Mapping Nature-Based Solutions in Hong Kong

Abstract: As climate change adversely affects Hong Kong's infrastructure and ecosystems, the region is beginning to utilise natural and pre-existing solutions to protect against natural disasters and improve local ecosystems and biodiversity. These newly implemented strategies are called Nature-Based Solutions (NBS). However, they have not been adopted for widespread use in Hong Kong due to a lack of information and incentives available to businesses and other organisations. Through collaboration with the Hong Kong Business Environment Council (BEC), this project aims to provide relevant stakeholders with an accessible and interactive source of information that will encourage them to engage with, invest in, and implement these initiatives. Throughout the project, information was collected through interview transcripts, audio recordings, photos and videos, and on-site notes. Areas of opportunity to increase the understanding and usage of NBS were identified, pertaining to policy advocacy, business incentives, and accessible information, and recommendations for ways to improve these areas were given to the Business Environment Council.

Team Members: Yan Acevedo, Maeve Hess, Kathryn Pagano, and Jingxu (Rick) Wang

Advisors: Professors Brajendra Mishra and Stephan Sturm

Sponsors: Business Environment Council (BEC)

WPI

This report represents the work of four WPI undergraduate students submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its website without editorial or peer review. For more information about the projects program at WPI, please see https://digital.wpi.edu/collections/iqp.

BUSINESS ENVIRONMENT COUNCIL 商界環保協會

Overview

Climate change is a prevalent issue of concern in everyday life for people all around the globe. Worldwide, temperatures have increased in recent years, resulting in continuous sea level rise and frequent intense storms. The repercussions of these events include loss of biodiversity, flooding, property destruction, and injury to the citizens of impacted areas.[1] Industrialisation has crucially intensified these outcomes by destroying the ecosystems that protect the environment and human civilization from the impacts of cyclones hurricanes and flooding.

The consequences of climate change have led to biodiversity loss, large storms, and flooded infrastructure in Hong Kong. These impacts have been adverse for the region's citizens and commercial sector.[2] Hong Kong primarily uses engineered infrastructure to withstand large storms and flooding, but the effectiveness of these solutions diminishes as climate events worsen.[3] To combat this, Hong Kong aims to utilise pre-existing solutions found in the natural world. Strategies using existing ecological features to protect against natural disasters are termed Nature-Based Solutions (NBS).[4] NBS yield long-term results and benefits and are commonly less expensive than engineered methods.

Implementation of NBS has begun in Hong Kong but has not yet been successful on a larger scale due to insufficient standards for proper and effective NBS. There has been little governmental or financial incentive to endorse NBS without proof of their efficacy. This drives the growing knowledge gap between businesses with the resources to invest in NBS and the non-governmental organisations that propose them.

Core Problem

Nature-based solutions are not widely used in Hong Kong, primarily due to a lack of information and incentives available to the relevant stakeholders in NBS. To address this, we must understand Hong Kong's changing climate, the NBS currently in use in the region, and what approaches can be taken to integrate NBS further into the business sector.

Project Introduction

This project aims to provide a platform to effectively inform Hong Kong businesses on Nature-Based Solutions and encourage them to invest in these sustainable ideas. To achieve this, we cultivated an extensive understanding of Hong Kong's current NBS and identified the most crucial criteria for successful NBS. We worked with Hong Kong's Business Environment Council (BEC) to gather information. We also developed an interactive mapping tool that pinpoints and explains exemplary NBS projects located in Hong Kong. The mapping tool provides businesses with an easy-to-access resource on why it is crucial to implement NBS and how this is currently being done. We also use current successful NBS projects in Hong Kong to create a working definition for Nature-Based Solutions in the context of Hong Kong. These resources provide insight into how to achieve successful widespread adoption and application of NBS in Hong Kong.

Hong Kong's Regional Climate

Hong Kong consists of different regions with varying terrains. The regions include Hong Kong Island, the Kowloon peninsula, Lantau Island, and the New Territories, which are all relatively mountainous. Most developed areas are found along shorelines and reclaimed land and are more likely to experience the effects of extreme weather events.[3] More extreme weather and flooding has made this problem even more urgent. Some climate problems are easily observable, including an increased number of hot days, extreme rainfall, and rising sea levels.[5]

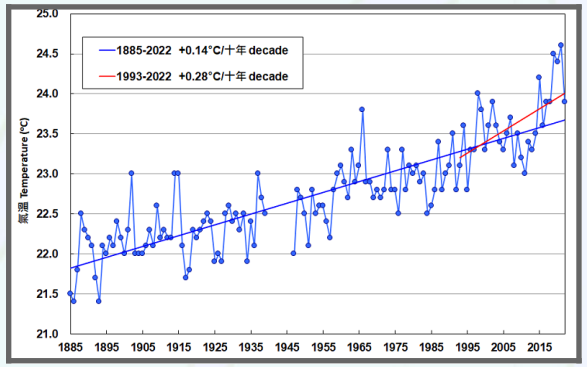

Figure 1: Annual mean temperature with overall trend from 1885 - 2022 and 1993 - 2022 recorded at the Hong Kong Observatory Headquarters (1885-2022) [5]

The annual temperature in Hong Kong has been slowly rising for decades, with a steeper increase in the past twenty years.[5] This can be seen in Figure 1, which displays mean temperature data collected from 1885 to 2022.

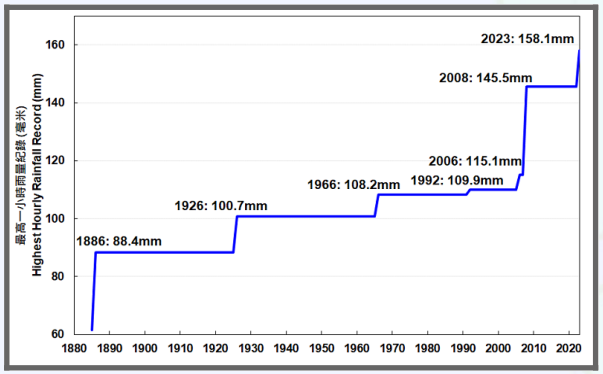

Figure 2: Highest hourly rainfall records at the Hong Kong Observatory Headquarters since1885 (as of 12 Sep 2023) [6]

In addition to rising temperatures, Hong Kong is facing increasing heavy rainfall. The extremity of rain events in Hong Kong has increased substantially over time, as can be seen in Figure 2. The extreme rainstorm in September 2023 ravaged Hong Kong, disrupting citizens' everyday lives.[7] Roads, buildings, and subway stations were severely flooded, and there were also several landslides and road collapses in the more rural areas. The rainstorm also resulted in significant economic disruption. Hong Kong needs to address the dramatic increase in sea level as well. The sea level rise is primarily due to the melting of polar ice sheets and glaciers, and the expansion of seawater as it warms up.[8] As seen in Figure 3, sea levels have varied less from year to year and experienced a general upward trend since 2010.[9]

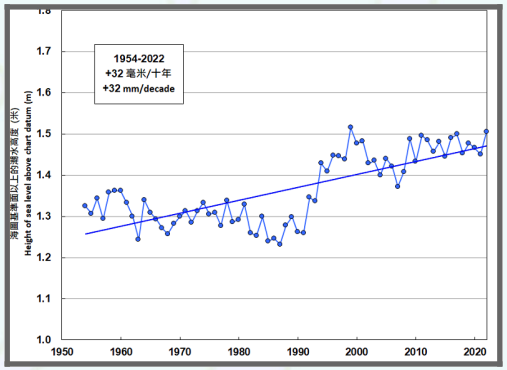

Figure 3: Annual mean sea level at Victoria Harbour (1954-2022) [9]

Climate Mitigation in Hong Kong

Engineered solutions such as sea walls or drainage systems, are the favoured methods used to mitigate climate risks. These fall under the category of grey infrastructure, which refers to the use of inorganic materials in urban planning.[10]

Limitations of Engineered Solutions

Engineered solutions are engineered for durability, efficiency, and stable functionality. Because engineered solutions yield quick and predictable results, they are frequently the first choice for implementation to solve problems.[11] However, these methods often leave large environmental footprints due to their consumption of materials, polluting construction processes, and the requirement of regular maintenance.[12] The specific and inflexible functions of engineered solutions such as concrete sea walls and underground water storage do not adequately address Hong Kong's rapid changes in sea level and yearly rainfall. Recent weather events have proved that the current grey infrastructure cannot handle the extremities climate change brings.[7]

Nature-Based Solutions (NBS)

"Nature-Based Solutions" is a relatively new term, however, it has become popular in climate risk mitigation, disaster risk reduction, and urban planning. These solutions work by incorporating nature into land development, which has existed for centuries.[14] Many involve projects primarily focusing on protecting habitats, restoring essential ecosystems, and improving land management.[4] Some examples of NBS include wetland restorations shown in figure 4, mangrove forest restorations, and green roofs.[15]

Figure 4: Example of Nature-Based Solution. Image taken at Hong Kong Wetland Park

Challenges of NBS

The implementation of NBS in Hong Kong has been met with less success than other areas with similar climates. This is due to a need for more regulations, policies, government support, and financial incentives.[16] Although the Hong Kong government has released some information about NBS, there are no comprehensive standards to facilitate the implementation of successful Nature-Based Solutions projects. Additionally, there is little published information in Hong Kong that is accessible to the general public and potential implementers. Without evidence that NBS is a more effective and sustainable option, the general public will likely not support investment in these projects. In turn, stakeholders do not want to invest because of this. For NBS to be effectively used in Hong Kong, improvements to the available specifications for implementation need to be made.

Incentives and Rationale for NBS

Without evidence that NBS are more effective and sustainable options, the general public will likely not support investment in these projects. In turn, stakeholders do not want to invest because of this gap in knowledge. Businesses are primarily driven by the bottom line and are generally not concerned with what may be the most environmentally ethical option. Offering incentives can give businesses and consumers greater confidence in NBS.

The lack of popularity and success of Nature-Based Solutions in Hong Kong is a circular problem connected back to the lack of accessible information on NBS. There is little published information that is accessible to the general public in Hong Kong and relevant stakeholders. Additionally, implementers need to be provided with resources that would result in a more effective project. More standardisations and guidelines are needed to ensure the successful usage of NBS. For the current businesses or non-governmental organisations that have implemented a successful project, it was not due to a concrete list of requirements presented to them. However, many more companies could create exemplary NBS projects if they had a palpable guideline to follow.

Success of NBS at Shenzhen, Hong Kong's Neighbour

One successful example of the implementation of Nature-Based Solutions can be found at Hong Kong's neighbour, Shenzhen. The NBS projects led to drastic changes in the landscape, making the city much more climate resilient.[17] China's Sponge City Program, initiated in 2013 by the Chinese government, aimed to address issues of urban flooding and droughts in cities across mainland China. The program incentivized the development of NBS to provide better water absorption and storage.[18] Shenzhen's restoration of mangroves became a major stop for migratory birds and protected the coastline from floods. Across the Shenzhen Bay at Ha Pak Nai, Hong Kong, there are the beginnings of some mangrove forests as shown in figure 5.

Figure 5: Example of baby mangrove forests growing in mud flats in the New Territories. Photo taken at Ha Pak Nai, Hong Kong mud flats

In addition, Shenzhen implemented green infrastructure such as greenways and permeable parking lots in addition to grey infrastructure such as sewage pipelines and water treatment plants. This eliminated flooding in several areas, cleaned up river branches, and reduced the urban heat island effect. Shenzhen has kept major infrastructure on its coastline safe from the rise in the sea level and major floods, and it can be a major inspiration for change that can be seen in Hong Kong.

International Standards of NBS

There are current existing international guidelines on NBS from the International Union for the Conservation of Nature (IUCN) published in 2020.[19] There are a total of 8 criteria with 28 indicators shown in figures 6 and 7 that focus on a variety of elements from the development and goals of the project to its management and maintenance after completion. The IUCN created the standard to provide clarity on the details of the concept of NBS and to ensure that policies and projects will be deployed successfully. The standard also creates a shared understanding of NBS across the world. However, since it is set in a global context, the standard covers many different regions and ecosystems. Therefore, in Hong Kong, some of the IUCN criteria are not as relevant, while others may be more crucial, so a local set of standards is still required to enable successful widespread NBS implementation.

IUCN Standards Graphic Content (Summary of all criteria and their indicators)

Addresses Societal Challenges	Design Informed by Scale	Biodiversity Net-Gain	Economically Viable
1. Most pressing societal challenges relevant to the beneficiaries are prioritised. 2. The societal challenges that are addressed are clearly understood and documented to ensure future accountability of the project. 3. Human well-being outcomes are identified and periodically assessed, and the targets should be measurable.	1. The design of the NBS considers the interactions of the economy, society, and ecosystems. 2. The design of the NBS integrates well with other interventions and seeks to interconnect with different sectors. 3. The design of the NBS identifies risk and risk management beyond the intervention site.	1. The NBS assesses the current state of the ecosystem and develop solutions guided by the local ecosystem. 2. Measurable biodiversity conservation outcomes are identified and monitored periodically. 3. Unintended consequences on nature from the NBS must be periodically monitored. 4. Enhancement of the ecosystem's integrity and connectivity must be identified and incorporated into the NBS.	1. The direct and indirect benefits and cost of the NBS are identified, including financial and non-financial elements. 2. The cost-effectiveness of the NBS must be studied to determine upfront and recurring costs. 3. The effectiveness of the NBS must be compared and justified against alternative solutions. 4. The design of the NBS must consider different resourcing options to determine investment for the long-term.

Figure 6: Summarized IUCN standards criteria 1-4 [19]

IUCN Standards Graphic Content (Summary of all criteria and their indicators)

Inclusive & Transparent Governing Processes

1. Feedback and resolution plans must be presented to all stakeholders before starting the project.
2. The NBS must exhibit mutual respect and equality on all affected.
3. Direct and indirect stakeholders are identified and involved in the creation and management process.
4. Decisions made must equally consider the rights and interests of all stakeholders.
5. Cooperation across different jurisdictional boundaries are made.

Balance Primary Goals with Secondary Benefits

1. The costs and trade-offs are acknowledged and plans are corrected if necessary.
2. The control and usage of the land used by the NBS is acknowledged and respected.
3. Safeguards are put in place for the consideration of trade-offs and reviewed and updated periodically.

Managed Adaptively Based on Evidence

1. Regular monitoring and evaluation of the NBS needs to be established.
2. A plan for monitoring and evaluation for the entire lifecycle of the NBS must be developed.
3. The management of the NBS should adapt to the results from the monitoring and evaluation.

Sustainable and Capable of Being Mainstreamed

1. The design and key takeaways from NBS need to be shared for transformative change and replicability.
2. Policies and regulations that allow mainstreaming of NBS are supported and those that work against the development of NBS need to be identified.
3. Contributions to national and global targets for human well-being, climate change, and biodiversity need to be documented for the role of NBS nationally.

Figure 7: Summarized IUCN standards criteria 5-8 [19]

Methodology

The knowledge we gathered from our background research into Kong Kong's climate and current NBS implementations informed the choices of methodology our team used to accomplish our goals for the project.

Project Goal

The primary goal of our project is to provide a platform to inform Hong Kong businesses about Nature-Based Solutions. Through collaboration with the Hong Kong Business Environment Council, we gained an extensive understanding of pre-existing exemplary NBS in Hong Kong, determined the information and incentives available to businesses for using NBS, and displayed this information in an accessible format to relevant stakeholders.

Understanding Pre-Existing NBS in Hong Kong

Our first objective was to understand pre-existing Nature-Based Solutions in Hong Kong and identify key commonalities. This provided authentic and relevant data that can be used to develop well-informed standards and guidelines. We adopted a research approach that addresses successful implementations of NBS in Hong Kong. When doing so, we considered the commonalities of the NBS projects. This helped us to develop a local definition and understanding of Nature-Based Solutions.

Collecting Information About NBS in Hong Kong

Online research was conducted to gain a brief understanding of the projects before conducting interviews and on-site case studies. The online sources included academic papers, news articles, and the organisations' websites. Observations and interviews were used to gather information such as the project's overall goals and how they benefit the environment and surrounding communities. The BEC scheduled visits to specific project locations in correspondence with our interviews, allowing us to get a more in-depth understanding of the project site while having the opportunity to ask the representatives specific on-site questions.

These locations include restoration sites, conservation parks, and informational exhibits. We also developed an internal rubric shown in figure 8 to compare the information from each NBS case study to the standards set by the IUCN and store it in an organised manner.

WPI x BEC Site Visit Rubric
Location:

ICUN Criteria:	IUCN Guidelines:	Y/N?	Notes:
#1 NBS effectively address societal challenges			
	Prioritizes the most pressing societal challenges for rights-holders		
	Societal challenge(s) addressed are clearly understood and documented		
	Periodically identifies and asses human well-being outcomes		
#2 Design of NBS is informed by scale			
	Design recognises and responds to interactions between the economy, society and ecosystems		
	Design is integrated with other complementary interventions and seeks cooperation across sectors		
	Design incorporates risk identification and risk management beyond the intervention site		
#3 NBS result in a net gain to biodiversity and ecosystem integrity			
	Responds current state of the ecosystem and common drivers of degradation and loss		
	Periodic assessment of clear and measurable biodiversity conservation outcomes		
	Monitoring includes periodic assessments of unintended negative impacts on nature/ecosystems		
	Opportunities to enhance ecosystem integrity and connectivity are identified and incorporated		
#4 NBS are economically viable			
	Direct and indirect benefits and costs associated (who pays and who benefits) are identified and documented		
	Cost-effectiveness study is provided including the likely impact of any relevant regulations and subsidies		
	Effectiveness of design is justified against available alternative solutions, taking into account any associated externalities		
	Design considers a portfolio of resourcing options such as market-based, public sector, voluntary commitments and actions to support regulatory compliance		

Figure 8: Sample of IUCN rubric used at site visits

We prepared our questions in advance and sent them to each interviewee at least one day in advance to ensure an effective and efficient interview. During each interview, all team members were present but took on different roles. Each interview had two interviewers, a note taker, and a rubric evaluator. The information from the interviews are documented through audio recordings and typed notes with the consent of the interviewee to either be quoted directly or indirectly. Pictures and videos of these locations are also collected and presented in our interactive mapping tool. The data collected from each interview and site visit is the primary source of information for our final deliverable.

Determining Potential Incentives and Motivating Factors

Our second objective was determining potential incentives and motivating factors for NBS usage. To determine the driving factors for NBS implementations, we needed to understand what information is currently available to businesses about NBS and how this might contribute to their involvement with these projects.

Understanding Perspectives on NBS

Data collection for this objective was completed entirely through interviews and discussions with representatives of companies within Hong Kong's private sector. We adapted our interview questions to align with the perspectives of businesses. The question set delved into the design, development, and management methods used to implement NBS projects. This gave us the opportunity to obtain insight into the information and collaborations businesses need to obtain for considering NBS projects. Interviews and data collection for private sector organisations were conducted using the same procedure as the previous objective.

Each interviewee had experience working with NBS but had varying perspectives on how NBS is used for their project. This resulted in us reviewing large amounts of qualitative data to identify common themes about what information businesses already have and what information they are interested in. To overcome this challenge, we made sure to keep our data organised and closely reviewed it. This allowed us to easily identify trends and commonalities to determine what information is most important to businesses. Through this, we identified areas of opportunity and potential incentives for businesses.

Displaying Information in an Accessible Format

Our final objective was to display the information we have collected in an accessible format for relevant stakeholders. We decided to create an interactive mapping tool housed in an informational website as it is accessible and easy to understand. The interview responses gave us a detailed understanding of each project, and our on-site observations provided the images and data of the current NBS projects, which are displayed on the interactive map. Each project has the same categories of information displayed on the site: ecosystem type, climate change impacts addressed, key stakeholders, societal challenges, project scale, and duration. The information for these categories was summarised from the data received from the interviews.

Research into pre-existing interactive maps was completed to determine the

best layout and categories of information to include. We needed to be able to display the projects we visited as pins on the map, and each project needed an upload option for images and other data. The media also needed to be displayed clearly and effectively. Many tools exist, but it took some exploration to identify which applications best fit our needs. We had to find a way to make a professional, user-friendly, and easily maintained deliverable.

Developing a Website and Interactive Mapping Tool

The biggest challenge was displaying our mapping tool and website together. Many easy-to-use map and website builders exist separately; however, we want to combine the informative and interactive portions of our deliverables onto one website for easy navigation and accessibility. We expected to advanced software, which allowed for more complex features. However, more user-friendly website-building applications met the needs of the project. The user-friendly features allowed us to develop our website and mapping tool more easily and will allow others to contribute to webpage easily.

We used Mapme for the interactive mapping tool and embedded the tool into our Squarespace website. We adapted to the design limitations of the pre-existing software applications to create an informative, user-friendly, and visually appealing result. This process produced a website that houses information about each project, the map itself, and additional information on Nature-Based Solutions. This website and map were the best options to provide palatable and accessible information about current Nature-Based Solutions implementations. The mapping tool makes it easy to see where NBS are being implemented, and the website provides information on their benefits. This tool will give its viewers many examples of current projects which will aid in their understanding of NBS in Hong Kong.

The information on the website also highlights some of the crucial elements of NBS in Hong Kong and provides a sense of standards that make NBS more consistent. This information creates a well-rounded guideline for NBS in Hong Kong and accurately represents the pre-existing NBS initiatives.

Overview of Methodology

The overall methodology is shown in figure 9. It shows how the objectives connect together to lead to a final deliverable. Objectives 1 and 2 provide the information on the existing NBS in Hong Kong and the incentives available to businesses, and objective 3 shows all of the information on the interactive mapping tool and website.

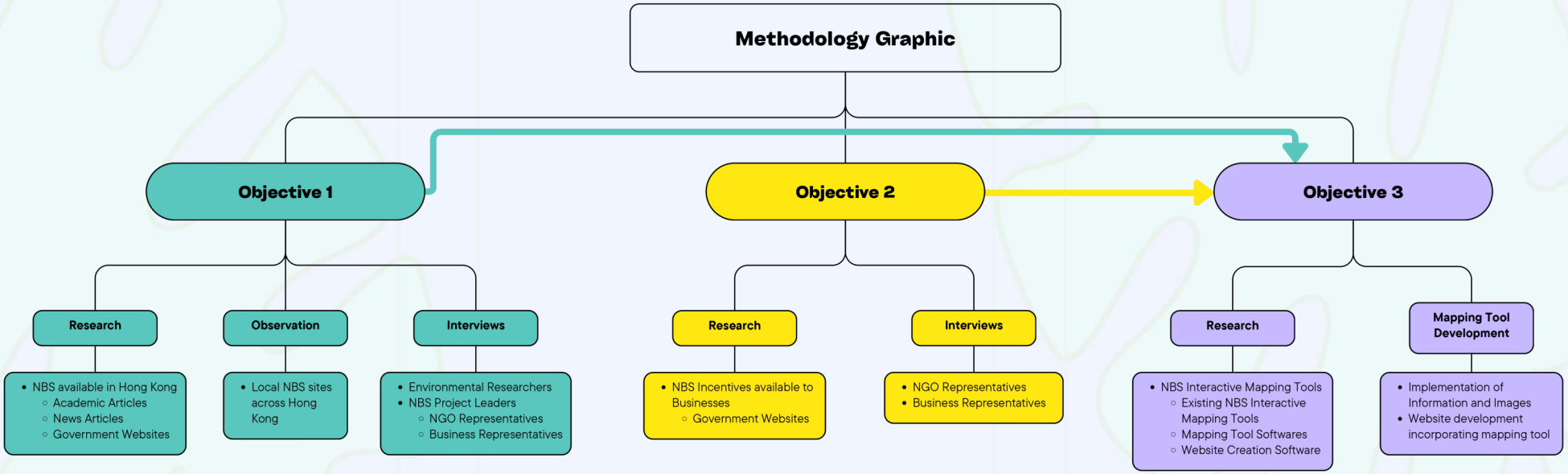

Figure 9: Graphic representation of project methodology

Mai Po Nature Reserve

WWF-HK

Mai Po Nature Reserve is managed by the World Wildlife Fund Hong Kong and aims to conserve the wetland and provide a suitable habitat for migratory birds. Guided tours for students and the general public offer education on the importance of wetlands and how the area's ecosystems are managed. WWF -HK works to restore and protect different habitats to accommodate many bird species and improve the area's biodiversity. The wetland environment can also store large amounts of water during heavy rainstorms and typhoons, and the mangrove forests act as a barrier to protect the coastal communities from heavy storm surges. Protection of the wetlands is key to migratory birds. The wetland is also important for mitigating the effects of climate

Figure 10: Mai Po Nature Reserve Site Summary

HK Wetland Park

URBIS

Hong Kong Wetland Park designed by URBIS, presents an immersive experience for visitors to explore and learn about the wetland ecosystem. There is a museum exhibit featuring aquariums that highlight local wildlife. The park consists of boardwalks and paths that guide visitors through the wetland to see its different habitats. There are also bird hides where visitors can observe the migratory birds that stop by the area. Wetland Park is much more interactive and open to the public than the Mai Po Nature Reserve, as it encourages people to explore the wetlands independently rather than requiring a guide to explore the area. Wetland Park regularly monitors the water quality and level, and other aspects of its surrounding ecosystems to ensure the wetland environment is still preserved despite the large number of visitors attending the park.

Figure 11: Hong Kong Wetland Park Site Summary

Project Prosperity

APOF

A Plastic Ocean Foundation (APOF) is an NGO implementing the first bamboo afforestation project in the Hong Kong region, Project Prosperity. The project aims to create new bamboo forests on previously abandoned farmland, which has since been polluted. Bamboo is capable of cleaning the soil it is planted on, and physically catching rubbish before it is blown into the ocean. Project Prosperity is located in Ha Pak Nai, and the management of the project has led to the creation of many new green jobs. This offers new opportunities for underemployed youth in the area to become involved with sustainability while also forming intergenerational connections with the elderly. The native species of bamboo used in Project Prosperity are also able to be harvested and sold to businesses that are looking to invest in sustainable materials for construction.

Figure 12: Project Prosperity Site Summary

Taikoo Place Redevelopment

Swire Properties

Swire Properties is a major property development firm located in Hong Kong and mainland China. Taikoo Place is a commercial building complex located in Quarry Bay that is currently under redevelopment by Swire Properties. The project plans to redevelop three techno-centres into two new office buildings and add two gardens: Taikoo Square and Taikoo Garden. This will not only add more greenery and open space to the area but also boost biodiversity and ecosystem connectivity. Swire is working with experts in ecological fields to ensure that the wildlife incorporated into the new green spaces is able to create green corridors in the urban space, ultimately improving the urban biodiversity. Swire plans to discover the baseline biodiversity in the current Taikoo Place and, after project completion, reevaluate to see if the project has made improvements. Taikoo Place is an incredible example of how an NBS can be successfully implemented in a dense environment, rather than a rural area.

Figure 13: Taikoo Place Redevelopment Site Summary

Figure 14: Oyster Reef Restoration Site Summary

Oyster Reef Restoration

TNC

The Nature Conservancy (TNC) is an international organisation that focuses on nature protection and restoration. In Hong Kong, they have launched an oyster reef restoration project that aims to understand and quantify oyster reef's critical ecological benefits, and to restore shellfish reefs in Deep Bay. Oysters can act as natural filters that improve local water quality and stabilize coastlines. The restoration is based in Ha Pak Nai, where there are mangrove forests and inter-tidal mudflats that offer a habitat for many species in the unique environment. In the past, villagers farmed oysters by putting rows of small concrete pillars in the mudflats, which the oysters would attach to and grow. Now, these farms are abandoned. TNC is working to restore these oyster farms by transforming these old farms into a layout that emulates a natural oyster reef habitat. TNC also has an exhibit at the Hong Kong Maritime Museum that features their work at the mudflats and educates visitors on the importance of oyster reefs.

Analysis

Comparison to IUCN Standards

Due to Hong Kong's lack of specialised guidelines for Nature-Based Solutions, a broader set of global standards was adopted to evaluate the various projects featured in the interactive mapping tool. We opted to use the criteria for Nature-Based Solutions set by the International Union for the Conservation of Nature. The IUCN standards consist of eight criteria, as described earlier, to help identify and elevate NBS.

Figure 15 displays each IUCN criterion having equal importance. However, once the data from the interviews for each project was evaluated, we determined that specific criteria held greater importance for Hong Kong.

Crucial Criteria of NBS in Hong Kong

The analysed data included audio recordings, notes taken on-site, interview transcripts, and photos and videos collected from each site visit, as shown in figure 16. Using this media, We determined that the most critical characteristics of NBS in Hong Kong include the societal challenges addressed, the benefits for biodiversity, the adaptive management of the project, and how the project can be mainstreamed. These criteria were key commonalities between the existing successful NBS in Hong Kong that future NBS projects need to focus on.

Addressing Societal Challenges

The most crucial aspect of a Nature-Based Solution is that it addresses a societal challenge. While NBS follow a nature-focused approach to mitigating environmental challenges, they must still benefit human interest to gain

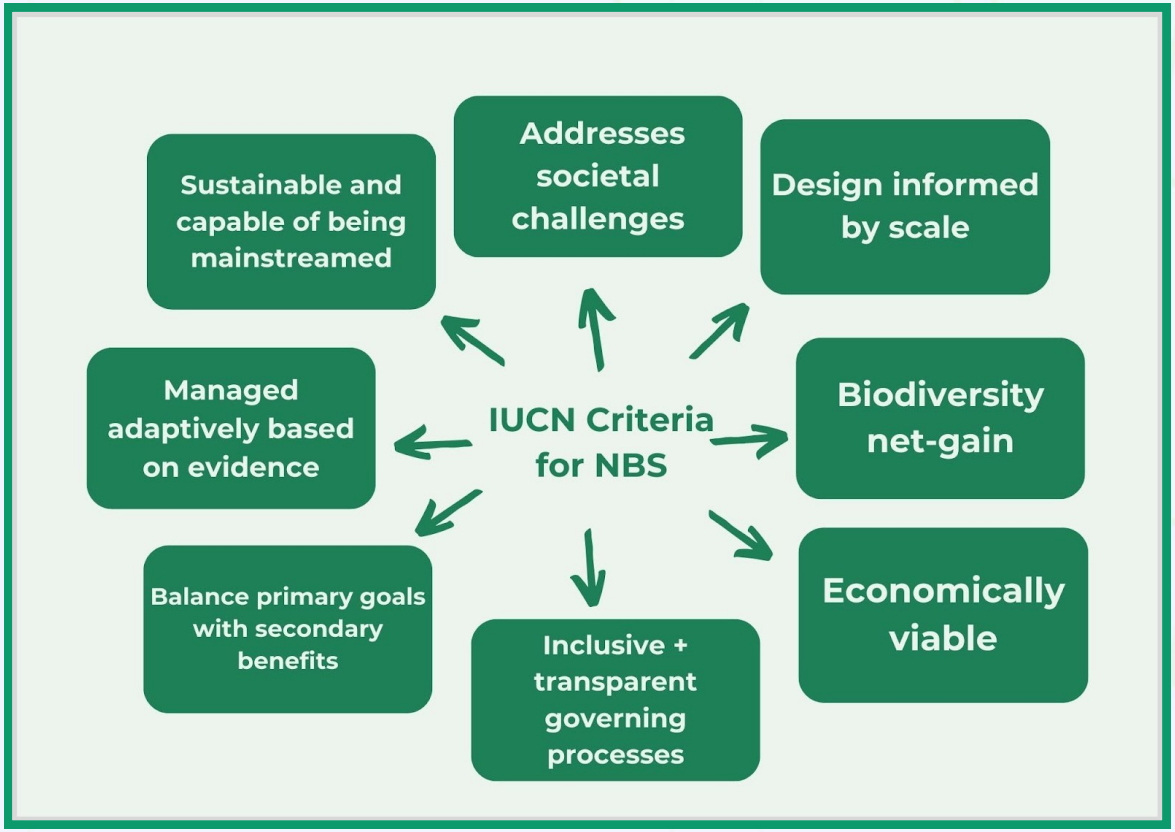

Figure 15: The eight criteria for Nature-Based Solutions according to the IUCN[19]

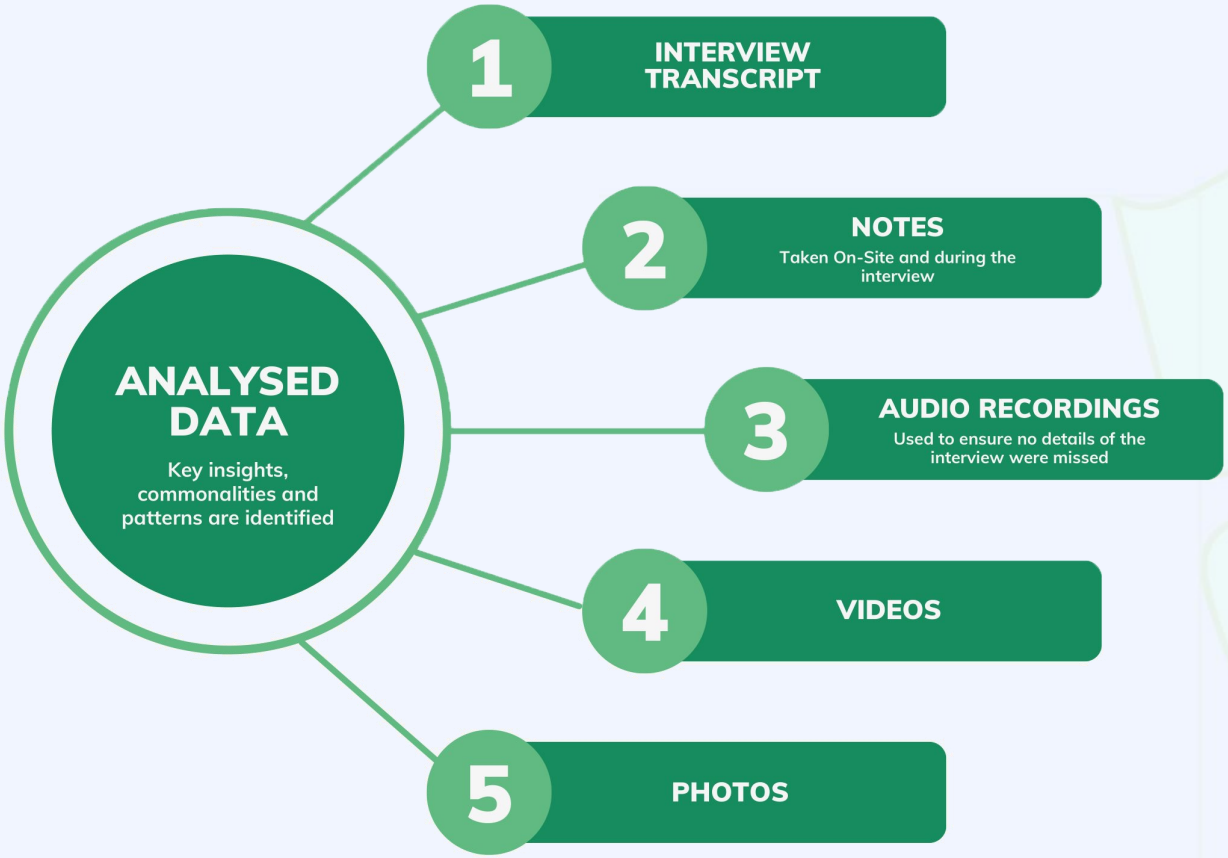

Figure 16: Types of data collected during Interviews and site visits

positive public opinion. Protecting nature is extremely important for the preservation of the planet. These NBS projects are exemplary because they not only prioritise the conservation of various ecosystems but also benefit surrounding communities. The projects solve many different challenges focused on human interest while also avoiding prioritising these secondary benefits to the projects' original goals of ecosystem protection. The projects address the complex interactions between the project, the surrounding community, and the environment.

For example, A Plastic Ocean Foundation (APOF) leases land from the villagers of Ha Pak Nai to operate their bamboo afforestation project, Project Prosperity. Afforestation is the process of establishing a forest on land that did not have tree cover in the past.[20] APOF needs to ensure that the land usage benefits the locals, and they need to maintain a positive relationship with the village chiefs. The maintenance of Project Prosperity has led to the creation of many new green jobs in the area. This offers new opportunities to underemployed youth in Ha Pak Nai to find jobs in sustainable businesses and form intergenerational relationships with older bamboo farmers APOF has hired to teach bamboo farming skills. Project Prosperity is an excellent example of how NBS can address different societal challenges in Hong Kong. However, it is rather unique compared to the problems other NBS try to alleviate.

Most challenges that are addressed focus on climate change mitigation and the preservation or restoration of ecosystems. Hong Kong's extreme weather events cause massive damage due to heavy rainfall and flooding. Due to this, many of the NBS projects place

a higher priority on climate resilience. There is also a significant focus on maintaining or improving biodiversity in project areas by managing and creating new ecosystems. This focus was common across all projects studied. There has been significant biodiversity loss in Hong Kong, adversely impacting ecosystem services.

Improving Biodiversity

Maintaining and improving biodiversity is an extremely important focus point in Hong Kong due to the significant biodiversity loss caused by environmental changes and urban development. It is important to prevent the worsening of biodiversity because ecosystems that can offer natural benefits such as flood reduction and carbon sequestration require each species to perform their environmental niche to thrive.

Each interviewee stressed the importance of biodiversity upkeep in our discussions with them. The managing director of URBIS Limited, Alexander Duggie, described the phenomenon quite well. According to Duggie, there are two major problems the world is currently facing. The first is climate change, and the second is the sixth extinction. The "sixth extinction" is severe biodiversity loss from the stress placed on ecosystems. Unfortunately, global education on climate change rarely covers the vital importance of biodiversity protection. For this reason, Nature-Based Solutions should focus on and emphasise protecting and restoring biodiversity.

Adaptive Management

Adaptive management is another important factor in developing and implementing Nature-Based Solutions. The global climate is rapidly changing, and so are the world's ecosystems. NBS must be able to handle increased rainfall and inconsistent temperatures and be adaptable to the needs of the ecosystem and surrounding communities. These projects are primarily long-term solutions, meaning flexibility is crucial for NBS projects to remain effective over time.

The importance of adaptive management was evident when learning about the continued monitoring efforts used at Hong Kong Wetland Park and Mai Po Nature Reserve. Both sites closely monitor the water level and habitat to provide the best habitats for migratory birds, as shown in figure 17. However, the location of NBS in Hong Kong can range from rural communities to dense urban areas.

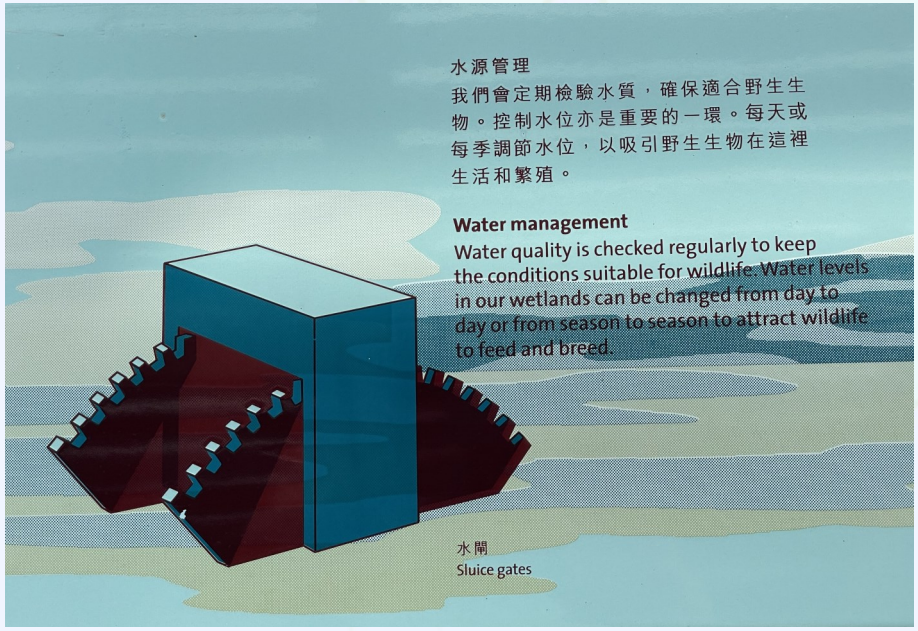

Figure 17: Sluice gate at Hong Kong Wetland Park for managing water levels

Each project faces specific challenges in interacting with residents and ecosystems. These projects each require unique monitoring and management of ecosystems and flexibility to modify projects based on environmental conditions and feedback. The nature of Hong Kong's subtropical climate and the variation of projects in the region make adaptability a must for successful NBS.

Mainstream Capability

The capability to be mainstreamed is important to NBS in Hong Kong, specifically due to the fact that there is no local standardisation on how to develop these projects. As Nature-Based Solutions become mainstream, the likelihood of local legislation and guidelines being written for these projects increases. Projects with transparent methods and clear results increase public opinion of NBS and inspire future implementers. The replication and expansion of projects make NBS more visible and increase the positive environmental impact of these projects.

If a project cannot be clearly explained or replicated, it is difficult for broader impacts to be made. "Nature-Based Solution" is a relatively new term in Hong Kong, and it is crucial to ensure projects can be picked up or expanded upon.

Motivating Factors for NBS

Throughout the interviews and site visits with representatives of NGOs and businesses, we also sought to understand the potential incentives and motivating factors for using NBS. There are various incentives, ranging from NBS's environmental and societal advantages to its financial benefits.

Many NGOs focus on the environmental and societal benefits of NBS since their goal as an organisation is to improve the environment and address societal challenges. They seek to contribute to factors such as reducing the impacts of climate change, increasing biodiversity, and creating green jobs. For example, organisations like the World Wildlife Fund Hong Kong (WWF-HK) and The Nature Conservancy (TNC) focus on restoring habitats and boosting biodiversity, and APOF works to clean up ecosystems and bring green jobs to the local communities. However, these driving factors are not as important to businesses.

While companies may care about the environment, their overall goal is still appealing to a customer base and upholding shareholder values. Therefore, most businesses stick to what works and only adapt to the changing market when necessary, while some businesses get involved in NBS to set themselves apart. Companies that focus on urban design and property development, such as URBIS and Swire Properties, can appeal to customers who seek better living and working environments that integrate elements of nature into the spaces.

While NGOs and businesses come from very different perspectives regarding using Nature-Based Solutions, there is one commonality. Both groups aim to reconnect society with nature. NGOs work to provide educational tours and events to the local communities and the general public, and businesses work to bring their customers into spaces integrated with nature. Environmental NGOs are the main driving factor behind the implementation of NBS since their

goals include improving the environment, and NBS falls within one of the methods used to achieve their goals. For businesses, there are still not enough incentives or motivations to implement NBS. Property developers like Swire Properties have proven that integrating nature into property development can be very successful. However, the fact that Swire Properties set itself apart by using NBS shows that most of the market does not have enough incentives to consider implementing NBS. Another factor to aid in promoting NBS is accessible information on why NBS are important. Understanding how they benefit the environment and help improve properties will allow different groups to see the benefits of using NBS.

Creating the Interactive Mapping Tool

The final deliverable for this project is a website that houses an interactive mapping tool which showcases different NBS projects around Hong Kong. Currently, it includes the five case studies we did. To make the tool as accessible as possible, we had to consider what information was relevant to include and how that information should be displayed. The design of both the mapping tool and website underwent multiple rounds of design and feedback with input from the representatives of the BEC to ensure the content was displayed in an accessible format and was concise and easy to read.

The design of the content for the mapping tool was constrained by the abilities of the mapping tool software Mapme. The content was only allowed to be shown in a vertical sidebar, so we decided that there should be a summary as well as some key facts for each project, as shown in figure 18.

However, the information presented on the mapping tool may not include everything businesses and the general public want to know about Nature-Based Solutions. Therefore, the mapping tool is only a portion of the overall deliverable. It is embedded in the website that introduces NBS overall and has more detailed pages on each project.

Creating the Informational Website

The website takes inspiration from other NBS websites and mapping tools to present the most relevant information in an accessible format. An

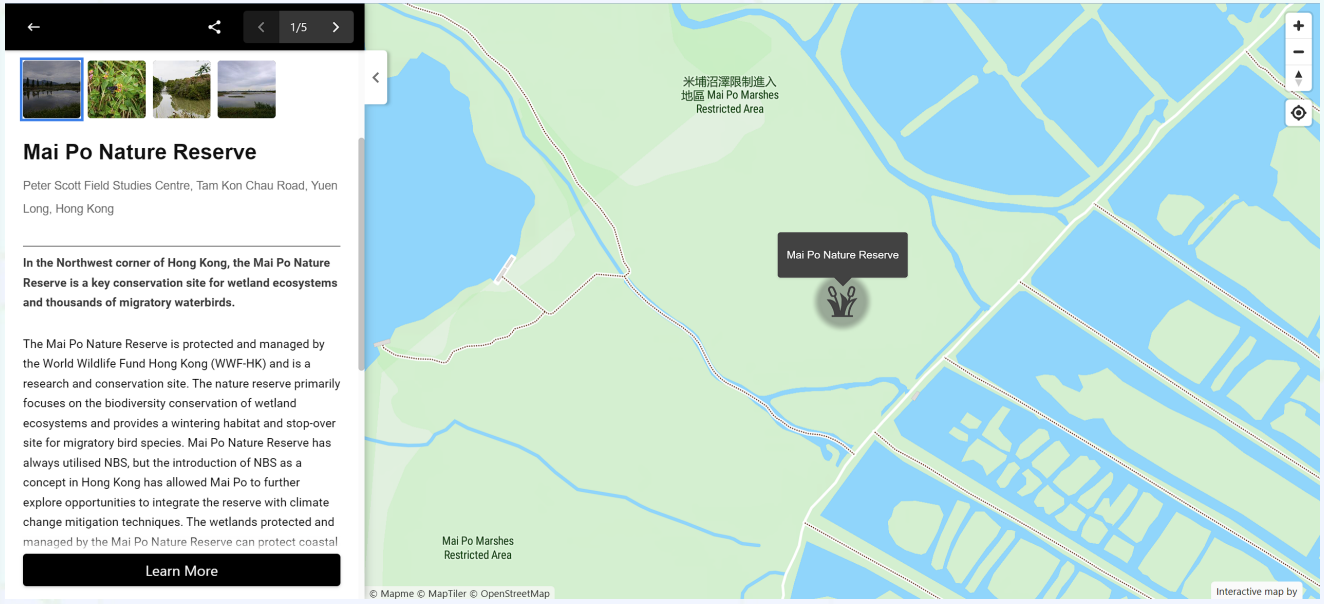

Figure 18: Mapping tool content for Mai Po Nature Reserve

example of this is the Nature-Based Solutions Initiative interactive mapping tool which features NBS projects from around the world, as can be seen in figure 19.[21] For this map, each project also has a detailed description of the project and some of its key elements.

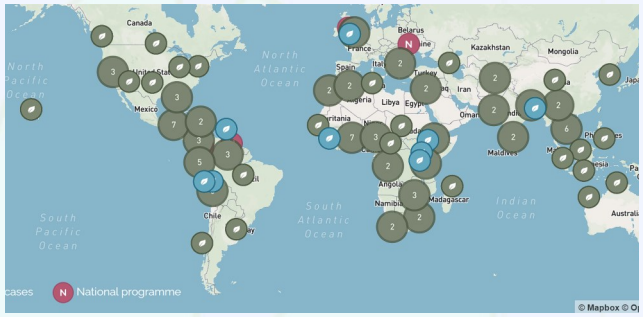

Figure 19: Nature-Based Solutions Initiative global map[21]

For our website, each project page has a sidebar on the left side with the key facts for each project, like the mapping tool. On the right side, there is more information in paragraph form with some icons to graphically guide the reader to each section. There is a more in-depth summary and context content and some important project elements which were included due to their relevance to the IUCN standards, as shown in figure 20.

The project elements chosen were determined to be the most important ones for all of the case studies, such as the societal challenges addressed, the benefits for biodiversity, and the governance and finance of the project. There is also an "area of opportunity" section where opportunities for growth for the project are discussed for further impact. All of the informational sections are put in drop-down sections so the site visitors are not overwhelmed with information. Instead, they can open the sections they are interested in to read more. Therefore, it is more accessible and useful for those who want to learn more about NBS and the NBS projects in Hong Kong.

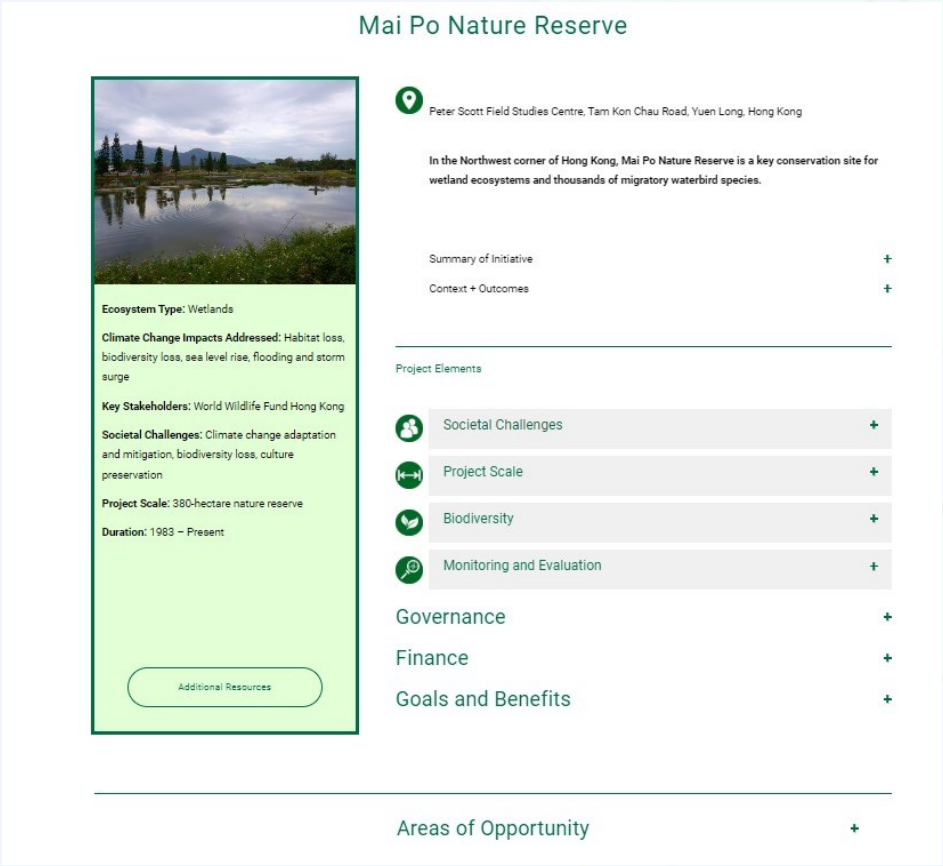

Figure 20: Mai Po Nature Reserve website page

Sources for NBS in Hong Kong

The website is only one of the sources of accessible information to bring NBS mainstream in Hong Kong. Other sources of information include detailed websites and videos explaining NBS, and websites specific to each project included on the mapping tool and website. The mapping tool and website are an important source of information because they summarise NBS in the Hong Kong

context. Businesses and the general public do not need to visit many different websites to learn about the different NBS projects going on across Hong Kong. Instead, they just need to visit one website and have all of the information available to them, from a visual map showing the projects and their locations to the projects page with more detail if they want to learn more.

Additionally, the map is a great visualisation of the projects in Hong Kong as it shows the diverse ecosystems in which NBS can be implemented, shown in figure 21.

The current projects in the map are mainly in the New Territories in rural environments, but there are also projects on Hong Kong Island in a more urban environment. The map localises NBS to Hong Kong citizens since it presents familiar regions and allows the viewers to visit the sites in person. Overall, the mapping tool and website present an accessible source for promoting NBS in Hong Kong.

Conclusion

In Hong Kong, policy advocacy, business incentives, and accessible information are essential to the success of Nature-Based Solutions. The Business Environment Council communicates with business leaders and government representatives to push for progressive change in Hong Kong's environmental practices. Continuing advocacy for legal policy and new business practices is necessary for awareness and legal standardisation of NBS while providing essential financial support.

NGOs and Businesses often receive press for these collaborations, thus increasing public awareness of NBS. Additionally, private-sector investments have fewer limitations on the time frame and use of the funding provided. Encouraging these collaborations is in the best interest of NBS implementation in Hong Kong.

Lastly, compiled and well-presented information about Nature-Based Solutions will ensure that businesses and the public are aware of NBS and their functions. Accessibility of information is the most critical challenge to overcome and is therefore addressed in our final deliverable. This user-friendly mapping tool and website display the information and planning of several local NBS projects.

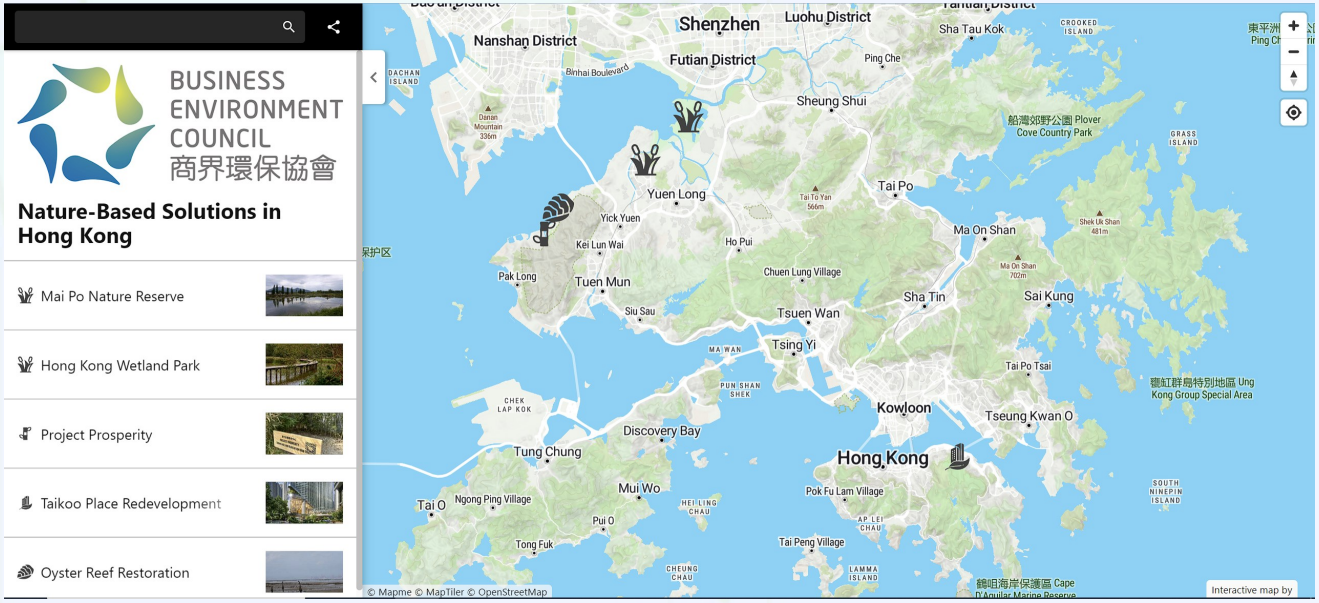

Figure 21: Mapping tool with all site visits in Hong Kong

These specific projects were selected because they are exemplary examples of effective NBS that have already been implemented locally. Nature-Based Solutions have the potential to aid Hong Kong in mitigating the current climate crisis and reducing biodiversity loss if the correct methods are employed to ensure their success and visibility.

Recommendations

Providing Standarisation and Guidelines for NBS in Hong Kong

Increasing Government support for changes to Hong Kong's environmental policies is a vital facet of Nature-Based Solutions gaining prevalence in the region. Navigating existing policies can often be a barrier to projects managed by NGOs. We recommend that the BEC should continue to advocate for policies that support NBS by utilising the influence of their stakeholders to create transformative change. The challenges faced by organisations involved in NBS include limited public funding and the lack of guidelines for these types of projects. Policies that promote and invest in the usage of NBS in the future will significantly benefit NBS investment and use throughout Hong Kong.

An example of this is the 2018 policy that approved the $1 billion Lantau Conservation Fund (LCF) to promote the conservation of Lantau. Organisations can apply for funding through the LCF to develop their sustainability initiatives. Funding similar to this initiative may aid the further implementation of NBS. This would increase the viability of these projects, which is essential to the future standardisation of Nature-Based Solutions and the development of legal guidelines. This is extremely important because compared to engineered solutions, which take fewer years to plan and construct, the short-term funding provided for the engineered solutions cannot be directly transferred to be used for NBS projects.

Increasing Incentives and Motivations for Implementing NBS

Another critical element of increasing NBS use is gaining the support of Hong Kong's private sector. Businesses and organisations are essential to the widespread adoption of these projects because of their social and financial influence. It is common for NGOs to depend on the support they gain from involvement with private stakeholders as their funding can aid in costs such as prolonged maintenance, recruiting field experts, and continuous improvement. This involvement with corporate stakeholders is oftentimes less rigid than government grants and subsidies.

We recommend that the BEC should aid in the transfer of knowledge between NGOs and businesses so the benefits of NBS can be communicated and gain support from businesses. There are existing incentives for businesses that invest in NBS, such as certifications, recognitions, and awards from organisations such as the Dow Jones Sustainability World Index. Further development of existing incentives and initiatives to attract businesses is also essential to navigating the challenges associated with NBS.

To achieve this, we recommend readably outlining the measurable benefits of NBS. Additionally, policies could be developed to create incentives such as tax breaks, subsidies,

and recognition or awards for organisations that choose to invest in or implement NBS in their future work.

Providing Accessible Information on NBS in Hong Kong

The final and most vital aspect of improving support for Nature-Based Solutions is accessible information. Resources must be available and user-friendly for potential stakeholders and implementers to understand why NBS are important and what makes them effective. Therefore, an interactive mapping tool, which serves as our deliverable for the BEC, is instrumental in providing relevant audiences with examples and information about NBS.

The map itself displays the location and overview of each project, while the additional information for each project gives a more in-depth view of the NBS elements. The information is presented in a format accessible to businesses and the general public, using language that is not complex or technical. The tool's utility can be determined with the analytics available to the website, which can be used to see where improvements can be made to be more accessible or increase usage.

The BEC will continue adding more case studies to the mapping tool and website to create a more comprehensive source of Nature-Based Solutions in Hong Kong. Once published, a link to the completed website and mapping tool can be found on the BEC website.

The research completed for this project can also aid the BEC in hosting informative events for businesses to learn and discuss NBS. This would open the door for further investment in NBS efforts.

Acknowledgements

Thank you to our sponsor, Laila Ali, Katie Chan, Merlin Lao, Simon Ng, and Ringo Leung from the BEC for their support throughout this project. Specifically thank you to Katie and Laila for their incredible guidance and for giving us this amazing opportunity.

Thank you to all of the interviewees who took the time to meet with us and provide us with valuable information and additional resources to help us with the project.

Additionally, thank you to our advisors from WPI, Professor Brajendra Mishra and Professor Stephan Sturm for their guidance and feedback.

Finally, thank you to the U.S. Consulate General in Hong Kong & Macau for making this project financially possible.

References

1. Colbert, A. (2023, November 30). Extreme Weather and Climate Change. Climate Change: Vital Signs of the Planet. https://climate.nasa.gov/extreme-weather

2. Siu, T., & Master, F. (2023, September 8). Hong Kong, Shenzhen deluged by heaviest rain on record. Reuters. https://www.reuters.com/world/asia-pacific/hong-kongs-heaviest-rain-least-140-years-floods-city-streets-metro-2023-09-08/

3. Rafferty, J. P. (2023, November 10). Humid subtropical climate | Temperate, Rainfall & Temperature | Britannica. Britannica. https://www.britannica.com/science/humid-subtropical-climate

4. Girardin, C. A. J., Jenkins, S., Seddon, N., Allen, M., Lewis, S. L., Wheeler, C. E., Griscom, B. W., & Malhi, Y. (2021). Nature-based solutions can help cool the planet—If we act now. Nature, 593 (7858), 191–194. https://doi.org/10.1038/d41586-021-01241-2

5. Hong Kong Observatory. (2022). Climate Change in Hong Kong—Temperature. Hong Kong Observatory. https://www.hko.gov.hk/en/climate_change/obs_hk_temp.htm

6. Hong Kong Observatory. (2022). Climate Change in Hong Kong—Rainfall. Hong Kong Observatory. https://www.hko.gov.hk/en/climate_change/obs_hk_rainfall.htm

7. Yeung, J. (2023, September 8). Hong Kong paralyzed by flash flooding after heaviest rainfall since 1884. CNN. https://www.cnn.com/2023/09/07/asia/hong-kong-black-rainstorm-flooding-intl-hnk/index.html

8. NASA. (2023, June). Sea Level | NASA Global Climate Change. Climate Change: Vital Signs of the Planet. https://climate.nasa.gov/vital-signs/sea-level

9. Hong Kong Observatory. (2022). Climate Change in Hong Kong—Mean sea level. https://www.hko.gov.hk/en/climate_change/obs_hk_sea_level.htm

10. Berlinger, J. G., CNN |. Joshua. (2020, July 26). Hong Kong's vast $3.8 billion rain-tunnel network. CNN. https://www.cnn.com/style/article/hong-kong-tunnels-climate-crisis-intl-hnk-dst/index.html

11. Conservation International. (2023). Green-Gray Infrastructure. Green-Greay Infrastructure. https://www.conservation.org/projects/green-gray-infrastructure

12. Schultz-Bergin, M. (2021). Engineering & the Environment. https://pressbooks.ulib.csuohio.edu/principles-of-engineering-ethics/chapter/engineering-the-environment/

13. Luedke, H. (2019, October 16). Fact Sheet | Nature as Resilient Infrastructure – An Overview of Nature-Based Solutions | White Papers | EESI. Environmental and Energy Study Institute. https://www.eesi.org/papers/view/fact-sheet-nature-as-resilient-infrastructure-an-overview-of-nature-based-solutions

14. Cassin, J. (2021). History and development of nature-based solutions: Concepts and practice. In Nature-based Solutions and Water Security (pp. 19–34). Elsevier. https://doi.org/10.1016/B978-0-12-819871-1.00018-X

15. Miles, L., Agra, R., Sengupta, S., Vidal, A., & Dickson, B. (2021). Nature-based solutions for climate change mitigation. 35.

16. Law, C. (2023, October 6). 地球之友 Friends of the Earth. Friends of the Earth. https://www.foe.org.hk/en/blog/Green%20Finance/blog/nature-based%20solutions%20enhance%20climate%20resilience

17. Thornett, R. (2023, January 27). Becoming a 'Sponge City' at Shenzhen Speed. The Diplomat. https://thediplomat.com/2023/01/becoming-a-sponge-city-at-shenzhen-speed/

18. Chan, F., Thadani, D., & Li, L. (2021, September 24). Sponge City Is Transforming Urban Flood Management. China Water Risk. https://chinawaterrisk.org/opinions/sponge-city-is-transforming-urban-flood-management/

19. IUCN. (2020, July 24). IUCN Global Standard for NbS | IUCN. https://www.iucn.org/news/europe/202007/iucn-global-standard-nbs

20. Vartan, S., & Brandstein, B. (2022, November 14). What Is Afforestation? Definition, Examples, Pros, and Cons. Treehugger. https://www.treehugger.com/what-is-afforestation-definition-examples-5114137

21. Seddon, D. (2024). NBS Case Search. Nature-Based Solutions Case Studies. https://casestudies.naturebasedsolutionsinitiative.org/case-search/

22. TNC. (2024). Hong Kong Oyster Restoration. The Nature Conservancy Hong Kong. https://www.tnc.org.hk/en-hk/what-we-do/hong-kong-projects/oyster-restoration/