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Designing a Sustainable Rural Township With Nature-based Solutions

A Visionary Study of Mui Wo, Hong Kong

April 2024

Contents

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TERM	MEANING IN THE REPORT
BIODIVERSITY	IPBES characterizes biodiversity as the diversity among living organisms from all contexts, including land, marine, and other aquatic ecosystems, plus the ecological complexes they belong to. It encompasses genetic, phenotypic, phylogenetic, and functional diversity, along with fluctuations in abundance and distribution over time and space within and among species, biological communities, and ecosystems.
CARBON SEQUESTRATION	Defined by IPBES, carbon sequestration refers to the long-term storage of carbon in plants, soils, geologic formations, and oceans. This process happens naturally and through human activities and is mainly about storing carbon that could quickly become carbon dioxide gas.
ECOSYSTEM SERVICE	IPBES describes ecosystem service as benefits provided inherently by an ecosystem due to its functional nature, examples include pollination, nutrient cycling, nitrogen fixation, and the dispersal of fruits and seeds.
ENVIRONMENTAL IMPACTS	Environmental impacts denote a broad array of effects on nature due to infrastructure development, enlargement, operation, and decommissioning, including pollution of air, soil, and water, as well as carbon emissions.
GREEN INFRASTRUCTURE	In this report, green infrastructure adopts the European Commission's definition: a strategically planned network of natural and semi-natural areas along with environmental features, aimed at delivering an extensive range of ecosystem services and enhancing biodiversity.
GREEN ROOF	A green roof is defined by the World Green Infrastructure Network as a vegetative layer purposefully integrated into the roofing system of a building.
NATURE-BASED SOLUTIONS (NbS)	The United Nations Environment Assembly (UNEA) has officially embraced the NbS definition as actions that protect, sustain, restore, responsibly use, and manage various ecosystems, both natural and modified, to confront societal, economic, and environmental challenges effectively and with adaptability, providing wellbeing, ecosystem services, resilience, and biodiversity advantages.
RESILIENCE	Resilience signifies the ability of an ecosystem to endure and adapt to recurrent disturbances or shocks and to modify itself post damage from ecological disruptions.

Foreword

Forging a Path to Mainstream NbS

A Collaborative Journey between Arup and WWF-Hong Kong, Authored by Arup Fellow

Biodiversity is essential for maintaining the health and functionality of ecosystems. Yet, the rapid expansion of the built environment is often at nature's expense. A particularly stark impact of urban development on biodiversity is the destruction and fragmentation of habitats.

At Arup, our objective is to "build back better," envisioning a world where human and nature exist in harmony and offering practical solutions to mend the cities' relationship with biodiversity.

Although the concept of nature-based solutions (NbS) is relatively novel in Hong Kong, we are actively engaging with clients to implement NbS in their projects. Our recent initiative involved the regeneration of one of Hong Kong's most pristine river systems. This was achieved by de-channelizing an artificial segment of the stream. We eliminated the concrete lining and substituted it with natural materials like river pebbles, which stabilize the banks and foster the growth of aquatic plants. We also incorporated structures such as fish ladders and flow deflectors to enrich biodiversity.

Dr Vincent Cheng

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Foreword

Unlocking the NbS potential in Hong Kong

In the face of climate and biodiversity crises, humanity confronts significant societal and environmental challenges. As urbanisation escalates, the imperative for sustainable development grows. Nature-based Solutions (NbS), leveraging the regenerative power of natural ecosystems, offer vast potential to rejuvenate both urban and rural landscapes for the betterment of humans and nature alike.

With the recent announcement of ambitious mega-development projects in Hong Kong, this report initiates a visionary exploration into the practical applications of NbS within a rural setting, selecting the diverse and enchanting Mui Wo as a case study. The fertile Mui Wo basin has been inhabited for centuries, but at the same supports all major habitat types found in Hong Kong. The serene rural scenery is not only treasured by the local populace but also draws visitors looking for a day in the countryside.

We are excited to collaborate with Arup in promoting the exciting opportunities offered by NbS in Hong Kong. By melding their engineering prowess with our ecological and conservation insights, we strive to showcase how NbS can fulfil the necessities of people, meet the local community's aspirations, and protect or restore nature. Our goal is to motivate individuals from various sectors throughout Hong Kong to embrace NbS, ensuring the preservation of our natural and cultural legacies for the well-being of our citizenry.

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Executive summary

Arup and WWF-Hong Kong have undertaken a joint visionary study to craft a sustainable and resilient rural community in Hong Kong through Nature-based Solutions (NbS). Recognised as a cost-effective strategy, NbS harnesses nature's potential to tackle societal challenges such as climate change, disaster risk reduction, human health, food and water security, and biodiversity loss. These solutions confer benefits on both humanity and nature while conforming to the United Nations' Sustainable Development Goals (SDGs). They are further acknowledged as key instruments for reaching targets within the Convention on Biological Diversity's (CBD) Kunming-Montreal Global Biodiversity Framework (GBF) and the United Nations Framework Convention on Climate Change (UNFCCC COP27).

Mui Wo, with its high ecological value and diverse human community, has been chosen as the locale for examining practical NbS applications in line with the IUCN Global Standard for NbS. An exhaustive methodology, including extensive literature reviews, repeated field visits, and focus group discussions, was employed to thoroughly understand the societal and ecological challenges at the site. Additionally, an opinion survey was carried out to gather the views and opinions of both residents and visitors.

Similar to other rural areas in Hong Kong, Mui Wo is experiencing tensions between development desires and the degradation of natural features and countryside lifestyle. Striking a delicate equilibrium between economic growth and environmental conservation is imperative. In this study, specific social and ecological challenges pertaining to Mui Wo were pinpointed, and six NbS were suggested to secure a sustainable future for the township.

These solutions aim to enhance nature tourism, boost local employment, create a safe and pleasant environment, and preserve wildlife habitats that are rapidly vanishing in Hong Kong. The proposed NbS include:

- Regenerative Agriculture
- Eco-shoreline
- Aerial Greening
- River Restoration
- Integrated Wetland Treatment System
- Water Buffalo Park

Each NbS is expounded upon in detail, elucidating the societal challenges addressed, its foundational principles, design elements, implementation factors, targeted SDGs, economic viability, legislative/planning impacts, monitoring strategies, and a self-evaluation according to the IUCN Global Standard.

To comply with the IUCN Global Standard for NbS, a comprehensive "Roadmap for NbS Implementation" is delineated, detailing the essential steps for planning and executing NbS that meet the IUCN NbS criteria, thereby guiding the successful incorporation of NbS in Hong Kong.

Potential of NbS application beyond Mui Wo is discussed using the Northern Metropolis as an example.

Chapter 1: Introduction

Chapter 1: Introduction

Background and Rationale

As we endeavour to mainstream Nature-based Solutions (NbS) in Hong Kong, the shift from theoretical frameworks to practical applications is crucial. In this visionary report, we have embraced an NbS approach to design a sustainable rural community in Hong Kong that adheres to global standards. Our ultimate aim is to catalyse the widespread adoption and scaling of NbS practices throughout Hong Kong and beyond, securing a sustainable and resilient future for our communities and the natural world.

In line with the government's sustainable development vision for Lantau, fully integrating NbS is vital for tackling societal challenges and preserving natural assets. Our chosen study site, Mui Wo, is a picturesque rural town on the southeastern coast of Lantau Island, offering an exemplary setting to showcase NbS at the community level. Mui Wo, known today for its recreational appeal with an array of natural habitats, was historically a flourishing agricultural hub renowned for rice production. The paddy fields have given way to some of Hong Kong's most pristine and extensive freshwater marshes, diligently maintained by roaming water buffalo and cattle. However, this symbiosis also poses challenges, particularly in managing human-animal interactions.

Leveraging NbS allows us to set a clear standard for creating a liveable rural community in Hong Kong, enhancing environmental, recreational, and social aspects. Mui Wo's unique rural charm and untapped potential make it an exemplary site to demonstrate the advantages of NbS. Through this report, we aim to spark a transformative movement, encouraging the infusion of NbS across Hong Kong in response to the growing developmental pressures on rural landscapes. By working together, we can chart a course towards a future that is both sustainable and resilient, where our communities flourish in harmony with nature.

Vision for a Sustainable Mui Wo

Dedicated to the prosperity of both people and nature, our vision aspires to establish Mui Wo as a model for sustainable rural towns in Hong Kong.

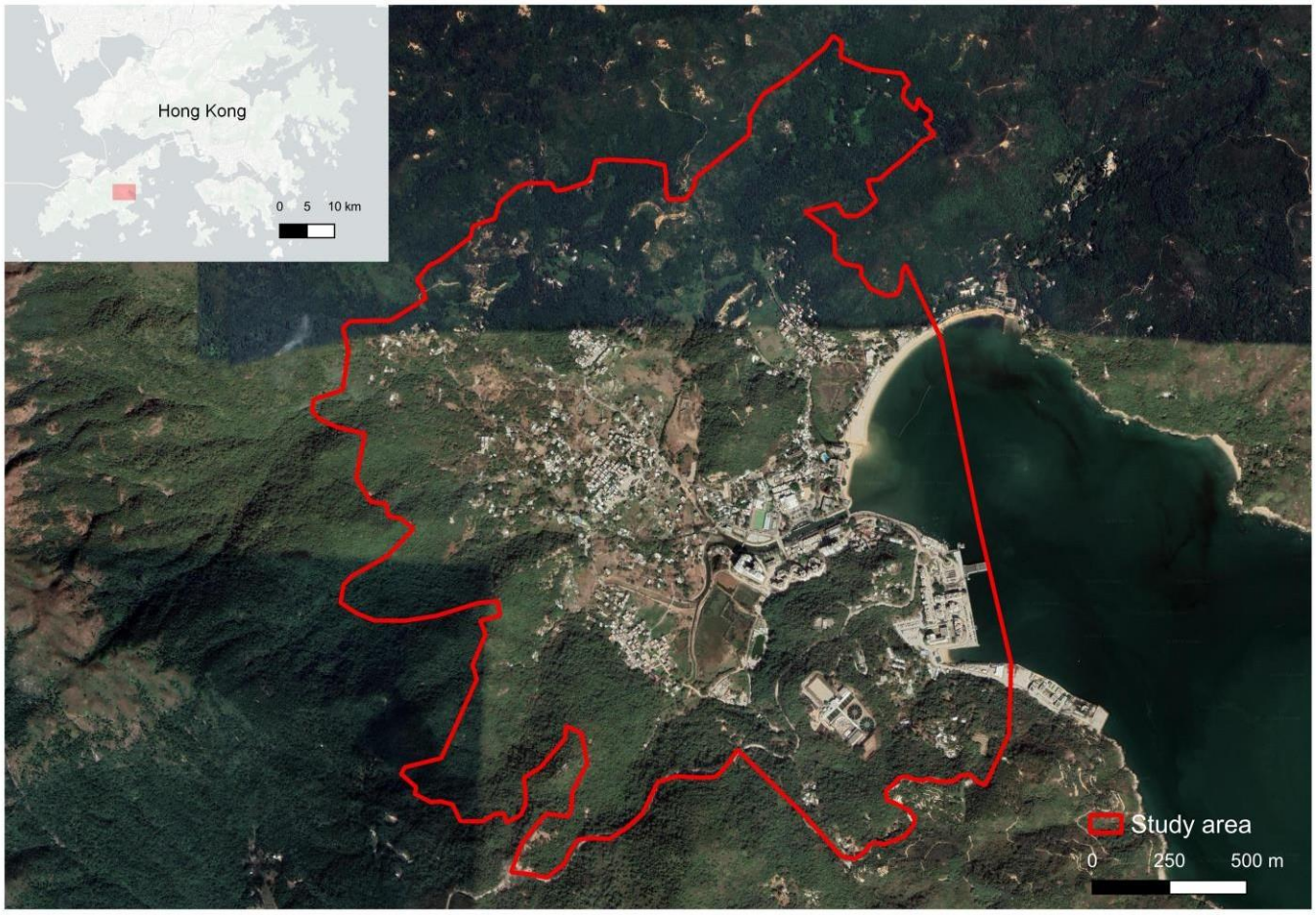
Water Buffalo at Mui Wo's Freshwater Marsh

Chapter 1: Introduction

Scope of the Study

The visionary study is designed to thoroughly investigate the societal challenges faced by Mui Wo and to pinpoint NbS that can be effectively implemented to create a positive impact.

This case study focuses on the fertile Mui Wo basin, encircled by the hilly terrain of South Lantau Country Park. It is a predominantly rural area, spanning 380 hectares, dotted with villages and anchored by a small, contemporary town centre adjacent to the River Silver. The study encompasses all significant habitat types found in Hong Kong,as well as the vast majority of Mui Wo's human inhabitants.



Study area of Mui Wo
© Map data: Google

Chapter 2: Understanding Nature-based Solutions (NbS)

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Key Components of NbS

Nature-based Solutions (NbS) are actions designed to address social, economic, and environmental challenges through the utilization of natural or modified ecosystems, be they terrestrial, freshwater, coastal, or marine. These solutions serve to enhance human well-being and provide ecosystem services, resilience, and biodiversity benefits, offering a sustainable alternative to traditional engineering-based methods. NbS are integrative, bringing together environmental, social, and economic considerations in both planning and execution, and are founded on the principles of sustainable development.

NbS prioritise the simultaneous management of societal challenges and the delivery of co-benefits for human well-being and biodiversity. Societal challenges addressed by NbS include:

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

NbS can be categorised based on the level of ecosystem transformation and ecological complexity involved:

- Utilisation of natural ecosystems
- Management or restoration of ecosystems
- Creation of new ecosystems

Within the scope of NbS, five ecosystem-based approaches are recognised:

- Restoration
- Issue-specific solutions
- Infrastructure-related approaches
- Ecosystem management
- Protection approaches

International Recognition and Adoption

NbS are globally acknowledged as means to tackle climate change, promote biodiversity conservation, and safeguard society in line with the Sustainable Development Goals (SDGs). In addition:

- The Kunming-Montreal Global Biodiversity Framework (GBF), established at the Convention on Biological Diversity (CBD) COP 15, recognises NbS as pivotal for achieving the 2030 Targets.
- The United Nations Framework Convention on Climate Change (UNFCCC) COP27 integrated NbS into its decision text for the implementation plan, as detailed in UNFCCC (2022). The COP28 Joint Statement on Climate, Nature, and People underscored the imperative of enhancing finance and investment in climate and nature through NbS, advocating for co-benefits and efficient use.
- The universally endorsed definition of NbS from the IUCN (2016) was officially adopted by multiple governments at the United Nations Environment Assembly 2022 (UNEA, 2022).

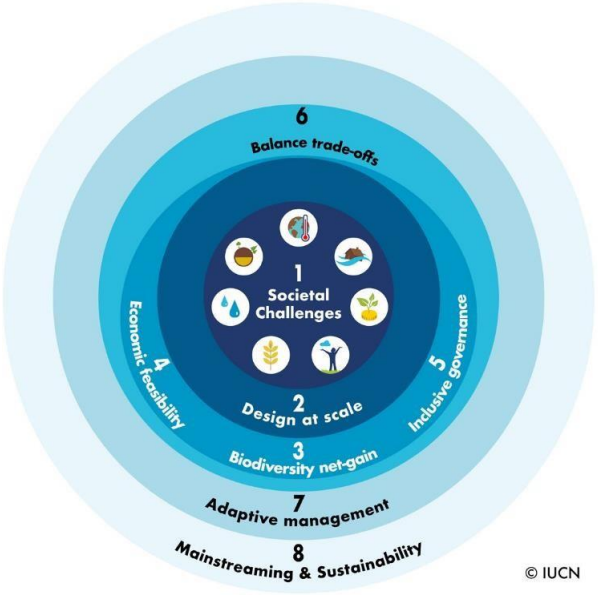
Chapter 2: Understanding Nature-based Solutions (NbS)

The IUCN Global Standard for NbS

In 2020, the International Union for Conservation of Nature (IUCN) introduced the inaugural global standard for NbS (IUCN, 2020). This standard encompasses eight criteria with associated indicators, and it is supported by a user guide and self-assessment tool. These instruments are essential for ensuring the consistent and credible design, verification, and scaling of NbS.

"For nature-based solutions to fulfil their potential, we must ensure that the actions put in place today bring about the desired benefits for society and biodiversity."

- IUCN's Global Director for the NbS Group Stewart Maginnis.



The Eight Criteria of NbS

Criterion	Summarised description of the criteria
1: Societal challenges	NbS must effectively tackle significant societal challenges confronting affected communities, delivering measurable benefits for human well-being.
2: Design at scale	NbS design must account for interactions across social and ecological systems, integrating diverse needs, strategies, programs, and policies across sectors. It should also embrace indigenous and traditional practices within the defined spatial context.
3: Biodiversity net-gain	NbS must enhance biodiversity and ecosystem integrity, yielding a net positive impact on biological diversity and the ecological integrity of the target area and its environs.
4: Economic feasibility	NbS must be economically viable, considering long-term sustainability beyond the lifespan of the intervention.
5: Inclusive governance	NbS require inclusive, transparent, and empowering governance processes, ensuring stakeholder engagement in consultation, decision-making, monitoring, feedback, and grievance redressal mechanisms.
6: Balance trade-off	NbS must fairly balance trade-offs between meeting their primary objectives and delivering multiple benefits. The outcomes of the intervention should be thoroughly evaluated, transparently communicated, and consented to by the stakeholders most impacted, to manage trade-offs effectively.
7: Adaptive management	NbS must be managed adaptively, using evidence to address unintended, unforeseen, and negative consequences.
8: Mainstreaming & Sustainability	NbS should be sustainable and mainstreamed within the relevant jurisdictional framework. Interventions should be crafted and managed to be consistent with existing institutional structures, policies, plans, laws, regulations, and adjacent initiatives.

Chapter 3: Mui Wo – A Thriving Rural Township

Chapter 3: Mui Wo – A Thriving Rural Township

Why Mui Wo?

Located on the southeastern coastline of Lantau Island, Mui Wo is a fertile coastal basin at the foothills of Lin Fa Shan and is the island's largest rural township with a population of 5,170, according to the 2021 Population Census. Its history stretches back over a millennium to the Song Dynasty when it was renowned for salt production. By the late 19th century, Mui Wo had shifted its focus to silver mining, although this faced challenges due to the ore's lowsilver content.

During the 1950s, Mui Wo blossomed into a significant agricultural centre in Hong Kong, with rice as the primary crop. However, the industrialisation of Hong Kong from the 1970s saw a decline in farming, and commercial agriculture ceased since the 1980s. In recent years, small plots have been revitalised for farming, and a small farming community has been formed. Presently, Mui Wo is treasured by locals and tourists for its tranquillity, natural beauty, and cultural heritage.

The selection of Mui Wo as our study site is based on several compelling reasons:

Mui Wo boasts a diverse range of ecosystems, including forests, shrubland, freshwater and brackish marshes, agricultural lands, ponds, watercourses, mangroves, and sandy beaches. These habitats support rich biodiversity that can be harnessed through NbS to bolster ecological resilience and enhance the area's recreational appeal.

Noteworthy are Mui Wo's paddy-derived freshwater marshes, among the last extensive buffalo-grazed marshes in Hong Kong which are both rapidly vanishing locally. This unique feature offers a chance to demonstrate the sustainable coexistence of humans and nature.

Mui Wo is celebrated as an outdoor recreation hub. Its scenic trails, tranquil beaches, picturesque countryside, and diverse wildlife attract outdoor enthusiasts and nature-loving tourists alike. Integrating NbS into Mui Wo can further enrich its natural allure, providing a foundation for sustainable tourism that benefits both the local economyand visitors.

As urbanization encroaches upon rural areas in Hong Kong, it is imperative to demonstrate the potential of NbS in crafting a liveable and eco-friendly rural township. We hope this study will inspire innovative rural development in Hong Kong, underscoring the significance of sustainable growth, community well-being, and environmental guardianship.

Mui Wo's location is in line with the government's sustainable development plans for Lantau. Incorporating NbS into future revitalization initiatives in Mui Wo can contribute to the goals of the government's sustainable development framework for Lantau and beyond, offering valuable insights for policymakers, planners, and otherstakeholders interested in adopting and expanding NbS in similar environments.

Chapter 3: Mui Wo – A Thriving Rural Township

Community Diversity and Heritage in Mui Wo

The villagers of Mui Wo are primarily of Hakka descent, with ancestors who migrated from various parts of Guangdong, including Heyuan, Wuhua, and Dongguan. The human population is distributed across several villagesengaged historically in agriculture:

- Luk Tei Tong: the first settlement in Mui Wo, dating back over 400 years, with the 'Kam' family arriving as early as the 1400s. Positioned in the southwestern part of the basin, the village benefits from fertile soil and plentiful water sources. In the 1980s, farming ceased due to water shortages, and the fields gradually becamemarshland.
- Tai Tei Tong: established around the 1860s by the 'Lam' and 'Sit' families, this village lies centrally in the MuiWo basin.
- Pak Ngan Heung: named after the region's silver mining past, it was settled by the 'To' family during the lateSouthern Song Dynasty. The village hosts a Man Mo temple from the 15th century.
- Chung Hau: developed along the lower reaches of River Silver, with settlement beginning in the 1800s, the area has evolved into the town centre, featuring retail outlets and government services, thus becoming a keyhub.
- Wang Tong: situated near Silvermine Bay Beach and isolated from other villages by Butterfly Hill, it has adiverse multinational community. Its official recognition as a village is pending.

Chapter 3: Mui Wo – A Thriving Rural Township

Urban Development

In the 1960s, the government-initiated land reclamation for the public pier, and in 1980, shed houses along River Silver were demolished to improve water quality at Silvermine Beach and enhance environmental hygiene. This development led to the construction of public housing estates like "Ngan Wan Estate" and the establishment of municipal facilities, including a public pool, sports grounds, parks, playgrounds, and other public amenities.

To further enhance Mui Wo's environmental quality, the government commenced a second development phase in 2014, revising urban planning concepts. Two public housing estates, Ngan Wai Court and Ngan Ho Court, were erected next to Ngan Wan Estate, providing about 700 units for over two thousand residents. Completed in 2018,these estates stand as the only tall buildings in Mui Wo.

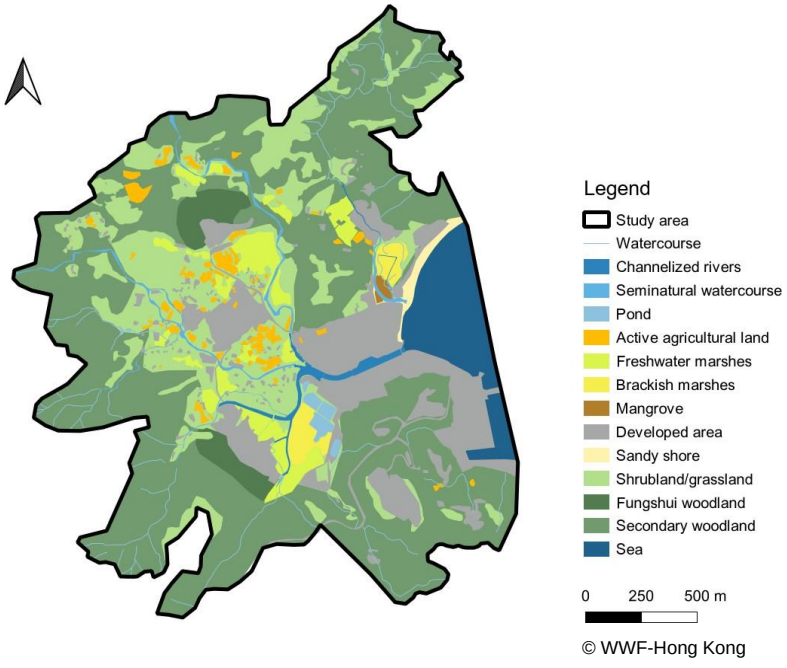
Chapter 3: Mui Wo – A Thriving Rural Township

Habitat diversity

Mui Wo boasts a full spectrum of natural habitats found in Hong Kong, including coastlines, watercourses, ponds, freshwater and brackish marshes, mangroves, farmland, shrublands, and woodlands. This diverse habitat mosaic supports a rich and varied biodiversity.

Key wildlife habitats of Mui Wo include:

- Wetlands: The paddy-derived freshwater marshes are arguably Mui Wo's most significant wetland type, found scattered throughout the basin with sizeable patches in Luk Tei Tong, Pak Ngan Heung, and Wang Tong. Considerable populations of free-roaming cattle and water buffalo help maintain these marshes' openness and microhabitat diversity. The Wang Tong Stream estuary hosts the only remaining mangrove formation, dominated by mangrove-associate Sea Hibiscus (*Hibiscus tiliaceum*) and, to a lesser extent, the true mangrove species *Kandelia obovata*. A few abandoned fishponds are located south of Ngan Ho Court, which are being overgrown by brackish vegetation.
- Watercourses: River Silver, originating from Lin Fa Shan (766 m asl), is the primary catchment, with tributaries running through Luk Tei Tong, Tai Tei Tong, and Pak Ngan Heung. Wang Tong Stream represents a separate drainage system, which receives water from the watershed that separates Mui Wo from Discovery Bay. Tidal influence affects the lower reaches of both Wang Tong Stream and River Silver, where scattered mangrove stands can be found.
- Forests and shrublands: As village livelihoods shifted, hillsides are now covered with native forests at various successional stages. Taller stands and higher plant diversity characterise the Fung Shui Woods behind the villages.



Habitat map of Mui Wo

Chapter 3: Mui Wo – A Thriving Rural Township

Species diversity

The diverse habitats in Mui Wo contribute to its renowned biodiversity. Species of conservation importance documented include 11 species of mammals, 41 birds, 5 amphibians, 5 reptiles, 6 butterflies, 6 odonates, 10 fishes, and 3 freshwaterinvertebrates.

Key characters of selected wildlife groups in Mui Wo:

- Birds: Over 140 bird species have been recorded, which include migratory species such as waders, buntings, flycatchers, and thrushes, as well as locally threatened, marsh-dependent species like the Common Snipe, Brown-cheeked Rail, and Watercock. The aquatic habitats support the Brown Fish Owl, and Tai Wai Yuen is a known night roost for egrets and herons.

- Amphibians and reptiles: Of the 12 amphibian and 16 reptile species recorded in Mui Wo, the marshes and farmlands support the nationally protected Chinese Bullfrog (*Hoplobatrachus rugulosus*), while the globally endangered Romer's Tree Frog (*Liuixalus romeri*) and Short-legged Toad (*Megophrys brachykolos*) inhabit hillside forests. Other threatened species, such as the Chinese Soft- shelled Turtle (*Pelodiscus sinensis*) and Chinese Cobra (*Naja atra*), have also been found.

Chapter 3: Mui Wo – A Thriving Rural Township

Species diversity

- Fishes: Of the 76 fish species recorded in Mui Wo, 10 are of conservation significance, such as two Flagtails (*Kuhlia spp*.) and the Small Snakehead (*Channa asiatica*). Diadromous fishes, like *Stiphodon spp.* and *Anguilla spp*., which migrate between fresh and marine waters, are also present.

- Butterflies: Mui Wo is a significant butterfly hotspot with over 110 species recorded. Rare species found in woodlands include the Plain Banded Awl (*Hasora vitta*) and Shiny-spotted Bob (*Isoteinon lamprospilus*).

- Dragonflies and damselflies: Over 40 dragonfly and damselfly species are known from Mui Wo. Species of local concern include the Chinese Yellowface (*Agriomorpha fusca*), Dingy Dusk-hawker (*Gynacantha subinterrupta*), Blue Chaser (*Potamarcha congener*), and Ruby Darter (*Rhodothemis rufa*). The site also holds regionally rare species like the Emerald Cascader (*Zygonyx iris*) and the globally threatened Mangrove Skimmer(*Orthetrum poecilops*).

Chapter 4: Methodology

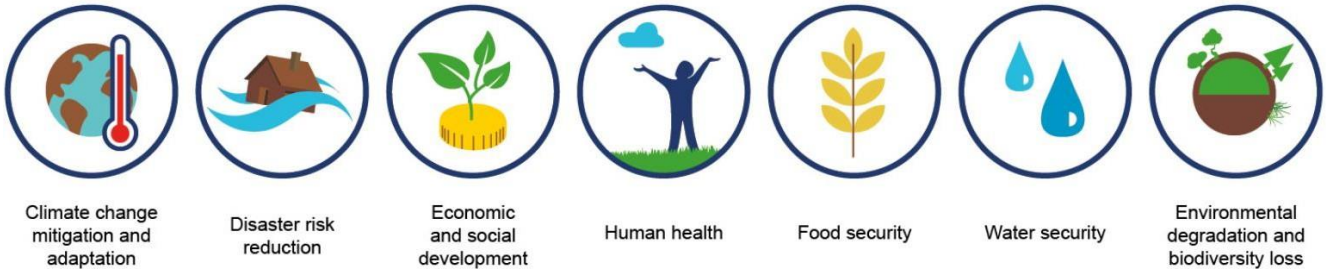
Chapter 4: Methodology

Research Design

As a visionary study, our primary aim is to pinpoint the societal challenges and opportunities unique to Mui Wo and recommend suitable Nature-based Solutions (NbS) that adeptly address these issues, capitalizing on the site's distinctive features. Additionally, we aspire to encourage broader application of NbS in Hong Kong by devising an implementation roadmap that serves as a practical guide, beneficial not only to Mui Wo but also to other rural communities throughout the region. To accomplish this, our study follows a series of steps designed to systematically develop NbS for Hong Kong.

Steps	Description
1. Site Assessment	Conduct a comprehensive literature review on Mui Wo's natural and socio-economic history, as well as its present conditions. Perform field visits to evaluate habitats and species diversity, verify site conditions, and assess the feasibility of NbS implementation.
2. Stakeholder Engagement	Engage with targeted stakeholder groups identified via stakeholder mapping in discussions, and conduct opinion surveys with residents and visitors to collect their perspectives, knowledge, and aspirations concerning sustainability and NbS initiatives.
3. Data Analysis	Analyse the collected data, including insights from literature reviews, field observations, and stakeholder interactions, to comprehend the ecological, social, and economic dynamics of Mui Wo. Pinpoint challenges and opportunities to guide the incorporation of NbS.
4. Vision Development	Craft a compelling and clear vision for Mui Wo, informed by site assessments and stakeholdercontributions.
5. NbS Identification and Design	Pin down specific NbS that resonate with the vision and tackle the identified challenges and opportunities. Formulate designs and strategies for NbS that emphasize community well-being andbiodiversity enhancement.
6. Evaluation of Proposed NbS	Evaluate the viability and impacts of the proposed NbS, using indicators like community well- being, ecological resilience, and potential trade-offs. Employ the IUCN Global Standard for NbS self-assessment tool to assess its alignment with global standard.
7. Roadmap for NbS Implementation	Create a detailed implementation roadmap for NbS that conforms to IUCN Global Standard for NbS, offering a structured approach for effective NbS execution. Outline steps and assign responsibilities to guarantee efficient implementation and ongoing monitoring.

Chapter 5: Identifying Societal Challenges in Mui Wo



Source: IUCN

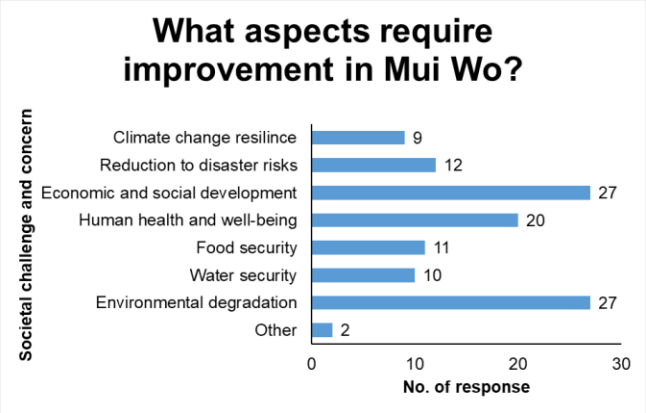
"Nature-based Solutions are actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits" (IUCN, 2016)

Chapter 5: Identifying Societal Challenges in Mui Wo

Opinions on Mui Wo

An opinion survey was conducted in Mui Wo to collect the views of locals and visitors. Out of the 49 participants, 40 are village representatives and residents from Mui Wo town centre, Luk Tei Tong, Tai Tei Tong, Pak Ngan Heung, Wang Tong, and other villages in Mui Wo. The remaining nine participants are visitors to Mui Wo, with five being frequent visitors.

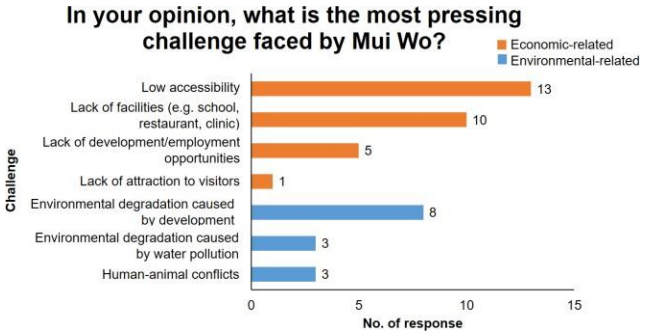
The survey findings highlighted two key challenges: over half of the participants expressed concerns regarding economic and social development, emphasizing the need for improvement in these areas. Additionally, over half of the participants mentioned environmental degradation as a significant concern for Mui Wo.



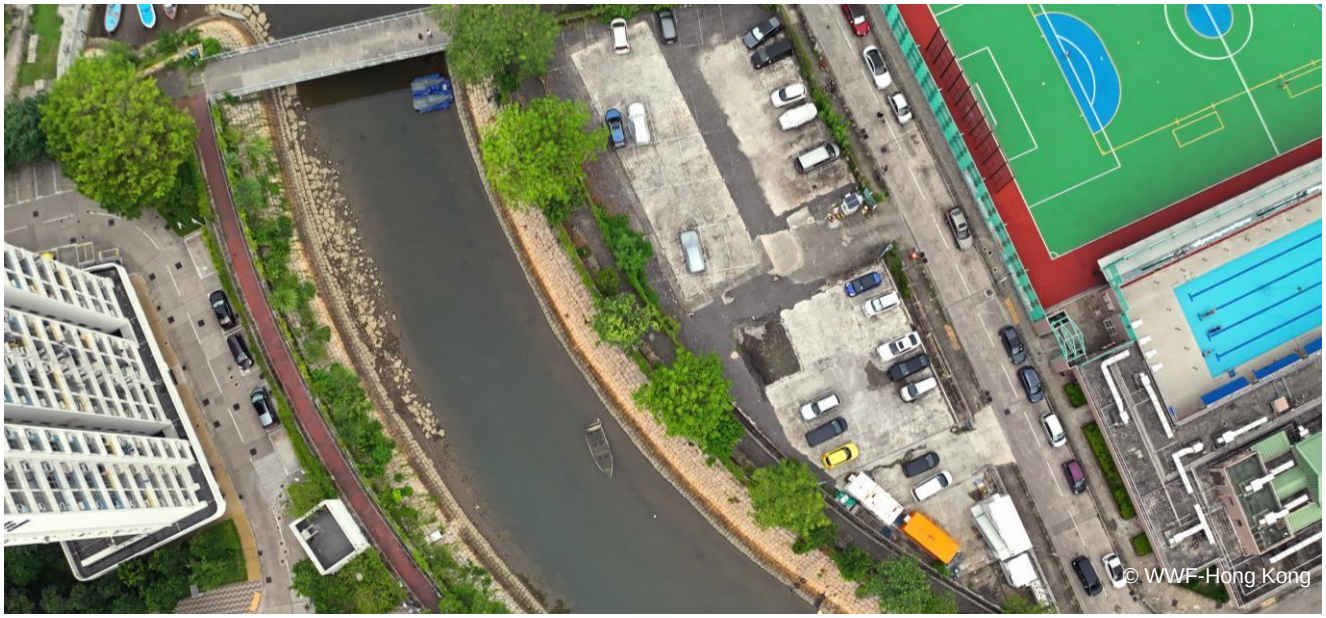
The survey identified major challenges and concerns

Economic and social development

The primary economic and social development challenge highlighted is the limited accessibility to Mui Wo. Participants also noted the lack of essential amenities such as clinics and restaurants. Furthermore, the scarcity of job opportunities poses challenges in attracting and retaining residents. Moreover, the absence of iconic tourist attractions and activities hampers Mui Wo's ability to draw visitors.



Major economic and environmental concerns of respondents

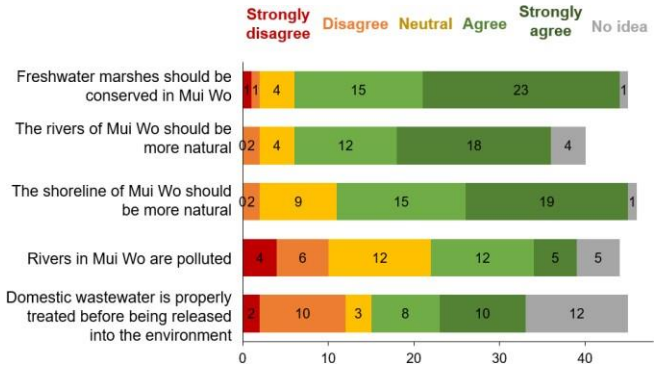


Chapter 5: Identifying Societal Challenges in Mui Wo

Opinions on Mui Wo

Environmental degradation and water security

Environmental degradation concerns primarily centered around incompatible development, river channelisation, and water pollution. A large majority of participants (84%) advocated for the conservation of freshwater marshes derived from paddy fields. Three-quarters of participants supported the need for more natural rivers and shorelines. Concerns were raised about the pollution of irrigation water in Mui Wo. While government- supplied water for household use was considered stable, 39% of participants noticed water pollution in the rivers, and 25% observed improper treatment of domestic sewage.



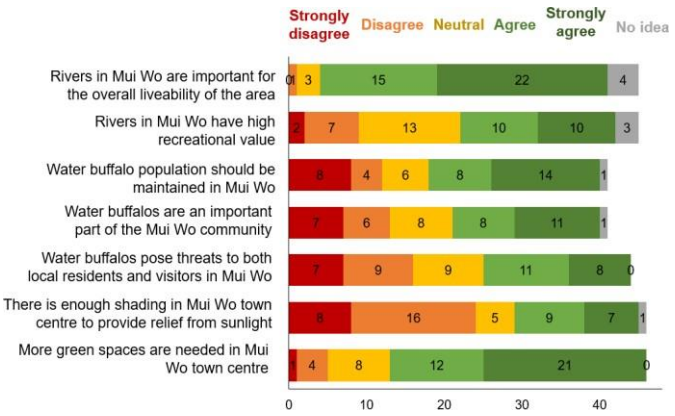
Respondents' views on environmental degradation andwater security

Human health and well-being

While only 44% of participants considered rivers to have high recreational value, the majority (82%) recognised their importance for the overall liveability of the area.

Opinions on the presence of water buffalo in Mui Wo varied, with 56% in support and 29% expressing disagreement. Supporters believed that water buffalo are an integral part of the community, while opposers cited perceived uselessness, associated dangers, and nuisance.

Additionally, half of the participants indicated that there is insufficient shade, and 71% indicated that more greenspace is needed in the town centre.



Respondents' views on human health and well-being

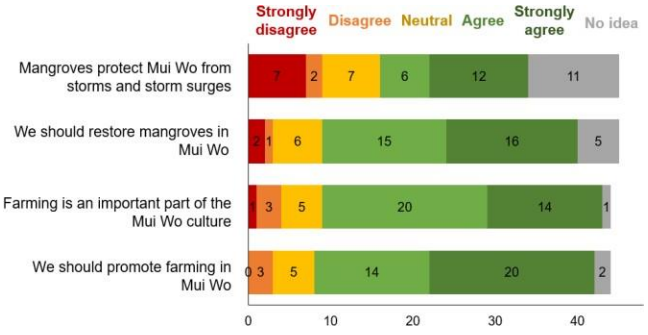
Chapter 5: Identifying Societal Challenges in Mui Wo

Opinions on Mui Wo

Climate change and disaster risks

Despite the increasing risks from sea-level rise, storms, storm surges, and flooding, the majority of participants did not perceive climate change and disaster risks as major concerns, likely because the impacts have not yet been felt in Mui Wo. About 71% of participants reported no impact from recent typhoons or black rainstorms.

Although only 31% believed that mangroves could effectively protect Mui Wo from storms and storm surges, 65% of participants supported mangrove restoration.



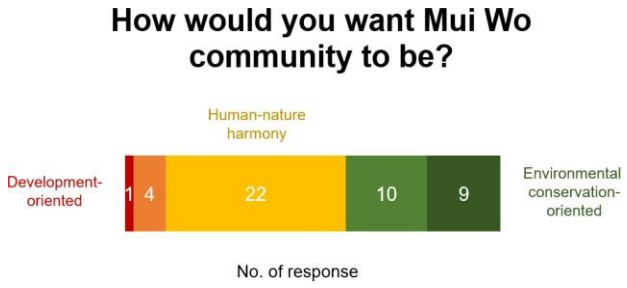
Respondents' views on mangrove and farming

Food security and farming culture

Even though most participants purchase their food from supermarkets or wet markets in Mui Wo, 72% still considered farming to be an important aspect of Mui Wo's culture and expressed support for promoting farming in the area.

Future outlook

More than 80% of participants valued the natural environment, including the beach and hillsides, as the best aspect of Mui Wo. Additionally, a significant portion (48%) envisions a future Mui Wo that embraces harmonious coexistence between humans and nature.



Most respondents look forward towards a community inhuman-nature harmony

Designing suitable NbS for multi-benefits

Opinions and information gathered have assisted in identifying the needs of stakeholders, enabling the design of NbS that offer multiple benefits to the community.

While enhancing transportation and public facilities may require higher-level planning support beyond the scope of NbS, the primary focus remains on designing NbS that enhance human well-being and biodiversity. These NbS aim to promote sustainable tourism, generate local employment opportunities, and create a safe and enjoyable environment while conserving the diverse wildlife habitats in Mui Wo.

Chapter 5: Identifying Societal Challenges in Mui Wo

Summary

Through an extensive literature review, stakeholder engagement, opinion survey, and evaluation of existing studies, reports, and plans, we have identified the most pertinent societal challenges and various concerns of Mui Wo as a rural town. These challenges have been assessed in terms of their relevance and seriousness. This comprehensive approach has allowed us to gain a robust understanding of the specific issues Mui Wo faces in its social landscape and to prioritize them accordingly.

Climate change ❗❗

Sea level rise: The low-lying regions along the coast of Silvermine Bay Beach, Mui Wo Pier, and the Sewage Treatment Plant are projected to experience flooding by the year 2100 (Climate Central, 2023).

Storms and storm surges: Ma Po Tsuen and Chung Hau in Mui Wo are among the 26 sites in Hong Kong identified as vulnerable to coastal risks (CEDD, 2022).

Disaster risk reduction ❗❗

Flooding: Historical records from the 2018 Typhoon Mangkhut show the highest flood level recorded at 3.73 mCD. Additionally, some areas have experienced flood depths exceeding 1m according to hydraulic simulations of a 1 in 200-year rainfall event.

Economic and social development ❗❗❗

Limited local job opportunities: Beyond public services, recreational activities, farming, and the foodindustry, local job opportunities in Mui Wo are scarce.

Limited market availability: The market for selling local food products in Mui Wo is limited.

Cultural distance: The traditional village culture in Mui Wo contrasts with the lifestyle of residents inpublic estates, expat-dominated villages, and visitors.

Human health ❗❗

Recreational opportunities: Mui Wo provides numerous recreational activities. However, land reclamation and the channelised nullah in the Chung Hau town centre have diminished the area's aestheticand, consequently, its recreational value.

Human-animal conflicts: The presence of free-roaming water buffalo and cattle presents safety and hygiene issues. Land conversion further contributes to habitat loss for these animals, pushing them intohuman settlement areas.

Food security ❗❗❗

Limited local food production: Mui Wo's heavy reliance on imported food supplies makes it vulnerable to disruptions in the transport network. Presently, around 7 hectares of active farmland in Mui Wo produce vegetables and fruits.

Chapter 5: Identifying Societal Challenges in Mui Wo

Water security❗

Water supply for domestic use: The majority of Mui Wo is served by the Silvermine Bay Fresh Water Supply Zone managed by the Water Supplies Department. However, there is no seawater provision for toiletflushing, which could conserve freshwater resources.

Polluted irrigation water: Point source pollution in watercourses used for irrigation has been identified, impacting the quality of farmland water.

Environmental degradation and biodiversity loss❗❗❗

Freshwater marsh degradation: Land use changes in Mui Wo threaten the existence of these critical wildlife habitats, with continued loss and degradation of freshwater marshes risking biodiversity and ecosystem disruption.

Degraded aquatic habitat: The heavily engineered watercourses and coastlines provide suboptimalhabitats for biodiversity, underscoring the need for ecological restoration efforts.

Chapter 6: Proposed NbS for Mui Wo

Chapter 6: Proposed NbS for Mui Wo

Proposed NbS

Six NbS are proposed for Mui Wo and each will be described in detail in the subsequent sections. It is crucial to follow the planning and implementation steps outlined in Chapter 7 to ensure adherence to all the criteria specified in the IUCN Global Standard for NbS. As this is a visionary study, identification of societal challenges, assessment on biodiversity and stakeholder engagement were conducted as the foundation to design proposed NbS. It is essential to follow the remaining steps in Chapter 7 if these proposed NbS were to be implemented.

1. **Regenerative Agriculture** to revitalise abandoned farmland, transforming Mui Wo into a sustainable agriculture hub.
2. **Eco-shoreline** to enhance the aesthetic and ecological values of the engineered shoreline and drainage channels, improving climate resilience and other ecosystem services of the township.
3. **Aerial Greening** to increase urban greenery areas, reduce carbon footprint and energy consumption, provide shading for pedestrians, and create habitats for urban wildlife.
4. **River Restoration** to restore the concrete channel of Wang Tong Stream to a more natural state, enhancing its ecological and aesthetic values.
5. **Integrated Wetland Treatment System** to utilise the natural filtration power of wetlands to address recurring household sewage issues.
6. **Water Buffalo Park** to alleviate human-wildlife conflict, preserve the ecology of freshwater marshes, serve as an auxiliary flood retention capacity, and become an iconic tourist attraction for Mui Wo.

Chapter 6.1: Regenerative Agriculture

Rationale and Key Concepts

Societal challenges and opportunities

- Mui Wo was once a major agricultural centre in Hong Kong, with farming considered a cultural heritage by many indigenous villagers.
- The basin boasts abundant arable land and water resources, with negligible contaminating industries compared to the New Territories.
- High-quality, smallholder farmers currently cultivate approximately 7 hectares of vegetable fields and a few orchards.
- Hobby farming is gaining popularity as an alternative lifestyle, highlighting the potential for farmland revitalization as an attraction in Mui Wo.
- There should be a stable local market for farms to trade their produce, and the promotion of more sustainable farming practices is essential.

Regenerative agriculture

Is a farming approach that actively seeks to regenerate natural resources rather than depleting them, key principles of regenerative agriculture include:

- Maintaining healthy and fertile soils through practices that improve soil structure, fertility, and microbial life.
- Recognising the importance of biodiversity by encouraging crop diversity and reducing pollution load, which provides habitats for beneficial organisms.
- Improving water management by optimizing water use and minimizing environmental impacts.
- Contributing to carbon sequestration by capturing and storing atmospheric carbon dioxide in soils and vegetation.
- Emphasising local food systems that benefit communities and enhance food security.

Community-supported agriculture (CSA)

CSA operates on a subscription-based model where consumers become subscribers to a farm or group of farms,which:

- Fosters mutual support and collaboration between farmers and community members, creating a strong community bond.
- Promotes a locally-oriented economy by supporting small-scale farmers and reducing reliance on imported food.
- Encourages subscribers to engage in farm activities, forging a deeper connection between consumers and their food sources.
- Advocates for sustainable and environmentally friendly farming practices.

Chapter 6.1: Regenerative Agriculture
Qualitative Assessment

Location
Existing and abandoned farmlands

Type of landscape
Rural

NbS approaches
Ecosystem-based management

Details of the NbS
- Convert farms to sustainable practices using regenerative agriculture, revitalizing abandoned farmland.
- Regenerative agriculture enhances soil health through reduced tillage and chemical inputs, mulching, composting, cover cropping, crop rotation and diversification, water management, and agroforestry.
- Implement a CSA system to bridge the gap between producers and consumers.
- Promote consumer involvement through CSA subscriptions and direct farm purchases.
- Support farm-to-table initiatives, supplying local restaurants with fresh produce.
- Transform community food waste into compost for soil fertilization.
- Organize food education tours to encourage sustainable practices.
- Adopt a landscape approach to farmland planning, using farmlands to connect to surrounding natural habitats.
- Initiate a citizen science program to monitor and assess natural, economic, and social systems, facilitating adaptive management.

Benefits on biodiversity
- Improved soil health bolsters biodiversity by nurturing diverse and flourishing soil organisms.
- Sustainable farmland management and varied crop cultivation benefit farmland-dependent species.

Co-benefits on the environment and people
- **Climate change mitigation and adaptation**: Restores soil organic matter, sequesters carbon, and bolsters climate resilience.
- **Disaster risk reduction**: Enhances water infiltration, diminishes runoff, and mitigates flood risks.
- **Economic and social development**: Generates green jobs, CSA ensures stable markets, and composting encourages sustainable waste management.
- **Human health**: Yields higher-quality food, strengthens the human-nature bond, and fosters mental well-being.
- **Food security**: Boosts self-reliance, cuts down on imported food dependence.
- **Water security**: Minimises chemical usage, betters water quality, and integrates water management techniques.

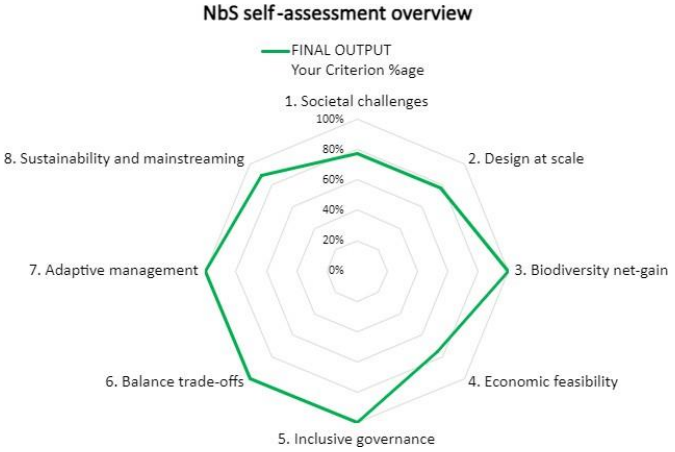
Technical feasibility
- Restoring the dilapidated irrigation system is vital for a consistentwater supply for agriculture.
- Collaboration among government authorities, NGOs, and localfarms is advisable for the establishment of a citizen science monitoring scheme.
- Soil regeneration takes time thus ensuring long-term, stable land tenure is imperative to encourage farmers to commit to sustainableland rehabilitation.

Economic feasibility
- Reduced food transport costs benefit both producers andconsumers.
- Utilizing volunteers can help lower labour costs for farming.
- A reliable supply of compost and mulching materials decreasesdependency on imported agricultural inputs.

Legislation / Planning Implication
- Fostering and sustaining a prosperous farmland community necessitates coordinated support from relevant government authorities, especially the Agriculture, Fisheries and ConservationDepartment.

Measurement and monitoring
- Monitor improvements in soil health and farmland biodiversity while maintaining adequate irrigation water quantity and quality.Optimize farm production and profitability, considering human well-being outcomes and benchmarks.

Self-assessment based on IUCN Global Standard for NbS



Chapter 6.2: Eco-shoreline
Rationale and key concepts

Societal challenges and opportunities

- Mui Wo's shoreline is reinforced by traditional seawalls built in the 1980s as part of the "Mui Wo Development Package." It can be broadly categorized into the vertical concrete seawall around the Ferry Pier, an elevated promenade linking the Pier and the beach, and sloping masonry walls on the outskirts.
- The lower reach of the Silver River has also been heavily engineered and realigned, with the riverbanks reinforced by sloping masonry walls.
- These man-made structures offer extremely limited wildlife habitats and provide minimal ecosystem services.
- There is significant scope for the introduction of eco-shoreline elements.
- From a top-down viewpoint, the continuous promenade with its existing cycling track and pedestrian path lays a solid groundwork for enhancing open spaces, increasing connectivity, and encouraging human-nature interaction.

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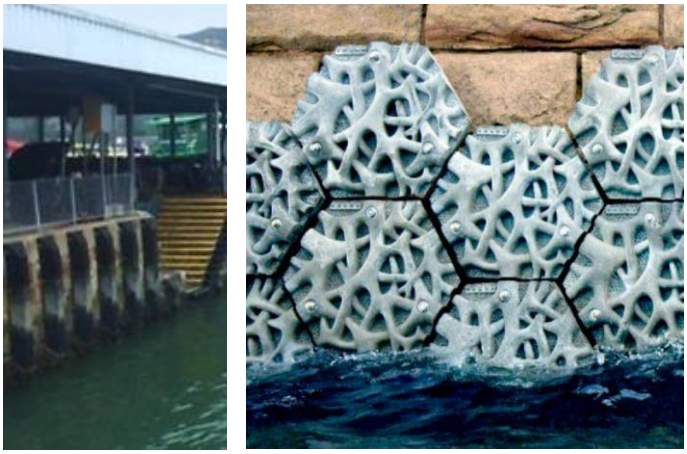
Eco-shoreline with bio-blocks to mimic rocky shore

Eco-shoreline

Considering factors like the geographical environment and tidal patterns, three types of eco-shoreline are advisable for Mui Wo:

- Mangrove eco-shoreline could be established in areas less affected by sea waves, potentially including the sloping masonry walls along the Silver River and the outer shorelines.
- Rocky eco-shoreline featuring bio-blocks could be placed in zones more exposed to sea waves, possibly beneath the elevated promenade.
- The vertical seawalls to the south of the Ferry Pier could be improved by affixing eco-tiles.



© WWF-Hong Kong, WPP
Eco-shoreline with vertical eco-tiles

© WWF-Hong Kong, HKSARG
Eco-shoreline with mudflat platform to encourage mangrove formation

Chapter 6.2: Eco-shoreline
Qualitative Assessment

Location
Along engineered shoreline and waterways

Type of landscape
Urban

NbS approaches
Ecological engineering, Natural infrastructure

Details of the NbS
- Redesign the engineered shorelines with mangrove plantation, artificial rock pools, and eco-seawalls.
- Enlist citizen scientists to aid in mangrove nursery and planting, as well as ecological monitoring of the eco-shoreline.
- Develop facilities for public access to appreciate the restored ecosystems.

Benefits on biodiversity
- Mangroves provide habitats and nursery grounds for coastal species, notably birds, fish, and aquatic invertebrates.
- Rock pools retain seawater during low tides, creating microhabitats for a variety of marine species.
- Eco-seawalls offer additional space for the attachment and growth of marine invertebrates.

Co-benefits on the environment and people
- **Climate change mitigation and adaptation**: Climate change mitigation and adaptation: Mangroves contribute to climate mitigation by capturing and sequestering carbon.
- **Disaster risk reduction**: Mangroves and bio-blocks aid in reducing the impact of storm surges, bolstering coastal defence.
- **Economic and social development**: Mangroves are critical nursery grounds for commercially important seafood species. The creation of green jobs to produce, install, manage, and maintain the eco-shoreline.
- **Human health**: Eco-shorelines enhance hard landscapes and improve human well-being. A greener environment with higher biodiversity fosters a deeper connection to nature and promotes better human health.

Technical feasibility
- The stability of the shoreline and waterways must be evaluated to ensure the infrastructure can support the establishment of mangroves and other organisms on the eco-structures.

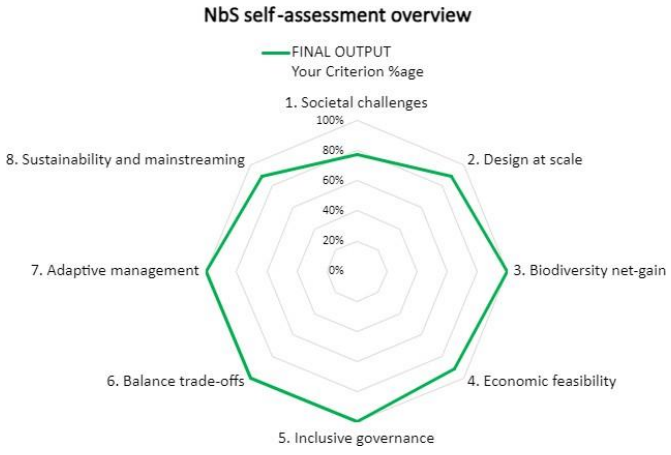
Economic feasibility
- Utilising volunteers can help mitigate labour costs in the nursery and planting activities for mangroves.

Legislation / Planning Implication
- Coordination with relevant government authorities, particularly the Drainage Services Department, Civil Engineering and Development Department, and Marine Department, is crucial to ensure adherence to legislation and effective planning for the eco-shoreline.

Measurement and monitoring
- Monitor survival and growth rates of planted mangrove seedlings.
- Track visitor numbers at eco-shoreline access points.
- Survey species diversity in mangroves, on eco-seawalls, and in artificial rock pools.
- Assess impacts on human well-being and establish benchmarks for evaluation.

Mainstreaming
- Since March 2019, the Government of Hong Kong conducted "eco-shoreline" site trials at selected conventional seawalls. This NbS aligns with the concept.

Self-assessment based on IUCN Global Standard for NbS



Chapter 6.3: Aerial Greening
Rationale and Key Concepts

Societal challenges and opportunities

- The heat island effect is prevalent in urbanised areas, characterised by higher temperatures in built environments compared to surrounding rural ones.
- Buildings, roads, and grey infrastructure restrict airflow and intensify heat absorption and re-emission due to impervious surfaces, resulting in increased temperatures.
- Mui Wo town centre and ferry pier area lack greening; locals have raised concerns about inadequate shading and the need for more green spaces.
- Rooftops, walls, and spaces on and among buildings in Mui Wo present untapped potential for greening efforts.

Green roof and vertical greening

Green roofs and walls, as green infrastructure, are effective urban NbS for enhancing habitability and space-efficient integration of vegetative surfaces within urban settings. The following are essential design components of these structures:

Green roof:
- Waterproofing to avert water leakage into the building.
- A barrier and drainage system to protect the waterproof layer from root damage and to prevent waterlogging.
- Substrate that supplies nutrients necessary for plant growth.
- Selection of plant species compatible with local conditions, structural capacity of the building, and aesthetic preferences.

Green shade:
- A tensioned sail that anchors between buildings, creating an overhead structure to support vegetation growth, paired with a specialized lightweight textile substrate conducive to plant development.
- An irrigation and water collection system to ensure adequate hydration for the plants on the sail.
- Choice of plant species that are suited to the local environment.

Vertical greening:
- A support structure that serves as the foundation for plant life and is attached to the building.
- Containers or panels filled with substrate to facilitate plant growth.
- Selection of plant species appropriate for vertical environments, including climbers and cascading varieties.

Chapter 6.3: Aerial Greening
Qualitative Assessment

Location

Rooftops and walls of government buildings, main streets frequented by residents and visitors

Type of landscape

Urban

NbS approaches

Ecological engineering, Green infrastructure

Details of the NbS

- Install green roofs and vertical greening across and amongst buildings to provide shade and evaporative cooling effects, effectively utilising rainwater in urban areas.
- Prioritize the use of native plant species.
- Diversify plant species to maximise environmental benefits.

Benefits on biodiversity

- Vegetation provides valuable wildlife habitat in urban areas.
- Enhances ecological connectivity between patches of wildlife corridors in urban spaces.

Co-benefits on the environment and people

- **Climate change mitigation and adaptation**: Mitigates urban heat island effect, reduces ambient temperatures, and improves microclimate. Lowers energy consumption inside buildings. Green infrastructure plants sequester carbon dioxide.
- **Economic and social development**: Reduces energy demands for cooling. Creates green jobs in nursery, installation, management, and maintenance of green infrastructures.
- **Human health**: Increases access to nature within urban environments, enhances the aesthetic appeal of urban surroundings, and absorbs air pollutants. Vertical greening also reduces noise pollution as a natural sound absorber.

Technical feasibility

- Securing agreement from all stakeholders involved is crucial for NbS implementation.
- Employing technical expertise in plant selection.
- Considering implications for structures, drainage, usage, and maintenance. Load-bearing capacity, drainage system impact, and associated usage changes must be carefully evaluated.
- Inspect and repair roof waterproofing prior to installation.
- Implement adequate safety measures and provide easy access for maintenance.

Economic feasibility

- Funding required for installation and maintenance.

Legislation / Planning Implication

- Coordinate with relevant government authorities.
- Adhere to design and construction standard procedures.
- Comply with applicable building regulations.

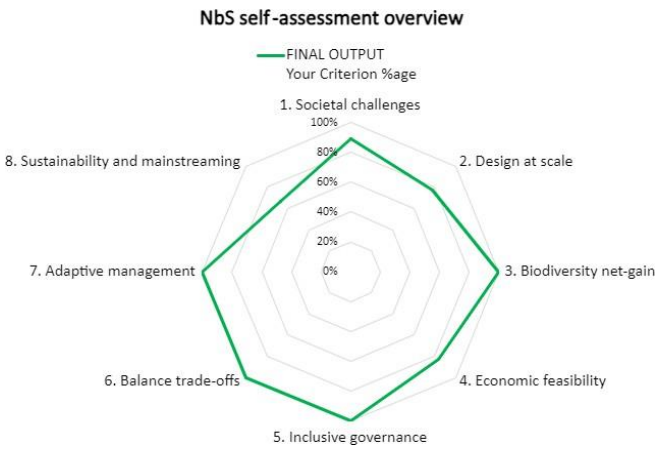
Measurement and monitoring

- Monitor plant health.
- Track temperature, energy consumption, and noise reduction.
- Survey biodiversity on green roofs/shades and green walls.

Mainstreaming

- The Hong Kong Climate Action Plan 2030+ and the Energy Saving Plan for the Built Environment 2015~2025+, as set out by the Environmental Bureau, aim to reduce Hong Kong's energy consumption.

Self-assessment based on IUCN Global Standard for NbS

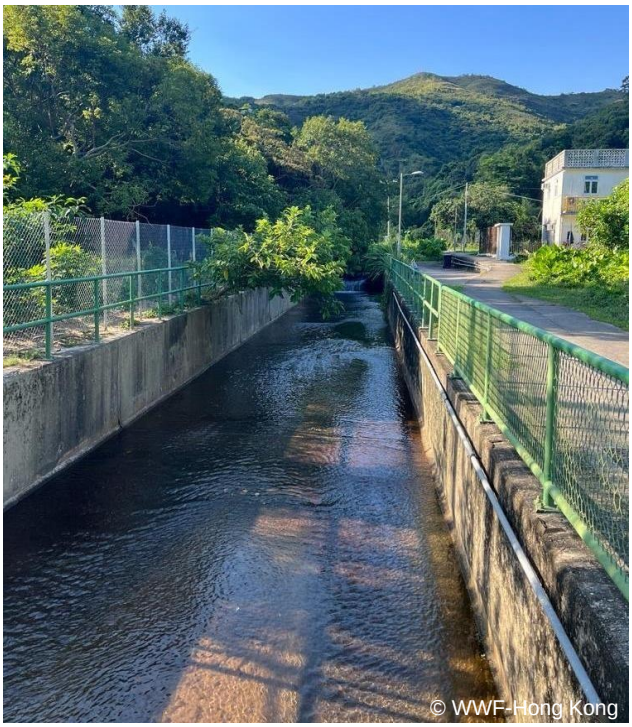


Chapter 6.4: River Restoration

Rationale and Key Concepts

Societal challenges and opportunities

- Hard engineering channelization has been widely adopted in Hong Kong for flood risk management.
- Concrete-lined, significantly widened drainage channels have replaced all the lowland natural watercourses in Mui Wo.
- Several irrigation weirs constructed in the watercourses of Mui Wo are major barriers for migratory aquatic species.
- These concrete drainage channels provide minimal ecological value and are considered unsightly by the community and visitors.
- Mui Wo is home to rare aquatic and riverine wildlife such as migratory fish species, highlighting the potential for river restoration.
- The Drainage Services Department (DSD) has been proactively revitalising concrete channels; fish ladders along River Silver have been installed to aid fish movement.



Channelised section of Wang Tong Stream

A Weir of Wang Tong Stream

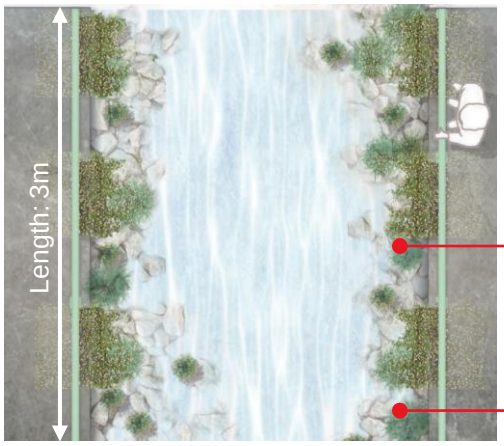
River restoration

Blue-green drainage infrastructure today goes beyond the primary objective of flood prevention. River restoration encompasses:

- Restoring riparian vegetation and natural riverbeds to enhance water quality and create microhabitats for wildlife.
- Removing weirs and constructing fish passages to restore river connectivity, enabling fish and other organisms to move freely to complete life cycle, and sustain healthy populations.
- Revitalising watercourses to a more naturalistic state to improve the aesthetic appeal of waterways.

Chapter 6.4: River Restoration
Rationale and Key Concepts

Conceptual design of restored river and potential carbon sequestrated



Scientific Name	Chinese Name	Native to HK	Features	Planting Area Per 100m	Carbon Sequestration Rate Per 100m (kgCO2e per year)
Commelina diffusa	節節草	Yes	Small blue flowers from Summer to Winter.	65.45 m^2	31.09 $kgCO_2e$ per year
Alternanthera sessilis	蝦鉗菜	Yes	Tinges of red.		

Chapter 6.4: River Restoration
Qualitative Assessment

Location
Existing channelised sections of watercourses

Type of landscape
Rural

NbS approaches
Ecological engineering, Ecological restoration

Details of the NbS
- Remove weirs or build fish passage to enable the movement of aquatic species.
- Restore riparian vegetation and the natural riverbed to enhance aquatic habitats.
- Improve the waterway's aesthetic appeal for residents and visitors.
- Utilize smart technologies for effective flood risk monitoring and an early warning system.

Benefits on biodiversity
- Enhances habitat quality and fluvial connectivity for freshwater and intertidal ecosystems, benefiting the overall biodiversity of Mui Wo.

Co-benefits on the environment and people
- **Climate change mitigation and adaptation**: Restored riparian vegetation captures and stores carbon, aiding in climate change mitigation.
- **Disaster Risk Reduction**: Riparian vegetation and a natural riverbed can absorb rainwater, mitigating flood risks.
- **Economic and social development**: Creates job opportunities for skilled labour and ongoing maintenance work.
- **Human health**: Natural watercourses enhance the aesthetic and recreational value of the area, promoting the mental well-being of residents. River restoration also improves environmental quality which is beneficial to human health.

Technical feasibility
- Weir removal and fish passage construction require substantial engineering efforts, including studies on river flow regimes and sediment transport.
- Smart technologies for flood risk monitoring and reduction are readily available and currently used in DSD projects.
- Comprehensive study of catchment hydrology and geomorphology is crucial for planning river restoration.

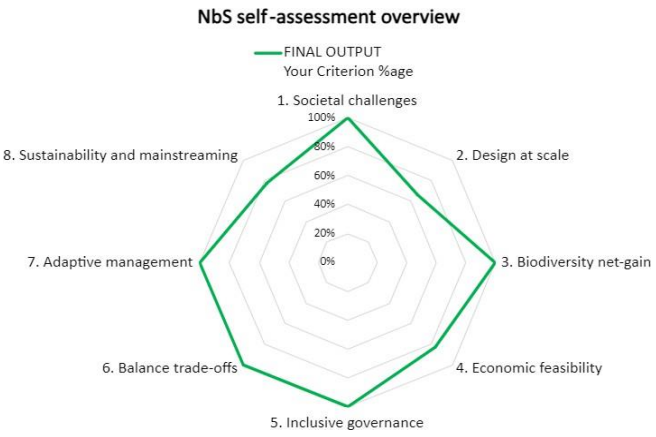
Economic feasibility
- Government funds allocated for drainage improvements and rural minor improvement works could support river restoration initiatives. With DSD's active role in revitalizing channelized waterways, funding is anticipated to be forthcoming.

Legislation / Planning Implication
- Comply with flood prevention standards.

Measurement and monitoring
- Monitor flow velocity and volume in restored channels.
- Monitor biodiversity recovery in restored channels.
- Evaluate outcomes related to human well-being.

Mainstreaming
- Hong Kong's Climate Action Plan 2030+, as published by the Environmental Bureau, promotes the "blue-green drainage infrastructure" concept of DSD.
- The "Rivers in the City" initiative, highlighted in the 2019 Policy Address, supports river restoration projects.

Self-assessment based on IUCN Global Standard for NbS



Chapter 6.5: Integrated Wetland Treatment System
Rationale and Key Concepts

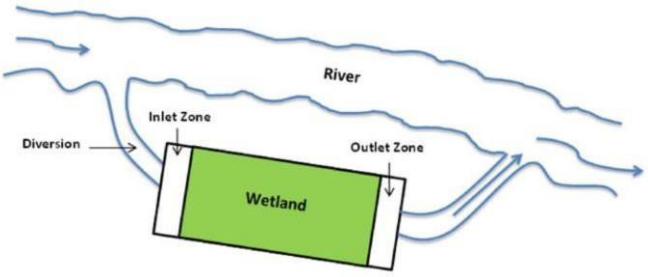
Societal challenges and opportunities

- As urbanisation continues to advance in Mui Wo, pollutants stemming from stormwater runoff is expected to rise, leading to water quality degradation.
- Household sewage not connected to a treatment system also contributes to point source pollution, creating eyesores and emitting foul odours.
- A lack of financial incentives impedes proper wastewater management.
- The plentiful wetland resources near the villages present a prime opportunity to leverage nature for wastewater treatment.

Treatment wetland

Wetlands serve as an effective agent for water quality improvement; integrated treatment wetland systems provide an innovative and sustainable solution for wastewater treatment:

- These systems harness natural wetland processes to efficiently purify wastewater.
- Wastewater is channelled to the treatment wetland, where it is detained for a prolonged period, allowing for the deceleration of flow and the settling of sediments for filtration purposes.
- Wetlands with dense vegetation facilitate biofiltration and microbial activity, where floating debris is captured, organic compounds are broken down, and nutrients are assimilated by the plants.
- Strategically chosen portion of an existing freshwater marsh could be designated as a treatment wetland to process polluted household water and surface runoff from impervious areas before the purified water is released into the marsh or watercourse.



Schematic design of a treatment wetland for point-source pollution

© Arup

An extensive reedbed provides biofiltration function as well as habitat for reed-associated wildlife.

Chapter 6.5: Integrated Wetland Treatment System
Qualitative Assessment

Location
Freshwater marshes

Type of landscape
Rural

NbS approaches
Ecological engineering, Natural infrastructure

Details of the NbS
- Link village homes and paved areas, such as roads and parks, to treatment wetlands designated within existing marshes.
- Extract pollutants from sewage via constructed and natural wetlands to remove litter, pathogens, and nutrients.
- Depend on natural processes for sewage treatment to avoid energy-intensive methods.
- Treated water can be reused for irrigation in parks and farmland.
- Design influenced by hydrology and topography to avoid the need for water pumping.
- Wetland plants need to be harvested periodically which can be utilised as mulch for local agriculture.

Benefits on biodiversity
- Optimise the 'use-value' of freshwater marshes, a mainly privately-owned habitat in Hong Kong.
- Preserve endangered marshland species.
- Marshes sustain feral buffalo and cattle, which in turn help preserve the ecological significance of this ecosystem.
- Enhance water quality in riverine and coastal ecosystems, supporting broader biodiversity.

Co-benefits on the environment and people
- **Climate change mitigation and adaptation:** Wetlands aid in climate change mitigation through carbon capture and sequestration.
- **Disaster risk reduction:** Acting as natural sponges, wetlands store excess rainwater, alleviating flood risks.
- **Economic and social development:** Harvested plants and litter from treatment wetlands provide mulch for farmers and leisure opportunities. The wilderness landscape can increase the value of village properties.
- **Human health:** Improved scenery and clean water boost environmental quality, fostering better health.

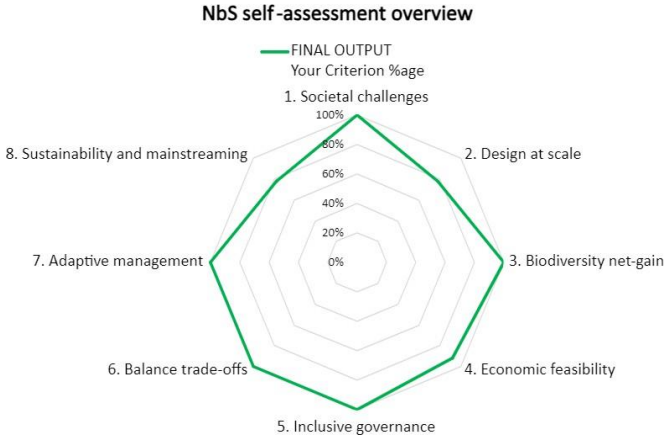
Technical feasibility
- Employ existing piping and ditch infrastructure to reduce new construction costs.
- Assess soil conditions, groundwater levels, and local hydrology thoroughly to ascertain the optimal size and placement of the treatment system, ensuring its effectiveness.
- Establish regular maintenance and monitoring protocols to maintain the efficiency and functionality of treatment wetlands for effective wastewater management.

Economic feasibility
- Treatment wetlands are less costly to construct and operate than traditional wastewater treatment plants, presenting an economically and environmentally sound alternative.
- Government funds for sewage treatment can be reallocated to the development and upkeep of treatment wetlands, maximising resource utilisation.

Legislation / Planning Implication
- Ensure treated water complies with standards for irrigation purposes.

Measurement and monitoring
- Assess water quality.
- Monitor biodiversity within the treatment wetland and adjoining marshland ecosystems.
- Evaluate human well-being outcomes and establish benchmarks.

Self-assessment based on IUCN Global Standard for NbS



Chapter 6.6: Water Buffalo Park
Rationale and Key Concepts

Societal challenges and opportunities

- A habitat assessment conducted by WWF-Hong Kong in 2023 identified approximately 17.4 hectares of freshwater marsh within the study area
- Urbanisation and land development are leading to the degradation of Mui Wo's freshwater marshes. Neglected maintenance and land repurposing for various uses have also resulted in the loss of marshland.
- Rising sea levels and malfunctioning tidal sluice gates have led to the encroachment of brackish vegetation and altered biotic communities in the once freshwater marshes of Mui Wo.
- In the remaining freshwater marshes, water buffalo play a critical role in maintaining ecological functions through grazing, trampling, and wallowing. Without the buffalo, these marshes quickly overgrow and risk drying out.
- Freshwater marshes are among the most endangered natural habitats in Hong Kong, with Mui Wo harbouring some of the largest and healthiest examples.
- As marshland continues to diminish, the water buffalo herds are forced into close contact with the human population causing human-buffalo conflicts; finding a win-win solution to mitigate the conflict between humans and water buffalo is essential.
- Visitors appreciate the free-roaming water buffalo and open marshland landscape, which hold significant potential as a local attraction.
- Wetland wildlife associated with buffalo-grazed marshes are becoming scarce in Hong Kong, yet they attract nature enthusiasts and wildlife photographers.
- With the increase in extreme weather events, extensive marshlands serve as natural flood storage during stormwater episodes.

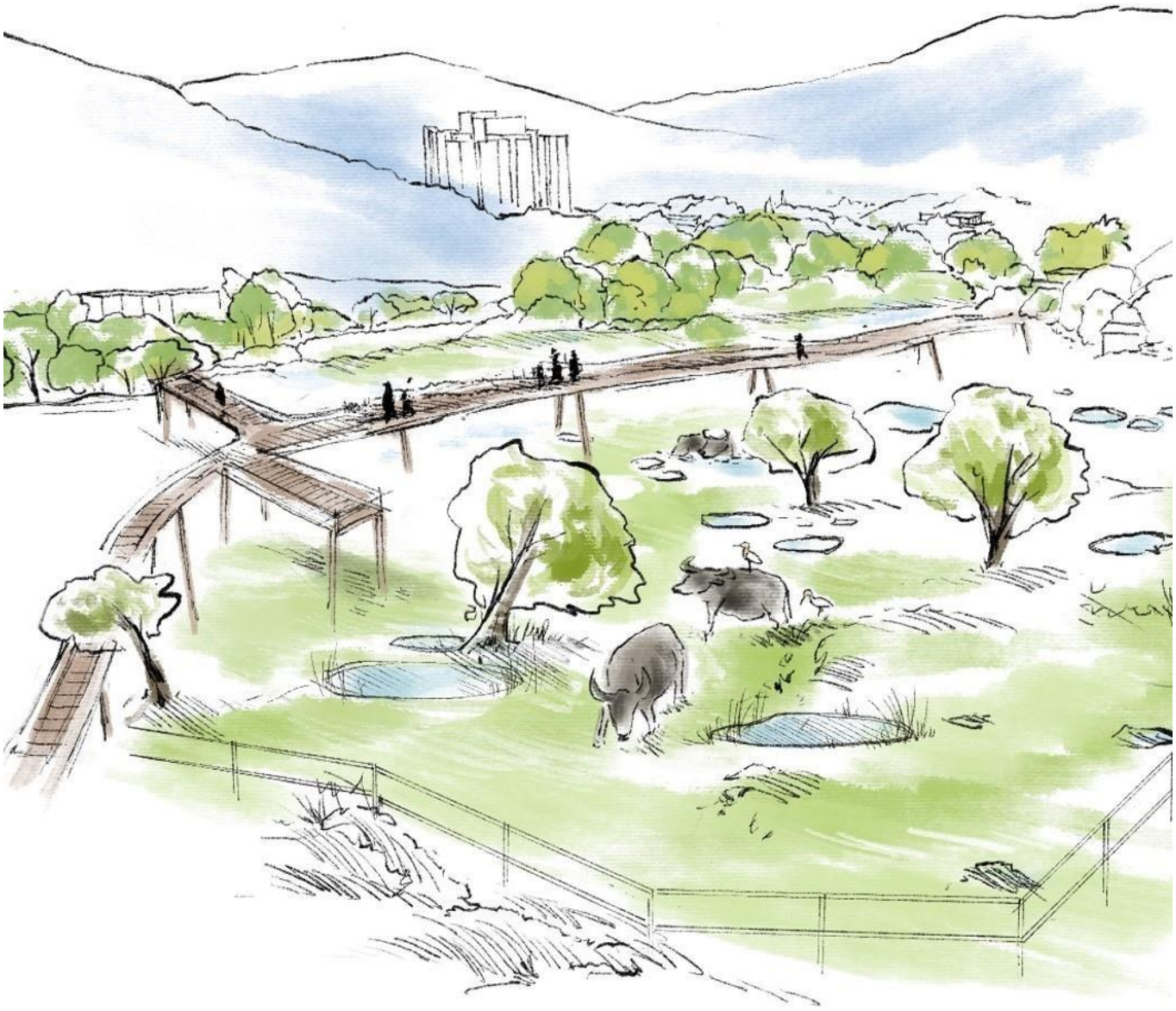
Water Buffalo Park

A Water Buffalo Park is proposed to minimise human-buffalo conflicts, preserve a healthy freshwater marsh ecosystem, provide alternative income for landowners, function as a flood storage area, and become an iconic tourist attraction for Mui Wo:

- Maintain a scientifically determined population of water buffalo within the park, which act as ecosystem engineers to preserve the freshwater marsh while also serving as a tourist draw.
- Design unobtrusive, low-impact visitor amenities such as viewing platforms, elevated boardwalks, and informative signs to ensure visitor safety and enjoyment, while minimising disturbance to wetland wildlife and the buffalo.
- Re-establish marshland vegetation and biotic communities in degraded areas.
- Design the park with a dual purpose, serving as a flood storage area during extreme weather events.

Chapter 6.6: Water Buffalo Park
Rationale and Key Concepts

Conceptual design of Water Buffalo Park



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Chapter 6.6: Water Buffalo Park
Qualitative Assessment

Location
Freshwater marshes

Type of landscape
Rural

NbS approaches
Ecological engineering, Ecological restoration

Details of the NbS
- Utilise water buffalo as ecosystem engineers through their grazing, trampling, and wallowing activities to maintain the quality of freshwater marshes.
- Maintain a scientifically informed number of buffalo within a large enclosure to mitigate escalating human-animal conflicts.
- Establish the first buffalo park in Hong Kong featuring low-impact visitor infrastructure, creating a unique landmark for Mui Wo.
- Design the buffalo park to also function as an auxiliary flood storage area during extreme rainstorms.

Benefits on biodiversity
- Preserve and enhance the quality of the freshwater marsh habitat.
- Revitalise marshland wildlife populations, many of which are becoming rare in Hong Kong.

Co-benefits on the environment and people
- **Climate change mitigation and adaptation**: The wetland acts as a carbon sink and absorbs stormwater, reducing the impacts of climate change.
- **Disaster risk reduction**: Freshwater marshes act as natural sponges, storing stormwater and diminishing the risks associated with climate change-induced disasters.
- **Economic and social development**: The maintenance of the buffalo park generates green job opportunities, such as buffalo caretakers, eco-tour guides, and infrastructure workers, fostering economic growth and community development.
- **Human health**: Enhance nature connections, alleviate stress. The enclosure of the buffalo marsh minimizes conflicts with local communities.

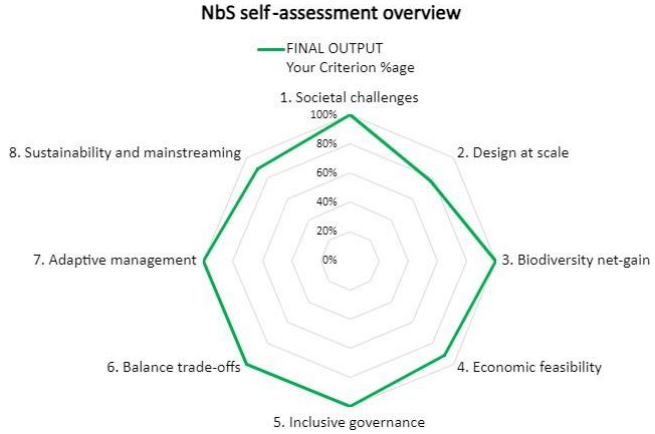
Technical feasibility
- Expertise in water buffalo and wetland management is vital for the successful implementation of the park.
- Secure land tenure for substantial marshland from multiple owners requires the full backing of the local community.
- Thorough examination of catchment hydrology is essential when planning floodwater storage facilities.

Economic feasibility
- Financial support is needed to procure sizeable farmland suitable for buffalo husbandry, maintain visitor infrastructure and a healthy buffalo population.
- Financial resources are also required for the establishment and management of water buffalo and visitor amenities.

Legislation / Planning Implication
- Changes in land use in target areas may have planning implications.
- Applications may be necessary to address statutory land use changes and to ensure compliance with regulations.

Measurement and monitoring
- Monitor the health and biodiversity of the marshland ecosystem.
- Ensure the health and well-being of the water buffalo.
- Inspect the condition of visitor infrastructure and track visitor numbers.
- Evaluate human well-being outcomes and establish benchmarks.

Self-assessment based on IUCN Global Standard for NbS



Chapter 7: NbS Planning and Implementation

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Roadmap for NbS Implementation

To ensure adherence to the IUCN Global Standard for NbS, the following actions are recommended to be taken bythe NbS practitioners during the planning and implementation stages of NbS projects.

No.	Criteria	Aim	Planning	Implementation
1	Societal challenges	Prioritise societal challenges	Conduct site visits and stakeholder consultations	Identify drivers and responses to societal challenges
			Document and share information with stakeholders	Regularly assess outcomes
			Identify human well-being outcomes	Implement action plans based on identified drivers
2	Design at scale	Incorporate interactions between systems	Identify and incorporate interactions in design	Regularly assess and adjust
			Identify synergies across sectors	Implement integrated design approaches
			Identify risks and drivers	Incorporate risk mitigation strategies
3	Biodiversity net-gain	Understand current state and drivers	Assess baseline	Regularly assess and adjust
			Identify biodiversity conservation outcomes	Plan and incorporate ecosystem enhancement in design
			Identify opportunities for ecosystem enhancement	Incorporate ecosystem enhancement in design
4	Economic feasibility	Examine costs and benefits	Conduct cost-effectiveness study and sensitivity analysis	Justify against alternative solutions
			Review long-term principles and complementary funding	Secure funding and resources for implementation
5	Inclusive governance	Identify affected stakeholders	Conduct stakeholder analysis	Incorporate stakeholders in decision-making
			Document and share information with stakeholders	Regularly assess and adjust
			Establish a feedback resolution mechanism	Implement feedback mechanisms for stakeholder engagement
6	Balance trade-offs	Identify costs and benefits	Conduct cost-benefit analysis	Document mutually-agreed limits and trade-offs
			Regularly review and safeguard	Regularly review and safeguard
7	Adaptive management	Regularly monitor and evaluate conditions	Plan monitoring and evaluation	Regularly assess and adjust
8	Mainstreaming & Sustainability	Support NbS mainstreaming	Share experiences	Identify and enhance relevant policies
			Support national and global targets	Report contributions to relevant platforms

Chapter 8: Conclusion and Recommendations

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Conclusion

This collaborative visionary study by Arup and WWF-Hong Kong presents the concept of Nature-based Solutions (NbS) and introduces the IUCN Global Standard for NbS through a Hong Kong case study. Using the culturally and ecologically diverse rural township of Mui Wo as a study site, we employed various methods to identify local societal challenges and developed six potential NbS that benefit both human well-being and nature. Since Mui Wo's landscape is representative of many rural areas in Hong Kong, and our proposed NbS are in line with the IUCN Global Standard for NbS, the methodology and ideas could be adopted across Hong Kong and in the wider region.

The report highlights the conservation value of Mui Wo's paddy-derived freshwater marshes and the role free- roaming bovines play in maintaining this rapidly vanishing wetland habitat. While some community members regard water buffalo as part of the area's fabric, others voice concerns about human-wildlife conflict. The absence of iconic tourist attractions and the scarcity of local job opportunities underscore the need for sustainable solutions to retain residents and rejuvenate the community's cultural and natural heritage. Additionally, Mui Wo's heavy reliance on food imports from urban areas, alongside a growing revival of farming and an alternative rural lifestyle in Hong Kong, suggests a potential niche market to boost the local economy through agricultural activities. The pollution of watercourses and Mui Wo's susceptibility to extreme weather events such as flooding further amplify the community's concerns.

The proposed solutions aim to promote low-impact nature tourism, generate local employment opportunities, create a safe and enjoyable environment, and conserve key wildlife habitats. The proposed NbS include:

- **Regenerative Agriculture** to establish Mui Wo as a centre for sustainable farming with ample high-qualityarable land.
- **Eco-shoreline** to restore coastal and estuarine ecology, enhancing the climate resilience of Mui Wo.
- **Aerial Greening** to improve urban green spaces and mitigate the heat island effect in Mui Wo.
- **River Restoration** to rehabilitate the ecology of impaired waterways and enhance their aesthetic appeal forresidents and visitors.
- **Integrated Wetland Treatment System** to address the localised domestic sewage issues using the widespreadand extensive freshwater marshes.
- **Water Buffalo Park** to leverage the existence of marshland and water buffalo population in Mui Wo, mitigate human-buffalo conflicts, provide alternative revenue for landowners, establish a unique tourist attraction, and contribute to flood prevention in Mui Wo.

These tailored solutions are designed to meet the specific societal challenges faced by Mui Wo, with the overarching aim of fostering its sustainable development. Moreover, these solutions offer practical models that canbe replicated and adapted to other rural areas of Hong Kong facing similar challenges.

Chapter 8: Conclusion and Recommendations

Recommendations

While this visionary study has its limitations, such as a limited opinion survey, not fully addressing land ownership constraints and some existing policies and regulations, its primary objective is to demonstrate the extensive potential of Nature-based Solutions (NbS) in crafting sustainable rural communities. Despite these constraints, the study provides actionable steps in the "Roadmap for Implementation" section, which is in line with the IUCN Global Standard for NbS. We recommend NbS practitioners to thoroughly examine the Standard and adhere to our Roadmap to create people-centric NbS that optimise benefits for both humans and nature.

- To ensure the relevance and effectiveness of NbS, future projects should prioritise extensive stakeholder mapping and regular co-development consultations throughout the planning and implementation stages.

- Collaboration among stakeholders, including government departments, NGOs, villagers and community organisations, is crucial for integrated planning and implementation, recognising the interconnections betweenNbS and other landscape-scale solutions.

- To facilitate the adoption of NbS, it is essential to revise or create policies and regulations that provide the necessary frameworks and incentives for incorporating NbS into existing planning and decision-making processes. Identifying specific policy and regulatory constraints for each NbS will help streamline future advancements.

- A comprehensive monitoring and evaluation plan is critical for the enduring success and adaptive management of each NbS initiative. We have outlined monitoring targets for each proposed NbS project to guide their progression.

- Investigating business models and securing funding support from government entities, the private sector, and thepublic is an important endeavour to ensure the economic feasibility of NbS.

- Assessing the ecosystem services rendered by NbS and examining funding and financing mechanisms for these services are key to guaranteeing long-term sustainability and promoting the widespread adoption of NbS.

In conclusion, the successful implementation of NbS in Hong Kong hinges on site-specific designs, proactive stakeholder participation, and a deep comprehension of local needs. A rigorous monitoring and evaluation framework, coupled with enabling policies and regulations, will underpin the integration of NbS into mainstream practices. By recognising synergies with other landscape-scale endeavours and cultivating collaborative efforts, Hong Kong can realise resilience, sustainability, and enhanced well-being through the careful application of NbS.

Chapter 9: Potential beyond Mui Wo

Chapter 9: Potential beyond Mui Wo

Application of NbS is not restricted to rural areas, like Mui Wo, and there are ample examples of successful NbS in urban landscape. Adopting NbS in the planning of large-scale development is equally critical to ensure win-win outcomes for both human and nature.

One prime example in Hong Kong is the Northern Metropolis, which is a strategic development area that holds significant potential for the city's future growth and development. It encompasses various districts in the New Territories, including areas such as Kwu Tung North, Fanling North, and Ta Kwu Ling. The HKSAR government has identified the Northern Metropolis as a key area for urban development, aiming to create a sustainable and livable community that can accommodate population growth, provide housing, create job opportunities, and enhance the overall quality of life for residents.

It covers large parts of the northern New Territories which is rich in cultural and natural resources, comprising urban areas, rural townships, villages, floodplains, hills, rivers, wetlands, fishponds, agricultural lands, countryside, bays and islands. The opportunity for adopting NbS in the Northern Metropolis is huge, helping to strike a balance between conservation and development and to demonstrate how NbS can be an integral part of large-scale development in existing rural areas.

NbS use the power of ecosystems to address various challenges, for instance, climate change, urbanisation, and ecosystem degradation. They can include measures like restoring habitats, implementing blue-green infrastructure, integrating nature into urban design. Utilising the IUCN Global Standard can help ensure the NbS are effectively integrated into the development of the Northern Metropolis.

This study provides actionable guidance for a range of stakeholders including the government, developers, and other related sectors to prioritise sustainability in Northern Metropolis projects, leading to a more sustainable and climate resilient Hong Kong.

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