale planning and design can better suit the local environment. This understanding encompasses two principal dimensions: the physical and biological environments of the project site and its surroundings.

At this scale, the physical environment refers to the underlying topography, geology, climate and hydrology of a site. The biological environment refers to the type and diversity of different habitats in the landscape (as shown in Figure 6), and the attributes of these habitats such as distinctiveness, diversity, rarity, and re-creatability.

> "Understand the physical and biological environments of the project site and its surroundings"

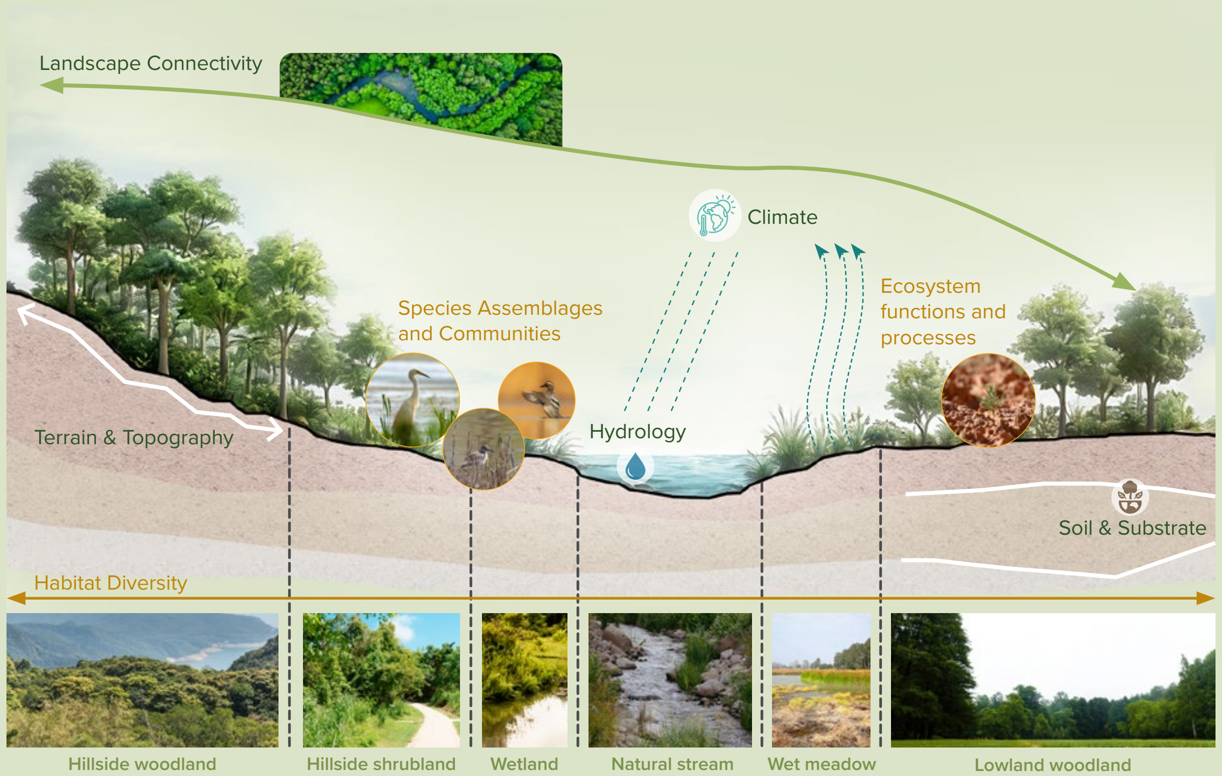


Figure 5 | Physical and Biological Environments

Figure 6 | Typical Habitat Types in Hong Kong Context

In macro-scale planning and design, increasing structural diversity can be achieved by promoting **habitat diversity (biological environment)** and **spatial arrangement diversity (physical environment)**. Apart from creating new habitats, NbS design should also incorporate **existing high-value natural habitats and features** (e.g. patches of woodland or wetland) through preservation, restoration and/or sustainable management. The design and planning of habitats at this scale should ensure adequate space is allowed for all habitats to maintain ecosystem functions.

The planning of NbS at a larger scale should also aim to enhance **ecological connectivity**. In urban environments, the movement of living organisms across a landscape is often inhibited by physical barriers created by development, especially transportation infrastructure (i.e. roads and railways). At a larger scale, linear NbS such as watercourses can serve as corridors linking habitat patches. At a smaller scale, connectivity can be improved by providing **tree corridors** and suitable **wildlife crossings** such as tunnels and bridges to traverse roads and railways.

Figure 7 shows the array of habitat types along a natural shoreline, illustrating how the changes in the physical environment can promote habitat diversity. **Figures 8 and 9** demonstrate how similar principles can be adopted when designing NbS, enhancing ecological performance, while also improving aesthetics and creating opportunities for recreational activities.

Figure 7 | Examples of Habitat Types along a Natural Shoreline

Poor

- Rigid layout and alignment
- Vertical banks
- Hard banks and beds
- Lack in habitat creation opportunity

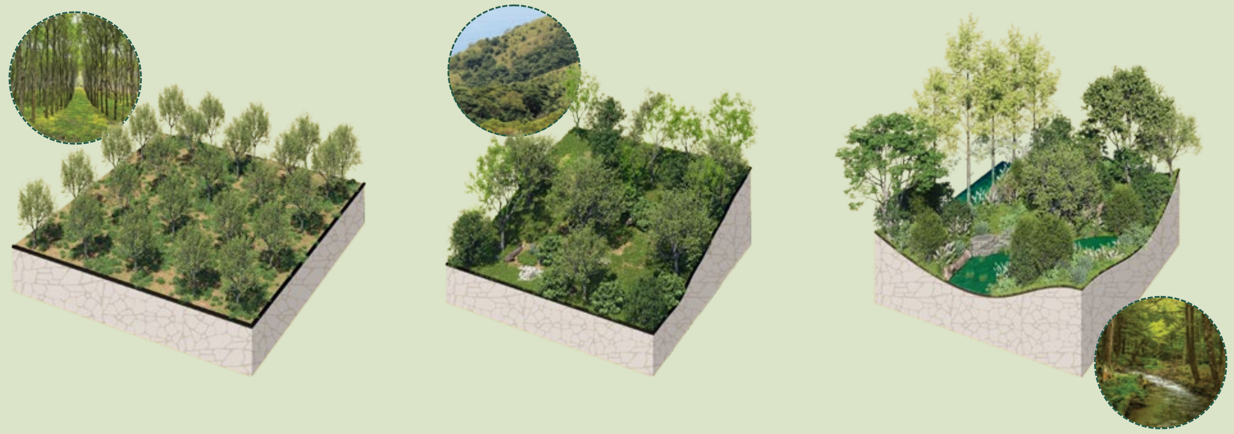
Better

- Natural layout and alignment
- Sloped banks
- Soft banks and beds
- Habitat creation opportunities at banks and beds

Preferred

- Natural layout and alignment
- Varying sloped banks
- Soft banks and beds
- Maximised habitat creation opportunities at banks and bed

Figure 8 | Example of Macro Spatial Configuration Comparison - Watercourse



Poor

- Rigid and gridded layout
- Mundane terrain
- Limited habitat variation
- Limited variation in plant sizes
- Limited range of species

Better

- Natural layout
- Variation in topography
- More habitat variation
- Variation in plant sizes
- More range of native species

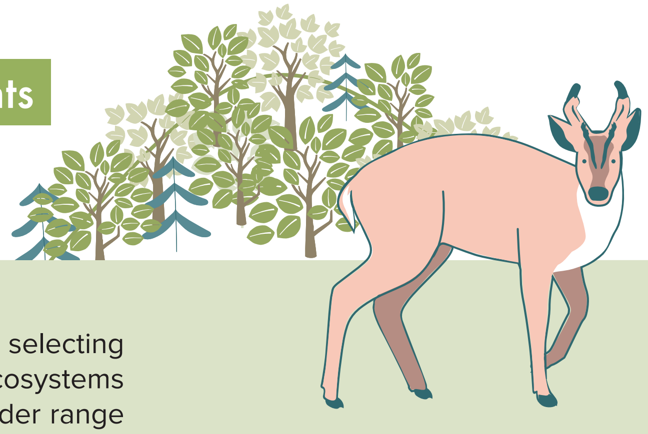
Preferred

- Natural and 3-dimensional layout
- High variation in topography
- Maximising habitat variation
- Maximising variation in plant sizes
- Maximising range of native species

Figure 9 | Example of Macro Spatial Configuration Comparison - Terrestrial

Guideline 2

Diversifying Habitat Components at Intermediate Scale



Guideline 2 underscores the importance of selecting individual components within habitats and ecosystems to enhance structural diversity, supporting a wider range of biodiversity and ecological functions. These habitat components can be in diverse forms and characteristics, sourced either directly from nature, reconfigured from natural resources, or introduced through man-made interventions that replicate natural elements, as illustrated in **Figure 10**.

Figure 10 | Examples of Habitat Components at Meso Scale

The composition, whether entirely natural, predominantly natural with some man-made components, or mostly man-made but designed to mimic natural environments, should be tailored to project objectives, constraints and requirements.

NbS practitioners are encouraged to select habitat components with appropriate physical and biological characteristics for an NbS project, to align with the key project objectives. **Diversifying the habitat components** is key to enriching composition at this scale, thereby enhancing the overall structural diversity of ecosystems. For NbS that involves vegetation planting and restoration, **native species should be used** as they are better adapted to local environmental conditions and more suited for local wildlife.

An exemplary case is the adoption of bio-blocks at the Tung Chung East (TCE) Eco-shoreline, alongside mangrove planting and oyster baskets. It showcases how man-made interventions can mimic the ecological functions of a natural rocky shoreline while serving as an essential component in coastal defence.

“Select habitat components for supporting a functioning ecosystem”

This concept is further illustrated in **Figure 11**, which shows a water edge design that draws on a diverse range of habitat components. Key features of this design include:

1 **Varied water depth** fosters **diverse habitat conditions** for a range of wildlife species.

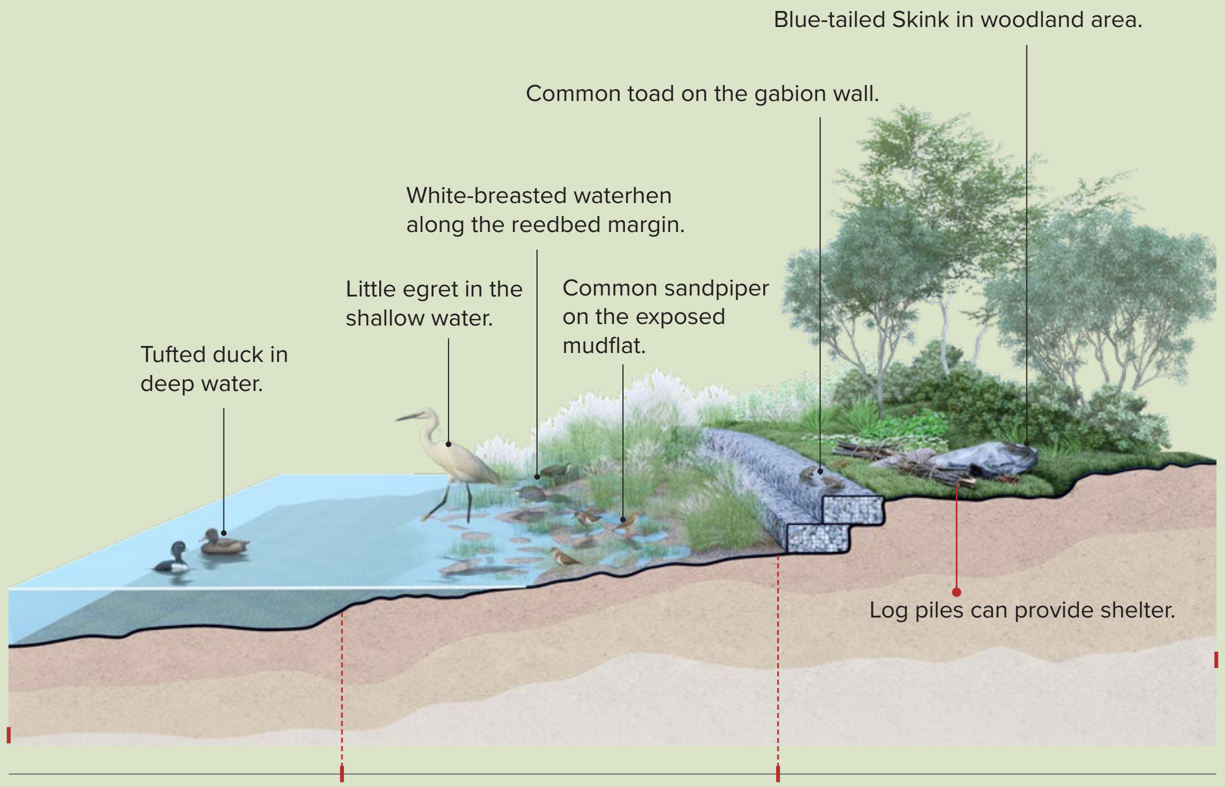
2 The interface between freshwater and terrestrial habitats is characterised by a **diverse array of planted species**, promoting biodiversity and enhancing landscape aesthetics.

3 Man-made interventions, like gabion walls, offer structural support as well as contributing to ecological enhancement, exemplifying their multi-functional role in engineering, aesthetics, and ecological aspects when integrated with thoughtful planting design. To enhance the effectiveness of gabion units, the units should incorporate planting recesses that can be filled with appropriate materials and maintained regularly.

4 The combination of natural slopes and gabion walls represents an effective engineering strategy for embankment design, particularly conducive to promoting water-friendly environments in urban settings.

Smaller elements of the habitat such as logs, branches, and rocks serve a dual purpose by fulfilling both engineering and ecological functions at a smaller scale, a concept that will be further elaborated in Guideline 3.

> **“Water edge design draws on a diverse range of habitat components”**



Deep water provides suitable foraging habitat for diving waterbirds, as well as a stable environment for aquatic organisms.

Shallow water margins support a mixture of open areas and emergent vegetation for diverse communities of fish and invertebrates.

Man-made interventions combined with strategic planting design, can enhance structural stability and resilience while providing a habitat for wildlife.

Figure 11 | Example of Water Edge Landscape Elements Contributing to Composition Richness

Guideline 3

Creating Complex Micro-habitats

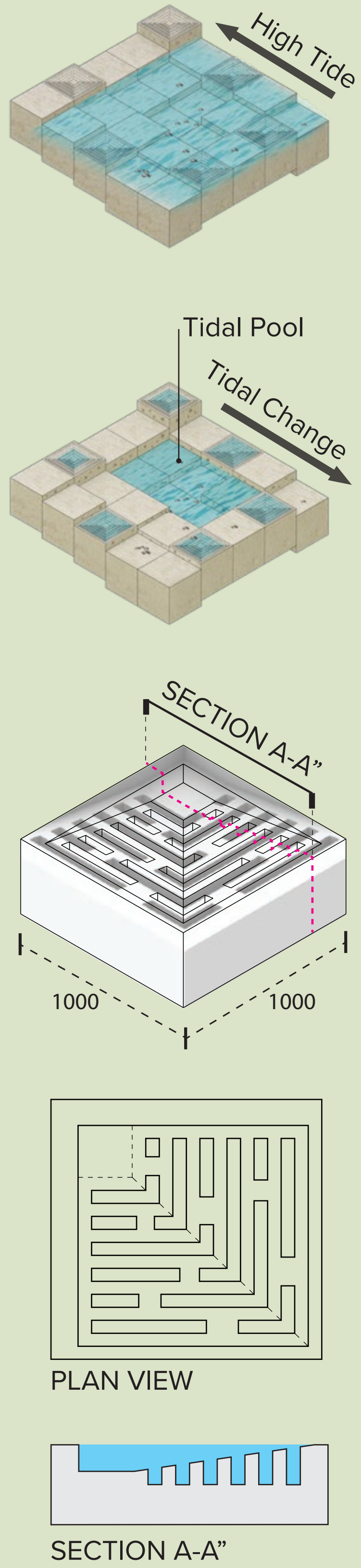
Structural complexity at a micro-scale, such as intricate textures, crevices and finishes, creates habitats that provide shelter and refuge for smaller organisms. Examples from the natural world provide valuable insights into how biodiversity flourishes in diverse microenvironments. The surfaces of tree bark, the eroded textures of rocky shorelines, and the root systems of aquatic plants as shown in **Figure 12** serve as excellent examples of structural complexity at this micro scale. Furthermore, the preservation of existing healthy top soil during construction should be prioritised, as it provides organic matter and supports native microorganism communities that are vital for ecosystem health.

Surface texture of tree barks

Natural rock surface texture at rocky shoreline

Root system of aquatic plants

Figure 12 | Examples from Nature – Complex Spatial Structures at Micro Scale



Applying through design: The design of NbS should consider how complexity can also be incorporated at this scale with reference to the solution objectives. This can be achieved through the incorporation of natural materials, as well as artificial elements such as bio-blocks, artificial reefs, and riverbed design with complex and diverse substrates. Specific artificial enhancement features like nest boxes and bat boxes (mimicking natural cavities in trees and sandbanks), can also benefit wildlife in both natural and urban environments.

When developing complex artificial structures for an NbS, factors to consider include the number of components, dimensional variability, density, relative abundance, and spatial arrangement. At Tung Chung East, the complex surface treatment of bio-blocks has been instrumental in establishing and supporting the targeted coastal biodiversity, as shown in **Figure 13**. The creation of various niches that offer different degrees of and exposure to physical stresses like heat and desiccation, as well as biological stresses such as competition and predation, fosters higher biodiversity. Concrete printing techniques can be harnessed to replicate the intricate micro-scale complexity of sub-tidal reefs. Similar principles can be applied on terrestrial elements within the surface finish of retaining structures and other hardscape elements.

Eco-shoreline

Slope reinforcement structure integrated with gabion

Figure 13 | Examples of "Creating Complexity" through Design and Construction at Micro Scale

Applying through management: Within terrestrial ecosystems, natural materials like fallen leaves and branches, as well as cut logs can be retained on site as part of an NbS management approach, as shown in **Figure 14**. These materials host a plethora of organisms such as lichens, mosses, fungi, and invertebrates. These organisms play essential roles in ecosystem functions like nutrient cycling and dynamics. In urban settings, there is a prevalent inclination to excessively manage landscaped areas by clearing away all fallen foliage and branches. Embracing a "lighter touch" in landscape management improve the ecosystem service performance of urban green spaces.

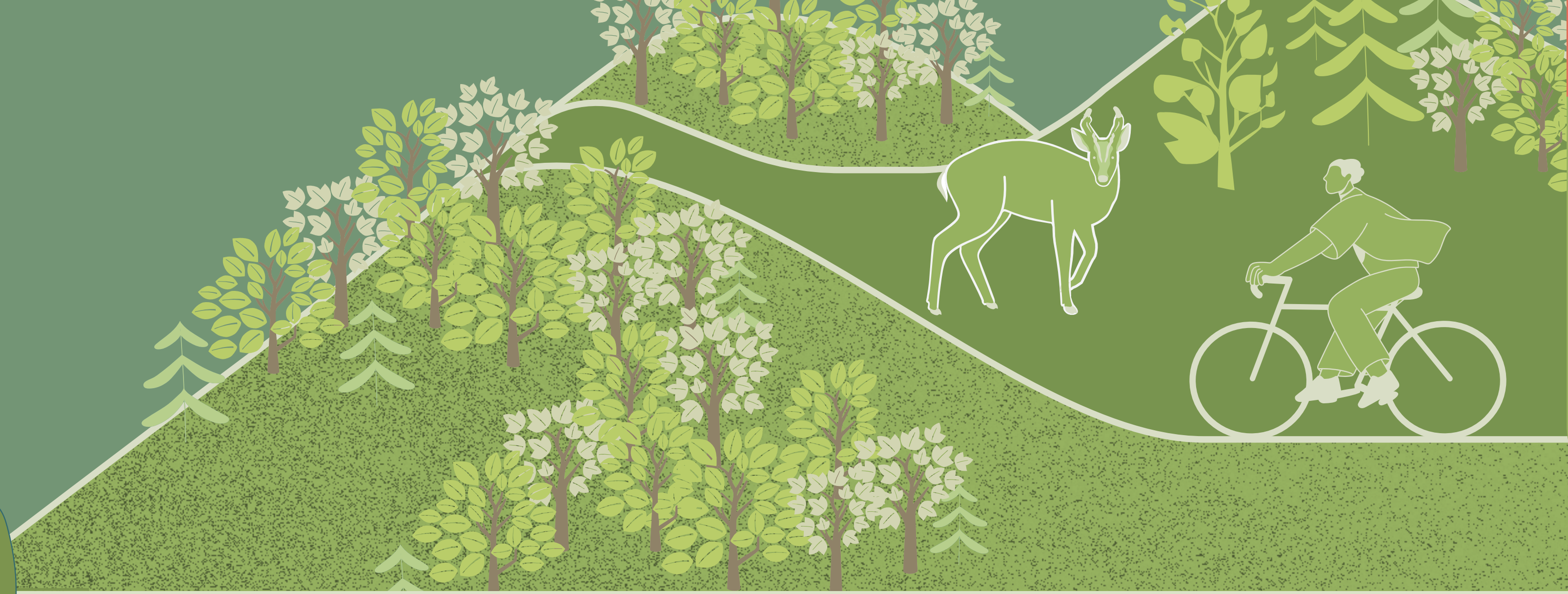
Intentionally unmanaged fallen leaves for nutrient cycling

Stacked-up branches and twigs as organisms' shelter

Naturalistic set up of logs and rocks as organisms' shelter

Figure 14 | Examples of "Creating Micro-Scale Complexity" through NbS Management

> "A lighter touch in landscape management can also help to create micro-habitats"



Core Principle II:

Embracing Human-Nature Coexistence for Mutual Benefits

As the climate crisis and biodiversity loss now affect urban areas and our communities, the urgency for change is becoming clear. Ecosystem-based approaches not only enhance biodiversity but also provide vital services, such as clean water, flood management, and food production. By effectively integrating NbS into our built and natural environments, we can maximise the benefits that natural systems offer, even in human landscapes, shaping our rural and urban environments and delivering multiple benefits to those who live and work there.

Principle II emphasises the relationship where two different entities, humans and nature, benefit mutually from their association. By highlighting the interdependence between built and natural environments, a philosophy of symbiosis emerges — one that views built spaces not as isolated entities but as integral parts of dynamic ecosystems. It underscores the importance of a design approach that recognises the significant impact humans have on the natural world and vice versa.

Guideline 4 Addressing Societal Challenges through Nature-based Solutions

Guideline 5 Designing Human-Nature Composition in Context

Guideline 6 Harmonising Urban-Nature Transitions

Figure 15 | Core Principle II: Embracing Human-Nature Coexistence for Mutual Benefits

Guideline 4

Addressing Societal Challenges through Nature-based Solutions

NbS can address different societal challenges and deliver a wide range of societal benefits derived from ecosystem services the natural components of the NbS deliver. Therefore, a critical first step in any project is to delineate its key objectives, needs, and limitations.

The Millennium Ecosystem Assessment (MEA, 2003) was an early attempt by the scientific community to fully describe and evaluate on a global scale the range of services people derived from nature. Ecosystem services were identified, evaluated, and categorised into four groups. Under these four categories, a recent study (Lai et al., 2022) further identified 20 key ecosystem services which are of high relevance to Hong Kong. **(Figure 16)**

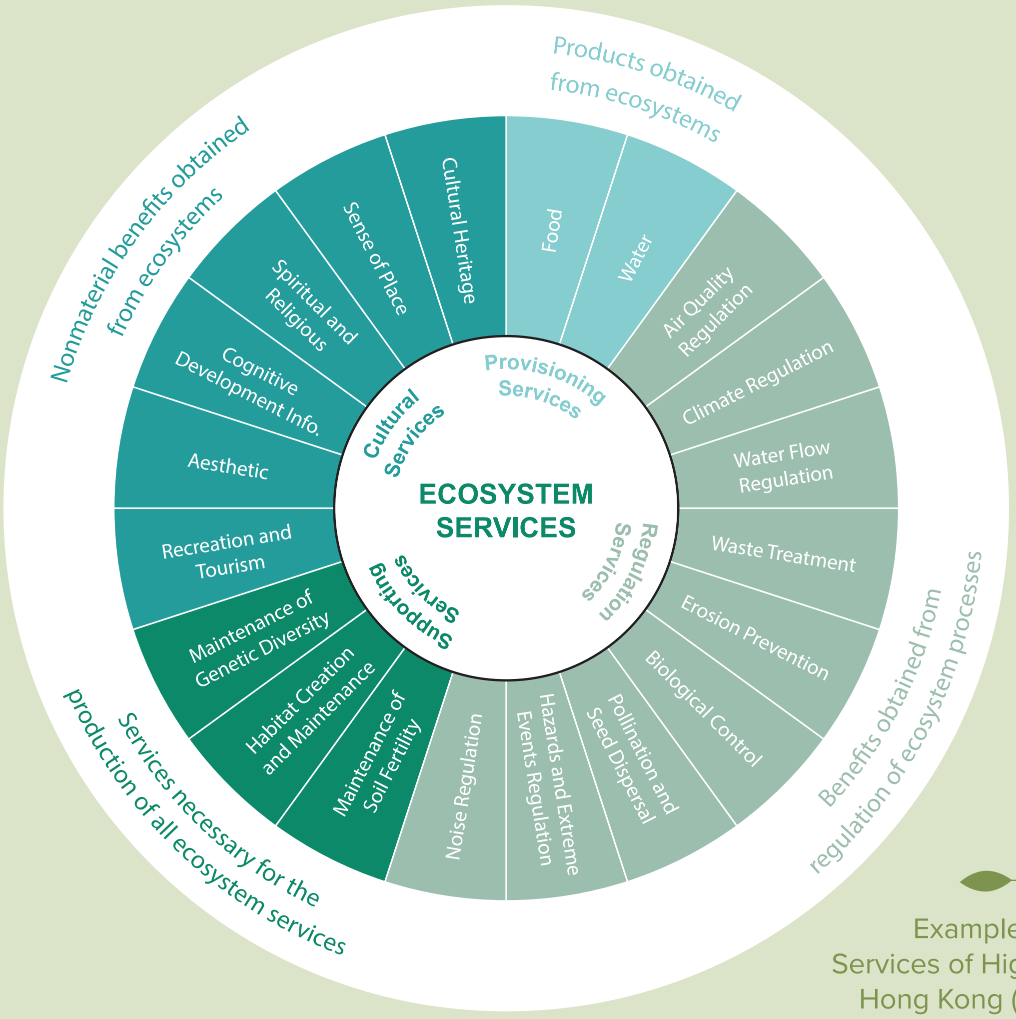


Figure 16

Examples of Ecosystem Services of High Relevance to Hong Kong (Lai et al., 2022)

Regulating services	Benefits obtained from regulation of ecosystem processes such as water purification, plant disease control and urban heat island regulation.
Cultural services	Non-material benefits from ecosystems such as education, cultural heritage and recreation.
Provisioning services	Products obtained from ecosystems such as freshwater, timber and food.
Supporting services	Services necessary for the production of all ecosystem services such as soil formation and nutrient cycling.

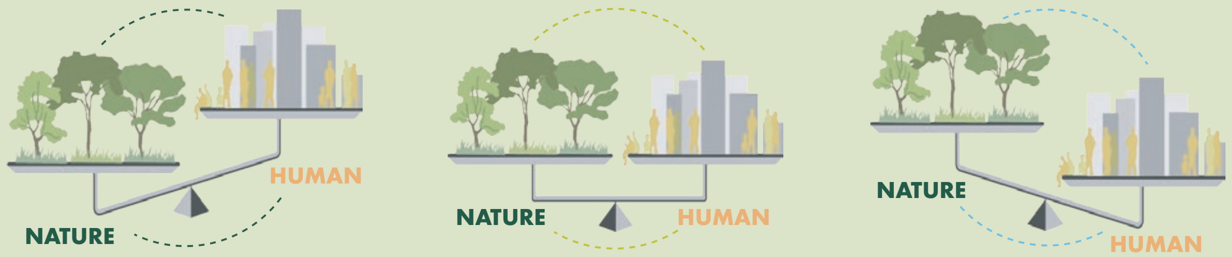
Particularly in urban settings where space and programme are constrained, project designers should first identify key societal challenges the project aims to address with the NbS, such as flooding or urban heat island effects. The feasibility of implementing a comprehensive NbS or integrating NbS with traditional methods to address these issues should then be assessed. Once it is determined that NbS is a suitable approach, designers should pinpoint the specific objectives of the NbS. This not only validates the use of NbS but also facilitates future monitoring of NbS performance.

Guideline 5

Designing Human-Nature Composition in Context

Considerations at project planning stage

NbS encompass a diverse array of forms and characteristics, spanning from managing protected areas and nature reserves to green building designs. A pivotal decision to be made at the outset of each initiative revolves around defining the interaction between humans and nature. Some situations may warrant minimal human intervention to the natural habitats as wildlife refuge, while others prioritise leisure amenities and human engagement. In urban settings like urban parks, roof gardens, and streetscape landscapes, a balanced approach is typically favoured to extend benefits to both humans and urban biodiversity. Projects situated in rural and countryside settings such as country parks, nature reserves, and wetland parks predominantly emphasise nature and wildlife conservation, while also offering recreational and educational opportunities. The balance and overall priorities of each design are shown in Figure 17.



- Conservation area
- Country park
- Nature park/reserve
- Wetland park

- Urban green spaces
- Waterfront promenade
- Pocket parks & gardens
- Street design

- Green building design
- Urban plaza
- Roof & podium gardens

Figure 17 | Defining Priorities at Planning Stage

> "Define suitable management foci across different parts of an NbS project"

Considerations at project design stage

While the balance between human and nature objectives is established at the project level, larger sites typically delineate management foci across different parts of the NbS. For instance, in a nature park where habitats are primarily managed for the well-being of wildlife, a small visitor zone is often provided in less sensitive areas to promote economic and societal advantages, as shown in Figure 18.

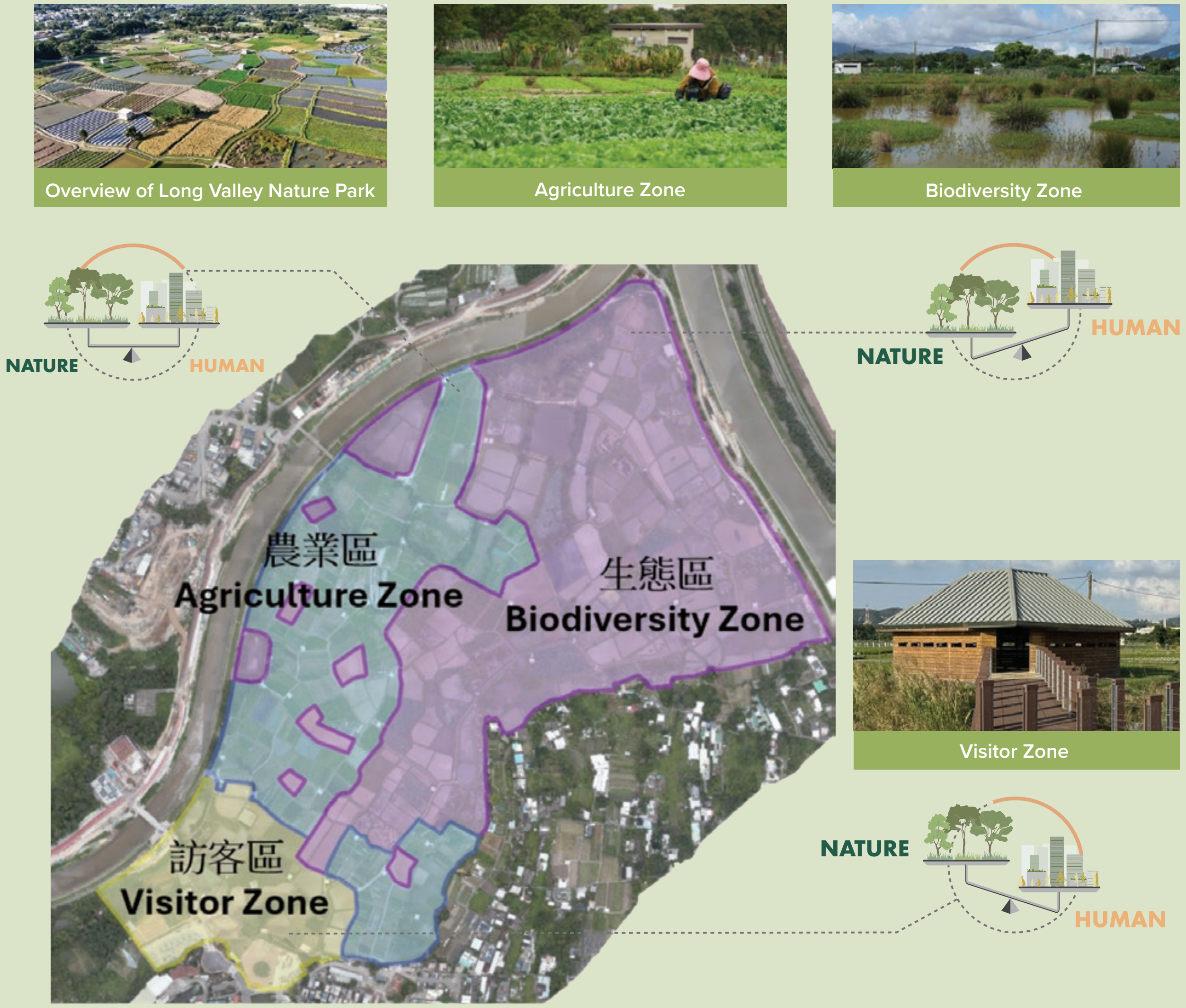


Figure 18 | Refining Human and Nature Relationship at Project Design Stage

Guideline 6

Harmonising Urban-Nature Transitions

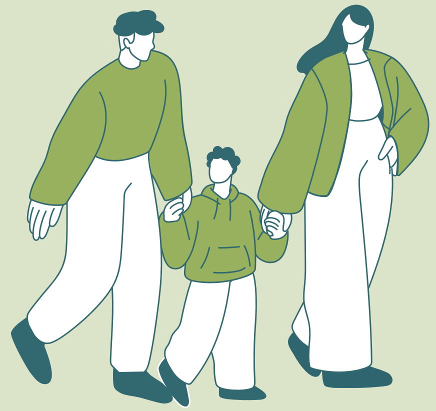
Ecotones are dynamic interfaces between adjacent ecosystems (e.g. between woodland and wetland), where a unique blend of flora, fauna, and environmental conditions is created. Functioning as transition zones, ecotones play a vital role in supporting diverse species, facilitating nutrient cycling, and serving as buffers for ecologically sensitive areas that enhance ecosystem resilience (e.g. Dai et al, 2023).

The concept of ecotone transitions can be adopted when considering the relationships between NbS and the surrounding environments, particularly in urban settings. Instead of hard boundaries, there can be a gradation of potential ecosystem interventions, from intense urban developments through to wilderness areas, along which the relative influence of human and natural environments changes as shown in **Figure 19**.

Figure 19 | Ecotone Transitions between the Built and Natural Environments

At each step along this gradient, we should carefully calibrate the interface between human activities and nature, creating vibrant and sustainable environments that deliver both ecological functions and the range of related ecosystem services. The type of ecosystem services provided will change along this gradient. For example, regulating and supporting services (e.g. coastal protection in mangroves) may be provided more substantially in more natural areas, while cultural services (e.g. recreation) would gain more importance closer to urban areas.

As shown in **Figure 20**, a seamless transition design approach serves as the foundation for harmonising urban and natural environments, integrating visual aesthetics, connectivity, landscape programs, and ecological functions to create a unified landscape.



> **“Carefully calibrate the ecotone transitions between human activities and the nature”**

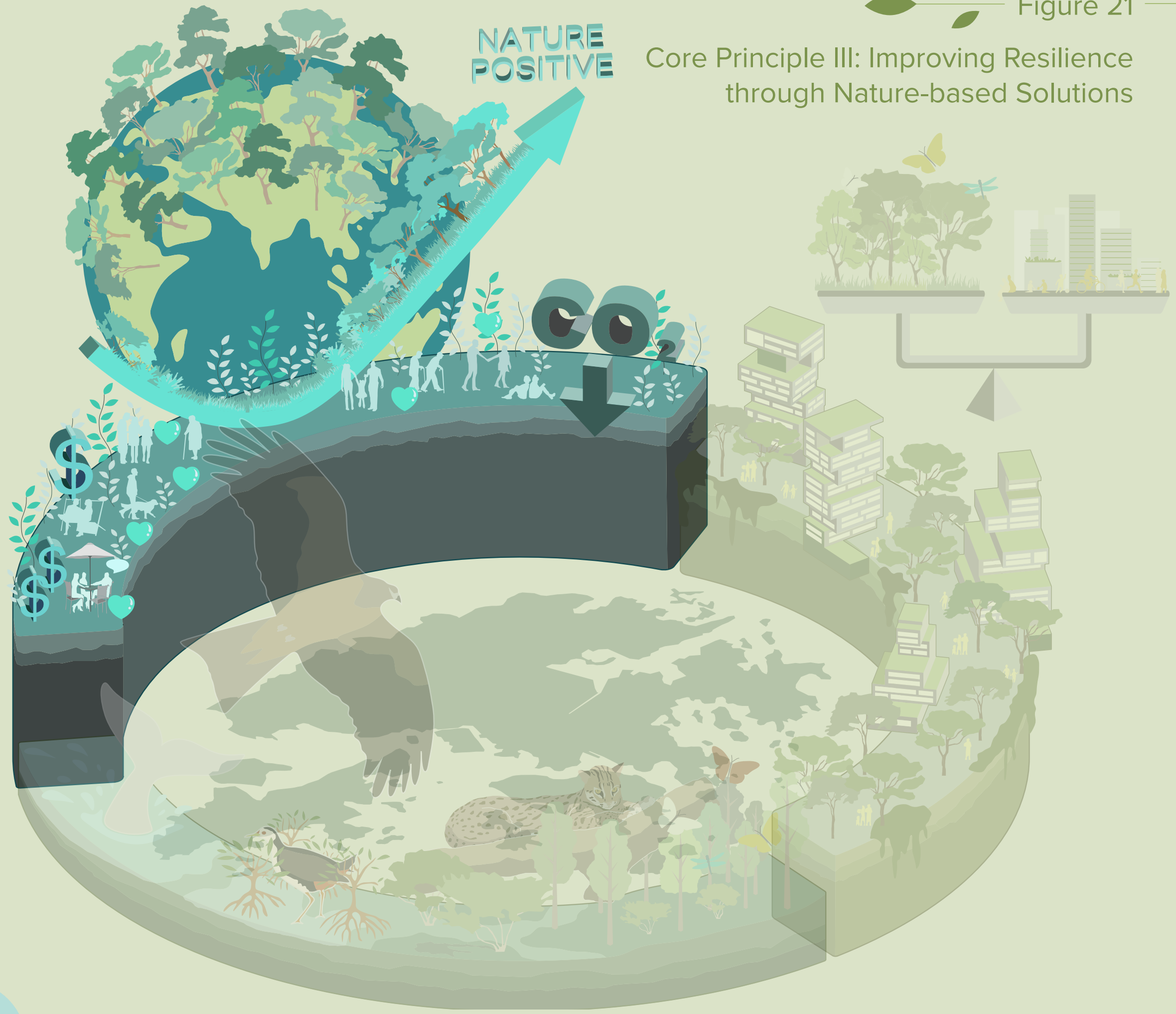
Figure 20 | Conceptual Ecotone Transition Between Urban Area and Nature

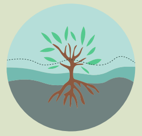
Core Principle III:

Improving Resilience through Nature-based Solutions

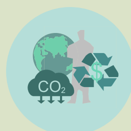
Resilience is an important component of NbS design. It refers not only to the ability of NbS to withstand adversity or significant stress, but also to the regulating services provided by ecosystems that help societies **adapt to and mitigate the impacts of the climate crisis**. Both efforts to eliminate risks at source and minimise impacts of the climate crisis are crucial in ensuring resilience in NbS design. It also has a **socio-economic dimension**. Designing, building, and managing NbS are often perceived as an additional cost to governments and stakeholders. However, creating NbS that minimise capital and management expenses, offers resilience to changing socio-economic conditions.

Figure 21
Core Principle III: Improving Resilience through Nature-based Solutions




Guideline 7 Addressing Climate Challenges


Guideline 8 Building Ecological Resilience


Guideline 9 Promoting Socio-economic Sustainability

Guideline 7

Addressing Climate Challenges

Key challenges from the climate crisis

The climate crisis poses significant challenges to urban areas, arising from increased flood risks, coastal vulnerabilities, and urban heat island effect, etc. as shown in **Figure 22**. Embedding climate resilience considerations in NbS design is essential in combating these intensifying climate impacts.

Increased flood risks | Coastal vulnerabilities | Urban heat island effect

Figure 22 | Key Challenges from Climate Change within Urban Context

Possible Solutions

In urban environments, challenges arising from climate change require planning and infrastructure to address, such as flood resilience, coastal protection, counter measures towards urban heat island effect, and carbon regulation.

NbS including revitalised river channels, bioretention systems, green roofs, porous paving and water harvesting act as natural sponges, reducing surface runoff entering the drainage system and reducing the risk of flooding.

Incorporating NbS for coastal defence involves constructing living shorelines that integrate natural elements such as wetlands and mangroves. These living shorelines provide a buffer against storm surges and rising sea levels, and can be combined with engineered structures to reduce erosion while working harmoniously with natural ecosystems.

Protecting and enhancing patches of natural vegetation, particularly forests, can improve their capacity to retain water and manage floods. Additionally, urban forest initiatives provide cooling effects for residents in densely populated districts.

The increased vegetation provided by NbS collectively contribute to carbon sequestration, with nature proved to be a potent ally in mitigating climate crisis by removing greenhouse gases and reinforcing ecological resilience.

> **"Challenges arising from climate change require planning and infrastructure to address"**

Inland flood protection & water management
- River restoration
- Permeable surfaces
- Integrative wetland design

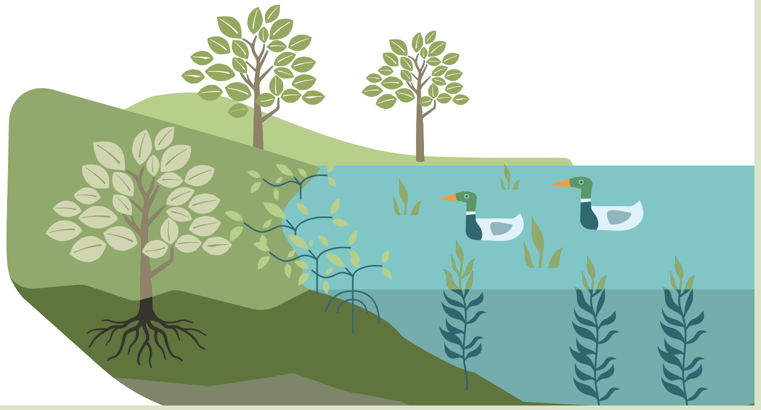
Coastal protection
- Promote living shorelines
- Promote eco-shoreline designs

Urban heat island mitigation
- Urban forestry initiatives within urban areas
- Increase canopy cover

Figure 23 | Possible Solutions – Embedding NbS with Climate Resilience in Urban Context

Guideline 8

Building Ecological Resilience



Key Challenges from the Nature Emergency

Over the past 55 years, we have witnessed a staggering depletion of nature, with more than 70% of global wildlife populations lost. Nature now faces a critical emergency, prompting global communities to unite in addressing and rectifying this urgent and dire situation. In 2022, the Kunming-Montreal Global Biodiversity Framework (GBF) (Convention on Biological Diversity, 2022) was released during COP15, with vision of where "by 2050, biodiversity is valued, conserved, restored and wisely used, maintain ecosystem services, sustaining a healthy planet and delivering benefits essential for all people." Towards this 2050 vision, the mission of the framework for the period up to 2030 is "to take urgent action to halt and reverse biodiversity loss to put nature on a path to recovery for the benefit of people and planet by conserving and sustainably using biodiversity and by ensuring the fair and equitable sharing of benefits from the use of genetic resources, while providing the necessary means of implementation." To better implement the 2050 vision and 2030 mission, four goals and 23 targets were established. It is imperative that NbS are designed in alignment with the GBF 2050 vision and 2030 mission, fostering ecological resilience and safeguarding the sustained provision of ecosystem services. While **Figure 24** highlights several key 2030 global targets of high relevance to NbS design, it is crucial to recognise that all 23 targets can be thoroughly considered in the design process.

Figure 24
Some 2030 global targets of the Kunming-Montreal Global Biodiversity Framework of High Relevance to NbS Design (Convention on Biological Diversity, 2022)

Possible Solutions

The changing climate is having significant impacts on the natural world: plants and animals are altering their distribution, seasonal patterns, and behaviours in reaction to evolving climatic circumstances, including factors like sea-level rise (Zeng, 2023). **Ecological resilience** emphasises the ability of ecosystems to withstand and recover from such disturbance.

When planning resilient ecosystems at the project level, it is essential to **anticipate future conditions** and select species that are native, or compatible with local environment and climate conditions.

The design of NbS shall **preserve and suitably manage** existing established high-quality habitats, considering they are critical in maintaining ecosystem functions and species and genetic diversity. Enlarging high-quality existing natural habitats further enhances nature's ability to withstand climate-induced alterations and human-induced disruptions, thereby **safeguarding the survival** of different species and ecosystems.

Maintaining **eco-corridors** and **connectivity** plays a crucial role in promoting species movement and dispersal, which maintains **genetic diversity** and help spread genotypes that can better adapt to different environmental changes (Krosby et al., 2010). It also facilities species migration in response to shifting climates to enhance survival.

Moreover, the avoidance of introducing exotic species that could potentially become invasive is paramount. Research indicates that climate change-induced disturbances can expedite the proliferation of invasive species (Cho, 2024). Allowing ecosystems **adequate room to adjust** to evolving environmental circumstances is equally critical.

Habitats of higher diversity

- Promote spatial variations
- Promote diverse species

Habitats of higher connectivity

- Design to promote species movements
- Buffer against disturbance
- Promote larger continuous habitats

Species native or compatible to local environment

- Promote the use of native species
- Design with species compatible with local environment and climate conditions

Figure 25 | Possible Solutions – Ecological Resilience Designs

Guideline 9

Promoting Socio-economic Sustainability

Key objective on socio-economic sustainability

Establishing economically sustainable, low maintenance NbS is critical for nurturing resilience and cost-efficiency. In the face of budget constraints and limited resources, such NbS minimise the requirement for ongoing upkeep and intervention.

NbS play a pivotal role in addressing societal needs, enriching the cultural and social dimension of our city, and improving the quality of life of our communities. Showcasing these social values provide strong and robust reasoning and incentives for adopting NbS, thereby ensuring long term ecological and social benefits from an NbS.

Possible Solutions

Baseline Understanding – The first essential step in creating self-sustaining ecosystems is to utilise existing assets. By conducting a comprehensive assessment of current environmental conditions — such as soil health, water availability, and native species — designers can effectively leverage these resources and minimise implementation costs. For instance, designing wetland systems that can be fully supplied by locally available water resources eliminates the need for additional potable water supply.

Park and Open Space Designs – Well-planned and sustainable open spaces serve as essential tools in fostering harmonious neighbourhoods, connecting communities along green corridors that promote cycling and walking, boosting community morale, cultivating a sense of belonging and identity within the local area, and bringing direct and indirect benefits to the local economy.

Blue-green Drainage Systems – A well-designed blue-green drainage system offers long-term economic advantages. It can reduce the scale and cost of expensive grey infrastructure (e.g. large underground storage tanks), while also delivering lasting landscape and ecological benefits over time.

> **“The first essential step in creating self-sustaining ecosystems is to utilise existing assets”**

Design with Natural and Native Materials – Utilising local resources minimises transportation costs and environmental impact while ensuring compatibility with the local ecosystem. Native plants shall be promoted to support local wildlife and create landscapes that thrive naturally. Once established, native plants are generally considered to require less water and maintenance over time than exotic species due to their adaptation to local and regional climates and soil conditions. Appropriate types of plant species should be selected based on site conditions and habitat requirements.

Design with Recycling and Upcycling – The potential for recycling and upcycling should be embraced within NbS. Yard waste can be reintegrated as part of NbS design, whereas crushed concrete, stones, and bricks can be repurposed into gabion, walls, paths and other structures. Embracing these practices also aligns with the city's sustainable development goals by fostering a circular economy approach.

Ecosystem Monitoring, Maintenance and Evaluation – Establishing a robust adaptive management approach in the planning and design stage of the project is essential for the resilience of NbS. This approach should outline management, monitoring and maintenance requirements for maintenance personnel, outlining proposed actions and responsibilities for ongoing ecological and socio-economic performance.

Cost effectiveness in capital investment

- Preserve and enhance existing natural capital resources
- Use local materials
- Recycle and upcycle opportunities in construction

Cost effective operations

- Promote self-sustaining, low maintenance interventions
- Adopt circular economic management approaches

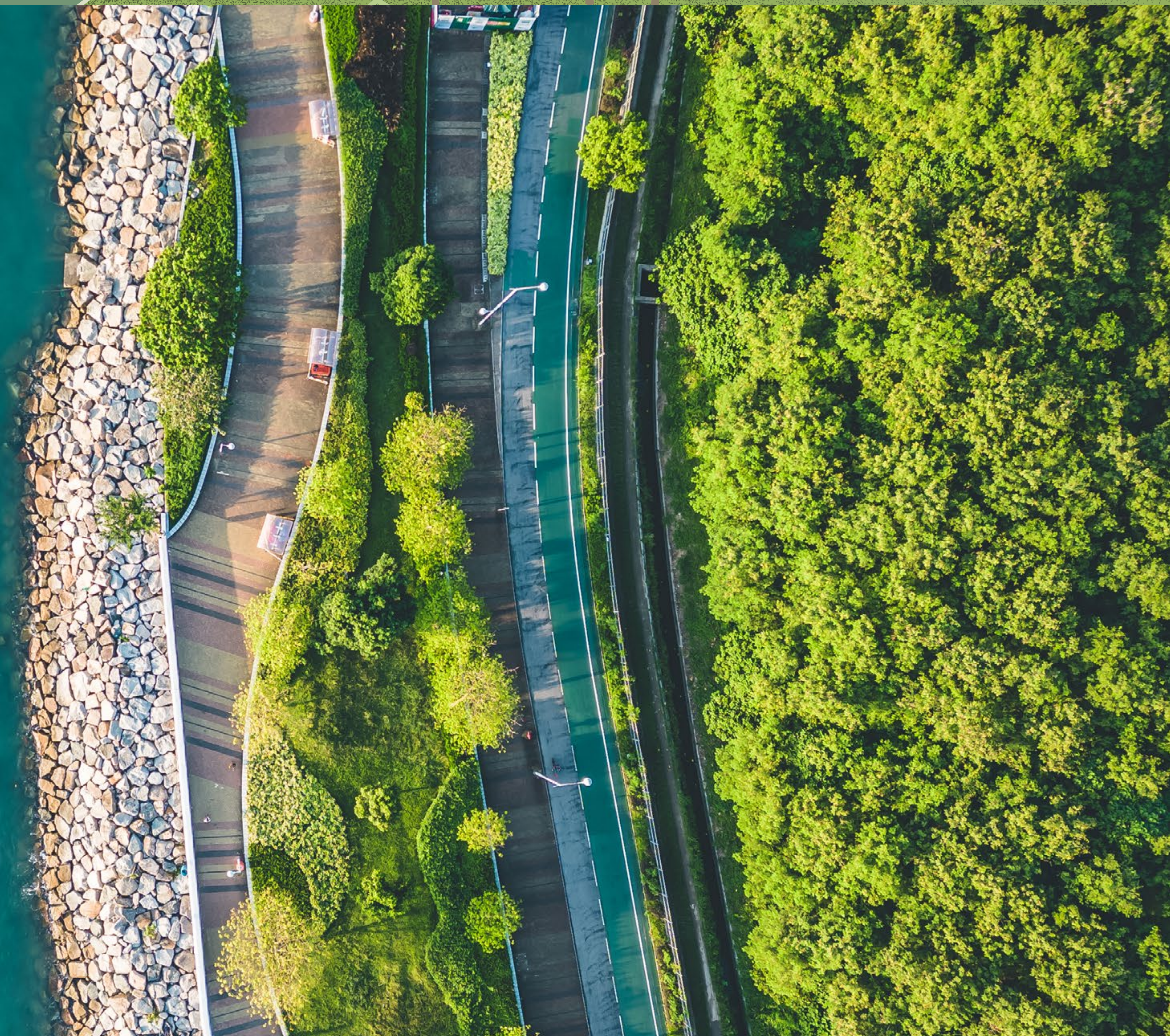
Benefiting people

- Promote local recreation and education opportunities
- Contribute to the physical and mental well-being of residents
- Support local businesses and generate revenue for local communities (e.g. eco-tourism)

Figure 26 | Possible Solutions - Promoting Socio-economic Sustainability with NbS

2.2 Mock-up Designs

Below are mock-up designs and renderings that visualise different types of NbS across typical environmental types in Hong Kong. These designs illustrate how the guidelines can be applied for planning and designing NbS across various contexts and environmental settings.



RIVER PARK | Consists of Rivers and Drainage Systems, Urban Open Spaces, and Man-made and Natural Terrains

GUIDELINE 1

Enhancing Habitat and Spatial Diversity at Macro Scale

The planning and design process starts with an understanding of the existing physical and ecological context to guide spatial designs for connectivity, and habitat creation.

GUIDELINE 2

Diversifying Habitat Components at Intermediate Scale

The water's edge design integrates ecological, visual, and engineering goals with diverse habitats, varied depths, gabion walls, and vegetated slopes.

GUIDELINE 3

Creating Complex Micro-habitats

The microhabitats are implemented through design (e.g. gabions 3.a and textured bank 3.b) and management (e.g. stacked-up branches 3.c) to support target species habitats and nutrient cycling.

GUIDELINE 4

Addressing Societal Challenges through Nature-based Solutions

The planning and design start with identifying key societal challenges e.g. flooding, urban heat island effects and community well-being. More ecosystem services are targeted to maximise benefits.

GUIDELINE 5

Designing Human-Nature Composition in Context

The planning and design of this park establish it as an urban green space to balance both nature and human priorities along the longitudinal axis.

GUIDELINE 6

Harmonising Urban-Nature Transitions

A seamless transition design approach is adopted to integrate urban open space with high ecological value riparian habitat.

GUIDELINE 7

Addressing Climate Challenges

The naturalised river design enhances climate resilience by mitigating urban heat island effect mitigation (7.a), flood retention functions (7.b), and reducing surface runoff (7.c).

GUIDELINE 8

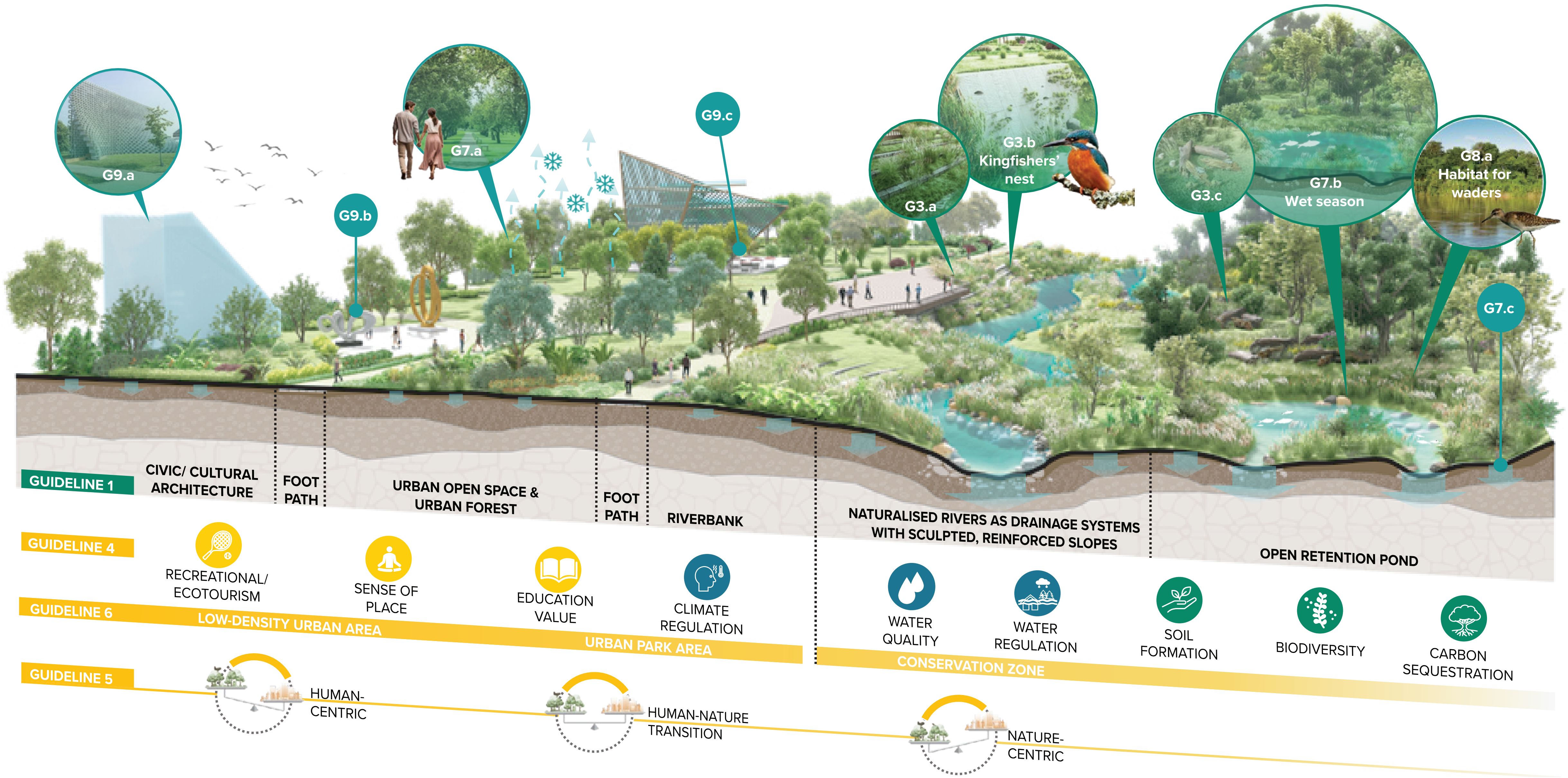
Building Ecological Resilience

The design enhances connectivity with a widened and naturalised river. It provides high-quality habitats to support target species' nesting and foraging activities (8.a).

GUIDELINE 9

Promoting Socio-economic Sustainability

The open space is paired with civic/ cultural architecture (9.a), sculptural parks (9.b) and alfresco-dining (9.c) to promote ecotourism, a sense of place, recreation, and economic growth indirectly.



URBAN NATURE PARK | Consists of Countryside and Rural Environments, Urban Open Spaces, and Man-made and Natural Terrains

GUIDELINE 1

Enhancing Habitat and Spatial Diversity at Macro Scale

The planning and design process starts with an understanding of the existing physical and ecological context to guide the preservation and enhancement of the existing egret habitat.

GUIDELINE 2

Diversifying Habitat Components at Intermediate Scale

Varying bio-engineered terrains create rich compositions to support different planting zones. Man-made insect hotels (2.a) are further proposed in the park area.

GUIDELINE 3

Creating Complex Micro-habitats

The microhabitats are implemented through design (e.g. grasspavers 3.a & rock bioswales 3.b) and applied through management (e.g. stacked logs 3.c) support diverse micro-organisms and nutrient cycling.

GUIDELINE 4

Addressing Societal Challenges through Nature-based Solutions

The planning and design process starts with identifying key societal challenges e.g. soil fertility, biodiversity and community well-being. More ecosystem services are targeted to maximise benefits.

GUIDELINE 5

Designing Human-Nature Composition in Context

The planning and design of this park establish it as a conservation area, prioritising nature, with visitor areas limited to the periphery.

GUIDELINE 6

Harmonising Urban-Nature Transitions

The planning and design adopt a seamless transition design approach to integrate urban open space as a buffer to sensitive woodland ecologies.

GUIDELINE 7

Addressing Climate Challenges

The extensive greenery enhances climate resilience through water retention, reduction of surface runoff (7.a), and carbon sequestration (7.b).

GUIDELINE 8

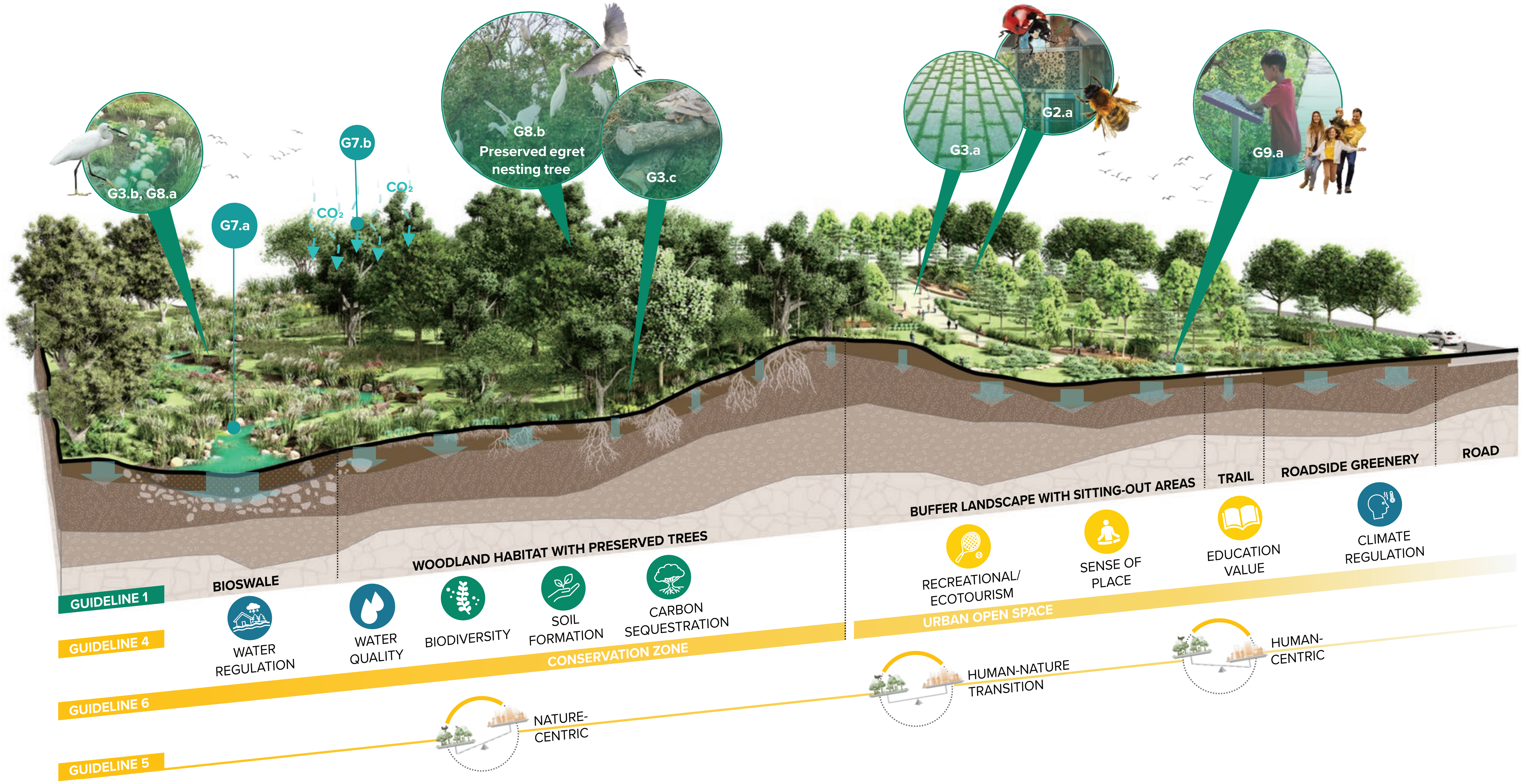
Building Ecological Resilience

The design preserves connectivity with urban areas. It maintains and enhances habitat quality to support target species' foraging (8.a) and nesting (8.b) activities.

GUIDELINE 9

Promoting Socio-economic Sustainability

The open space preserves and enhances the existing egret nesting environment, promotes a stronger sense of belonging, and provides recreational and educational value (9.a).



PROMENADE | Consists of Marine Environments and Coastlines, and Building Environments

GUIDELINE 1

Enhancing Habitat and Spatial Diversity at Macro Scale

The planning and design process starts with an understanding of the existing physical and ecological context to guide coastal habitat creation effectively despite the challenges posed by strong currents.

GUIDELINE 2

Diversifying Habitat Components at Intermediate Scale

The shoreline is engineered with eco-engineered features (G2.a & G2.b) and backshore vegetation, supporting intertidal and terrestrial habitats. Birdhouses (G2.c) are further proposed in the urban areas.

GUIDELINE 3

Creating Complex Micro-habitats

Eco-tetrapods (G3.a), surface treatment at artificial rocky features (G3.b) and mangrove roots (G3.c) create complex microhabitats with varying water depth, surfaces, and shelters for diverse species.

GUIDELINE 4

Addressing Societal Challenges through Nature-based Solutions

The planning and design process starts with identifying key societal challenges e.g. flooding, coastal erosion and community well-being. More ecosystem services are targeted to maximise benefits.

GUIDELINE 5

Designing Human-Nature Composition in Context

The planning and design of this promenade establish it as an urban public realm primarily focused on human use, while also supporting urban ecological needs.

GUIDELINE 6

Harmonising Urban-Nature Transitions

A seamless transition approach is adopted to integrate high-density urban areas with sensitive intertidal ecologies.

GUIDELINE 7

Addressing Climate Challenges

The eco-shoreline and green infrastructures with continuous canopies enhance climate resilience, reducing storm surges (7.a), erosion, and urban heat island effects (7.b).

GUIDELINE 8

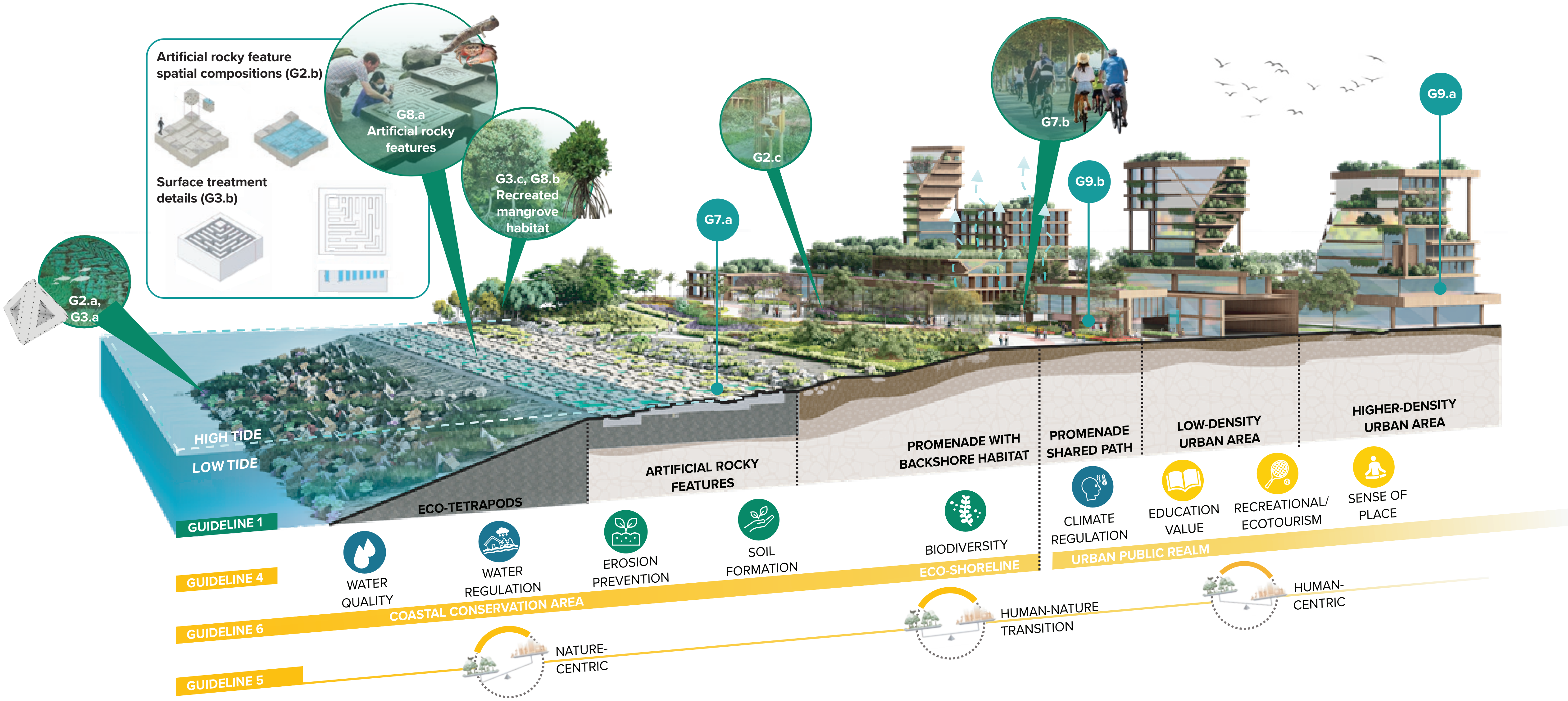
Building Ecological Resilience

The design enhances connectivity through a continuous eco-shoreline and improves intertidal habitat quality to support target species' nesting and foraging (8.a & 8.b).

GUIDELINE 9

Promoting Socio-economic Sustainability

The coastal fronting mixed-use developments (9.a) with alfresco dining (9.b) promote recreation, foster a sense of place, and support economic growth indirectly.



3. NbS Performance Evaluation

3.1 The Principles of Performance Monitoring

3.1.1 Background

An evidence-based approach is essential for the successful planning, design and management of NbS, and relies on collecting data through monitoring and evaluation. This general principle can be applied to all key aspects of NbS, demonstrating that societal challenges are being addressed effectively and adaptively, while providing benefits for both human well-being and biodiversity. In this context, performance monitoring is required in three main aspects of the NbS Design and Performance Life Cycle:

- ***Projection*** – Undertaking an initial assessment of potential NbS performance during the planning and design stage.
- ***Monitoring and Assessment*** – Confirming the actual NbS performance once the project is completed, with the performance monitoring being used for adaptive management.
- ***Improvement*** – Collating monitoring data from multiple projects to create a catalogue of best practices that can enhance future NbS planning and design.

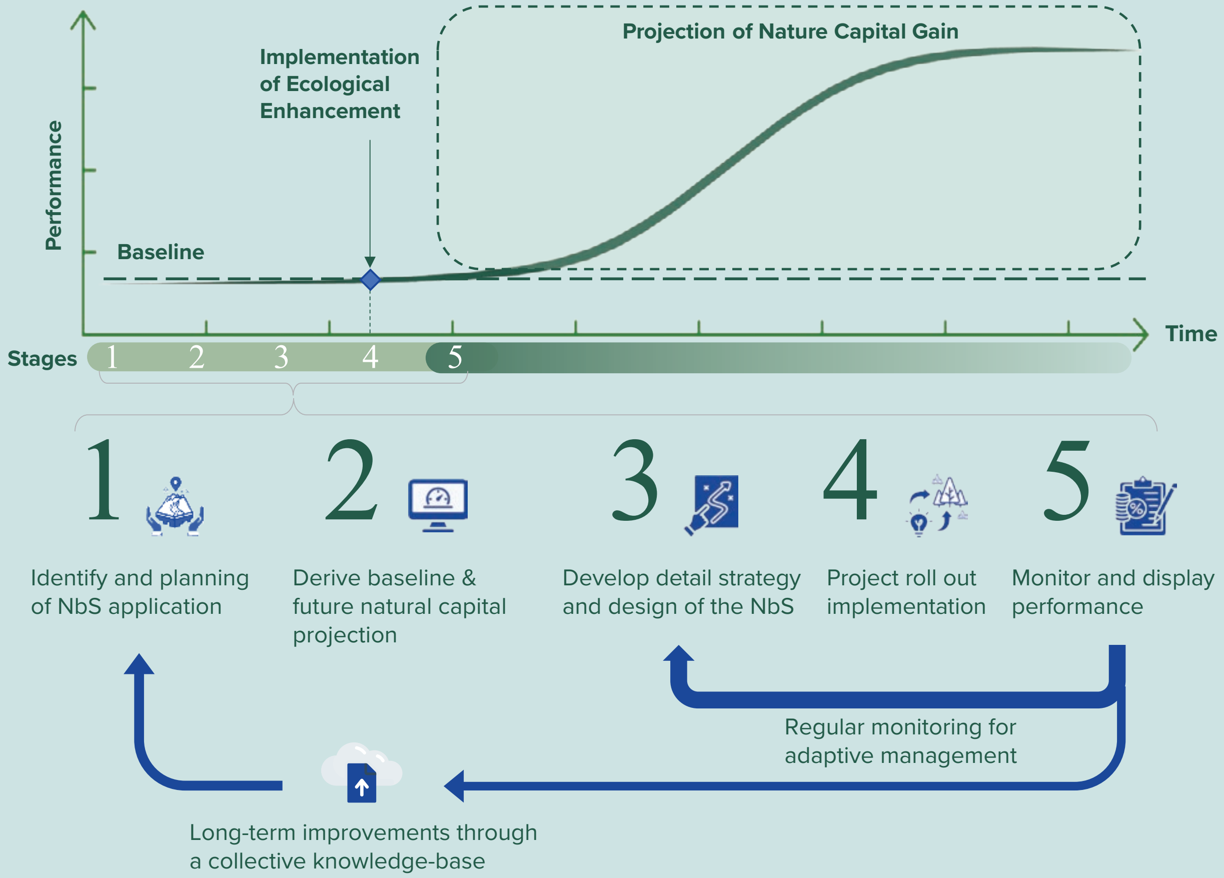


Figure 27 | NbS Design and Performance Life Cycle

Projection

An initial assessment and projection of NbS performance is required during the **early planning and design stages** of the project to provide a basis for important decisions, such as:

- NbS projects often undergo cost-benefit analysis in the early planning stages to justify predicted Capital Expenditures (CAPEX) and Operating Expenditures (OPEX). This requires an initial estimate of the type and scale of social and environmental gains provided by the project.
- Initial projections are also used to **compare and benchmark** NbS performance with other potential solutions (e.g. conventional grey infrastructure); as well as during 'optioneering' for different NbS designs and approaches.
- As with all project types, it is good practice to engage **a broad range of stakeholders** during NbS planning and design. Performance projections can help **build consensus** during this engagement process by clearly identifying the type and scale of NbS benefits.
- Understanding **potential gains** in ecosystem services is important for **attracting investment** in NbS projects, especially from the private sector.

Baseline Information

Baseline condition provides information on the **degree of challenge** to be addressed which can be used to determine the specific objectives of an NbS, and can serve as a benchmark for assessing NbS performance. It is therefore vital to conduct baseline assessments prior to the projection. The Guidance for using the *IUCN Global Standard for Nature-based Solutions* (IUCN, 2020) outlines basic baseline information to be acquired, including:

1. **Important ecosystem functions and structure,** and the spatial distribution of key ecosystem types within land/seascapes, according to the scale in the interest area and their current conservation status;
2. **Species composition,** including the abundance of species from key taxonomic groups (e.g. vascular plants, mammals, birds and soil micro-organisms) and species' current conservation status;
3. **Information on key ecosystem functions** (e.g. rates of productivity, flows of water and nutrients, and biotic interactions);
4. **Key aspects of the physical environment** (e.g. water quantity and quality and information on the physical and chemical properties of soils and other substrates);
5. **Connectivity,** including corridors of natural or semi-natural vegetation across the land / seascape that link protected and semi-protected areas and other refugia for biodiversity, and that allow for exchanges of propagules, water and materials among ecosystems;
6. **External threats** to the ecosystem or land/ seascape and risk of collapse for ecosystems; and
7. **Existing or ongoing conservation interventions** for the species and ecosystems at risk in the landscape/seascape

Monitoring and Assessment

Once an NbS is constructed and functioning, **regular monitoring** is required to confirm that the project performs as predicted and sufficient resources shall be made available to support this. Depending on the type of NbS, the monitoring can go on for many years to capture the **full project performance**. For example, a reinstated woodland habitat would take many years to mature and provide expected uplift.

Regular and long-term monitoring is especially important for NbS, which have an inherent degree of uncertainty due to the **complex, dynamic, and self-organising** nature of the ecosystem approach (IUCN, 2020). While such complex systems have a high degree of **resilience**, they may react to changing environmental factors in unexpected ways.

Performance monitoring is also central to the **adaptive management approaches** for NbS and other projects based on natural resources. Adaptive management is defined by USDI (2009) as:

> ***"[a process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process……"***

A monitoring, evaluation and maintenance plan/framework drawn up **at the early planning phases** of an NbS project will support the allocation of necessary resources, development of effective stakeholder engagement strategy and integration of different monitoring methods (e.g. citizen science) within the overall process of NbS design, implementation and management (Cardinali et al., 2021). Early planning and clear understanding of the objectives and benefits delivered by the NbS also facilitate **collection of suitable data** at appropriate scale.

Improvement

Performance monitoring data from individual NbS projects can be used to help improve the planning and design of future NbS projects in Hong Kong. In this regard, there have been initiatives in other geographies to establish reference books (e.g. FIDIC et al., 2023) and online clearing houses (e.g. Network Nature, 2025) that provide reference information about successful NbS applications. A similar initiative at a local scale would be greatly beneficial to improving the knowledge base for practical NbS design and management in Hong Kong.

3.1.2 Key Natural Capital Uplift provided by NbS

As described under Guideline 4, it is important to identify what ecosystem services can be provided by any particular NbS to address **key societal challenges**, with these ecosystem services being the basis of any performance monitoring program. Considering the natural capital assets underpinning the provision of ecosystem services, with reference to the reviewed international guidelines, we have identified **five key natural capital assets** that are highly relevant to our unique set of societal challenges, and can be uplifted by NbS. Where possible, all five of these elements should be **measured**, but in some instances, this would not be possible (i.e. the use of the 'soil' indicator might not be possible for some marine NbS). Additional indicators can be included to cater for specific needs of the NbS. Considering the nine Design Guidelines are focused on design, some aspects of NbS not directly related to design performance (e.g. green jobs, stakeholder engagement) are not included in this set of indicators. The list of indicators can be expanded as needed in later versions of the HKNbSDG.

Biodiversity Benefits

Providing biodiversity benefits (alongside addressing societal challenges) is a key objective of all NbS (IUCN, 2020). Though small in size, Hong Kong supports surprisingly **high levels of biodiversity**. For example, Hong Kong comprises less than 1% of the area of Guangdong Province, but we have more than one-third of the amphibian species recorded in the region. Our record of bird species accounts for over one-third of the total recorded in Chinese Mainland (AFCD, 2025). Through careful design and management, NbS can provide high quality habitats that enhance species richness and diversity, and can help conserve species that are rare, endangered, or have other important characteristics. In addition, diverse and species rich communities tend to have **higher resilience** to climate change and other human-driven environmental changes (e.g. Cleland, 2011).

> **"Measuring natural capital can act as a proxy for the performance of NbS in providing ecosystem services in Hong Kong"**

Water Regulation

NbS play an important role in regulating the water cycle, managing flood risks, and reducing water pollution. These ecosystem services are particularly relevant in Hong Kong. While flooding risks have been greatly reduced in recent years due to drainage improvement works, the severity of storm events is increasing because of the climate crisis. In 2023, for example, rainfall associated with Typhoon Haikui led to 158.1 mm of rainfall being recorded within one hour, the highest hourly rainfall rate ever in Hong Kong since records began in 1884. NbS can help **manage surface runoff** alongside with conventional drainage infrastructure.

Non-point source pollution from urban areas remains a key issue affecting the quality of our rivers and coastal waters. As well as attenuating flood-risks, NbS can also help to **manage urban stormwater pollution**, as vegetation and soils in the NbS help to trap and remove sediments, oils, nutrients and other contaminants from the water. The ability of NbS to help manage urban water quality is recognised in the Government's future plans to adopt **'blue-green infrastructure'** to improve water quality in Victoria Harbor and other receiving water bodies (e.g. EPD, 2021).

Clean Air

Air pollution is the greatest environmental threat to public health globally and accounts for an estimated seven million premature deaths every year (WHO, 2024). In Hong Kong, the implementation of a comprehensive vehicle emission control program has resulted in significant air quality improvement, but street-level air quality remains an issue (HKG, 2025) in our compact and densely developed urban areas. Air pollution and climate change are closely linked as all major pollutants have an impact on the climate and most share common sources with greenhouse gases. Improving our air quality will bring health, development, and environmental benefits. The **vegetation in NbS** can reduce the concentrations of airborne pollutants, especially of **particulate matter (PM)**, through several different processes. This makes green spaces, especially in urban areas, a valuable mechanism for reducing air pollution. Additionally, green spaces can help attenuate the **urban heat island effect**. Studies have shown that land reclamation, urbanisation, and changing urban morphology in Hong Kong have resulted in significant increases temperature compared to the regional background (Yee and Kaplan, 2022). Climate change is exacerbating heating and making urban areas unbearably hot.

Healthy Soils

Soil health is an important but often overlooked issue in Hong Kong. Our urban soils are generally compacted and have very poor quality, having lost natural soil horizons, being excessively stony and coarse-textured, having an alkaline pH and low organic content (Jim, 1998). On our hillsides, the loss of natural vegetation cover through centuries of logging, burning and agricultural activities has resulted in almost complete loss of nutrient rich top-soil in some areas (KFBG, 2025). Healthy soil is a complex system that contains **minerals, organic matter** and **water** which provides suitable environment for a wide range of micro-organisms, fungi, animals, plants. NbS support the formation and maintenance of healthy soils. In turn, these soils are essential for **resilient** NbS and underpin the services they provide, including the **growth and survival of vegetation**, which create habitat and food for wildlife, and reducing the risk of soil erosion, nutrient runoff and water pollution, which can have negative impacts on the environment and human health.

Carbon Storage

The ability of ecosystems to **absorb carbon** from the atmosphere and store it helps regulate the climate and fight the worst impacts of the climate crisis. This process is known as **carbon sequestration**, which refers to the total amount of carbon stored in ecosystems both in living (i.e. biomass) as well as non-living (i.e. soil) material. While Hong Kong only covers a small geographic area, there is still scope for significant carbon sequestration through implementation of NbS. For example, research by HKU found that 1975 hectares of degraded shrubland or grassland in the hillside areas of the Northern Metropolis are suitable for **reforestation**. This would allow an additional 340,000 tonnes of carbon sequestered by 2035, equivalent to the carbon output from 113,029 people per year (TNC, 2024).

Biodiversity Benefits

Water Regulation

Clean Air

Healthy Soils

Carbon Storage

Figure 28 | Key Natural Capital Uplifts provided by NbS

3.2 Suggested Indicators for Measuring NbS Performance

3.2.1 The Characteristics of Good Indicators

Good indicators need to be easily understood and meaningful to those using the information they provide. As with other disciplines, indicators of natural resource performance should be **SMART** (specific, measurable, achievable, relevant, and time-bound), with the following characteristics:

- **Specific** - Indicators should be specific and clearly defined, focusing on a specific aspect of NbS performance.
- **Measurable** - Indicators must be discrete and measurable, ideally quantified, allowing easy comparison with other options, or tracking of progress towards a goal.
- **Achievable** - Indicators should be achievable and realistic, meaning that they can be measured with the resources available.
- **Relevant** - Indicators should focus on the key potential functions of NbS.
- **Time-bound** - Indicators should be time-bound, with a clear framework for delivering performance objectives, and when measurements need to be made to check on performance.

In these nine Design Guidelines, we have suggested a number of 'Detailed' and 'Simplified' indicators for assessing common elements of NbS design performance relevant in Hong Kong, including indicators of **Biodiversity, Water, Soil, Air, Carbon, and Socio-economic** aspects[1]. It should be noted that these indicators are recommendations only: project proponents are encouraged to review indicator requirements according to the objectives and specific needs of individual projects.

The proposed indicators enable **monitoring and tracking of improvements** in key ecosystem services. These indicators are essential elements of an NbS that reflect the impacts of the decisions made. Whereas the socio-economic indicators focus on other aspects of NbS performance that cannot be captured by natural capital.

[1] these indicators cover aspects of NbS related to measuring design performance. Indicators of other aspects of NbS (such as mainstreaming and stakeholder engagement) will be addressed in subsequent versions of the HKNbSDG.

'Detailed' indicators rely on relatively detailed, quantified data and analysis that can be used to predict and track the performance of the key natural capital uplift provided by NbS. They can be **presented as simple metrics** that allows the public to understand the benefits of NbS. The simplicity of presentation may facilitate private sector investment in NbS.

While the detailed indicators provide a detailed, quantitative assessment of NbS design performance, it is recognised that the data required to calculate these indicators (and/or the resources required to analyse the data) are not always available. In these instances, a set of **'simplified' indicators** can be used to provide a **general assessment** of the natural capital uplift provided by NbS. It should be noted that even the simplified indicators should be calculated by suitably **qualified experts** in the corresponding fields to maintain the accuracy of the evaluation and to ensure the results are correctly interpreted.

When evaluating the performance of an NbS, numerical values of the indicators should only be compared between the NbS options and baseline and/or "business as usual" conditions (i.e. grey engineered option) for the same project, but **not** between different NbS projects, as scores can be attained by a certain project will vary considerably depending on the **type, size** and **investment** of the project.

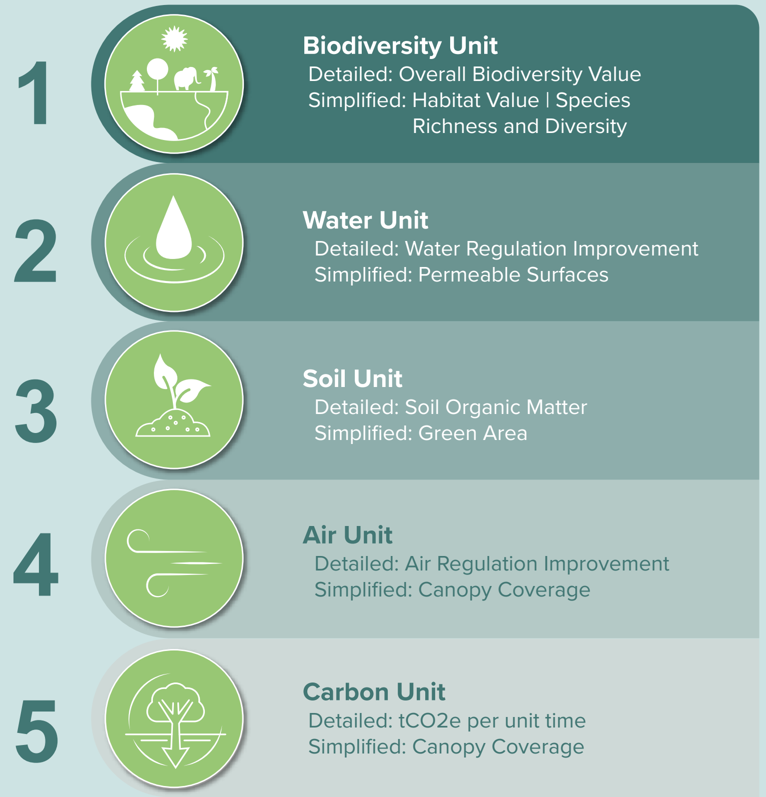


Figure 29 | Suggested Indicators

3.2.2 Suggested Natural Capital Indicators

Biodiversity Unit

Biodiversity is generally more difficult to quantify than other key performance indicators due to its complexity, diversity, and lack of equivalence. Biodiversity also exhibits significant natural variability, further complicating data collection and analysis. With this in mind, accounting approaches have been developed to quantify biodiversity by assigning values to habitats, reflecting their overall contribution to biodiversity in the form of units.

Should there be insufficient information for assessing the overall biodiversity value, simplified measurements of habitat value and species richness and diversity can be used for assessment of biodiversity performance.

Detailed Indicator: Overall Biodiversity Value

Biodiversity accounting metrics provide a simple way of assessing the biodiversity value of a site, usually adopting habitats as an indicator of overall biodiversity value, taking into account the **size, condition, significance and type** of habitats. All habitats within the site should be assessed. This information is used to calculate an overall **biodiversity metric value** of a site, usually expressed in biodiversity units, allowing project proponents to understand **objectively** the biodiversity value of a site before and/or after any proposed intervention.

In this way, accounting metrics can be used to assess biodiversity outcomes for different types and scales of projects, including gains achieved through NbS. It should be noted that the biodiversity accounting metric accounts for **direct impacts** on the overall site, but not the indirect impacts or gain/loss of habitats for individual species.

Biodiversity accounting metrics are typically designed to be specific to **local ecological resources**. As an example, Singapore recently developed a metric tailored to local conditions (AECOM & Camphora, 2024), based on the United Kingdom's Statutory Biodiversity Metric (Natural England, 2024).

The metric will derive one single unit for each habitat parcel by multiplying four coefficients: distinctiveness, condition, strategic significance and area. Where:

Distinctiveness

This refers to the average biodiversity value of a habitat type, based on criteria such as species richness, number of species of conservation importance, habitat re-creatability (i.e. difficulty of recreating the habitat), habitat rarity (i.e. area of particular habitat type as a portion of all terrestrial/marine land mass) and naturalness (i.e. creation of habitat from natural succession or man-made process).

Condition

The values are derived from data relating to species richness and abundance, number of species of conservation importance, vegetation structure and size composition, presence of nursery/breeding ground, disturbance and habitat degradation, presence of exotic and invasive species, structural diversity, and function. This information allows habitat parcels with the same distinctiveness value to be compared and assessed based on their relative condition.

Strategic Significance

It takes into account the presence of site of high conservation importance, which can be measured based on the distance of habitat parcel to sites of high conservation importance.

Area

This refers to the total area of habitats with the same distinctiveness and condition scores across the site.

Adoption of NbS can uplift the biodiversity value through **increasing distinctiveness** and/or **condition** of an area. For example, replacing exotic plantation with native secondary woodland can increase biodiversity value as woodland has higher distinctiveness than plantation. Whereas revitalising channelised river can increase the number of vegetation structures and improve water quality, thereby improving condition.

While the biodiversity units derived from biodiversity metrics indicate the overall changes in biodiversity values across the entire project process, which covers the overall evaluation of **intrinsic ecological value** and **ecosystem services**, it is acknowledged that some projects would have more specific and small-scale biodiversity targets (e.g. increasing the population of certain species in the area). In such cases, project proponents are encouraged to include **additional monitoring indicators** to track the progress towards these targets.

Biodiversity Unit

1. Distinctiveness

Average value of a particular habitat type:
- a. Rarity
- b. Diversity
- c. Endemic species
- d. Re-creatability

X

2. Habitat Condition

Relative value of a particular habitat:
- a. Pollution
- b. Size
- c. Noise disturbance
- d. Structural diversity
- e. Fragmentation

X

3. Strategic Significance

Distance from sites of conservation importance

X

4. Habitat Area

Area of each habitat

Exotic plantation | **Native secondary woodland** | **Channelised river** | **Restored river**

Examples of Enhancing Biodiversity through NbS

Figure 30 | Biodiversity Unit

Simplified Indicator 1: Habitat Value

General estimates of biodiversity performance can be assessed through a qualitative review of NbS habitat value. Table (2) in Annex 8 of the Technical Memorandum on Environmental Impact Assessment Process provides for some general criteria that can be used for evaluation of the ecological importance of a site/habitat. Please note that these criteria are not exhaustive and may carry different weight in different cases.

Table 1 Some General criteria for Evaluation of the Ecological Importance of a site/habitat as in the Technical Memorandum on Environmental Impact Assessment Process (Table (2), Annex 8)

Criteria	Remarks
Naturalness	Truly natural habitats (i.e. not modified by man) are usually highly valued. However, most areas of the territory have been modified. Generally, those habitats less modified will tend to be rated higher.
Size	In general, larger area of habitat(s) shall be more valuable than smaller ones, all else being equal.
Diversity	The more diverse the species assemblages and communities of a site, the higher is its conservation value.
Rarity	Rarity can apply to habitats as well as species. The presence of one or more rare habitats and species will give a site higher value than those without rarity.
Re-creatability	Habitats which are difficult to be re-created naturally or artificially are usually valued higher.
Fragmentation	In general, the more fragmented habitat, the lower is its value.
Ecological linkage	The value of a habitat increases if it lies in close proximity and/or links functionally to a highly valued habitat of any type.
Potential value	Certain sites, through active management or natural processes, may eventually develop a nature conservation interest substantially greater than that existing at present. Factors limiting such potential being achieved shall be noted.
Nursery/ breeding ground	Such areas are very important for the regeneration and long-term survival of many organisms and their populations
Age	Ancient natural or semi natural habitats are normally highly valued. For some habitats such as woodlands, older ones are normally valued much higher than recent ones.
Abundance/ richness of wildlife	In general sites supporting more wildlife will be rated higher.

Shoreline with vertical seawalls

Natural rocky shoreline

Figure 31 | Habitat Designs with Different Habitat Values

Simplified Indicator 2: Native Species Richness and Diversity

Simple measures of richness or diversity of native species can be adopted as general indicators of biodiversity benefits. Species richness refers to the total number of species occurring in a habitat or site.

Species diversity indices (such as the Shannon diversity index) are quantitative measures that reflect both the number of different species occurring in a habitat or site, and how evenly the individuals are distributed among those species. There are numerous on-line tools that can be used to calculate Shannon Diversity Index, adopting the following formula:

$$\text{Shannon Index (H)} = -\sum_{i=1}^{S} p_i \ln p_i$$

Where **p** is the proportion **(n/N)** of individuals of one particular species found **(n)**, divided by the total number of individuals found **(N)**, **ln** is the natural log, **Σ** is the sum of the calculations, and **s** is the number of species.

Water Unit

Improvements to water regulation reflect two ecosystem services delivered by NbS: stormwater attenuation and water quality improvement. Assessing changes in these factors before and after implementation will reflect the water regulation improvements resulting from the NbS. Formulation of a composite unit that takes into account these two factors can provide an easy-to-understand overall score for evaluation of NbS performance.

Should there be insufficient information for assessing stormwater attenuation and water quality improvement, permeable surface can be used as a simplified indicator of water regulation improvement functioning.

Detailed Indicator: Water Regulation Improvement

Two factors, storm water attenuation and water quality improvement are considered under the water unit indicator:

Stormwater Attenuation: providing NbS will increase the coverage of vegetation and permeable surfaces that act like a sponge, absorbing excess water during heavy rainstorms then gradually releasing the water, reducing peak flows and flooding risks.

Water Quality Improvement: urban stormwater carries various pollutants from buildings, pavements and roads. Vegetation and soils in the NbS act as a filter and remove pollutants that are carried in stormwater.

The analysis generally uses a modelling approach to analyse climate data (average/peak precipitation), water quality, site topography, NbS design, current land use and vegetation to estimate characteristics of stormwater attenuation (e.g. runoff volume in m^3/yr) and water quality improvement (e.g. sediment loading in TSS/kg/yr). Typical models that can be used to assess stormwater attenuation and water quality improvement include Storm Water Management Model (SWMM) and eWater MUSIC Model. For ease of understanding, indicators for stormwater attenuation and water quality improvement can be reported separately under water units.

To formulate a composite score that takes into account both factors, values for stormwater runoff volume and stormwater runoff sediment load can be normalised with min-max normalisation ($x' = \frac{x - \min(x)}{\max(x) - \min(x)}$), and added up with incorporated weighting allocation (see Figure 32). The weightings for the two factors can be adjusted according to the objectives and specific needs of the projects (i.e. for some projects, runoff volume would be a more important factor than water quality, or vice versa).

Water Unit

1. Runoff Volume

Normalised stormwater runoff volume:

SWM Model to assess total volume of surface run-off (m^3/year)

X

2. Weighting (I)

+

3. Sediment Load

Normalised sediment runoff volume:

SWM Model to assess sediment load in surface run-off (TSS/kg/year)

X

4. Weighting (II)

Sponge city design

Flood retention facilities

Reforestation of degraded hillsides

Good Examples of Design Solutions

Figure 32 | Water Unit

Simplified Indicator: Permeable Surfaces

A simplified indicator of water regulation functions can be provided by calculating the total area of permeable surfaces within the NbS. Areas with a higher proportion of permeable surfaces (i.e. vegetation areas, gravel/woodchip paths, grasscrete and porous paving system) will generally function better in reducing surface run-off and pollution loading than areas with more impermeable surfaces.

Vegetation Areas

Permeable Paving

Woodchip Paths

Figure 33 | Good examples of permeable surfaces

Soil Unit

A measure that can be used to track improvements in soil health achieved through NbS is Soil Organic Matter (SOM). Should there be insufficient information for assessing SOM, green area within an NbS can be adopted as a simplified indicator that indicates healthier soil conditions.

Detailed Indicator: Soil Organic Matter

Whilst most sub-tropical ecosystems have a lower SOM than their temperate counterparts, higher SOM content is generally an indicator of better-quality soils. This can be measured directly through simple collection of soils and laboratory analysis to give a % value of SOM. Reference literature can also be used to estimate SOM (e.g. Zhang et al. 2007).

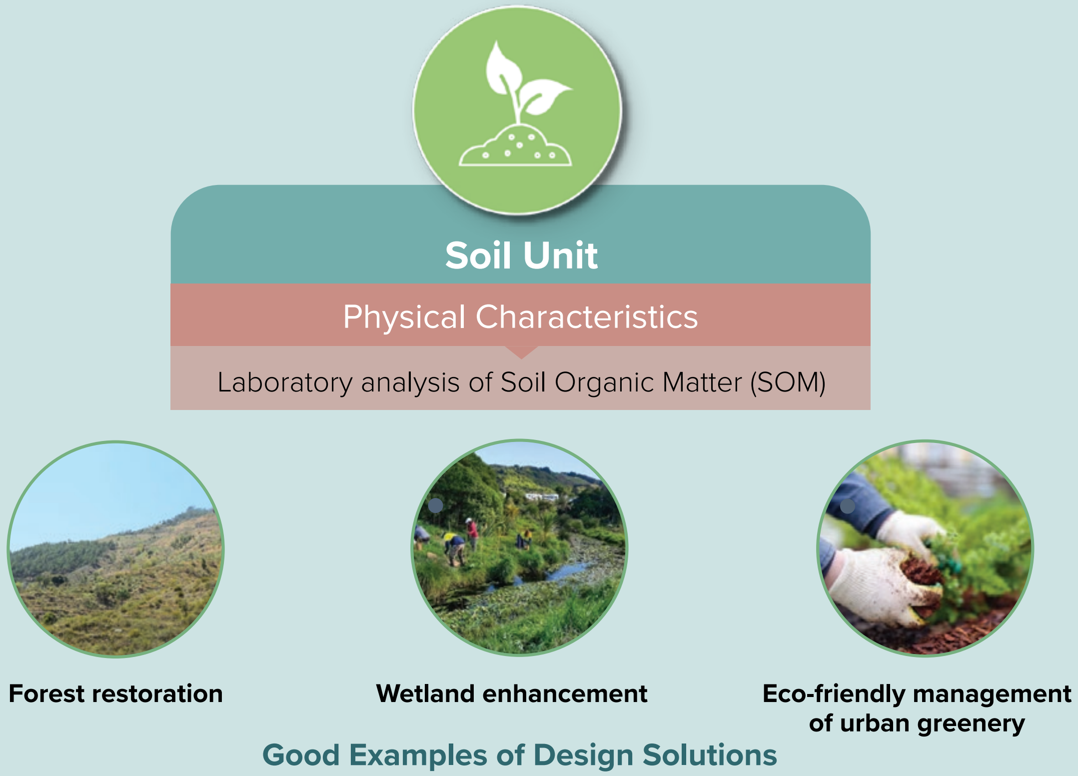


Figure 34 | Soil Unit

Simplified Indicator: Green Area

A general indication of soil health can be gauged by calculating the green area or softscape within an NbS. Green spaces will have soils interacting healthily with the surrounding environment and capable of supporting plant growth. It can therefore be assumed that the soils are in reasonable condition, and healthier than in sites where the topsoil has been removed and/or covered with concrete or other materials.

Air Unit

Two factors can be used to assess NbS performance related to air: air pollutant removal potential and outdoor thermal comfort (OTC). Similar to water units, formulation of a composite unit that takes into account these two factors can provide an easy-to-understand score for evaluation of NbS performance. Should there be insufficient information for assessing air pollutant removal potential and OTC, canopy coverage can be used as a simplified indicator for air regulation performance.

Detailed Indicator: Air Regulation Improvement

Air Pollutant Removal Potential: the air pollutant removal potential of NbS for key pollutants (i.e. PM2.5) can be estimated using simple approaches in published literature (e.g. Xiao et al., 2015) that consider three factors to estimate total pollutant removal efficiency per year (kg/yr): climate (wind speed and precipitation), ambient pollution levels, and the characteristics of vegetation in the Project Area (i.e. Leaf Area Index).

Outdoor Thermal Comfort (OTC): assessing the impact of NbS on OTC can adopt a variety of methods. Typically, this assessment requires complex Computational Fluid Dynamics (CFD) modelling or microclimate modelling to simulate the conditions before and after the implementation of NBS. These models necessitate a range of input data, including urban morphology, meteorological data, and information on shading devices. As this modelling approach can be both time-consuming and costly, other simplified methods can be employed. For instance, green space assessment tools like i-Tree (USDA Forest Service, 2025) and INvest (NatCap at Stanford, 2025) can provide estimates of the cooling benefits from urban trees and green spaces based on simple input data. These tools offer a more accessible way to gauge the potential impact of NbS on outdoor thermal comfort without the need for extensive modelling. These models can also be used to estimate air pollutant removal potential of NbS.

Similar to the water unit, to formulate a composite score that takes into account the two factors, value for PM2.5 and OTC temperature can be normalised with min-max normalisation $(x = \frac{x - \min(x)}{\max(x) - \min(x)})$, and added up with incorporated weighting allocation (see **Figure 35**). Note that the weightings for the two factors can be changed according to the objectives and specific needs of the project (i.e. for some projects, air pollutant removal potential would be a more important factor than OTC, or vice versa).

Air Quality

1. Air Quality

Normalised coefficient:

Estimated removal of PM2.5 (kg/ year)

X

2. Weighting (I)

+

3. Temperature

Normalised coefficient:

Modelling of Outdoor Termal Comfort

X

4. Weighting (II)

Street tree canopy

Urban forestry

Rural reforestation

Good Examples of Design Solutions

Figure 35 | Air Unit

Simplified Indicator: Canopy Coverage

The ability of NbS to improve air quality and improve outdoor thermal comfort is typically linked to canopy cover: trees with a large and dense canopy coverage provide higher rates of air pollution removal and greater shading and evapo-transpiratory cooling than the absence of vegetation or vegetation with smaller and more sparse leaves of incomplete canopy. Hence, canopy cover is proposed to serve as a general indicator of air regulation functions provided by NbS.

Urban streets with no tree provisions

Urban streets with dense canopies

Figure 36 | Designs with Different Canopy Coverage Values

Carbon (tCO2e)

Carbon sequestration can be measured as the sum weight of carbon contained in a particular ecosystem, or the amount of carbon absorbed by that ecosystem per unit of time. Should there be insufficient information for assessing tCO2e per Unit time, canopy cover can be adopted as a simplified indicator for carbon sequestration.

Detailed Indicator: tCO2e per Unit time

Direct measurement of **carbon sequestration** (by sampling biomass and soils to determine the quantity of carbon they contain) is a time consuming and expensive process, so it is common to deploy other techniques to estimate carbon sequestration. Site investigations can be undertaken to characterise **vegetation** and **habitats** on the site (i.e. habitat types, dominant/common tree species, tree densities, tree age profile, soil depth). This information will be coupled with typical sequestration rates of different types of habitat/tree species in the biogeographical location of the project, and combined in a simple model to determine baseline carbon sequestration rates. The same model will then be used to estimate sequestration of following the implementation of the NbS.

A number of existing projects in Hong Kong have assessed carbon sequestration of different habitat types in Hong Kong (e.g. Delang & Yu, 2010 (forest, shrubland and grassland); Zhao & Shing, 2022 (mangroves and mudflats)). Average rates presented in these papers can be referenced to provide a general estimate of sequestration rates of NbS supporting different habitat types. There are two projects currently in progress (CUHK, 2025 and CA & HKU, 2021) that will provide more detailed estimates on carbon sequestration from different habitats in Hong Kong when published.

There are also **green assessment tools** available on-line that can be used to estimate NbS carbon sequestration. These include *i-Tree* (USDA Forest Service, 2025), *INvest* (NatCap at Stanford, 2025) and *Pathfinder* (Climate Positive Design, 2025).

Carbon Unit

1. Above Ground Biomass

+

2. Below Ground Biomass

↓

3. Scientific Literature/ Field Data

Sequestration rate multiplier for estimating total carbon stock from available sources:

a. Published scientific literature
b. Remote sensing data
c. Field measurements

X

4. Weighting (II)

Area of each habitat

Improved soil management
(Below Ground Biomass)

Rural reforestation projects
(Above & Below Biomass)

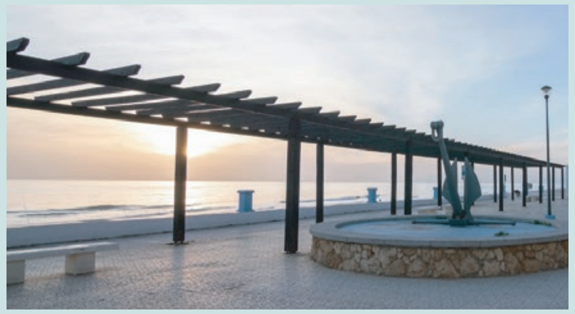
Mangrove planting
(Above & Below Biomass)

Good Examples of Design Solutions

Figure 37 | Carbon Unit

Simplified Indicator: Canopy Coverage

Increased canopy coverage can serve as a general indicator of carbon sequestration: NbS supporting a higher percentage of canopy cover typically performs better by providing more embedded biomass that can store more carbon.



Promenade with no tree provisions

Promenade with continuous canopies and shade

Figure 38 | Comparison of Canopy Coverage of Different Designs

3.2.3 Suggested Socio-economic Indicators

Both the detailed and simplified indicators focus on the key natural capital uplift provided by NbS. However, there are usually scenarios where other aspects of NbS performance need to be assessed, particularly relating to:

- Indicators of other ecosystem services, especially cultural ecosystem services
- Practical aspects of NbS construction and operation.

Six socio-economic indicators have been identified and should be applied alongside detailed and/or simplified indicators as needed. While quantifying these indicators may not always be practicable, rationales and criteria of each indicator are described to guide general assessments on the NbS approach. The six indicators are selected specifically to guide common considerations of planning and designing NbS projects: the capital cost examines both initial expenses and long-term value; buildability assesses resource efficiency; maintenance ensures sustainability; public accessibility focuses on inclusiveness; and spatial quality emphasises both social interaction and visual aesthetics.

Capital Cost

Capital cost includes all expenses required for the initial establishment of the NbS. The NbS approach to capital cost is to prioritise achieving the best value for money by optimising costs, benefits, and sustainability. When assessing NbS projects, the principle of 'the lowest cost wins' is not the sole criterion. Instead, the evaluation of NbS shall be holistic, focusing not only capital cost but also on balancing the other NbS ecosystem services (i.e. such as contribution to the restoration of ecosystems, societal benefits, and climate resilience).

Maintenance and operation

The NbS approach to maintenance and operation should be evaluated by balancing long-term maintenance needs, operational efficiency, and the maximisation of other beneficial factors. Designs that are low in maintenance and self-sustainable, while simultaneously providing ecological, social, and climate resilience benefits, shall be prioritised.

During the design stage, considerations for design flexibility for future modifications to adapt to evolving challenges shall be made. During the operational stage, monitoring and evaluation shall be implemented to inform adaptive management and drive continuous improvements in the NbS.

Buildability

Buildability of NbS shall be evaluated from material sourcing to the construction method. The NbS approach to buildability aims to strike a balance between ease, efficiency, and the other NbS ecosystem services. In line with this, plans for resource efficiency should be integrated into designs to optimise process efficiency and minimise environmental footprint. Priority should be given to locally sourced and sustainable materials, taking into account their advantages in reducing transport costs, mitigating environmental impacts, and facilitating future replacements. Additionally, innovative bioengineering construction methods should be considered for adoption.

Public accessibility

NbS shall be equally accessible for the inclusion of the widest possible array of users. During the planning stage, connectivity with populated areas shall be studied. Harmonious access strategies for both humans and wildlife to coexist should be considered.

Moreover, NbS outside of environmentally sensitive areas should be open to the public for enjoyment by adopting universal and inclusive accessible design principles.

Continuous green corridors

Universal access design considerations

Figure 39 | Good examples of accessibility

Spatial quality - social interaction & enjoyment

The benefits of NbS for social inclusion, health and well-being shall be promoted and captured in its spatial quality. During design stage, gathering spaces that encourage interactions among users shall be considered. Both active and passive recreational activities shall be promoted within the spaces.

Flexible design elements should be incorporated to cater to diverse uses. During the design process, communities shall be engaged to examine existing social needs and design with respect to local cultures and traditions. By taking these into account, the NbS shall foster a sense of belonging and community.

Multi-use gathering space for enjoyment

Designing promoting local and cultural identity

Figure 40 | Good examples of spatial quality - social interaction and enjoyment

Spatial quality - visual & aesthetic

Innovative and creative designs in the aesthetic appearances of NbS shall be promoted and captured in its spatial qualities. During the early design stages, NbS projects shall conduct site investigations to examine the existing site characteristics. During design stage, designs that promote visual harmony with the surrounding environment shall be adopted. Considerations shall be made to create visual interest and aesthetically pleasing appearance by designing focal points and landmarks for visual intrigue. By taking these into account, the spatial quality of NbS shall promote a sense of visual enjoyment.

Buildings designed for visual harmony with surrounding environment

Sculptures designed with natural capital uplifts (e.g. rainwater harvesting for water regulation)

Figure 41 | Good examples of spatial quality - visual and aesthetic

3.2.4 Example of Metric Application

Example with the Simplified and Socio-economic Indicators

An example of the metric with simplified indicators for natural capital and socio-economic indicators evaluated for a hypothetical drainage channel design is shown below.

Indicators are scored on a simple numerical five-point scale consisting of 5 (excellent), 4 (good), 3 (moderate), 2 (poor), and 1 (very poor). The weighting of individual scores can be adjusted on a case-by-case basis, depending on the specific goals of a project (e.g. biodiversity can be assigned a higher weighting if this is a core objective of the project).

In this example, two NbS options are evaluated against a baseline (abandoned vegetated drainage channel) and a grey engineered option to show how the metrics can be used to assist in NbS planning and design. Simplified indicators were used for a general assessment, but a more detailed assessment can be conducted using the five detailed indicators should more information be available. Scores for all indicators are projected values of the Final stage (e.g. for NbS options, projected value when the NbS vegetation/ecosystems mature will be evaluated).

The overall lower score of the grey engineered option reflects its limitations in providing ecosystem services, considering concrete lined channels are impermeable, have minimal structural complexity and do not support vegetation. However, this option scores more highly in some socio-economic aspects; as concrete lined channels are generally easier to construct, have a simple design and lower cost, and have very low maintenance requirements. As would be expected, the NbS options generally exhibit higher scores on key NbS functions, though they may require higher building cost, with more complex designs and greater maintenance. Based on the scores of different options, project proponents can select the option that best suits their objectives and needs.

Baseline: Abandoned vegetated drainage channel

Nbs Option 1: (People Focus) Hybrid drainage channel

Grey Engineered Option: Engineered drainage channel

Nbs Option 2: (Nature Focus) Natural drainage channel

Figure 42 | Hypothetical examples of drainage channel design

Table 2 Metric application example with simplified and socio-economic indicators

Simplified and Socio-economic Indicators	Baseline	Grey Engineered Option	NbS Option 1 (People Focus)	NbS Option 2 (Nature Focus)
Five Simplified Indicators on Key NbS Functions				
Habitat value	3	1	4	5
Species richness/ diversity	2	1	4	5
Permeable surfaces	3	2	3	5
Green area	3	1	4	5
Canopy coverage	1	1	4	5
Sub-total unweighted score of simplified indicators	12	6	19	25
Six Socio-economic Performance Indicators				
Capital cost	NA	3	3	5
Buildability	NA	4	3	5
Maintenance and operation	NA	5	3	4
Public accessibility	NA	1	5	3
Spatial quality - social Interaction & enjoyment	NA	1	5	3
Spatial quality - Visual & aesthetic	NA	1	5	5
Sub-total unweighted Score of socio-economic Performance	NA	15	24	25
Nbs composite score	12	21	43	50

3.2.5 Other Aspects to Evaluate for Addressing Societal Challenges

To provide project proponents with further tools to evaluate NbS performance in addressing societal challenges, the following indicators can be considered. These tools are intended for adoption based on the site-specific context and the individual needs of each project.

Equity to Nature

An NbS approach to population catchment shall ensure equal accessibility within neighbourhoods without compromising the ecological integrity of the site. To promote social equity, the design should facilitate the inclusion of the widest possible array of users as part of shared public benefits. Echoing the 15-minute neighbourhood concept promoted in the Northern Metropolis, this indicator assesses NbS designed with a 15-minute walking access threshold from population catchment to the boundaries of the NbS, aiming to maximise the daily exposure of targeted users to nature. While ensuring universal and inclusive access through strong connectivity with populated areas, the strategy must not overlook nature objectives; instead, it should implement harmonious access strategies that allow both humans and wildlife to coexist.

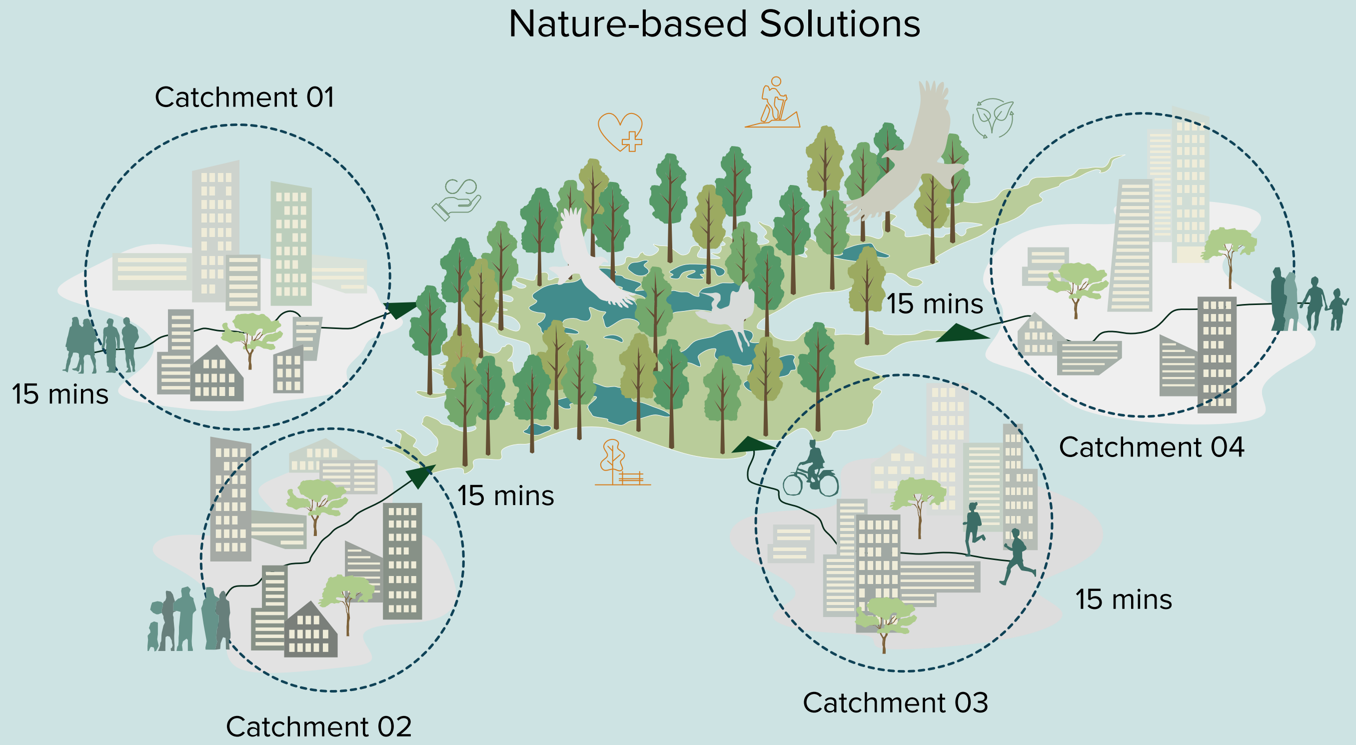


Figure 43 | Conceptual Diagram of Population Catchment in 15-min neighbourhood

NbS Related Job Opportunities

The evaluation of job opportunities should emphasise the role of NbS in stimulating employment linked directly and indirectly to natural capital. Direct job creation includes roles for eco-stewards with a specific focused on education and nature management, as well as a potential new green-tech sector in ecological data monitoring responsible for both adaptive and NbS-performance management. Indirect job creation refers to the potential of a NbS to enhance business performance within its proximity.

For example, an iconic NbS design could act as a catalyst for local economic vitality, leveraging synergies with mixed land uses, active frontages, and businesses that utilise NbS-derived resources such as improved visual and spatial quality, enhanced climate resilience, better air quality, and other sensory stimulation, etc. Furthermore, projects could be assessed on their collaboration with educational institutes to establish "living laboratories" that build a skilled workforce and attract talent for long-term NbS-related employment.

Direct job opportunities through ecological data monitoring

Indirect job opportunities through alfresco dining

Figure 44 | Examples of NbS Related Job Opportunities

Wellness Impact

The NbS approach to wellness and active living should highlight the role of therapeutic landscapes in providing physical and psychological health benefits through high-biodiversity environments. Performance can be measured by how effectively the design leverages regulating ecosystem services—such as air filtration, acoustic buffering, and outdoor thermal comfort—to meet the needs of users for a holistic, active lifestyle.

Spaces should be designed to encourage biophilic interactions through sensory gardens, enhanced visual connections to nature, and community stewardship programmes. Finally, the design must demonstrate adaptive multi-functionality to manage seasonal dynamics, such as a space that serves as a vibrant community gathering area during dry seasons and a sunken plaza for flood retention during extreme weather.

Gathering spaces for communal active lifestyles

Sensory gardens to encourage biophilic interactions

Figure 45 | Examples of Wellness Impact of NbS

3.3 Data Collection and Digital Monitoring

3.3.1 Introduction

The **indicators** outlined in the above rely on substantial amounts of data. While some of these can be sourced from published literature, site data is preferable, and essential for longer term performance monitoring and adaptive management. Using traditional methods, collecting these data can be time consuming and resource intensive. For this reason, measuring and monitoring the performance of NbS can make use of various emerging technologies that enhance data collection and analysis using digital monitoring techniques.

Figure 46 | Traditional methods to be enhanced using digital monitoring techniques

3.3.2 Emerging Technologies for Data Collection and Digital Monitoring

Emerging technologies can facilitate data collection and analysis. Technologies typically save time and money when becoming mature and credible and increasing the effectiveness of NbS monitoring and management.

Four key digital monitoring approaches are outlined below.

Figure 47 | Digital Monitoring Tools

Camera Traps

Camera traps are an established ecological survey technology that can be deployed to collect data on cryptic/low density species such as Eurasian Otter. More modern GPS/4G camera traps allow for footage to be remotely accessed, viewed and automatically uploaded into a cloud for auto-processing by an AI tool. This significantly improves the efficiency of data sorting and analysis.

Figure 48 | Applications of Camera Traps

Bioacoustics Recorders

Similar to camera traps, bioacoustics recorders can be deployed remotely, recording vocalising animals (i.e. birds, amphibians and bats) over an extended period of time. AI software can be used to automate data processing and identification of animals and track changes in species composition.

Figure 49 | Applications of Bioacoustics Recorders

Environmental DNA (eDNA)

Environmental DNA (eDNA) refers to fragments of genetic material left in the environment by the organisms. Modern laboratory techniques mean that these small fragments can be collected in samples of water, soil or air from any particular environment, allowing us to identify the animals, plants, bacteria and fungi once present in that location. This powerful new sampling tool is especially useful in surveying microorganisms (a core component of soil biota and an indicator of soil health) as well as cryptic, rare species that are difficult to record with more conventional survey methods.

Figure 50 | Applications of Environmental DNA (eDNA)

LIDAR

LIDAR refers to Light Detection and Ranging methods that use lasers to build up detailed, geo-referenced 3-D digital images. LIDAR equipped drones (and increasingly hand-held LIDAR units) can be used to map the location of trees and assess the size and spread of tree canopies: important data for assessing ecosystem services such as:

- **Assessing forest structural diversity to assist in biodiversity metric calculations;**
- **Measure canopy coverage to assist in air quality and outdoor thermal comfort assessments; and**
- **Estimating above ground biomass to assist in carbon sequestration assessments.**

Figure 51 | Applications of LiDAR and Drone

4. Conclusion

4.1 The Way Forward

As we move forward, the commitment to NbS in Hong Kong remains steadfast. These Design Guidelines have been meticulously prepared to make key NbS design concepts accessible to a broader audience, including government staff, private developers, researchers, scientists, non-governmental organisations, and civil society. By providing a common understanding of NbS design elements, we aim to foster cross-sector collaboration and to address key societal challenges such as climate change adaptation and mitigation, as well as biodiversity enhancement.

These Guidelines focus on NbS design principles, and do not yet cover some common non-design elements of NbS. Future versions of this HKNbSDG could be expanded to incorporate guidance and best practices for future financing, management and maintenance, and stakeholder engagement.

4.2 Conclusion

Looking ahead, the Hong Kong Government will continue to actively support and develop NbS initiatives, ensuring they are integrated into our urban planning and sustainable development. By focusing on education, co-creation, community engagement, financing, management, monitoring, and maintenance, we aim to build a resilient and sustainable future.

We would like to extend our heartfelt gratitude to all stakeholders, practitioners, and community members for their invaluable support of and contributions to the HKNbSDG. We commit to continuously improve the quality of life in Hong Kong, where nature and urbanity can co-exist harmoniously, enhancing biodiversity and societal well-being for generations to come.

In conclusion, the successful implementation of NbS in Hong Kong requires a collaborative and inclusive approach that addresses the local environmental and development context, and considers the diverse opinions of various stakeholders. We hope that these Guidelines promote the widespread adoption of NbS across Hong Kong.

References

AECOM & Camphora. (2024). Singapore Biodiversity Accounting Metric: Version 1.1. Plan Engage. http://anz.planengage.com/singapore-bio-metric

Agriculture, Fisheries and Conservation Department (AFCD). (2025). Biodiversity of Hong Kong. Hong Kong Biodiversity Information Hub. https://bih.gov.hk/en/about-us/index.html

Beijing Municipal Administration for Market Regulation (n.d.). Code for the evaluation of territorial ecological restoration plan implementation (draft for soliciting opinions).

Cardinali, M., Dumitru A., Vandewoestijne, S., & Wendling L. (2021). Evaluating the impact of nature-based solutions: A summary for policy makers. European Commission EC, 2021.

Chinese Hydraulic Engineering Society (n.d.) Technical guide for ecological design of sea dike (draft for approval).

Cho (2024). How Climate Change Drives the Spread of Invasive Plants. https://news.climate.columbia.edu/2024/03/12/how-climate-change-drives-the-spread-of-invasive-plants/

Cleland, E. E. (2011). Biodiversity and Ecosystem Stability. Nature Education Knowledge 3(10):14

Climate Positive Design. (2025). Pathfinder. https://climatepositivedesign.org/education/

Connop, S., Nash, C., Elliot, J., Haase, D., & Dushkova, D. (2020). Nature-based solution evaluation indicators: Environmental Indicators Review. Connecting Nature. https://connectingnature.eu/sites/default/files/images/inline/CN_Env_Indicators_Review_0.pdf

Convention on Biological Diversity. (1992). Text of the convention. United Nations. https://www.cbd.int/convention/text/

Convention on Biological Diversity (2022). Decision Adopted by the Conference of The Parties to the Convention on Biological Diversity. 15/4. Kunming-Montreal Global Biodiversity Framework.

Dai, T., Liu. R., Zhou, X., Zhang, J., Song, M., Zou, P., Bi, X., & Li, S. (2023) Role of Lake Aquatic–Terrestrial Ecotones in the Ecological Restoration of Eutrophic Water Bodies. Toxics 2023, 11(7), 560; https://doi.org/10.3390/toxics11070560

Delang, C., & Yu, Y.H. (2010). Remote Sensing-Based Estimation of Carbon Sequestration in Hong Kong Country Parks from 1978 to 2004. Open Environmental Sciences. 3. 10.2174/1876325100903010097. https://www.researchgate.net/publication/228422273_Remote_Sensing-Based_Estimation_of_Carbon_Sequestration_in_Hong_Kong_Country_Parks_from_1978_to_2004

Drainage Services Department (DSD) (2021) Drainage Services Department Practice Note No. 3/2021 Guidelines on Design for Revitalisation of River Channel. Version No.1.

Drainage Services Department (DSD) (2022a) Drainage Services Department Practice Note No. 3/2022 Guidelines on Bioretention System. Version No.1.

Drainage Services Department (DSD) (2022b) Drainage Services Department Practice Note No. 4/2022 Guidelines on Water Harvesting. Version No.1.

Environmental Protection Department (EPD). (2021). Legislative Council Panel on Environmental Affairs Enhancing the Quality of Coastal Waters of Victoria Harbour. LC Paper No. CB(1)908/20-21(05). The Legislative Council Commission. https://www.legco.gov.hk/yr20-21/english/panels/ea/papers/ea20210524cb1-908-5-e.pdf

Graham, N.A.J. & Nah, K.L. (2013). The importance of structural complexity in coral reef ecosystems. Coral Reefs 32: 315–326.

Hong Kong Government. (2025). Air Quality in Hong Kong. GovHK. https://www.gov.hk/en/residents/environment/air/airquality.htm

International Federation of Consulting Engineers (FIDIC), World Wildlife Fund (WWF), & AECOM. (2023). A Playbook for Nature-Positive Infrastructure Development. World Wildlife Fund. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/3cv0m8510d_WWF_Playbook_v1_1_Pages_1_.pdf

IUCN. (2016). WCC-2016-Res-069-EN Defining Nature-based Solutions. IUCN: https://portals.iucn.org/library/sites/library/files/resrecfiles/WCC_2016_RES_069_EN.pdf

IUCN (2020). Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS. First edition. Gland, Switzerland: IUCN. https://doi.org/10.2305/IUCN.CH.2020.08.en

Jim, C.Y. (1998). Urban soil characteristics and limitations for landscape planting in Hong Kong. Landscape and Urban Planning 40(4): 235-249. https://www.sciencedirect.com/science/article/abs/pii/S0169204697001175

Kadoorie Farm and Botanic Garden (KFBG). (2025). Soil Enhancement. KFBG.https://www.kfbg.org/en/caring-for-our-hillside/working-the-ground/soil-enhancement

Kovalenko, K.E., Thomaz, S.M. & Warfe, D.M. (2012). Habitat complexity: approaches and future directions. Hydrobiologia 685: 1-17.

Krosby, M., Tewksbury, J., Haddad, N. M., & Hoekstra, J. (2010). Ecological Connectivity for a Changing Climate. Conservation Biology, 24(6), 1686–1689.

Lai, D.Y.F., Tai, A.P.K., Ng, M.K., Brander, L. (2022). Provision of Consultancy Service to Conduct a Study on Ecosystem Services in Hong Kong – Revised Final Report.

Luo, M., Zhang, Y., Cohen-Shacham, E., Andrade, A., Maginnis, S. (eds.) (2023). Towards Nature-based Solutions at scale: 10 case studies from China. Gland, Switzerland: IUCN, and Beijing, the People's Republic of China: Ministry of Natural Resources.

Millennium Ecosystem Assessment (MEA). (2003). Ecosystems and human well-being: A framework for assessment. Island Press, Washington.

Ministry of Ecology and Environment (n.d.a). Technical guideline for the evaluation of ecological and environmental impact of human activities within the ecological conservation redline (draft for soliciting opinions).

Ministry of Ecology and Environment (n.d.b). Technical guidelines for eco-environmental performance assessment of ecological conservation and restoration projects (on trial) (draft for soliciting opinions).

NatCap at Stanford. (2025). The Natural Capital Project. Standford University. https://naturalcapitalproject.stanford.edu/about

National Development and Reform Commission Ministry of Natural Resources (2020). 全国重要生态系统保护和修复重大工程 总体规划（2021—2035年）.

Natural England. (2024). The Statutory Biodiversity Metric User Guide. Department for Environment, Food & Rural Affairs. https://assets.publishing.service.gov.uk/media/669e45fba3c2a28abb50d426/The_Statutory_Biodiversity_Metric_-_User_Guide__23.07.24_.pdf

Network Nature. (2025). Nature-based solutions knowledge databases. Network Nature. https://networknature.eu/nature-based-solutions-knowledge-databases

Public Utilities Board (PUB) (2024) ABC Waters Design Guidelines. 5th edition.

Somarakis, G., Stagakis, S., and Chrysoulakis, N. (Eds.). (2019). ThinkNature Nature-Based Solutions Handbook. ThinkNature project funded by the EU Horizon 2020 research and innovation programme under grant agreement No. 730338. doi:10.26225/jerv-w202

Sowińska-Świerkosz, Barbara & García, Joan. (2021). A new evaluation framework for nature-based solutions (NBS) projects based on the application of performance questions and indicators approach. Science of The Total Environment. 787. 147615. 10.1016/j.scitotenv.2021.147615.
https://www.sciencedirect.com/science/article/pii/S0048969721026863

The Chinese University of Hong Kong (CUHK). (2025). Assessing the Contribution of Coastal Wetlands on Lantau Island to Carbon Sequestration in Hong Kong. Lantau Blue Carbon Research. https://www.lantaubluecarbon.org/en/about

The Conservancy Association (CA) & The University of Hong Kong (HKU). (2021). Forest Carbon Stock Estimation in Hong Kong. https://csthk21.wixsite.com/website

The Nature Conservancy (TNC). (2024). Unlocking The Potential Of Nature In Climate Action and Planning: A Report on Hong Kong's Nature-based Solutions. The Nature Conservancy.https://www.tnc.org.hk/content/dam/tnc/nature/en/documents/TNCHK_NBS_Report_March2024.pdf

Third Institute of Oceanography, Ministry of Natural Resources, Island Research Center, Ministry of Natural Resources, Second Institute of Oceanography, Ministry of Natural Resources, Ocean University of China. (2021). Technical guidelines for marine ecological restoration

UNEP. (2022, Dec 19). Decision Adopted by The Conference of the Parties to the Convention on Biological Diversity 15/4. Kunming-Montreal Global Biodiversity Framework. https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf

U.S. Department of Agriculture Forest Service (2025). I-Tree. https://research.fs.usda.gov/products/dataandtools/i-tree

U.S. Department of the Interior (USDI) (2009). Adaptive Management: The U.S. Department of the Interior Technical Guide. 2009 Edition. https://pubs.usgs.gov/publication/70194537

World Bank, 2021. A Catalogue of Nature-based Solutions for Urban Resilience. Washington, D.C. World Bank Group

World Health Organization (WHO) (2024). Ambient (outdoor) air pollution. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

WWF Hong Kong (2024). Adopting Nature-based Solutions for a Better Hong Kong

WWF. (2023, Sep 6). Nature Positive Initiative launches to promote the integrity and implementation of the Global Goal for Nature. WWF: https://wwf.panda.org/wwf_news/?9615416/nature-positive-initiative-launch

Xiao Yu , Wang Shuo , Li Na , Xie Gaodi , Lu Chunxia , Zhang Biao, Zhang Changshun . Effect of urban green space on reducing atmospheric PM 2.5 in Beijing [J]. Resources Science, 2015, 37(6): 1149-1155.https://www.resci.cn/CN/Y2015/V37/I6/1149#4

Yee, M & Kaplan, J.O. (2022). Drivers of urban heat in Hong Kong over the past 116 years. Urban Climate 46.https://www.sciencedirect.com/science/article/pii/S2212095522002267

Zeng, Y. (2023) The Impact of Climate Change on Wildlife and Ecosystems. Journal of Biodiversity & Endangered Species. Review Article (11) 478.

Zhang, H., Luo, Y., Wong, M., Zhao, Q., & Zhang, G. (2007). Soil organic carbon storage and changes with reduction in agricultural activities in Hong Kong. Geoderma, 139(3–4), 412–419. https://doi.org/10.1016/j.geoderma.2007.03.003

Zhao, L.C., & Shing, Y.L. (2022). Sediment carbon sequestration and sources in peri-urban tidal flats and adjacent wetlands in a megacity, Marine Pollution Bulletin 185(B). https://doi.org/10.1016/j.marpolbul.2022.114368.

Appendix

Local Case Studies

This Appendix reviews several local projects that showcase various elements of the NbS Principles and Guidelines. The case studies cover a diversity of landscape types and development contexts, demonstrating how the Principles and Guidelines can be applied in different scenarios. The Appendix highlights key guidelines of most relevance to each case study.

Case Study 1: Long Valley Nature Park

Introduction

As a key component of the Kwu Tung North and Fanling North New Development Area, the 37 ha Long Valley Nature Park (LVNP) uniquely integrates wetland conservation, farming operations, and nature education in one place. LVNP has achieved significant biodiversity enhancement by transforming underutilised farmlands into diverse wetland habitats, expanding the wetland area by 8 hectares, and attracting critically endangered birds like the yellow-breasted bunting. Additionally, LVNP has implemented an innovative water treatment wetland that purifies irrigation water from the Sheung Yue River through sedimentation, macrophyte filtration, and natural disinfection, ensuring sustainable irrigation water supply for irrigation and for supporting the wetlands of the park. The comprehensive management approach reinforces Long Valley Nature Park's role in supporting biodiversity and sustainable practices in the area, which helps provide climate change mitigation and adaptation, promote economic and social development, enhance human health, food security and water security, and address environmental degradation and biodiversity loss.

Exhibited NbS Guidelines

Guideline 1:
Enhancing Habitat and Spatial Diversity at Macro Scale

The LVNP contains a mosaic of wet and dry agricultural land, marshes, water ponds and water channels. The ratio of wet and dry habitats is maintained at 7:3 and arranged in a mosaic spatial pattern to increase the habitat diversity for wildlife with different ecological niches, thereby enhancing overall biodiversity. These mosaics of habitats allow the bird number to increase by 20% - 40% in different seasons compared to pre-project levels on the basis of HKBWS data, and discovery of new bird species within LVNP.

Guideline 3:
Creating Complex Micro-habitats

Different crops and native wetland plant species such as water spinach, water chestnut and reed are being planted with different density and water depth in different areas of the LVNP to increase habitat complexity to cater for needs of different species.

Guideline 4:
Addressing Societal Challenges through Nature-based Solutions

Although first established as an ecological mitigation measure for the Kwu Tung North and Fanling North New Development Area, the LVNP was designed to provide a large public open space for recreation and education use, while also resulting in multiple societal benefits. It provides regulating services such as water purification and flood control, cultural services in the form of public education, provisioning services like food production and supporting services including nutrient recycling and soil nutrient enrichment.

Guideline 5:
Designing Human Nature Composition in Context

The park employs a zoned management approach, dividing the area into Visitor, Agriculture, and Biodiversity Zones, which balances ecological conservation with human activities while minimising disturbances to wildlife habitats.

Guideline 7:
Addressing Climate Challenges

A 1.9-kilometer irrigation network was constructed to resolve the existing pre-project irrigation issues across the site, as well as providing climate resilience to future water supply insecurity. The irrigation network was constructed with natural materials (i.e. gabion units) that harmonise with the park's natural landscape, offering a habitat for reptiles and amphibians.

Guideline 8:
Building Ecological Resilience

By restoring and/or enhancing abandoned and/or low ecological value habitats and expanding wetland areas by 8 hectares, LVNP provided large areas of wetland habitats with different spatial and species variation, which enhances connectivity of the overall wetland ecosystem in the New Territories, thereby strengthening the nature resilience of the entire area.

Guideline 9:
Promoting Socio-economic Sustainability

The planning and design of the LVNP acknowledges the original freshwater agriculture setting of Long Valley while enhancing area for conservation. In addition to providing biodiversity benefits, the LVNP also provides a venue for farmers to continue their farming operations, and opportunities for nature education and recreation.

Figure A1 | Long Valley Nature Park

Case Study 2: Tung Chung East Eco-shoreline

Introduction

Tung Chung East Eco-shoreline is a reclamation project under Agreement No. CE 69/2015 (CE) – Tung Chung New Town Extension (East) – Design and Construction. The Project is designed to integrate sustainable practices that enhance local biodiversity while minimising environmental impact, addressing the need for shoreline protection and recreational space in the area. In this context, the project aims to balance ecological integrity with community demands. The design maximises structural diversity by incorporating various habitat types, including rocky, mangrove, and vertical eco-shorelines, to improve ecological functionality and habitat diversity. Bio-blocks with complex textures and cavities were deployed. These features provide essential shelter and breeding sites for over 30 types of marine organisms, enriching local biodiversity and promoting a robust coastal ecosystem. The eco-shoreline can provide climate change mitigation and adaptation, reduce disaster risk, enhance human health, and address environmental degradation and biodiversity loss.

Exhibited NbS Guidelines

Guideline 1:
Enhancing Habitat and Spatial Diversity at Macro Scale

The sediment and nutrient-rich, low-salinity waters of Tung Chung support extensive soft-shore communities such as mangroves, mudflats, and sandy beaches, where suitably sheltered shorelines occur. These communities tend to be more productive and diverse than hard shorelines in the area. Although hard-shoreline habitats are likely to support a lower abundance and diversity of intertidal fauna and flora than soft-shoreline habitats, they provide habitats that support different community types not associated with the mangroves and mudflats, particularly epifaunal species such as rock oysters, limpets, barnacles, and mussels. The design of the Tung Chung East Eco-shoreline includes rocky, mangroves, and vertical eco-shorelines. The mangrove eco-shoreline comprises of mudflats, oyster baskets, as well as planting of mangrove. The rocky eco-shoreline comprises of bio-blocks and oyster baskets. The vertical eco-shoreline comprises of eco-pattern, eco-drillhole, eco-pot and bird resting area.

Guideline 2:
Diversifying Habitat Components at Intermediate Scale

The adoption of bio-blocks at the Tung Chung East Eco-shoreline, showcasing within NbS through man-made interventions, can mimic the ecological functions of a natural rocky shoreline while serving as an essential component in coastal defence, ensuring the integrity of the shoreline is maintained. In addition, planting of mangrove at the mangrove eco-shoreline also provided multiple microhabitats for coastal wildlife, as well as natural coastal defence.

Guideline 3:
Creating Complex Micro-habitats

Bio-blocks designed in intertidal zones with enhanced surface complexity are instrumental in establishing and nurturing vibrant marine ecosystems. The creation of various niches that offer different degrees of and exposure to physical stresses like heat and desiccation, as well as biological stresses such as competition and predation, fosters higher biodiversity, spanning from algae and invertebrates to fish.

Guideline 4:
Addressing Societal Challenges through Nature-based Solutions

Alongside the major objectives of providing coastal protection for climate change mitigation and adaptation through artificial and natural defences, as well as mimicking natural intertidal zones to provide suitable habitats for growth of marine organisms, the eco-shoreline also provide a wide range of ecosystem services including soil formation through planting of mangrove, water purification, as well as recreational and educational opportunities.

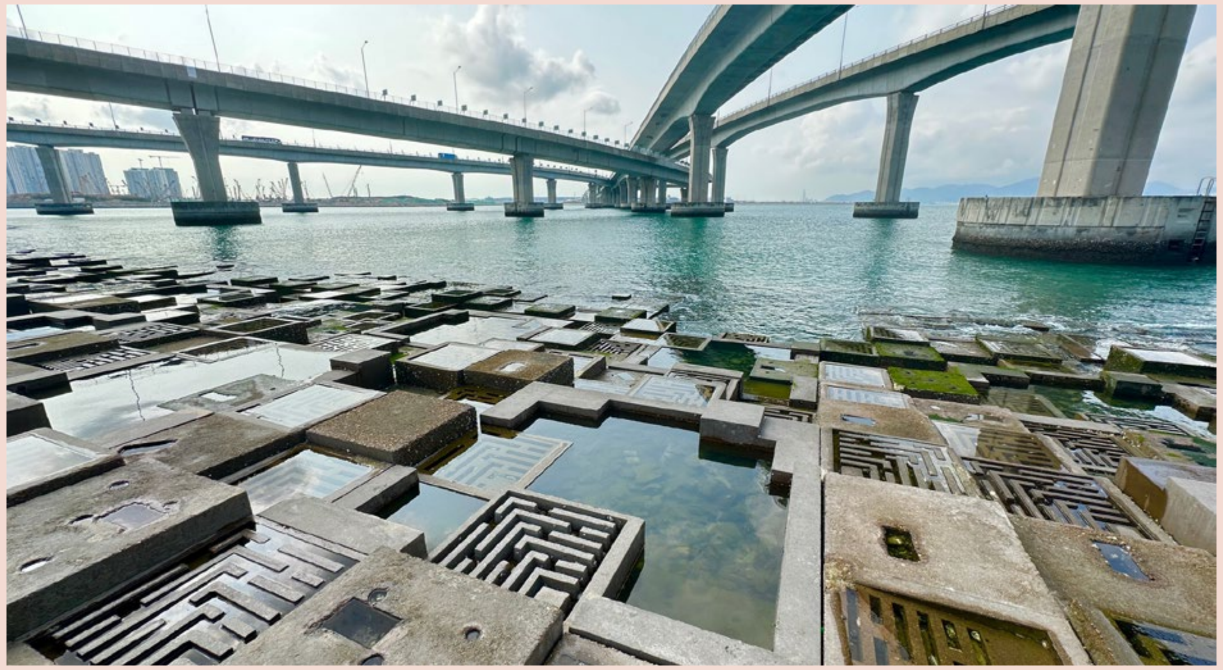


Figure A2 | Bio-block at the Tung Chung East Eco-shoreline

Guideline 7:
Addressing Climate Challenges

Eco-shoreline stabilises the shoreline, reducing erosion caused by waves and storms, provide habitats for various species, promoting biodiversity and supporting ecosystems, absorb wave energy and reducing storm surge impacts. Also, the vegetation used in eco-shorelines can capture and store carbon, helping to mitigate climate change.

Case Study 3: Kadoorie Farm and Botanic Garden Forest Restoration

Introduction

The Forest Restoration and Rejuvenation project at Kadoorie Farm and Botanic Garden (KFBG) aims to restore and enhance the ecological value of the northern slopes of Tai Mo Shan. Initially barren in the 1950s, the area saw extensive planting of fruit and fast-growing trees. However, many of these non-native trees have aged poorly, leading to issues such as dense thickets, soil erosion, and safety hazards. To facilitate recovery in the wake of the removal of these old trees, a large number of native tree seedlings are being planted, particularly along the Never-Never Trail, at the old Signpost Corner, on Kwun Yum Shan, and around the Kadoorie Brothers Memorial Pavilion. All the seedlings are tagged and protected by tree guards, and their basal diameter and height are regularly measured. With the vigorous efforts of arborists, ecologists, and horticulturalists, KFBG's hillside is slowly but surely reverting to mixed native woodland of high ecological value. The forest restoration and rejuvenation project can provide climate change mitigation and adaptation, reduce disaster risk, promote human health, and alleviate environmental degradation and biodiversity loss.

Exhibited NbS Guidelines

Guideline 1:
Enhancing Habitat and Spatial Diversity at Macro Scale

The changing physical environment of the reforestation site paves the way for habitat recovery design and planning. For example, the decomposition of the needles of *Pinus elliottii*, a conifer from the south-eastern United States, has altered the pH and other properties of the soil, making it difficult for native species to establish. Hence, these old trees are being removed, and native tree seedlings are being planted to create mixed native woodland habitat that enhance the ecological performance.

Guideline 4:
Addressing Societal Challenges through Nature-based Solutions

Restoration of the forest not only brings back native biodiversity and recover ecological condition of the slopes of Tai Mo Shan, but can bring about various ecosystem services, including carbon sequestration, water purification, and air quality improvement. It also supports local wildlife, improves soil health, and enhance the safety of visitors.

Guideline 8:
Building Ecological Resilience

Native tree species, including ivy tree, Lingnan mangosteen, glossy-leaved *Elaeocarpus* etc., were planted in mid-elevation forest. Native trees are well-adapted to the local climate, soil, and ecosystem. This means they are more likely to thrive and require less maintenance compared to non-native species (old and aged trees). Native trees provide habitat and food for local wildlife, including birds, insects, and mammals. This helps maintain and enhance biodiversity, creating a balanced and resilient ecosystem.

Figure A3 | Outlook prior to reforestation

Figure A4 | Outlook after reforestation

Case Study 4: Taikoo Place

Introduction

Situated in a highly dense urban environment, Taikoo Square transforms this constraint into an opportunity by using biophilic design to enhance biodiversity and promote community well-being. The project features green corridors connecting to nearby natural areas like Mount Parker and Quarry Bay Park, facilitating wildlife movement and enriching urban biodiversity. By integrating over 260 native and exotic plant species, it creates diverse habitats that support local wildlife, including birds, butterflies, and insects. Additionally, Taikoo Square improves the microclimate by enhancing rainwater retention and air quality through its landscaped areas, fostering a resilient urban environment that can withstand climate challenges while supporting diverse wildlife habitats. The adoption of biophilic design can provide climate change mitigation and adaptation, enhance human health, and address environmental degradation and biodiversity loss.

Exhibited NbS Guidelines

Guideline 2:
Diversifying Habitat Components at Intermediate Scale

"Fung shui woodland" tree species, including *Endospermum chinense*, *Sarcosperma laurinum*, and *Sterculia lanceolata* seedlings from the local Kadoorie Farm and Botanic Garden, were procured and planted on-site. Both native and exotic plant species were planted in Taikoo Square, fostering a complex and rich species composition.

Guideline 4:
Addressing Societal Challenges through Nature-based Solutions

With an aim to increase urban biodiversity and connect people with nature, Taikoo square also brings about a wide range of benefits, including regulating ecosystem services like heat regulation, air quality improvement, rainwater retention, and recreation as a cultural service.

Guideline 6:
Harmonising Urban-Nature Transitions

The selection of over 260 native and exotic plant species to enhance the overall ecological value for local wildlife, forming a green corridor that enables birds, butterflies, and other insects to move from neighbouring natural environment (Mount Parker and Quarry Bay Park) to built environment (Taikoo Place), further boosting biodiversity within the otherwise highly urbanised area. A recent discovery of orange-headed thrush (which mainly lives in closed-canopy forests and mature shrublands) at the garden has showcased the ability of this green corridor in attracting non-urban species into more urbanised areas.

Guideline 9:
Promoting Socio-economic Sustainability

Native species planted in Taikoo Square allow the formation of a captivating yet low maintenance landscape, which has become the key feature and selling point of Taikoo Place. The provision of open space and park areas offers public enjoyment and serves as habitats for urban landscapes within the NbS community. The low maintenance requirement together with the social values provided incentive for maintaining the NbS in the long run for continued benefits, thereby enhancing socio-economic resilience of this NbS.

Figure A5 | Taikoo Place

Case Study 5: The Nature Conservancy Oyster Reef Restoration Pilot Project

Introduction

The Nature Conservancy (TNC) has launched an ambitious initiative to understand and quantify the critical ecological benefits of oyster reefs and to restore shellfish reefs in Deep Bay, northwestern Hong Kong. They have deployed two pilot oyster reefs in Lau Fau Shan and Tolo Harbour using discarded shells, which can provide climate change mitigation and adaptation, and help alleviate environmental degradation and biodiversity loss. Over the coming years, TNC will continuously monitor the growth of these reefs and their impact on biodiversity and water quality. These pilot projects are crucial for collecting data and developing restoration methods for future large-scale efforts.

Exhibited NbS Guidelines

Guideline 2:
Diversifying Habitat Components at Intermediate Scale

Oyster reefs are created from recycled oyster, mussel, and scallop shells, which are then being laid in the sun for a few months. The shells are bagged up and taken to our reef restoration sites. As part of the reef construction process, the recycled shells are placed into the sea as a 'settlement substrate' for juvenile oysters to grow onto. The man-made oyster reef structure is a replica of natural oyster reef habitats.

Guideline 7:
Addressing Climate Challenges

By promoting healthy marine ecosystems, oyster reefs contribute to carbon sequestration, helping to mitigate climate change. It also provides habitats for a variety of marine life, supporting biodiversity and healthy ecosystems.

Guideline 8:
Building Ecological Resilience

Oyster reefs are habitats for juvenile fish and other marine life. Oyster can clean up murky waters to create healthy environments for seagrass, small fish and other species to thrive, hence increasing local biodiversity. This diversity strengthens the ecosystem, making it more resilient to environmental changes and disturbances.

Figure A6 | Bags of recycled oyster shells to be used as substrate for new reefs

Case Study 6: Revitalisation of Tsui Ping River

Introduction

The revitalisation of Tsui Ping River comprises the transformation of about one kilometre of the existing King Yip Street Nullah alongside King Yip Street, King Yip Lane and Tsui Ping Road into Tsui Ping River with environmental, ecological and landscaping upgrading. The key objectives of this project included revitalising the river channel and enhancing water quality through various waterscape, landscape and ecological features (e.g. water gates, aquatic plants and engineered wetlands) to provide a green riverine corridor and improve living environment for the community; improving riverside walkways and providing cross-river footbridges and landscaped decks to enhance walkability and connectivity of the River with the surroundings; creating a green riverine corridor with water scenery and amenity for the community that create synergy with adjacent Tsui Ping River Garden and other amenity and recreational spaces in the vicinity; and strengthening hydraulic capacity of the existing watercourse through means like removing existing footbridge ramps, deepening the channel and installing 1.2m tall flood walls at upstream section. The project also comprises provision of Dry Weather Flow Interceptor (DWFI) system and modification of underground stormwater storage tanks near the River. The revitalisation of Tsui Ping River has been completed and were opened for public use in December 2024. The revitalisation of Tsui Ping River provides climate change mitigation and adaptation, reduces disaster risk, promotes human health and water security, and alleviates degradation and biodiversity loss.

Exhibited NbS Guidelines

Guideline 1:
Enhancing Habitat and Spatial Diversity at Macro Scale

The revitalisation project involved planting aquatic vegetation along the River, and provision of engineered wetland. These wetland habitats, alongside terrestrial habitats kept along the bankside and the watercourse habitat, maximised the habitat diversity. The revitalisation work can enhance the ecological performance of the watercourse.

Guideline 3:
Creating Complex Micro-habitats

In this revitalisation project, multiple features are included to create a series of microhabitats for wildlife in surrounding areas. These included wooden hunting perches for birds to rest and forage, rock pools and tidal pools for aquatic species to live and breed, and ecological walls to enhance surface complexity.

Guideline 4:
Addressing Societal Challenges through Nature-based Solutions

The objective of the project is clearly defined at the early stage to maximise societal benefits and ecosystem services, including revitalising the river to improve environment for both human and urban wildlife, improving walking environment and connectivity, fostering a vibrant public space and reducing flood risk. The revitalisation work provides regulating services of water purification and water regulation, cultural services such as education, aesthetics and recreation, provisioning services of freshwater, and supporting services like nutrient cycling. Additionally, the water quality and hygiene within the nullah would be improved, and odour nuisance to the nearby resident would be alleviated.

Guideline 5:
Designing Human-Nature Composition in Context

A balanced approach is typically adopted to cater to both humans and urban wildlife in the Tsui Ping River revitalisation works. In addition to ecological features mentioned above, The provision of walkways and public open spaces is proposed along the River to allow the public to better enjoy the view of the revitalised waterscape and ecological enhancement features. To enhance connectivity of water to communities, the River features Amenity Area, landscape deck, and floating pontoon.

Guideline 9:
Promoting Socio-economic Sustainability

The water gates and deepening of river channel strengthened the hydraulic capacity to reduce the risk of flooding and protect the users of river channel from being harmed. Freshwater discharge from existing drainage outlet will also be partially intercepted and conveyed for treatment prior to being used in the water play feature. River revitalisation works enhance the social dimensions within communities.

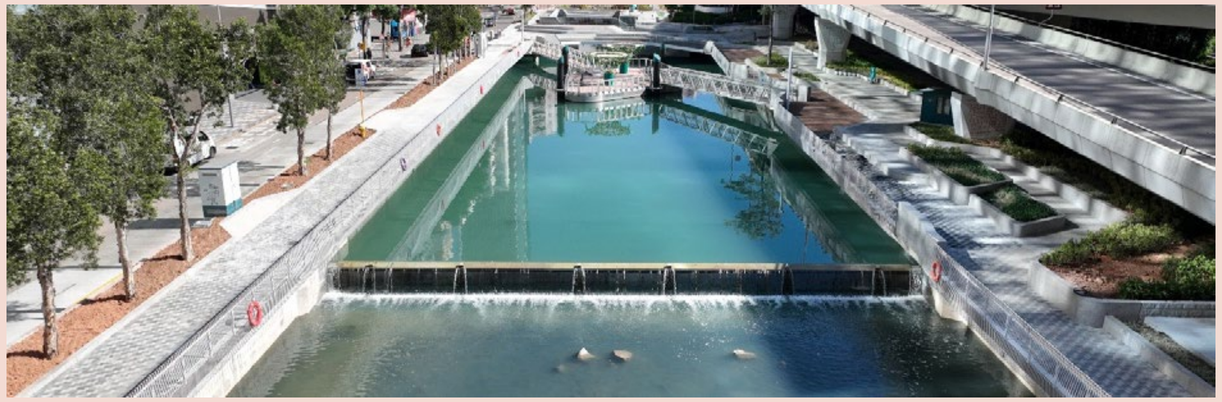


Figure A7 | Revitalised Tsui Ping River

References of the Appendix

AECOM (2023) Agreement No. CE69/2015 (CE) Tung Chung New Town Extension (East) – Design and Construction, Eco-shoreline Implementation Plan (Rev. A). https://env.tcnte.hk/ep-submissions/202306%20Ecoshoreline%20Implementation%20Plan/Eco

AECOM (n.d.) Long Valley Nature Park: A Beacon for Biodiversity and Conservation. https://aecom.com/hk/projects/long-valley-nature-park-a-beacon-for-biodiversity-and-conservation/?qp=

Development Bureau (2021). Energizing Kowloon East Office – Tsui Ping River and Tsui Ping River Garden. https://www.ekeo.gov.hk/en/smart-green-resilient-cbd/green-buildings-and-smart-infrastructure/tsui-ping-river-garden/index.html

Development Bureau (2025). 活化翠屏河 提升防洪能力 實踐河畔城市. http://devb.gov.hk/en/home/my_blog/index_id_1575.html?y=2025&p=1

Drainage Services Department (2018). Revitalization of Tsui Ping River. https://tsuipingriver.hk/en/

Drainage Service Department (n.d.) Environmental Management. https://www.dsd.gov.hk/Documents/SustainabilityReports/1819/en/environmental_management.html

Kadoorie Farm and Botanic Garden (n.d.). Forest Restoration and Rejuvenation. https://www.kfbg.org/en/caring-for-our-hillside/restoring-resilience/forest-restoration-and-rejuvenation

Swire Properties (2021) Biodiversity GRI 304. https://sd.swireproperties.com/2021/en/performance-environment/biodiversity

Swire Properties (2023) Nature and Biodiversity GRI 304. https://sd.swireproperties.com/2024/en/performance-environment/nature-and-biodiversity

The Nature Conservancy (n.d.). Hong Kong Oyster Restoration. https://www.tnc.org.hk/en-hk/what-we-do/hong-kong-projects/oyster-restoration/

The Nature Conservancy (n.d.) Less Trash and More Reefs. https://www.nature.org/en-us/about-us/where-we-work/asia-pacific/hong-kong/stories-in-hong-kong/recycling-shells/