CHAPTER 25
Naturalising our Parks Framework

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Objective of the Framework

Imagine relaxing in a park immersed in nature with lush greenery and nature-based activities around you where you can feel the positive energy to your physical and mental well-being. Transforming to a City in Nature, towards a more liveable, sustainable and resilient Singapore, requires a paradigm shift on how we plan, design, develop and manage our green spaces. NParks has put together a framework to enhance the naturalisation of our parks and gardens, which is being applied to our parks and development projects.

Approach to Naturalising our Parks

When the British arrived in Singapore in 1819, Singapore was covered with rainforest, swamps, and mangroves. By 1900, 90% of the primeval forest had been cleared and exploited for timber extraction, agriculture, and the creation of settlements. While the British designated forest reserves and nature reserves, much of these areas were eventually replaced by plantations and agriculture, leaving only small reserves scattered across the island. Today, Singapore is home to over 300 parks with a variety of coastal, riverine, forest and urban habitats. Each park has a unique natural history ranging from largely undisturbed by human interference to completely transformed by human activities. In attempting to naturalise our parks, each park requires a tailored approach based on factors that include the current ecological condition of the site, the historical habitat type and the natural processes that supported the historical habitat.

The paper entitled Managing the whole landscape: historical, hybrid, and novel ecosystems (Hobbs *et al.*, 2014) gave direction on appropriate habitat restoration. The paper identified the issue of landscapes being increasingly composed of ecosystems that have been altered to varying degrees, thus requiring different approaches on how to intervene. It recommends moving away from the traditional approach of partitioning landscapes into dichotomous categories (e.g., natural/unnatural, intact/degraded) and instead to see landscapes as a complex mosaic of ecosystems in varying states of modification.

NParks' framework to naturalise parks and gardens proposes three nature restoration intervention models or goals, namely natural, novel and hybrid landscapes. Natural landscapes comprise habitats that have largely retained their natural ecosystems spanning over a significant period with minimal intervention by humans. Examples in Singapore include the mature secondary forests around the Bukit Timah Nature Reserve and Central Catchment Nature Reserve and wetlands at Sungei Buloh. These natural landscapes provide the greatest potential to restore nature to the predevelopment state through targeted restoration techniques such as species recovery programmes. Rifle Range Nature Park outlined later in this chapter is one such example.

Novel landscapes comprise habitats that have largely been disturbed by humans and therefore the ecological processes that supported that historical habitat are largely degraded. An example in Singapore is Jurong Lake Gardens which was formerly a freshwater mangrove swamp before it was cleared and levelled in the 1960s for industrial developments. When ecological processes have changed beyond the point of being feasibly restored, such as the hydrology at Jurong Lake Gardens, it might no longer be possible to restore the site to its predevelopment state. Instead, restoration goals should take a new direction to create alternative habitat types. Jurong Lake Gardens outlined later in this chapter is one such example.

Hybrid landscapes are similar to novel landscapes in that they have largely been disturbed by humans. However the difference is that the ecological processes that supported that historical habitat can partially be restored. Pasir Ris Park which is featured in Chapter 21 is an example of a hybrid landscape which historically consisted of a mangrove forest until land reclamation works in the 1970s severely degraded the habitat. Restoration took place in 2001 to replant the mangroves, but was only limited to areas which were feasible to do so due to the constraints in restoring the site's hydrology. Hybrid landscapes restoration comprises a mosaic of habitat types depending on the level of ecological process restoration. Bukit Canberra outlined later in this chapter is another example.

The Three Phases of the Framework

The process of naturalising our parks requires a sustained effort that starts from the onset of planning for the parks all the way to the day-to-day management and running of the parks after

the development phase. The framework to naturalise our parks covers the full range of efforts required during the Planning Phase, Implementation Phase and Programmatic Phase.

The Planning Phase involves identifying the goals of restoration with a detailed analysis of the site, which is done at both the macro and micro levels. Macro level analysis includes researching the wider historical, ecological connectivity and land use layers. Micro level analysis includes researching the site's topography, biodiversity and microclimate layers. Once the analysis is completed and there is a full understanding of the site's past and present, it is then possible to identify the goals of restoration i.e., natural, novel or hybrid.

The Implementation Phase involves three steps. The first step is to establish that the ecological processes that support the desired habitat can be restored and/or created, which can include modifying the hydrology, topography, soil composition, etc. The second step involves ways to restore/create the habitats, which includes determining the vegetation structure such as planting in multi-tiers to create a rainforest structure. It also includes identifying key flora and fauna species to help in species recovery programmes. The third step involves ecological aesthetics, which entails creating immersive nature experiences for visitors to enjoy, and therefore requires design considerations to maximise the habitat's attractiveness to visitors.

The Programmatic Phase involves the hardware and software to activate the park, add vibrancy and help connect visitors with nature in a variety of exciting ways. The hardware includes sensitively incorporating features such as nature playgardens, therapeutic gardens and nature fitness areas. The software includes NParks' community programmes such as Community in Bloom, Friends of the Park and the OneMillionTree movement. Planning for these programmes at the project inception stage ensures all the relevant infrastructures are in place to support the activities once construction is completed.

Naturalising our Parks Framework Checklist

To help guide practitioners that include designers, project managers, landscape architects and horticulturists to naturalise green landscapes, a checklist as part of the Naturalising our Parks Framework has been created. The checklist provides a comprehensive guide on the information, steps and processes involved, such as information needed for the site analysis, design considerations as well as implementation strategies at construction stage, and outreach and

engagement programmes that follow, to achieve the goals of restoration. The checklist is intended to be a document that follows the planning, development and management of the park to guide and provide the various thought processes to realise the project's goal of restoration. The checklist can be found in Annex A.

Case Studies

To demonstrate the operationalisation of the three phases of the framework as well as the three goals of restoration, three case study projects are outlined below.

Rifle Range Nature Park: Case study model for natural landscapes

Rifle Range Nature Park is a 66-hectare nature park located at the southern end of Bukit Timah Nature Reserve. The park serves as an important buffer to the Bukit Timah Hill, Singapore's highest hill, which remains one of the few areas of primary rainforest and home to around 40% of Singapore's native flora and fauna. As a buffer park, Rifle Range Nature Park provides not only habitat for native fauna but also food sources for them to survive on. This park development was part of a holistic approach to strengthen the conservation of the biodiversity in Singapore's nature reserves while providing interesting alternative venues for the public to enjoy nature-related activities in the city-state.

Fig. 1. View from the Colugo Deck at Rifle Range Nature Park.

The key challenges for the nature-sensitive project were to find a point of balance between the development for recreational uses and conservation of biodiversity based on data-driven, science-based approach at all stages of the park development.

Planning Stage

From the early stages of the park's planning, a clear goal of restoring the natural historical ecosystems had been established. Historically, the site was a granite hill with secondary forests, villages, and past quarrying activities from the 1950s to the 1980s. By the 1990s, quarrying activities stopped and the quarry was backfilled. Villagers were also resettled as a result of this closure. With decades of minimal human intervention, species of flora and fauna from the Bukit Timah Nature Reserve have since established themselves in the Nature Park. The clear goal of restoration served as an important guide in the making of the nature park as the decisions to protect ecological habitats were prioritised over recreational needs.

The planning and design of Rifle Range Nature Park were heavily driven by scientific data. As the site is an existing forest, areas of high biodiversity and large trees of conservation significance needed to be identified and protected even before works to design the park commenced. A nine-month long biodiversity study was commissioned to document and map out the floristic and fauna diversity of the 66-hectare site. The study entailed line-transect surveys of over 10 kilometres conducted by systematically walking the site and recording sightings of flora and fauna, plot sampling, and deployment of over 110 camera traps strategically placed throughout the forest. The camera traps were programmed to be active 24-hours a day at high sensitivity to collect video footages when triggered by movement or changes in temperature. This detailed baseline study at the planning stage was fundamental for the subsequent design and implementation of the park.

Implementation Stage

A site-sensitive approach was adopted during the development of the park. With an accurate inventory of flora and fauna data collected and geo-mapped from the baseline study (Fig. 2), the design consultants comprising architects, engineers, geotechnical specialists, landscape architects and builders were able to provide site-sensitive solutions. They worked as a team with the biodiversity researchers to ensure that development works avoided important ecological habitats and catered animal-specific design solutions to enhance ecological connectivity in the park (Fig. 3).

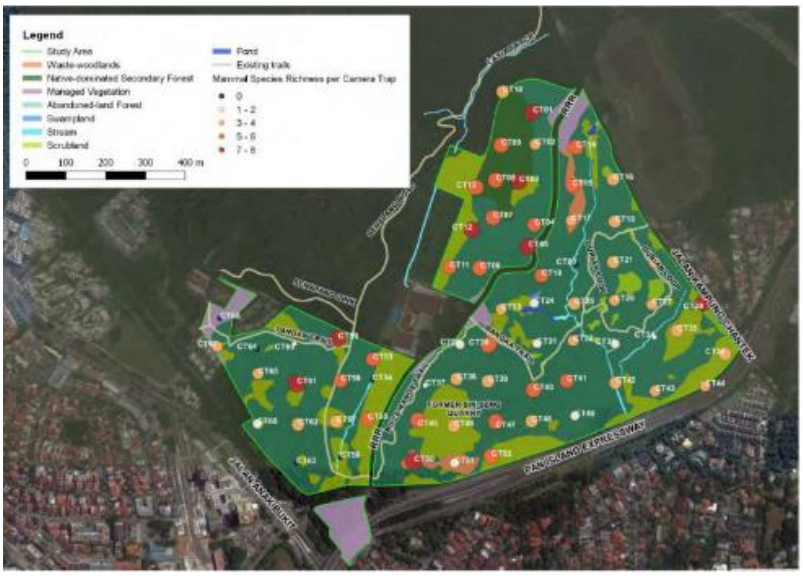


Fig. 2. Mammal Species Richness overlaid on Vegetation Map. (Image credit: Camphora Pte. Ltd.)

Figs. 3. Prototyping and Installation of Aerial rope bridges and Colugo Poles.

Throughout the construction of the park, conscious efforts were made to collect biodiversity data, with an Environmental Mitigation and Monitoring Plan (EMMP) being put in place to proactively manage any impacts of construction activities to ensure that the stipulated Environmental Quality Objectives (EQOs) for the project were not exceeded.

The park visitors' experience was designed with biophilia in mind, that, according to biologist E.O. Wilson, was an innate and genetically determined affinity of human beings with nature. The design sought to capitalise on and bring out the beauty of the site's existing terrain and hydrology. From the Rambai Boardwalk entrance to the Bayan Trail exit, the journey was curated

for visitors to feel close to nature. The park starts with an invigorating experience along the wheelchair-accessible Rambai Boardwalk (Fig. 4). Any visitor can instantly escape from the hustle and bustle of the Beauty World precinct into a rejuvenating young secondary forest surrounded by the calls of native birds such as the endangered Straw-headed Bulbul (*Pycnonotus zeylanicus*). With the carefully designed earth trails, visitors can feel the natural undulating earth beneath and may be able to chance upon native fauna species such as the Sunda Pangolin (*Manis javanica*) and Horsfield's Flying Squirrel (*Lomys horsfieldii*). Native crabs, frogs, fishes, and snakes may also be spotted at the slow-flowing sandy Banyan Stream crossing.

Fig. 4. Rambai Boardwalk from the Beauty World Precinct.

A hike up the challenging quarry trail will take adventure seekers up to the Colugo Deck, a vantage point that hangs over the 50-metre high granite quarry cliff and overlooks the freshwater quarry wetland (Fig. 5). The park development took the opportunity to create a freshwater habitat from the former backfilled quarry for marsh birds and aquatic animals. Overall, the park was designed and built for interesting encounters with native flora and fauna, so that visitors can feel at one with nature.

Fig. 5. Freshwater quarry wetland at Rifle Range Nature Park.

Programmatic Stage

A long-term effort to monitor biodiversity in the operation phase of Rifle Range Nature Park has been catered for with animal-monitoring CCTVs placed at strategic locations of the park (Fig. 6). This is part of a science-based approach to provide valuable data for continued research in native flora and fauna, and also engages visitors to learn and appreciate the importance of native biodiversity and efforts towards ecological conservation. The Roadway Animal Detection System (RADS) has also been installed along Rifle Range Road. RADS is an advanced form of an animal detection system that uses CCTV cameras enabled by Artificial Intelligence (AI). When animals are detected, RADS alerts motorists by activating blinking signages to react and take the necessary precautions, such as reducing vehicular speed and exercising heightened vigilance. This technology aims to reduce road kill incidents in the long run.

Fig. 6. Animal monitoring camera installed on Arboreal Crossing for long term biodiversity monitoring.

Nature-sensitive programmatic planning is important for Rifle Range Nature Park to engage, educate and involve communities to help with nature conservation. The Invasive Species Management (ISM) is a programme that involves residents and the nature community to help weed out invasive alien species as the threat they cause is ever-increasing if left unmanaged (Fig. 7). To help the propagation of native flora, a Community Nursery has been built at the park for volunteers to help with the propagation of native plants in the park.

Fig. 7. Community involvement in invasive species management.

Jurong Lake Gardens: Case study model for novel landscapes

Jurong Lake Gardens is Singapore's third national gardens, and is situated within the heartlands. It is a people's garden, where spaces are landscaped and created for families and the community to come together for leisure and recreation amidst lush greenery and scenic lakeside setting. The design and development of the Garden take into consideration suggestions from the community through extensive public consultation (Fig. 8). The 90-hectare Gardens comprise Lakeside Garden, Chinese Garden, Japanese Garden, and Garden Promenade. The 60-hectare Lakeside Garden opened in two phases to the public in April 2019 and April 2023, focusing on the themes of nature, play and the community. The remaining 30 hectares, comprising Chinese Garden, Japanese Garden and Garden Promenade, focus on the themes of tropical horticulture, garden artistry, and sustainability and technology. The Gardens as a whole exemplifies NParks City in Nature vision, and have emerged as a model for the enhancement and landscaping of novel habitats in urban environments.

Fig. 8. Visitors enjoying the tranquil sunrise at Rasau Walk at Lakeside Garden.

Planning Stage

The original habitat of the Jurong area consisted of freshwater swamp and mangrove habitats flanking the banks of Sungei Jurong. During the 1970s, these habitats were cleared to give way to factories and urban areas as part of Singapore's industrialisation efforts. Today, the only remaining natural freshwater swamp habitat is found at Nee Soon Swamp Forest in the Central Catchment Nature Reserve. One of the key planning considerations for Jurong Lake Gardens was the implementation of a Garden-wide habitat creation masterplan (Fig. 9), within which the re-creation of freshwater swamp habitats was imperative. Large mature Ficus trees along the shoreline were retained as they serve as keystone species providing food and shelter to a wide range of birds. A comprehensive biodiversity survey was also undertaken to identify significant areas of vegetation rich in bird life. These areas were conserved and protected, and buffer woodland planting was implemented to reinforce the integrity of these important nodes. Connectivity with adjacent natural areas was also carefully studied as part of landscape planning. Areas abutting Nature Ways along Yuan Ching Road and Boon Lay Way were planted with complementary vegetation to enhance these green spaces as corridors for the movement of biodiversity.

The conversion to an urban environment in the Jurong area had been very significant, resulting in higher temperature fluctuations and reduced humidity in many exposed areas where vegetation had been cleared. As part of the biodiversity study conducted for the Jurong Lake District, biodiversity hotspots were identified within the district (Fig. 9), and novel habitats planned as part of the habitat creation masterplan (Fig. 10). A good example of this was the grasslands, where six different species of grasses were planted in a 3.5-hectare open area devoid of tree cover to provide habitat for a wide range of grassland birds. The success of these efforts is evident from the ubiquitous flocks of Scaly-breasted Munias (*Lonchura punctulata*) that frequent the tufts of grasses, as well as sightings of the Zitting Cisticola (*Cisticola juncidis*) in search of grass seeds.

Identified biodiversity hotspots in Jurong Lake District

Blue (highly important)
- Banyan clump at the golf course
- Casuarinas at the southern tip of Japanese Garden

Mauve (very important)
- Chinese Garden
- Japanese Garden
- Secondary forest near and behind the existing Science Centre
- Woodlands on west side of the lake between the Chinese and Japanese Gardens
- Proposed boardwalk area near the islets at the south of JLGW

Green (important)
- Existing Jurong Lake Park just northwest of the Chinese Garden
- Secondary forest near Chinese Garden MRT
- Trees north of former Tang Dynasty land

Fig. 9. Identified biodiversity hotspots in Jurong Lake District.

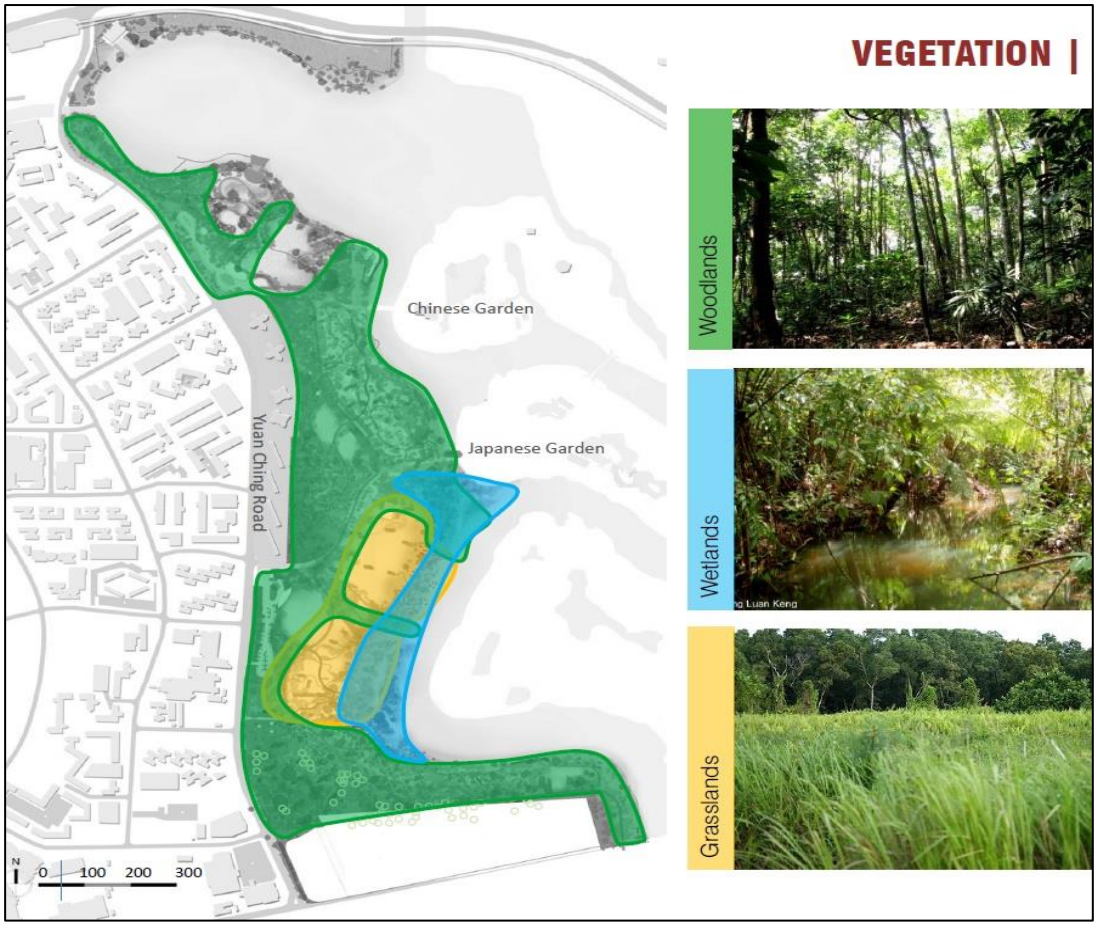


Fig. 10. Novel habitats within Lakeside Garden.

Implementation Stage

Some of the most visible landmarks within Jurong Lake Gardens were the large, vegetated swales running from the west of Lakeside Garden towards Jurong Lake. These swales were conceived as a mitigation solution to manage the high water table of the site. During the planning phase, hydrological and topographical analyses revealed that almost the entire site was low-lying, with significant water logging situations in areas in the north and south of the site. To mitigate these issues, swales were implemented to drain the site and lower the level of the water table. One prominent example where this was done was the creation of Neram Streams, where an existing 300-metre long concrete monsoon canal was de-concretised and de-canalised to create a series of braided, naturalised and vegetated streams that reduce the speed of surface runoff and cleanse the water discharged from upstream urban catchments before being discharged into Jurong Lake (Fig. 11). These swales now serve as habitat for a wide range of dragonflies, damselflies and other aquatic and riparian species.

Fig. 11. Creation of Neram Streams by transforming a 300-metre concrete canal into a series of braided, naturalised and vegetated streams.

Ecological aesthetics was another area in which significant emphasis was placed during the landscaping of the Gardens. To achieve this, landscape planning was performed on a broad scale. To complement the activity levels of spaces within the gardens, the landscape theme was planned with ornamental planting in the northern active zones gradually giving way to native planting in biodiversity-rich areas towards the south. Colour was also an important consideration in species selection. A ribbon of pink-flowering trees and shrubs was planted along the park

connector network spine stretching from north to south, and also along the shoreline to create splashes of colour along the waterfront (Fig. 12). Trees and shrubs were planted to emulate natural growth habits in nature, by varying the heights of trees and shrubs within clusters, and also by considering carefully the layering of vegetation to mimic the natural vegetation strata in forests. More than 3,000 existing trees were conserved on the site and over 200 transplanted, to form a connected corridor for wildlife and biodiversity. As part of species recovery efforts, native orchids such as *Cymbidium finlaysonianum* were also planted on mature rain trees.

Fig. 12. Ribbon of pink-flowering trees along park connector network spine and Lakeside Garden waterfront.

A third key feature of Jurong Lake Garden's implementation was the deliberate intention to create opportunities for biophilic experiences. One good example is the Forest Ramble, which is also Singapore's largest nature playgarden, where the individual play equipment sets were inspired by the actions and movements of animals that live within a freshwater swamp forest (Fig. 13). In using the play equipment, children emulate the motions of native swamp forest animals, resulting in the play experience being enriching and educational at the same time. Another example is the Rasau Walk, which is a 300-metre long boardwalk designed to bring people closer to the waterfront where a wide range of shorebirds frequently forage for food.

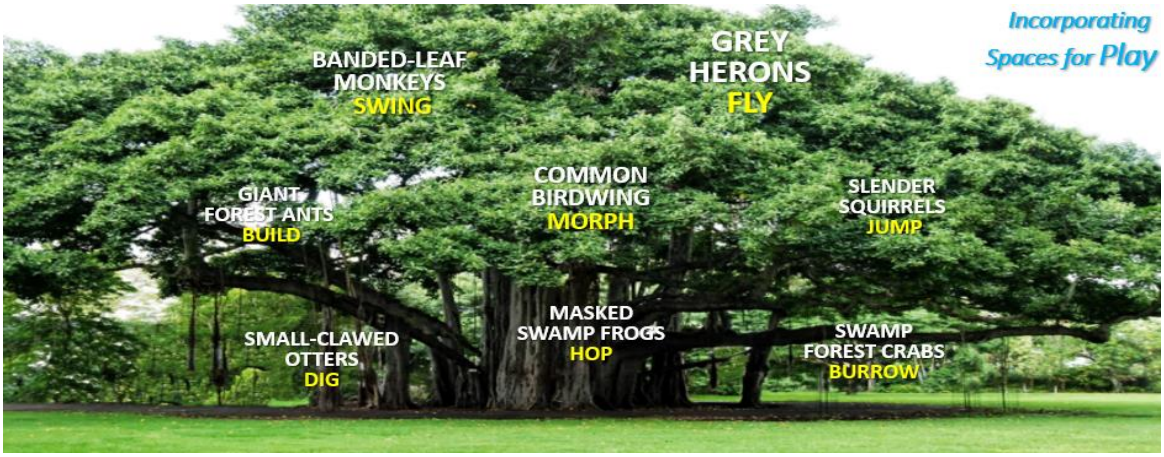


Fig. 13. Design consideration for playground elements at Forest Ramble for biophilic experiences.

Sustainability and Technology also form one of the key themes of Jurong Lake Gardens. A Sustainability and Technology masterplan was formulated with eight focus areas to guide the development of the gardens (Fig. 14), and to support Whole-of-Government efforts in line with the Singapore Green Plan 2030. An integrated management system consisting of a suite of environmental and facilities management sensors integrated to a central monitoring and control platform was also implemented to enhance situational awareness in day-to-day operations. The Gardens also actively serves as NParks' living lab for new technologies, ranging from robotics and automation to the use of sustainable building materials.

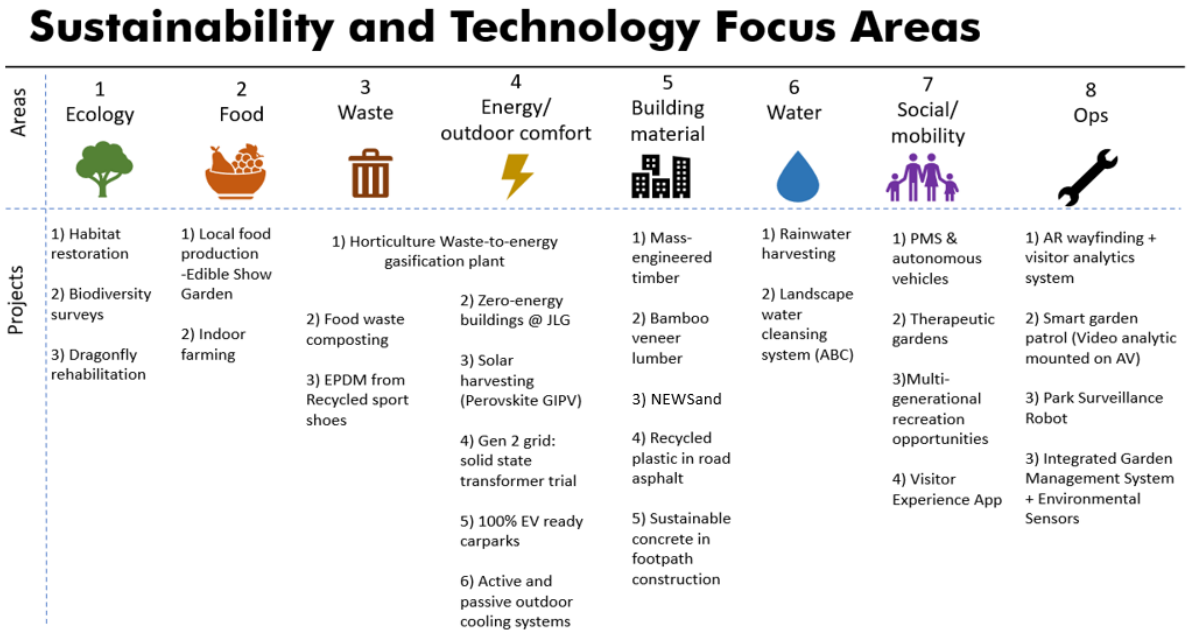


Fig. 14. Jurong Lake Gardens' sustainability and technology focus areas.

Programmatic Stage

Programmes within the Gardens are carefully curated to complement the Gardens' themes. Jurong Lake Gardens serves as the venue for events such as the Singapore Garden Festival Horticulture Show, Sustainable Festival as well as Mid-Autumn Festival. Regular programmes include activities such as nature guided walks and workshops that allow participants to learn about freshwater swamp forest habitats as well as native bird life. Activities such as composting workshops and Sustainable Festival also contribute towards increased environmental awareness.

Lakeside Garden houses Singapore's largest allotment garden, with 300 plots fully subscribed by local residents to grow their own fruits and vegetables. In December 2021, Singapore's largest therapeutic garden was opened, and it was also the first therapeutic garden to feature a children's zone designed and planted to cater to the needs of children with autism as well as seniors with dementia.

Bukit Canberra: Case study model for hybrid landscapes

Bukit Canberra, a vibrant and accessible 12-hectare integrated community hub is well interspersed with new habitats as well as a restored 1.5 hectares of secondary forest (Fig. 15). Bukit Canberra had been modified through the introduction and compounding of new planting strategies into the natural and historical sites. These approaches accompanied with nature-based solutions were the key strategies that identified this development's status as a restored hybrid landscape system. This project is being developed in stages.

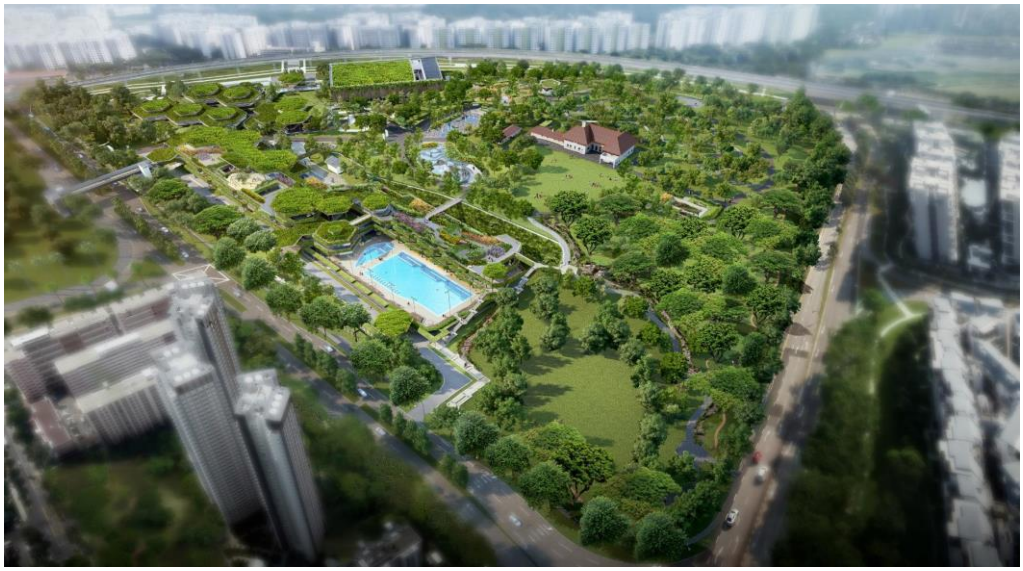


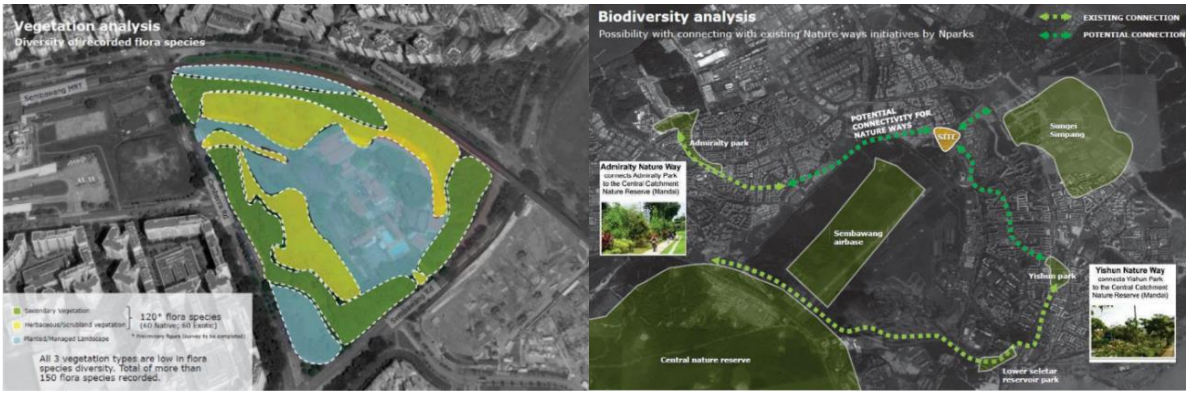
Fig. 15. Artist impression overview of Bukit Canberra integrated community hub. (Photo credit: SportSg)

In the early 1800s, Bukit Canberra's ecology comprised an array of habitats within an undisturbed primary rainforest. From the mid-1800s, the rich ecology of the site's surrounding areas made way for gambier and pepper plantations before rubber and pineapple plantations took over in the 1900s. In 1939, Canberra House was built on the site's hilltop. Despite rapid urbanisation of the site and its surroundings, some patches of regenerated secondary forest were found remaining at Bukit Canberra. Today, the enhancement plans include not only restoring but also reinterpreting the natural heritage of the site.

Planning Stage

Historical maps were used to identify past habitat types, vegetation types and natural heritage significance before determining the level of ecological restoration to be carried out at Bukit Canberra. Accompanied by a comprehensive analysis on the existing flora and fauna, identifying ecological connections for biodiversity conservation was prioritised for the Bukit Canberra site.

Three main vegetation types were found: secondary forest, herbaceous scrubland, and planted and managed vegetation (Fig. 16). A total of more than 150 flora species were recorded in all three areas. Within the secondary forest vegetation, there were exotic and native species, with more native species found on the southwestern and southeastern side of Bukit Canberra. While this area had a low to moderate sensitivity value, a few species of conservation status such as *Oxyceros longiflorus*, *Guioa pubescens*, *Litsea firma*, *Cyathea laterobosa* and *Pouteria obovata* were found. The scrubland vegetation was generally low in flora species and was mainly dominated by exotic grass species such as *Imperata cylindrica* and the native grass species such as *Ischaemum muticum*. Lastly, for the planted and managed landscape, more than 40 out of 150 flora species were exotic.



Figs. 16. Contextual mapping of vegetation types. (Image credit: SportSG)

The macro level analysis revealed existing Nature Way connections and ecological stepping stones in close proximity such as at Admiralty Park, Sungei Simpang and Central Nature Reserve. Identifying these connectivity considerations in the planning stage was crucial in strategizing new habitat creation at Bukit Canberra allowing it to contribute to habitat defragmentation effort.

Fig. 17. Mapping of habitat zones within Bukit Canberra. (Image credit: SportSG)

With the above ecological studies of the site, various habitat zones were planned throughout the entire development (Fig. 17). As most of the built forms would be developed within the Urban Zone, the habitat zones were strategized to minimize any stark contrast in landscape character between these built and landscape areas (Fig. 18). The existing secondary forest edge was retained and further enhanced progressively into a lush and dense forest buffer. A riparian habitat was planned to maximise water catchment, slow down water runoff and continue into the built areas in the form of vegetated swales and bioswales. Food forests and woodlands were also planned to encourage pollination cycle through the help of bees and other biotic pollinators. Finally, grassland habitat, that would mostly consist of either flowering shrubs or grasses, would provide foraging areas for grass-dependent bird species.

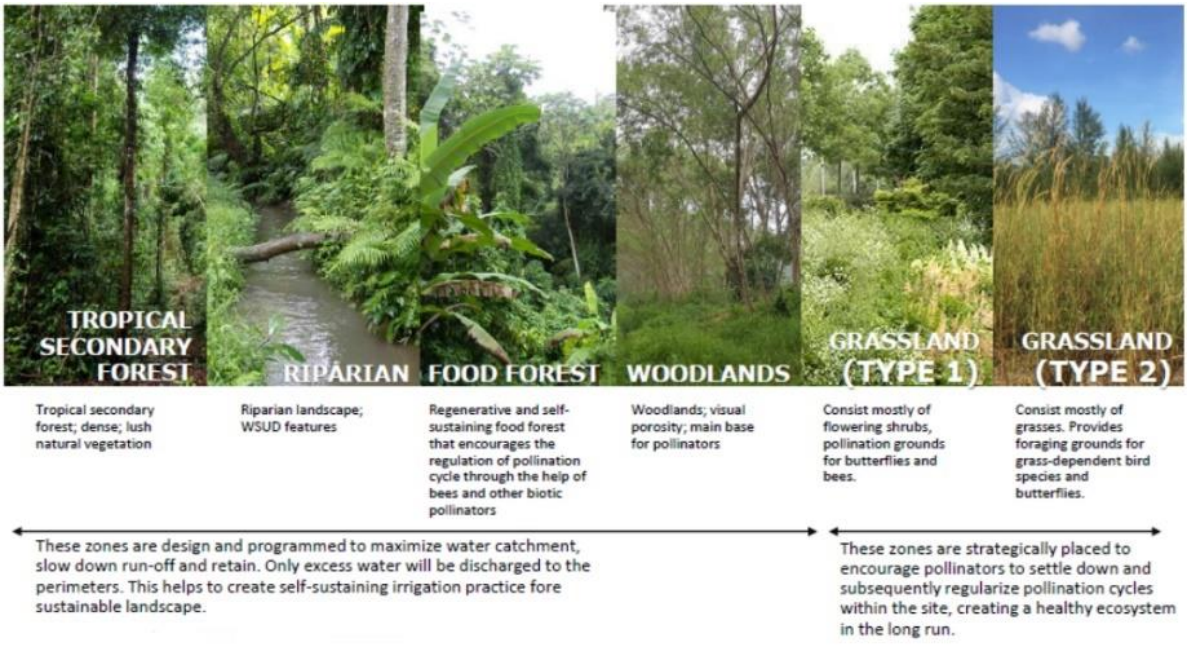


Fig. 18. This is an artist impression of the zones produced by the consultancy. (Image credit: SportSG)

Implementation Stage

Bukit Canberra's level of ecological restoration comprised several biodiversity enhancement strategies, including the conservation of existing habitats and areas of high biological integrity and enhancement of existing habitats by increasing the diversity of flora species to attract more fauna while recreating habitats. These were applied in the three habitat zones (Fig. 19).

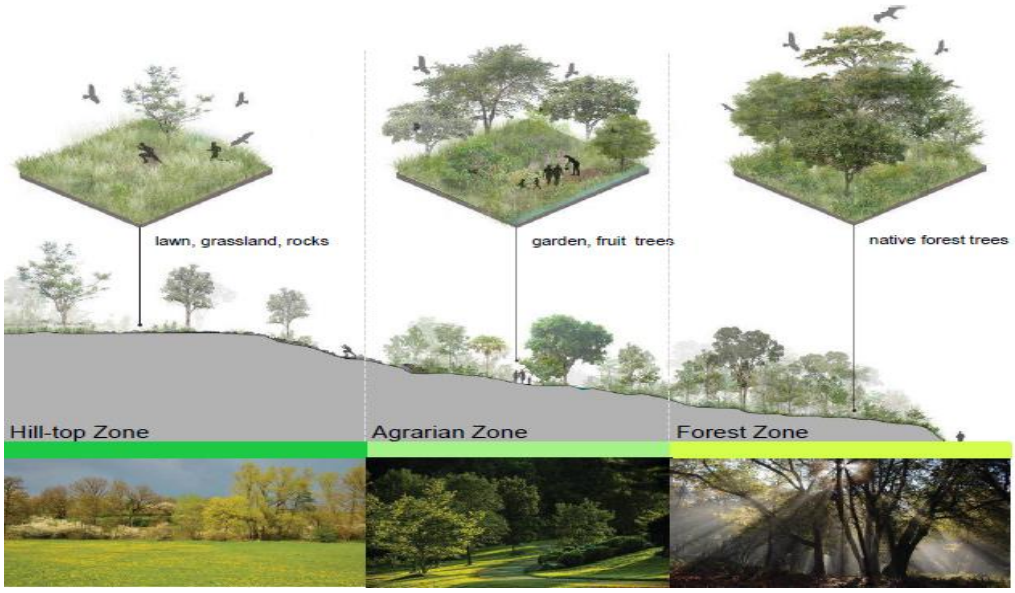


Fig. 19. This is an artist impression of the habitat types produced by the consultancy. (Image credit: SportSG)

The Forest Zone that had minimally 70% canopy coverage with high density trees was targeted to be ecologically linked to the surrounding nature ways in Sembawang while serving as the main refuge core for biodiversity and habitat creation. The Agrarian Zone would form a transitional landscape before the Hilltop Zone, where dense and multi-tiered planting of fruit trees and herbaceous shrubs contributed to a woodland habitat with 40–50% canopy coverage. At the Hilltop Zone, where most of the existing managed landscape were, significant trees such as Ficus were retained to allow for biodiversity hotspots to continue up the hilltop whilst bringing in more thematic yet naturalistic gardens to complement the English Arts & Crafts style of the Canberra House, through the use of native flora species.

Bukit Canberra's greenery plan encompasses a diverse and thematic comprehensive planting strategy (Fig. 20) that serves to simultaneously function as an attractive recreational and ecological landscape.

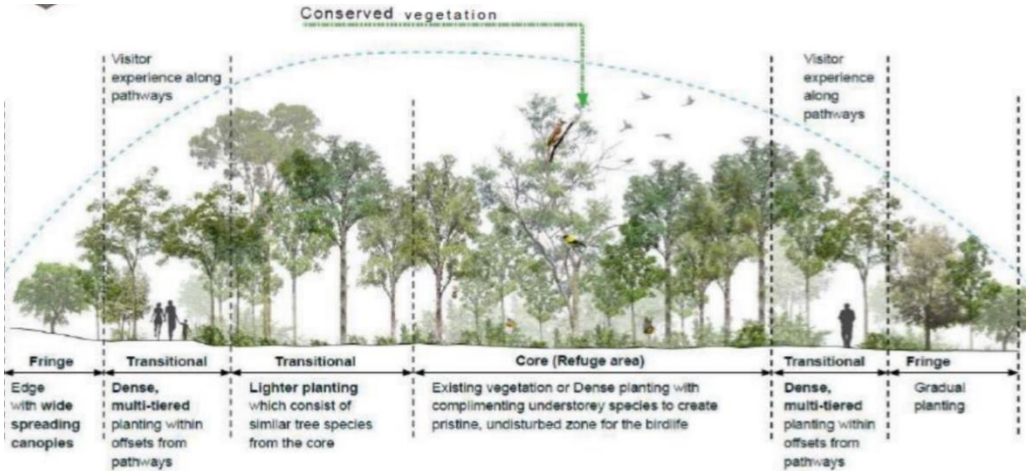


Fig. 20. This is an artist impression of the greenery plan encompassing a diverse and thematic planting stratetegy produced by the consultancy. (Image credit: SportSG)

Connectivity of users of all ages and abilities to the natural environment was ensured in three distinct areas, firstly, the Forest Gym, secondly, the Nature Playgarden and lastly, the Therapeutic Garden. These spaces drew inspiration from nature, providing users a healthier environment to interact in. In the Forest Gym, users would be able to do physical workout with equipment that were made of natural material such as recycled timber while being immersed in a dense forest-like environment. Similarly, in the Nature Playgarden, users of a young age would be introduced to a play environment that mimic the forest and natural environment. This would help to increase biophilia and facilitate connection with nature at a young age. The

Therapeutic Garden provides a platform for nursing homes and local community to have horticultural therapy where the interaction with flora helps to heal through a multi-sensorial experience.

Bukit Canberra contains a high percentage of built structures including a hawker centre and sports centre that seamlessly integrate into the landscaped hill that will be implemented progressively. This will be achieved through various vertical greenery such as green roofs, balcony greening and pocket gardens within the buildings. These help to cool the micro-climate, improve air quality and enhance aesthetics, among others.

Lastly, Bukit Canberra incorporates PUB's Active Beautiful and Clean water sensitive urban design typologies. Detention basin and vegetated swales are introduced as nature-based solutions for drainage systems while also serving as a platform to restore aquatic habitats. Through this habitat restoration, users will get to enjoy a fresh array of diverse planting along the riparian habitats, thus, increasing user interaction with these nature-based features during both flooded and non-flooded periods.

Programmatic Stage

To further strengthen Bukit Canberra as a community hub, various programmatic software will be incorporated and supported at an inter-agency level which includes Sports Singapore, Ministry of Health Singapore Holdings, National Environment Agency, National Heritage Board, People's Association and National Parks Board. Bukit Canberra's hardware is also programmed such that it encompasses an array of spaces for users of all ages and background that focuses on health, sport and fitness, education, history and many more. With cross-programming between agencies and various events using the integrated facilities designed within Bukit Canberra, the use of an integrated service counter for all programmes and events will help users to easily access links to various co-locating agencies and public services.

Bukit Canberra is also promoted as a lifestyle destination where music, arts, heritage trails and health and wellness sessions are all supported with activities and messages that aim to inculcate civic-mindedness within the community (Fig. 21). Additionally, volunteers will be rallied as Friends of Bukit Canberra, where they can be involved in leading the guided walks or tours,

providing advice and guidance to tenants of Bukit Canberra on gardening within the childcare centre and elderly care centre.

Fig. 21. Artist impression of therapeutic garden in Bukit Canberra. (Image credit: SportSG)

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Annex A

Project name: _____

Project Lead:	
Project Coordinator:	
Specialists:	
Date:	Version:

Phase/Stage 1: **PLANNING**		**Check**	**NA**
Site Context Analysis			
1	Historical Maps - Identify key historical vegetation and waterways. - Highlight ecological connectivity to nature areas. - Historical maps of Singapore: https://libmaps.nus.edu.sg/ - NAS for old aerial images https://www.nas.gov.sg/	☐	
2	Connectivity: Park Connector Network (PCN) Masterplan Connectivity: Nature Ways	☐	☐
3	Surrounding Land-use: URA Masterplan - https://www.ura.gov.sg/maps/ - URA Parks and Waterbodies plan	☐	☐
4	Satellite image (latest): Parks Planning (PP)/MAVEN - MAVEN/Google	☐	☐
5	Topography: SLA Lidar and Topography Survey - Request from PP/Design SLA Lidar - Parks Development (PD) to conduct topographic survey	☐	☐
6	Roads: Plans to reflect LTA road kerb, Road Reserve layers, Road works and new roads. - Request from PP. - Refer to MAVEN, to seek rights from IT when necessary.	☐	☐
7	Surrounding Buildings: - Request from PP latest development in the development proximity. - Refer to MAVEN or OneMap for existing buildings - Information on Building height, footprint, design and use.	☐	☐

8	Drainage Reserve & Services: - Request from PP/Greenery & Development Planning (GDP) for drainage reserve layer/pipeline/sewer works/services (SP power, Singtel etc). - Refer to MAVEN, to seek rights from IT when necessary.	☐	☐
9	Vegetation Layer: - Request for vegetation map layer info rights on MAVEN from National Biodiversity Centre (NBC). - NUS satellite studies from NBC. - PD/Ops conduct tree (>1m girth) tagging survey and flora survey.	☐	☐
10	Biodiversity: - Request for significant biodiversity areas from NBC/BIOME. - NUS satellite studies from NBC. - PD/Ops conduct Biodiversity survey (identify transects, areas for camera trapping, stream surveys, water quality tests, soil data)	☐	☐
11	Heat Resilience: - Refer to heat resilience document - Hardscape to greenery ratio (3:7 ratio)	☐	☐
12	Flood Resilience: - Check whether the park is in the flood-risk area pertaining to sea level rise - Check whether park is within flood-prone areas – localised context	☐	☐
13	Sustainability - Understanding parks energy requirement - To identify goals for sustainable energy usage (BCA Zero energy buildings) - Identifying areas to locate solar panels/skylights/solar tubes - Identify amount of savings/cost recovery - Consider other sustainable sources of sustainable energy (Wind energy, waste to energy plant, kinetic energy, etc.) - Sustainable infrastructure and building materials (Mass Engineered Timber, Bamboo, reconstructed wood) - Food Sustainability (Edible gardens, allotment gardens, plant factory)	☐	☐

14	Smart Operations - Integrated Garden Management System - Smart Lighting - Mobile Application for Parks - Robotic video analysis - Automated Irrigation - CCTV and People-counting systems (face recognition, temperature screening) - Automated lawnmower - Visitor Service Smart Kiosk	☐	☐

Goals of Restoration: ***(tick one of the following goals for the project)***

Identify/Produce a plan on the habitat types that will be created/restored

Habitat Types: _____ *(e.g., Grasslands/Wetlands)*

NATURAL: *The distinctiveness of a purely natural ecosystem that spans over a long undisturbed period from minimal interventions of man. (Untouched, Wild, Spontaneous)*

e.g., Primary and secondary forests: Rifle Range Nature Park

NOVEL: *Where ecosystems have been pushed beyond their historical range of variability. (Designed, Managed, Wild, Spontaneous)*

e.g., Regional parks with 'ecological' planting: Bidadari/Jurong Lake Gardens

HYBRID: *An ecosystem that is modified/compounded with curated landscapes. (Designed, Managed, Wild, Historical, Spontaneous)*

e.g., Nature parks, Parks at the forest edge: Pasir Ris Park

Phase/Stage 2: **IMPLEMENTATION**	**Check**	**NA**
Ecological Processes		
• Discuss based on information on processes such hydrology, edaphic (soil) conditions, topography, biodiversity baseline and ecological connectivity gathered at planning stage • Determine topographical, hydrological and landform changes necessary to achieve habitat goals		
1 Naturalise Waterways & Waterbodies **Vegetated swales, bio-retention ponds, flood plains and waterbodies**		
• To identify goals for increasing naturalised waterways	□□□	□
• Treatment of runoff of total site area through ABC design features (10%, 11–35%, >35%)	□□□	□
• To site naturalised drains at suitable location - Point of interest/attraction - Biodiversity corridor (connection to forest vegetation/vegetation patches) - Area with maximum visual porosity (less tree planting along naturalised streams) - Human interaction with stream	□□□	□
• To consider catchment and quality of water source - Topographic study - Water quality sampling - Identify the pollutants to remove	□□□	□
• To consider storm water management requirements - Function (collection pond/drainage) - Capacity of stream/rain garden - Level of inundation - Frequency of flood – Flood evacuation plan (if necessary)	□□□	□
• To identify opportunities for rainwater harvesting (Irrigation)	□□□	□
• To restore/create habitats - Identify habitat goals/species recovery goals - Stream habitat/fish habitats/dragonfly habitat/butterfly attracting planting - Planting along streams to encourage biodiversity roosting along streams	□	□

Resources:

- Naturalising existing blue infrastructure
- Design guidelines and toolkit for naturalised waterways and waterbodies

Naturalise coastal waterfront

- Identify historical stream connection to sea and goals for naturalising (25%/50%/100%) ☐ ☐
- To site naturalised waterfront/intertidal stream at suitable location ☐ ☐
    - Point of interest/attraction
    - Biodiversity corridor (connection to forest vegetation/vegetation patches)
    - Human interaction/experience
- To consider catchment and quality of water source ☐ ☐
    - Topographical study
    - Water quality sampling
    - Identify the pollutants to remove
- To consider coastal erosion impacts ☐ ☐
    - Conduct Coastal erosion and deposition study
    - Optimising coastal protection measures with habitat creation substrate
- To restore/create habitats ☐ ☐
    - Conduct biodiversity baseline studies along existing coast
    - Identify habitat goals/species recovery goals
    - Degree of daily inundation
    - Planting/structures along streams to encourage biodiversity roosting along streams

Habitat Restoration		CHECK	NA
2	Conserve more Native Plants & Animal Species Add in the characteristics		
	Vegetation structure		
	• To identify goals for native vegetation conservation (e.g., large trees (>1m girth))	☐	☐
	• To identify goals for native vegetation enhancement/rehabilitation (25%/50%/100%)	☐	☐
	• Study existing greenery/habitats within and abutting park and plan new zones of habitat improvement/intervention (e.g. new back mangrove buffer zone around mangrove core, new coastal forest areas, new freshwater swamp belt integrated with Nature Way)	☐	☐
	• Plan vegetation structure along both horizontal and vertical planes. Habitat heterogeneity along each plane is key to allow for diversity of ecological niches.	☐	☐
	- (Horizontal:) Establish a Habitat Mix Plan within park (e.g., freshwater swamp, grassland, woodlands)	☐	☐
	- (Vertical:) Create the different levels within a rainforest structure (e.g., ground, shrub, subcanopy, canopy and emergent layers)	☐	☐
	Plant Selection		
	• To identify goals for retaining existing site floristics (25%/50%/100%)	☐	☐
	• Plan floristic assemblage of each habitat zone based on habitat restoration goals, e.g., use of native species found in specific habitats vs use of exotics at hybrid or novel landscapes (e.g., Jurong Lake Gardens Grasslands)	☐	☐
	• Create planting plans based on palettes for each habitat type	☐	☐
	• Curate unique native plant collections (discussion with specialist)	☐	☐
	Conservation of Biodiversity		
	• Identify goals of biodiversity conservation (species, habitat)	☐	☐
	• Identify goals of habitat creation and biodiversity connectivity (species, habitat and compatibility to park programmes)	☐	☐

• Integrate with network of green spaces that function as ecological corridors (i.e., nature way, PCN)	☐	☐
• Enhance habitats that harbour biodiversity and provide conduits for movement between nature areas	☐	☐
• Consider infrastructure to aid fauna connectivity (rope bridges, culverts) and habitat creation (habitat boxes, bee hotels)	☐	☐
• Enrich existing habitats to support Species Recovery Programme (consult specialists)	☐	☐
• Study measures to reduce potential human wildlife conflict (if any).	☐	☐

Resources:

- Plant palette templates by habitat types
- Green spaces designated as collections
- Species Recovery/Re-introduction List
- Introducing fauna design guidelines

Ecological Aesthetics		CHECK	NA
3	Curate more Natural Habitats/Vegetation		
	Non-manicured landscapes		
	• Mimics tropical forest structure	☐	☐
	• Randomised planting in clusters and groves	☐	☐
	Multi-tiered planting		
	• Mix of small, medium & large trees with understorey plants	☐	☐
	Plant diversity		
	• Diversity of plant species showcasing foliage colours and textures	☐	☐
	• Integrating and extending nature ways into parks	☐	☐
	• Consideration for native and exotic species	☐	☐
	• Shade provision	☐	☐
	Sustainable landscapes & ecosystems		
	• Bringing back historical vegetation and habitat	☐	☐
	• Plants, planting and care regime to suit site context and landscaping themes	☐	☐
	Resources:		
	- Naturalistic landscape design guide		
	- Naturalistic landscape maintenance guide		

Phase/Stage 3: **PROGRAMMATIC (Hardware)**			**Check**	**NA**
Therapeutic Landscapes				
1	-	Design guidelines for Therapeutic Gardens (TG) in Singapore	☐	☐
	-	Grow the TG network	☐	☐
		New TG typologies		
Nature Playgardens				
2	-	Nature playgarden design guidelines	☐	☐
	-	Strategy plan for nature play in Singapore	☐	☐
	-	Courses for NParks and external audiences	☐	☐
Skyrise Greenery				
3	-	Raise industry's standard and increase outreach	☐	☐
	-	Skyrise naturalistic planting	☐	☐
	-	Pilot projects/showcase projects	☐	☐
Biophilic Designs				
4	-	Design guideline for developers to provide additional setback for certain areas for ecological/green connectivity	☐	☐

Phase/Stage 3: **PROGRAMMATIC (Software)**		**Check**	**NA**
1	**Community in Bloom:** A nationwide, ground up gardening movement that aims to foster a community spirit and bring together residents, both young and old, to make Singapore our garden.	☐	☐
2	**Community in Nature:** Encourage stewardship of nature amongst Singaporeans through organized research endeavours plus collecting information that will inform conservation management strategies.	☐	☐
3	**Friends of The Park (FoTP):** Ground-led initiative to promote stewardship through active stakeholders and volunteers from diverse backgrounds.	☐	☐
4	**FoTP:** Citizen Parks Engagement: involve communities in the design, development and management of our parks and green spaces.	☐	☐
5	**One Million Trees Movement:** Aims to redouble Singapore's efforts to green its urban infrastructure on an unprecedented scale, to achieve the vision of making a City in Nature.	☐	☐
6	**Gardening with Edibles:** Brings nature into homes, where the community plays a key role in the ownership and stewardship for nature which will bring forth benefits of health and well-being.	☐	☐
7	Education and Volunteer programmes	☐	☐
8	Youth@SG Nature	☐	☐