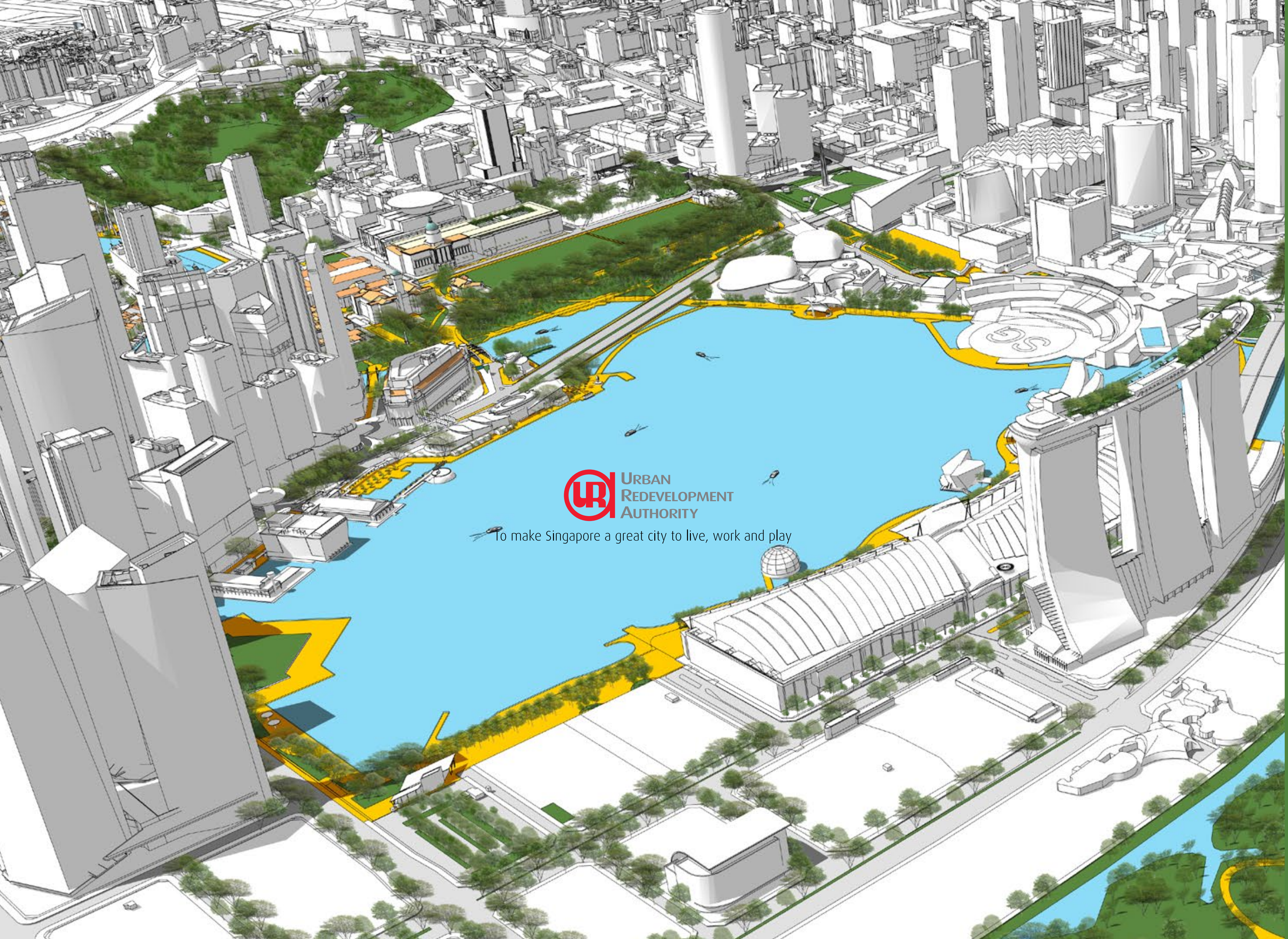
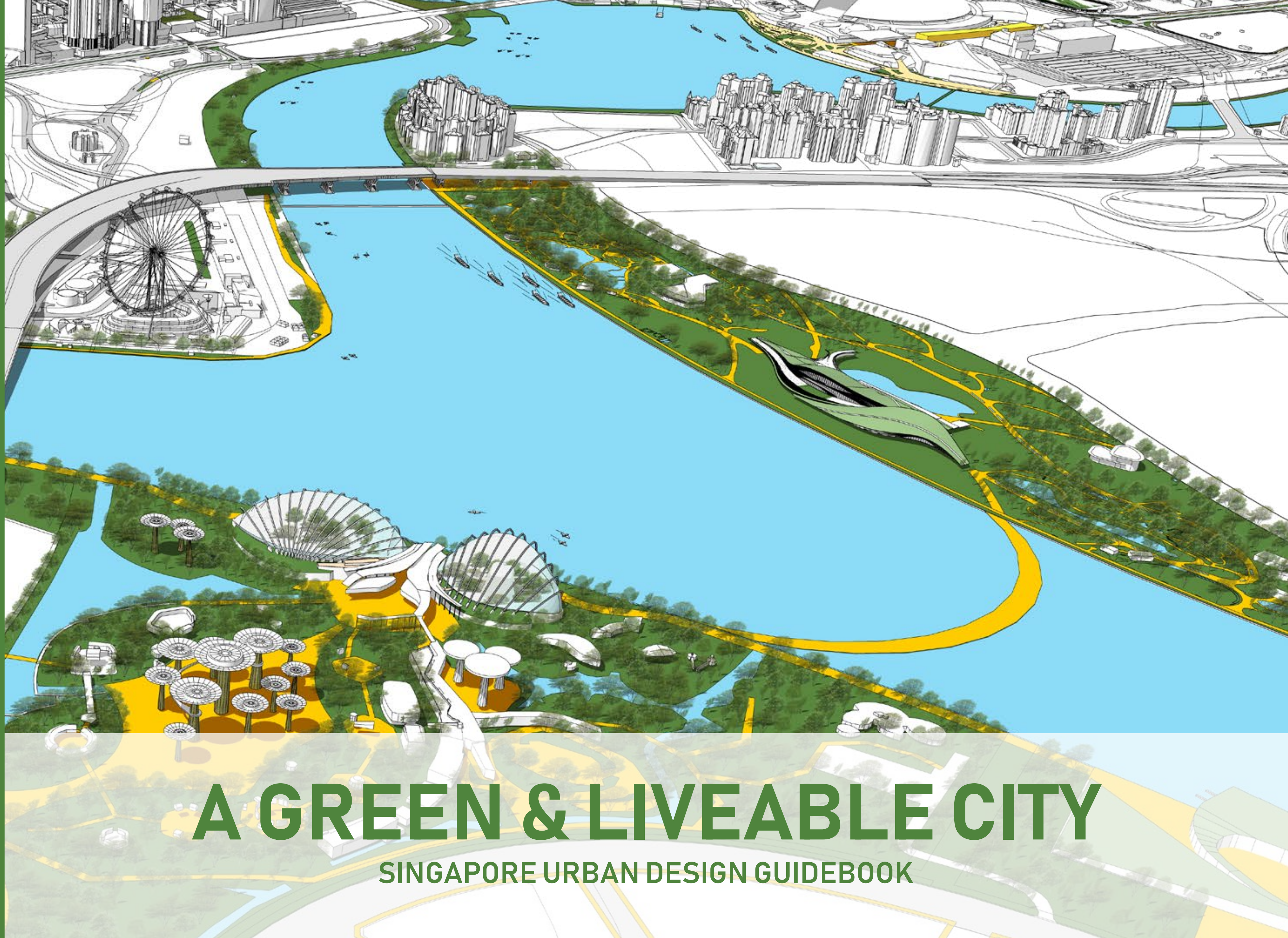


URBAN
REDEVELOPMENT
AUTHORITY

To make Singapore a great city to live, work and play

A GREEN & LIVEABLE CITY



# A GREEN & LIVEABLE CITY

## SINGAPORE URBAN DESIGN GUIDEBOOK

# A GREEN & LIVEABLE CITY

## SINGAPORE URBAN DESIGN GUIDEBOOK


# PREFACE
# REVEALING THE HAND OF URBAN DESIGN IN SHAPING A CITY IN NATURE

This second book in the Urban Design Guidebook series details URA's strategies in shaping a Green and Liveable City. The garden city vision was introduced by then Prime Minister Lee Kuan Yew in 1967 to transform Singapore into a city with lush greenery to create a clean environment for better living. This resulted in over 55,000 trees planted around Singapore by 1970, with the Parks and Trees Act enacted in 1975 to require all developers including HDB and JTC to set aside spaces for trees and greenery. Today, roadside trees and green buffers are ubiquitous features in our cityscape. In addition, many buildings feature skyrise greenery in the form of sky terraces and roof gardens.

This book explains the role urban design plays in coordinating the overall outcome, helping Singapore to transition into its stated ambition to become a City in Nature*.

Urban design governs the built environment, covering both buildings and the spaces between them, including streetscapes, public spaces and landscapes. It therefore plays a significant role in the overall effort to restore nature into the urban environment, to create a more liveable, sustainable and climate-resilient Singapore.

By working closely with our agency partners, URA has developed guidelines and policies to ensure that greenery is integrated into developments and the wider public realm. Recognising that creation of greenery is not enough, URA works with NParks and researchers to understand how urban greenery supports ecological outcomes and ecosystem resilience in the city, updating our LUSH (Landscaping for Urban Spaces and High-rises) policy over the years to reflect these findings.

Greenery is a key priority in urban design in Singapore. It is one of the 9 urban design elements that form the toolkit for URA's urban designers that drives URA's urban design work. URA was an early promoter of greenery in buildings before it became a priority around the world – incentivising the creation of sky terraces, planter boxes and covered communal ground gardens since the 1990s, before launching the LUSH (Landscaping for Urban Spaces and High-rises) policy in 2009 to consolidate these guidelines and make landscape replacement mandatory in key areas.

LUSH is now into its fourth edition, expanding its scope to extend landscape replacement standards to even more areas in Singapore, and introducing guidelines to enhance the ecological capital of developments. This guidebook is being launched at an opportune time to recap the various initiatives under LUSH that promote urban greenery, and outline new strategies that promote sustainability such as passive cooling in developments.

The achievements in the greening of Singapore would not have been possible without support and collaboration of the architecture and landscape design fraternity, developers and building owners as well as the landscape maintenance industry. Their contributions have also been profiled in this series of guidebooks, to inspire us with their creativity and commitment to integrative architecture and landscape design.

**Fun Siew Leng**
*Chief Urban Designer,*
*Urban Redevelopment Authority*

**Over the years, the Garden City vision has evolved into "City in a Garden"(2011) and now "City in Nature" (2020) to reflect growing efforts to integrate nature into the city and meet sustainable development goals under the Singapore Green Plan 2030.*


**Editors:**
Fun Siew Leng
Yap Lay Bee

**Lead Writer**
Nicholas Li

**Illustrations by:**
Andrew Teo
Chan Hui Yuan
Chan Jun Hao
Chan Yu Shen
Chew Shan Wei
Claire Wong
Clifford Au Yong
Keith Law
Lim Xiao Wei

**Layout by:**
Janet Er
Mohamad Iswadi
Muhammad Hairul
Wang Youquan



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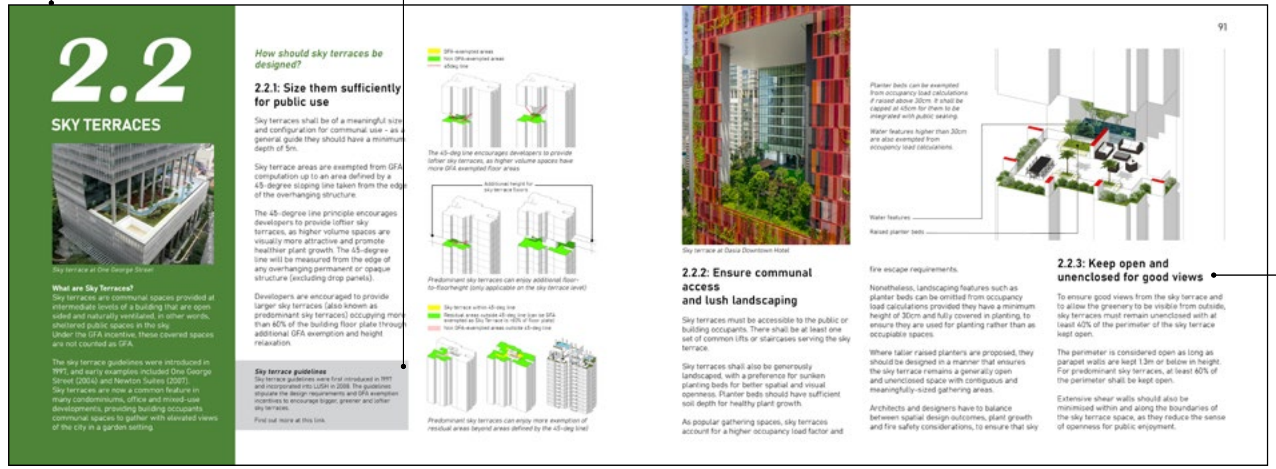


Each chapter explains 3-4 key considerations around each topic / policy

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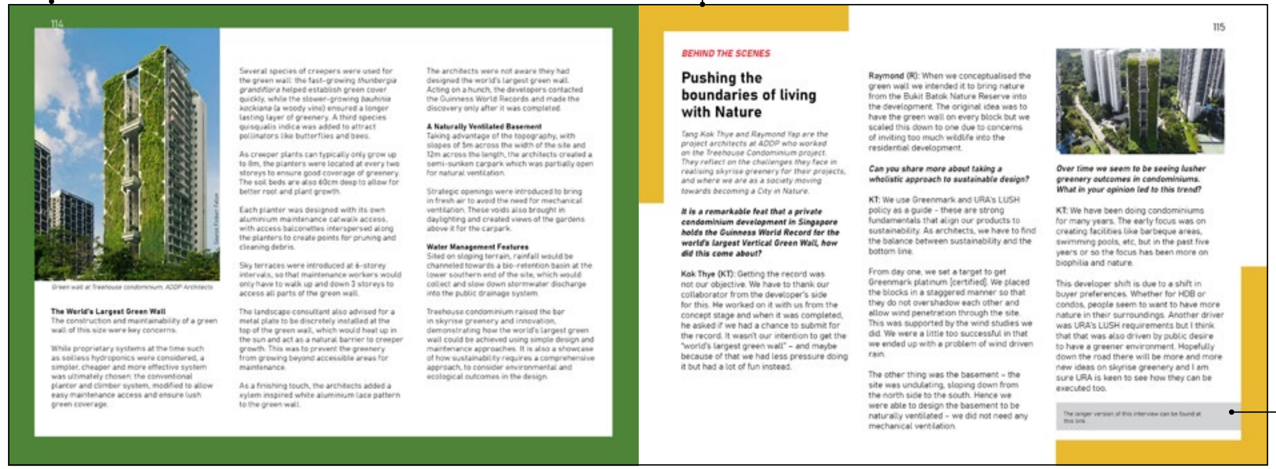



Online links to full versions of interviews



# About this series

Behind the many places that are loved and cherished across Singapore are careful and concerted efforts and strategies to shape them, sometimes hidden from plain sight. This series on urban design aims to demystify the work of urban designers and illuminate the impact of their work in shaping Singapore.

It will provide insights into URA's planning and urban design policies, explaining the rationale and interpretation of various guidelines through 3D visualisation. It also provides best practice guides on the application of these guidelines, highlighting successful examples by architects, developers and government agencies in shaping positive urban outcomes..

Through a curated selection of projects and initiatives, this series will unpack the insights, innovations, learning points and outcomes of urban design efforts that have shaped the physical environment of Singapore.

Different books are planned within the Urban Design Guidebook series to cover the range of issues urban design efforts address in the city.

## DISTINCTIVE & DELIGHTFUL

This book looks at the urban design strategies used to enhance the legibility and imageability of the city's districts and urban form to make Singapore distinctive and delightful. It also looks at placemaking strategies that enhance the "sense of place" and result in endearing places that people are emotionally connected to.

## CONNECTED & INCLUSIVE

Urban design plays a key role in shaping effective walking networks that are functional and enjoyable in the city. This book looks at the various scales of connectivity in the city and how comprehensive walking and cycling networks are realised through different mechanisms.

## GREEN & LIVEABLE

This book looks at the ways greenery is integrated into the urban fabric at various scales to enhance the liveability of the city, covering planning and urban design efforts to help Singapore transition from being a "Garden City" to a "City in Nature".

## FROM PLANS TO REALITY

Realising urban design outcomes requires careful navigation of complex development frameworks and processes. This book examines how good urban design is realised through guidelines, incentives, promotion and education efforts, with close collaboration between public and private sector entities.

## How is urban design realised in Singapore?

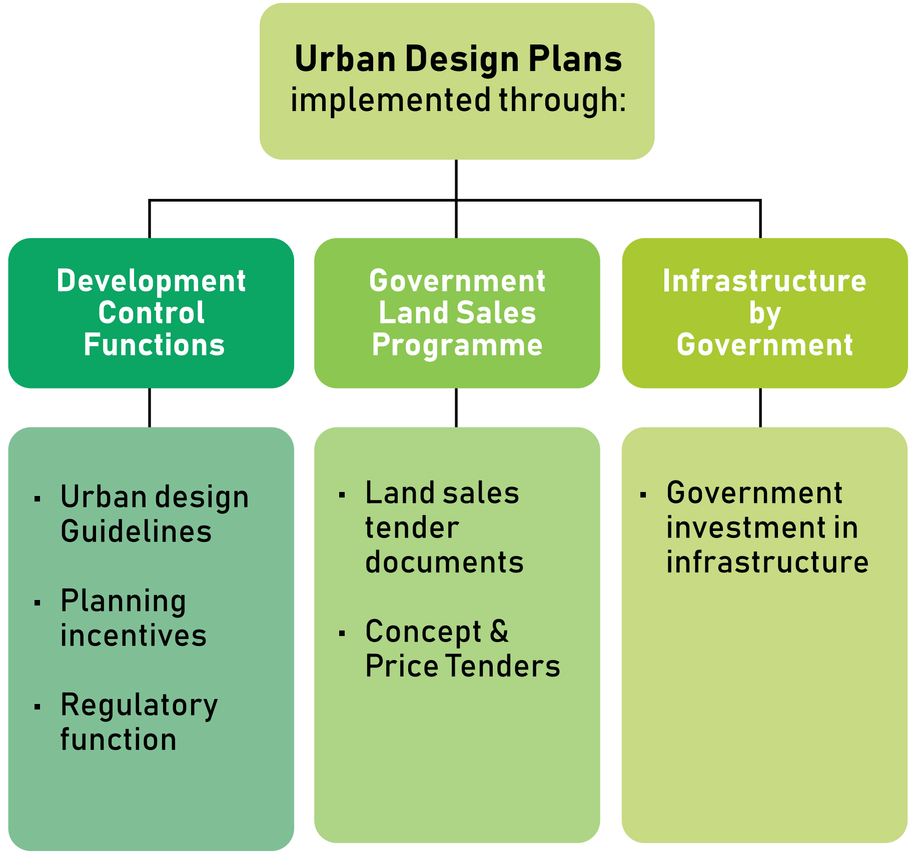
Urban design entails the complex act of bringing together many elements of the built environment to create a coherent and cohesive whole, such that the city is made more functional, attractive and liveable.

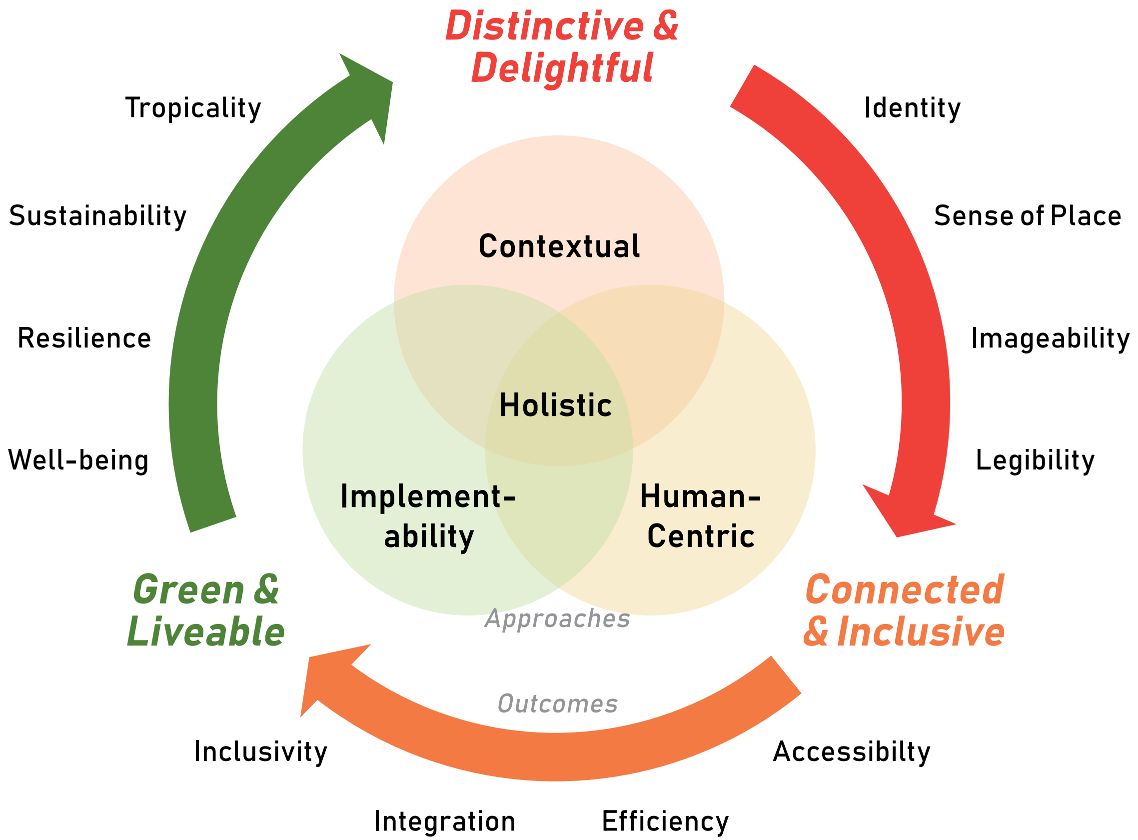
URA uses three main levers to realise urban design outcomes across Singapore:

**Development Control**
Development and building works are regulated through the Development Control arm of the URA. As the planning authority in charge of planning and development approvals, URA is able to ensure that urban design guidelines and conditions are adhered to before planning permission is granted for development and building works. This means that every time new buildings are built or buildings undergo redevelopment and major alterations works, they are guided by a set of urban design guidelines relevant to their site context.

**Sale of Sites**
Secondly, URA is also the land sales agent for the government and is therefore able to include urban design guidelines as part of the tender conditions issued for the sale of sites, and ensure that they are complied with as part of the development approval process. In addition, URA may convene a Design Advisory Panel to guide the design of strategic developments in the city.

**Infrastructure**
Thirdly, where necessary, URA also implements works to enhance the city, such as environmental improvement works at key streets and public spaces. These works help to improve the image of the city or create conditions for developments to achieve better design outcomes. These works help to improve the image of the city or create conditions for developments to achieve better design outcomes.






## URA's urban design framework

URA's approach to urban design can be summed up in the diagram below:

**Contextual:** Urban design always starts by having a thorough understanding of the unique demands of each site, resulting in proposals and interventions that respect and enhance the existing physical, social and economic context.

**Human-centric:** Urban design focuses on people – shaping environments that are safe and comfortable to be in and to move around to conduct daily work and social life.

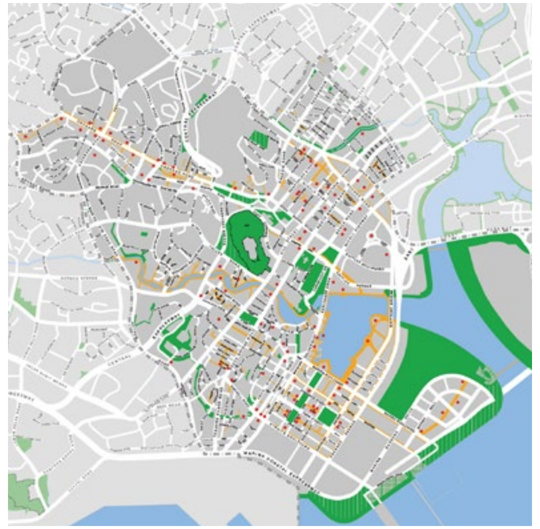
**Implement-ability:** Implement-ability: This is what separates plans from reality. Urban design guidelines are grounded in realities like development costs, timing and market conditions, often requiring private sector participation.

It is also part and parcel of urban design work to develop procurement mechanisms and incentives to encourage good design outcomes.

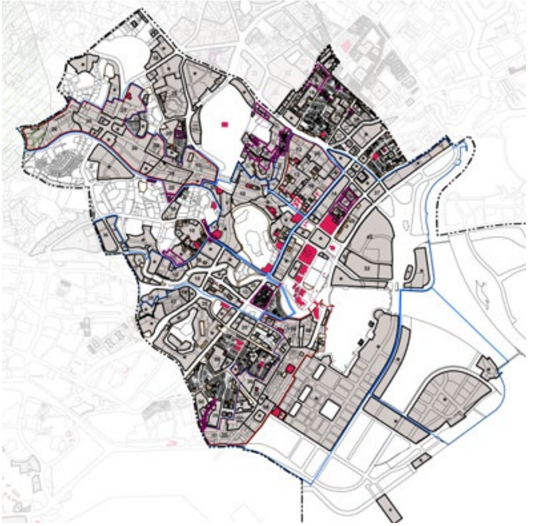
# The guiding plans for urban design in Singapore

Over the years, URA has developed several key plans which serve as the guiding framework for its urban design work.

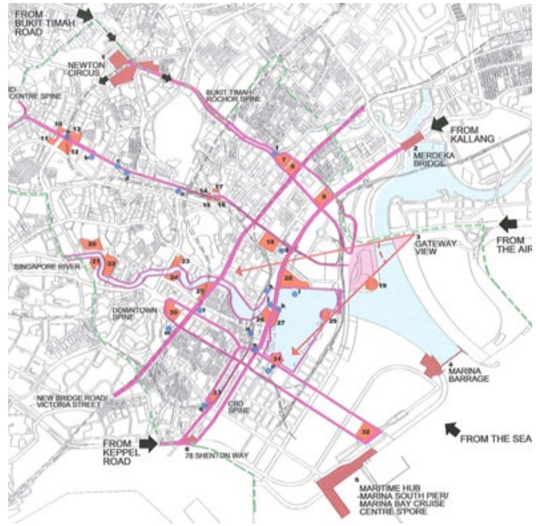
**District Character Plan**
This plan outlines the various districts in the Central Area which are distinctive due to their unique positioning, land use, built form and history. Detailed urban design guidelines have been developed for each district to enhance their characters and identities.



**Parks and Waterbodies Plan**
This plan maps out where existing and future green spaces and open spaces are envisioned, and how they will be connected by comprehensive walking and cycling links. Developments are required to contribute to the network of parks and open spaces as part of redevelopment or major additions and alterations work.

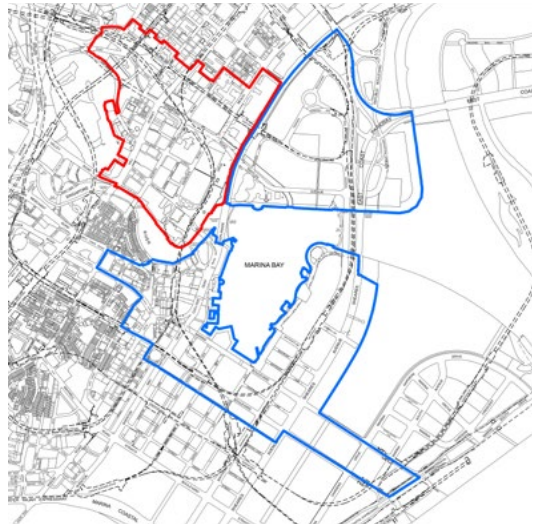


**Building Height Plan**
Certain sites or districts are subject to building height controls to shape legibility in the urban form. For example, building heights may be guided to relate to natural features like hills and waterways to avoid overshadowing them. Higher heights may be stipulated around transport nodes to optimise development density around transit.



**Landmark and Gateway Plan**
This plan identifies strategic sites that mark key locations and approaches in the city where landmarks and gateway developments are desired, to strengthen sense of orientation and structure for the urban fabric. These sites are subject to special urban design guidelines and design evaluation through different mechanisms such as Design Advisory Panels or Concept Price Tenders.

**Activity Generating Uses Plan**
This plan identifies where activity generating uses (AGU) such as shops and restaurants are required along the 1st storey of developments to enliven key activity corridors in the city, such as along pedestrian malls and waterfront promenades.



**Night Lighting Master Plan**
This plan identifies areas where there are requirements and guidelines for external building lighting, to contribute to the character of each district.

# Explaining the urban design elements

The nine urban design elements were developed as a toolkit for URA's urban designers to better identify and organise the components of the built environment for intervention and guidance.

The initial list started with seven elements but expanded to include Nightlighting and Greenery to reflect the importance of these aspects as URA developed plans and policies around them in later years.

The elements form the basis of urban design guidelines which have been developed for various areas around Singapore

***Urban Design Guidelines***
Urban design guidelines have been published for different areas in Singapore such as Central Area districts and the Regional Centres.

They can be found at this link.


Source:
Building Form: Teo Zi Tong
Open Space: NParks
Greenery: Patrick Bingham-Hall
Nightlighting: Patrick Bingham-Hall

**Urban Pattern**
Urban pattern refers to the way of organising and structuring the city in a legible and identifiable way – by providing a structure to distribute and place the different functions and elements of the city.

**Building Form**
Building form refers to the three-dimensional expression of development in the city, manifesting in different building typologies. Detailed guidelines ensure that building forms are compatible with their context, for example encouraging party-walled developments versus standalone towers, or terraced houses versus bungalows.

**Pedestrian Network**
These refer to the network of pedestrian walkways which improves the walkability of an urban area. A comprehensive pedestrian network encourages seamless movement between transportation nodes, open spaces and points of interest.

**Open Space**
Open spaces provide spatial relief in the city and are important for the well-being of its inhabitants. Open spaces are usually comprehensively planned as a network of spaces in conjunction with pedestrian networks, through city-scale urban design plans such as the Parks and Waterbodies Plan.

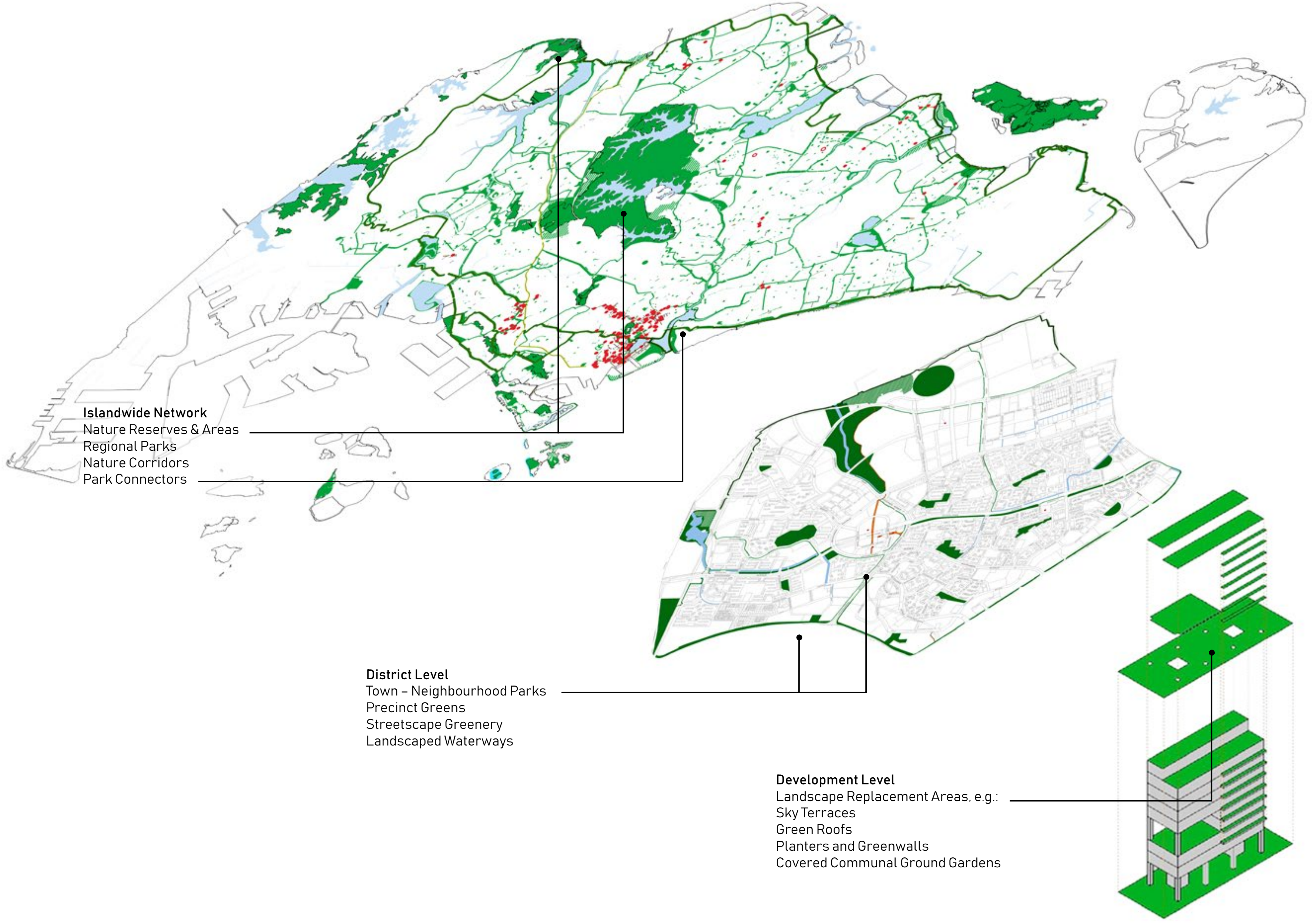
**Streetscape**
Streetscapes are important components of the public realm where people interact and experience the city. More than just residual space between buildings and vehicular roads, well-designed streetscapes have the potential to contribute to the vibrancy and walkability of urban areas.

**Nightlighting**
Nightlighting contributes to district vibrancy and supports a night economy for Singapore. It focuses on the management of the amount and quality of lighting on buildings and in public spaces, as well as prevention of glare and light pollution.

**Greenery**
Greenery became a key element of urban design when the idea of marrying greenery into the built environment was introduced through the Landscaping for Urban Spaces and High-rises (LUSH) programme, which required developments to replace

**Roofscape**
Roofs are considered to be the 'fifth' elevation of buildings that need to be designed to complement the overall building form, with the potential to contribute to district character. Increasingly, roof spaces are also encouraged to be designed as communal spaces for public enjoyment.

**Vehicular Access**
Vehicular access refers to the management of vehicular ingress/egress and service access points of developments to minimise disruptions to pedestrian movement and pedestrian-vehicular conflict, which are key strategies in shaping a more walkable and liveable city.






# How do we make the city green and liveable?

**Scales of Implementation**
By taking a systematic approach of creating greenery at different scales in the city, Singapore has managed to preserve and expand its area of green cover to 46.5%[1], one of the highest amongst comparable cities in the world.

At the macro level, major areas of greenery and biodiversity are set aside as Nature Reserves. They act as green lungs and provide ecosystem services like clean air and water. Next, parks and open spaces are created at different scales to serve as green relief and recreational spaces in the city. Park connectors and other green links are created to connect them together. Come 2030, every household will be within a 10-minute walk to a park[2].

Singapore's roadways are also a major contributor of greenery, with mandatory tree planting within the road space. Landscaping is also used to provide shade and shape the character of roads and streets. Waterways are carefully designed to achieve unique blending of green and blue outcomes.

At the development scale, Green Buffer planting around the boundary contributes to greenery provision. In addition, greenery is also incorporated into buildings in the form of Sky Terraces, Roof Gardens, Green Walls, etc, which were introduced via guidelines and incentives over the years. These policies were consolidated into LUSH (Landscaping for Urban Spaces and High Rises) in 2009, which also introduced mandatory landscape replacement requirements.

**Quality and Sustainability**
Singapore's Green and Blue assets are also managed as integrated systems to be self-sustaining and resilient. This is also referred to as an urban systems approach.

To ensure that the Nature Reserves can function as healthy repositories of biodiversity gene pools, nature corridors are also identified between them to allow for ecological connectivity with surrounding habitats. Nature Parks are also established around them to buffer from developments and human activity.

Nature Ways are being implemented along our roads to facilitate movements of birds and butterflies between habitats. These strategies help strengthen Singapore's overall ecological resilience and biodiversity value.

To tackle the challenges of climate change, Singapore is beefing up its network of parks and open spaces to enhance cooling of the city, with wind corridors introduced in major development areas to facilitate passive cooling of buildings and public spaces.

Agencies and developers are adopting biophilic design approaches, to plan and design townships and buildings that integrate with nature. For example, bioswales and rain gardens help with storm water management, while bird sanctuaries and butterfly gardens help with habitat creation, among others.

At the scale of individual developments, skyrise greenery is also being harnessed as a tool to cool ambient temperature, reduce stormwater runoff and filter air pollutants. Green Plot Ratio was introduced in LUSH to ensure higher density and quality of planting. URA also actively reviews landscaping proposals to ensure viability of plant growth and optimal layouts for public access to greenery.

These efforts ensure that there is quality, not just quantity, of green and blue assets in Singapore.

By taking an urban systems approach, Singapore's green and blue resources can be carefully managed to ensure that they enhance liveability and sustainability in the long run.

In this guidebook on shaping a Green and Liveable City, we delve into how greenery is created at various scales in the city, from the urban scale to development level, and explore the art and science behind how they are shaped to bring value to peoples' daily lives.

***1.0 Greenery at the urban scale***
*This first part of the book will look at how greenery is shaped and created at the macro-scale. From setting aside space for parks and open spaces to shaping the green and blue networks that connect them, with detailed look at streetscape greenery and waterway treatment.*

# 1.1

## PARKS & OPEN SPACES

Seen from the sky, parks and open spaces form a green tapestry in the urban fabric providing relief and breathing spaces for the city. They have been planned and created strategically around Singapore to ensure good accessibility for all.

*Why are they needed in the urban fabric?*

### 1.1.1: Enhance the liveability of the city

**General benefits for liveability**
Parks and open spaces are crucial in a highly urbanised city as they provide relief and enhance the well-being of its inhabitants. Interaction with greenery is proven by research to have cognitive and physiological benefits.

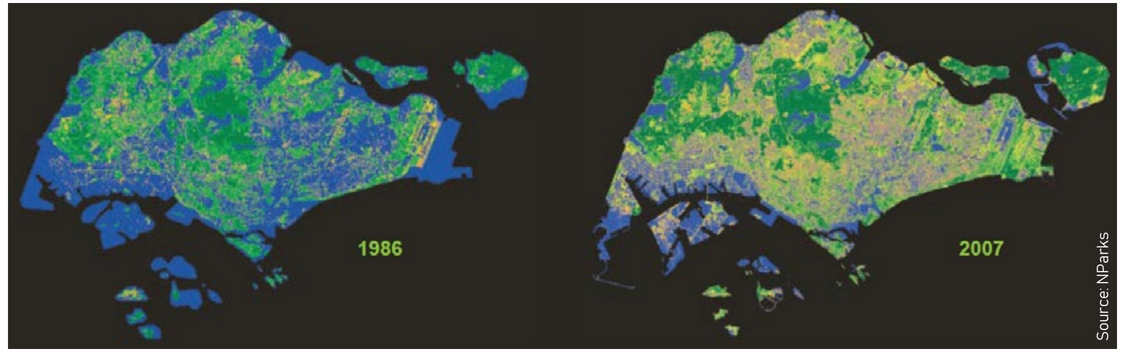
They act as gathering spaces in the city, for activities and chance encounters, and support community bonding. Social interaction is also important for the elderly to improve mobility and prevent cognitive decline.

They are also important for ambient heat regulation in the city. There is increasing evidence that even small pockets of greenery have cooling effects on their surroundings[3].
This makes them critical tools in the fight against climate change and urban heat island effects.

**The challenge of creating space for greenery**
Singapore has the challenge of fitting in the functions of a nation in an area typically suited to a small city (being ten times smaller than London), having to carve out space for ports, military bases, reservoirs in addition to space for working, living, learning and recreation without any hinterland. This makes setting aside land for greenery all the more challenging.

Yet, through careful planning, Singapore has managed to increase the amount of green cover in the city from 35.7% to 46.5% between 1986 to 2007[1].

This is done through comprehensive planning and careful design, beginning from when plans are first drawn up for new development areas to when planting is introduced and maintained in individual developments.



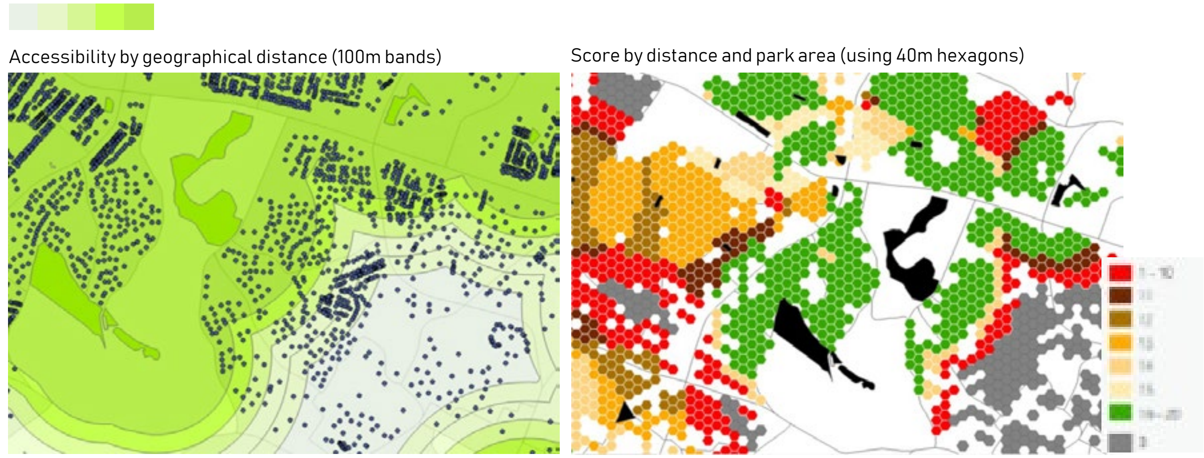
*How are parks and open space created in Singapore?*

## 1.1.2: Create park spaces 10 minutes from every household

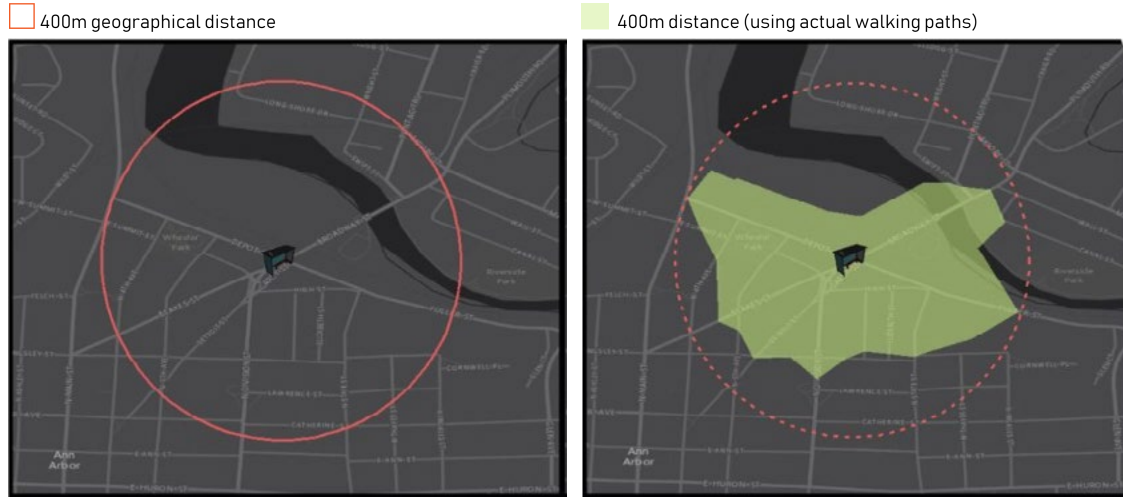
When developing new and existing areas of the city, parks and open spaces are located strategically within the urban fabric for good accessibility, ensuring they are well-distributed and within walking distance from every household.

On a macro level, URA's planners ensure there is good provision of park spaces islandwide, striving to set aside at least 0.8 hectares of green space (about the size of one Raffles Place Park) for every one thousand people by 2030.

Data analytics is used to establish the optimal level of coverage based on the size and proximity of parks around the island. A method known as Network Analysis is used to calculate proximity factors based on actual walking distances for more accurate results.




*Park coverage by Euclidean distance (left) and park score (distance + park area) (right)*

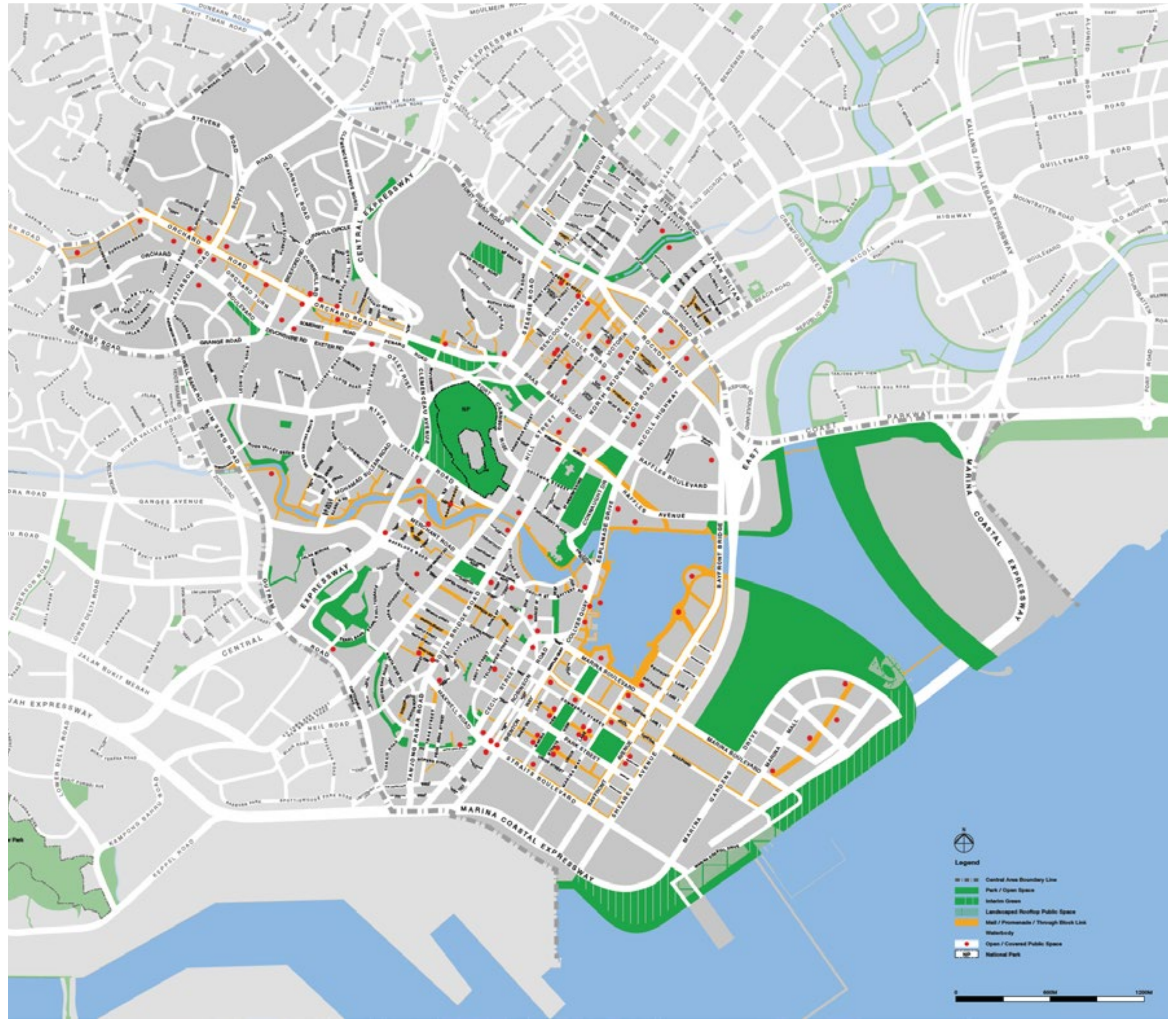



*Network Analysis using actual walking paths gives more accurate proximity assessment than using distance "as the crow flies"*

After assessing the existing context and spatial availability, the locations where new parks and open spaces are required are then stipulated in the Parks and Waterbodies plan, which is one of the Special and Detailed Control Plans of the Master Plan. This provides clarity and a framework for the realisation of these green spaces, by government agencies and developers.

As the main government land sales agent, URA guides the implementation of new parks and open spaces through tender requirements of Government Land Sale Sites.

Through its development control function, URA also provides guidance to land owners to realise new parks and open spaces as part of major redevelopment proposals.



*The Parks and Waterbodies plan – green areas and red dots denote existing and planned parks and public spaces respectively*

## 1.1.3: Ensure a variety of park typologies

To meet the diversity of recreational and social needs of the city, URA and NParks have developed a hierarchy of parks that perform a variety of functions to serve the city at different scales, from regional parks to compact city parks and neighborhood greens.

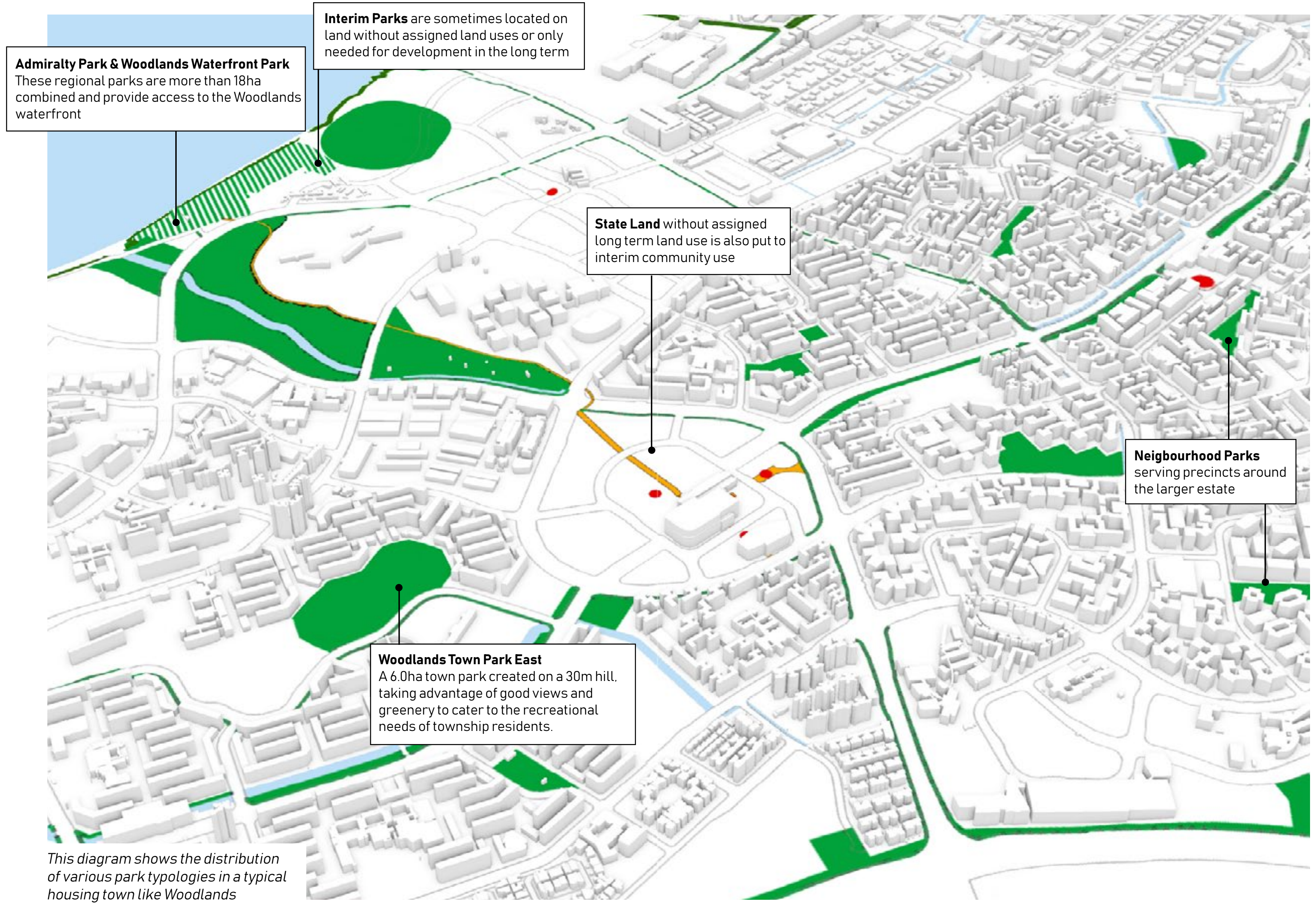

*Regional Parks*
*At the larger end of the spectrum, regional parks serve the major regions of the island. Their wide range of facilities help provide for recreational needs at a national level*

*Town Parks*
*Next, major parks are created to serve residents at the town level, e.g. Toa Payoh Town Park, Jurong Park, Pasir Ris Town Park, Ang Mo Kio Town Garden West.*


*Neighbourhood Parks*
*Smaller community parks are provided in neighbourhoods and precincts, serving local communities*


*City Parks (found in Central Area)*
*City parks comprise a variety of green spaces found in the Central Area, some of which are historic, e.g. Fort Canning, or created to provide public spaces to serve new areas, e.g. Merlion Park*






*This diagram shows the distribution of various park typologies in a typical housing town like Woodlands*


**Gardens by the Bay**
*A series of three gardens spread over 101ha and three sides of Marina Channel to form the centrepiece of Marina Bay, giving it its "waterfront city in a garden" identity*

**Jurong Lake Gardens**
*90ha gardens set around Jurong Lake, with "destination islands" in a garden setting. The lake was formed by the damming of Sungei Jurong in the 60s*

## 1.1.4: Create memorable experiences and sense of place

URA's planners take advantage of geography, topography and the presence of water to create dramatic, memorable park spaces around the island. This approach also maximises the functional and aesthetic values of existing forests, hills and waterbodies in the city.

Major regional parks like Jurong Lake Gardens and Gardens by the Bay were created around newly created waterbodies in the city, while parks like the Southern Ridges were created by connecting the peaks of adjacent hills. Parks and publicly accessible Nature Areas have also been created around the Central Catchment Nature Reserve, to allow people to come close to lush rainforests with rich biodiversity.

Park planners and designers take cues from context and history to shape identity and create a "sense of place". Historic structures like gates, follies, fountains can be preserved, sometimes strategically relocated, to act as focal points in parks and open spaces.

Another technique in the urban designer's repertoire is the creation or protection of significant views and vistas that enhance the park experience. Framing views of landscape elements was a technique of 'picturesque' English gardens in the 1800s and widely employed in the Botanic Gardens [4].

Many other parks are formed around major view corridors in the city, such as Zhongshan Park – created to open up views of the Sun Yat Sen Memorial Hall from Balestier Road. The trees around Empress Lawn were relocated in 2015 to reestablish views from Anderson Bridge towards Victoria Theatre and Concert Hall.


**Esplanade Park**
*Created in 1922, this former sea fronting park is home to monuments such as the Cenotaph and Lim Bo Seng memorial. The Tan Kim Seng fountain was also relocated here in 1925 from Fullerton Square when the Fullerton Building was constructed*


**Telok Ayer Green**
*The 0.5ha pocket park sandwiched between shophouses has sculptures of a Chinese lantern procession and Indian milk trader to recall the history of Telok Ayer as the landing point for immigrants in the 1800s*

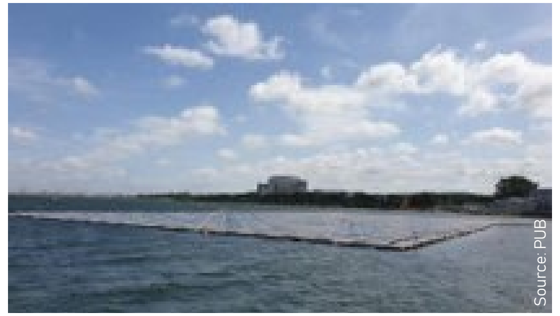
*View corridor across Empress Lawn towards Victoria Theatre and Concert Hall and Anderson Bridge*

*View corridor across Zhongshan Park to the Sun Yat Sen Nanyang Memorial Hall*

## 1.1.5: Take an integrated urban systems approach

URA takes an optimisation approach to planning, ensuring that even parks and open spaces are multi-functional in use. These large areas of greenery contribute to the healthy functioning of Singapore's urban systems like greenery, water and even energy.

*Bishan-AMK Park was redesigned with a floodplain in 2012 that has become a popular place to wade into a river and come close to flora and fauna*




*The 1.5MWp floating solar PV systems at Bedok Reservoir and Lower Seletar reservoir collectively generates enough energy to power 800 four-room HDB flats annually*

**Green urban system**
Large areas of greenery contribute ecosystem services like fresh air and clean water, sustaining the urban water cycle through evaporation and precipitation.

Singapore has set aside 4 Nature Reserves and 20 Nature Areas, which protect our core biodiversity.

By making them accessible with trails and observation points, park visitors can learn about unique indigenous ecosystems (like lowland dipterocarp forests, freshwater swamps, sea grass meadows, etc) and find respite from the city – discovering jungles and swamps in the heart of Singapore.

**Water urban system**
Parks and open spaces can play a role in urban hydrology, combining infrastructure like detention ponds and pumping stations with recreational uses, through clever design.

For example, Marina Barrage was designed with a roof garden that concealed a pumping station below, and has become a popular spot for kite flying and watching fireworks at Marina Bay.

**Energy urban system**
Today, even reservoirs are being fitted with floating photovoltaic cells to generate energy.

Floating solar PV systems perform better than a typical rooftop solar PV system in Singapore, primarily due to the cooler temperatures of the reservoir environment. Additionally, the solar panels, being out in the open waters, do not experience shade from any nearby buildings or structures, which further enhances their ability to maximise solar energy generation.



### *CONCEPTS EXPLAINED*

## *How do parks and open spaces cool down the city?*

Scientific research has shown that green spaces and vegetation help to cool the city through the process of evapotranspiration: trees and plants consume heat during photosynthesis, and provide cooling when water evaporates from their surfaces.

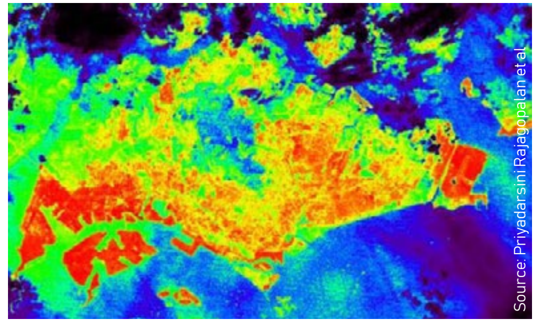
Research from Richards, Fung, Belcher and Edwards (2020) [5], on the "Differential air temperature cooling performance of urban vegetation types in the tropics", showed that green areas had a measurable cooling effect in the city, with secondary forest having the greatest cooling effect while increasing the cover of managed trees also significantly reduced temperatures.

A NUS study in 2006 by Chen, Wong, on the "Thermal Benefits of City Parks" [6] studied Clementi Woods and Bukit Batok Nature Park, and suggested that up to a 1.3 degrees cooling effect can be measured within a 50m cooling radius of the park.

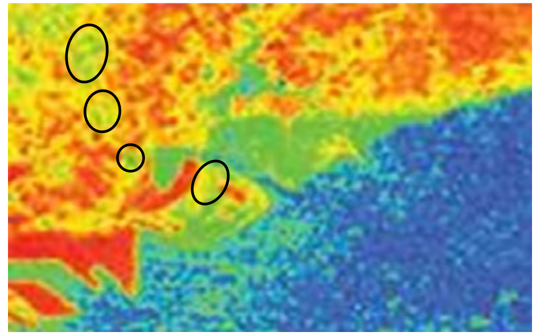
Green spaces in the city also combat urban heat island (UHI) effects, by reducing the amount of urban surfaces that trap heat during the day. In 2006, research by Asst Prof Winston Chow and Prof Matthias Roth from NUS reported that UHI in Singapore can be as high as 7 degrees Celsius [7].

Reports emerged in 2019 from the Meteorological Service Singapore that Singapore has been heating up twice as fast as the rest of the world, at 0.25 degrees celsius per decade [8]. With high humidity levels, such temperature increases can cause heat-related body stress and affect liveability in the city.

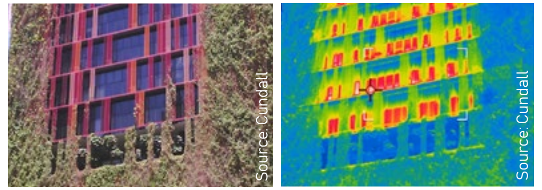
This makes our efforts to provide green spaces around Singapore even more critical as we combat climate change.




*Urban heat island map of Singapore*



*Cooler patches of green are observed around park bodies like Fort Canning Hill and Gardens by the Bay (circled)*




*This infra-red heat mapping of Oasia Hotel Downtown reveals the cooling effect of green surfaces*


*CASE STUDY*

# The parks and open spaces network at Marina Bay

***City Rooms***
City Rooms are sheltered public spaces within developments, or Privately-owned Public Spaces (POPS). They may be excluded from GFA computation under the POPS scheme if they are large enough – at least 1sqm for every 50sqm of total development GFA, or 25% of the building footprint, whichever is lower.

Find out more about the POPS guidelines at this link.

Parks and open spaces are not planned as standalone features in the city, but often integrated into larger green and blue networks that help to maximise people's encounters with nature in their daily lives.

The various green spaces of Marina Bay are no exception, comprising major public greens and intimate "city rooms" within developments, linked together by a convenient network of walkways, pedestrian malls, through block links and cycling paths, to ensure easy accessibility for residents and workers in Marina Bay.

**The Gardens by the Bay**
At the heart of Marina Bay lies the 101ha Gardens by the Bay, sprawling over three sides of the Marina Channel. This park was configured to take advantage of generous waterfront spaces as well as create extensive park frontages for the developments around the district.

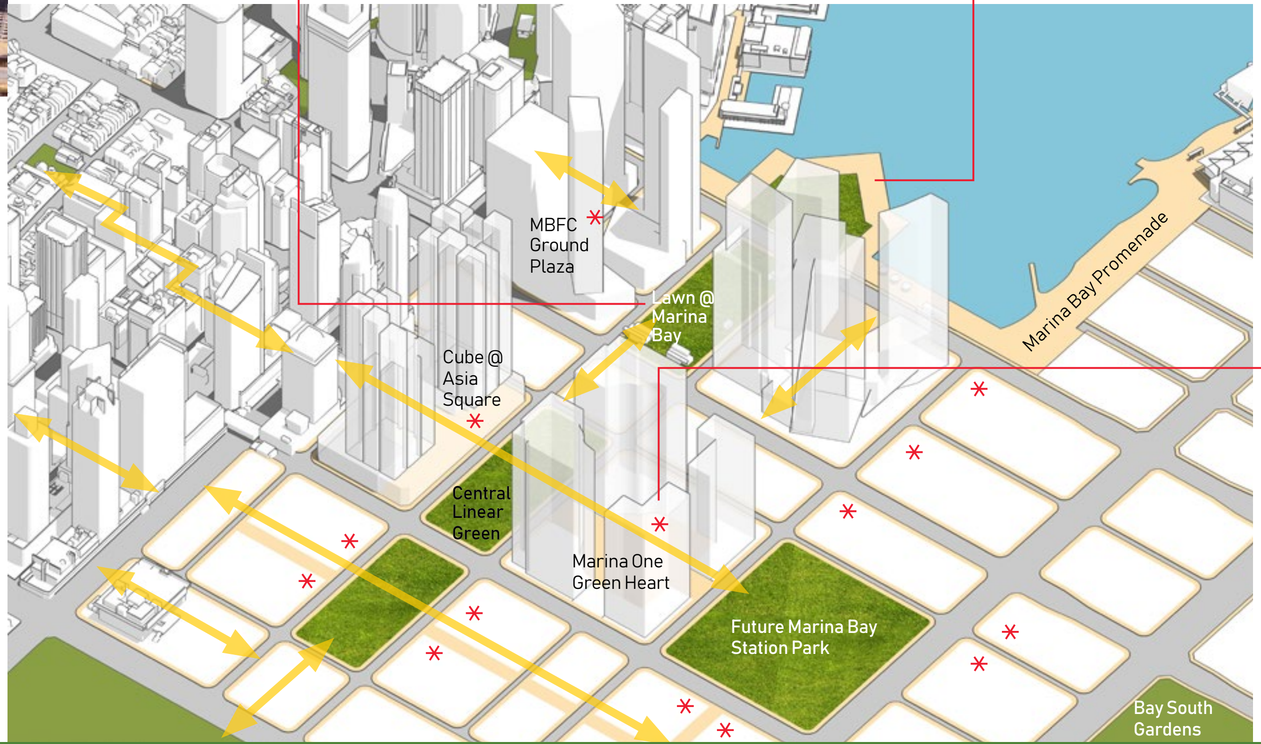
The Bay South Gardens were completed in 2012 after a Design Competition that attracted 70 entries from 170 firms from 24 countries. The Bay East Gardens will host the Founders' Memorial targeted to be completed in 2027.



**The Lawn@Marina Bay**
The Lawn is a linear open space extending inland from the promontory, about 140m in length and 50m wide, with commanding views of the bay. It accommodates up to 3,000 people and is popular for concerts and events such as the Prudential Marina Bay Carnival.

**The Promontory**
A promontory extends out into Marina Bay as part of the necklace of attractions along the waterfront. It was originally conceptualised as part of I M Pei's masterplan for a pair of landmark towers in Marina Bay in the 1980s. The 1.6ha space is one of the many attractions around the bay and is used in the interim as a site for events and festivals.

**Getting the private sector involved**
Developers play a part in building up the green and open space network. Within land parcels sold under the Government Land Sales programme, URA has included requirements for developers to create "city-rooms" as an extension of the public space network, where people can gather and enjoy activities.




**Green Heart - Marina One**
The Marina One development has created a "green valley" in response to the "city-room" requirement. The lushly planted green open space terraces resemble cascading paddy fields or a green tornado depending on how some visitors describe it.

The developer was also guided to create a pedestrian mall connecting the city-rooms towards the Central Linear Park and future Marina Bay Station Park through the building.

Utilising a network of open and sheltered walkways, through-block links and pedestrian malls, URA ensures that the parks and open spaces of districts like Marina Bay are well-connected as a network.

# Shaping the Gardens by the Bay

**Focus on greenery from the beginning**
The Gardens by the Bay were the culmination of plans to make Marina Bay a one-of-a-kind "Waterfront City in a Garden", starting from studies by Kenzo Tange and I M Pei in the 1980s.

Reclamation of Marina Bay began in 1971 and masterplan studies for the reclaimed area began shortly after. In 1981, URA commissioned Kenzo Tange and I M Pei to explore development concepts for Marina Bay. They each proposed different reclamation profiles and masterplan concepts as part of their studies.

I M Pei's plan for a grid-like urban structure was eventually adopted. His plan emphasized the provision of greenery, proposed a large city park in the Marina South area and created a continuous waterfront promenade around the bay.

**A waterfront city in a garden**
Around the turn of the millennium, cities around the world began undertaking major regeneration projects to compete for investors, talent and visitors. To set Singapore apart from the competition, URA and the agencies positioned Marina Bay as a one-of-a-kind "Waterfront City in a Garden", capitalising on the tropical climate and waterfront setting of the area.

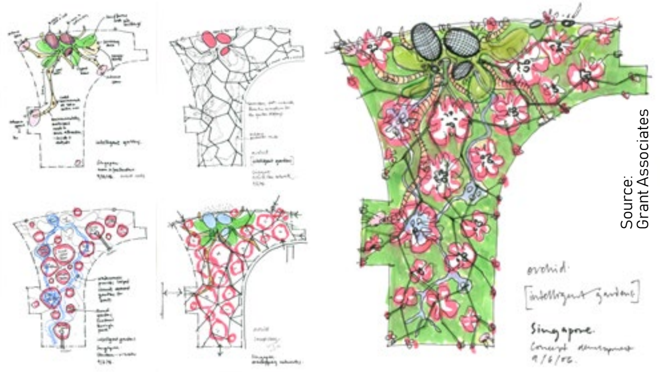
The decision was taken to set aside 101ha of land for the gardens, a massive investment in greenery to allow the gardens to compete in scale with Central Park in New York City and Hyde Park in London. The gardens and waterfronts helped extend a sense of 'islandness' to the core of the city centre, where people could live, work and play near the water, surrounded by lush greenery.

**Design competition**
An international design competition was organised in 2006 to generate ideas for a world class gardens.

Grant Associate's winning design for Bay South Gardens was inspired by the geometry of the orchid. They focused on creating a Supertree grove at the heart of the Gardens, which would rise 25-50m to break the flatness of the site.

The Supertrees instantly became iconic additions to the Marina Bay skyline, transforming nightly as part of an exuberant light show. They functioned as vertical gardens (with more than 200 plant species embedded in the structure) as well as pipes to purge hot air from the conservatories.


*Masterplans for Marina Bay: left by I M Pei and right by Kenzo Tange*



Source: Grant Associates

*Design sketches for Bay South Gardens*



**Sustainability at the heart of the gardens**
In line with the vision for Marina Bay to be sustainable and liveable, the carbon emissions from cooling the buildings within the Gardens aimed to not exceed those of typical office buildings in Singapore.

To achieve this, the conservatories and gardens were designed to share energy and water processes symbiotically. Hot air from the conservatories is purged through the Supertrees to drive ventilation and create breezes at ground level, while rainwater is collected throughout the gardens to irrigate the conservatory.

Biomass is collected and burnt to create power, supplemented by solar energy in the Supertrees which help power the nightly light shows.

Find out more about the sustainability initiatives in Gardens by the Bay – articulated by the environmental and sustainable design consultant, Atelier Ten here.

**Integrating developments with the gardens**
Located between the gardens and the Singapore Straits, a precinct called Marina South is being developed as an attractive urban mixed-use residential neighbourhood with pleasant walking streets. The pedestrian network will connect seamlessly with the gardens through elevated links, while shaded walkways and cycling paths will enable residents to get around easily.

The first developments will soon rise at Marina South. New buildings shall be oriented and stepped in height to create wind corridors and maximise views of the gardens. Buildings will be required to provide sky terraces, roof gardens and communal planters in line with the LUSH policy ("Landscaping for Urban Spaces and Highrises" – a topic which will be covered later in this book). This will ensure that the greenery of the gardens extends visually and physically into the precinct.

*Planned Marina South District next to Bay South Gardens*

BEHIND THE SCENES

# Assembling the puzzle of green spaces at Marina Bay

*Linda Lui and Andrew David Fassam oversaw the planning and urban design of Marina Bay during the early 2000s. They share more on the planning and urban design considerations that took place behind the scenes.*

**What led to the decision to set aside a large tract of land for a waterfront park right in the heart of Marina Bay?**

**Andrew:** The decision to set aside almost 101 hectares of prime waterfront reclaimed land for the Gardens by the Bay was a bold one, considering that the prime downtown area could have been easily assigned for development of premium apartments and office buildings instead. This decision was not taken lightly, and was carefully studied and evaluated by the agencies and ministries.

In the early 2000s, extensive studies were carried out with NParks on the optimum scale and configuration for the gardens, that would meet the ambition to create a world class green space while balancing development outcomes for Marina Bay.

There were a number of options that were explored and the process involved a lot of iteration as we layered in the sometimes conflicting considerations into the final outcome.

*Greenery and open spaces set aside in Marina Bay*

**What were some of the key considerations in the shaping of the Gardens?**

**Andrew:** The intention was to take advantage of the water body at Marina Channel to create multiple waterfronts for the Gardens, hence they were laid out over three parts of the coastline around Marina Bay, from Marina South, Central to East. The waterfront would allow visitors to observe aquatic activities along Marina Channel.

The Bay South Gardens, at 54 hectares, was also centrally located within the Marina South precinct to maximise the potential enhancement to surrounding land uses, which could enjoy views of the gardens on one side, and major waterbodies on the other.

Overall, the gardens retained a predominantly east-west alignment to maximise solar insolation for plant growth, and minimise over-shadowing from surrounding high-rise buildings.

The plans for the gardens also took into consideration the former Marina City Park, building on it and extending towards the then upcoming Marina Barrage in a sweeping 'fan shape', creating the a characteristic curve to Marina Gardens Drive.

The Marina Barrage and Pumping Station was also being designed at this time. With guidance from the URA team and the Design Advisory Panel, the design team developed the roof above the pumping station as an accessible landscaped public space which formed a seamless extension of the adjacent gardens.



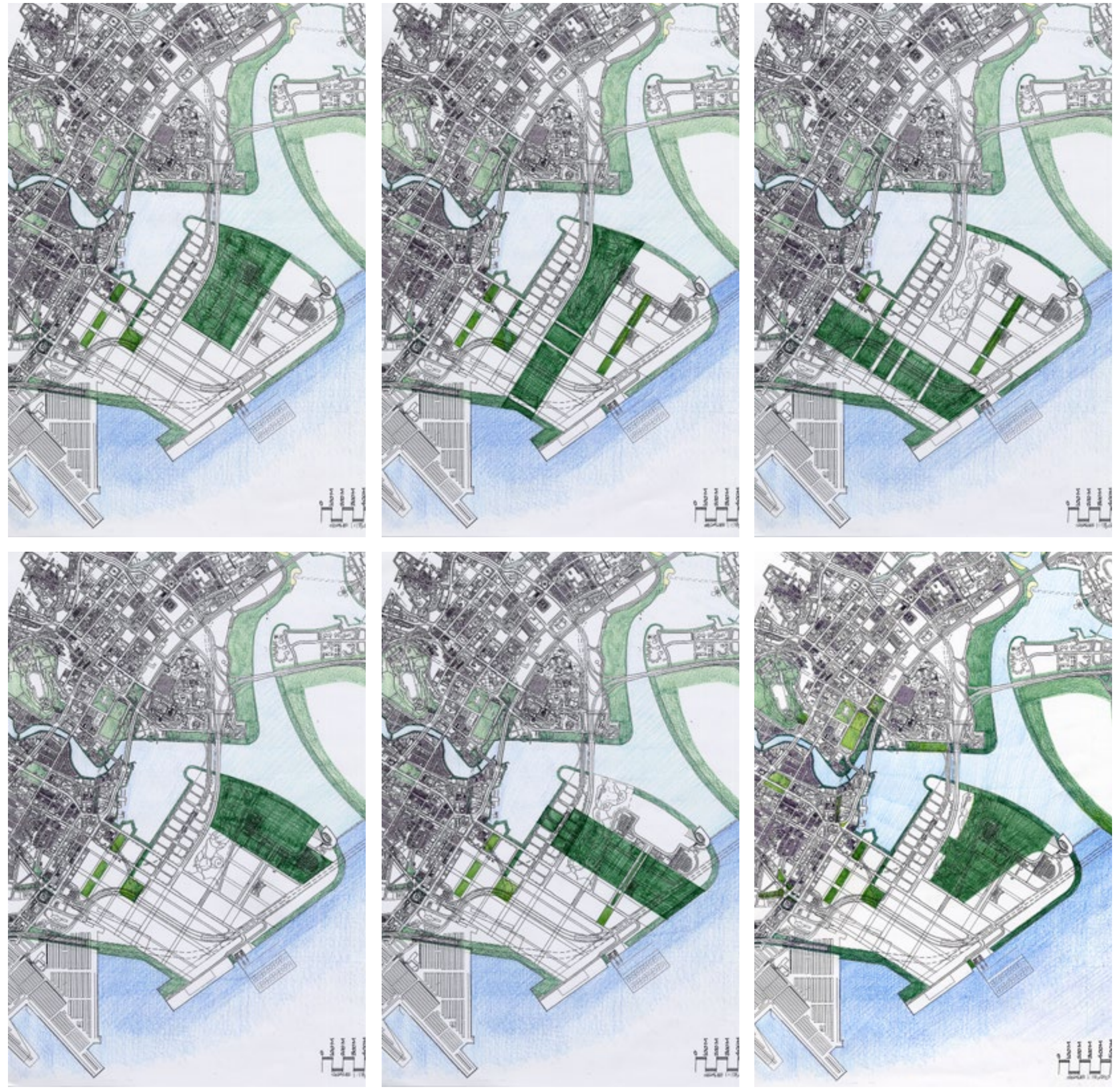
All these design moves were carefully staged and calibrated to ensure that various pieces of the Marina Bay puzzle would come together to form a coherent whole, orchestrating a blending of green and blue at the heart of URA's plans.

**Then Minister Mentor Lee Kuan Yew was very involved in the plans and development of Marina Bay. What guidance did he give to the team in shaping the Marina Bay we know today?**

**Linda:** It is widely publicised that Mr Lee Kuan Yew was responsible for challenging the government agencies to dam up the Marina Channel and create Marina Reservoir. This has had a pivotal part in the place making of Marina Bay as it resulted in the phasing out of the ferry and lighter activities at Collyer Quay and allowed for the bay to be not just converted into a freshwater reservoir, but into a recreational space that has been used for water-based activities such as sailing, dragon boat festivals, F1 powerboat races, firework display and light and water shows.

The phasing out of the former activities at Collyer Quay also allowed for the injection of new public fronting uses that have opened up access to this part of the waterfront and allowed for the completion of the waterfront pedestrian promenade around the entire Bay.

The longer version of this interview can be found at this link.

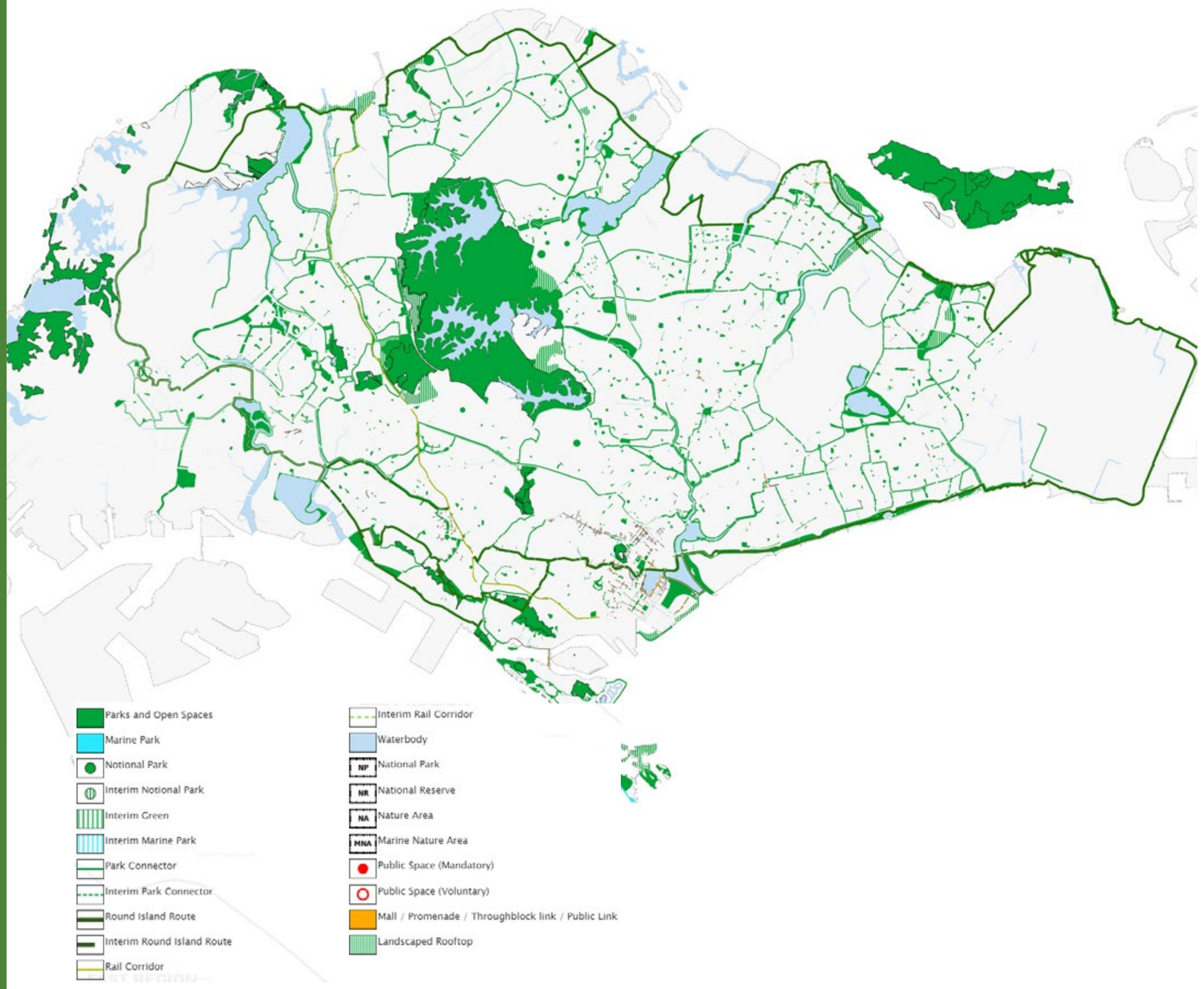


*Configurations of the Gardens by the Bay, in relation to other green spaces in Marina Bay, that were studied by URA and NParks (sketches from 2004)*

# 1.2

## GREEN & BLUE NETWORKS

Over the years, URA has coordinated the linking of up park connectors, greenways, waterfront promenades and bridges to create extensive green and blue networks that bring people closer to nature and recreation in a small urbanised island. This is coordinated through the Parks and Waterbodies Plan which was first introduced as the "Green and Blue Plan" in the 1991 Concept Plan.




### *Why are green and blue networks needed in a city?*

### 1.2.1: Create an integrated, larger sense of nature

Green and blue networks refer to walking and cycling infrastructure built up to connect parks and waterbodies around the city, making them accessible to people and part of daily lives.

Given its limited land, Singapore lacks large areas of uninterrupted greenery. These networks connect individual green and blue spaces together to help create a larger sense of contiguous and immersive nature.

People usually have to travel far out of the city to enjoy walking trails, hikes and long distance cycling experiences. With well-planned and immersive networks, these experiences can be created within the city and enjoyed by more people.



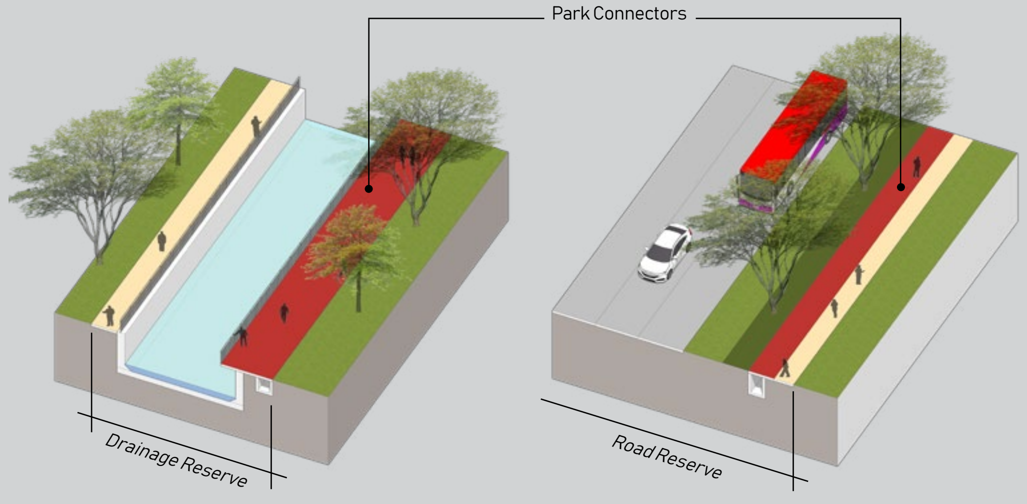
### *How did these networks first come about?*

The main challenge to realising green and blue networks is finding space in the city for connectors and pathways. They can be planned upfront in new development areas, but existing built-up areas often lack available land.

To find space for such connections, government agencies are repurposing existing infrastructure like drains and spaces under viaducts, which are linear spaces that are too narrow for other uses, to build these connections.

This approach to double up infrastructure for recreational use began in the 1980s, when the Drainage department first provided jogging paths over drains. This led to the creation of the Park Connector Network.

To extend the experience of lush greenery along the Park Connector Network, a strategy of "borrowing greenery" from adjoining land is also used, by placing walking and cycling paths next to planted areas like green buffers and peripheral planting strips within developments.




*Walking and cycling paths are often integrated into the Drainage Reserve to optimise land that cannot be used for other purposes*

*Likewise, walking and cycling paths are often stacked on top of road side drains within the Road Reserve*

*Promenades (yellow) and greenways (green)*

## 1.2.2: Connect people to nature and recreation spaces effectively

The main priority of green and blue networks is to connect people to nature, providing convenience and choice.

These networks comprise walking and cycling paths and are sometimes planned on a separate system from roads. They are also lushly planted so that they form seamless extensions of the parks they connect to.

The Parks and Waterbodies Plan (PWB) maps out existing and planned green and blue spaces islandwide, and the connections between them. There are three main types of connections in the PWB plan.

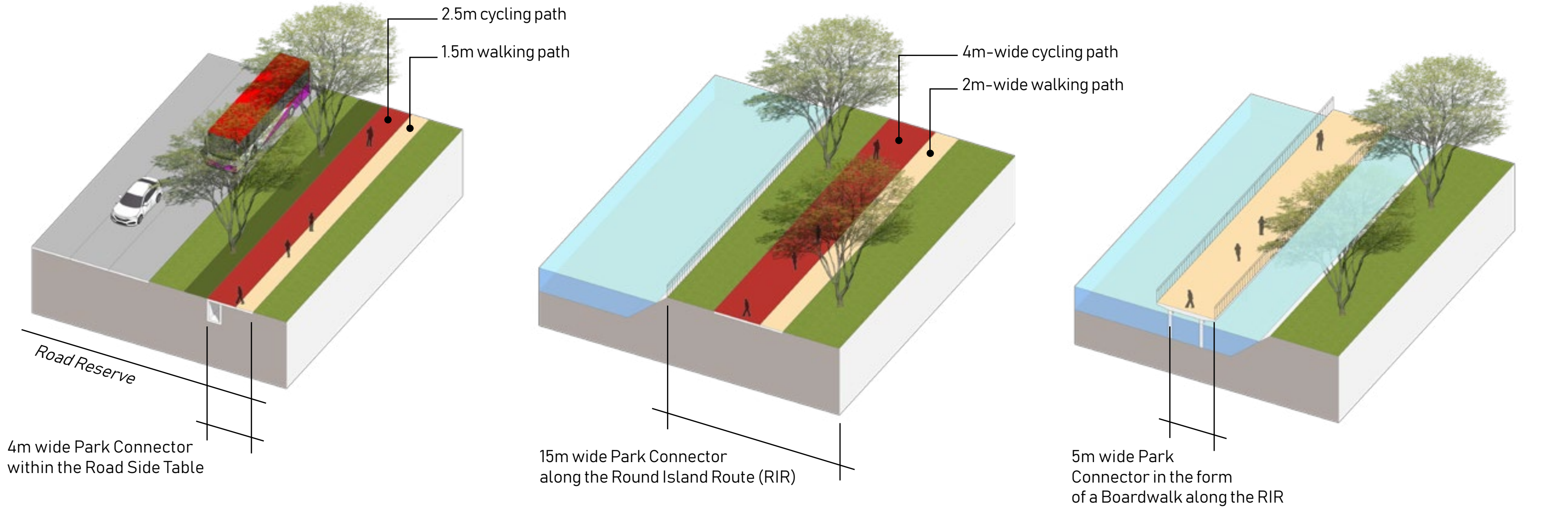
**Types of connections**
Green lines in the PWB plan represent park connectors, comprising shared paths for walking and cycling.

Wider green lines represent various types of greenways or green corridors, usually linear parks managed by NParks or green fingers running through public housing developments or private developments.

Yellow lines represent malls or promenades in various settings, such as pedestrian malls cutting through development parcels or along linear urban features like boulevards or waterways.

**Implementation framework**
The Parks and Waterbodies Plan provides clear direction and an implementation framework for connections:

- Within privately owned land, land owners are required to realise parts of the walking and cycling network as shown in the plan when they undertake major development works.
- Within State Land, URA coordinates with the agencies to implement the network.
- Connections are sometimes realised within the drainage reserve overseen by PUB, or under park land managed by NParks. Linear strips of park zoning on the Master Plan reflect this arrangement.




***How should connections be designed?***

## 1.2.3: Optimise land and beautify infrastructure

The PWB plan maps out existing and planned walking and cycling paths in 2D. The challenge sometimes lies in realising these links on the ground as there is often need to integrate connections into infrastructure like drains and canals, to create seamless connections across different settings and even topography.

With creative and sensitive design, some of these utilitarian connections can also be turned into scenic green and blue spaces.

**Park Connectors**
Park Connectors are represented by green lines in the PWB Plan. The standard typology for a park connector is a 4m section comprising a 2.5m wide shared walking / cycling path and 1.5m planting space.

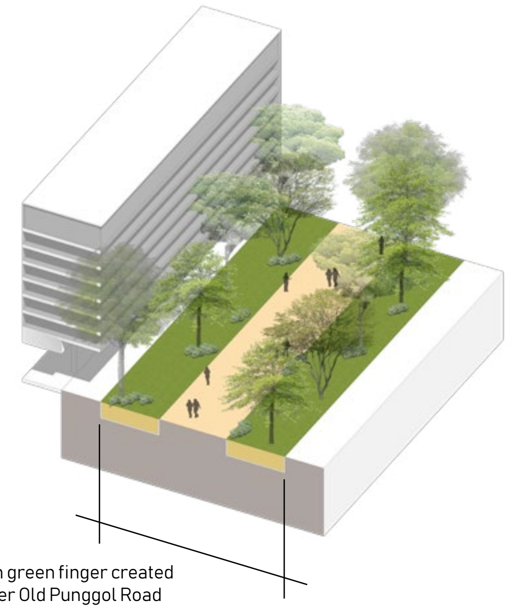
Within the roadside table, drains are decked over to create space for the PCN, while greenery is borrowed from planting within adjacent developments for a lusher outcome.

Within the Drainage Reserve, PCN can be created from space carved out of the sides of drains and canals. Under the Active Beautiful Clean (ABC) Waters programme, some of these canals are naturalised and landscaped to resemble rivers.

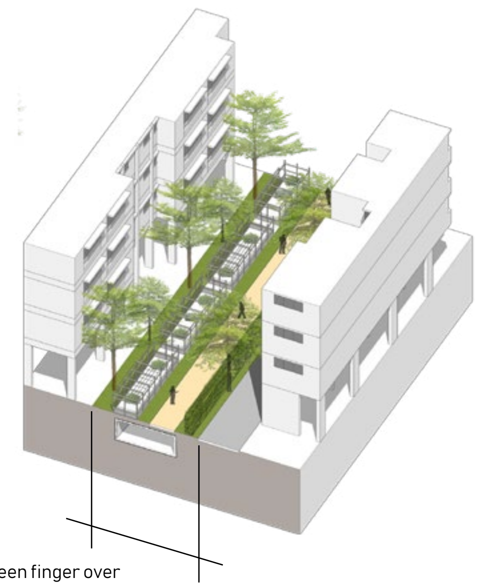
In more generous settings, like coastal sections of the Round Island Route, the walking and cycling paths can be separated and more generous planting space provided.

***Walking and Cycling Path Standards***
A set of design guidelines has been published to guide the development of walking and cycling paths around Singapore. For example, intra-town cycling paths are required to be at least 2.0m wide, while Inter-town cycling paths have to be at least 2.5m wide.

Find out more about the design standards at this link.



6m green finger created
over Old Punggol Road
(former roadway)

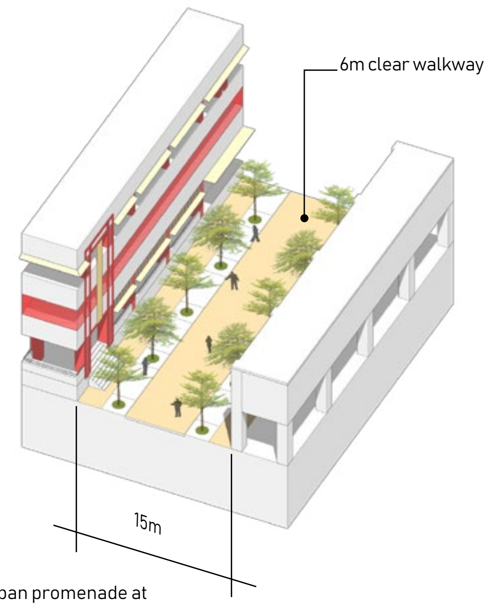


4m green finger over
existing drainage reserve
at Haig Walk

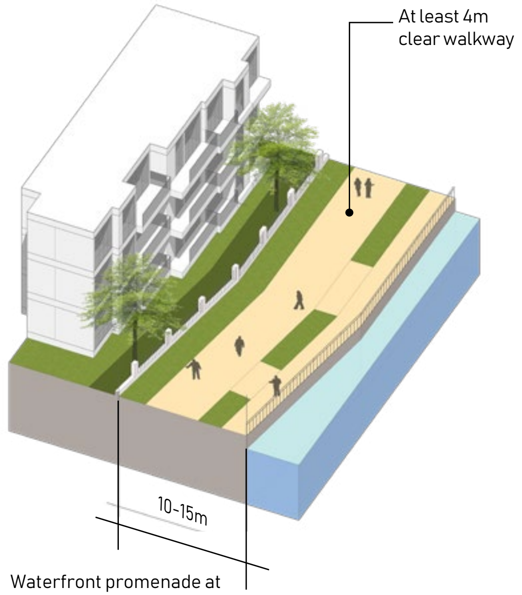
**Greenways**
Greenways are represented as thicker green lines on the PWB Plan. Greenways are either created as **linear parks** or as **green fingers** cutting through developments (not zoned as park but maintained as green spaces).

Linear parks are often created along natural features like waterways (e.g. Kallang River) or created to form larger green networks (e.g. Bidadari). Sometimes they are created out of former transport infrastructure like railways (Rail Corridor) and expunged roads (Old Punggol Road).

**Green Fingers** are usually found running between public or private developments. Within public housing, they can be inserted into spaces between buildings. Within private developments, they are usually either carved out as green spaces and returned to the state for ownership and maintenance (a process known as vesting) or retained in private land but physically set aside as publicly accessible green space within the development.




Urban promenade at
Albert Mall, Bras Basah.Bugis



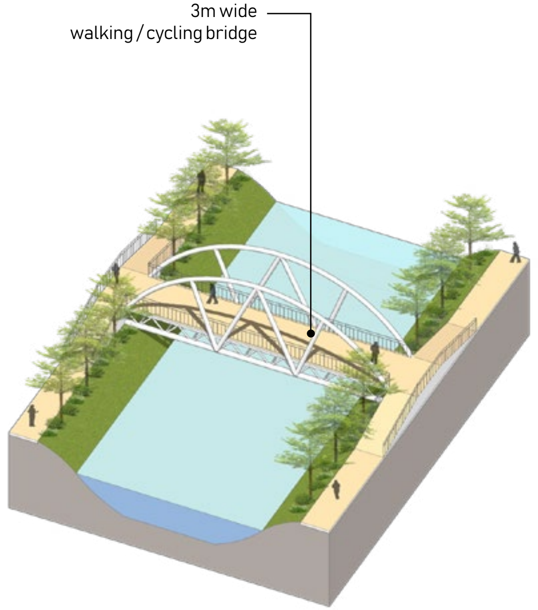

Waterfront promenade at
Keppel Bay

**Promenades**
Malls or promenades are represented as orange lines in the PWB Plan. Promenades can be found in urban corridors or along waterfronts, as popular spaces to gather and stroll.

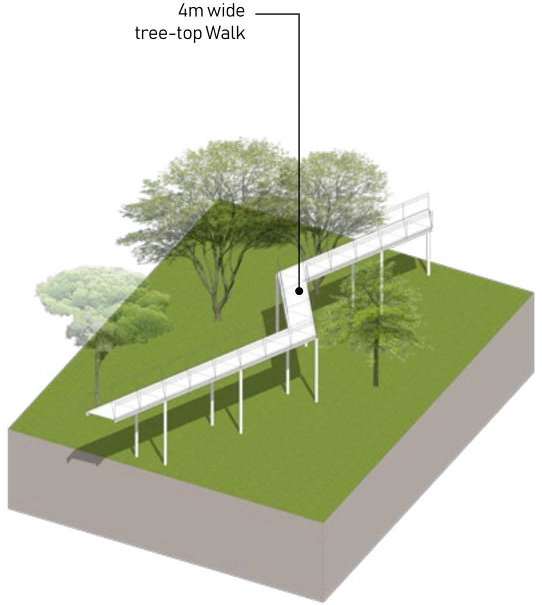
They usually range between 10m to 25m in width, to provide enough space for walking and cycling paths, planting and even seating areas and alfresco dining spaces.

Adjacent buildings are typically guided to provide human-scale and active frontages to frame promenade spaces sensitively, and provide vibrant street life. Pedestrian malls can be created by pedestrianising former roadss (e.g. Albert Mall) or carving land out of development parcels to be built as pedestrianised streets (e.g. One North).

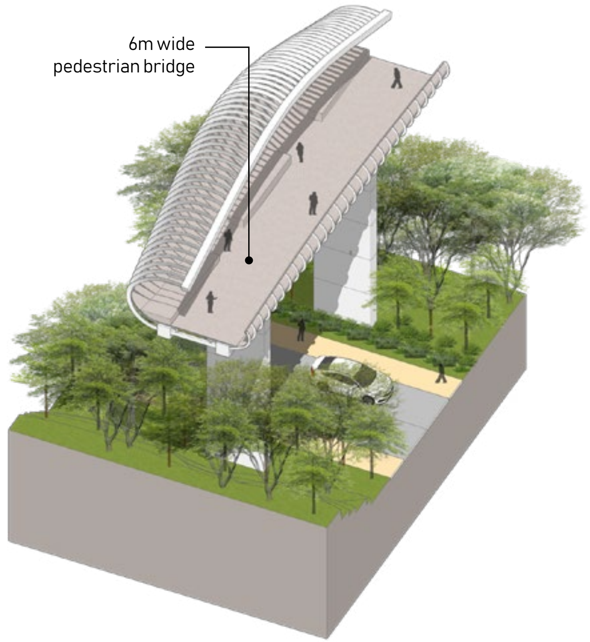
Waterfront promenades are usually created along popular waterways and waterbodies like Singapore River and Marina Bay, with the land zoned as open space or park land. They are also sometimes created by pedestrianising former riverfront roadways, or carved out of private developments under the Foreshores Act which requires part of waterfront land to remain publicly accessible, such as at Keppel Bay.




Bridge over Kallang River at Kolam Ayer




Bridge in the form of a tree-top walk at Southern Ridges




Bridge over roadway – Henderson Waves at Southern Ridges

**Bridges**
Bridges are used to create access across impassable features like rivers and highways, and sometimes mitigate level differences to reach locations like hilltop parks. They are represented either as green or orange lines crossing elements like roadways and waterbodies in the PWB plan.

They can provide enjoyable vantage points over the city and unique experiences, like tree-top walks.

For significant bridges, URA procures designs through competitions or consultancies to ensure attractive engineering and design solutions, such as the sculptural Alexandra Arch and Henderson Waves along the Southern Ridges, and the Helix Bridge around Marina Bay.



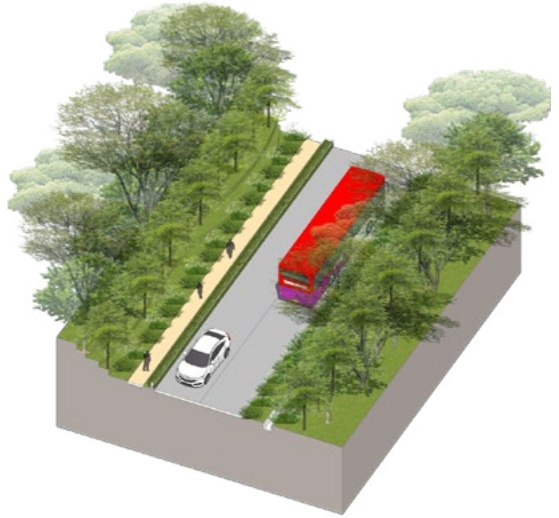
## 1.2.4: Support movement of flora and fauna between key biodiversity areas

From creating access to nature for people, green and blue networks are increasingly being planned and designed for biodiversity and ecological outcomes.

Park connectors and roadside greenery are being strengthened with Nature Way planting, to mimic natural forest structures and provide sources of food for wildlife.

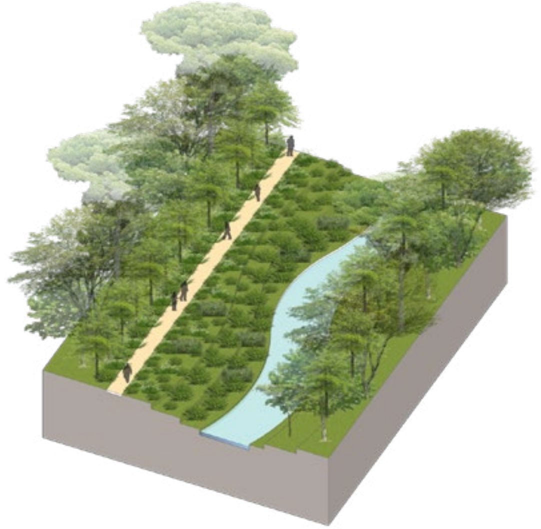
In 2015, a 62m long purpose-built bridge for wildlife, Eco-link@BKE, was built to connect the Bukit Timah and Central Catchment Nature Reserves over a six-lane highway. The first of its kind in Southeast Asia, the bridge facilitated wildlife movement between the nature reserves to expand their habitats and widen their gene pools[9].

In 2021, an islandwide Ecological Profiling Exercise was carried out by NParks to understand how our vegetated spaces act as refugia for biodiversity or ecological connectivity, strengthening nature conservation efforts by the agencies. One major outcome is the planned creation of the Clementi Nature Corridor, which connects Bukit Timah Nature Reserve and the Southern Ridges.



*Nature Ways created using road side planting designed to mimic natural forest structures and facilitate movement of insects and birds*

*Eco-link@BKE: a purpose-built bridge for wildlife moving between Nature Reserves at Bukit Timah*



*Clementi Nature Corridor: a vegetated corridor which enhances ecological connectivity*

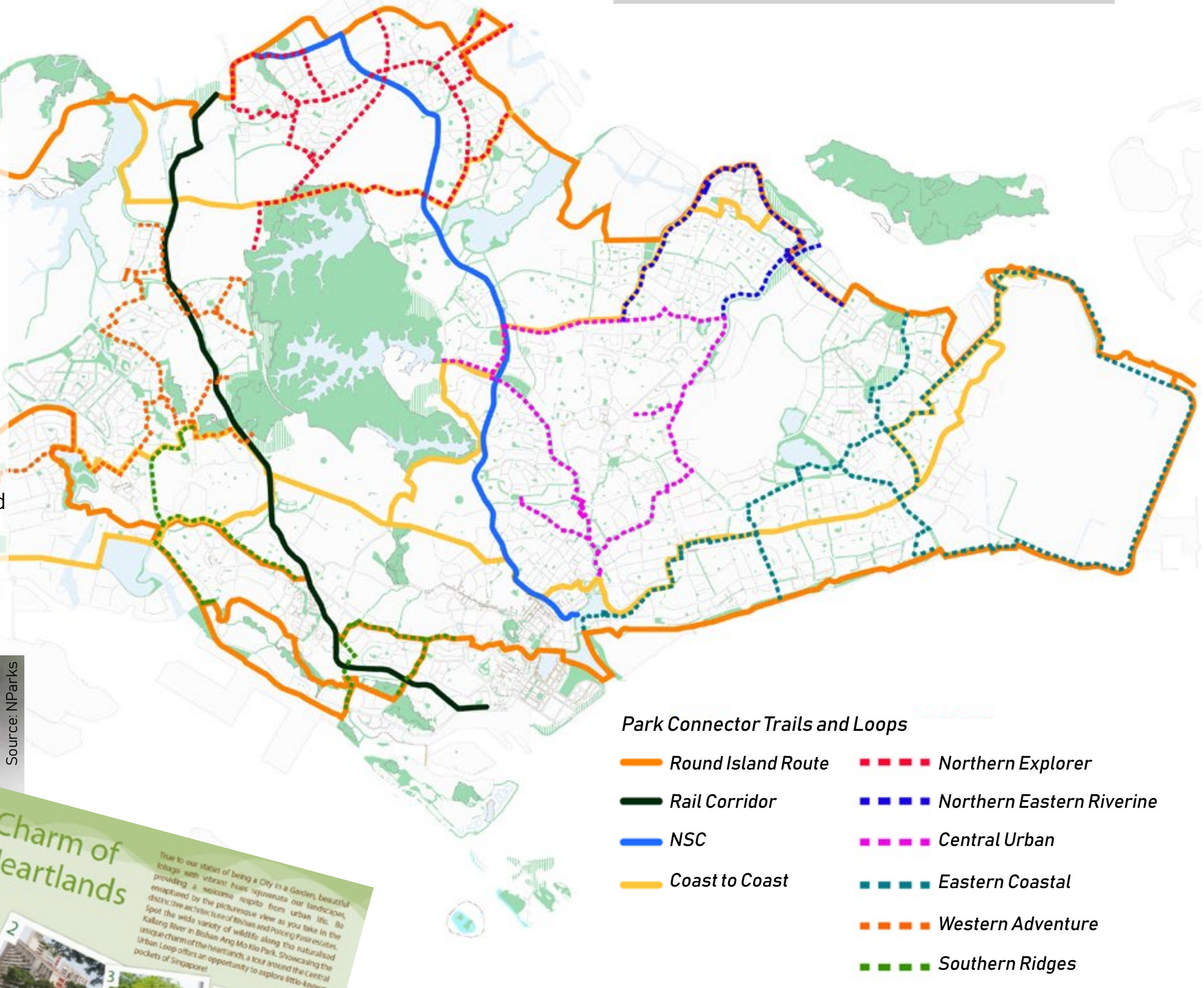
Find out more about the various routes and trails that form the national Park Connector Network, covering more than 370km of paths around Singapore at this link.

## 1.2.5: Tap on context and heritage to create clear positioning and identity

To help people make sense of the plethora of park connectors, greenways, promenades and bridges built up over time, themes and narratives are sometimes used to help differentiate parts of the network from each other.

For example, the more than 370km of park connectors criss-crossing the island are structured as six regional loops. Each has its own positioning and identity, such as the 36km long Central Urban Loop that showcases the charm of heartland towns at Bishan and Potong Pasir.

Additional notable routes include the "Round Island Route" and several "Coast to Coast Trails", which help to provide a sense of structure to the overall network.







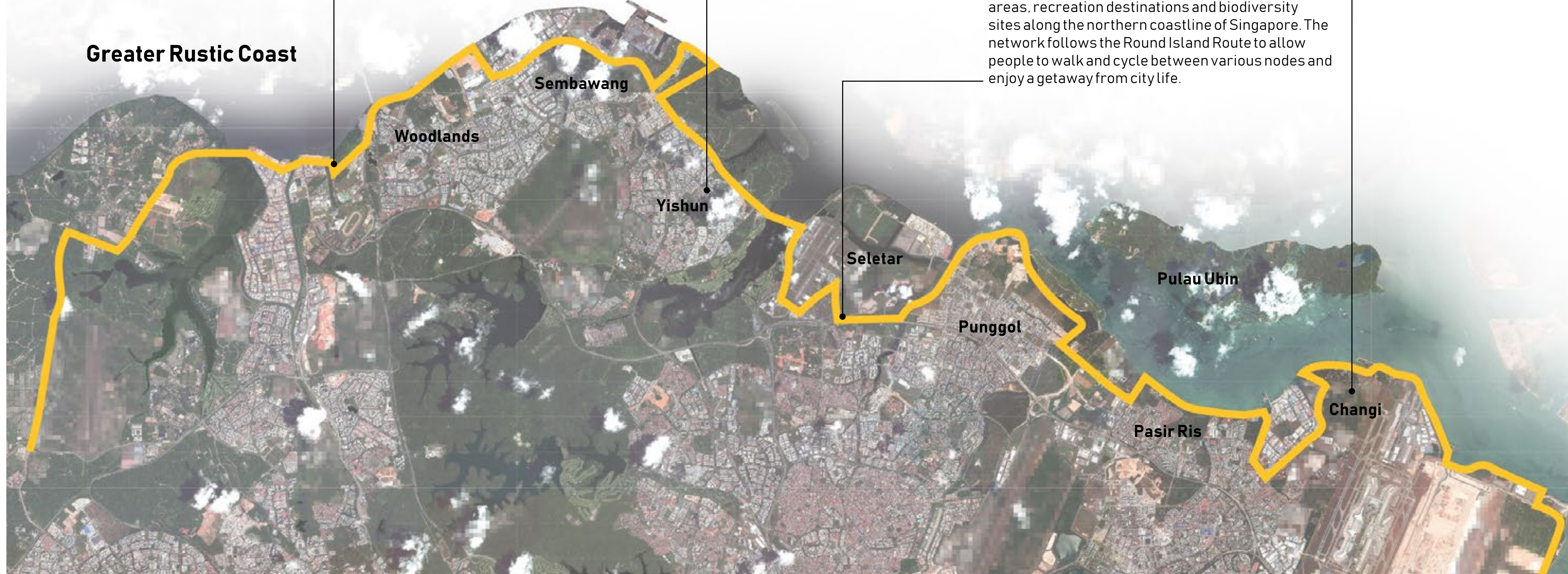
Mandai Mudflats


Sungei Khatib Bongsu

Jalan Kayu

Colonial bungalow at Changi Point

Tapping on history and heritage also helps to create identity for various networks. The 50km long Greater Rustic Coast was curated to create a journey through military and industrial heritage areas, recreation destinations and biodiversity sites along the northern coastline of Singapore. The network follows the Round Island Route to allow people to walk and cycle between various nodes and enjoy a getaway from city life.




Urban Design guidelines and other interventions can also be layered onto these networks to create or enhance a sense of place. For example, along the 6km long historic green connection from Botanic Gardens to the Singapore River, landscaping guidelines will be introduced to reinforce the sense of lush greenery, while road spaces will be reclaimed to create public spaces for people to enjoy.


*Artist impression of a possible nature playgarden on a pedestrianised segment of Orchard Road in future*



*Mid-level bridge connection: Alexandra Arch*

*High level bridge connection: Henderson Waves*

*Tree-top boardwalk: Forest Walk*

*CASE STUDY*

## The green and blue network of the Southern Ridges

**How the idea came about**

From as early as 1989, the idea of linking Mount Faber and Telok Blangah Parks was briefly explored, but it was only from the early 2000s that the idea for a network of interconnected parks along the Southern Ridges took shape. Extensive public consultation as part of the Concept Plan Review in 2001 revealed strong public support for URA's proposal.

Some of the key connections envisioned to realise the network were in the form of a high-level bridge across Henderson Road and a mid-level boardwalk across Alexandra Road. Together they would link up the existing network of trails across the hilltop parks into a 9km long system.

**Design competition**

A design competition was organised for the two bridges in November 2003, attracting 65 submissions. 2 schemes were selected for further development: "The Surface Bridge" by RSP Architects / IJP Corp for Henderson Crossing, and "The Mile-a-minute" bridge by LOOK Architects / ECAS-EJ Consultants for Alexandra.

URA worked with the teams to refine the engineering design of the bridges, selection of materials and lighting proposals. They looked at how the bridges could be constructed with minimal impact to the natural environment and remain easy to maintain in future.

Within the first two years of the Southern Ridges opening, more than a million people visited it.

"It is a rare contiguous recreational space in densely populated Singapore," said the Jury when the Southern Ridges was awarded the Urban Land Institute Global Awards for Excellence in 2010.

The bridges became popular photography spots thanks to their stunning views of the surrounding landscape, while the tree top walk and hilltop trails allowed people to come up close to the spectacular nature of the Southern Ridges, comprising colourful birds, majestic trees and flowering plants.


*The Southern Ridges route connects to nearby coastal walks, nature trails and park connectors to form a green and blue network for the area*



**Connecting the ridges to the coast**

After the completion of the Southern Ridges trail in 2008, URA conceptualised an extension of the network towards Labrador Nature Reserve and the Keppel waterfront, in the form of a 2.1km long Labrador Nature and Coastal Walk, weaving green and blue together as part of the overall network.

This extension was completed in January 2012, comprising a long park connector known as the Alexandra Garden Trail, a mangrove boardwalk called Berlayer Creek and a seaside walkway known as the Bukit Chermin Boardwalk. These provided a wide variety of coastal habitats to explore – mudflat, mangroves, coastal forest, rocky shore and Adinandra Belukar (a type of secondary forest).

To further connect the Southern Ridges towards Sentosa Island, the coastal walking network had to pass through several condominiums occupying waterfront land.

URA was able to secure public access through them under the provisions of the Foreshores Act, which was introduced in 1901 to govern the use of coastal areas defined by the high tidal water mark.

Amendments to the act in 1983 enabled URA to require developers to set aside their waterfronts for public access in the form of a pedestrian promenade. In this case, the developers and architects worked with URA to design the promenade with attractive walking space, seating and landscaping, to form a seamless extension of the coastal walking network.

In time to come, this coastal trail will seamlessly connect the Southern Ridges hilltops to Sentosa and the Greater Southern Waterfront.


*Publicly-accessible boardwalks through waterfront condominiums at Keppel Bay*

*The Bukit Chermin Boardwalk*


**Creating visual connections to water**
Connections to green and blue do not always imply physical walking or cycling links. Another way the Southern Ridges are connected to the waterbody at Keppel Bay is through view corridors established from key vantage points on the hill tops.

These view corridors protect views of the channel of water between Sentosa and the mainland, from Mount Faber. The heights of buildings along the waterfront are moderated so that the water channel is not blocked, without which the view of the island and the sea from the hill would be lost.

This is a subtle but important detail that allows visitors to continue to appreciate the unique geography around Sentosa and the Southern islands.

Today with advancement in simulation software, URA is able to map out views on a digital model to allow urban design guidelines to be even more specific and fine-tuned. View cone analysis can be carried out to accurately map out the visual impact of new developments along the waterfront.

*Digital model analysis of views from Mount Faber – cyan denotes parts of the water channel that are visible from the important vantage points around Mount Faber*

# Forming a necklace of gems at the Southern Ridges

*Teo Chong Yean joined URA as an architect in 2003 and was closely involved in many aspects of the Southern Ridges project. We take a behind the scenes look at the challenges faced as he and his team brought the plans to reality.*

**How does URA plan and achieve connectivity and linkages in the city, how did this lead to the conceptualisation of the Southern Ridges?**

Chong Yean: In planning and urban design, we take a macro view of the area to (re)discover and visualise the possibilities. The Southern Ridges has always been there. For a long time, we saw and treated the parks as separate gems and jewels. It was only when we took a step back and looked at a map from a broader perspective that we realised we could stitch the parks with bridges, elevated walkways, boardwalks and footpaths. The gems now form a necklace.

The necklace of parks at the Southern Ridges and the waterfront allow us to walk, jog and cycle in different natural environments – from manicured gardens to secondary forest, mangrove swamp, rocky beaches and deep harbour. The loop, which passes several transport nodes, allows us to plan a two-hour, half-day or full-day excursion, immersing ourselves in a circuit of nature.


*Map of the Southern Ridges showing the two hilltop bridges as drawn up by URA*

**What are some challenges in realising connections in the city, especially in built up areas where space is not available, or in the case of the Southern Ridges – linking up the various hilltop parks?**

Chong Yean: One of the most important consideration is the trade-offs that we need to make in terms of spatial provision – in the case for the Southern Ridges, how much greenery will we be affecting? When building the Forest Walk, we told the contractor that the construction access through the secondary forest on the slope was only the width of the elevated walkway and 500mm on both sides of the walkway. While the Architect had designed for the parts to be fabricated offsite and assembled onsite, the contractor must find ways to bring in the parts. To bring in the metal gratings, they assembled a 'flying fox' and sailed them down to slowly assemble them from the from the top. As a result, many large mature trees were kept intact.

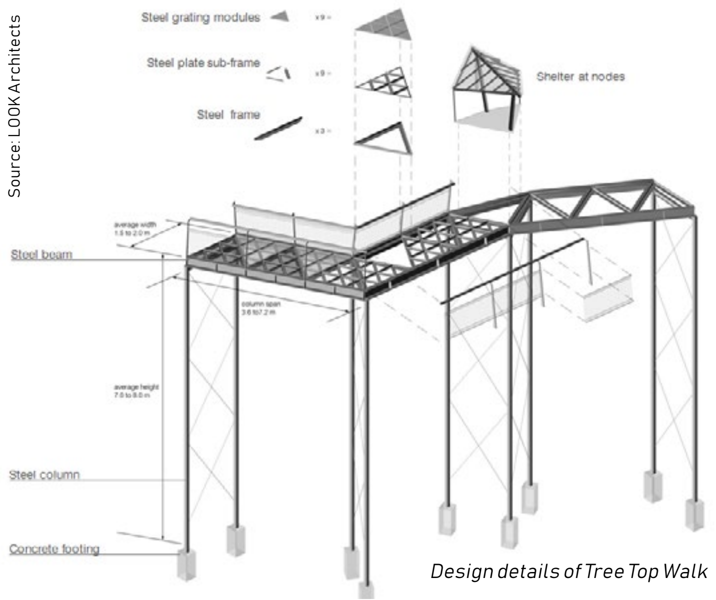
**Can you share any interesting experiences you had while working on the Southern Ridges?**

Chong Yean: 1 December 2007 was a memorable night. On that night, the longest segment of the Henderson Waves was lifted 36m above ground and placed in position over Henderson Road, completing the structure. The Contractor had earlier assembled the 55m long segment above the Henderson Road. The road was closed for this launching. The segment was lifted at the rate of 10m rate using hydraulic jack and four 180mm diameter steel cables – each capable of lifting 180 tonnes and was only used once.
It reached the top only at 6am on the following day. Watching the launch the entire time, the architect and myself cheered when we heard the contractor said it was in place.

The longer version of this interview can be found at this link.



Source: LOOK Architects




*Design details of Tree Top Walk*

Source: RSP Architects

*Simulations of Henderson Waves Crossing*

*Aerial photograph of Tree Top Walk*

Source: Patrick Bingham-Hall (photographer) & LOOK Architects

Streetscape planting can turn expressways into lushly landscaped corridors


# 1.3

## STREETSCAPE GREENERY

Streetscape greenery is pervasive in Singapore. It comprises trees and shrubs along almost every road across the island. Streetscape greenery is an important consideration in urban design, contributing to the success of street life and Singapore's image as a City in Nature.



*Why is streetscape greenery needed?*

### 1.3.1: Increase surface area for planting in Singapore

Given Singapore's limited land area, the doubling up of streets and roadways as planting space is key to maximising green coverage in the city for liveability outcomes.

In addition to increasing plantable areas for trees and other landscaping, they also help to enhance ecological connectivity across the island, supporting the movement of birds and insects between areas of biodiversity.

Streetscape greenery also softens the edges of the city, turning otherwise prosaic roadways into lushly landscaped corridors. They also keep streets shaded and cool enough for walking during the day, supporting street life and restoring nature into the urban fabric.

Streetscape greenery reinforces Singapore's image as a City in Nature and has become a key part of its tropical identity. The use of landscaping can also shape streetscape character, enhancing district identity for imageability and legibility of the urban fabric. This is done through comprehensive planning and careful design, beginning from when plans are first drawn up for new development areas to when planting is introduced and maintained in individual developments, such as the case with Marina Bay.

**When did streetside planting become a priority?**

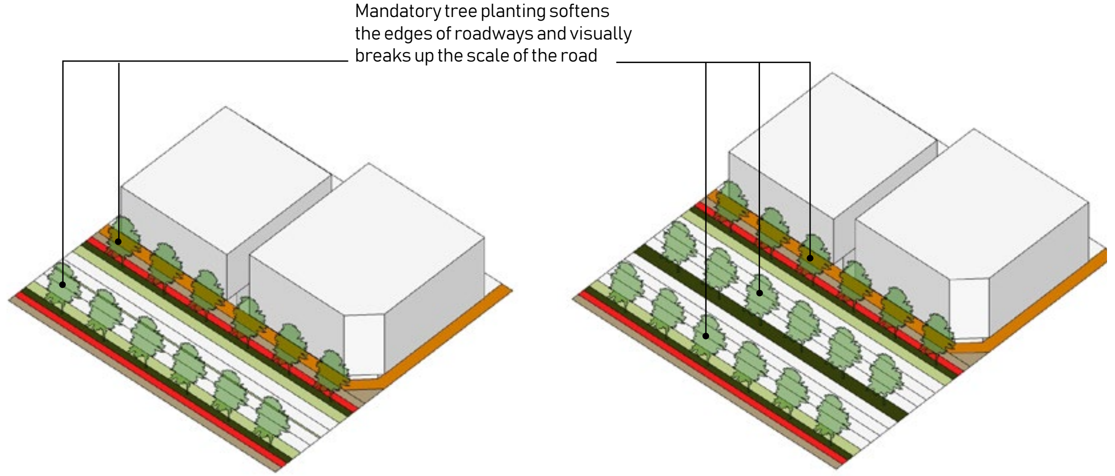
The sight of interlocking rain trees forming a green tunnel along the East Coast Parkway is usually a welcome sight for many Singaporeans and visitors returning from Changi Airport.

Efforts to green the city started since 1967 when then-Prime Minister Lee Kuan Yew initiated the Garden City campaign to help transform Singapore into a clean and green city to improve the well-being of Singaporeans and attract investors to the country [10].

A mere three years from the launch of the campaign, 55'000 trees were planted all over Singapore [11], primarily within newly-created parks and along roadways. Legislation such as the Trees and Plants Act was introduced in 1971 and road codes were developed to protect the newly planted trees around the island. Today there are over two million trees planted along roads, park connectors, parks and State Lands in Singapore [12].

**Guidelines on Greenery Provision and Tree Conservation for Developments**
NParks has published guidelines on the different types of greenery provision required along roadsides as well as within developments.

Find out more at this link.




*With lushly planted Central Medians, pedestrians on either side only visually perceive half the road*

### *How is streetscape greenery shaped under urban design?*

## 1.3.2: Create layers of greenery along streets and roadways

Layers of landscaping are integrated into Singapore's streetscapes under its codes governing road and development design. This is why tree-lined roads are so pervasive in the City in Nature.

The primary provision for streetscape greenery are green verges of minimum 2m width for tree planting lining the road carriageway within the Road Reserve.

Trees need sufficient space and soil depth to grow well – many people believe that tree roots mirror the shape of the tree crown, but in reality most roots spread out and extend no deeper than 2m.

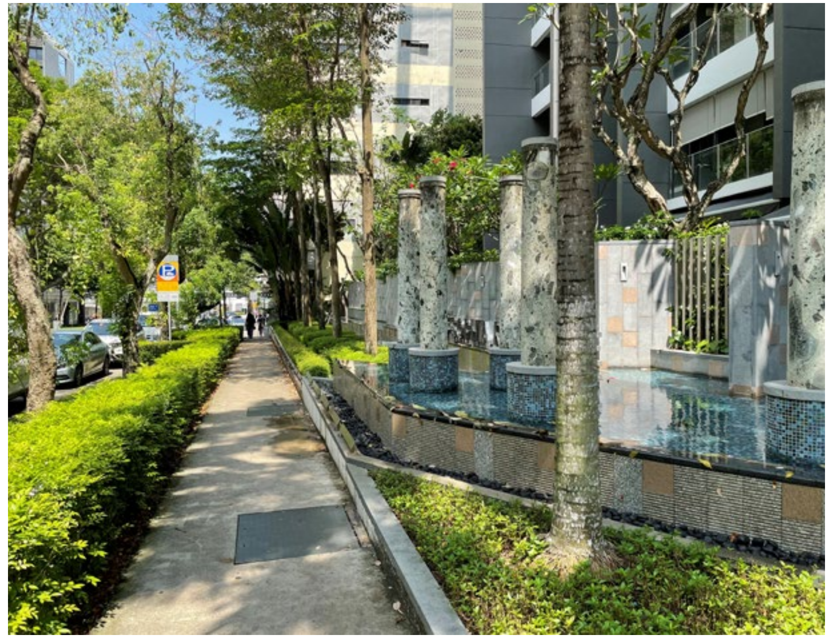
Wider multi-lane roads tend to have Centre Medians to divide traffic flow and can accommodate additional planting, which further soften the impact of the road by dividing it visually into half.

To augment tree planting within the Road Reserve, Green Buffers are provided along the sides of the development boundaries that front a public road. Green buffer requirements range from 3m for lower category roads to 10m for Heritage Roads with significant green character.

To enhance the visibility of Green Buffers from the street, URA would require boundary fences along some streets to be visually porous. Another strategy is to externalise Green Buffers by setting back the boundary fence behind the green buffer line.

In urban settings where there is more human traffic or activity along the street, Green Buffers may not be required under urban design guidelines to allow unimpeded movement of people between covered walkways in buildings.

*Example of Externalised Green Buffer at The Creek@Bukit*



*Example of Externalised Green Buffer at Sophia Residence*



*CONCEPTS EXPLAINED*

## *Why does URA sometimes ask for the Green Buffer to be "externalised"?*

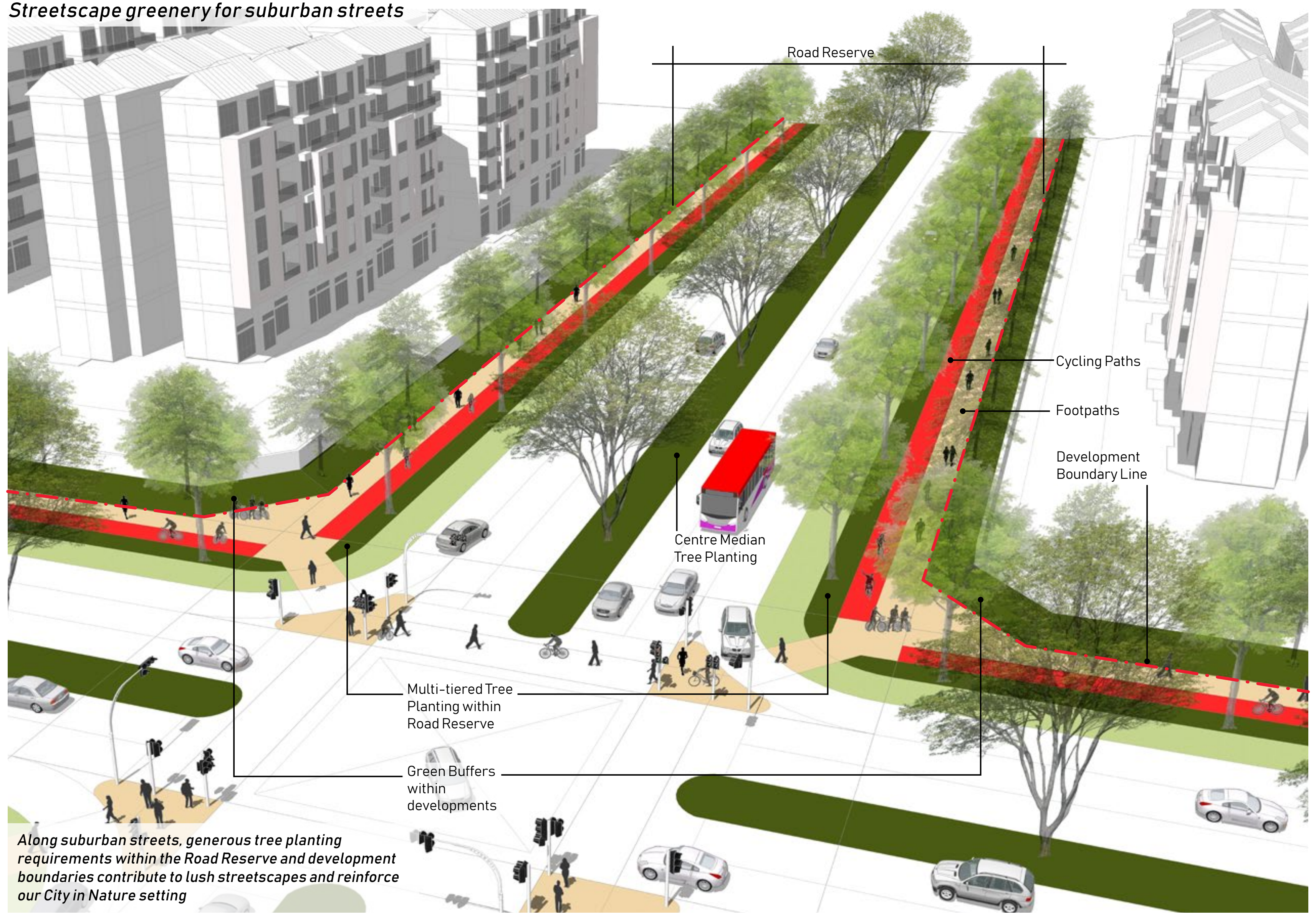
Around Singapore, NParks requires most developments to provide Green Buffers fronting public roads. This is a strip of planting area along the boundary line that serves as a vegetation buffer between the development and the road. It also helps to augment roadside greenery. The only types of developments exempted from this requirement are Landed Housing fronting Category 5 roads, or certain developments in urban design areas where urban streetscapes are desired, e.g. along Orchard Road.

Depending on the category of the road, the width of the green buffer will differ. Generally, the higher the road category (i.e. the more major the road), the wider the green buffer required. It ranges from 3.0m to 5.0m.

Where the development type tends to have boundary fences, e.g. residential condominiums, URA may sometimes guide the green buffer to be "externalised" – by setting back the boundary fence behind the green buffer. This allows the planting to directly contribute to the greenery along the street, and is only pursued in districts or streets where there is urban design intention for streetscape greenery to be augmented, e.g. Lentor Hills. There are also many examples of developments that have externalised their green buffers voluntarily, contributing lush planting and even water features along the streetscape for all to enjoy.

There are also many examples of developments that have externalised their green buffers voluntarily, contributing lush planting and even water features along the streetscape for all to enjoy.

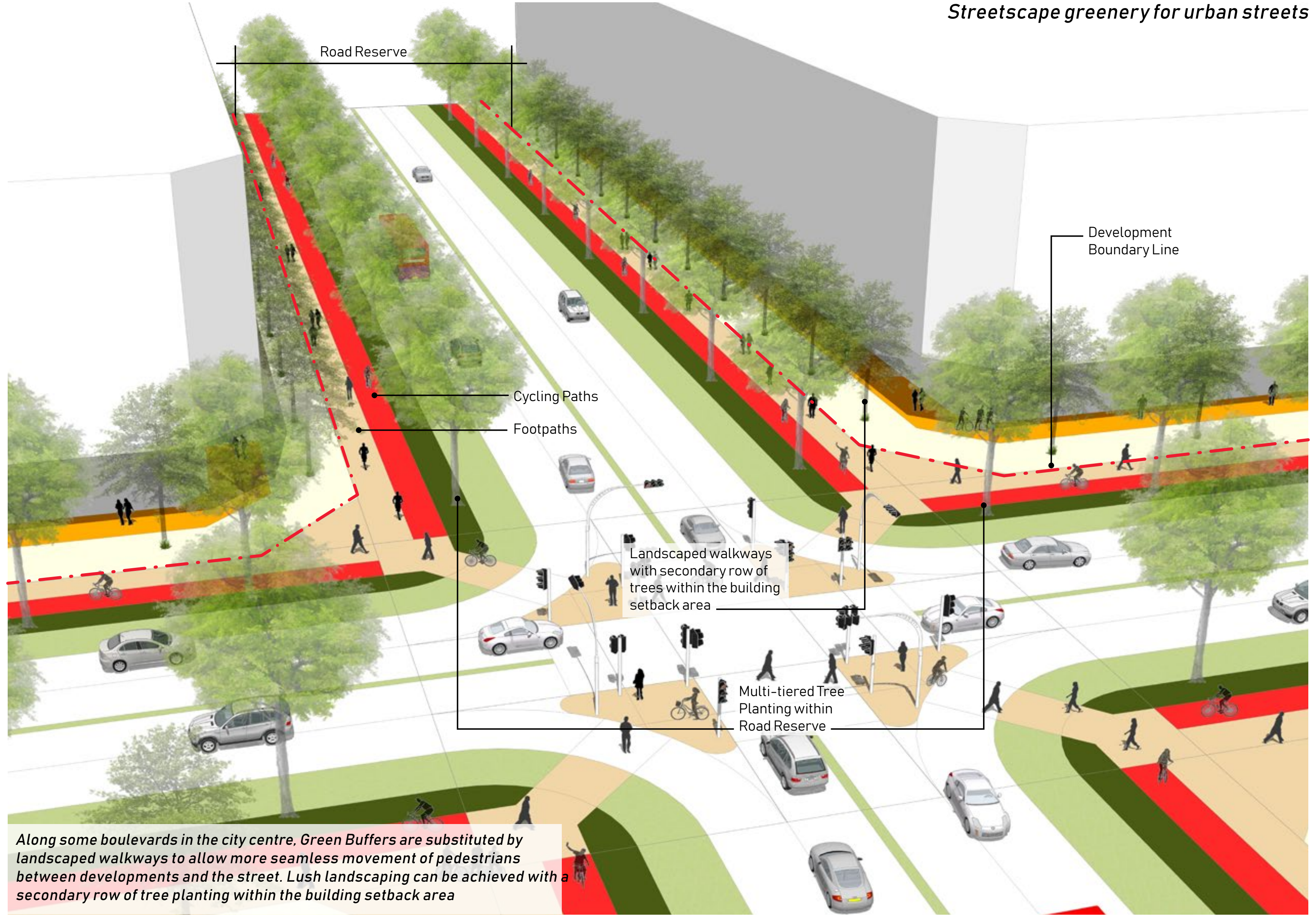
## *Streetscape greenery for suburban streets*




*Along suburban streets, generous tree planting requirements within the Road Reserve and development boundaries contribute to lush streetscapes and reinforce our City in Nature setting*

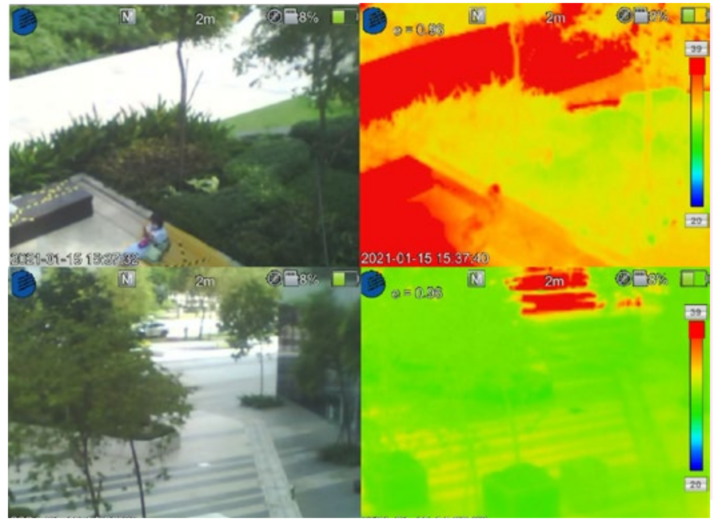


## *Streetscape greenery for urban streets*




*Along some boulevards in the city centre, Green Buffers are substituted by landscaped walkways to allow more seamless movement of pedestrians between developments and the street. Lush landscaping can be achieved with a secondary row of tree planting within the building setback area*


Spot readings demonstrate the cooling effect of the landscaping along Orchard Road



Thermal analysis shows that planting can lower temperatures by 8-9 degrees in unshaded areas (Paya Lebar Quarter – top row) and by 1-2 degrees in shaded areas (Fusionopolis – bottom row)

## 1.3.3: Maximise shade, create thermal comfort for pedestrians

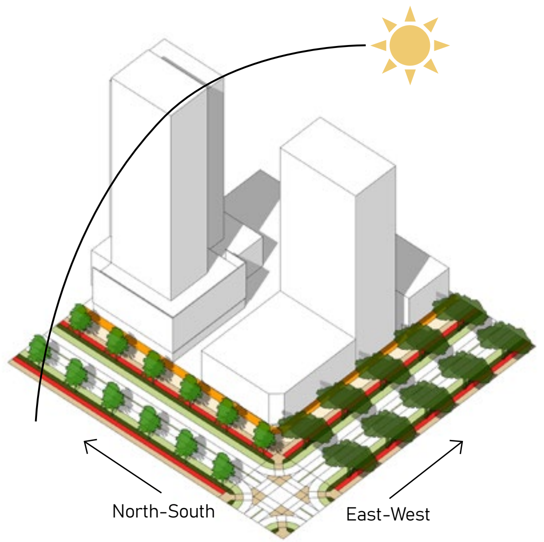
In Singapore's hot and humid climate, many people prefer the comfort of shopping malls and underground links to outdoor streets and public spaces.

Local research suggests that with humidity levels hovering above 80%, temperatures higher than 31.7 result in conditions outside the range of thermal comfort [14].

Under the afternoon sun however, exposed streets in Singapore can frequently measure 40 degrees and above.

Unlike cities in the northern or southern hemisphere, where buildings can permanently cast shade on sidewalks, the sun is usually overhead in Singapore, rendering building shadowing effects seasonal at best. Trees therefore form a central strategy in creating comfortable conditions for street life.



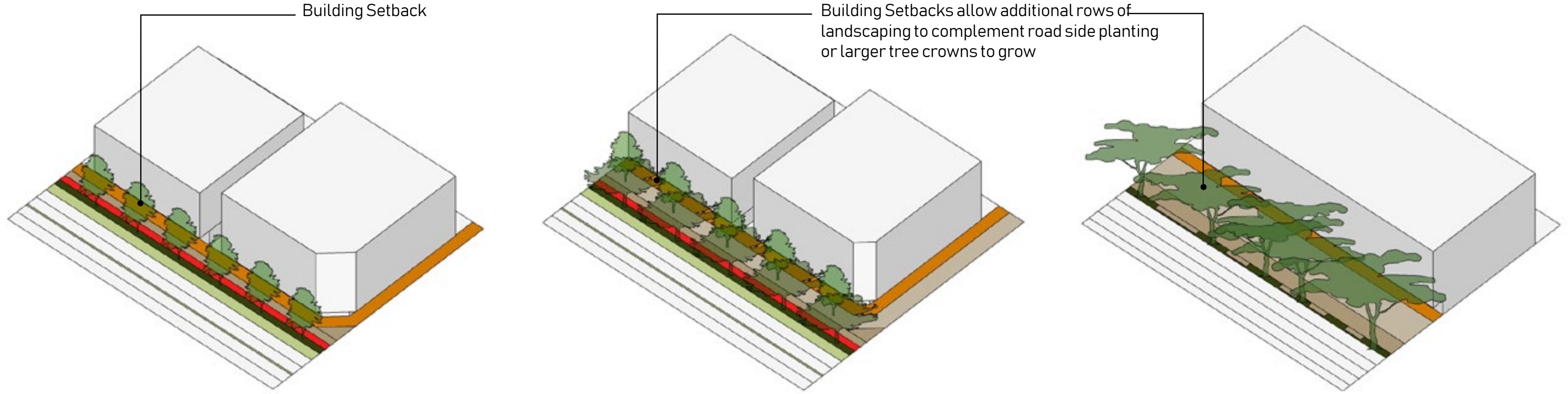



*Trees with wider crowns are usually planted along east-west streets to maximise shade for pedestrians*

**Maximising shade given climate and context**
With the objective to maximise shade, the types of trees planted are tailored based on the orientation of the street. East-west streets receive more solar exposure throughout the day, hence trees with wide-spreading canopies are frequently used. Trees with wide crowns are thus commonly deployed along major thoroughfares like Orchard Road (a predominantly E-W oriented road).

On the other hand, north-south oriented streets are better shaded by adjacent buildings as the sun moves east-west during the day, hence tree crowns with less spread are usually used to ensure that sufficient sunlight reaches the street for healthy plant growth.

The choice of tree planting also depends on the availability of space for the tree crown to spread. When buildings are built up to the Road Reserve Line, the facades are usually only 3-5m away from the trees planted along the road, this limits the choice of trees to those with narrower crowns. Wider setbacks allow trees with larger crowns to be used, or another row of landscaping to be introduced.



## 1.3.4: Create unique character using shapes, colour and smells

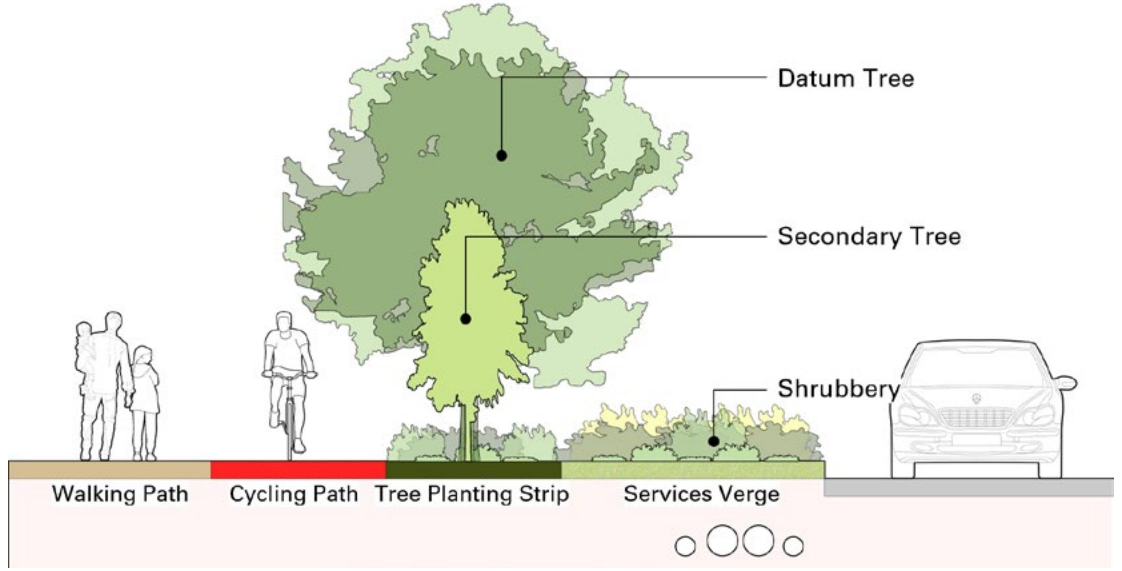
Streetscape greenery is often used to create a sense of place and identity for streets and corridors, which helps to create structure for the city, define its districts and shape memorable experiences.

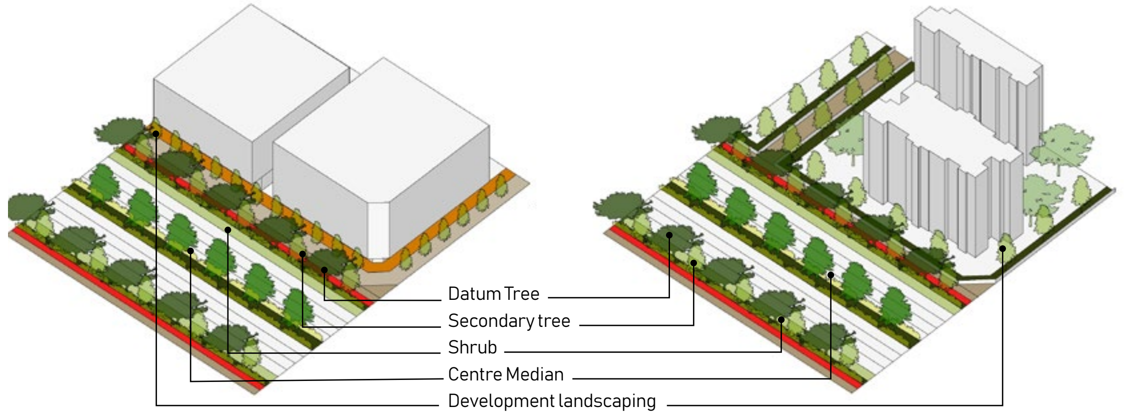
**Coordinating different layers of planting**
Usually, a datum tree is chosen as the primary element for streetscape identity, to line both sides of the road. Other secondary trees and shrubs may be added to further enhance the local identity.

Planting within developments can also be aligned with the landscaping identity of the street or district, through guidelines that stipulate preferred species for green buffers, peripheral planting zones, building setback areas etc.

**Relating to different scales of the city**
When shaping the desired street character, designers take into account perception of the landscape at different scales of the city, at the city, motorist and pedestrian levels.

Over the years, more attention has been paid to shaping the pedestrian experience, as Singapore transitions from car-centric planning to people-centric environments. Many streets today have a variety of smaller shrubs planted to enhance the street view experience.




*Layers of greenery created along streetscapes in urban and suburban setting*

*Larger trees can be appreciated from afar - their size, shape and colour form the primary impression of the streetscape at the city level. Medium sized trees are highly impressionable to motorists, and usually planted at intervals between the larger trees to reinforce local identity. At pedestrian level, smaller shrubs and flowers add visual and sensory accents to the landscaping, such as smell and even seasonal displays of colour*




*Streetscape Elevation view showing layers of landscaping to create shape, colour and even smell*

**Using different attributes of planting to create character**
Designers use different arrangements of size, shape, colour and even smell in streetscape greenery to create different characters and evoke varying sensory experiences.

Trees with strong shapes arranged in repeating order can create a formal and rhythmic effect, suggesting a sense of procession and ceremony. This formal effect is often deployed along key boulevards and gateways in the city, like Orchard Road and the ECP.

Landscaping with atypical attributes, like shades of purple or unusual shapes, can convey a unique sense of place and mark a special destination in the city, such as Bayfront Avenue near the Gardens by the Bay with conical Jelutong and Chengal Pasir trees.

Less structured arrangements of trees and plants, sometimes mimicking natural forest structures, can create a scenic, rustic effect.

The choice of colour can also convey meaning on district positioning. For example, a gold and yellow palette is used in the Central Subzone of Marina Bay to connote wealth and prosperity around the business and financial district.

Identity can also be based on the history of the street. The landscaping of Orchard Road takes into account its heritage as a road of plantations, with plans to introduce former crops like nutmeg and cloves at strategic locations.

## 1.3.5: Mimic self-sustaining forest structures

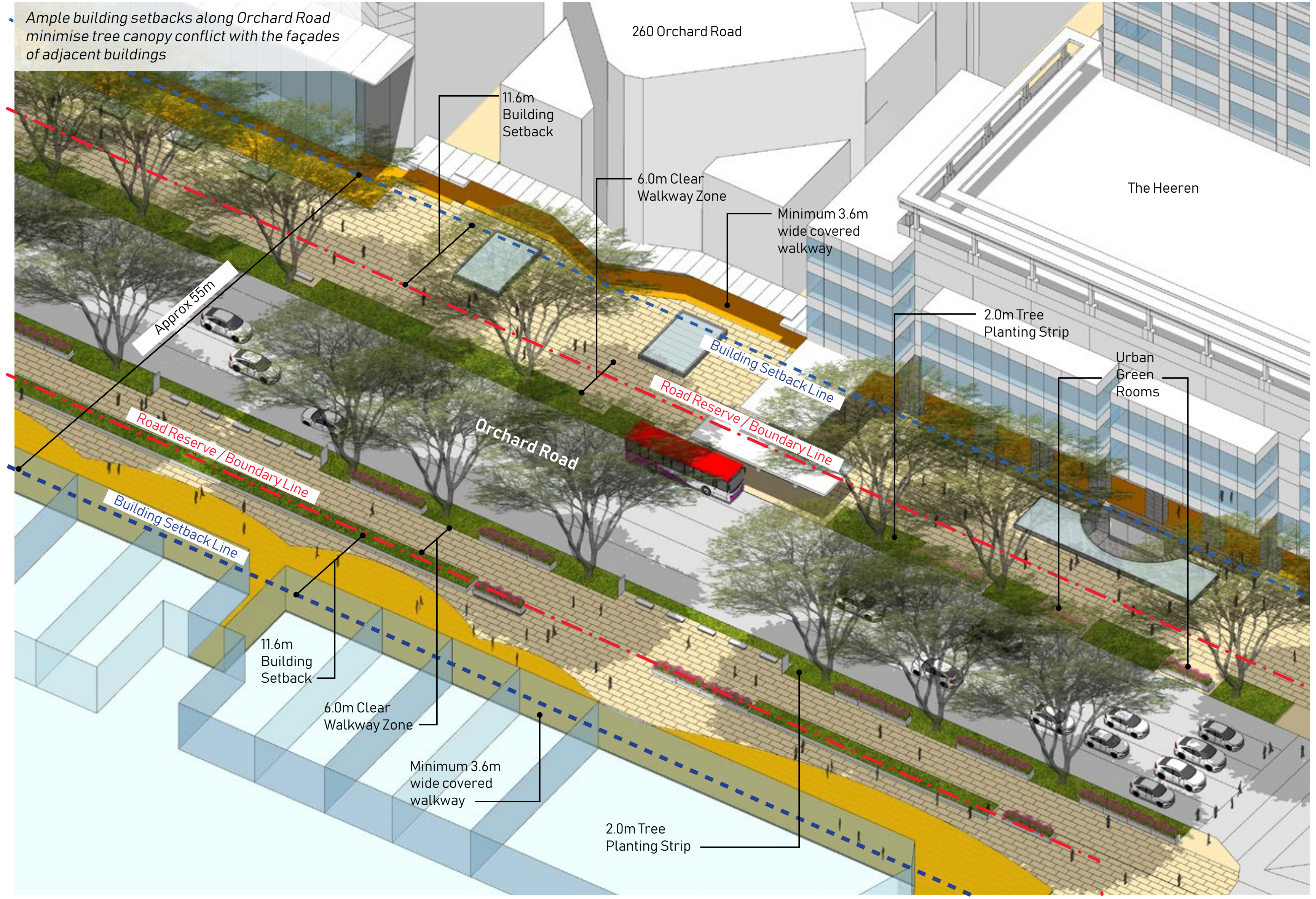
As Singapore transitions to a City in Nature, streetscapes have evolved to provide more ecological functions. NParks' Nature Way planting, for example, connects our green spaces and restores nature into our urban fabric by introducing multi-tiered tree planting. The emergent, canopy and understorey tree layers mimic the natural forest structure, and species that provide food and habitat for biodiversity are selected.

By 2030, about 300km of such Nature Ways will connect Singapore's green spaces.

In suitable locations, streetscapes can also be designed to be more naturalistic. For example, shrubs and native plants that require less frequent maintenance can be chosen.

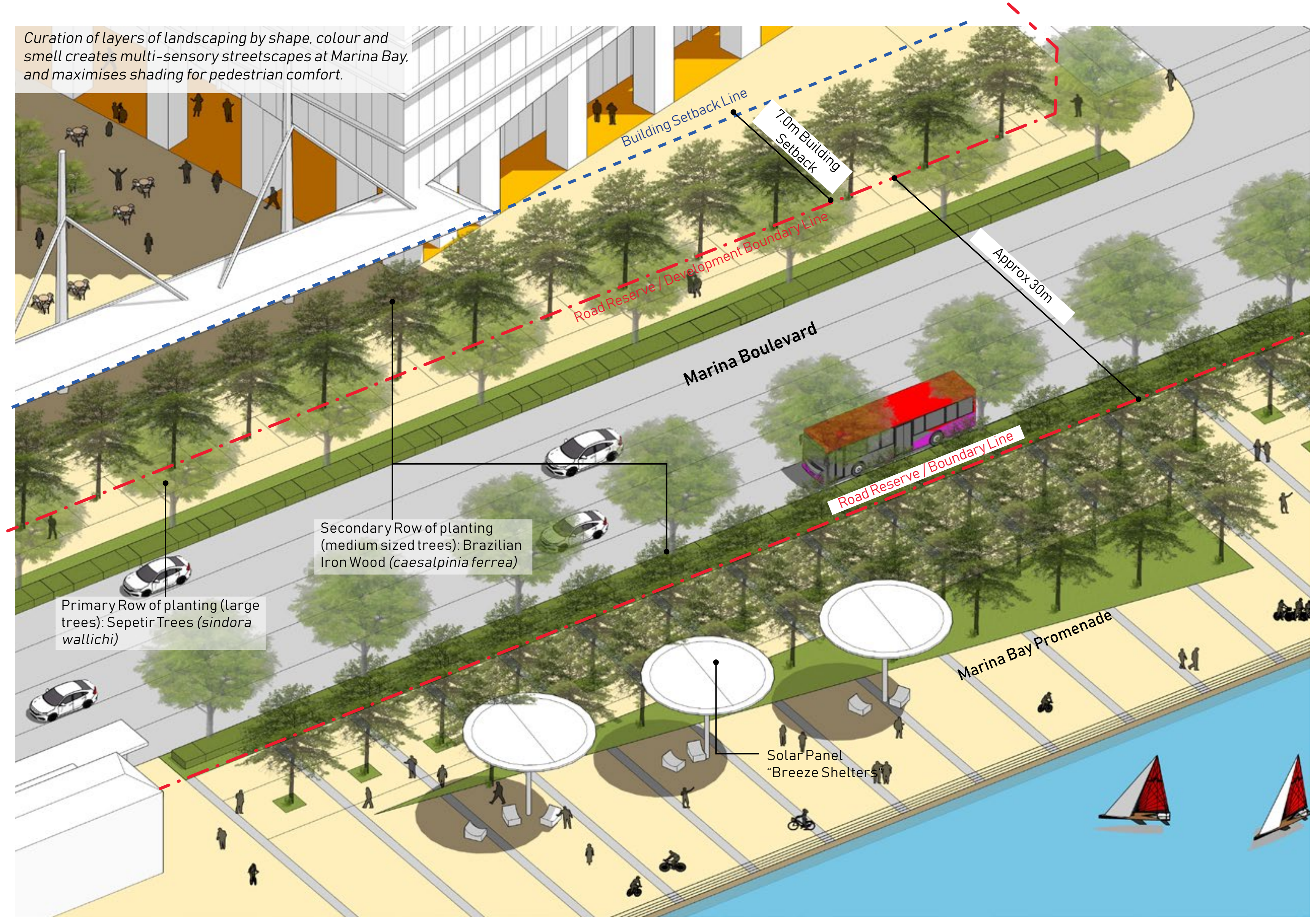

***From roadways to Nature Ways***
NParks has introduced strategies to transform streetscape greenery to support ecological outcomes.

Find out more about Natureways at this link.




*Ample building setbacks along Orchard Road minimise tree canopy conflict with the façades of adjacent buildings*






*Curation of layers of landscaping by shape, colour and smell creates multi-sensory streetscapes at Marina Bay, and maximises shading for pedestrian comfort.*

**CASE STUDY**

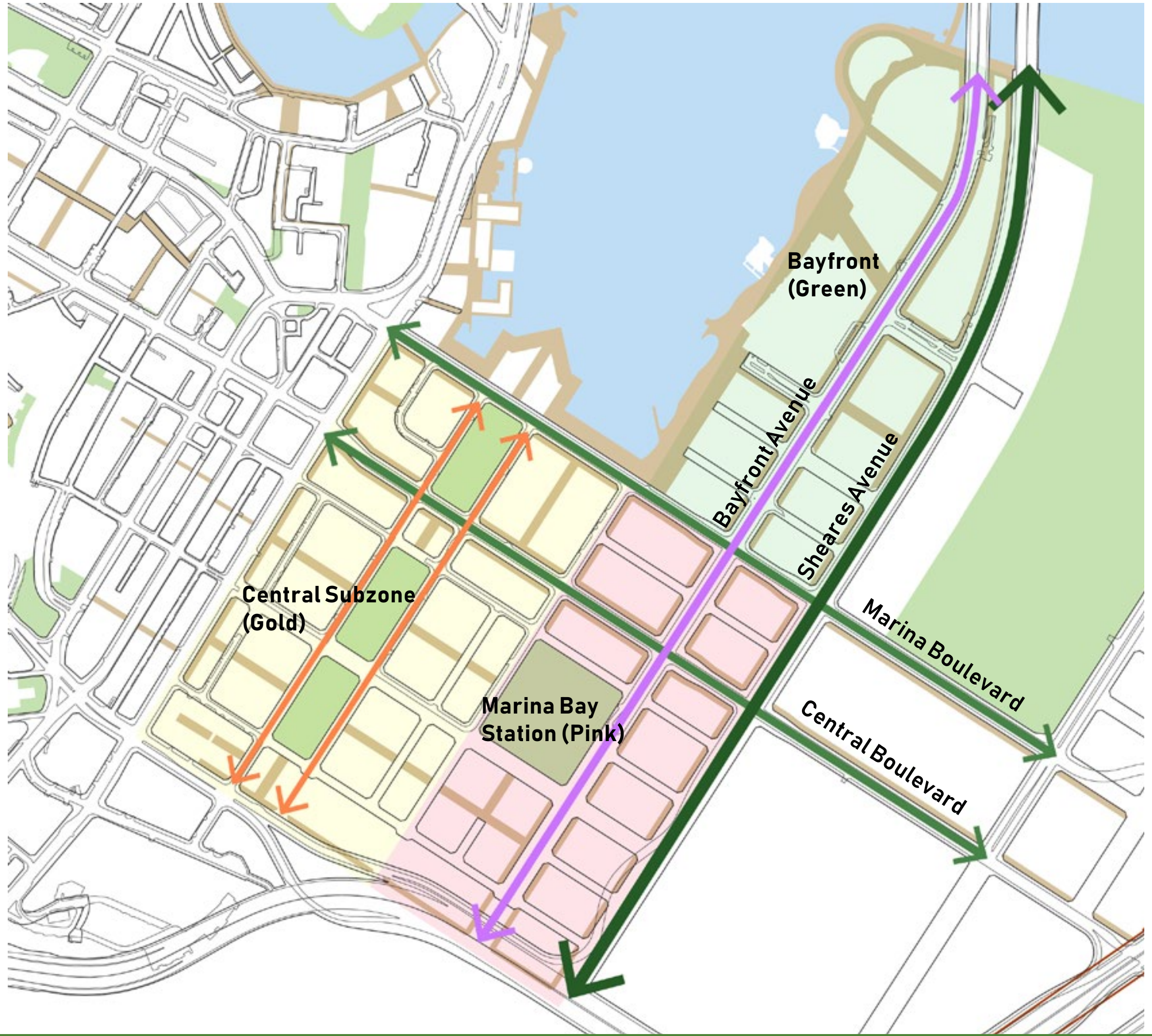
# Sensory streetscapes at Marina Bay

A Landscape Masterplan was developed for Marina Bay to create unique characters and identities for different districts. The Masterplan considered the shape, colour and smell of trees and plants to create multi-layered sensory experiences.

**Maximising thermal comfort in the tropics**
A key objective of the landscaping strategies was A key objective of the landscaping strategies was ensuring thermal comfort along the streets and public spaces to encourage street life and vibrancy. Trees with wider crowns were chosen along east-west oriented streets for shade throughout the day, while smaller crown trees were used along North-South streets where shade from adjacent buildings was in abundant supply.

**Colours by the Bay**
Another strategy was using colour in landscaping to set apart the different neighbourhoods, using flowers, fruits and even colourful leaves. The introduction of colour focused on creating accents to the greenery to allow for subtle differentiation of the precincts.

Yellow and gold were chosen for the Central Subzone to connote wealth and prosperity, pink was chosen around the Marina Bay Station to symbolise happiness, and green around Bayfront to symbolise peace and harmony around the waterfront.






**Shaping street identity**
The various landscaping attributes were carefully orchestrated to create different identifies for the key corridors of Marina Bay, to assist in wayfinding and orientation.

**Marina and Central Boulevards**
Forming the main east-west spine of Marina Bay, a formal boulevard effect was created using large round canopy Sepetir Trees *(sindora wallichi)*, which cast generous shade throughout the day. They were complemented by double rows of Brazilian Iron Wood *(caesalpinia ferrea)* trees planted in the building setbacks, to add a 'dappled' shading effect along the sidewalks.

**Bayfront Avenue**
Columnar Jelutong Trees *(dyera costulaata)* and Chengal Pasir *(hopea odorata)* were used to create a distinctive image while allowing sunlight to more easily filter down along a north-south oriented street. These were complemented by *pseuderanthemum* pink shrubs to create a reddish carpet effect, complementing the pink colour scheme around Marina Bay Station.

**Sheares Avenue**
As the main gateway connecting to the East Coast Parkway, Sheares Avenue was planted with Rain Trees *(samanea saman)* as an extension of the ECP, forming a grand gateway into Marina Bay from the airport. Colourful shrubs such as *crinums* and *hippeastrums* added bright flowers to the streetscape.


*Formal Boulevard Effect: Marina and Central Boulevards*


*East-west orientation of the street requires trees with wide spreading crowns for shade*


*Signature Drive with columnar trees: Bayfront Avenue*


*North-south orientation requires trees with narrow crowns to ensure sunlight reaches the street*


*Grand Gateway with iconic rain trees: Sheares Avenue*


*Rain Trees are planted to form an extension of the ECP gateway into the city*

***From taming water to embracing water***

*Singapore's relationship with water used to be fraught with challenges, and early efforts focused on quelling floods and ensuring clean water supply by building up an extensive network of drains and canals around the island.*

*The 1991 Concept Plan signaled a paradigm shift to Singapore's approach, from developing water infrastructure to transforming them into recreational spaces. Water is integrated into many urban environments today – such as waterways weaving through Punggol Town and mangrove rivers running through Pasir Ris, as well as attractive urban waterways at Singapore River and Marina Bay.*

Source: huntergol hp

# 1.4

## LANDSCAPED WATERWAYS

Singapore has 17 reservoirs, 32 major rivers and 7000km of waterways[16], making them a constant presence in the landscape. Urban design guidelines help to shape attractive waterfront outcomes, through landscaping, public realm and building form design.

*Landscaping strategies have enhanced the sense of place at Robertson Quay, with Trumpet Trees adding colour to the predominantly residential precinct*

### *Why is waterway enhancement important?*

### 1.4.1: Reinforce a sense of islandness and promote well-being

Given the busy urban lives of Singaporeans, it is easy to lose sight of the fact that the city is a small island surrounded by water. Urban design helps to integrate waterways into the urban environment sensitively so that water is never too far from the daily routines of Singaporeans.

Time spent by the water is greatly restorative, promoting relaxation and well-being. Urban "blue spaces" are increasingly seen as a measure to provide public health benefits in the city.

Successful waterfront design also enhances people's quality of life, bringing character and vibrancy to different districts, even attracting investment and enhancing land values.

The city's waterways can also be settings of rich biodiversity, supporting unique ecosystems and boosting Singapore's natural capital.

*How do we turn waterways into recreational spaces?*

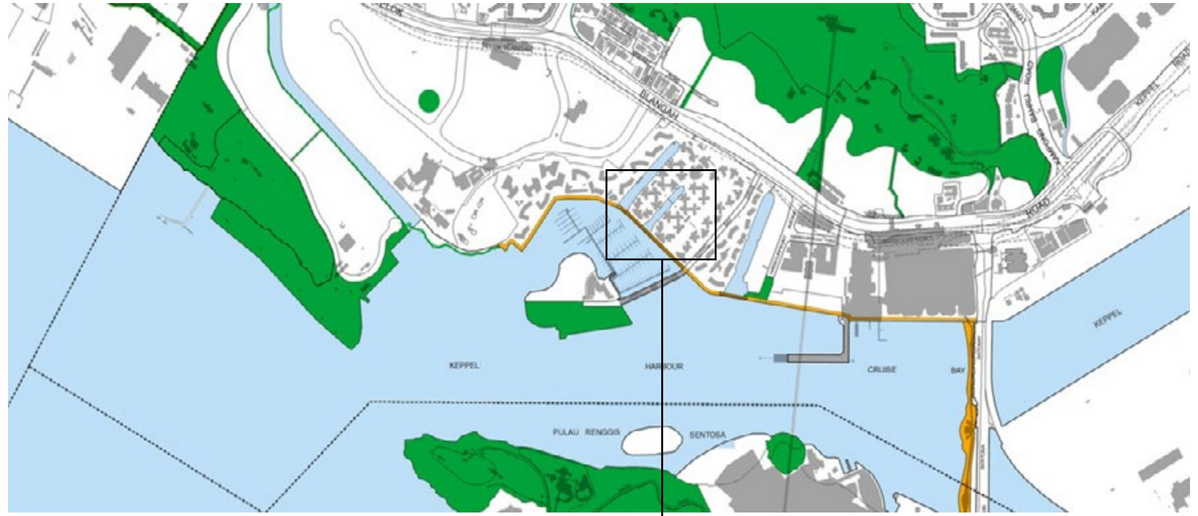
## 1.4.2: Create networks of publicly accessible waterfront spaces

For any waterfront to be successful, the issue of access has to be addressed upfront. URA relies on the Foreshores Act to ensure that waterfront spaces are set aside and designed for public enjoyment.

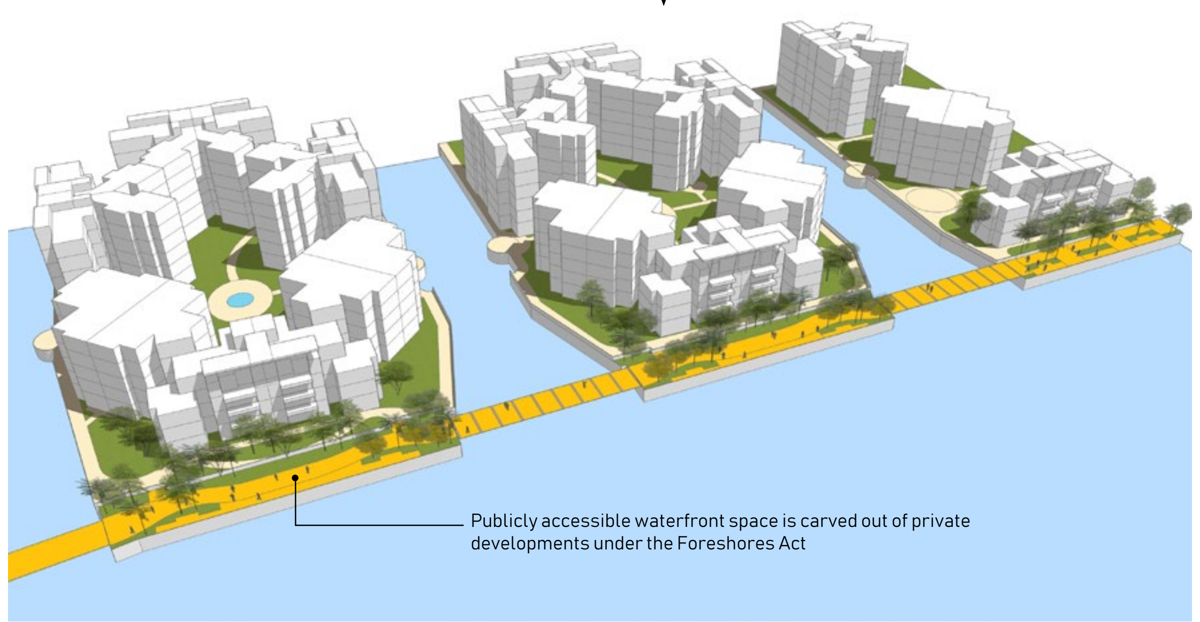
Introduced in 1901 to govern allowable uses of foreshore land (defined as the area between the high and low water mark of the spring tide), the act includes provisions for URA to review any proposed development works within 15m of the foreshore line. This space is usually safeguarded for public use with walking paths, public seating and landscaping.

**Coastal Promenades**
Coastal promenades are created this way – waterfront developments are required to set aside 10-15m of space fronting the water for public access as attractive promenades. URA guides the design outcomes during the Development Application stage. After completion, these spaces may continue to be owned and maintained by the developments, or be vested back to State. They are sometimes linked up by bridges or boardwalks to form extensive green and blue networks.

Along Keppel Harbour, private developments like Vivocity and Reflections at Keppel Bay have provided parts of a coastal promenade that includes the government-built Bukit Chermin Boardwalk and Berlayer Creek, to form part of the larger Labrador Nature and Coastal Walk.

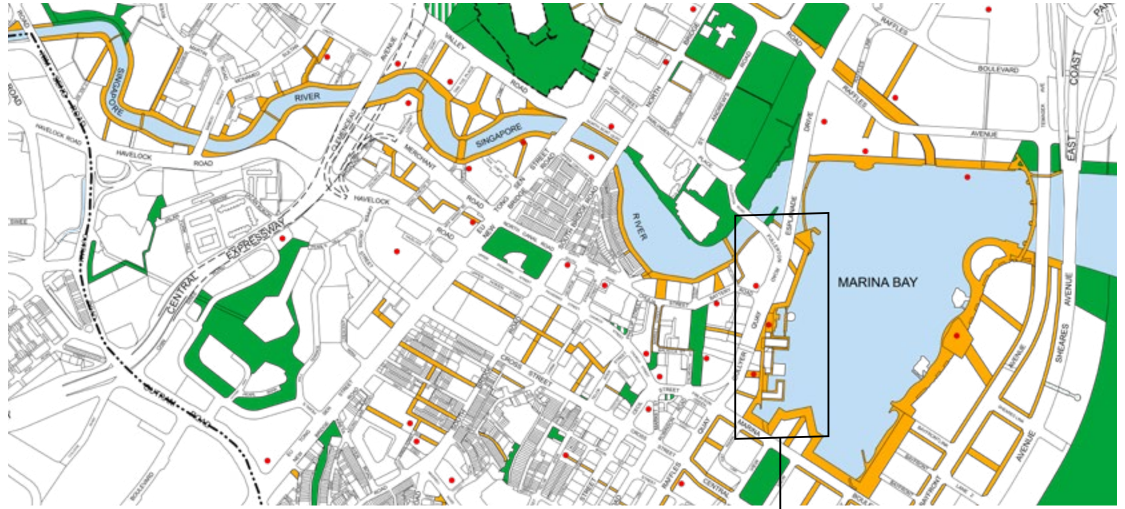


*Coastal promenade network at Keppel Bay*

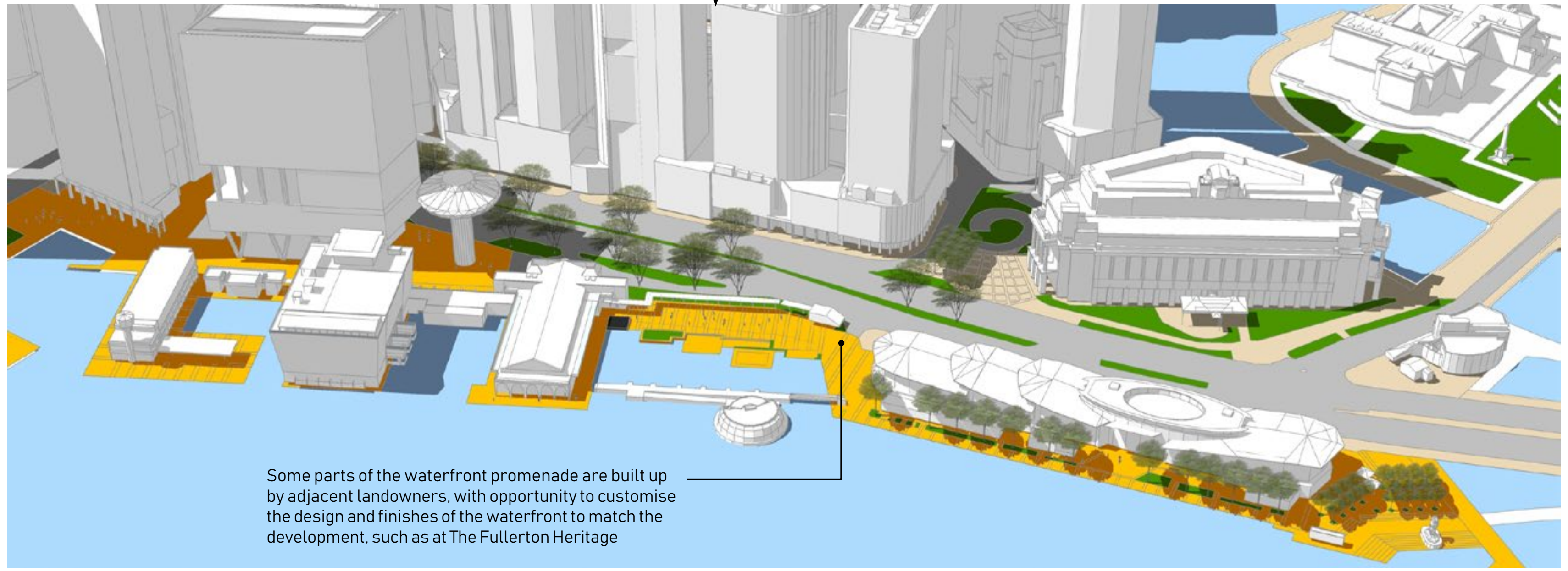


Publicly accessible waterfront space is carved out of private developments under the Foreshores Act





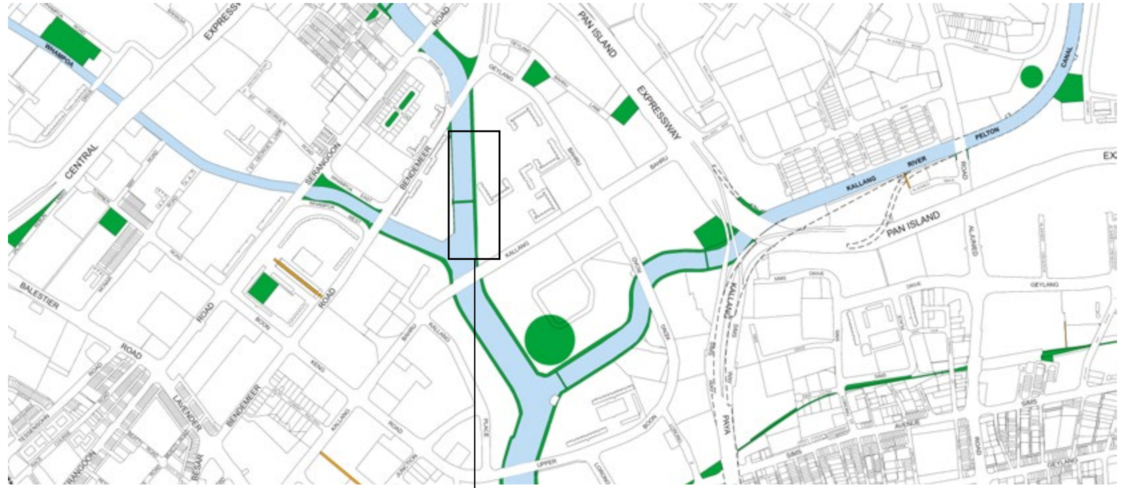

*Waterfront promenades in the city centre, zoned as open space, largely built over former trading quays and service roads*



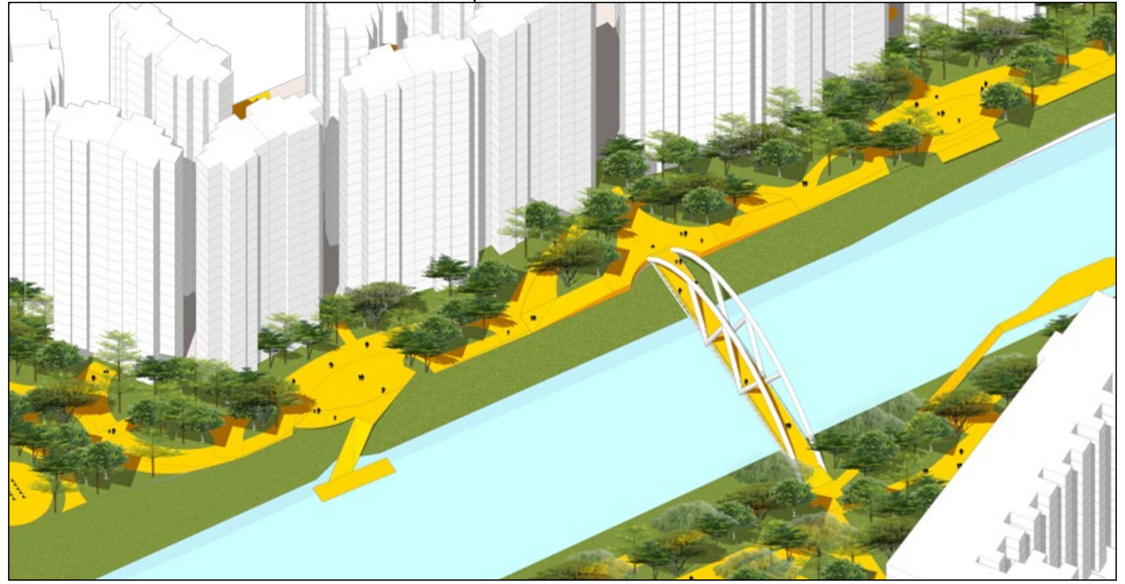
Some parts of the waterfront promenade are built up by adjacent landowners, with opportunity to customise the design and finishes of the waterfront to match the development, such as at The Fullerton Heritage

**Urban Waterfronts**
In the city centre, former trading quays along Singapore River and Collyer Quay have been transformed into lively pedestrian riverfront promenades. Many of these were rezoned from former service roads and quay spaces into "open space" in the Master Plan. They are also marked as promenades in the Parks and Waterbodies plan.

These promenades are seamlessly connected to each other with bridges and under-road crossings, so that people can use them as a network for walking and cycling. The network also extends "inland" to multiple side streets and nodes like MRT stations and bus stops to improve overall accessibility.



*Riverine parks and park connectors along Kallang River, created within the Drainage Reserve and park land lining the river*



**Riverine Parks and Park Connectors**
Outside the city centre, where waterways are less urbanised, access to the water is mainly secured through the creation of walking and cycling trails within the Drainage Reserve (DR) or a strip of land zoned as park zoning along the water.

Many scenic waterways are also used as park connectors, and feature look out decks, floating pontoons and water sensitive urban design (WSUD) features like water remediation gardens and stormwater detention ponds.

Where possible, such infrastructure is built up within the Drainage Reserve (DR) encompassing the waterway. Additional land along the DR is sometimes zoned for park use, to provide more space for park connectors and even lush planting.

Most of these riverine parks and park connectors are implemented by the government. Popular riverine parks like Kolam Ayer ABC Waterfront and Alexandra Canal were completed under PUB's ABC Waters Programme.



## 1.4.3: Create blending of green and blue elements

Littoral spaces present opportunities to create unique blending of green and blue outcomes.

Along urban waterways, landscaping design tends to focus on providing shade, colour and visual interest, which can complement the local waterway character, e.g. blooming Trumpet Trees are used to shape a unique character for the residential segment of Robertson Quay. Landscaping is also often used to frame picturesque views of the water.

Along natural waterways, the line between green and blue is usually blurred, with trees branching out over the water surface, mangroves straddling land and water, riparian vegetation lining riverbanks etc. Here, landscaping can take on more ecological considerations, to serve as habitat creation or provide ecological connectivity.

Littoral spaces in Singapore also offer diverse ecosystems to explore, such as fresh and seawater mangroves, rocky shores and even sea grass meadows.

*Many of these ecological spaces can be found in outlying areas such as Chek Jawa in Pulau Ubin and Sungei Buloh. Some are fairly close to the city centre, such as Labrador Nature Reserve at Keppel Bay. Segments of Kallang River are already lush riparian environments that are attractive to roving otters and other riverine and avian species*

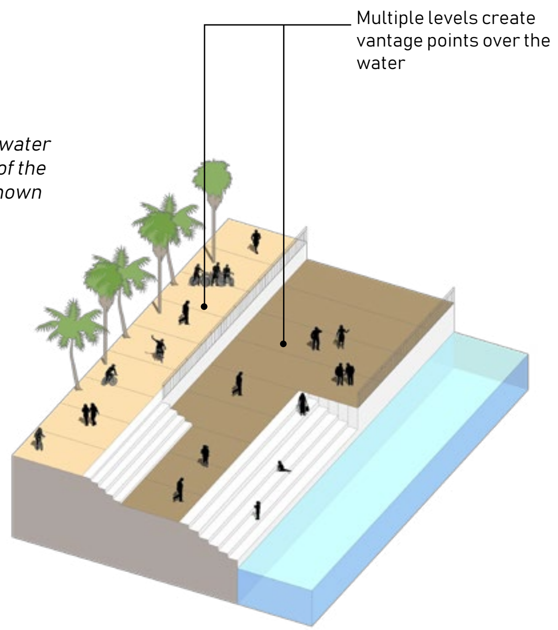
## 1.4.4: Create opportunities to sit near or look out over the waterway

URA and the agencies aim to design waterways with opportunities for people to come as close to the water as possible to enjoy its therapeutic effects.

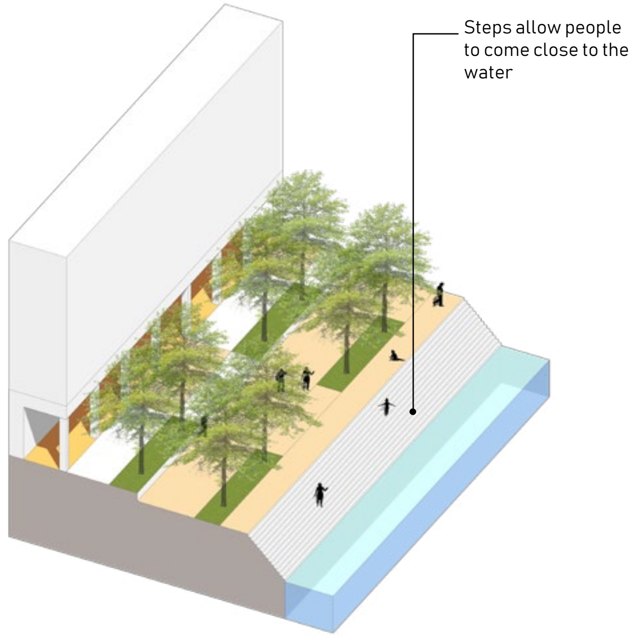
**Levels**
One strategy is to design the waterfront with different levels –upper promenades serve as fast activity zones for joggers and cyclists whereas lower boardwalks act as slow activity zones that allow people to sit and stroll closer to the water.

Waterfronts are designed for universal accessibility, with levels mitigated by barrier-free ramps as far as possible.

***Water edge treatments in natural settings***
*The range of design options to bring people closer to water are only limited by the designer's imagination. Some of the common typologies in Singapore are illustrated as shown*




*Lower boardwalk at Marina Bay Sands*




*Steps and terraces at Singapore River*

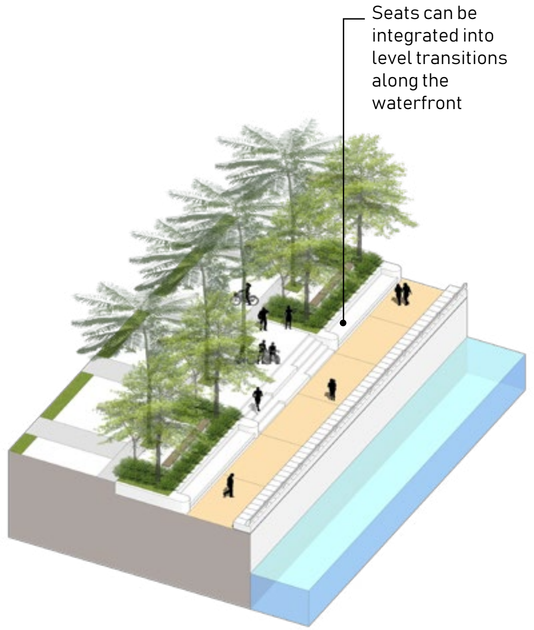


**Seating**
Comfortable, shaded seating spaces are needed to allow people to sit by the water. Major waterfronts that host events like performances or fireworks require ample seating to serve the crowds of people during events.

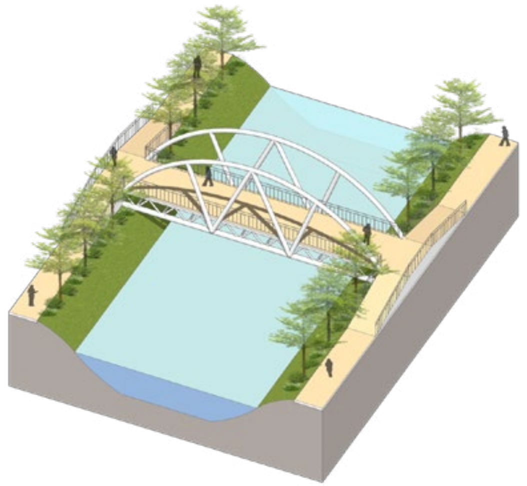
Seating can be standalone or integrated into fencing right at the water's edge. Sometimes steps and terraces that lead down to the water can double up as popular seating spaces.

**Boardwalks and floating structures**
Boardwalks, floating pontoons and bridges give people the opportunity to venture out further over the water.

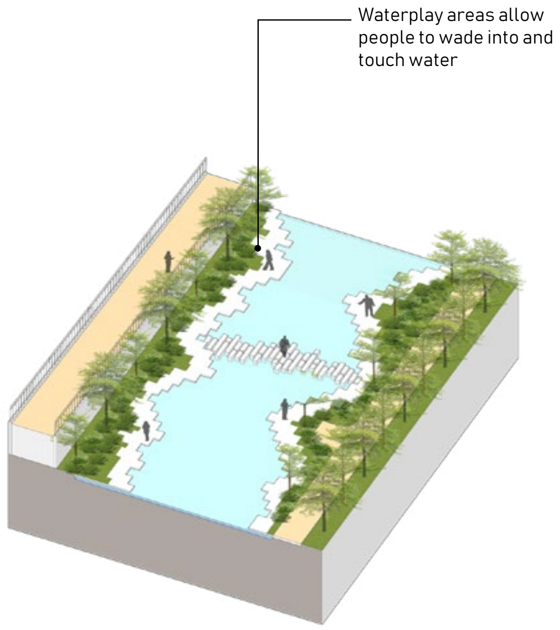
The meeting point between water and land also gives rise to unique ecosystems. In such natural settings, these devices allow people to come close to semi-aquatic habitats, to observe and engage with nature.




*Public space with seating integrated with fence at Esplanade*



*Pedestrian bridge at Kolam Ayer*




*Trails and waterplay areas at Alexandra Canal*

## 1.4.5: Design the environment to stimulate the senses

Good urban design strives to engage and delight the human senses, creating environments which are delightful to see, touch, smell and even hear. Waterfronts, at the confluence of land and water, offer a wide range of these sensory stimuli.

**Visual**
Research shows there is a deep biological connection between our minds and water. The sight of water can induce a flood of neurochemicals that promote wellness, increase blood flow to the brain and induce relaxation[17]. Another theory is that the soft simuli of water promotes involuntary attention and recovery from cognitive fatigue, this is called attention restoration theory[18].

Waterfront design is about maximising visual and physical engagement with water. This can be enhanced by creating levels that step down to the waterline, creating multiple vantage points.

Al fresco dining areas, or Outdoor Refreshment Area structures (ORAs), along the waterline should be designed to be visually porous so that views of the water are not blocked. ORA structures along Boat Quay were enhanced to open up views of the Singapore River in 2015.

Layering also creates depth and visual complexity for the waterfront. The rows of walkways, landscaping, alfresco areas, etc are intended to give order to space but also create layers of "scenes" along the promenade, making them ideal places to watch the world go by.

*Meandering river and cascades at Bishan-Braddell ABC*

*Granite tiles, terracotta pavers and timber promenades are among the materials found along Singapore River*

**Auditory**
Soundscapes can sometimes be more effective than visual stimuli in arousing moods and emotions[19]. Designers should consider the existing auditory qualities of water and the surroundings to derive the appropriate spatial design response.

Gentle grassy slopes with benches allow people to come closer to the meandering river at Bishan-Ang Mo Kio Park to enjoy the sound of trickling water, which is calming - a form of "white noise".

A cantilevered promenade at ABC Waters @ Kallang River (between Bishan and Braddell Road) allows people to perceive the din of cascading water along the canal, which conveys vitality and awe, from afar.

Sounds of human activity are an important part of the experience – Marina Bay was sized strategically to ensure that sounds and energy from opposite sides of the bay can be heard from any one point along the promenade.

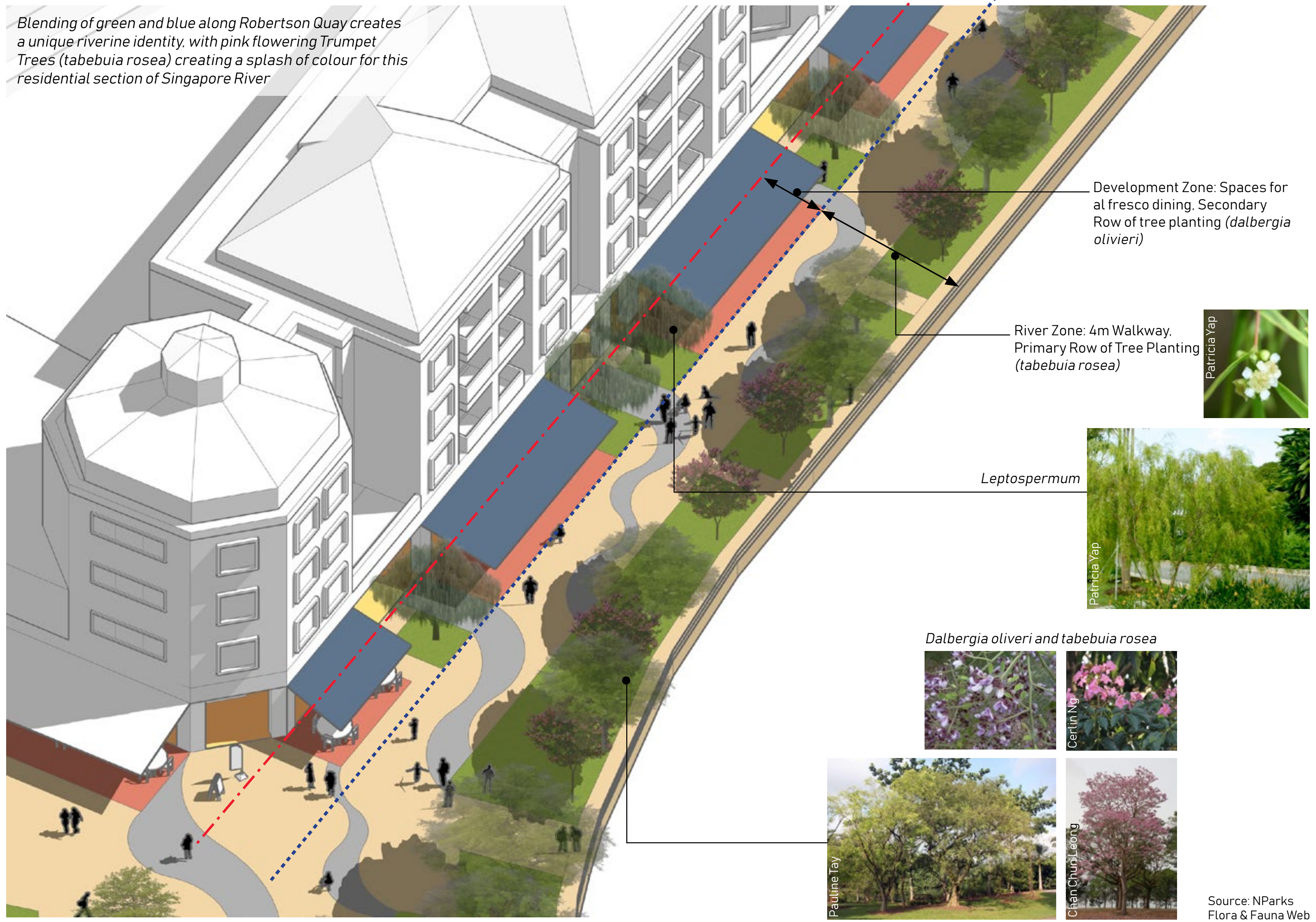
**Tactile**
Tactile design plays a key role in creating pleasure. Materials and finishes need to be carefully considered in the overall design. Different floor materials suit different activities, e.g. sturdy granite tiles can support high speed activities like cycling and jogging along the promenade, terracotta pavers are loosely packed and create the feeling of walking along quaint cobble stone streets, timber planks used for lower boardwalks evoke the feeling of walking on historic piers, etc.

Materials should remain comfortable to touch even after being exposed in the hot sun. Along Empress Place, seating ledges are lined with timber planks for people to sit on, instead of exposed granite.

**Olfactory**
The sense of smell has been described as the one most closely related to memory and emotion. Certain smells inherent to waterfront settings can be nostalgic – the salty air of the sea, or even moisture around reservoirs.

Unfortunately, littoral spaces are also prone to unpleasant odours. In fact, before it was cleaned up, the biggest affliction of the Singapore River was its smell – an aspect still commonly remembered. Today, pollution is prevented through careful planning, thereby eliminating the worst smells from Singapore's waterways.

*Blending of green and blue along Robertson Quay creates a unique riverine identity, with pink flowering Trumpet Trees (tabebuia rosea) creating a splash of colour for this residential section of Singapore River*



Development Zone: Spaces for al fresco dining. Secondary Row of tree planting *(dalbergia olivieri)*

River Zone: 4m Walkway, Primary Row of Tree Planting *(tabebuia rosea)*

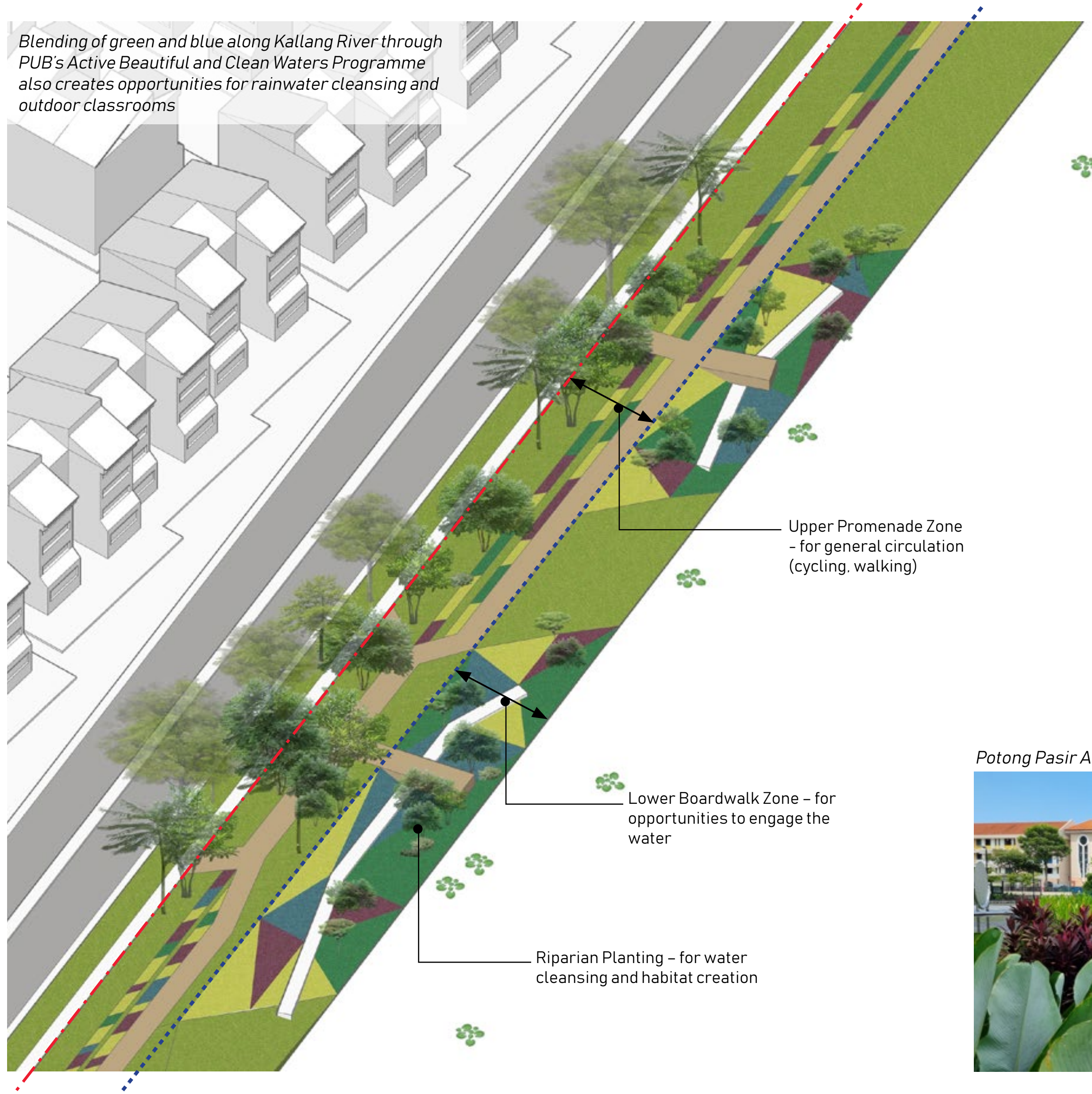
*Leptospermum*

*Dalbergia oliveri and tabebuia rosea*

Source: NParks Flora & Fauna Web



*Blending of green and blue along Kallang River through PUB's Active Beautiful and Clean Waters Programme also creates opportunities for rainwater cleansing and outdoor classrooms*



Upper Promenade Zone – for general circulation (cycling, walking)

Lower Boardwalk Zone – for opportunities to engage the water

Riparian Planting – for water cleansing and habitat creation


*Ixora orange*

*Licuala grandis*


*Cordyline fruticosa*

*Clerodendrum laevifolium*

*Potong Pasir ABC Waters Project*

*CASE STUDY*

# A green riverbend at Robertson Quay

Walking upstream towards where the Singapore River transitions into the Alexandra Canal after Kim Seng Bridge, we find a section of the Singapore River that is especially green and lush, in response to a variety of urban design strategies.

***Singapore River Promenade Design Guidelines***
The Promenade Design guidelines were first published in 1999, to provide an overview on landscaping, space planning and design parameters for different stretches of the Singapore River Promenade.

Find out more about the requirements at this link.

**Lush tree planting**
The Singapore River Promenade Guidelines guides the realisation of lush planting along the river, prioritising local species to enhance the tropical identity of the river.

Along this stretch of Robertson Quay, two rows of Tamalan Trees *(dalbergia oliveri)* line the pedestrian walkway, casting generous shade and creating a lush green environment.

**Gently sloping river embankment.**
The promenade guidelines also guide the type of riverwall condition depending on the location along the river and its historic condition.

At this location, a Type A river wall condition is required – where the promenade meets the river in the form of a 4m wide gently sloping grass embankment. This offers a softer edge to the river compared to the more urbanised stretches elsewhere.

**Skyrise greenery**
Looking up between the trees, lushly planted Sky Terraces with overhanging creepers rise up the sides of the Rivergate condominium.

URA had permitted the development to exceed the prevailing standard 4-10 storey building height control along Singapore River due to the landmark status of the site, on the basis of an innovative design concept which successfully carried greenery both horizontally and vertically through the development.

**Green landscape deck**
The Rivergate condominium sits on a carpark deck which has been concealed from view by a sloping landscaped berm (with a 1:2.5 slope). URA's Landscape Deck policy allows carpark decks to be bermed up at the sides so that they do not have be fully sunken underground, creating green landscaped berms along the development boundary.

The boundary fence has also been set back to the top of the berm, so that the greenery around the development boundary is externalised for public enjoyment.

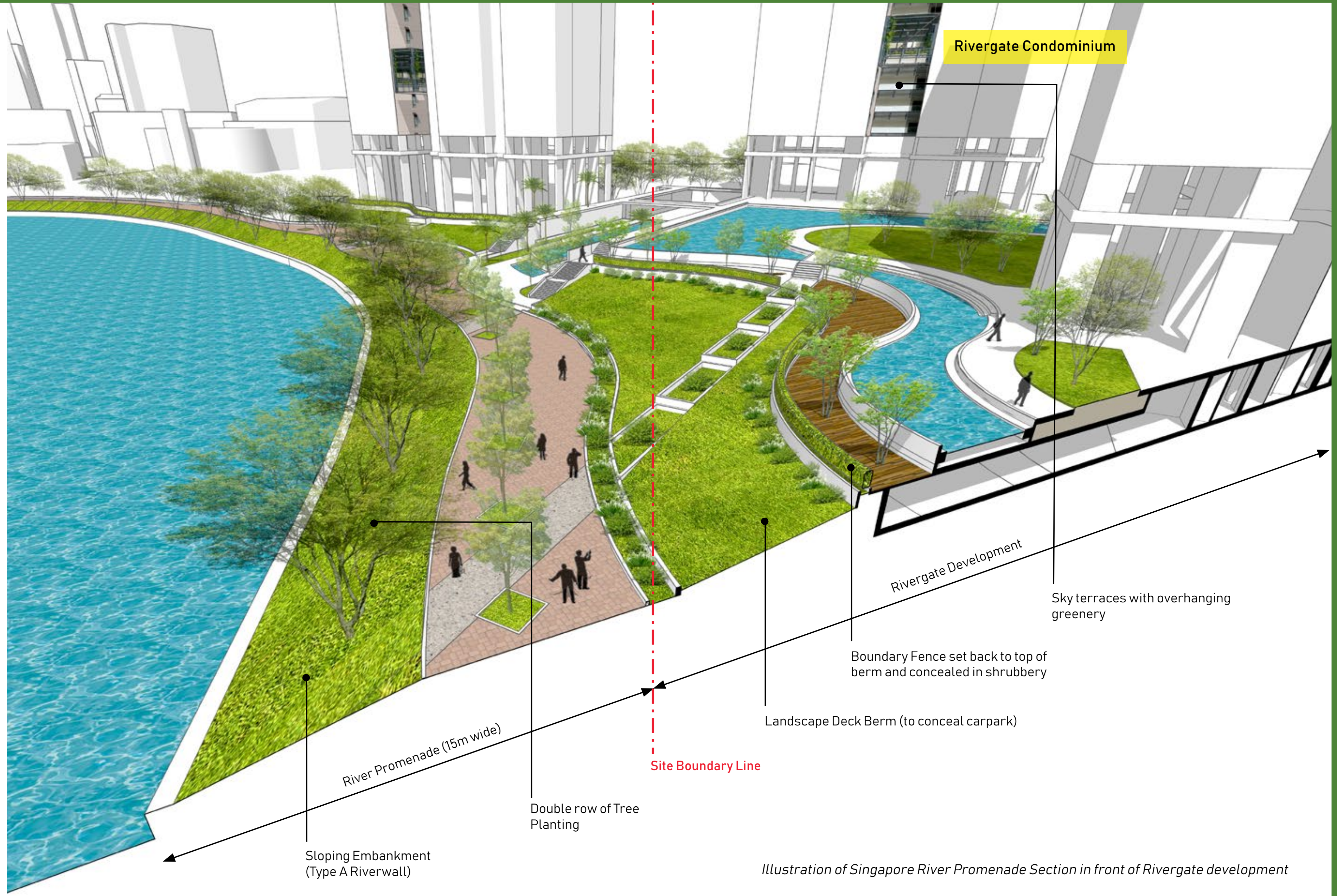



*Illustration of Singapore River Promenade Section in front of Rivergate development*

The Oliv by W Architects

Source: Oliv - Teo Zi Tong

### 2.0 Greenery at the development scale

*The second part of the book will look at how greenery is realised and integrated within developments, taking the form of sky terraces, roof gardens, green walls, etc. so that greenery is brought closer to the daily lives of Singaporeans.*

# 2.1

## LUSH & LANDSCAPE REPLACEMENT

Having seen how greenery is systematically created at different scales in the city in the past four chapters – from setting aside land for Nature Reserves and Nature Parks, to planting along streets and waterways to form the green and blue network, the next few chapters will look into how greenery is created within development spaces where people live, work and play.

### *Why does URA require greenery provision in developments?*

### 2.1.1: Augment provision of greenery in the city

While individually small, greenery in developments can collectively impact the city by increasing overall green surface area, increasing ecological spaces, improving carbon sequestration and reducing energy consumption, amongst other urban system benefits for Singapore.

Greenery in developments also improves quality of life factors such as mental well-being, physical activity and social interaction, by increasing connections to nature for building occupants.

Beyond creating greenery, it is important to take a science-based approach to preserve and enhance surrounding biodiversity and ecosystem services, to ensure that the development gives back to nature as much as it is enriched by it.

**How did skyrise greenery come about?**

The origin of the term skyrise greenery can be traced back to a series of skyrise garden exhibitions in the 1990s held by the National Parks Board to promote gardening in high-rise apartments. Skyrise greenery also began to be incorporated in buildings as an energy conservation measure under Green Mark, which was introduced in 2005 by BCA. Between the 1990s to 2000s, URA also introduced various guidelines and incentives that promoted skyrise greenery, such as for sky terraces, planter boxes and 1st storey communal landscaped areas.

In 2009, URA consolidated the various skyrise greenery guidelines into the LUSH programme and introduced the landscape replacement requirement for developments in strategic areas like the Downtown Core and Jurong Lake District. As of 2020, the programme has contributed more than 176 hectares of greenery. The total amount of LUSH greenery island wide has also been increasing at an annual average of 15 per cent.

*CONCEPTS EXPLAINED*

# *What is landscape replacement and why is it required?*

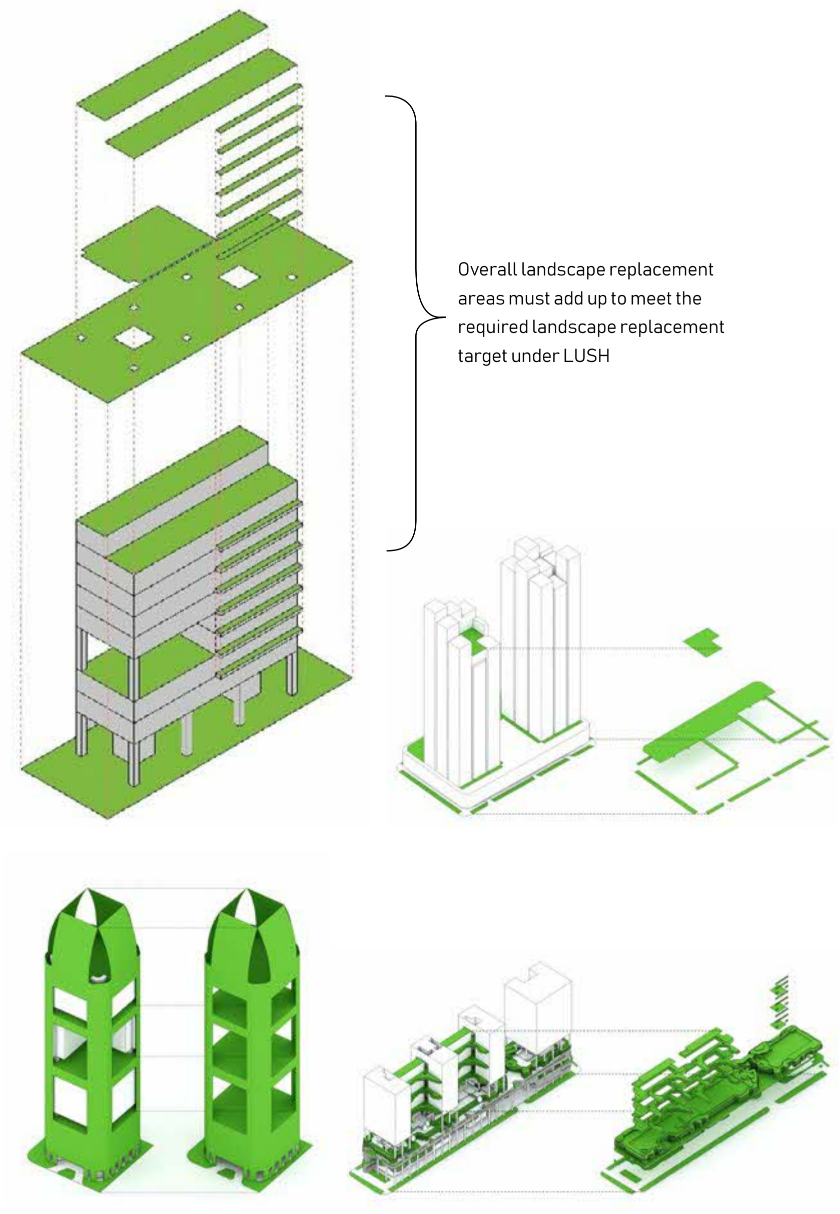
**Replacing greenery as we develop**
The Landscaping for Urban Spaces and High-Rises policy, also known as "LUSH", plays a key role in creating greenery in developments by requiring landscape replacement.

The premise of landscape replacement is simple – developments must create green areas in the building equivalent to the site area, so that greenery displaced during development is replaced. This is to ensure that as Singapore continues to urbanise, the overall amount of greenery on the island is sustained.

Landscape replacement areas comprise a multitude of horizontal and vertical, exterior and interior, exposed and enclosed spaces in a development that can accommodate planting.

The total area of these surfaces are added up to meet the landscape replacement area requirement, which will vary according to the location of the development.

The LUSH guidelines has been reviewed several times over the years to expand the range of greenery typologies that can be counted as landscape replacement, and include more areas where landscape replacement is required.






*How do we replace greenery as we develop?*

## 2.1.2: Turn horizontal and vertical surfaces into plantable areas

**Landscape replacement requirements**
With part of the site consumed by the physical building footprint, it is necessary to maximise horizontal and vertical surface areas in the development for greenery to meet the landscape replacement requirements under LUSH.

Within strategic areas like the Downtown Core and Jurong Lake District, the total replacement requirement is set at 100% of the site area (70% if there are height limitations).

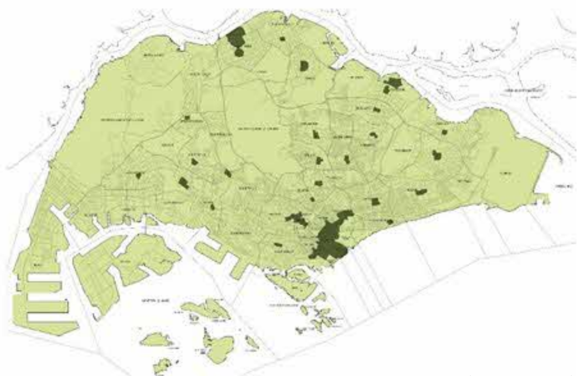
This can comprise a mix of softscape, which are permanent planting areas, and hardscape, which are circulation or recreational spaces around softscape areas.

Outside of strategic areas, the replacement requirement varies depending on the development intensity, ranging from 30-40% of the site area, with only softscape areas counted towards the requirement.

Additionally, Green Plot Ratio (GnPR) standards were introduced in 2019 to ensure higher quality and density of planting within softscape areas, which is computed by the following formula:

$$\text{Green Plot Ratio} = \frac{\text{Total leaf area of greenery counted as Landscape Replacement (softscape)}}{\text{Site Area}}$$

The overall summary of landscape replacement area (LRA) and green plot ratio requirements for developments around Singapore is as follows:



*LUSH strategic areas (dark green)*

| Location | LRA | Minimum Softscape | Minimum GnPR |
|---|---|---|---|
| In strategic areas height control ≥ 80m SHD | 100% | 40% | 4.0 |
| In strategic areas height control ≥ 80m SHD | 70% | 40% | 4.0 |
| Outside strategic areas GPR ≥ 2.8 | 40% | 40% | 4.0 |
| Outside strategic areas 1.4 ≥ GPR ≥ 2.8 | 35% | 35% | 3.5 |
| Outside strategic areas GPR ≥ 1.4 | 30% | 30% | 3.0 |

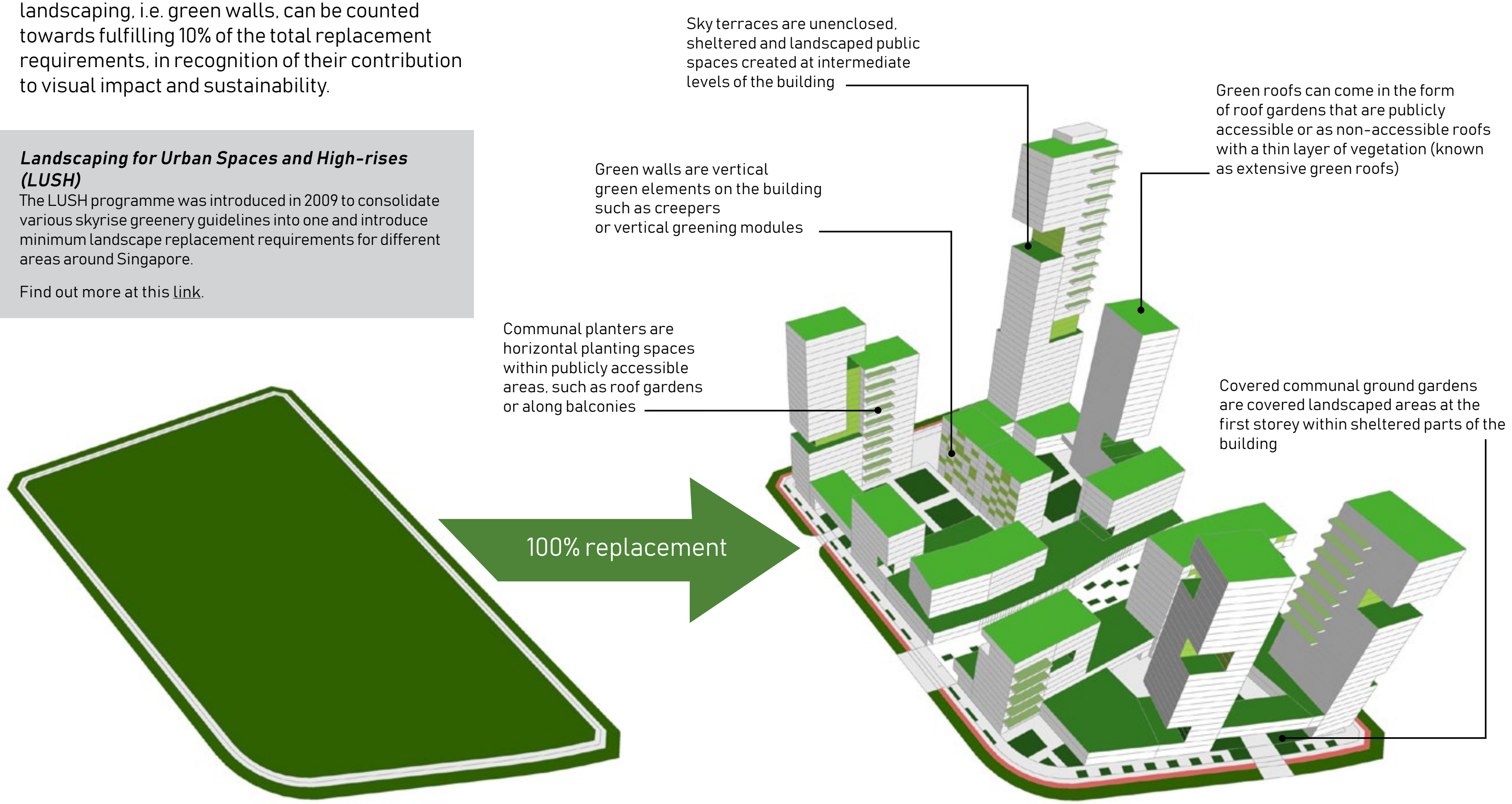
**Types of Landscape Replacement Areas (LRAs)**
LRAs can take the form of horizontal or vertical green spaces, with horizontal ones prioritised as they can be more easily integrated into common circulation areas like roof gardens and sky terraces for public enjoyment.

Starting with LUSH 3.0 in 2019, vertical landscaping, i.e. green walls, can be counted towards fulfilling 10% of the total replacement requirements, in recognition of their contribution to visual impact and sustainability.

***Landscaping for Urban Spaces and High-rises (LUSH)***
The LUSH programme was introduced in 2009 to consolidate various skyrise greenery guidelines into one and introduce minimum landscape replacement requirements for different areas around Singapore.

Find out more at this link.

The types of horizontal and vertical green spaces within a building that are counted as LRAs can be broadly defined as a number of skyrise greenery typologies, shown in the following diagram.




*How do we increase human connections with nature?*

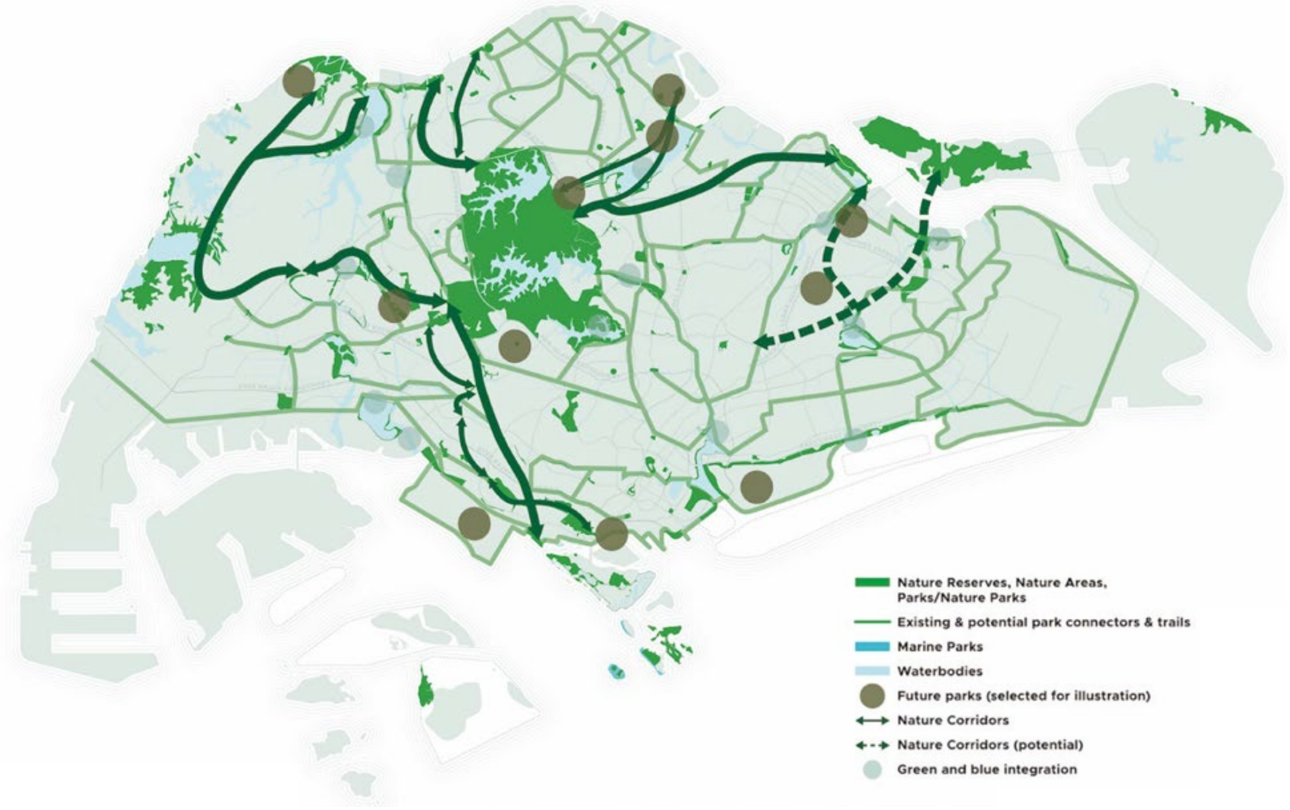
## 2.1.3: Ensure greenery in developments are well-designed, accessible and enjoyable

The key principles governing the design of different LRA typologies are driven by the intention of maximising human connections with nature.


**Open and naturally-ventilated**
All landscape replacement areas within the development are required to be either unenclosed and open-to-sky, or if sheltered – open-sided and naturally ventilated. This is to ensure sufficient access to sunlight and fresh air for plant growth as well as human enjoyment. Building occupants who spend more time outdoors as part of their daily routines are less likely to suffer the detrimental side effects of "sick building syndrome".

**Publicly-accessible**
Landscape replacement areas should also be located in areas that are easily accessible to the public or building occupants. Certain spaces like sky terraces are required to be accessible to all occupants of the building, with at least one set of communal access via lift or staircase. Types of LRA which may be harder to access, such as green walls or extensive green roofs, should be well-externalised and visible to building users and the general public.

**Well-designed and integrated**
Landscape replacement areas should be well-designed and integrated into the overall form and architectural treatment of the building. To encourage this outcome, URA allows communal planter boxes to be wider than 1.0m if they are integrated with a larger landscaping scheme. This ensures that landscaping works together in a development to create immersive environments and meaningful nature contact for building occupants.




*Green and Blue Plan showing ecological connectivity corridors*

### *How do we ensure that development greenery has environmental benefits?*

## 2.1.4: Take an ecologically sensitive and science-based approach

Going beyond landscape replacement, it is important to take an in-depth, science-based approach to restore and enhance nature within a site.

Within ecologically sensitive areas, URA and NParks require Environmental Impact Assessment (EIA) studies to be done prior to development works. EIAs provide a systematic framework to identify existing biodiversity in a site and determine the appropriate mitigation measures against development work.

Beyond ecologically sensitive areas, EIAs are not required but developers and architects may conduct biodiversity surveys to help understand the ecological attributes of their site.

These approaches allow for more effective strategies to be developed. For example, landscape designers can plant the types of trees and shrubs that serve as food sources for nearby insects and wildlife, or they can more accurately restore habitats for rare or endangered plant and animal species discovered on site.

To assist in the identification of ecologically sensitive areas islandwide, NParks carried out an Ecological Profiling Exercise (EPE) in 2021 for terrestrial, coastal and marine environments, using agent-based modelling to identify areas and corridors of ecological value in Singapore.

The outcomes of the profiling exercise are reflected in the Green and Blue Plan.



### *CONCEPTS EXPLAINED*

# *What are Environmental Impact Assessments (EIAs) and what do they look at?*

Environmental Impact Assessments (EIAs) are tools used to assess the impact of development projects on the environment, in particular to the development site and its context.

They are systematic frameworks that identify the potential impact of development and mitigation measures at each stage of the project. Planning approvals are only granted by URA when they have met the requirements by regulatory agencies such as NEA and PUB for pollution and NParks for wildlife issues.

**Steps in the process**
The EIA starts by conducting extensive baseline surveys to determine the existing flora and fauna on site, using methods such as physical mapping of vegetation types and camera traps to record wildlife movement.

The conservation value of the recorded biodiversity on site is then evaluated based on a number of factors, such as overall species richness, presence of rare species, level of disturbance etc, to help determine the right conservation strategies for the site.

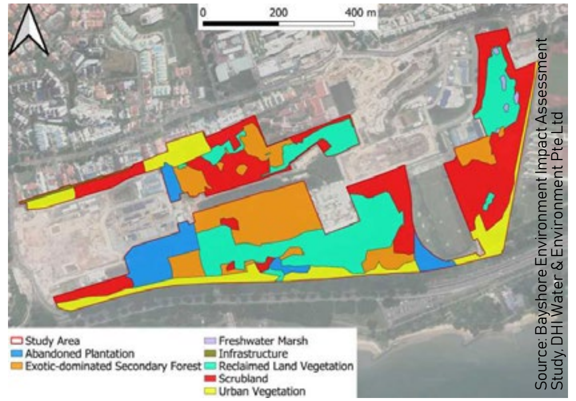
Potential development impacts are then identified, covering the full life cycle of the development works, from pre-construction to post-completion. Such impacts can include loss of habitat, disturbance from construction activities, and even light nuisance to sensitive animals post-completion.

Mitigation measures are proposed in response to the findings, which can include the protection of significant patches of biodiversity, replanting of certain plant species that support the wildlife, using biodegradable construction elements etc.

Finally, environmental management and monitoring plans are developed to ensure regular tracking of environmental performance and adjustments of mitigation measures where needed.

EIAs are carefully considered by the agencies in consultation with community stakeholders, including nature groups, before granting planning approval for the project to proceed. EIA reports are also made publicly available online. Some development areas that have conducted EIAs include Bayshore, Springleaf and former Keppel Club.

Source: DHI Water & Environment (S) Pte Ltd




Source: Bayshore Environment Impact Assessment Study, DHI Water & Environment Pte Ltd

*CASE STUDY*

# A greener development at Springleaf

**An ecologically-sensitive site**
Springleaf is located between the Central Catchment Nature Reserve (CCNR) and Upper Seletar Reservoir. It was part of Nee Soon village and subsequently a swamp forest before the construction of the Seletar Expressway. Today, the site is mainly forested with some historic buildings still remaining (the former Seletar Institute and Nee Soon Post Office).

Originally planned for mixed commercial, residential and park use in the 2014 Master Plan, URA revised the zoning after completing an environmental baseline study and environmental impact assessment between 2018 – 2021.

The study identified the swamp forest in the middle of the site as a "Core Conservation Area", while the area around it comprised various habitat types that were also important for biodiversity, such as grassy woodland, secondary forest and riparian stretches.

The study also revealed that the freshwater swamp was home to a rich variety of flora and fauna, some of which were unique to Springleaf, such as *aglaia yzermannii* (a type of flowering plant from the Mahogany family).


Source: Sitetectonix Pte Ltd



*Springleaf in previous Master Plan*

*Expanded Park Area in amended Master Plan*

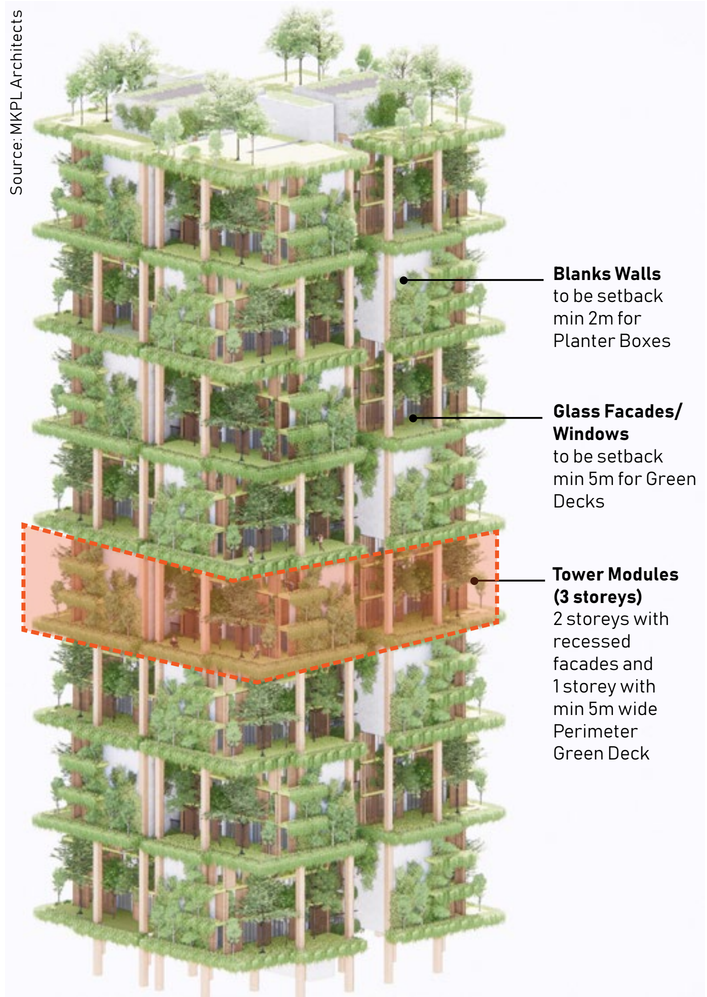

**Multi-disciplinary Study**
Following up from the baseline study, URA engaged a multi-disciplinary team of architects, ecologists, landscape architects and other experts to explore ideas for a biodiversity-sensitive development within Springleaf. This led to the formulation of the following strategies for the site:

- Adopting a Biodiversity-Sensitive Urban Design (BSUD) framework and related principles to guide master planning of the site;
- Designating the most ecologically sensitive areas as Significant Conservation Areas (SCA) and immediate surrounding areas a 'no-go zones";
- Limiting development to less sensitive parts of the site that are already urbanised or disturbed areas;
- Keeping building footprints small to minimise habitat loss;
- Designing buildings with greener facades to minimise bird strike;
- Enhancing ecological connectivity through targeted tree planting;
- Integrating Active, Beautiful, Clean (ABC) water design features into waterways and drainage infrastructure; and
- Exploring new development typologies that would respond sensitively to the site.

**Environment Impact Assessment**
An Environment Impact Assessment (EIA) was conducted in 2020 to better understand the impact of these strategies in a proposed masterplan. An Environmental Management and Monitoring Plan (EMMP) was also prepared to provide a framework to track the mitigation measures.

Based on the proposed development masterplan, the EIA proposed the following additional measures to protect the sensitive biodiversity on site:

- Safeguarding an additional 30m buffer zone beyond the SCAs for extra protection;
- Targeted reforestation or revegetation of corridors to enhance connectivity between Springleaf and the adjacent forests; and
- Implementing a landscape planting guide to maintain the forested nature of the site.




*Building typology explored by MKPL Architects to increase greenery in building facades*

**Greenery requirements to support ecological outcomes**
Taking the feedback from nature and heritage groups, industry experts and academics, URA will be refining the plans for the area to achieve an ecologically sensitive development.

The development will be required to meet minimum landscape replacement and softscape requirements under LUSH, to maximise the area of greenery within the site. It will also have to respond to the unique challenges of preserving and enhancing the rich biodiversity and ecological value of the Nee Soon Swamp Forest.



*Lush greenery within Shangri-La Hotel*

# 2.2

## SKY TERRACES


*Sky terrace at One George Street*

**What are sky terraces?**
Sky terraces are communal spaces provided at intermediate levels of a building that are open sided and naturally ventilated, in other words, sheltered public spaces in the sky.
Under the GFA incentive, these covered spaces are not counted as GFA.

The sky terrace guidelines were introduced in 1997, and early examples included One George Street (2004) and Newton Suites (2007).
Sky terraces are now a common feature in many condominiums, office and mixed-use developments, providing building occupants communal spaces to gather with elevated views of the city in a garden setting.

### *How should sky terraces be designed?*

### 2.2.1: Size them sufficiently for public use

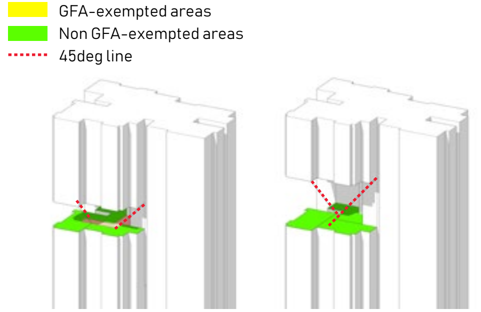
Sky terraces shall be of a meaningful size and configuration for communal use - as a general guide they should have a minimum depth of 5m.

Sky terrace areas are exempted from GFA computation up to an area defined by a 45-degree sloping line taken from the edge of the overhanging structure.

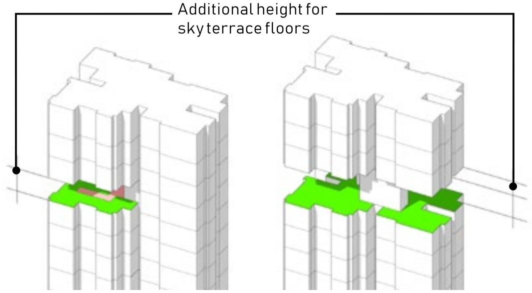
The 45-degree line principle encourages developers to provide loftier sky terraces, as higher volume spaces are visually more attractive and promote healthier plant growth. The 45-degree line will be measured from the edge of any overhanging permanent or opaque structure (excluding drop panels).

Developers are encouraged to provide larger sky terraces (also known as predominant sky terraces) occupying more than 60% of the building floor plate through additional GFA exemption and height relaxation.

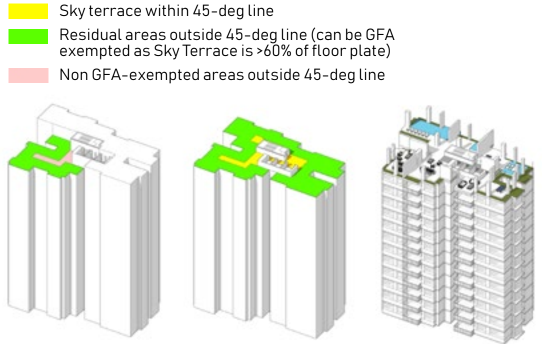
> ***Sky terrace guidelines***
> Sky terrace guidelines were first introduced in 1997 and incorporated into LUSH in 2008. The guidelines stipulate the design requirements and GFA exemption incentives to encourage bigger, greener and loftier sky terraces.
>
> Find out more at this link.



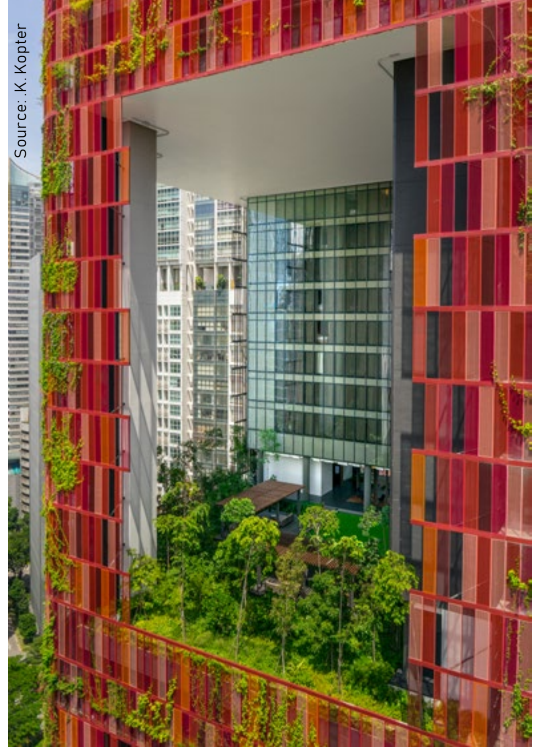

*The 45-deg line encourages developers to provide loftier sky terraces, as higher volume spaces have more GFA exempted floor areas*




*Predominant sky terraces can enjoy additional floor-to-floor height (only applicable on the sky terrace level)*




*Predominant sky terraces can enjoy more exemption of residual areas beyond areas defined by the 45-deg line)*



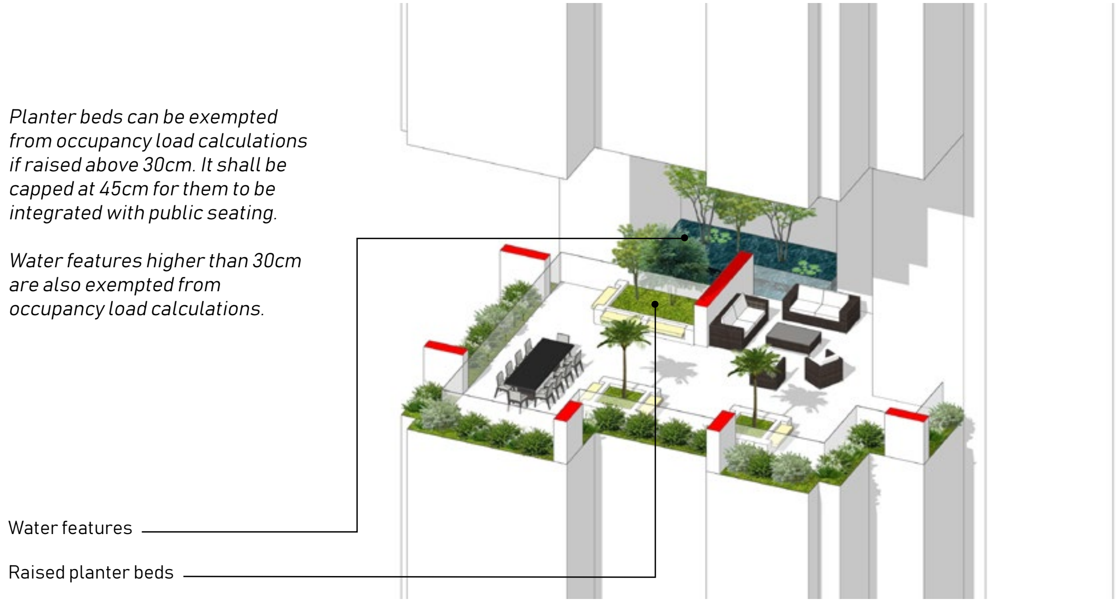

*Sky terrace at Oasia Downtown Hotel*

### 2.2.2: Ensure communal access and lush landscaping

Sky terraces must be accessible to the public or building occupants. There shall be at least one set of common lifts or staircases serving the sky terrace.

Sky terraces shall also be generously landscaped, with a preference for sunken planting beds for better spatial and visual openness. Planter beds should have sufficient soil depth for healthy plant growth.

As popular gathering spaces, sky terraces account for a higher occupancy load factor and fire escape requirements.




Nonetheless, landscaping features such as planter beds can be omitted from occupancy load calculations provided they have a minimum height of 30cm and fully covered in planting, to ensure they are used for planting rather than as occupiable spaces.

Where taller raised planters are proposed, they should be designed in a manner that ensures the sky terrace remains a generally open and unenclosed space with contiguous and meaningfully-sized gathering areas.

Architects and designers have to balance between spatial design outcomes, plant growth and fire safety considerations, to ensure that sky terraces remain enjoyable public spaces and are designed with safety considerations.

### 2.2.3: Keep open and unenclosed for good views

To ensure good views from the sky terrace and to allow the greenery to be visible from outside, sky terraces must remain unenclosed with at least 40% of the perimeter of the sky terrace kept open.

The perimeter is considered open as long as parapet walls are kept 1.3m or below in height. For predominant sky terraces, at least 60% of the perimeter shall be kept open.

Extensive shear walls should also be minimised within and along the boundaries of the sky terrace space, as they reduce the sense of openness for public enjoyment.

**CASE STUDY**

# A living tower of green

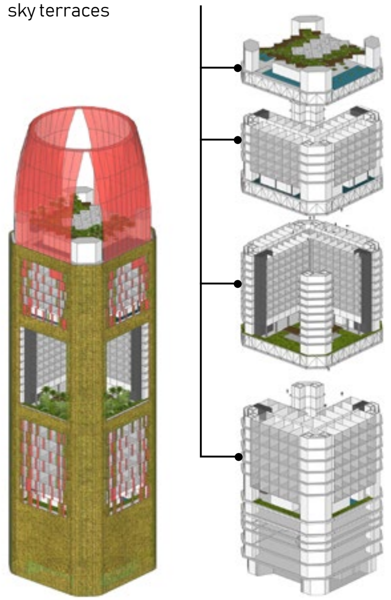
## Oasia Hotel Downtown | 2016

Location: 100 Peck Seah Street
Developer: Far East SOHO Pte Ltd
Architect: WOHA Architects Pte Ltd
Landscape Consultant: Sitetectonix Pte Ltd
Main Contractor: Who Hup (Private) Ltd
Mechanical & Electrical Engineer: Rankine & Hill (S) Pte Ltd

Source: Patrick Bingham-Hall

One project that has stretched the imagination on how sky terraces can be integrated in a development is Oasia Hotel Downtown.

Completed in 2016, it is hard to miss this landmark with its red mesh façade covered in flowering creepers rising 191m tall next to Tras Link Park in Tanjong Pagar.



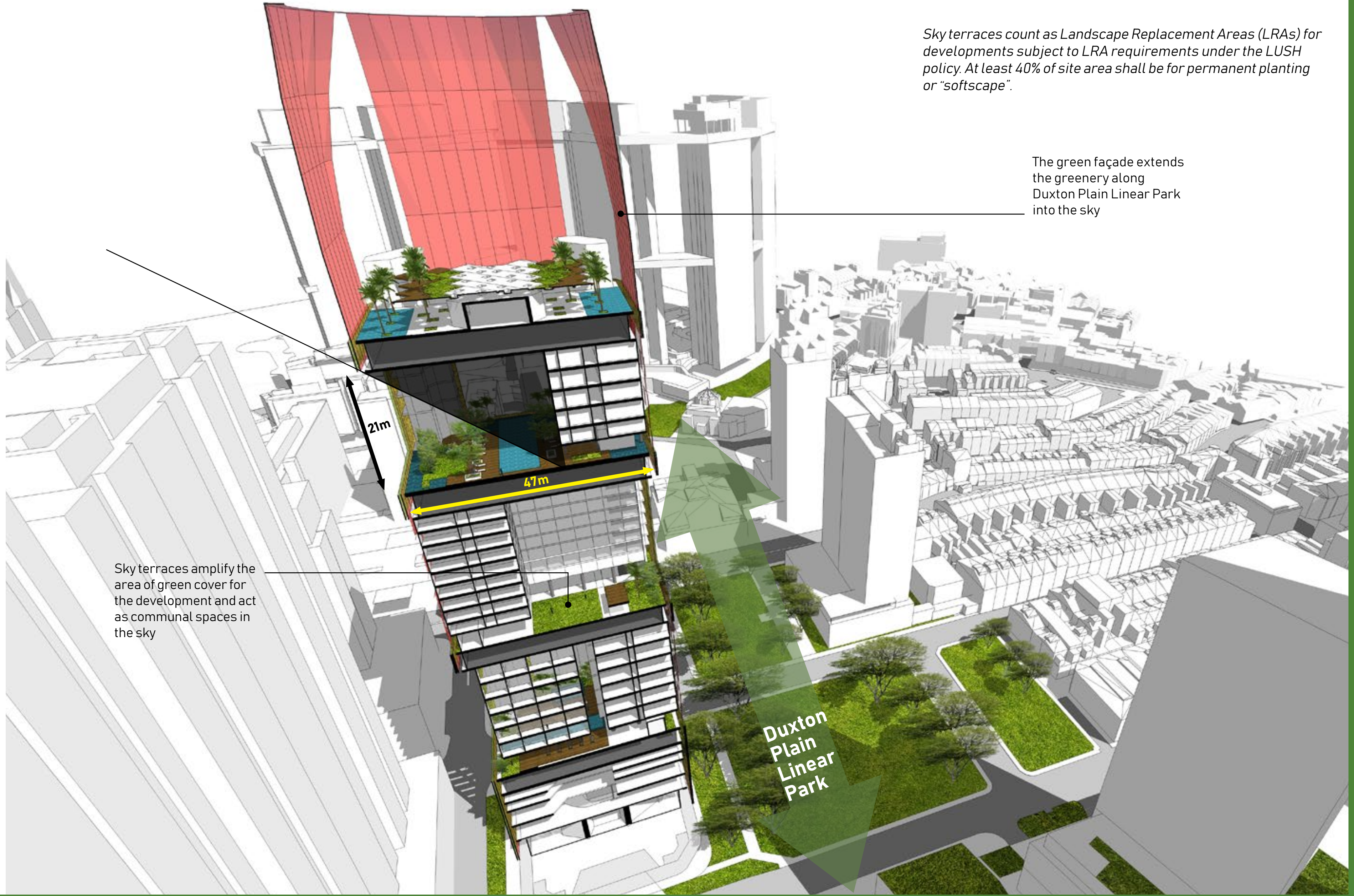

Described as a "device in the city that supports a thriving eco system three-dimensionally in a very dense environment", Oasia Hotel Downtown is designed around a series of three lofty, lushly planted sky terraces that define the building in four distinct segments. It also has a vegetated outer skin of aluminium mesh covering the entire building.

**Predominant sky terraces**

WOHA Architects designed each sky terrace to occupy almost the full building floor plate, with the lift and service cores at the four corners of the building. This opened up the sky terrace into a more contiguous space enjoying 360-degree views of the city, which would not have been possible with a typical centre-core tower.

By occupying more than 60% of the floor plate and being more than 60% open-sided, each sky terrace qualified for additional GFA exemption for residual areas and additional height allowance, under the 'predominant sky terrace' incentive.

An additional bonus height of 15m was granted to be used for the sky terrace floors (different height bonuses are applicable depending on the overall storey height of the development). Each sky terrace therefore has at least a 1:1 height-depth ratio, creating a bright and airy environment with generous cross-ventilation.



**More than 10x green**
According to the design team, the amount of replacement greenery in Oasia Hotel Downtown is over 10 times the site area.

The development has managed to achieve this with the help of generous sky terraces.

Compared to a traditional podium-tower building, which has limited horizontal surface areas for greenery (see diagram below), Oasia Hotel Downtown's three Predominant Sky Terraces and roof garden created additional areas of greenery, multiple times the site area.

**An easily maintainable green façade**
An extensive green façade covers the entire building, adding an additional 25,000sqm of landscaped surface area to the building, forming a "vegetated outer skin".

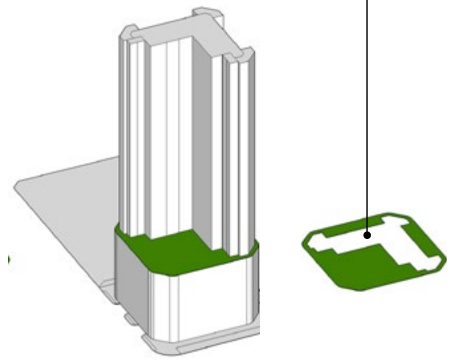
The green façade also acts as a sun break, absorbing heat and providing self-shading to combat the greenhouse effect in the hotel rooms.

Oasia Hotel Downtown extends the greenery of the linear park from ground level to the sky through its extensive green facades.

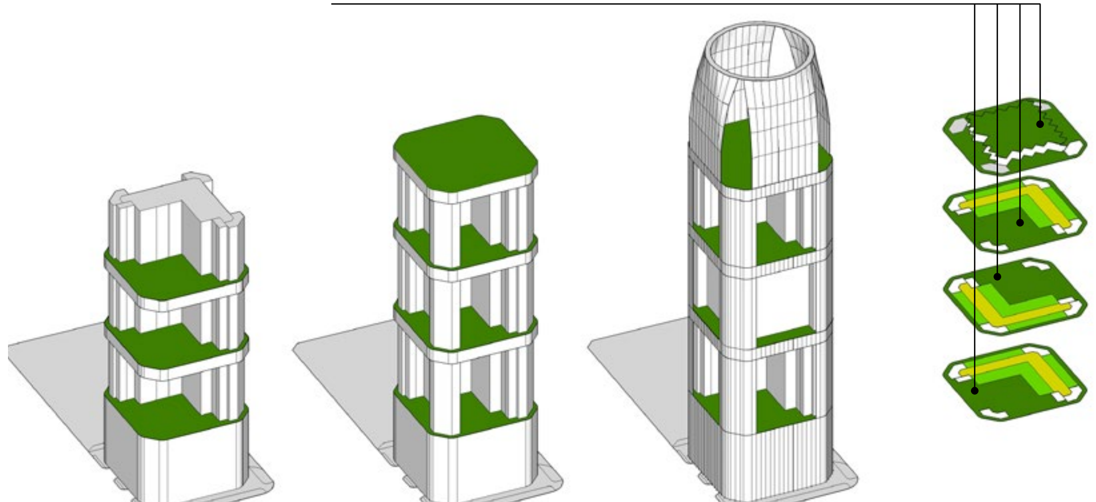
The landscape architects stressed the necessity of easy maintenance and good soil depth for the green facade planters to ensure lush plant growth in keeping with the ambition and scale of the greening. Hence they designed 1m deep planters all along the edge of the façade, at each level or at least every other level of the building.

Access was built in to every planter in the form of cat-ladders, so that maintenance can be done without the need for ropes or gondolas.

A traditional podium-tower block has limited horizontal surface areas for greenery



Oasia Hotel Downtown's three sky terraces and roof garden have multiplied the site area for greenery by several times





This diagram illustrates how GFA exemption was applied for the 21st storey sky terrace in Oasia Hotel Downtown.

To qualify for GFA exemption, the sky terrace shall be:

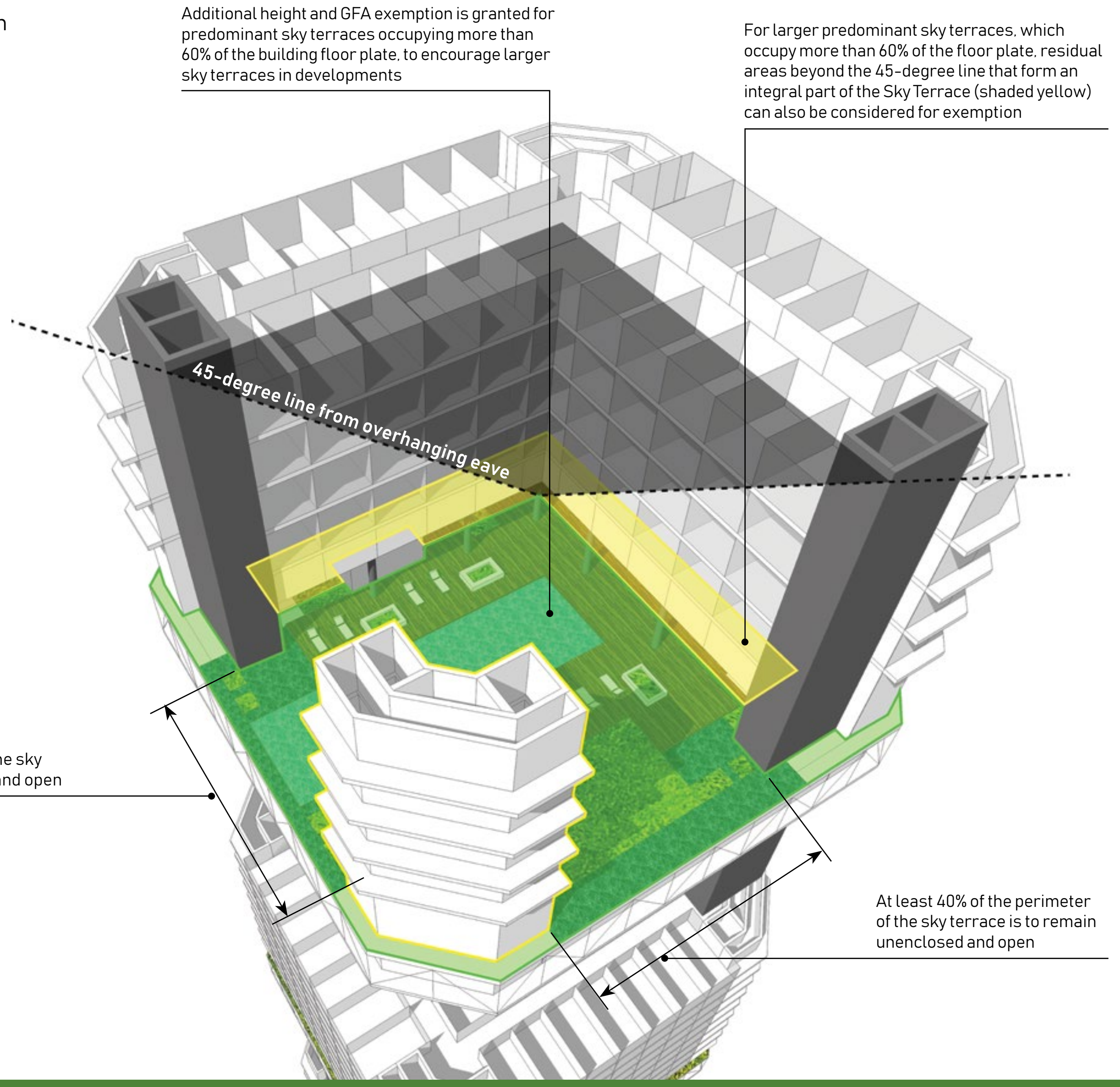
a) Lushly landscaped;

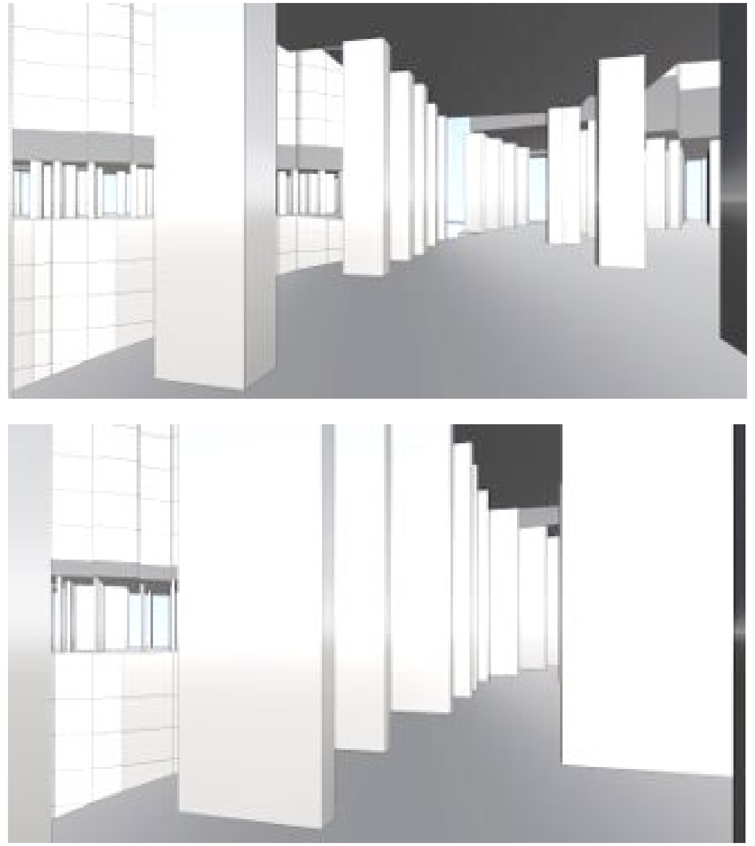
b) For communal use;

c) Generally kept open (at least 40% of the perimeter of the sky terrace is to remain unenclosed); and

d) Minimally 5m in depth.

The general area of the sky terrace that is exempted from GFA is defined by a 45-degree line from the overhanging eave / external wall (shaded green).





*Studies on shear wall depth around the perimeter of sky terraces*

*CONCEPTS EXPLAINED*

## *Why does URA discourage long shear walls along sky terraces?*

There is performance criteria for sky terraces to meet in order to qualify for GFA exemption. In general, they are required to be open-sided, lushly landscaped and communally accessible, to ensure that they work well as attractive public spaces in the sky.

URA requires sky terraces to be open-sided and unenclosed to ensure that greenery within them can be enjoyed by the building users as well as the surrounding environment. It also ensures qualities of openness and good views for occupants within the sky terrace.

At least 40% of the perimeter of the sky terrace must be kept open. While parapet walls can be provided along these stretches, they should not exceed 1.3m in height. For predominant sky terraces, the requirement is 60% of the perimeter.

The use of shear walls especially in Residential developments sometimes poses a challenge in meeting this objective. Without careful management, extensive shear walls and deep columns can significantly affect the spatial quality and sense of openness of sky terraces. They can form continuous visual walls when viewed from an angle and significantly narrow the field of vision of people in the sky terrace.

Where possible, developments should minimise the depth and frequency of shear walls along the outer edges of sky terraces. One option is using transfer beams to reduce the needed depth of column members or creating openings in the shear walls to create visual porosity. Planters should also be sited along the edges of the sky terrace to allow them to be appreciated from the surrounding environment.

# 2.3

# GREEN ROOFS


*Extensive green roof at Skool4Kidz Campus@Fernvale*

**What are green roofs?**
Green roofs refer to publicly accessible roof gardens or non-accessible roof covers planted with greenery.

They are a relatively easy way to make up for the shortfall of green spaces and surfaces in the city, as existing buildings can be quickly retrofitted with green roofs.

Non-load bearing roof canopies with a thin layer of planting are known as **Extensive Green Roofs.** Newer developments are usually designed upfront with publicly accessible roof gardens, with deep soil beds to support plant growth – these are also known as **Intensive Green Roofs.**

Green roofs help with energy conservation, with some studies suggesting they can reduce up to 79% reduction of peak cooling load on buildings. They are also known to help mitigate pollution and support biodiversity in the city[20].



### *How should roof gardens be designed?*

### 2.3.1: Form attractive landscaped areas for public enjoyment

Prior to the introduction of the LUSH Guidelines in 2009, roof areas in buildings around Singapore were typically inaccessible spaces used for M&E services.

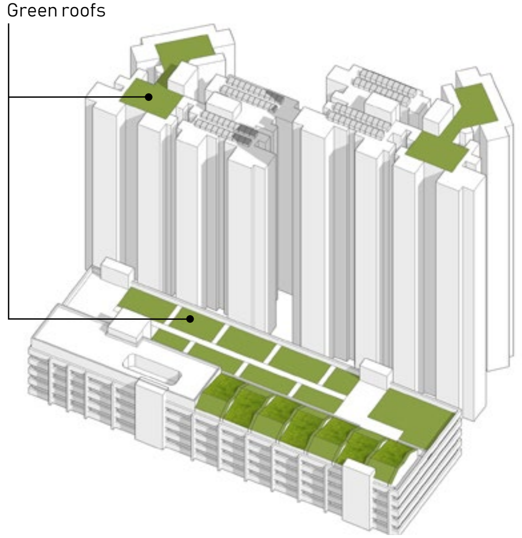
When landscape replacement area provision became mandatory for certain developments under LUSH, roof areas quickly became critical areas for planting, being horizontal planes that could be designed with greenery.

New developments began to incorporate lush gardens into roof spaces for public enjoyment. NParks also offered a cash grant to co-fund the installation of green roofs on existing older buildings in 2008.

To count as LRA, green roofs have to be well-designed and lushly landscaped for communal use by the public or building occupants.

Under LUSH 3.0, extensive green roofs, which are not accessible, are also allowed to qualify as LRA.


*Intensive green roof at Kampong Admiralty (publicly accessible)*




*Green roofs can take the form of publicly accessible roof gardens or non-accessible extensive green roofs*

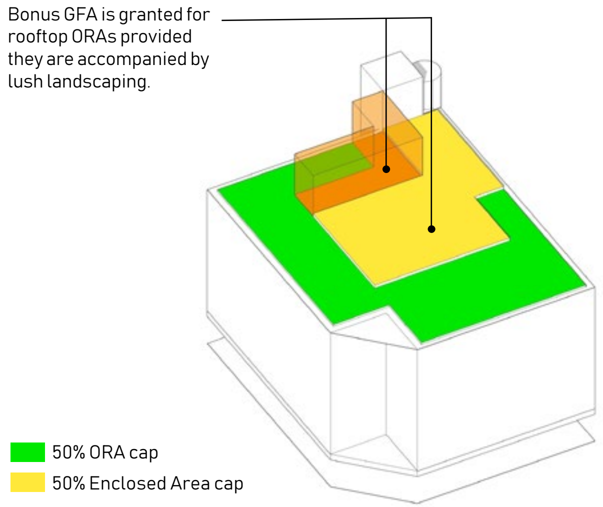
## 2.3.2: Support activities such as rooftop dining, urban farming and solar farms

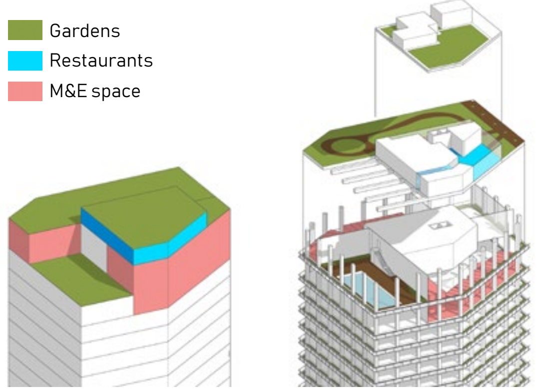
To encourage building owners to convert rooftop spaces into attractive roof gardens, URA began to grant bonus GFA for rooftop outdoor refreshment areas (ORAs) under LUSH in 2009.

The guidelines were introduced for developments in Downtown Core, as well as parts of Orchard and Singapore River planning areas, and incentivised rooftop bars and restaurants in open settings, offering dining options with dramatic views and lush greenery in the city.

Under the scheme, the rooftop ORA is capped at 50% of the overall roof space or 200sqm, whichever is lower, to ensure that the majority of the roof area is kept for landscaping. The ORA is to be designed as an open and porous structure, with only 50% of the bonus GFA allowed to be enclosed (e.g. as kitchens or service areas).

URA also began allowing rooftop urban farms and greenery beneath solar panels to be counted as landscape replacement areas under LUSH 3.0 in 2017. This helps to augment Singapore's food and energy resilience, beginning a new chapter on roof areas being used as green and productive spaces.




*Rooftop M&E spaces are encouraged to be transferred to one of the top three floors below the roof to free up the roof area for greenery*

## 2.3.3: Transfer M&E spaces to one of lower three floors

Prior to LUSH, rooftops were usually used for M&E equipment where they were exempted from GFA, being open to the sky or concealed under screening trellises or roof covers.

URA now allows rooftop M&E services to be transferred from the roof to one of the top three floors directly below the roof, where they could continue to be exempted from GFA, in order to free up the roof area for greenery.

Any M&E services or back-of-house facilities remaining on the roof level, such as lift motor rooms or staircase cores, shall be clustered and integrated into the roof design.



**CASE STUDY**

# Village green for a vertical kampung

## Kampung Admiralty | 2017

Location: 676 Woodlands Drive 71
Developer: HDB, MOH, NEA, NParks, LTA, ECDA and Yishun Health Campus (YHC)
Architect: WOHA Architects Pte Ltd
Landscape Consultant: Ramboll Studio Dreiseitl Singapore Pte Ltd
Main Contractor: Lum Chang Building Contractor Ltd
Mechanical & Electrical Engineer: AECOM Pte Ltd

In land-scarce Singapore, green spaces are making a comeback in the form of green roofs on buildings. In the north of Singapore, a lush roof garden paradise with edible plants, vegetables, fruits and spices, is being tended to by senior citizens and nearby residents, located within an integrated community development.

This integrated community development is Kampung Admiralty, combining senior care, studio apartments, hawker centre and medical centre with a lush roof garden, in the heart of Admiralty.

A mixed-use planning approach was adopted to co-locate different uses in this development to create a convenient one-stop senior care hub next to the MRT station.

The green roof became a unifying architectural feature to tie the various uses together and create an immersive, therapeutic environment for seniors to live, work, play and farm in a 'kampung' (referring to villages in the local vernacular) setting.

**Behind the design**
The project was initiated through the collective effort of several agencies – the Housing Development Board, Ministry of Health, Alexandra Health System, National Environment Agency, NParks, Land Transport Authority and Early Childhood Development Agency. Various functions were integrated with the development.

The close proximity of healthcare, social, commercial and other amenities supports inter-generational bonding and promotes active aging in-place.

This means that the elderly residents of 104 studio apartments in Kampung Admiralty can continue to live and age actively and independently in their own homes and community, with easy access to medical and other institutional support.

To bring the different programmes and users together, WOHA designed the green roof at Kampung Admiralty as a series of terraced gardens, spread over the 3rd to 9th storey, to act as a "village green" for the development.

## A blending of green and blue

To recreate the setting of a tropical forest and 'kampung', the roof garden was covered in burgeoning fruit trees, herbs and spices, vegetables and medicinal plants. Familiar edible plants being harvested by the residents here are chiku, longan, chilli, and sweet potato leaf.

In total, permanent greenery covers over 50% of the building's site area, helping to contribute to 100% landscape replacement area.

What is less visible is the water management system designed into the building and roof garden, which collects and cleanses rain water for irrigation of the development's landscaping and community farm.

A rain garden on the 3rd storey forms a dramatic landscape bringing light and greenery into the medical centre. A rainwater harvesting tank detains and recirculates excess water to the drainage network.


*Section of Kampung Admiralty*

## Multiplier effects on biodiversity

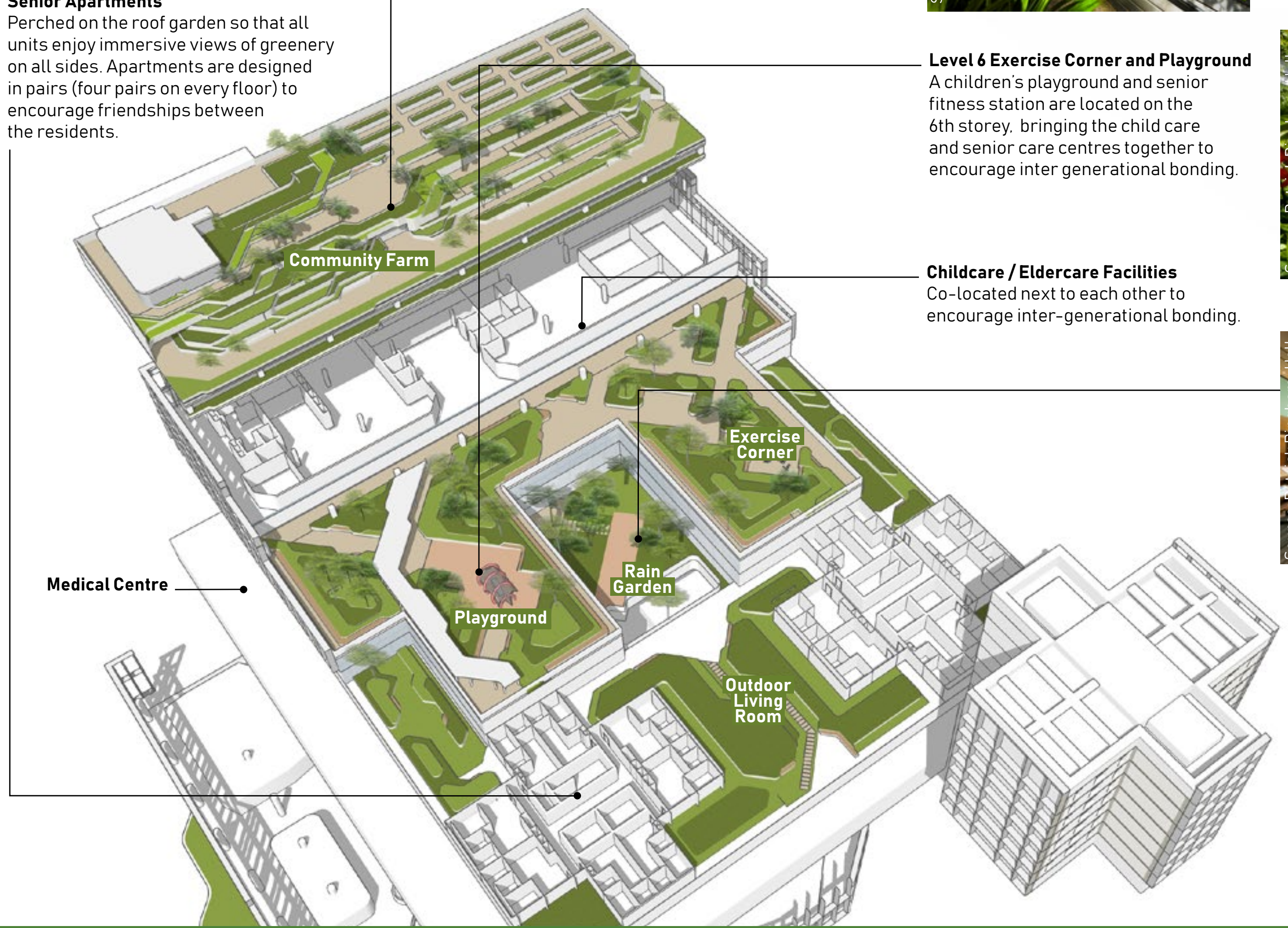
bioSEA conducted a biodiversity audit for Kampung Admiralty in 2018 and found a rich diversity of 50 animal species attracted to the development, attracting more animal species than nearby parks such as Woodlands Crescent Park and Woodlands Admiral Garden. [21]

Their study concluded that this could be attributed to the community farm on the green roof, as it was largely kept pesticide free and had a rich variety of edible plants.

WOHA designed the green roof as a series of terraced gardens, spread over the 3rd to 9th storey, to act as a "village green" for the development.

The roof garden is lushly landscaped to create an immersive green environment that put residents and visitors at ease, and cleverly structured around different themes that supported social interaction.

**Senior Apartments**
Perched on the roof garden so that all units enjoy immersive views of greenery on all sides. Apartments are designed in pairs (four pairs on every floor) to encourage friendships between the residents.




**Level 9 Urban Farm**
The community farm is located on the 9th storey, with farming boxes linked by handicapped-friendly ramps for barrier free access. This farm is tended to by volunteer gardeners under NParks' Community in Bloom initiative.

**Level 6 Exercise Corner and Playground**
A children's playground and senior fitness station are located on the 6th storey, bringing the child care and senior care centres together to encourage inter generational bonding.

**Childcare / Eldercare Facilities**
Co-located next to each other to encourage inter-generational bonding.

**Level 3 Rain Garden**
The 'rain garden' courtyard sits in the middle of the polyclinic on the 3rd storey, bringing sunlight and greenery views to patients and staff. Rainwater is also channeled here first before going to the eco pond on the first storey.

BEHIND THE SCENES

# Pushing the boundaries of living with nature

*Phua Hong Wei and Pearl Chee are directors at WOHA, which is responsible for three of the case studies in this book, namely Kampung Admiralty, Oasia Hotel Downtown and PARKROYAL Collection Pickering. They talk about WOHA's motivations behind its impressive track record in creating trend-setting biophilic architecture.*

***WOHA's projects regularly stand out when it comes to greenery and sustainability. Can you share with us what drives WOHA to constantly push the limits of green design?***

**Hong Wei**: We imagine tropical buildings as a generous, responsible and sustainable typology that can contribute back to the city. It is not just about green-washing, but how the greenery can benefit not just the development but the surroundings.

**Pearl**: I think that passive design really needs to make a comeback. For a very long time we have tried to emulate what the west is doing. Because we are going for high density, high-rise, hence we see glass boxes in our downtown.

From our experience with the three buildings [in this guidebook] people are actually quite comfortable to be outdoors. We are studying how these typologies that incorporate natural ventilation can work in other climates too.

***PARKROYAL Collection Pickering is a project described as having a higher upfront cost to get the greenery and sustainability systems in place, with cost savings in the long run. How were these costs and savings quantified, and has this actually panned out well for the building owners?***

**Hong Wei**: Sometimes we do get pragmatic with the numbers and costs but the benefits of nature cannot be quantified entirely because the returns are always much, much more. We make it a point to commission ecosystem services surveys to understand the performance of the building in health and comfort, and biodiversity surveys to quantify and track nature attracted by the building.

The costs of maintenance are always a concern. However, the benefits of nature cannot be entirely quantified – the value of greenery in our buildings is so much more.

**Pearl**: The simple rule-of-thumb for designers is we always want to be able to walk right up to the landscape to maintain it. If there are maintenance units or cranes then usually it is not very sustainable, or acceptable to the developer.

**Hong Wei**: It almost has to be low tech. It takes a collective effort from the developer, consultants and stakeholders to steward the project to deliver more socially and environmentally responsible buildings. We cannot run away from maintenance, we have to see maintenance as a means to desired outcomes too. In PARKROYAL Collection Pickering, the client was convinced of the design, as they also saw that the finished product would be differentiated from others.

***Urban greenery can significantly boost the natural ecosystem if done right. Are there any interesting ecological outcomes as a result of your building designs?***

**Hong Wei**: It made some news the year before. A Himalayas vulture was seen hovering around Oasia Downtown Hotel. For Oasia, it's only one building surrounded by a concrete jungle, so there's only so much you can do in terms of attracting or supporting an ecosystem.

However we commissioned ecosystem surveys for Oasia and Kampung Admiralty. Dr Anuj of bioSEA did a projection that if you have ten Oasias they would create sufficient mass to host the same number of urban adapted species as you can find at Duxton Park.

**Pearl**: We are happy that with data evidence, greenery in buildings can be successful and it will be beneficial to the city – to link and connect greenery between buildings if possible. Like Hong Wei said - if we had ten Oasias, the impact on the city can be tremendous.

***What do you think should be the next step for LUSH and URA?***

**Hong Wei**: The LUSH programme is a game changer. It motivates and reinforces the need to have skyrise greenery. I think we all can see that Singapore is ahead of the curve in terms of that. It is now up to the designers to see how we can optimize and maximise the guidelines.
attracting or supporting an ecosystem.

The longer version of this interview can be found at this link.

# 2.4

# COMMUNAL PLANTERS


*Publicly accessible Communal Planters at PARKROYAL Collection Pickering*

**What are Communal Planters?**
These are externalised planter boxes installed within the building that support vegetation growth, within publicly accessible areas.

Planters can form a significant part of landscape replacement strategy in a development, especially multiplied over many floors in a high-rise building.

Research has found that greenery on building facades, especially along urban canyons, can reduce nitrogen dioxide ($NO_2$) and particulate matter (PM) along the street by 40% and 60% respectively[22].

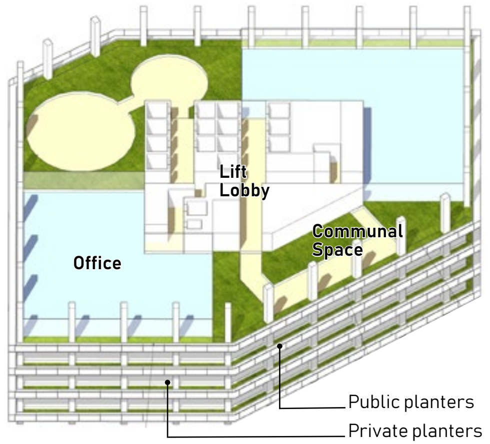


*How should communal planters be designed?*

## 2.4.1: Locate in communal areas for public enjoyment

To enjoy GFA exemption, planters shall be located along communally accessible areas of the building, where more people can enjoy them. Planters accessible only from individual residential or office units are considered private planters and not eligible for GFA exemption.

This is because such planters could be converted to other uses, or have their planting removed over time.




*Green roofs can take the form of publicly accessible roof gardens or non-accessible extensive green roofs*

## 2.4.2: Design for function – plant growth and maintenance

Planter beds and boxes provide the medium for vegetation to grow in developments. To support healthy plant growth, they should have sufficient soil depth. The recommendation is minimum 1m depth for trees and 50cm for shrubs and other smaller plants.

Hence the planters shall be designed upfront as part of the building design, instead of having to be modified around beams, slabs and columns which are planned before the landscaping stage.

Structural engineers have to account for heavier soil weight assumptions to account for plant growth, e.g. a large tree can weigh 2-4 tonnes initially and increase to 4-5 tonnes over 10 years.

Good drainage is also needed in the planters to prevent waterlogging of soil which leads to root rot.

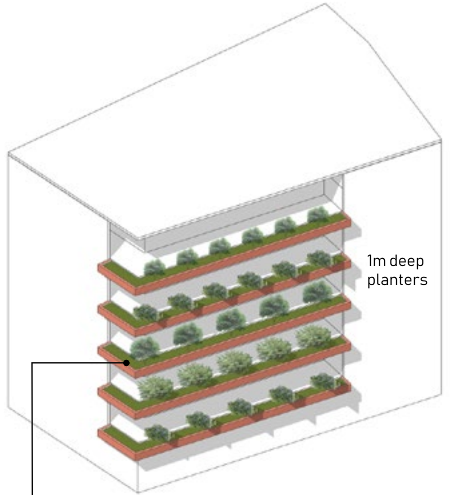
Architects should also plan for easy maintenance. Planters on the building exterior shall be designed for easy access by gardeners, e.g. with catwalks or maintenance paths.


*Planters up to 2.2m wide are incorporated into the façade of the Lee Kong Chian Natural History Museum*

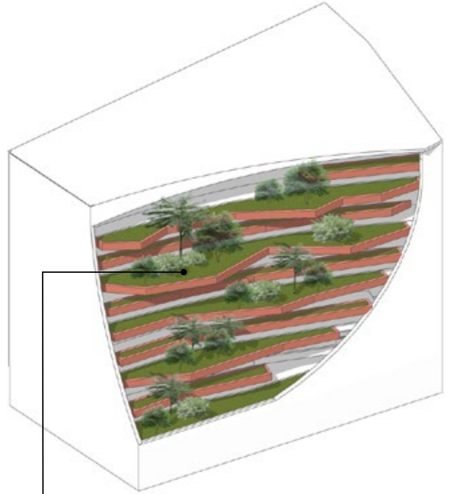
## 2.4.3: Incorporate as part of integrated landscape designs

To be exempted from GFA, communal planters are generally to be kept at 1m in width and should have a minimum depth of 50cm to support plant growth. Communal planters should also be sufficiently externalised and visible from outside the building.

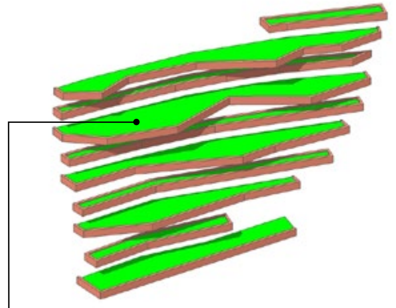
However, larger communal planters exceeding 1m width can also be considered for GFA exemption, in consideration of the overall landscaping scheme for the development.




Typically, planter boxes must be communally accessible and not exceed 1 metre width to qualify for GFA exemption



URA may consider GFA exemption for larger communal planter boxes if they are part of a larger landscaping scheme, based on design merit



GFA exemption areas – more than 1m width per planter

### *CONCEPTS EXPLAINED*

# *What is green plot ratio and how is it computed?*

To ensure better density and quality of planting, green plot ratio (GnPR) standards were introduced as part of LUSH 3.0.

The GnPR framework was originally developed by Dr Ong Boon Lay of NUS in 2002, to help estimate the environmental benefits of greenery[23].

Higher leaf density would generally result in greater water retention and carbon dioxide uptake by the plant. Setting minimum green plot ratio standards therefore ensure higher density and quality of planting in a building.

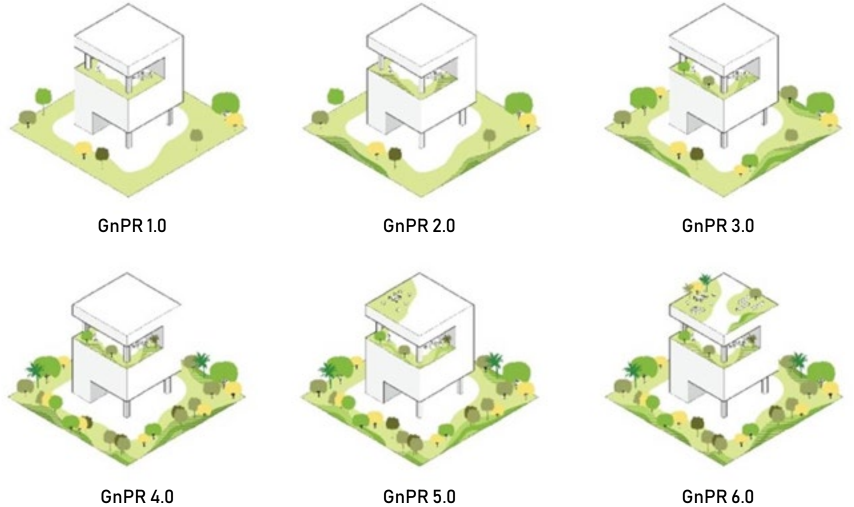
GnPR is computed by taking the total leaf area of greenery provided in softscape areas divided by the site area. Larger, leafier trees and plants have a higher leaf area index (LAI) value.

To obtain the Leaf Area Index (LAI) of various plant species, applicants can refer to the Flora Fauna web portal set up by NParks.

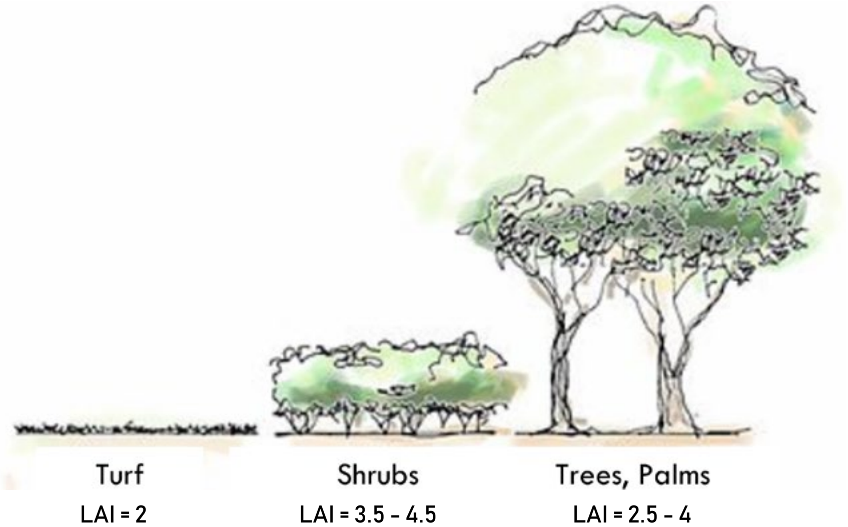
The minimum GnPR requirement for developments ranges from 3.0 to 4.0, depending on the development density (GPR) and location (within or outside Strategic Areas).

***Green Plot Ratio***
The green plot ratio (GnPR) provides an objective measure of the density of greenery within a site. Find out more about the requirements at this link.

The Leaf Area Index of various plants can be found at the NParks Flora and Fauna web portal, at this link.




$$\text{Green Plot Ratio} = \frac{\text{Total Leaf Area within LRA}}{\text{Site Area}}$$



*CASE STUDY*

# Planters in the sky

## PARKROYAL Collection Pickering | 2013

Location: 3 Upper Pickering St
Developer: UOL Group Limited
Architect: WOHA Architects Pte Ltd
Landscape Consultant: Tierra Design Pte Ltd
Main Contractor: Tiong Seng Contractors (Pte) Ltd
Mechanical & Electrical Engineer: BECA Carter Hollings & Ferner (S. E. Asia) Pte Ltd

Source: Patrick Bingham-Hall

PARKROYAL Collection Pickering needs little introduction. Its breathtaking greenery hanging over the sides of terraces and planters, overlooking Hong Lim Park, have fired the collective imagination of travellers and fans of green architecture worldwide.

So much so that when the Council of Tall Buildings and Urban Habitat (CTBUH), an international body in the field of tall buildings, compiled the list of 'The 50 Most Influential Tall Buildings of the last 50 years' in 2019, this building was one out of only three buildings with vertical greenery featured, amongst other landmark buildings like Burj Khalifa (Dubai) and One World Trade Center (New York) in the list.

**A vertical extension of Hong Lim Park**
When URA launched this sale site in 2007, the intention was for the greenery of Hong Lim Park to be extended into the development through well-landscaped open spaces at street level.

WOHA Architects, with the support of the client, conceptualised the design for planters at various levels of the building to extend the sense of green from park vertically up the building. They also took it upon themselves to ensure that sustainability would permeate all aspects of design, including the long-term performance and maintenance aspects of the building.

**Behind the design**
The design of the building was strongly motivated by the idea of 'giving back to the city', continuing the act of altruism of Mr Cheang Hong Lim's, when in 1876 he bought and donated the land that became Hong Lim Park, a 9'400sqm patch of greenery in the city[24].

The architects and client were inspired to mirror the creation of greenery on a vertical scale, and would go on to eventually achieve a reported 15,000sqm of greenery within the development, double that of the site area.

In addition, the valuable ground plane was kept open as a porous public space, instead of being maximised for other commercial uses. Planters were widely deployed throughout the development to create walls of greenery along Upper Pickering and Upper Hokien Streets.

The building treats the tree canopy line as a new datum of greenery in the city, one which visually merges with the lushly landscaped podium deck and breaks the volume of the building into two parts, to allow it to respond to the city at different scales.

The 5-storey tall podium, housing the carpark and lobby, forms a human-scale presence along the street with a tiered sculpted façade embellished with planters.

Above it are perched the hotel and office towers on stilts, with sky gardens and planter boxes hanging on the façade that are visible from surrounding areas.

**An orchestration of planters**
PARKROYAL Collection Pickering features planters ranging in widths up to 3.9m wide, allowing a symphony of planting to be created across the building.

The landscaping palette was also carefully developed to create a lush and exotic tropical garden.


Source: WOHA Architects

*Section of PARKROYAL Collection Pickering*

**City Scale** – towers and sky gardens relate to the skyline

**Street Scale** – podium and planters relate to the streetscape

**Planters in the sky**
The sky garden planters at tower level facing the park are planted with a combination of tall Palms and Frangipanis, which frame views of the city from the hotel room windows.

Sky garden planters at the rear are planted with man height shrubs like *calathea lutea* to screen away the rear service lane.

To avoid the need to use a maintenance gondola to maintain the greenery, the architects divided the building into blocks with linkways and terraces to allow ease of access for a gardener and a wheelbarrow to attend to every section of planting.

**Planters along the street**
The podium façade planters are planted with broad-leafed shrubs like *monsteras* to screen the podium carpark, while fast growing overhanging plants spill over the tiered planters.

On the street level, tall Frangipanis create an arbor along Upper Pickering Street to form an extension of Hong Lim Park. Dense undergrowth shrubbery prevent jay walking.
Shade-loving plant species were also chosen in response to varying light conditions along the four sides of the building.

An automatic irrigation system reduces need for manual watering of the planters. Gardeners only check and do trimming twice a week across the property.




**Supporting healthy plant growth**
Planter boxes shall be minimally 50cm deep to ensure sufficient soil depth to accommodate healthy plant growth. URA requires communal planters to be at least 1m in width and 50cm in depth to be considered for GFA exemption

**Naturally ventilated corridors**
Naturally ventilated corridors are additionally cooled by water features and overhanging creepers to make for a comfortable walk

**Putting greenery at eye level**
Planters are raised 500mm from finished floor level to ensure that the greenery is at eye level for guests seated or in the bath tub

# 2.5

## GREEN WALLS


*Green wall at Ocean Financial Building*

**What are green walls?**
Green walls refer to vertical surfaces of a building that are covered in greenery, that work hand in hand with communal planters to green up the building facade.

Some have climbing plants with self-clinging roots growing directly on cables or other surfaces. In recent years green walls have evolved to feature more varieties of plants on vertical mounting systems, sometimes with built-in irrigation.

Over the past 10 – 15 years in Singapore, green walls have made the transition from being mainly indoor features (e.g. Changi Airport Terminal 3, Six Battery Road) to building exteriors, sometimes covering the full height of skyscrapers (e.g. Oasia Hotel Downtown, Treehouse Condominium).

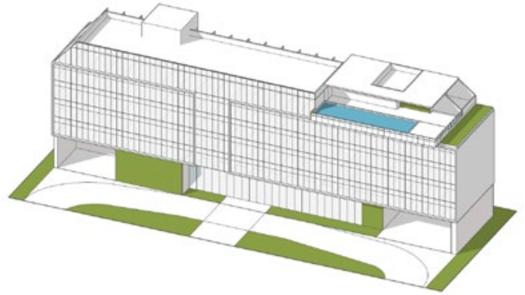
*How should green walls be designed?*

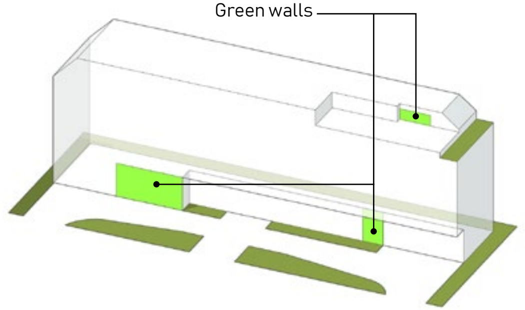
### 2.5.1: Integrate with overall building form and architectural treatment

As with communal planters, green walls shall be well-integrated into the overall design expression of the building, and visibly showcased.

Architects have used green walls to shield afternoon sun facing facades (e.g. Treehouse Condominium), dress up building frontages around a park (SMU), mark dramatic entryways (Ocean Financial Centre) and even wrap up entire buildings (Oasia Downtown Hotel).

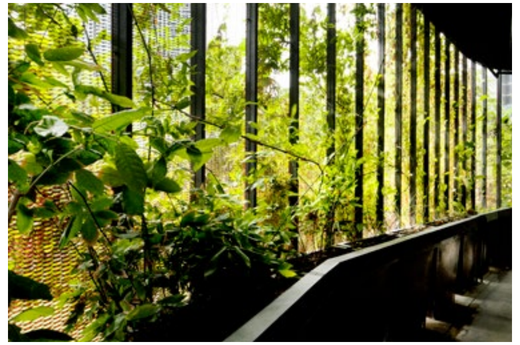
Under prevailing guidelines, green walls can count towards LRA requirements (capped at 10% of site area) if they are well-designed and integrated in the façade, externalised and visible from surrounding areas.






*Green walls should be well-integrated into the overall façade design and visibly located*

*Example of a tray system green wall*



*Example of a planter and climber system*

### 2.5.2: Ensure easy maintenance and upkeep

A wide variety of green wall systems are available for application in different contexts.

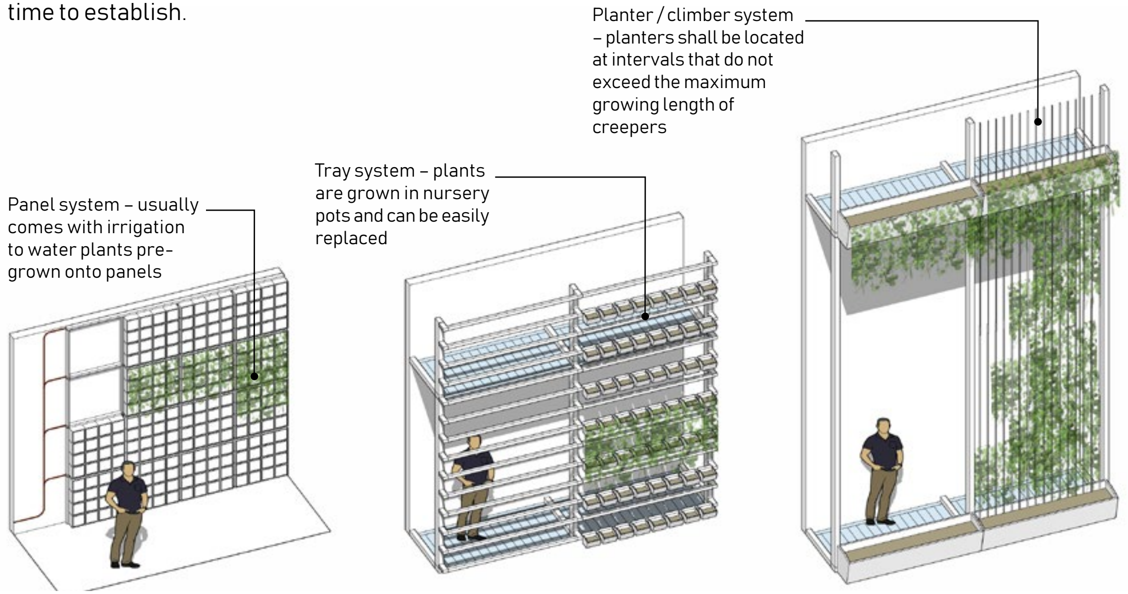
Panel systems green walls come with plants pre-grown onto panels (or cassettes) and installed vertically onto mounting structures.

Tray systems keep plants in nursery pots and can be quickly set up and refreshed.

Conventional planter and climber systems provide cables for creepers to climb on and take time to establish.

Regardless of the format, architects can design planters to be easily accessible for maintenance, e.g. through catwalks and ladders.

Certain green walls have provision of built-in irrigation systems to minimise the need for maintenance visits.




*Common green wall systems in Singapore include panel systems, tray systems, as well as planter and climber systems*

### 2.5.3: Harness cooling effects, shape ecological outcomes

Research carried out collaboratively by NUS, NParks and BCA indicated that vertical green walls help reduce temperatures, with a maximum of about 12 degrees recorded in the afternoon. This can lead to significant reduction in energy consumption to cool down the building.[25]

Many developments in Singapore therefore install green walls along facades facing the afternoon sun.

Green walls can also support local ecosystems. Flowering plants and creepers are attractive to pollinators and even birds. Bees have been known to fly up to the 19th storey of the green wall at Treehouse Condominium [26], while Himalayan Vultures have visited Oasia Downtown Hotel in Tanjong Pagar.[27]

Biodiversity surveys for the site can help identify appropriate plant species for the green wall that can benefit nearby wildlife.

***Green Walls***
Green Walls can be counted towards Landscape Replacement requirements.

Find out more about the requirements at this link.

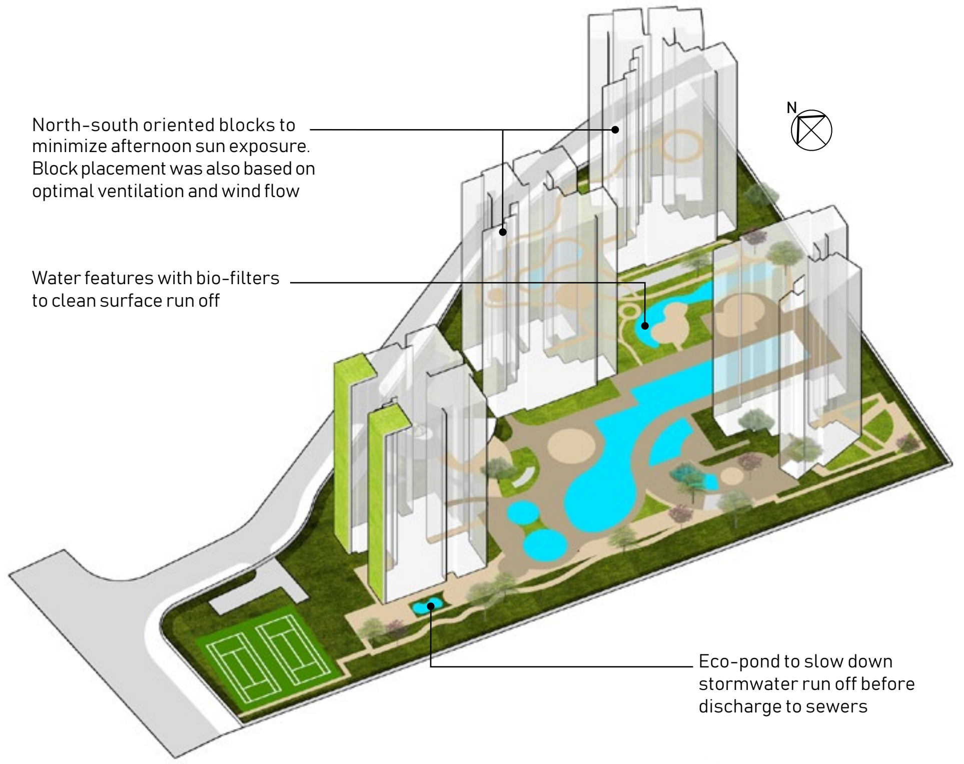
CASE STUDY

# Biomimicry: nature-inspired solutions

## Treehouse Condominium | 2013

Location: 60 Chestnut Ave
Developer: Chestnut Avenue Developments Pte Ltd
Architect: ADDP Architects LLP
Landscape Consultant: COEN Design Intl Pte Ltd
Main Contractor: Tiong Seng Contractors
Mechanical & Electrical Engineer: United Project Consultants Pte Ltd

Rising 24 storeys into the sky, the Treehouse condominium is a local landmark in the Dairy Farm neighbourhood. Strikingly, the entire façade is one continuous green wall – in fact the largest green wall in the world as certified by the Guinness World Records, a remarkable feat for a residential project in the suburbs of Singapore.



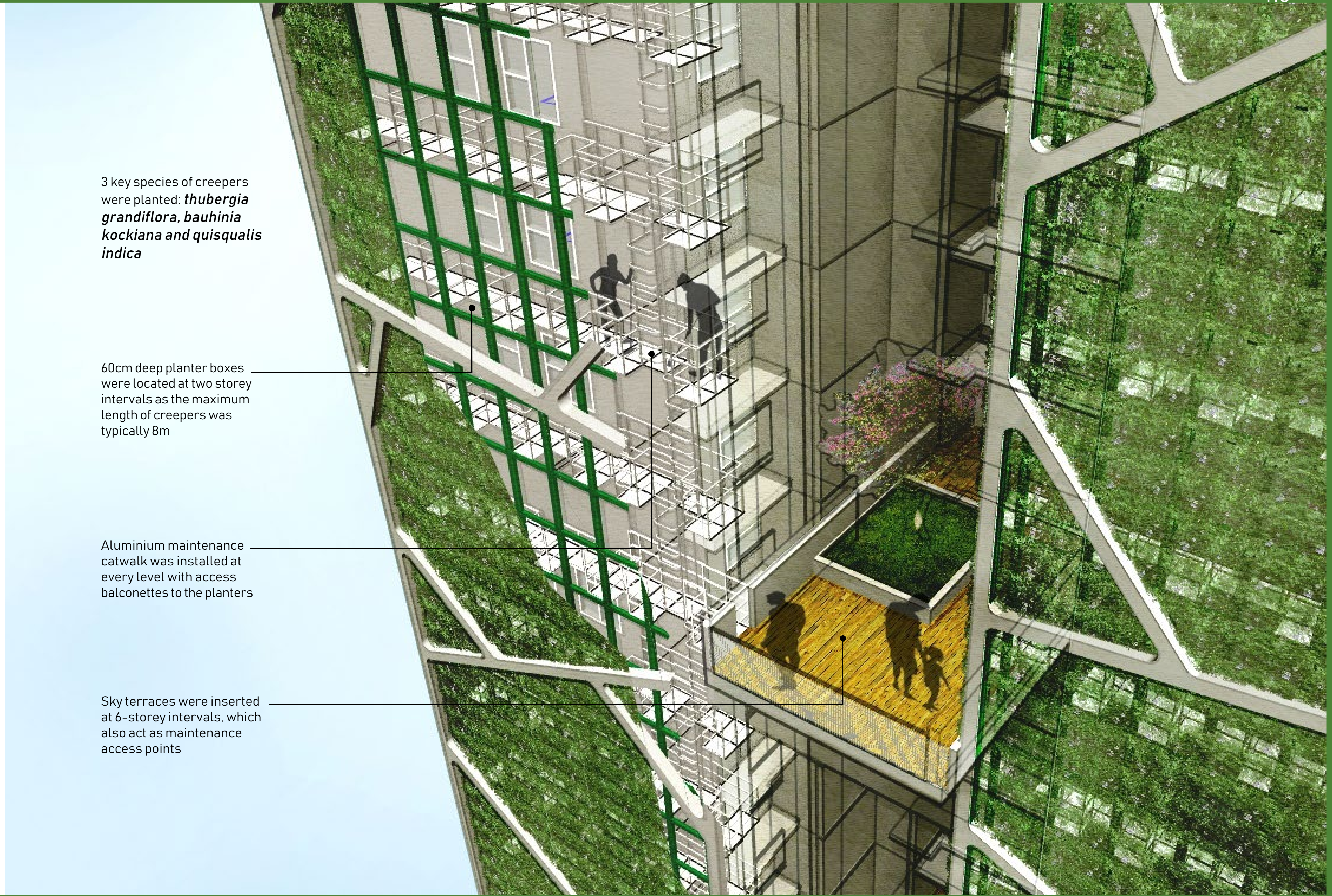

The architects at ADDP drew inspiration from the site context, to create an environmentally and ecologically sensitive development that would fit in and complement the nearby Bukit Timah Nature Reserve.

**A vertical bio-shield**
Bio-mimicry is not new in architecture, offering us solutions inspired by nature as we work towards more sustainable outcomes. In the case of Treehouse, the idea of photosynthesis was the starting point of inspiration for the architects.

Leaves can absorb sunlight as energy and yet dispel excessive amounts of it as heat. This inspired the architects to propose a 24-storey high green wall to act as a bio-shield on the westfacing end of the building, to harness the sun for vegetation growth but also block solar radiation heating up 48 master bedrooms behind the wall.

The developer shared that the green wall has cut the building's carbon footprint by reducing the need for air-conditioning, saving the residents between 15% to 30% of energy usage and over $500,000 in utilities costs a year.





*Green wall at Treehouse condominium, ADDP Architects*

**The world's largest green wall**
The construction and maintainability of a green wall of this size were key concerns.

While proprietary systems at the time such as soilless hydroponics were considered, a simpler, cheaper and more effective system was ultimately chosen: the conventional planter and climber system, modified to allow easy maintenance access and ensure lush green coverage.

Several species of creepers were used for the green wall: the fast-growing *thunbergia grandiflora* helped establish green cover quickly, while the slower-growing *bauhinia kockiana* (a woody vine) ensured a longer lasting layer of greenery. A third species *quisqualis indica* was added to attract pollinators like butterflies and bees.

As creeper plants can typically only grow up to 8m, the planters were located at every two storeys to ensure good coverage of greenery. The soil beds are also 60cm deep to allow for better root and plant growth.

Each planter was designed with its own aluminium maintenance catwalk access, with access balconettes interspersed along the planters to create points for pruning and cleaning debris.

Sky terraces were introduced at 6-storey intervals, so that maintenance workers would only have to walk up and down 3 storeys to access all parts of the green wall.

The landscape consultant also advised for a metal plate to be discretely installed at the top of the green wall, which would heat up in the sun and act as a natural barrier to creeper growth. This was to prevent the greenery from growing beyond accessible areas for maintenance.

As a finishing touch, the architects added a xylem inspired white aluminium lace pattern to the green wall.

The architects were not aware they had designed the world's largest green wall. Acting on a hunch, the developers contacted the Guinness World Records and made the discovery only after it was completed.

**A naturally ventilated basement**
Taking advantage of the topography, with slopes of 5m across the width of the site and 12m across the length, the architects created a semi-sunken carpark which was partially open for natural ventilation.

Strategic openings were introduced to bring in fresh air to avoid the need for mechanical ventilation. These voids also brought in daylighting and created views of the gardens above it for the carpark.

**Water management features**
Sited on sloping terrain, rainfall would be channeled towards a bio-retention basin at the lower southern end of the site, which would collect and slow down stormwater discharge into the public drainage system.

Treehouse condominium raised the bar in skyrise greenery and innovation, demonstrating how the world's largest green wall could be achieved using simple design and maintenance approaches. It is also a showcase of how sustainability requires a comprehensive approach, to consider environmental and ecological outcomes in the design.



*BEHIND THE SCENES*

# Pushing the boundaries of living with nature

*Tang Kok Thye and Raymond Yap are the project architects at ADDP who worked on the Treehouse Condominium project. They reflect on the challenges they face in realising skyrise greenery for their projects, and where we are as a society moving towards becoming a City in Nature.*

***It is a remarkable feat that a private condominium development in Singapore holds the Guinness World Record for the world's largest Vertical Green Wall, how did this come about?***

**Kok Thye (KT):** Getting the record was not our objective. We have to thank our collaborator from the developer's side for this. He worked on it with us from the concept stage and when it was completed, he asked if we had a chance to submit for the record. It wasn't our intention to get the "world's largest green wall" – and maybe because of that we had less pressure doing it but had a lot of fun instead.

**Raymond (R):** When we conceptualised the green wall we intended it to bring nature from the Bukit Batok Nature Reserve into the development. The original idea was to have the green wall on every block but we scaled this down to one due to concerns of inviting too much wildlife into the residential development.

***Can you share more about taking a wholistic approach to sustainable design?***

**KT:** We use Greenmark and URA's LUSH policy as a guide - these are strong fundamentals that align our products to sustainability. As architects, we have to find the balance between sustainability and the bottom line.

From day one, we set a target to get Greenmark platinum [certified]. We placed the blocks in a staggered manner so that they do not overshadow each other and allow wind penetration through the site. This was supported by the wind studies we did. We were a little too successful in that we ended up with a problem of wind driven rain.

The other thing was the basement – the site was undulating, sloping down from the north side to the south. Hence we were able to design the basement to be naturally ventilated – we did not need any mechanical ventilation.

***Over time we seem to be seeing lusher greenery outcomes in condominiums. What in your opinion led to this trend?***

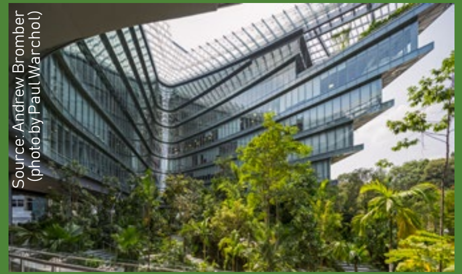
**KT:** We have been doing condominiums for many years. The early focus was on creating facilities like barbeque areas, swimming pools, etc, but in the past five years or so the focus has been more on biophilia and nature.

This developer shift is due to a shift in buyer preferences. Whether for HDB or condos, people seem to want to have more nature in their surroundings. Another driver was URA's LUSH requirements but I think that was also driven by public desire to have a greener environment. Hopefully down the road there will be more and more new ideas on skyrise greenery and I am sure URA is keen to see how they can be executed too.

The longer version of this interview can be found at this link.

# 2.6

## COVERED COMMUNAL GROUND GARDENS (C2G2)

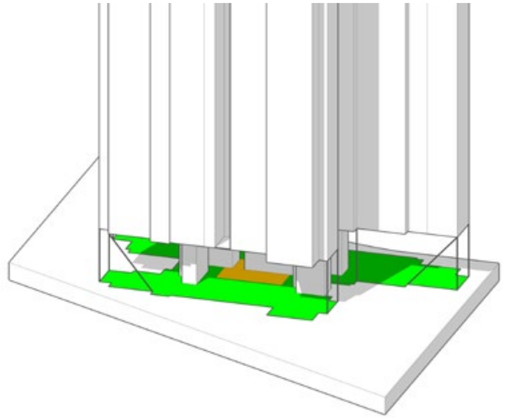


*Covered ground garden at Sandcrawler Building*

**What are C2G2?**
C2G2 refer to landscaped areas on the ground floor covered by the building footprint. Visually they come across as gardens flowing from the outside to interior spaces of the building.

To facilitate such blending of "outdoor" and "indoor" greenery, URA exempts the covered landscaped areas from GFA computation, despite them being covered habitable spaces.

This has encouraged designers to create bright and airy garden settings around lobby areas. In some developments, it is possible to wonder through the gardens and not realise one has passed through the building.

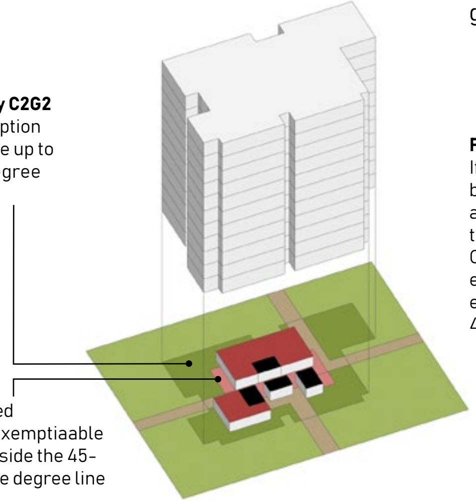

Landscaped areas within the 45-degree line which can be exempted from GFA under the C2G2 guidelines (green)

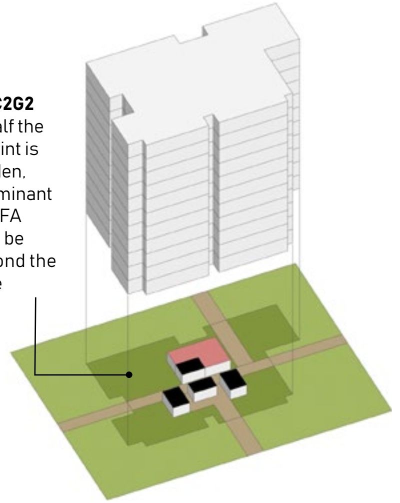
***How should covered communal ground gardens be designed?***

### 2.6.1: Cover ground areas generously, blur boundaries between inside and outside

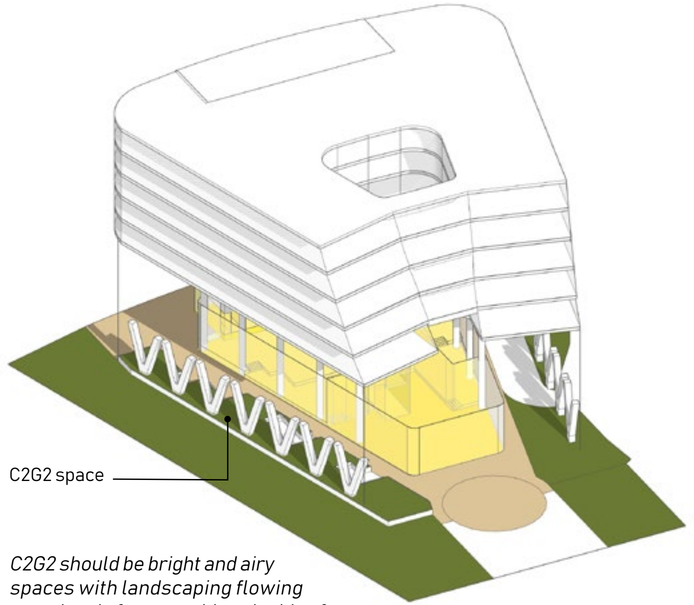
Under the C2G2 guidelines, landscaped areas within the building footprint can be exempted from GFA, up to the extent of a 45-degree line measured from the edge of the overhead structure.

To encourage more generous ground greenery, GFA exemption can be extended beyond the 45-degree line if the covered garden occupies more than half the building footprint, and at least 60% of the covered garden is lushly landscaped. These are termed predominant covered communal ground gardens.




*Predominant C2G2 can enjoy GFA exemption beyond the 45-degree line if the covered garden is more than half the building footprint*



*C2G2 should be bright and airy spaces with landscaping flowing seamlessly from outside to inside of the building*


*C2G2 space at GSK Building*

### 2.6.2: Form bright and airy spaces

Predominant C2G2 shall be designed as bright and airy spaces. This is sometimes achieved by lifting up the building from the ground for a loftier ground floor and C2G2 space.

The landscaping should also flow seamlessly into surrounding landscaped areas (outside the building footprint), through an integrated landscaping scheme.

GFA exemption will not be extended to landscaped spaces tucked away in dark or inaccessible corners at the ground level which are not conducive for landscaping and public use.

### 2.6.3: Landscape luxuriously and ensure public access

C2G2 spaces should have luxurious provision of quality landscaping with variety of vegetation.

Shade loving plants tend to perform better in covered spaces. The spaces should be open and inviting, and remain accessible during operation hours of the building, e.g. in office developments.

ORAs are sometimes provided within these spaces to create alfresco dining experiences (the ORA spaces are not computed as GFA).

***Covered Communal Ground Gardens***
There are two types of C2G2: Secondary and Predominant C2G2.

Find out more about the requirements at this link.

*CASE STUDY*

# An other-worldly ground garden

## The Sandcrawler | 2013

Location: 1 Fusionopolis View
Developer: Lucas Real Estate Singapore Pte Ltd
Architect: Andrew Bromberg of Aedas
Landscape Consultant: Adrian L Norman
Main Contractor: Obayashi Corporation
Mechanical & Electrical Engineer: J Roger Preston

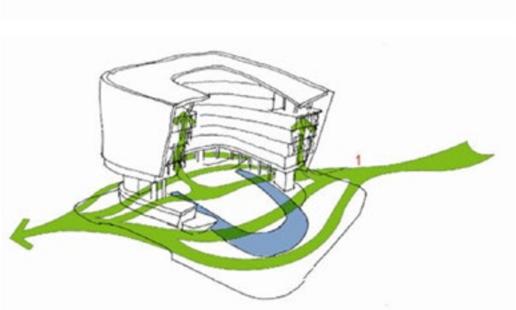
Set within the Fusionopolis cluster at one-north, the Sandcrawler building stands out as an icon resembling its cinematic namesake, yet blends in harmoniously with the surrounding buildings and greenery.


This seamless flow of greenery from the outside to inside spaces, from uncovered to covered parts of the building at ground level is facilitated by the covered communal ground garden policy under LUSH, also known as C2G2.

**A seamless open and covered ground garden**
The sprawling garden carries through the ground plane of the building, elevating four meters from one end to the other. Enclosed by the wings of the building, the gardens were lushly planted in a natural, overgrown manner, almost akin to a secret garden. The meandering paths invited exploration, while scattered benches invited people to sit and converse in relative privacy.

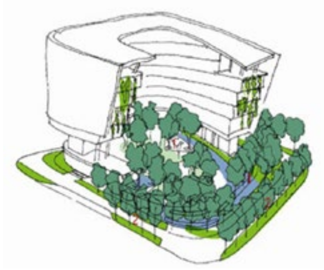
**The benefits of nature contact**
The ground gardens within Sandcrawler contribute to a better working environment and employee health, creating opportunities for contact with nature.

Psychological researchers have studied the brain and stress response after exposure to greenery at the work place. Nature contact restores stress fatigued minds to enhance coping abilities, and stimulate underutilised portions of the brain to help concentration and reduce stress[28].



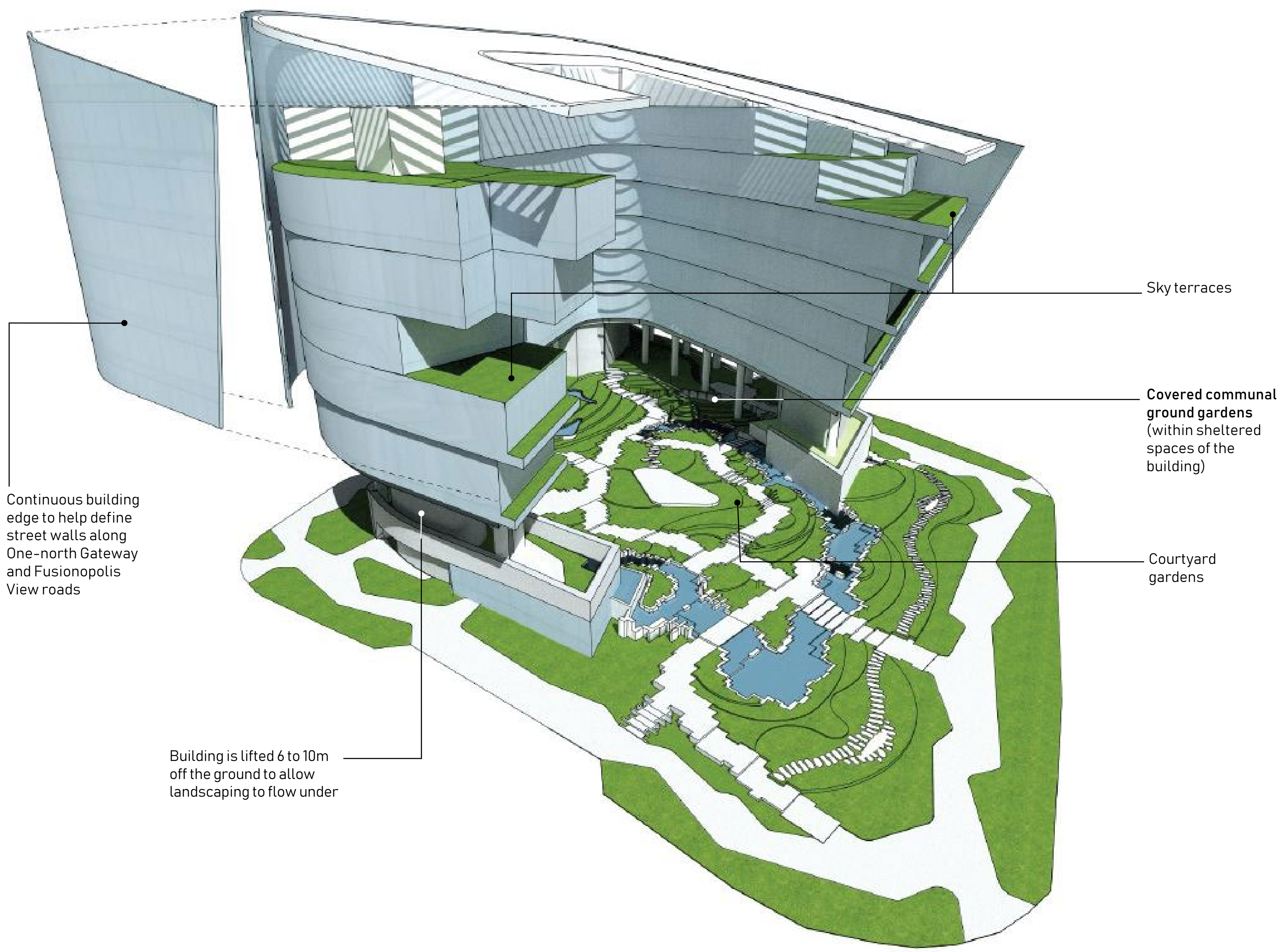
*A green corridor was created through the building to connect Nepal Hill to the courtyard and one-north Park*

*Sculptural mounding was created within the central courtyard to support planting and create terrain differences*



*Rows of large trees were planted to the perimeter to create enclosure for the site*








*BEHIND THE SCENES*

# Urban design for business parks

*Tang Hsiao Ling leads the Urban Planning and Architecture Division at JTC, where she guides the design outcomes of business parks like One-North, Jurong Innovation District and Punggol Digital District. We find out more about the unique challenges she faces in their area of work.*

***Can you tell us when urban design and greenery became an important part of JTC's work?***

**Hsiao Ling:** When JTC planned Jurong as the first industrial township in the 60s and 70s, greening was already a key planning strategy to attract workers to work and live in the West.

Urban design became increasingly important from the 2000s, when Singapore sought to secure the competitive edge in the region as a key technopreneurial and knowledge-intensive research hub. Inclusive urban work-centric developments such as One-north were created to attract international and local talents such as innovators, technology entrepreneurs, business consultants, media artists, and scientific researchers, creating a new typology of mixed-use environments and buildings where one could work, live, play and learn.

*One-north business park*

***How does JTC use urban design and placemaking to shape identity for its research and business campuses?***

**Hsiao Ling:** The urban design strategies and guidelines unify the clusters as a collective whole, integrating the spaces in the public realm within common areas and in private developments. This ensures seamless connectivity to the transport and activity nodes, creating "urban living rooms" as gathering points for workers through provision of fenceless and porous ground floor spaces, as well as green pockets and spines that form natural breakout spaces for the community.

Complementing the hardware, placemaking and programming play a big part as the software, injecting vibrancy into the workspaces, encouraging interactions and chance encounters to further collaborations and knowledge exchange within the knowledge districts.

***Has there been any feedback from your tenants and businesses on the value greenery brings to their operations or general well-being?***

**Hsiao Ling:** Companies have shared that their workers enjoy spending their time amongst the lush greenery in the shaded courtyard spaces and sky terraces within their developments. Landscaped atrium spaces also serve as popular gathering spaces for lunch breaks and company events such as durian parties!

Some workers have even taken the opportunity to turn their green buffers and rooftop terraces into areas where they can have regular communal gardening sessions and experiment with growing fruits and vegetables which can be enjoyed as part of their meals, while bonding with their colleagues.

The longer version of this interview can be found at this link.

*3.0 Sustainability*
*This third part of the book looks at how urban design safeguards sustainability outcomes beyond shaping greenery in development, from leveraging passive design strategies to using technology to reduce energy consumption in buildings.*

# 3.1 SUSTAINABILITY

The buildings sector account for over one third of total energy consumption [29] and 14% of total carbon emissions in Singapore, making them important to address in the transition towards a net zero emissions future [30].

Urban design looks at ways to reduce energy consumption through strategies like passive design, low energy construction and leveraging on technology.

*Capitagreen development is designed with extensive Passive Design features like a wind scoop at the top of the building, extensive planters that screen window openings from direct sun and a double skin façade that reduces solar heat gain to the building*

*How can developments become more sustainable beyond using greenery?*

## 3.1.1: Reduce energy consumption and impact on environment

Greening Singapore's buildings without real sustainability can be dismissed as "green washing", by presenting the buildings as more environmentally friendly than they are. It is important to reduce energy consumption and waste in buildings, to reduce their impact on environment.

While it is possible to lower energy consumption in buildings using state-of-the-art technology, it is more sustainable to design buildings with passive design principles, to maximise the cooling effects of wind and sun shading so that there is less need for active cooling systems in the first place.

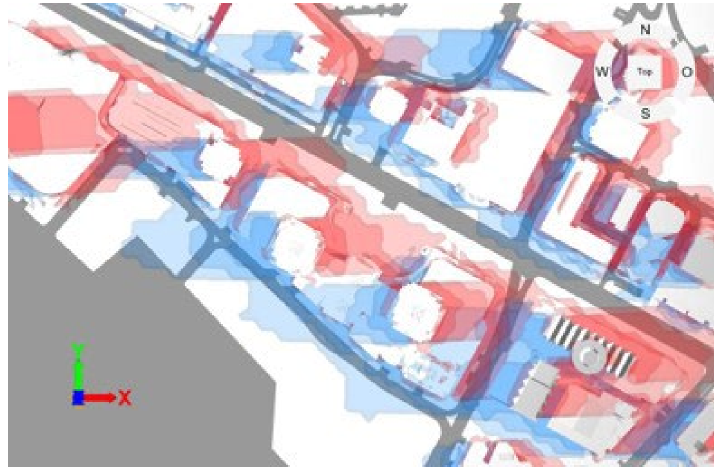
This chapter will look at three key strategies that help to reduce energy consumption in buildings:

- Using passive design to reduce heat gain
- Enhancing wind flow for cooling; and
- Leveraging on technology and systems to reduce energy use

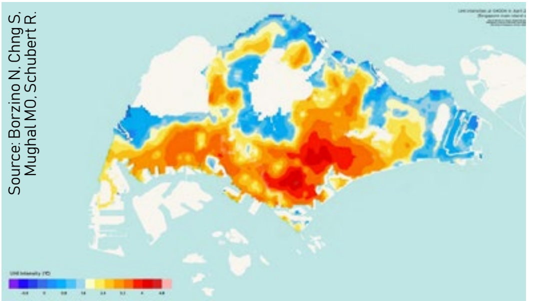
## 3.1.2: Use environmental modelling for more accurate interventions

**Shadow analysis studies**
Shadow analysis studies are widely used to inform site planning, allowing designers to optimise building layout and massing to maximise shading of public spaces and circulation areas.

Typically, shadow conditions are simulated for the equinoxes and solstices to cover the full movement of the sun over the year, and simulated on an hourly basis to quantify the duration of shade in a year for a given location.



*Shadow Analysis diagram of Orchard Road showing extent of shade at different hours of the day of shade at different hours of the day*




**Cooling Singapore**
Cooling Singapore is a multi-disciplinary research study initiated in 2017 to develop solutions to address urban heat challenges in Singapore, involving university researchers and government agencies.

Studies have shown that urban heat island (UHI) effects, where built-up areas capture, store and release heat back into the environment, has resulted in higher temperatures of up to 7 deg C in Singapore's urban environment [31] especially at night.

The study has created a roadmap for reducing heat through seven clusters of mitigation strategies, including urban geometry. This means that the form and massing of buildings can be used as a tool to keep the city cool, by creating shade over public spaces, protecting openings from direct sun and shaping wind flow through the neighbourhood, etc.

*How do we reduce heat gain in buildings?*

## 3.1.3: Adopt passive design principles to minimise sun exposure

Before the invention of air-conditioning, houses and buildings in Singapore already used passive design principles to block, screen and filter direct sun to keep interior spaces cool. The Greenmark Scheme, which was introduced by BCA in 2005 to improve energy performance and sustainability in local buildings, encourages such passive design strategies for modern buildings.

Some strategies architects use to minimise heat gain in building design include orientating windows and openings away from the east-west direction to avoid afternoon sun, installing sun screening to block or filter direct sun exposure, and using the right materials that reduce heat transfer – such as coatings with high reflectance index and windows with high shading coefficients.

At the district level, urban designers have also developed the following strategies to reduce heat gain for buildings as a whole:

1. Plan for north south orientation in buildings. This keeps building openings and views away from exposure to afternoon sun. Detailed simulations are done at the masterplanning stage to ensure that buildings can achieve this orientation on site.
2. Encourage balconies and verandas that shield internal spaces from direct sun exposure.
3. Shape building form and massing to provide shade for public spaces and circulation areas to encourage more activity and street life throughout the day. One strategy is placing public spaces eastwards of tall buildings to provide shade from the afternoon sun
4. Require minimum shading standards for public spaces. The POPS (privately owned public spaces) guidelines requires public space areas and seating areas to be at least 50% shaded throughout the day
5. Orientate streets and corridors according to the type of activities they support. Retail streets may work better in a north-south orientation as this maximises shading from adjacent buildings in the morning and evening when there is most retail activity.

*How do we leverage on wind to cool down buildings?*

## 3.1.4: Shape buildings to maximise wind flow through developments

Wind speeds in Singapore are generally not high, averaging about 1-2.5m/s that only registers as "light air" on the Beaufort scale[32]. However, there are urban design strategies that can shape wind into comfortable breezes (4-5m/s and above), enable wind flow through districts and direct them towards desired areas in the neighbourhood such as public spaces.

Some strategies urban designers use to manage wind flow on a district level are:

1. Create wind corridors that channel wind through the district. They should be aligned with prevailing wind directions, which are usually north-east and south due to monsoon patterns in Singapore. Wind corridors can range in width from about 30m wide (or the width of a local street) to hundreds of metres at a regional level. Where possible, align the street blocks / road network of the district with prevailing wind direction so that the streets double up as natural wind corridors

2. Provide spacing and porosity between buildings to allow wind to distribute through the site or concentrate along desired corridors. As a general principle, buildings fronting the predominant wind direction should be spaced out to ensure that developments further away from are not blocked

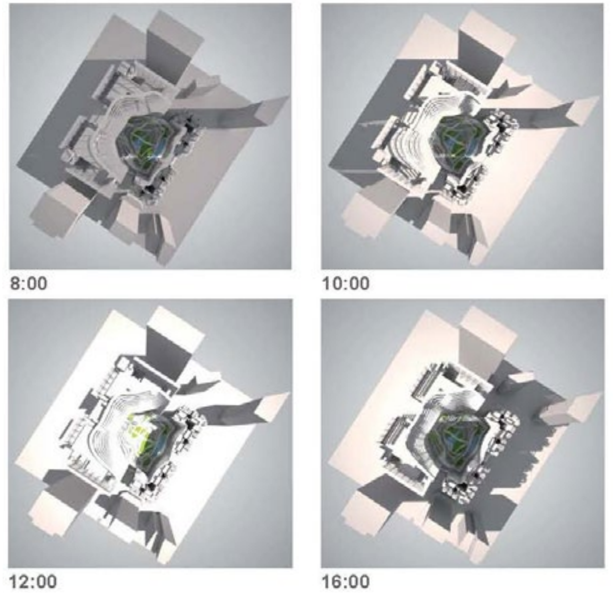
3. Vary building heights to capture wind. Staggering building heights allows for the creation of downwash and canyon effects on wind flow, to direct wind to street level. Building heights and spacing work together to influence air flow, hence detailed wind simulations are required to test different configurations to achieve the performance levels.

4. Select building forms and typologies that better facilitate wind flow. Breaking up large multi-storey podiums allows wind to reach open spaces at street level more easily. Lining the edges of streets with tall buildings can also create wind canyon effects. The effect of different building forms is tested using wind simulations to understand their impact.

5. Prioritise planting of trees and greenery where they can provide cooling effects. Parks and waterbodies can provide cooling effects to passing wind, hence wind corridors should be aligned with green and blue surfaces in the district where possible.

Shadow studies at Marina South

Shadow studies at Marina One




## *CONCEPTS EXPLAINED*

# *When are shadow analysis studies needed?*

**Planning stage**
Shadow analysis studies are often carried out by URA in the planning stages for new development areas, or in built up areas where there are redevelopment opportunities, to determine optimal building form that maximises shade in the public realm.

For example, public spaces may be sited to the east of buildings to enjoy protection from the afternoon sun. Streets that are oriented north-south also tend to enjoy more sidewalk shade in the morning and late afternoons, making them more conducive to street life.
These strategies are layered into the urban pattern – to guide the placement of roads, buildings and public spaces.

**Development Design stage**
When it reaches implementation, as part of the development design stage, individual developers may conduct shadow analysis studies to determine the effectiveness of building orientation and shading devices, to meet targets under Greenmark.

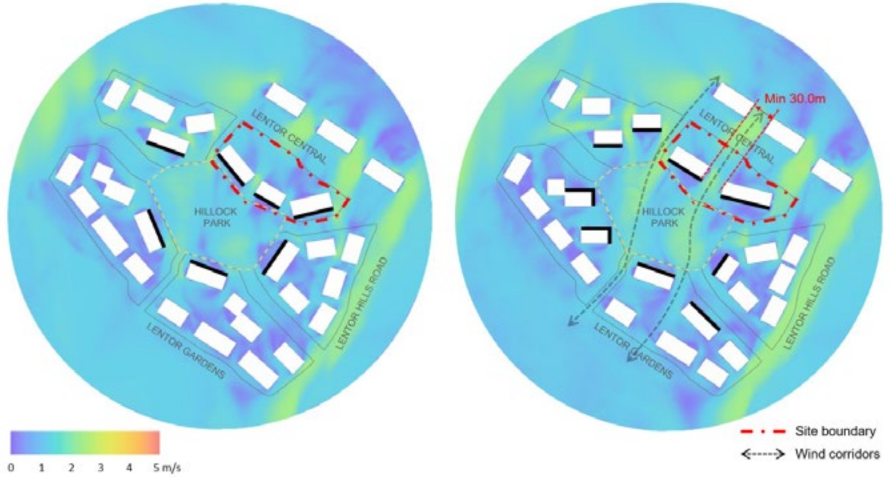
If proposing public spaces under the POPS guidelines (Privately-owned Public Spaces), architects will also have to conduct shadow analysis studies to ensure that at least 50% of the public space is shaded at the specified timings.

**Submission requirements**
URA requires shadow studies for public spaces to demonstrate compliance with the POPS guidelines. Shadow diagrams for 9am, 12pm and 4pm need to be submitted to show that at least 50% of the total public space area and 50% of the public space seating is shaded.

Typically, shadow studies are simulated for Equinox (21 Mar / Sep) because it is the midpoint between the maximum declination of the sun at winter or summer solstice, representing the most "typical" sun condition. In Singapore, URA asks for simulation during the summer solstice (21 Jun) as it is the longest day of the year.




Wind corridors at Lentor Hills




Wind analysis studies at Lentor Hills

## *CONCEPTS EXPLAINED*

# *When are wind simulation studies needed?*

As part of a move towards more evidence-based urban design, URA carries out detailed wind analysis studies in new development areas where the urban form can be shaped upfront for better wind flow and ventilation outcomes.

To maximise achievable wind speeds within developments, URA tests different configurations of building layout and orientation to determine optimum wind corridor alignments and site porosity requirements.

URA uses a number of computational fluid dynamics (CFD) software to conduct wind simulations. These are supported by on-site wind data collection to serve as the baseline conditions for the simulations.

At the development design stage, developers and architects may then conduct their own wind analysis studies to test their proposed building layouts. There is flexibility to counter-propose requirements set by URA, if backed by robust wind analysis studies.

As each development in a new area gets built up, URA reviews the overall simulation regularly to ensure that the safeguarded wind corridors continue to function as planned. Tweaks may be made on the requirements for subsequent development sites.

A case study on the application of wind analysis for Lentor Hills Estate will be shared at the end of this chapter.

*What else can we do?*

## 3.1.5: Improve energy efficiency and leverage on technology

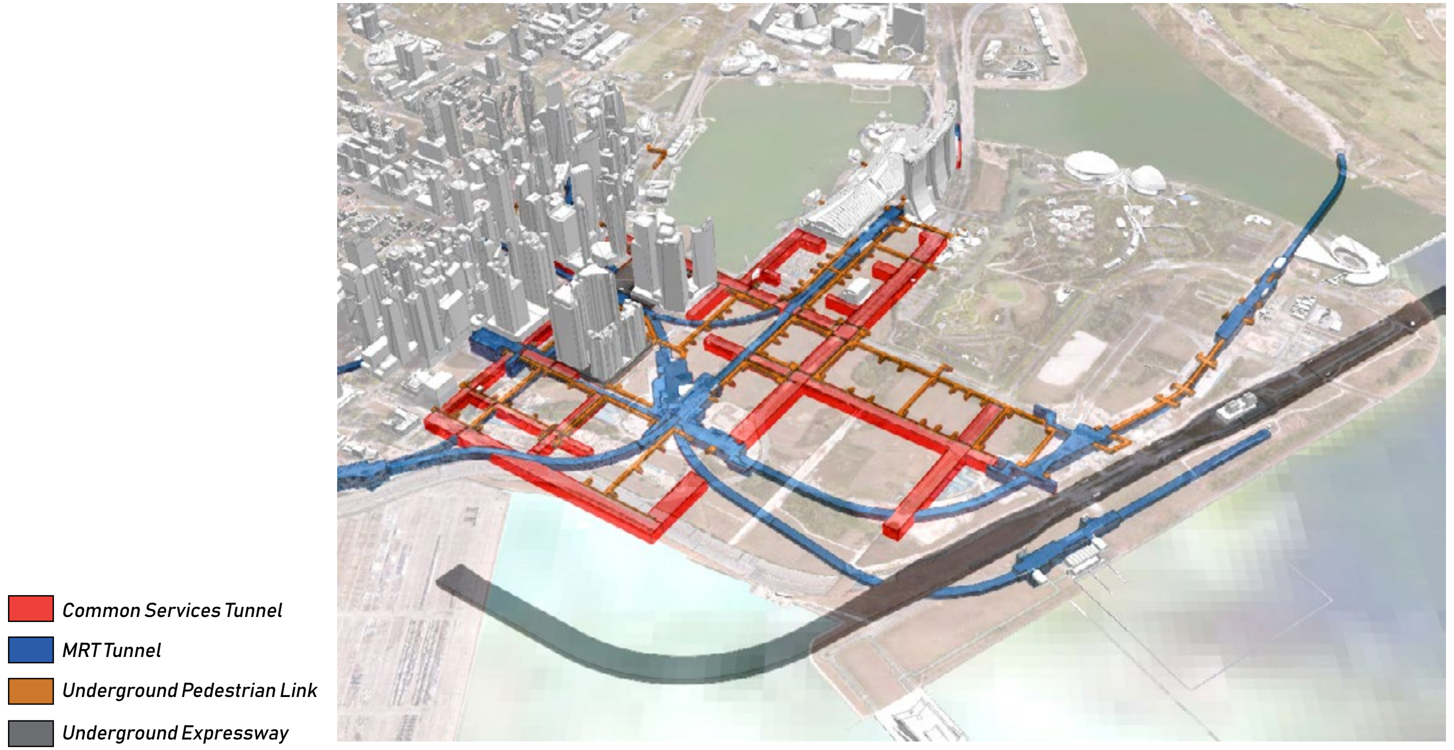
**Development level strategies**

Presently, energy consumption in typical office buildings in Singapore is mainly attributed to cooling (60%), lighting (15%) and mechanical ventilation (10%)[33]. Efforts have focused on addressing each of these systems to bring down overall energy use in buildings.

Technologies that reduce unnecessary lighting and cooling include **Smart lighting systems** and **Optimised Air-conditioning systems**, which use sensors to track and activate the systems around actual human activity in the building.

Other innovations that reduce the energy load of cooling include **Hybrid Cooling Systems** which tap on solar energy to reduce use of compressors, and Passive Displacement **Ventilation systems** which use natural convection instead of mechanical fans to deliver cool air.


*With PDV, cool air is supplied into rooms at a lower level to displace warmer air which rises, using natural convection energy to circulate air and reduce energy consumption*




*DCS system at Marina Bay*

**District level strategies**

**District cooling systems** (DCS) can help reduce overall energy consumption for cooling on a district scale. Chilled water from a centralised plant is circulated to multiple buildings using a network of pipes. This allows reaping of economies of scale by removing the need for individual cooling plants and sharing of cooling load between buildings.

In mixed-use developments this reduces the overall cooling capacity required as offices and apartments have different usage patterns.

Singapore has the world's largest underground district cooling system (DCS) at Marina Bay which started operations in 2006. New DCS are being developed at locations like Tengah and Jurong Lake Gardens.

***Super Low Energy Buildings***

The BCA Green Mark for SLE Certification Framework will certify buildings that consume 40 per cent less energy as SLE, while buildings that generate enough renewable energy to cover all their energy consumption will be certified as Zero Energy Buildings.

Find out more at this link.

*CASE STUDY*

# Lentor Hills – sustainability in a lush green estate

**A lush garden district**

Located next to Teachers' Housing Estate near to Lower Peirce Reservoir Park, Lentor Hills is planned to be a pedestrian-friendly neighbourhood set amidst lush greenery with good connectivity to public transport, being served by the Lentor MRT station along the Thomson-East Coast Line.

Existing greenery on the site has been retained (including significant trees like a prominent *alstonia angustiloba*) which will be developed into a hillock park to serve the neighbourhood. Developments are also required to meet 45% of landscape replacement in the form of softscape planting, with additional conditions to provide sky terraces in every high-rise building and externalise green buffers along the streets in the estate.

**Wind corridors for passive cooling**

Beyond the protection and creation of lush greenery for the area, URA introduced passive design strategies in the form of wind corridors in an effort to make the district more sustainable. These are minimum 30m no-build zones through the development parcels that are aligned with the predominant wind directions.

*Artist Impression of Lentor Hills Estate*

*Existing Alstonia Tree to be retained*

*Artist Impression of future Hillock Park*



URA took an iterative approach to determine the placement, alignment and width requirements for the wind corridors, using computational fluid dynamics (CFD) simulations to test the impact of various configurations.

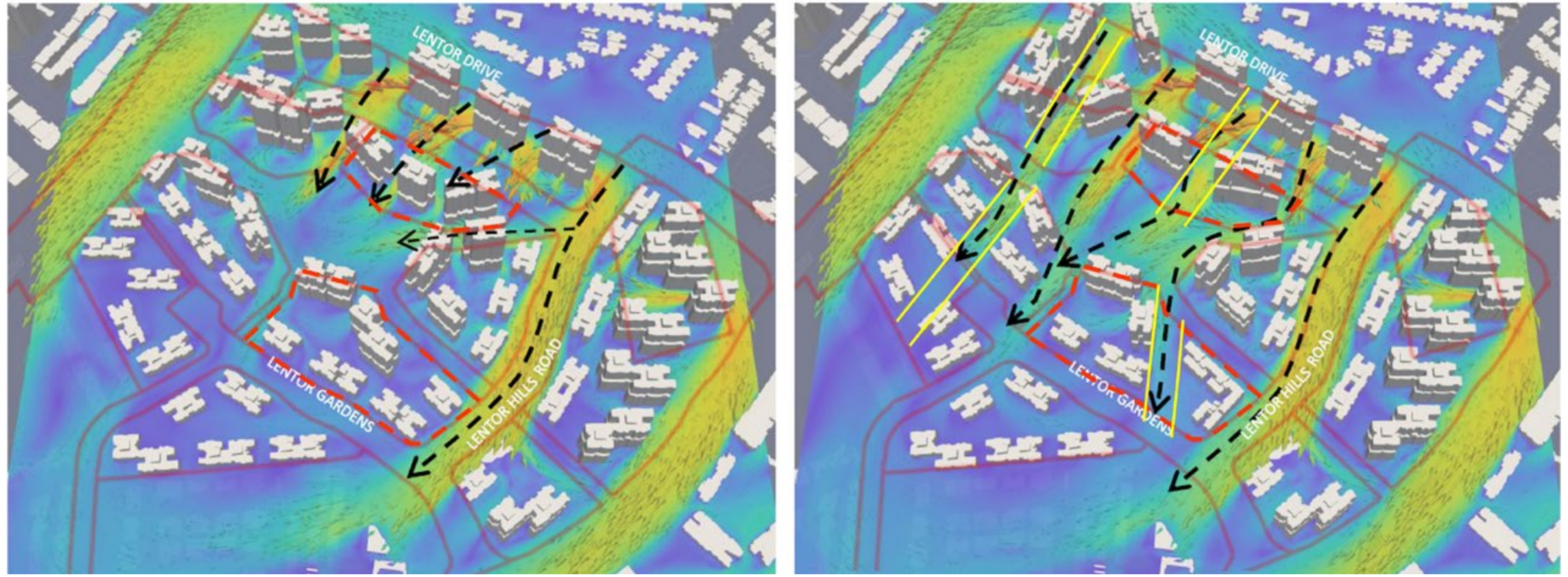
First, using meteorological data from the nearest weather station, URA determined the predominant wind directions to be from the north-east and south for the district. Then it tested wind corridors of varying widths and alignments to see which arrangement resulted in the most enhancement to average wind speeds across all of the development parcels.

The results showed that with 30m wide wind corridors, predominant winds from the north east filtered through into the southern most parcels of the area, and raised overall wind speeds within the developments. Average wind speeds along the wind corridors were elevated to the level of a "gentle breeze", which will bring air and ventilation to most buildings across the district.

The arrangement of the wind corridors also ensures that the developers have sufficient flexibility for development layout and tower placement to achieve the gross plot ratio, with detailed simulations carried out for each site.

As the parcels were progressively launched for sale, URA revisited the overall wind simulation multiple times to incorporate updated development layouts. This resulted in tweaks to the wind corridor requirements for subsequent sale sites.

URA also provided flexibility for developers to counterpropose the alignment of the wind corridors if substantiated by robust wind analysis studies. Advisory notes were included in the tender conditions on the appropriate methodology and parameters to assume for independent wind analysis studies from the developers.




*Wind Analysis Study showing enhancement of wind speeds through Lentor Hills estate before (left) and after (right) creation of wind corridors*

*THE WAY FORWARD*

# FROM GARDEN CITY TO CITY IN NATURE

**From garden city to city in nature**
Modern urban lifestyles can lead to health issues like chronic stress and lack of physical activity. Greenery, in the form of parks, open spaces and skyrise greenery, can help mitigate these effects for better health and well-being of city-dwellers.

The early push to make Singapore a Garden City meant that much of the urban fabric is planned with ample parks and open spaces, while its modern road network is lined with trees. The advent of LUSH in 2009 also led to a proliferation of skyrise greenery in the form of sky terraces, roof gardens, green walls, etc.

In line with Singapore's vision to become a City in Nature, urban design and planning are taking a more biophilic approach, blending nature into developments and strengthening ecological networks across the island. These measures have helped Singapore score highly on most rankings of the greenest and most liveable cities across the world today.

As urban warming in the city continues to outpace the global average, how can Singapore cope with these changes and become more resilient?

**Environmental impact of skyrise greenery**
WOHA worked with Dr Anuj Jain of bioSEA to assess the impact of Oasia Hotel Downtown to the larger Tanjong Pagar neighbourhood over a period of 6 months.

The study found that the vibrant skyrise greenery within Oasia attracted 18 species of insects and birds, nearly 50% of the species found in the neighbourhood. Oasia's greenery also released more than 48 tonnes of oxygen per year and reduced heat energy by 242kW, more than the average annual energy consumption of a large office building in Singapore.

bioSEA concluded that Oasia's greenery performed at a level of 8-68% of a pristine rainforest for different ecosystem services. This suggests that when done well, skyrise greenery can substitute some functions of natural greenery, helping us grow into a "City in Nature"[34].

**Urban Heat Island and outdoor thermal comfort**
The Urban Heat Island (UHI) effect is of particular concern for Singapore, given the extent of the island's urbanisation. Researchers have warned that the thermal impact is as much as an additional 7 degrees celsius at night, which would add considerable discomfort to the city[35].

Park creation at the right scale and conservation of major patches of greenery will help provide cooling effects to the city.

Upcoming districts are being planned with these principles in mind, with wind corridors planned to optimise prevailing wind conditions and maximise ventilation in areas such as Marina Bay and Lentor Hills, and optimal shading requirements for streets and public spaces.

**Rising sea levels**
Current projections estimate sea level increase at up to 4-5m in a worst case scenario (with storm surges) by 2100. As an island nation, Singapore is particularly vulnerable with 30% of our island currently less than 5m above sea level[36].

Studies are underway to incorporate sea walls along future coast line areas to protect low lying areas. There are also plans to use mangroves and corals to break the impact of waves in locations such as Sungei Buloh and Pulau Ubin.

The minimum platform level of new developments has been raised from 3m to 4m above mean sea level as a precaution against localised flooding in the event of extreme rainfall.

Urban design principles are applied in these studies to continue to safeguard good connectivity and greenery outcomes around coastal and flood protection infrastructure.

**The role of greenery in developments**
As Singapore continues to grapple with the pressing challenges of climate change, greenery in developments will become an increasingly important tool for environmental sustainability. In addition to combating the urban heat island effect and other heat-related stresses arising from climate change, greenery in the city also improves air quality and contributes to carbon sequestration.

Aside from its environmental benefits, research has also shown that people are mentally, physically and socially healthier around greenery.

The LUSH policy plays a key role in the introduction of greenery to achieve these benefits. To date, the programme has contributed more than 250 hectares of greenery over the past decade, equivalent to about 400 football fields.

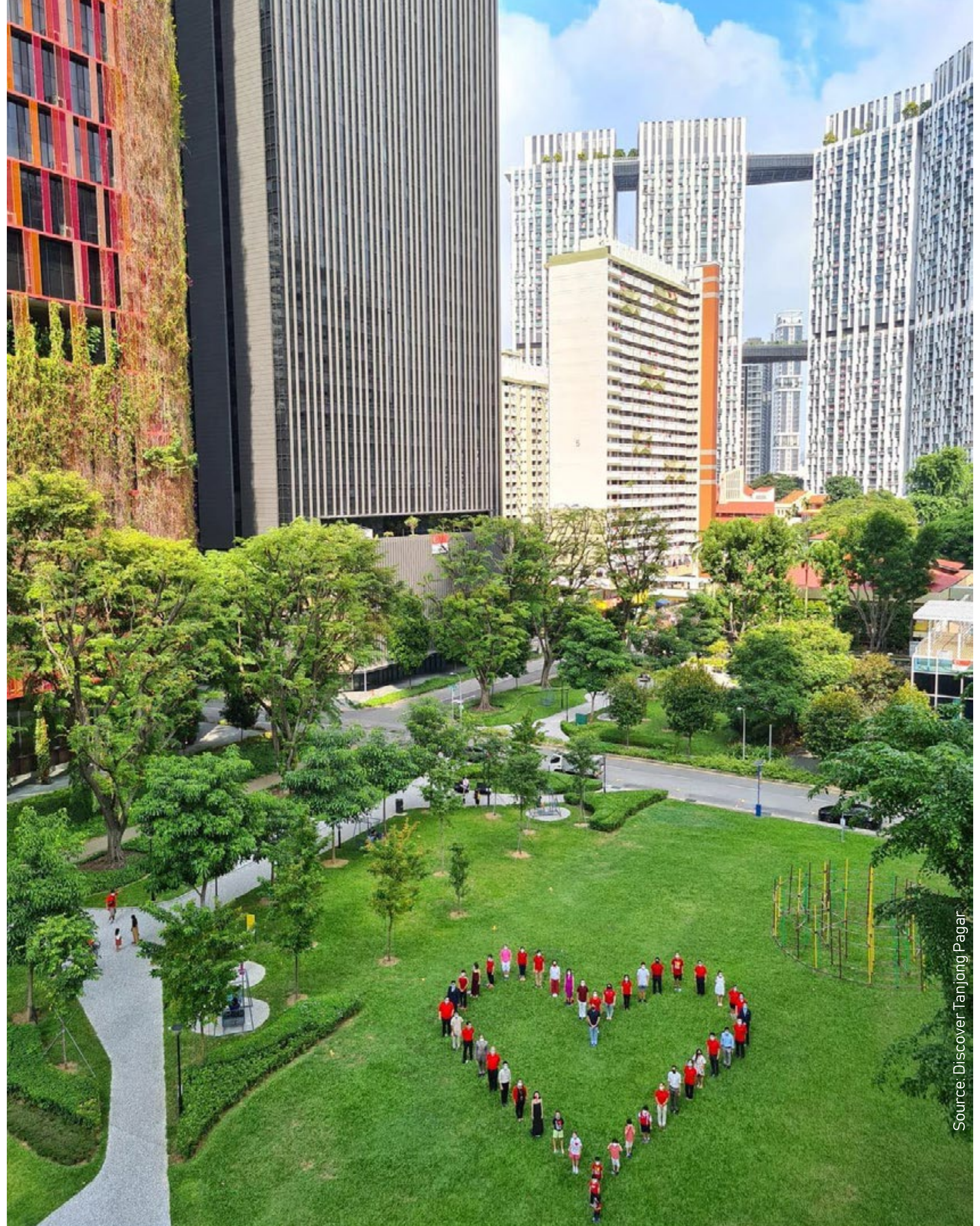
**New directions for LUSH 4.0**
The LUSH programme will continue to evolve, taking into account the feedback from built environment professionals and members of the public on how they envision Singapore to become a greener and more sustainable city. Some ideas that have been shared with URA include the introduction of ecologically-sensitive development guidelines and ensuring that the implementation and upkeep of greenery within developments is done in a sustainable manner.

URA will continue to review the LUSH programme to incorporate some of these ideas. URA foresees the future iterations of LUSH moving beyond merely ensuring that greenery of a certain amount and quality is proposed, to ensuring that it is implemented in a way that enables it to deliver multiple environmental benefits while enhancing the city's resilience to climate challenges.

**Shaping our future together**
Urban design remains a highly contextual and iterative process, made richer through the exchange of ideas between professionals and the community.

URA's efforts to make Singapore green and liveable will only succeed with strong support from the private sector, to adopt sustainable design strategies and development practices. These will be supported by guidelines and policies from URA and partner agencies.

It is URA's hope that this book has been able to articulate the rationale for different urban design guidelines have been made clearer from the examples in this book, so that developers, architects and designers will be able to apply them with their creativity and ingenuity, with a shared vision to make Singapore a greener and more sustainable city.


Source: Discover Tanjong Pagar

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**Private / Non-profit organisations and institutions**

ADDP Architects
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Architects Team 3
Axis Architects Planners
Changi Airport Group (CAG)
Cambridge CARES
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DCA Architects
DHI Water & Environment
Discover Tanjong Pagar
DP Architects
DUO Singapore
The Esplanade Co
Freight Architects
Grant Associates Singapore
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Ingenhoven Architects
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Little India Shopkeepers and Heritage Society (LISHA)
Look Architects
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**Resources and references**

**Wikimedia images**
Ch 2.5 Green walls
Ocean Financial Building, taken by Smuconlaw
https://commons.m.wikimedia.org/wiki/File:Green_wall,_Ocean_Financial_Centre,_Singapore_-_20150327.jpg

Flora and Fauna Web images
Ch 1.4 Landscaped Waterways
Arthur Ng
Cerlin Ng
Chan Chun Leong
Chua Liat Seng Gary
Patricia Yap
Vicky Lim Yen Ngoh

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**The way forward**

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## RELEVANT LINKS

**Intro**

Urban Design Guidelines
https://www.ura.gov.sg/Corporate/Guidelines/Urban-Design

**Chapter 1**

Privately-owned Public Spaces Guidelines
https://www.ura.gov.sg/Corporate/Guidelines/Development-Control/gross-floor-area/GFA/Privately-OwnedPublicSpacesPOPS

Walking and Cycling Path Standards
https://www.ura.gov.sg/Corporate/Guidelines/-/media/BD725DB201DB496A93569C8072DD9FD0.ashx

Park Connector Network
https://pcn.nparks.gov.sg/

Guidelines on Greenery Provision and Tree Conservation for Developments
https://www.nparks.gov.sg/partner-us/development-plan-submission/guidelines-on-greenery-provision-and-tree-conservation-for-developments

Nature Ways
https://www.nparks.gov.sg/gardens-parks-and-nature/nature-ways
Singapore River Promenade Guidelines
https://www.ura.gov.sg/Corporate/Guidelines/Urban-Design/Singapore-River

**Chapter 2**

Landscaping for Urban Spaces & High-Rises Guidelines
https://www.ura.gov.sg/Corporate/Guidelines/Circulars/dc17-06

Sky Terrace Guidelines
https://www.ura.gov.sg/-/media/User%20Defined/URA%20Online/media-room/2009/apr/pr09-19a3.pdf?la=en

Green Plot Ratio Guidelines
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Green Walls Guidelines
https://www.ura.gov.sg/-/media/Corporate/Guidelines/Development-control/Circulars/2017/Nov/dc17-06/dc17-06-Appendix-1.pdf

Covered Communal Ground Gardens Guidelines
https://www.ura.gov.sg/Corporate/Guidelines/Development-Control/gross-floor-area/GFA/CoveredCommunalGroundGardens

**Chapter 3**

Super Low Energy Program
https://www1.bca.gov.sg/buildsg/sustainability/super-low-energy-programme

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