CHAPTER 9

Seeding Inter-agency Exchange behind the Restoration of Kallang River, focussing on Bishan-Ang Mo Kio Park, as an Ecological Connector

Damian Tang & Mayura Patil

Introduction

The ambitious Kallang River master plan was first conceived in 2006 by the National Parks Board (NParks), in collaboration with PUB, Singapore's National Water Agency. Led by PUB, the project began as a straightforward plan that required only a planting palette from NParks to green up both sides of the canal as the Marina Barrage was getting constructed, turning the tidal waterway into a freshwater canal. The greening project took a turn when the master plan was proposed, involving the naturalisation of the canal – novel habitats would be weaved with the river, integrating vegetation and wildlife with water.

The master plan was presented with various landscape strategies and a visionary image that illustrated the possibilities of waterways and water bodies that could be transformed in different phases – from its current concrete state into an ecologically and aesthetically enhanced vibrant space for people and biodiversity. It aimed to integrate the canal with several green spaces, including Bishan Park (the previous name for Bishan-Ang Mo Kio Park), and to enhance the biodiversity along the Kallang River. This plan was approved from the then CEO of PUB, Mr. Khoo Teng Chye, and then CEO of NParks, Mr. Ng Lang, who set the vision for the projects.

However, there were many challenges and a lack of technical experts to implement these ideas. It would require strong collaboration between both PUB and NParks and the recognition of landscape planning expertise to realise the master plan. Damian Tang, then with NParks, was seconded to PUB for six months and during his secondment, a 300-metre stretch of park connector along Kallang River was proposed to be redeveloped as a demonstration site under the PUB's ABC Waters Programme. The Kolam Ayer demonstration site was launched in 2008, and it became a vibrant green space by the river for community activities to be held and biodiversity to thrive.

The exchange of knowledge between NParks and PUB further bore fruit in the years that followed, with the successful redevelopment of Bishan-Ang Mo Kio Park as a flagship project under the ABC Waters Programme.

Site analysis and precedent studies for the ecological restoration of Kallang River

1a. Site context

Fig. 1. Location of Kallang River. The Kallang River originates from the North of Singapore at the Lower Pierce Reservoir and flows through dense urban areas towards the Marina Bay at the South. (Image credit: Mayura Patil)

1b. Ecological potential of the site

The river stretches to approximately 10 kilometres, which could play a crucial role as an ecological connector between various habitats (Fig. 1). The origin of the river is in close proximity to primary forest vegetation as well as freshwater swamp forest, and old and young secondary forest patches. The river passes through various urban habitats such as neighbourhood parks, park connectors, linear green spaces, as well as large-scale recreational landscape areas towards the south of the river. The river has the potential to create suitable conditions for the growth of various habitats ranging from natural freshwater aquatic habitats to novel aquatic ecosystems towards the south.

1c. Water levels in the river

The water levels and the river profile varied along the entire stretch (Fig. 2). It was important to consider the need for maintaining certain water levels for the hydraulic capacity. The variation in the water level allowed for the creation of various types of habitats along the river stretch. The masterplan also had to consider the changes in the water levels after the intervention of Marina Barrage (Fig. 3).

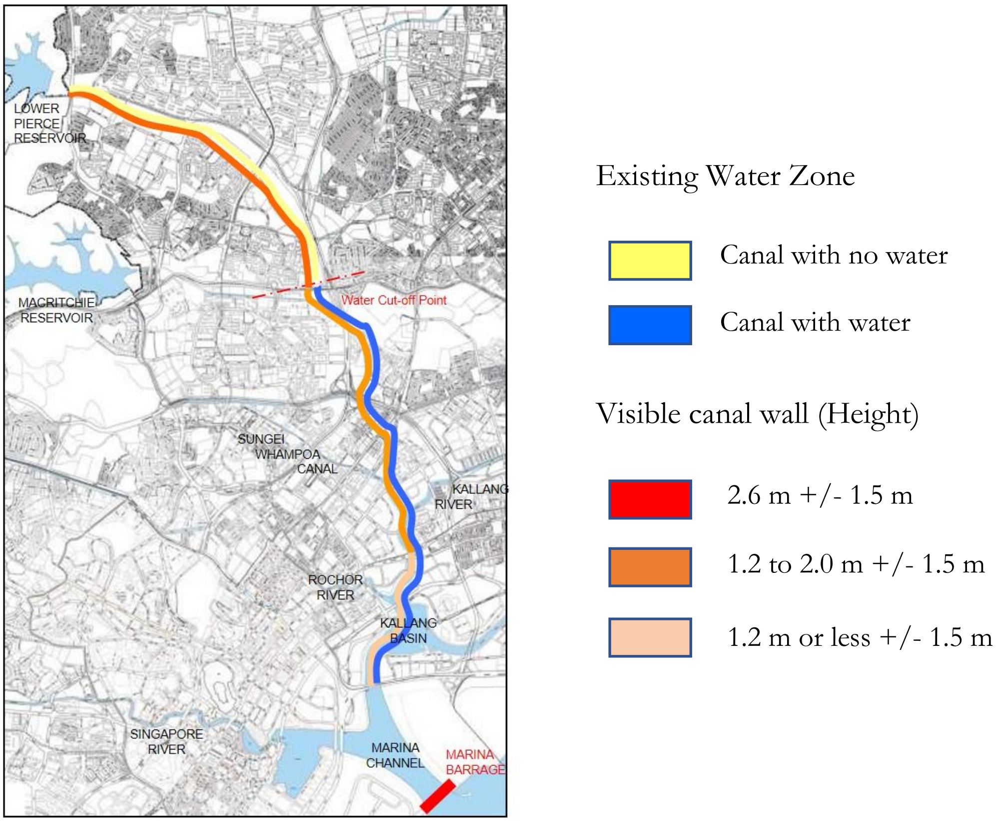


Fig. 2. Variation in water level and river profile along the longitudinal stretch of the river. (Image credit: Damian Tang, based on data from PUB, 2006)

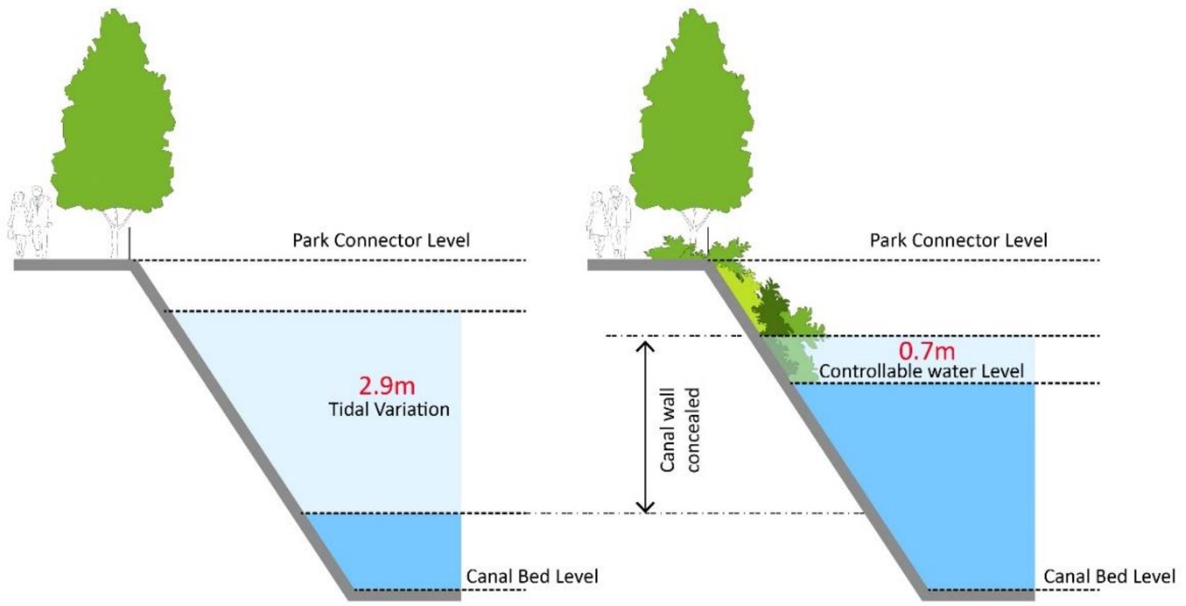
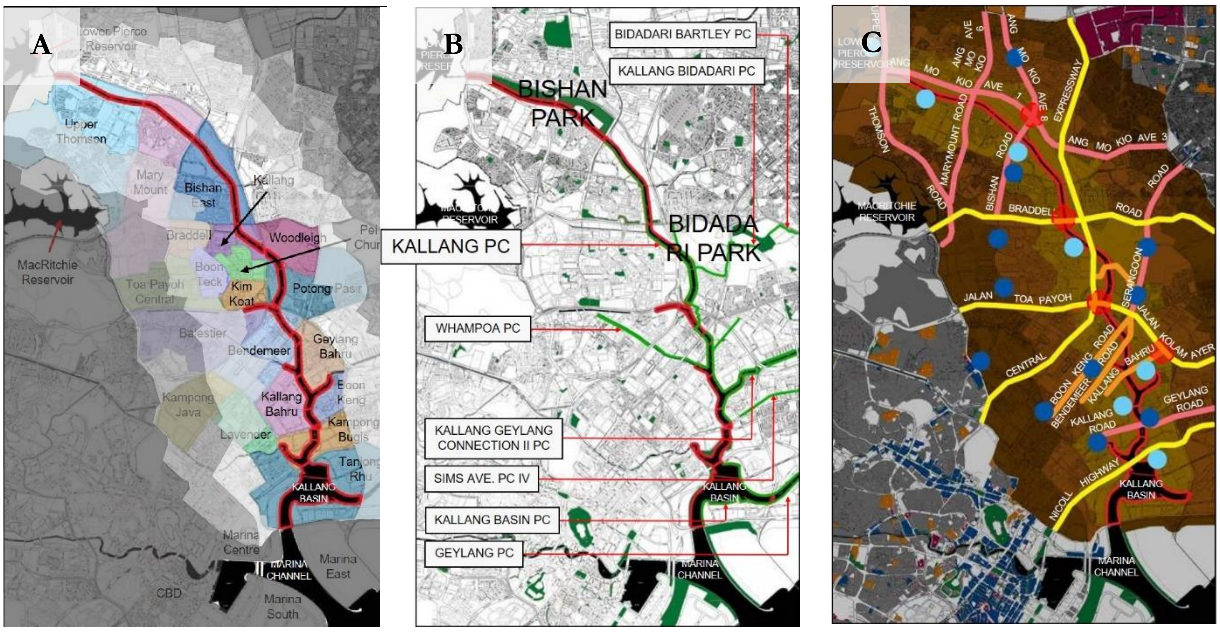


Fig. 3. Changes in the water level at Kallang basin before (left) and after (right) the intervention of the Marina Barrage (2006). (Image credit: Mayura Patil, based on data from PUB)

1d. Land use and constraints

The team studied GIS (geographic information system) maps to get a better understanding of the neighbouring areas and the surrounding catchment areas related to the river. The immediate neighbouring land use was studied to conceptualise ways to connect the users who would benefit from this project. Physical constraints such as expressways and other vehicular roads that intersected with the river were mapped to foresee potential issues in creating a continuous pedestrian and ecological links along the river (Fig. 4).



Figs. 4. (A) Neighbourhood towns and GIS mapping (proximity); (B) Parks and park connectors; (C) Site constraints. (Image credit: Damian Tang, based on GIS data, 2006)

1e. Learning from other success stories

The preliminary design vision for the Singapore river was to rejuvenate the river such that it would not only benefit the people but would also support flourishing biodiversity along the river edge. This would be the first project in Singapore of this scale where landscape and civil engineering experts had to work together. Hence, relevant case studies from different countries were conducted to encourage others to understand the potential of this site and to help them reimagine urban rivers.

Case study 1: In the 1890s, the Isar river in Munich, Germany was straightened and squeezed into a rigid canal. As a result, the water velocity and temperature changed unfavourably. To resolve these issues accelerating over the years, the Isar was reformed into a near-natural river in 1995 (Fig. 5). The new restorative design included flood protection features and achieved bathing water quality in the river.

Figs. 5. Isar River, Munich, Germany before restoration (left) and after restoration (right). (Photo credit: Mahida, 2013)

Case study 2: In the 1960s, the polluted Cheonggyecheon stream in Seoul was covered with concrete and a six-lane highway was built over it. This snatched away the potential of bringing Seoul's residents back to enjoy the stream. In 2003, the highway was torn down and the 600-year-old historical stream was restored by integrated engineering solutions, resulting in wide pedestrian landscaped corridors and accessible water with high water quality (Fig. 6).

Figs. 6. Cheonggyecheon Stream, Seoul, South Korea in 1960s (left) and 2003 (right). (Photo credit: Global Designing Cities Initiative, 2023)

Case study 3: From the 1820s, increased free trade caused overcrowding along the Singapore river which resulted in water pollution. The water quality degraded over the years and the river became devoid of marine life. In 1987, the river was cleaned up which attracted riverside commerce and residences. The revitalised river encouraged new recreational activities such as boating and attracted tourism.

Design vision

The Kallang River is approximately double in length than the similar precedent studies. It passes through areas of varying land use and has many site characteristics (Fig. 7). Hence, the masterplan had more constraints than what were posed in the case studies.

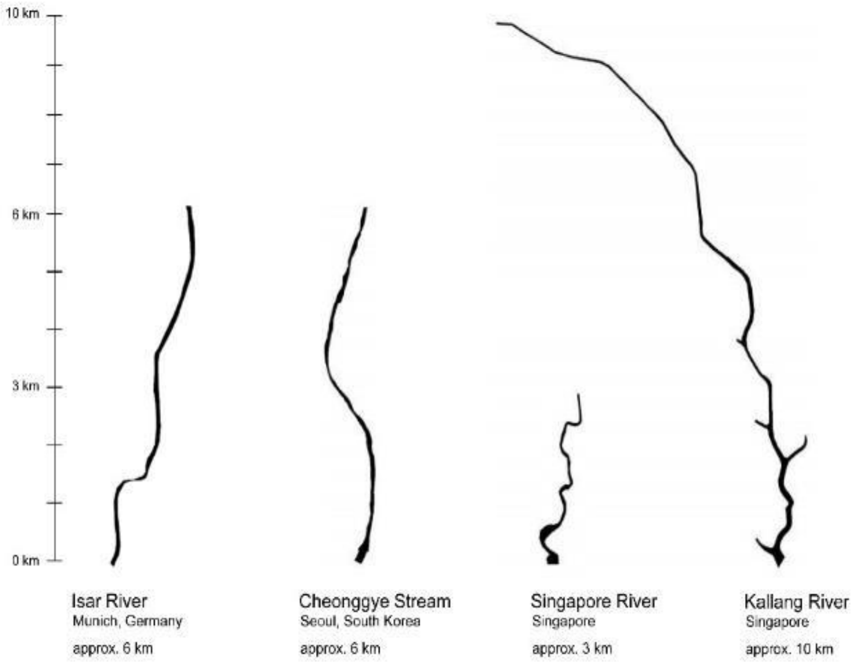


Fig. 7. Size comparison between case studies and the site. (Image credit: Damian Tang)

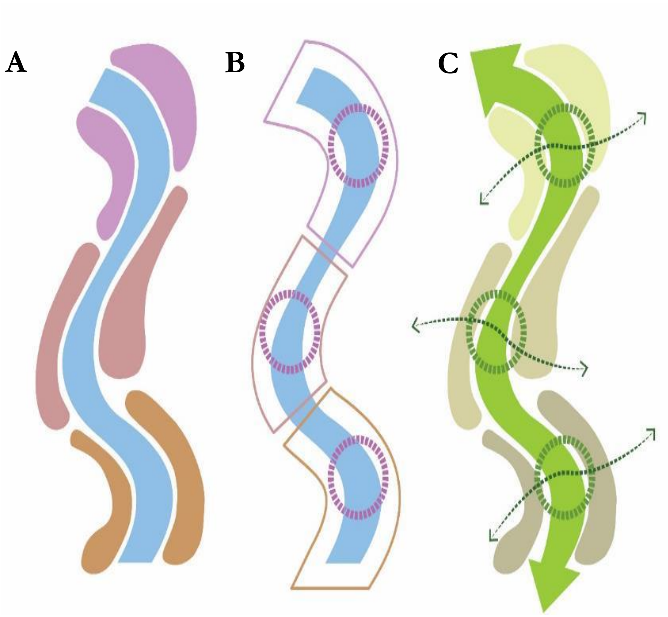
2a. Social and landscape zoning

The Kallang River aimed to transform the physical and social landscape of its adjoining neighbourhoods with the implementation of a coherent and consistent riverfront strategy.

Initially, PUB engineers were worried about bringing people in physical contact with the waterbodies, as this might be considered a health hazard, raising concerns to public safety. But they were also very keen on testing different programmes to activate the waterbodies especially the canal edges.

Landscape zoning was planned to give different characteristics to the river edge and create a distinct identity for the river. Different thematic zones were proposed along the river to reinvent the river as a new recreational destination. Lateral social and landscape connections were envisaged to socially and ecologically connect the river to the city. A linear ecological connection was proposed to establish the river as an ecological corridor.

By finding the solutions to on-site constraints, a unified design strategy could thus be created. The river was divided into three different zones based on the water level and profile of the river (Fig. 8). Different zones allowed for distinct landscapes and riverine identity with various ecological habitats.



Figs. 8. (A) Landscape zoning; (B) Recreational nodes; (C) Lateral and linear landscape connections. (Image credit: Mayura Patil)

2b. Designing a habitat corridor

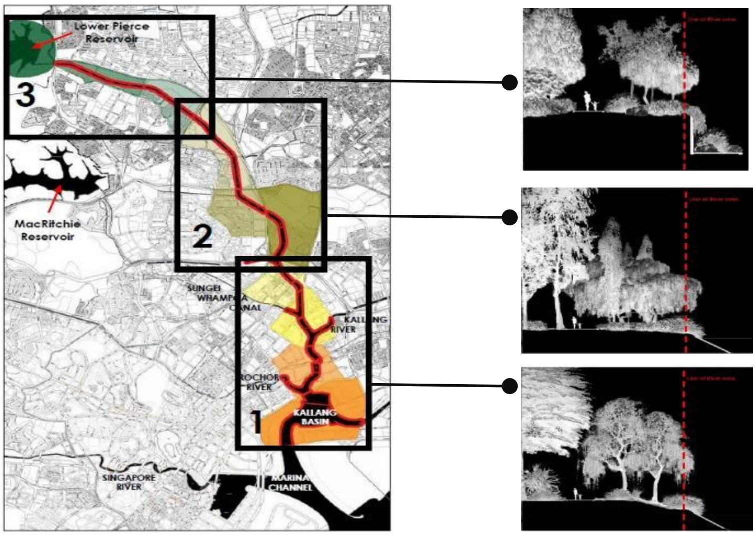
While designing an ecologically sensitive masterplan to improve biodiversity, it is important to analyse the source habitats. In urban landscapes, the source habitats are often large patches of greenery, such as nature reserves and vegetated parks. Although the effects of habitat fragmentation are under constant debate (Fahrig, 2017), many scientific studies show that habitat fragmentation may disrupt landscape connectivity, interfering with species dispersal and enhancing the risk of extinction for certain species (With, 2002).

Once the key patches are identified, it is necessary to find a way to connect them. Scientific research summarised landscape connectivity as a combined effect of (1) landscape composition (structural connectivity) and (2) the species' ability to move among the habitat patches (functional connectivity) (Tischendorf *et al.*, 2000). According to Tischendorf, corridors are narrow, continuous strips of landscape habitats that structurally connect patches. The 10-kilometre stretch of Kallang River provided the opportunity to create an ecological corridor that connects habitat patches along its course. In areas where connection is difficult, small vegetation areas should be identified as stepping stones. Stepping stones create functional connectivity and are especially important for birds to fly from one area to another, providing food and refuge. Depending on the feeding diets of avifauna, vegetation structure and plant species need to be carefully curated.

Although Singapore's biodiversity per unit area may be the highest in the world (Turner, 1994), it is crucial to manage the existing biodiversity-rich habitats by maintaining connectivity. Ecological connectivity through habitat corridors plays a crucial role in maintaining biodiversity. Without it, the habitats will be isolated from one another and degrade in terms of the quantity and quality of the existing flora and fauna. The Singapore River masterplan was based on the principles of habitat connectivity to connect various natural as well as novel urban habitats along its course. The river was designed with ecological principles in mind, so that it would not only serve as a conduit for people or water, but also for native wildlife. It was also designed to take into account biodiversity guidelines and considerations to support biodiversity conservation efforts. The river edge provided an opportunity to increase the percentage of natural and semi-natural areas in the urban environment. The linear and lateral habitat connections helped reduce the rate of biodiversity loss in the novel urban ecosystems. The uninterrupted vegetated river edge reduced habitat fragmentation, which enhanced ecosystem diversity.

2c. Planting strategies

Various planting strategies were developed to create distinct identities and habitats in the different zones. A thicker layer of greenery was proposed along the river edge with plants, not only to create an aesthetically improved edge, but also to provide a biodiversity-rich habitat linkage that creates lateral ecological connections with the existing urban landscapes. The planting palette was developed based on the water level, river profile, available planting space, and different activities proposed in different zones (Fig. 9).



Zone 3: Planting scheme to reflect dry riverscape and create novel aquatic habitats with weirs

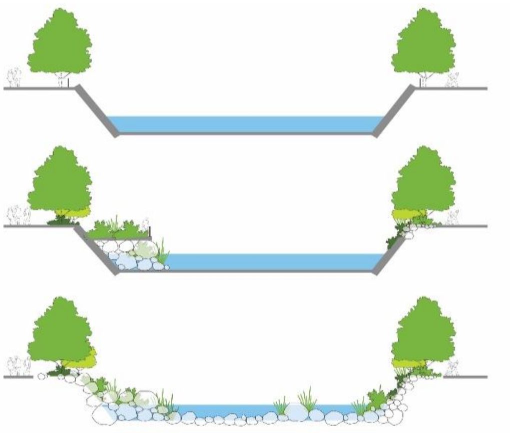
Zone 2: Trees with flowy and weeping form, together with pillar shaped trees, to create screening from existing dense developments

Zone 1: Wide river to be supported with bigger planting forms with historical marshland characteristics

Fig. 9. Proposed planting zones. (Image credit: Damian Tang)

2d. Species selection and composition

The research shows that avifauna diversity is correlated to vegetation density and flora diversity (Briffett *et al.*, 2004). Dynamic variations in the water levels and vegetation compositions created suitable microclimates for diverse flora and fauna values. Native and fauna-attracting species were preferred over only aesthetically appealing species. The proposed habitat recreation and connection aimed to achieve the objectives of the "Singapore Index on Cities' Biodiversity (please refer to Chapter 23). Riverine vegetation structure was designed to attract birds and wildlife while still making it aesthetically attractive to the people (Fig. 10). Tree species were planted in layers to attract bird species (Fig. 11). Combinations of diverse plant species were proposed to enhance flora and fauna diversity and various habitats were proposed to create suitable microclimates for the growth of natural ecosystems.



Concrete bank

Partial naturalisation of the river bank

Naturalised river bank

Fig. 10. Transformation of river banks from concrete bank to natural bank. (Image credit: Mayura Patil)

Fig. 11. Conceptual riverine planting scheme. (Image credit: Mayura Patil)

Core of the inter-agency exchange

Biodiversity enhancement or habitat restoration, which are concepts that landscape architects regularly work with, may not be familiar to most engineers. As such, the landscape architects from NParks and civil engineers from PUB needed to know each other's strengths, while aiding the understanding of terminology often used in their respective professions.

3a. Understanding requirements of other agencies

PUB has been around for more than half a century, providing Singapore with effective drainage systems, and continuously making improvements to alleviate any flash flood situations. It was important to know the priorities of PUB and the civil engineers' key technical considerations when dealing with the waterways and waterbodies. For many years, the concrete channels have been highly effective in channelling stormwater discharge during rainy weathers. The utilitarian design has specific requirements and calculations undertaken by the engineers to ensure the performance of these channels. Therefore, when designing waterways under PUB ABC Waters programme, one needs to understand the three key aspects of stormwater discharge in a channel:

I. **Hydrological analysis:** PUB takes multiple parameters in consideration while designing effective drainage systems. The first step to design drainage is to determine the catchment area that will be served by the drainage. The size as well as the type of existing and future development on the catchment area is also analysed before designing the drainage system. Based on the rainfall data, the hydrological analysis also estimates peak runoff generated from the related catchments.

II. **Hydraulic design:** The hydraulic design of the drainage system is a result of multiple factors. The design involves the calculation of developed runoff coefficients and peak runoff rates. Maximum allowable peak discharge is calculated to withstand the "1-in-50 years" storm event. The profile of the canal is also determined by the hydraulic capacity as well as the immediate surrounding of the drains.

III. **Maintenance:** The drainage maintenance regime by PUB required a 3-metre clearance for vehicular maintenance buffer on one side or both side of the drain depending on the technical and spatial constraints. The maintenance regime was rethought for the naturalised canal at Bishan-Ang Mo Kio Park. The new maintenance guidelines initiated a maintenance regime that suited the ecological and aesthetical needs of the landscape along the PUB drains.

Engineers may have a limited understanding of greenery, in terms of plants that form vegetation to create landscapes. However, the landscape architects select plants in terms of their ecological, functional, and aesthetic purposes, and create designs with those considerations in mind. Such differences in perspectives meant that during the inter-agency exchange, the scientific reasoning behind the landscape designs needed to be broken down to the civil engineers, so that the ecological outcomes could be achieved without obstructing technical requirements.

3b. Simplifying complex ideas

A master plan of this scale was expected to have ecological, hydrological as well as social components, and required inputs from experts from various agencies. With such varied considerations and different viewpoints needed, it was important that everyone understood each other's expectations better and communicating their knowledge and ideas in a simplified manner. For instance, landscape architects would need to explain how to create the river as a habitat corridor that connected habitat patches structurally and connected smaller stepping stones functionally.

3c. Performance based landscape

To design an effective drain, the engineers needed to perform various calculations considering various factors such as channel surface irregularity, channel shape variation, obstructions, type and density of vegetation, and degree of meandering (Cowan, 1956). Layers of vegetation were added on the river profile to naturalise the concrete canal. For an effective hydraulic performance of the waterway, the engineers considered the organic nature of plants, which varied in shape, size, texture, and growth rate. Hence, they used a roughness coefficient in the required calculations that took into account the changed texture on the canal profile. Thus, for an effective green-blue infrastructure, the designers had to take a note of the density, type of vegetation proposed on the river edges as well as the shape of the river flow.

3d. Involving external consultants

It was important to understand the strengths and gaps of the project team. As the grand plan for Bishan-Ang Mo Kio Park was the first-of-its-kind large-scale project, PUB engaged German landscape consultant Atelier Dreiseitl (now called Henning Larsen) who specialised in projects of similar type and scale. The consultant helped the agencies to deliver a complex modelling of the meandering Kallang River with vegetation integrated with the park. It required precise calculations to meet the capacity and hydraulics requirements from PUB, while maintaining the vision of a riverine flood plain with lush greenery.

Demonstration phase

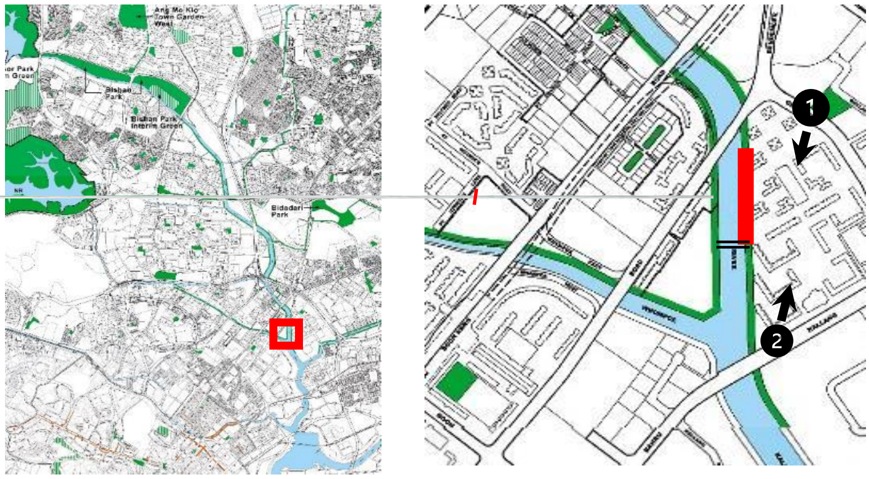
4a. Kolam Ayer

The Kolam Ayer project proved to be a great learning endeavour to successfully kickstart the ABC Waters revitalisation project for Kallang River. The demonstration phase of the ABC Waters Programme officially opened in Kolam Ayer in 2008.

The result of effective collaboration between multiple agencies as well as the local residential communities, the project sought to create an interconnected network of habitats that formed a unified ecosystem, resulting in the following:

- Park connectors along the river stretch were developed to create an uninterrupted linear link to physically connect the city to the river.
- Lateral connections were established through extending the ecosystems to the adjacent neighbourhoods.
- The proposed planting design supported the wide river profile and softened the existing edge.
- New recreational spaces were introduced to better use the under-utilised spaces along the river (Fig. 12–14).

- The activities proposed did not only establish visual connection between the users and the water, but also encouraged them to interact with water via play or exercise.
- The novel ecosystem created at the river edge also extended to the surrounding residential areas in the form of community gardens.
- From aquatic plants at the river edge, to ornamental plants along the riverside paths, the ecological network weaved in the residential areas by the means of small-scale community gardens of edible plants (Fig. 15–17).
- This network of landscaped areas encouraged public to own the new spaces and become an integral part of the project.
- Wildlife like herons, egrets, the Collared Kingfisher, and butterflies returned to the site (Fig. 18).



Figs. 12. Location of Kolam Ayer Demonstration project, 2005. (Photo credit: Damian Tang)

Before development:

Figs. 13. (A) Site 1 before enhancement; (B) Artist's impression of boardwalks and viewing decks. (Photo credit: Damian Tang)

Figs. 14. (A) Site 2 before enhancement; (B) Artist's impression of interactive water play area. (Photo credit: Damian Tang)

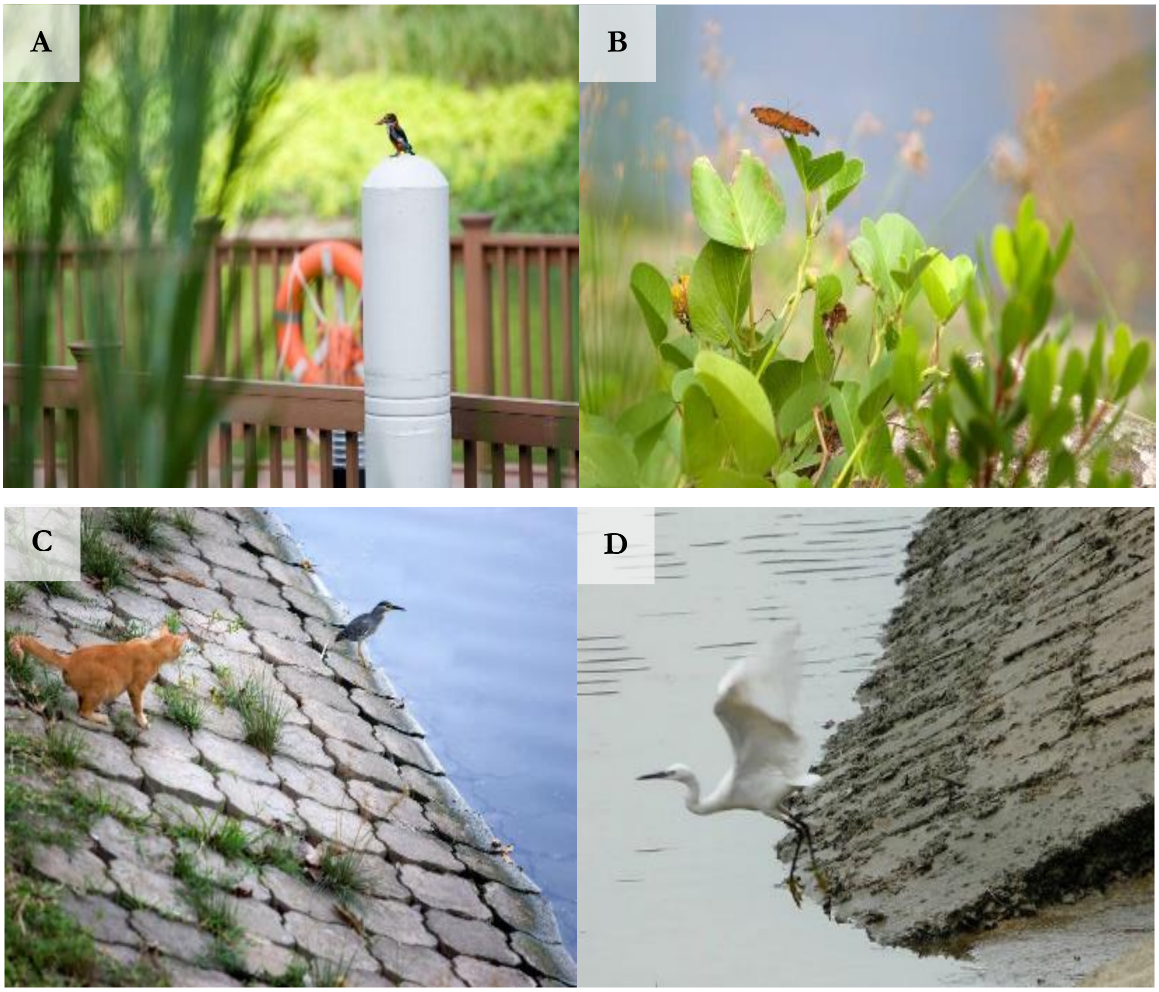
After development:

Figs. 15. (A) A view of the naturalised river edge; (B) water interactive exercise equipment at Kolam Ayer. (Photo credit: Damian Tang)

Figs. 16. (A) Water interactive play for the young and elderly; (B) viewing decks at Kolam Ayer. (Photo credit: Damian Tang)

Figs. 17. (A) Spaces along the river edge designed to encourage communal activities and (B) community gardens along the river at Kolam Ayer. (Photo credit: Damian Tang)

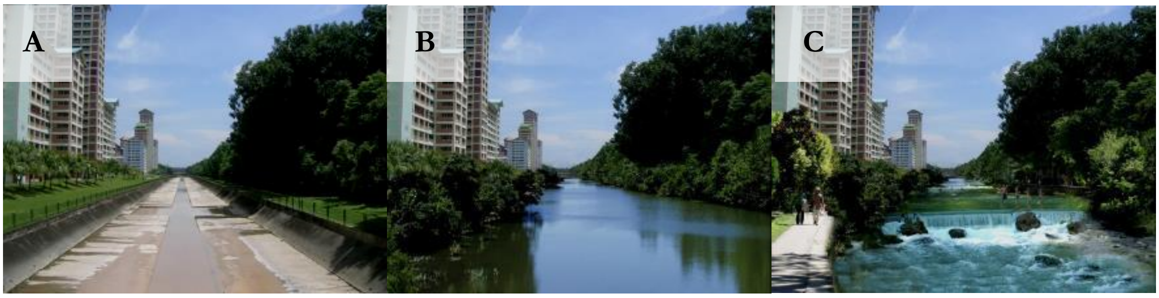
Biodiversity spotted after completion of the project:



Figs. 18. (A) Blue-eared Kingfisher (*Alcedo meninting*); (B) Tawny Coster (*Acraea terpsicore*); (C) Striated Heron (*Butorides striata*); (D) Little Egret (*Egretta garzetta*). (Photo credit: Damian Tang)

4b. Rejuvenating Bishan-Ang Mo Kio Park

The visionary images of Kallang River illustrated the possibilities of waterways and waterbodies that could be transformed in different phases (Fig. 19). The idea behind the integrated landscape design for Bishan-Ang Mo Kio Park arose from the broader Kallang River master plan, where certain nodes were identified for potential rejuvenation. The transformation of Bishan Park (with its concrete canal) to the biodiversity-rich riverine Bishan-Ang Mo Kio Park became clearly visible from the image documentation, a vision that we wish to bring to other waterways in Singapore. The Bishan Ang Mo Kio Park would later win multiple awards including the prestigious 'Landscape of the Year' award at the World Architecture Festival, 2012.



Figs. 19. (A) Concrete canal in Bishan Park, 2012; (B) 'Naturalising river edge' artist's impression of Bishan-Ang Mo Kio Park; (C) 'Vision for our river' artist's impression of Bishan-Ang Mo Kio Park. (Photo credit: Damian Tang)

The naturalised river in Bishan-Ang Mo Kio Park has created community spaces and diverse habitats for several fauna species. The park's biodiversity has increased over the years, including 150 species of wildflowers, up to 155 species of birds (data provided by eBird, www.ebird.org, and created on 7 June 2023), 38 species of dragonflies and damselflies, 47 species of butterflies, four species of mammals, and eight aquatic species (Hwang *et al.*, 2020). Some of the fauna species observed at the park are listed in the Annex (National Parks Board, 2020).

Learning points

For projects that do not have precedents in Singapore, it is important to learn from other case studies that are of similar scale and type, involving a similar-sized location and similar design fundamentals. While studying other cases, it is also important to collect and analyse information about constraints and problems faced during the realisation of the project. Designers must not forget that behind every calculation lies a performance, which is the most important factor that will determine the effectiveness of the project.

To make the landscape truly functional, planners need to develop landscape strategies beyond designated bureaucratic boundaries. Such strategies can be formulated based on learning from demonstration sites and the results of interventions tested on those sites. When undertaking such large-scale projects, multiple agencies need to work together and leverage each other's expertise, while facilitating communication within the large team by simplifying complex ideas.

At the same time, it is important to recognise the gaps in the team's expertise and strengths, and getting other field experts, such as external consultants, involved at the right stage of the project.

Ultimately, all agencies and other consultants will need to manage differences and trade-offs while keeping the bigger picture of achieving highly functional ecologies in mind.

In conclusion, Singapore's approach to urban green spaces and biodiversity conservation involves a combination of preserving natural areas, creating green spaces within the city, and restoring degraded ecosystems. These efforts have not only improved the overall liveability of the city but also provided opportunities for nature exploration, environmental education, and ecological connectivity. By recognising the value of green spaces and implementing sustainable practices, Singapore continues to set an example for other cities around the world in balancing urban development with environmental conservation.

Acknowledgements

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Annex: List of fauna observed at Bishan-Ang Mo Kio Park after the completion of the project.

Birds

	Common name	**Scientific name**
1	African Grey Parrot	*Psittacus erithacus*
2	Arctic Warbler	*Phylloscopus borealis*
3	Ashy Minivet	*Pericrocotus divaricatus*
4	Asian Brown Flycatcher	*Muscicapa dauurica*
5	Asian Glossy Starling	*Aplonis panayensis*
6	Asian Koel	*Eudynamys scolopacea*
7	Barn Swallow	*Hirundo rustica*
8	Black Bittern	*Ixobrychus flavicollis*
9	Black Crowned Night Heron	*Nycticorax nycticorax*
10	Black-headed Munia	*Lonchura malacca*
11	Black-naped Oriole	*Oriolus chinensis*
12	Blue tailed Bee Eater	*Merops viridis*
13	Blue Throated Bee Eater	*Merops philippinus*
14	Blue-Crown Hanging Parrot	*Loriculus galgulus*
15	Brahminy Kite	*Haliastur indus*
16	Bronze Mannikin	*Lonchura cucullata*
17	Brown Shrike	*Lanius cristatus*
18	Brown-throated Sunbird	*Anthreptes malacensis*
19	Cattle Egret	*Bubulcus ibis*
20	Changeable Hawk Eagle	*Spizaetus cirrhatus*
21	Chinese Pond Heron	*Ardeola bacchus winter*
22	Collared Kingfisher	*Todiramphus chloris*
23	Common Flameback	*Dinopium javanense*
24	Common Iora	*Aegithina tiphia*
25	Common Kingfisher	*Alcedo atthis*
26	Common Myna	*Acridotheres tristis*
27	Common Sandpiper	*Actitis hypoleucos*

Birds ***(Cont'd)***

28	Common Tailorbird	*Orthotomus sutorius*
29	Coppersmith Barbet	*Psilopogon haemacephala*
30	Crested Goshawk	*Accipiter trivirgatus*
31	Crested Honey Buzzard	*Pernis ptilorhynchus*
32	Crimson Rumped Waxbill	*Estrilda rhodopyga*
33	Crimson Sunbird	*Aethopyga siparaja*
34	Dollarbird	*Eyrystimas orientalis*
35	Eurasion Tree Sparrow	*Passer montanus*
36	Germain's Swiftlet	*Aerodramus germani*
37	Golden-bellied Gerygone	*Gerygone sulphurea*
38	Grey headed Swamphen	*Porphyrio poliocephalus*
39	Grey Heron	*Ardea cinerea*
40	Grey Rumped Treeswift	*Hemiprocne longipennis*
41	Hill Mynah	*Gracula religiosa*
42	House Crow	*Corvus splendens*
43	Intermediate Egret	*Egretta intermedia*
44	Japanese Sparrowhawk	*Accipiter gularis*
45	Javan Myna	*Acridotheres javanicus*
46	Javan Pond Heron	*Ardeola speciosa*
47	Large-Billed Crow	*Corvus macrorhynchos*
48	Little Bronze Cuckoo	*Chrysococcyx minutillus*
49	Little Egret	*Egretta garzetta*
50	Long-tailed Parakeet	*Psittacula longicauda*
51	Long Tailed Shrike	*Lanius schach*
52	Lutino Lovebird	*Agapornis roseicollis var.*
53	Olive Backed Sunbird	*Nectarinia jugularis*
54	Orange Cheeked Waxbills	*Estrilda melpoda*
55	Oriental Magpie Robin	*Copsychus saularis*
56	Oriental Pied Hornbill	*Anthracoceros albirostris*
57	Oriental Reed Warbler	*Acrocephalus orientalis*

Birds ***(Cont'd)***

58	Oriental White-eye	*Zosterops palpebrosus*
59	Pacific Golden Plover	*Pluvialis fulva*
60	Pacific Swallow	*Hirundo tahitica*
61	Paddyfield Pippit	*Anthus rufulus*
62	Pied Fantail	*Rhipidura javanica*
63	Pied Triller	*Lalage nigra*
64	Pink-necked Green Pigeon	*Treron vernans*
65	Purple Heron	*Ardea purpurea*
66	Rainbow Lorikeets	*Trichoglossus moluccanus*
67	Red Junglefowl	*Gallus gallus*
68	Red Turtle Dove	*Streptopelia tranquebarica*
69	Red-breasted Parakeet	*Psittacula alexandri*
70	Red-Whiskered Bulbul	*Pycnonotus jocosus*
71	Rock Pigeon	*Columba livia*
72	Rose-ringed Parakeet	*Psittacula krameri*
73	Scaly-breasted Munia	*Lonchura punctulata*
74	Scarlet Minivet	*Pericrocotus speciosus*
75	Scarlet-backed Flower Pecker	*Dicaeum cruentatum*
76	Slaty-breasted Rail	*Gallirallus striatus*
77	Spotted Dove	*Streptopelia chinensis*
78	Spotted Wood Owl	*Strix seloputo*
79	Stork-Billed Kingfisher	*Pelargopsis capensis*
80	Striated Heron	*Butorides striatus*
81	Striped Tit Babbler	*Macronus gularis*
82	Sunda Pygmy Woodpecker	*Dendrocopus moluccensis*
83	Swinhoe's White-eye	*Zosterops simplex*
84	Tiger Shrike	*Lanius tigrinus*
85	White Breasted Waterhen	*Amaurornis phoenicurus*
86	White Headed Munia	*Lonchura maja*
87	White Wagtail	*Motacilla alba*

Birds ***(Cont'd)***

88	White-bellied Sea Eagle	*Haliaeetus leucogaster*
89	White-throated Kingfisher	*Halcyon smyrnensis*
90	Yellow Bittern	*Ixobryshus sinensis*
91	Yellow-bellied Prinia	*Prinia flaviventris*
92	Yellow-fronted Canary	*Serinus mozambicus*
93	Yellow-vented Bulbul	*Pycnonotus goiavier*
94	Zanzibar Red Bishop	*Euplectes nigroventris*
95	Zebra Dove	*Geopelia striata*

Dragonflies and damselflies

	Common name	**Scientific name**
1	Blue Adjutant	*Aethriamanta aethra*
2	Blue Dasher	*Brachydiplax chalybea*
3	Blue Percher	*Diplacodes trivialis*
4	Blue Sprite	*Pseudagrion microcephalum*
5	Coastal Glider	*Macrodiplax cora*
6	Common Amberwing	*Brachythemis contaminata*
7	Common Blue Skimmer	*Orthetrum glaucum*
8	Common Bluetail	*Ischnura senegalensis*
9	Common Chaser	*Potamarcha congener*
10	Common Flangetail	*Ictinogomphus decoratus*
11	Common Parasol	*Neurothemis fluctuans*
12	Common Redbolt	*Rhodothemis rufa*
13	Common Scarlet	*Crocothemis servilia*
14	Crimson Dropwing	*Trithemis aurora*
15	Emperor	*Anax guttatus*
16	Fiery Coraltail	*Ceriagrion chaoi*
17	Grenadier	*Agrionoptera insignis*
18	Indigo Dropwing	*Trithemis festiva*
19	Look-alike Sprite	*Pseudagrion australasiae*

Dragonflies and damselflies *(Cont'd)*

20	Ornate Coraltail	*Ceriagrion cerinorubellum*
21	Pond Adjudant	*Aethriamanta gracilis*
22	Saddlebag Glider	*Tramea transmarina*
23	Sapphire Flutterer	*Rhyothemis triangularis*
24	Scarlet Adjudant	*Aethriamanta brevipennis*
25	Scarlet Basker	*Urothemis signata*
26	Scarlet Grenadier	*Lathrecista asiatica*
27	Scarlet Skimmer	*Orthetrum testaceum*
28	Slender Duskdarter	*Zyxomma petiolatum*
29	Spine-tufted Skimmer	*Orthetrum chrysis*
30	Trumpet Tail	*Acisoma panorpoides*
31	Variable Sprite	*Argiocnemis rubescens*
32	Variable Wisp	*Agriocnemis femina*
33	Variegated Green Skimmer	*Orthetrum sabina*
34	Wandering Glider	*Pantala flavescens*
35	Water Monarch	*Hydrobasileus croceus*
36	White-barred Duskhawk	*Tholymis tillargis*
37	Yellow-barred Flutterer	*Rhyothemis phyllis*
38		*Aethriamanta* species

Butterflies and moths

	Common name	**Scientific name**
1	Atlas Moth	*Attacus atlas*
2	Autumn Leaf	*Doleshallia bisaltide bisaltide*
3	Black Vein Tiger	*Danaus melanippus hegesippus*
4	Blue Glassy Tiger	*Ideopsis vulgaris macrina*
5	Blue Pansy	*Junonia orithya wallacei*
6	Bush Hopper	*Ampittia dioscorides camertes*
7	Chocolate Grass Yellow	*Eurema sari sodalis*
8	Chocolate Pansy	*Junonia hedonia ida*

Butterflies and moths ***(Cont'd)***

9	Ciliate Blue	*Anthene emolus goberus*
10	Common Bluebottle	*Graphium sarpedon lucatius*
11	Common Grass Yellow	*Eurema hecabe contubernalis*
12	Common Mime	*Papilio clytia clytia*
13	Common Mormon	*Papilio polytes romulus*
14	Common Palmfly	*Elymnias hypermnestra agina*
15	Common Rose	*Pachiliopta aristolochiae asteris*
16	Common Sailor	*Neptis hylas*
17	Common Tiger	*Danaus genutia genutia*
18	Common Tit	*Hypolycaena erylus teatus*
19	Contiguous Swift	*Polytremis lubricans lubricans*
20	Cycad Blue	*Chilades pandava*
21	Dark Grassy Tiger	*Parantica algeoides algeoides*
22	Green Baron	*Euthalia adonia pinwillia*
23	Jacintha Eggfly	*Hypolimnas bolina jacintha*
24	Julia Heliconian	*Dryas iulia*
25	Lemon Emigrant	*Catopsilia pomona pomona*
26	Leopard	*Phalantha phalantha*
27	Lesser Dart	*Potanthus omaha*
28	Lesser Grass Blue	*Zizina otis lampa*
29	Lime Butterfly	*Papilio demoleus malayanus*
30	Mottled Emigrant	*Catopsilia pyranthe pyranthe*
31	Orange Emigrant	*Catopsilia scylla cornelia*
32	Painted Jezebel	*Delias hyparete metarete*
33	Pale Bob	*Suastas gremius gremius*
34	Pale Palm Dart	*Telicota colon argeus*
35	Pea Blue	*Lampides boeticus*
36	Peacock Pansy	*Junonia almana javana*
37	Peacock Royal	*Tajuria cippus maxentius*
38	Plain Tiger	*Danaus chrysippus chrysippus*

Butterflies and moths ***(Cont'd)***

39	Psyche	*Leptosia nina malayana*
40	Pygmy Grass Blue	*Zizula hylax pigmaea*
41	Short Banded Sailor	*Phaedyma columella singfa*
42	Small Branded Swift	*Pelopidas mathias mathias*
43	State Flash	*Rapala manea chozeba*
44	Striped Albatross	*Appias libythea olferna*
45	Tailed Jay	*Graphium agamemnon agamemnon*
46	Tailless Line Blue	*Prosotas dubiosa lumpura*
47	Tawny Coster	*Acraea terpsicore*

Bees and wasps

	Common name	**Scientific name**
1	Andrew's Blue-banded Digger Bee	*Amegilla andrewsi*
2	Asian Honey Bee	*Apis cerana*
3	Black Mud Wasp	*Delta emarginatum*
4	Carpenter Bee	*Xylocopa aestuens*
5	Confusing Cone-waisted Cuckoo Bee	*Coelioxys confusa*
6	Emerald Cuckoo Wasp	*Chrysis sp.*
7	Giant Honey Bee	*Apis dorsata*
8	Greater Banded Hornet	*Vespa tropica*
9	Himalayan Cloak-and-dagger Bee	*Thyreus himalayensis*
10	Lesser Banded Hornet	*Vespa affinis*
11	Pearly Banded Bee	*Nomia strigata*
12	Potter Wasp	*Rhynchium haemorrhoidale*
13	Shadow-winged Resin Bee	*Megachile umbripennis*
14	Wide-footed Carpenter Bee	*Xylocopa latipes*