MALAYSIA ARCHITECTURAL JOURNAL

Malaysia Architectural Journal

Journal homepage:
https://majournal.my/index.php/maj
e-ISSN : 2716-6139

Designing Bangalore City for Human-Avian Coexistence: A Step Towards Including Non-Human Species in Design

Shraddha Jathan[1], Nikita Rathish[2*]

[1]Architect, Rahul Mehrotra Architects, India
[2]Junior Architect, SJK Architects, India

ARTICLE INFO

Article history:
Received
Received in revised form
Accepted
Available online

Keywords:
Avian; Urban-ecosystem; Adaptive Habitat; Human- Avian Interactions

ABSTRACT

For an ecosystem to function, there must be ongoing interactions between different species and their habitats, ways of life, and surroundings throughout their individual life cycles. However, Anthropocentric developments over the years have adversely affected the biodiversity of ecosystems across the globe. While certain species have adapted to urbanization and even benefit from living in proximity to humans (Synanthropes), some species today are at risk of endangerment. The human tendency to favour certain species selectively based on their aesthetic value puts the avians at a disadvantage. As a result, even though avians are an essential ecosystem component, they have a dearth of design inclusion in city planning. One of the nations with the fastest economic development, India is home to a wide variety of bird species, both resident and migratory. Bangalore, the city chosen for this study, is the centre of India's high-tech industry known for its gardens and lakes. The garden city holds a vast population of different cultures, diversity, and services and houses many urban wildlife. It faces the consequences of rapid urbanization: overwhelming population, inadequate infrastructure, poor planning, and the possible threat of losing some of its native and migratory avian species. This study will focus on serving as a model for developing design recommendations for the cohabitation of Humans and Avians in Bangalore. The need for an interdisciplinary approach in design will be explored by understanding the natural and adaptive habitats & life cycles of avian species along with human-avian interactions (Conflicts, issues, and responses) to plan and reinvent the cities into being inclusive. The paper aims to establish a comprehensive framework to assist city planners in leveraging existing natural assets, such as gardens, green spaces, lakes, and infrastructure, alongside new construction projects to foster the creation of more vibrant and environmentally conscious cities.

* *Shraddha Jathan.*
E-mail address: shraddhajathan.writes@gmail.com

1. Introduction

Species (the functional units), their Interactions & habitats, nutrient cycling & food webs, life cycles, and surroundings form an ecosystem's basis [1]. The loss of biodiversity, primarily caused by anthropogenic activities over the years, has led to the destabilization of ecosystems across the globe, and the Garden City of India, Bangalore, is no exception [2]. Urbanization, loss of biodiversity and thus habitat degradation, climate change, and environmental pollutants are major threats to avians in India, along with energy infrastructure (wind energy and power lines), artificial illumination, noise pollution, & glass buildings, which lead to collisions. Although urbanization is a dynamic and complex historical process, cities are perhaps the newest ecosystem type on the planet. In these settings, human appropriation of net primary production occurs, and as a result, the most significant impact on the environment is observed. Thus, it should also be the setting where major interventions should ideally occur to accommodate all species [4]. The introduction of guidelines based on research and cross-disciplinary (Ecologists, Landscape Architects, Urban Planners, Architects, Decision-making Bodies/governments, organizations, representatives for human/non-human users, etc.) approach, depending on the type of development becomes all the more necessary to help the city's development in an ecologically better direction, benefitting all stakeholders and their interests (human and non-human). This helps bridge gaps to have a holistic understanding of a more inclusive design, which is not purely anthropocentric and truly sustainable considering the rate of Earth's degradation. The economy's growth has culminated in the invasion and contamination of water bodies, the felling of thousands of trees, the urbanization of green spaces, and the extensive conversion of parks and open spaces into residential, commercial, and industrial locales. There have been many detrimental impacts on human health and well-being due to these combined changes in ecosystems, land use, and governance [3].

Biodiversity is quite complex to quantify precisely. However, the vast array of bird species and populations in each region is a primary bio-indicator of a healthy environment. Thus, an effort to diversify the species of flora & fauna in general and birds in particular will assist in boosting the region's biodiversity [5, 6]. Birds provide four types of ecosystem services: provision, regulation, cultural and support service. Predation, pollination, scavenging, seed distribution, seed predation, and ecosystem engineering are all significant functions they play [7]. The homogeneity of the environment in cities makes species composition more common for certain regions, while green infrastructure can improve rural bird diversity [2]. When it comes to human-avian relations, irked by birds using building components as their new habitat, sill depth, etc., are being made smaller to avoid their presence around; this inadvertently also makes the interior spaces more uncomfortable during the summer months. Hence reducing their options for habitation. High-rise and glass buildings have affected their juvenile flight and predation training and increased their head-on glass collisions (365 recorded in Bangalore in the last three years). Surplus artificial lighting at night creates havoc in survival and feeding instincts. The loss of lakes and green cover has resulted in the loss of the respective bird biodiversity [6]. The existing building blocks, Facades, Lakes and green cover (Gardens and parks) will thus be the intervention area for this study. These elements are the common ground for human-avian interaction in the city. It is essential to consider endangered, threatened, and vulnerable species in design while planning cities and infrastructure.

Currently, laws are in place for conserving biodiversity and sensitive ecosystems. Still, interventions are needed where humans primarily use the land for their purposes [4]. Biodiversity is vital for achieving the Sustainable Development Goals (SDGs). However, little attention has been paid to urban biodiversity, an essential aspect of SDG11 (sustainable cities and communities). It is in continuity with the delivery of SDG11 (Life below water) and SDG15 (life on land) [2, 8]. Despite numerous efforts to integrate biodiversity into urban planning processes (e.g., Niemelä 1999), biodiversity and ecosystem service supply must still be mainstreamed into landscape and urban design. The contradiction between urban planning and biodiversity conservation stems primarily from the fact

that biodiversity and ecosystem services are not included during the early stages of project design, when developers, architects, and landscape architects construct unified project concepts. Civic initiatives play a significant role in urban ecosystem preservation. As a result, it is critical to begin making changes at that level to guarantee that designers follow the essential steps in the form of standards until it becomes the norm and enough awareness grows among the public. Building biodiversity in neighbourhood parks in Bangalore city, India: Ordinary yet essential recorded avians to be one of the high-ranked species amongst others in a fondness survey for neighbourhood parks of Bangalore, which suggests the possibility of integrating their conservation through landscape interventions benefitting not only humans but the avian group.

The existing guidelines (URDPFI), Zonal Regulations, and Building Bylaws for the cities are highly anthropocentric in India **[6]**. The identification of species for every district/region of the city and their status is essential compiled data that needs to be considered during the concept phase of design (WID). The central concept is seamlessly incorporating animal habitats into urban open and green space planning. Understanding the necessity of formulating solutions/recommendations that include non-humans, non-invasive to humans, and ideally even beneficial is essential. This is necessary because the recommendations will only be incorporated into urban open and green space planning if they appeal to the builders, urban planners, architects, and landscape architects [4].

2. Methodology

2.1 Study Area

Bangalore, the capital of Karnataka State, which is located in the heart of South Deccan of Peninsular India, has a temperate climate (moderate climatic condition year-round), and the vegetation was classified as dry deciduous forest-type under the *Terminalia-Anogeissus latifolia-Tectona* series. The region lies between latitudinal parallels 12º 39'- 13º 18' N and longitudinal parallels 77º22' - 77º52'E at an 839- 962m elevation above sea level with an annual average rainfall of 900 mm, distributed well among the South-West and North-East monsoon.

Statistics show that the study site, Bangalore, saw drastic urban, vegetation, and water cover changes between 1973 and 2013.

Tab. 1.

Temporal Land use dynamics

CLASS	**URBAN** (Residential, Industrial areas, paved area, mixed pixel with built-up area)		**VEGETATION** (Forests, plantations)		**WATER** (Tanks, lakes, reservoirs, lakes)		**OTHER** (Rocks, quarry pits, open land, croplands, nurseries, dry land)	
YEAR	Hectare	%	Hectare	%	Hectare	%	Hectare	%
1973	5448	7.97	46639	68.27	2324	3.4	13903	20.35
2013	50440	73.72	10050	14.69	445.95	0.65	7485	10.94

Source: ([15])

Today, the area of Bangalore is about 741 sq. km. Bangalore currently has only 1 tree/7 persons, whereas the minimum requirement is 1.15 trees/person, and the ideal requirement is 8 trees/person [13]. These drastic changes have garnered the citizens' attention and concern, leading to the rise of multiple organizations and groups (Hasiru Usiru, Eco-Watch, B.Pac, et al., to name a few). For this study, data on the avian species of Bangalore has been collected from Bird Count India- A partnership of organizations and groups that works by engaging with citizen scientists (birdwatchers) across the country to generate both informal (casual birding) and formal (systematic surveys and monitoring)

data on birds and converting this data into knowledge, State of India's Birds (2023) [14, 15]. The primary data used in this report is from BirdLife International Data Zone, a globally partnered NGO for bird conservation. Additionally, the data from eBird and State of India Birds Report 2023 was combined with supporting information for each species — including their taxonomic grouping, habitat, migration, endemicity and diet — to create the summaries in the report. Secondary data used for the study are primarily in the form of journal articles/research papers, Government websites/records, and local newspaper articles for an in-depth understanding of the city's state; all the sources qualify for the CRAAP test.

AAD (Animal Aided Design), BSUD (Bio- Diversity Sensitive Urban Design), WID (Wildlife Inclusive Design), & BID (Biodiversity Inclusive Design) are frameworks developed between 2010 and 2023 that guide design for "non-human" species (Flora & Fauna) as clients. They are utilized as the base for developing guidelines and recommendations for avian-inclusive design in Bangalore. The various threatened, vulnerable and thriving species were identified to analyze how cities can accommodate non-human species (avians) in cities through design. Their Habitat and life cycles were studied along with the existing case studies and species-inclusive design frameworks such that the two aspects can be overlayed for the case of Bangalore. The design recommendations will target the SDGs, LEED, and GRIHA requirements to make the avian-inclusive design recommendations beneficial and appealing to the stakeholders involved. The ideal extent of intervention to avoid human-avian conflicts and allow peaceful co-existence with humans can only be confirmed through evidence-based research and existing case studies, which would be the next step after the study.

The paper draws on four frameworks developed between 2010 and 2023—AAD (Animal Aided Design) [4], BSUD (Bio-Diversity Sensitive Urban Design) [48], WID (Wildlife Inclusive Design) [49], and BID (Biodiversity Inclusive Design) [16]—which offer guidance for designing with non-human species (both flora and fauna) as clients. These frameworks serve as the foundation for crafting avian-inclusive design guidelines specific to Bangalore. The study delves into bird-friendly design recommendations from cities worldwide, such as Vancouver, Chicago, and Australia, to inform the structuring of these guidelines. Additionally, insights from reports and recommendations concerning lake preservation and conservation contribute to shaping design guidelines for lakes in Bangalore.

2.2 Structure: an avian-inclusive design for Bangalore

The proposed framework can be used as a roadmap for projects of different scales within the city of Bangalore. The developed framework;

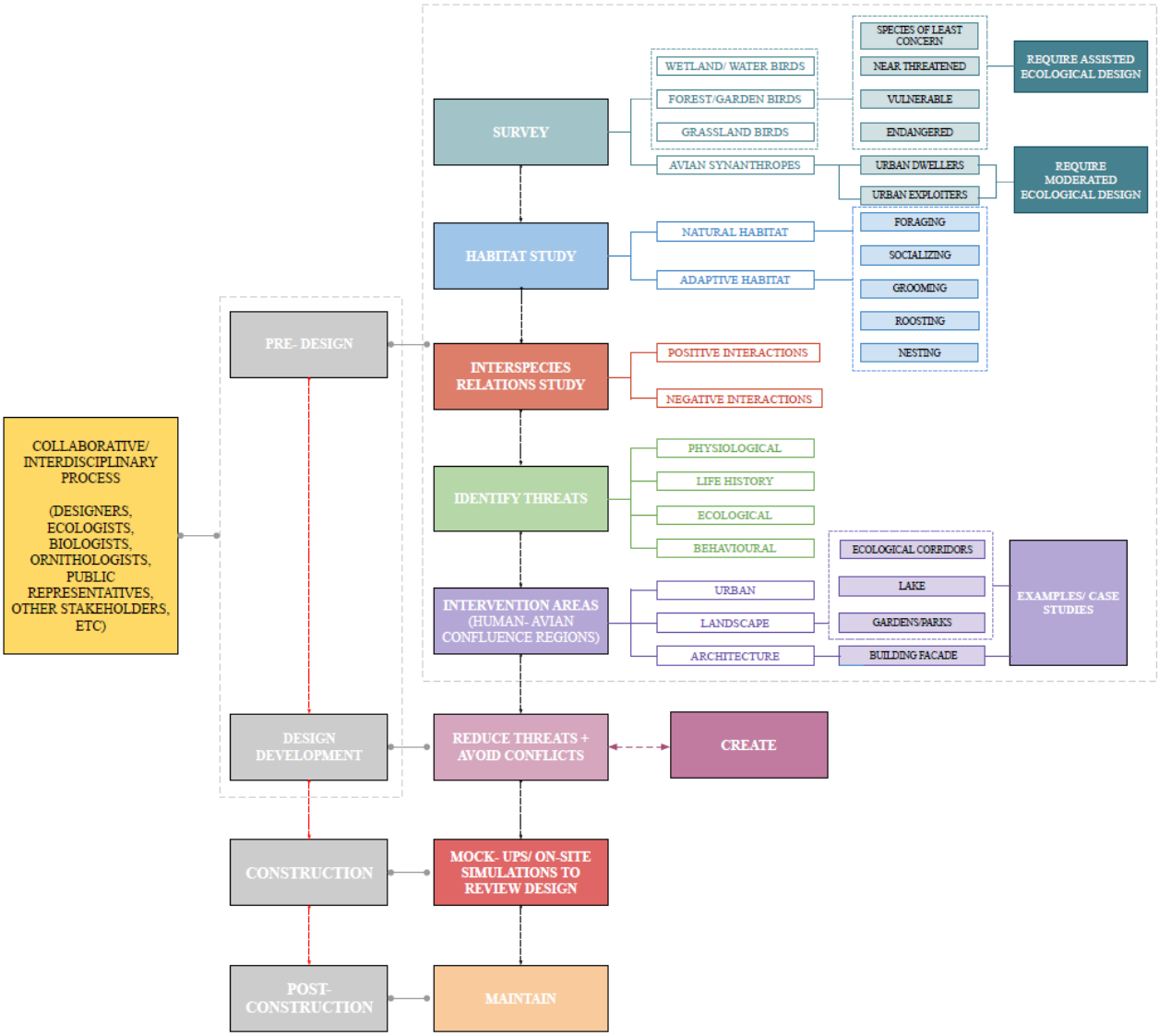

Fig. 1 Avian-inclusive Design for Bangalore: A Framework

2.3 Survey: Species Selection

The bird species that should be carefully considered while designing are the endangered and vulnerable, which require enabling in the form of ecological architecture, and the urban exploiters, whose invasive interaction with humans requires regulation. In selecting target species for a project, relying on publicly available data on species occurrences poses certain limitations. These limitations primarily stem from two types of errors: false absence data and false presence data. To mitigate these issues, the monitoring study area encompasses a 50 km radius around the project site as per [38]. Adopting such a broad scale helps mitigate the problem of false presence data under the condition that not all observers commit identical identification errors. Given that the current radius of Bangalore, encompassing both urban and rural areas, is significantly smaller than 50km, categorizing birds based on their three primary natural habitat typologies—Wetland, Forest, and Grassland—proves valuable for comprehending avian habitat requirements. The table presents a compilation of Bangalore's bird species, elucidating their natural habitats and adaptive behaviours. It is not feasible to design for each bird species in the region during a project; rather, it is more practical to develop an overarching understanding of their foraging patterns, habitat preferences, and life-cycle requirements. It is

important to note that the IUCN categorization is, however, not always the true status of the birds locally as it is an international red list.

Tab. 2.
Species, Scientific Name, Natural and Urban habitat, Seasonal movement, IUCN Category, diet type and Wildlife Protection Act Schedule of selected birds in Bengaluru city

S. NO.	SPECIES OF BIRD	SCIENTIFIC NAME	NATURAL HABITAT TYPE	URBAN HABITAT	SESONAL MOVEMENT	IUCN CATEGORY	DIET	WPA SCHEDULE
1	Painted stork	*Mycteria leucocephala*	Wetland (marshes, agricultural fields)	(Canals and Drainage Channels, Ditches, Wastewater Treatment Areas, Water Storage Areas)	Locally Migratory (Widespread winter visitor)	Near Threatened	Vertebrates & Carrion	2
2	Oriental Darter	*Anhinga melanogaster*	Wetland (Freshwater)		Resident	Near Threatened	Fish, invertebrates (insects), aquatic reptiles	2
3	Spot-billed Pelican	*Pelecanus philippensis*	Wetland (Freshwater) Trees	Wastewater Treatment Areas, Water Storage Areas	Resident	Near Threatened	Fish, frogs	2
4	Black-headed Ibis	*Threskiornis melanocephalus*	Wetland (Agricultural fields, dry fields, coastal areas)	Human-modified Landscape	Resident	Near Threatened	Insects, small vertebrates (frogs, snakes, etc)	2
5	Black-tailed Godwit	*Limosa limosa*	Wetland (grassy wetland, marshes, tidal flats	Arable land	Migratory (Widespread winter visitor)	Near Threatened	Invertebrates (larvae, fish eggs, spiders)	2
6	River Tern	*Sterna aurantia*	Wetland (sandy island, freshwater)		Resident	Near Threatened	Fish, insects, frogs	1
7	Tytler's Leaf-Warbler	*Phylloscopus tytleri*	Wetland (shrubs, wet hilltops)		Resident	Near Threatened	Small insects	2
8	Lesser Flamingo	*Phoeniconaias minor*	Wetland (alkaline lakes, coastal lagoon)	Wastewater Treatment Areas, salt exploitation sites	Resident & Winter visitor	Near Threatened	Algae, Small invertebrates	2
9	Great Snipe	*Gallinago media*	Wetland (marshes, wet meadows)	Arable land	Migratory (Vagrant)	Near Threatened	Insects, seeds	2
10	Eurasian Curlew	*Numenius arquata*	Wetland (Coastal marshes, mud flats)	Flooded agricultural lands, arable land	Migratory (Widespread winter visitor)	Near Threatened	Fruits, seeds, small vertebrates (lizards, small fish, small birds, small rodents), insects	2
11	Black-necked Stork	*Ephippiorhynchus asiaticus*	Wetland (swamps, rivers, lakes, flooded grassland)	Trees, cultivated sites	Resident	Near Threatened	Vertebrates (Small fish, snake, lizard, frog), invertebrates (insects)	2
12	Black-bellied Tern	*Sterna acuticauda*	Wetland (barren flats, sandy islands in rivers		Resident	Endangered	Insects & small fish	1
13	Wood Snipe	*Gallinago nemoricola*	Wetland (along rivers, vegetated marshes or swamps)		Resident	Vulnerable	Insects, seeds	1
14	Brahmy Kite	*Haliastur indus*	Wetland (marshes, rivers, lakes, swamps, rice fields)	Artificial structures	Resident	Least concern	Rodents, snakes, frogs	1
15	Indian pond heron	*Ardeola grayii*	Wetland (rivers, lakes)		Resident (Widespread resident)	Least concern	Invertebrates (small fish, frogs), vertebrates (insects)	2
16	Red-wattled Lawping	*Vanellus indicus*	Wetland (wet grassland, large gardens)	waste, fallow, ploughed land, grass along highway	Resident	Least concern	Invertebrates	2
17	Little Egret	*Egretta garzetta*	Wetland (shallow water)	Canals and Drainage Channels, Dit	Resident	Least concern	Small vertebrates (frogs, fish, small birds, rodents), insects	2
18	Greater Spotted Eagle	*Clanga clanga*	Forest, Grassland, open land and Wetland (mudflats, marshes)	Arable land	Resident & Widespread winter visitor	Vulnerable	Small Vertebrates (lizards, small fish, snakes, small birds), carrion	1
19	Black kite	*Milvus migrans*	Forest, Grassland, open land and Wetland (rivers, lakes)	scrublands, agricultural habitats near human settlements	Local Migrants	Least concern	Vertebrates (Rodent, snakes, frogs, small birds, fish, lizard), household refuse	2
20	House crow	*Corvus splendens*	Forest, Grassland, open land, Wetland and human habitation	Gardens, Waste disposal areas, Urban areas	Resident	Least concern	Vertebrates (Rodents, lizards), Invertebrates (insects), grains, nectar, carrion	2
21	Large-billed Crow	*Corvus macrorhynchos*	Forest, Grassland, open land, Wetland and human habitation (large trees, particularly those close to slaughterhouses, rubbish dumps & small fishing ports)	Gardens, Waste disposal areas, Urban areas	Resident	Least concern	Vertebrates (rodents, lizards, frogs etc), large invertebrates, insects, fruit, nectar, carrion	2
22	Black drongo	*Dicrurus macrocercus*	Forest, Grassland, open land, Wetland and human habitation	telephone wires & poles, roadside trees, parks, gardens	Resident	Least concern	Insects, small vertebrates (small birds, lizard, bats)	2
23	white-throated kingfisher	*Halcyon smyrnensis*	Forest, Grassland, open land, Wetland and human habitation (canals, ponds, swamps, mudflats, trees)	large gardens, roadside trees, light industrial sites	Resident	Least concern	Vertebrates (frogs, lizrds, fish), Invertebrates	2
24	Laggar Falcon	*Falco jugger*	Forest, Grassland, open land	Power poles, buildings	Resident	Near Threatened	Small vertebrates (lizards, bats, birds), insects	4
25	Egyptian Vulture	*Neophron percnopterus*	Forest, Grassland, open land	Cliffs, buildings, trees	Resident	Endangered	Vertebrates & Carrion	1
26	Indian Vulture	*Gyps indicus*	Forest, Grassland, open land (agricultural fields)	Parks, sactuaries	Resident	Critically Endangered	Vertebrates & Carrion	1

27	White-rumped Vulture	*Gyps bengalensis*	Forest, Grassland, open land (agricultural fields)	Parks, sanctuaries, Dumps, slaughterhouses, trees (droppings kill trees)	Resident	Critically Endangered	Carrion (especially cattle)	1
28	Great Indian Bustard	*Ardeotis nigriceps*	Forest, Grassland, open land	Arable land	Resident		Grains, fruits, invertebrates (insects), Vertebrates (small snakes, lizards)	1
29	Black-winged kite	*Elanus caeruleus*	Forest, Grassland, open land	Arable land	Resident	Least concern	Insects, Vertebrates (rodents, small birds, lizards, Carrion	2
30	Eastern Cattle Egret	*Bubulcus ibis*	Forest, Grassland, open land, and human habitation	Arable land	Migratory (Sparse winter visitor)	Least concern	Insect, fish, frog, small snakes	2
31	Ashy Prinia	*Prinia socialis*	Forest, Grassland, open land, and human habitation	Gardens, plantations, arable land	Resident	Least concern	Small invertebrates (insects), nectar	2
32	Asian Koel	*Eudynamys scolopaceus*	Forest, Grassland, open land, and human habitation	Plantation, garden, urban areas	Resident	Least concern	Insects, fruit, nectar	2
33	Rose- ringed Parakeet	*Psittacula krameri*	Forest, Grassland, open land, and human habitation	Gardens, arable lands	Resident	Least concern	Grains, seeds, fruits, nectar	2
34	Rock pigeon	*Columba livia*	Forest, Grassland, open land, and human habitation	Cavities, overpasses, bridges	Resident	Least concern	Seeds, fruits, grains	4
35	Green Bee Eater	*Merops orientalis*	Forest, Grassland, open land, and human habitation	Plantations, gardens, arable lands	Resident	Least concern	Insects (ants, bees, butterflies, flies, termites, moth etc.)	2
36	Common Myna	*Acridotheres tristis*	Forest, open land, and human habitation	Plantations, arable land, urban areas	Resident	Least concern	Fruits, nectar grains, insect, small vertebrates (frogs, lizards, mice)	2
37	Purple-rumped Sunbird,	*Leptocoma zeylonica*	Forest, open land, and human habitation	gardens, isolated trees	Resident	Least concern	Fruits, nectar, insects	2
38	Blyth's Reed Warbler	*Acrocephalus dumetorum*	Forest, open land, and human habitation	Gardens	Resident	Least concern	Invertebrates	2
39	Nilgiri Wood-Pigeon	*Columba elphinstonii*	Forest		Resident	Vulnerable	Fruits, berrier and buds	1
40	Greenish Warbler	*Phylloscopus trochiloides*	Forest	roadside trees and plantation, edge of cultivation, parks	Resident		Invertebrates, fruits, seeds	2
41	Yellow-throated Bulbul	*Pycnonotus xantholaemus*	Forest(near rivers, streams)		Resident	Vulnerable	Insects, termites, fruits	2
42	Kashmir Flycatcher	*Ficedula subrubra*	Forest	Gardens	Resident	Vulnerable	invertebrates	1
43	White-cheeked Barbet	*Megalaima viridis*	Forest (fruit trees)	Gardens, parks, woodland	Resident	Least concern	Fruits, nectar	2
44	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	Forest (plantation, cultivated land)	PLantation, Urban areas, gardens	Resident	Least concern	Fruits, nectar, insects	2
45	Lesser Florican	*Sypheotides indicus*	Grassland (scrublands, crop fields)	Arable land	Resident	Endangered	Seeds, fruits, insects, small invertebrates (lizards, frogs)	1
46	Pallid Harrier	*Circus macrourus*	Grassland (agricultural field, open spaces)	Arable land	Migratory (winter)	Near Threatened	Lizard, insects,Vertebrates & Carrion	1
47	Greater coucal	*Centropus sinensis*	Grassland (swarms, gardens, paddyfields)	Gardens	Resident	Least concern	Fruits, seeds, insects, small vertebrates (frog, snake, lizard, mice)	2

Source: ([15], [47], Bombay Natural History Society_BNHS)

2.4 Habitat Study: Natural + Adaptive Habitats of the Avians of Bangalore

Some birds have specialized habitat requirements, whilst others have adapted to flourish in various human-influenced environments. These adaptive plants can be found in plantations, agricultural fields, fallow ground, and urban settings. Avian requires niches, ledges, platforms and cavities during different stages of life. Hence- providing these components generally for species groups with similar requirements is better than providing them separately for specialists unless the species is endangered.

2.4.1 Wetland

While these ecosystems are highly productive and diverse, they are also susceptible. They are greatly linked with waterbirds, sustaining varied groups of these avian species. Waterbirds perform essential roles at various trophic levels in wetland food webs and contribute significantly to nutrient cycles in these habitats. These birds like to rest and sleep in areas with intermediate plant coverage, avoiding too open or thickly planted wetlands. Furthermore, there is a substantial positive link between the waterbird population and various parameters such as lake size, island presence, water coverage, water depth, tree density, number of nests, and weed species diversity. Winter brings the most significant number of waterbird species due to the arrival of migrating waterbirds [17].

While some species remain locally common and non-migratory, they are declining for several reasons. Some are seeing population declines due to a scarcity of suitable nesting locations, such as cavities. Meanwhile, other bird species that nest in tree canopies are expanding in numbers near Bangalore's lakes [18].

2.4.2 Forest/ Agroforest

While each bird species may generally favour a particular habitat type, many display diverse behaviours and utilize different aspects of a forest throughout various life stages, requiring a range of

behaviours even within the same species. In tropical forests and agroforests, insect-eating birds are often the most abundant and diverse. The availability of various food sources for both adult and juvenile birds, along with safe nesting and roosting habitats in and around agroecosystems, is key to the presence and abundance of insect-eating species [19].

According to Savitha Swamy's research, birds in parks rely on nearby green spaces within a 5-kilometre radius. The study recorded migrant bird species within an area containing expansive green areas, numerous tree-lined streets, and many neighbourhood parks [20].

2.4.3 Grassland

Consequently, these species are highly sensitive to habitat features, such as vegetation type, making them vulnerable to land-use changes

Grasslands are one of the most threatened ecosystems on Earth today, a condition they share with other open natural ecosystems. Their favourable topographical features and fertile soils have made grassland habitats the most extensively modified ecosystem by human activity. Grassland birds often specialise in open habitats. Many grassland specialist birds either ground nests or build small nests camouflaged in grasses and reeds to avoid nest predation. Consequently, these species are highly sensitive to habitat features, such as vegetation type, making them vulnerable to land-use changes [21].

2.5 Ecological Behaviour of the Target Species

Foraging, socializing, grooming, roosting, and nesting are various categories in avian ecological behaviour research. Foraging is a primary activity for most birds, functioning as a natural behaviour critical for survival and reproduction. Birds often spend a significant amount of time seeking and finding food to support themselves and their offspring. To lessen predation risks, birds frequently graze in densely vegetated regions that provide shelter and reduce exposure to potential dangers. Insectivores, nectarivores, frugivores, and omnivores are the four broad dietary categories for bird species.

For many bird species, choosing a nest site is crucial because vegetation provides both possibilities for nesting and shelter from predators. Birds typically select nest sites close to borders to improve early detection and defence against disturbances from neighbouring groups.

Migration patterns also influence bird behaviour, with species migrating to areas with different food resources according to seasonal changes. Analyzing nest counts seasonally reveals patterns favouring nesting activities during the pre-monsoon season. This trend aligns with the availability of fresh vegetation and abundant insect populations, such as caterpillars and flying ants, stimulated by local showers during pre-monsoon rains. Conversely, nesting activities decline during heavy monsoon and post-monsoon periods due to factors like uprooted trees, loss of vegetation, and reduced availability of perching and roosting sites, rendering habitats unsuitable for breeding [22].

Ecological design involves designing methods that reduce environmental harm by blending with natural processes, including living systems, natural flows, cycles, and patterns [23]. In this context, birds' life cycle becomes an integral part of the design process.

Previous studies have highlighted that Indian cities serve as havens for colonial nesting water birds. These urban environments provide suitable microhabitats that support various aspects of the birds' life cycle and behaviour, including feeding, nesting, and breeding activities. Additionally, cities offer refuge to these birds by reducing predation pressures during the breeding season [24].

2.6 Interspecies Relations Study: Human- Avian Interactions
2.6.1 Response of avian towards Human

Animals often see humans as a threat, even in harmless situations, triggering responses similar to those provoked by natural predators. In densely populated tropical regions, species sensitive to human presence may suffer adverse effects, including increased metabolic costs, heightened stress hormone levels, compromised immune function, reduced foraging efficiency, and diminished reproductive success and survival, with potential cascading impacts on population sizes.

Bengaluru's urbanization since the late 1980s has transformed extensive natural scrublands into built-up areas, displacing bird species reliant on these habitats due to human overcrowding [6].

However, some species, known as "urban dwellers," are exceptionally tolerant of human disturbance and can attain far larger densities in urbanized areas than rural ones. In densely urbanized regions with higher human densities, birds may have shorter flight distances when disturbed, likely as an adaptive response to frequent environmental disruptions.

Positive interactions between humans and wildlife can arise from the benefit animal's gain, such as protection from predators and parasites. For instance, birds nesting inside buildings typically experience greater reproductive success than those nesting outdoors [26].

2.6.2 *Response of Humans Towards Avians*

People's attitudes toward animals can be influenced by inherent human tendencies to empathize with them based on factors such as their status, utility, attractiveness, or perceived intelligence [26]. These attitudes are also shaped by personal values and beliefs regarding wildlife and nature, which may reflect humanistic or utilitarian perspectives. Previous experiences and knowledge about specific species or groups of animals play a significant role in forming these attitudes. The relationship between humans and a species, including its cultural significance, practical usefulness, or conservation status, further impacts how animals are perceived. Additionally, individual perceptions of species, such as their aesthetic appeal, perceived intelligence, or perceived threat level, are crucial in shaping attitudes—a key focus of the current study [27]. For instance, the Kite bird, known for its aggressive behaviour towards humans, has shown that attacks on humans are concentrated in specific areas of the city rather than being randomly distributed. These incidents have been linked to indicators of human activity, such as improper waste disposal practices, religious ritual feeding, and the intensity of human presence in the streets [39].

2.7 Interspecies Relations Study: Human- Avian Interactions

2.7.1 Physiological Attributes

Urban birds encounter various stressors, such as uneven food distribution, traffic noise, artificial light, and chemical pollution. Some of these bird species have adapted to these stressors, while others have not shown any alteration in their stress levels. Additionally, decreased stress levels can be attributed to a diet low in protein available to them in the city.

2.7.2 Life History Attributes

Urban avians often exhibit distinct reproductive patterns compared to their rural counterparts. While urban avian populations generally demonstrate slightly annual productivity, nestling weight is often lower. However, specific raptor species in urban settings may produce fewer offspring, particularly in instances of limited prey availability or increased human disturbance. A variety of factors, including alterations in vegetation structure, the introduction of non-native plant species,

habitat fragmentation, predatory pressure, and food availability, contribute to shaping the life history traits of urban birds.

2.7.3 Ecological Attributes

Diversity and abundance: A decreased overall abundance of birds is observed in urban areas. Species richness also shows a decreasing trend with increased urbanization, a pattern observed globally. The species richness and density of seasonally migrating species also reduce with increased built infrastructure.

2.7.4 Specialist and Generalist Species

Specialist species, unlike others, decrease in number due to urbanization as they depend on one or few habitat types. While generalist species thrive in cities due to decreased competition from these specialists.

2.7.5 Diet

Omnivore birds are likely to feed on food scraps and discarded food items and, thus, seem to be possibly using the food resources that humans discard. The number depends on the type of trees available in urban space and the ready-made food they receive from humans directly/ indirectly.

2.7.6 Nesting

Research suggests that urbanization does not always improve the availability of cavity-nesting places. However, because of their nesting habits, cavity nesters may be less vulnerable to predation and do better in cities. Species that are adapted to urban settings are more abundant in urban areas. Other species, such as open-cup nesters, who rely on trees and bushes to sustain their nests, are inversely correlated with metropolitan areas.

2.7.7 Behavioral Attributes

Traffic noise, reflective structures, vegetation density, ambient temperature, and temporal changes in noise levels due to human activities affect song communication in birds. Low-frequency anthropogenic noise tends to block out bird songs, resulting in poor song transmission and, eventually, poor reproductive success. Birds often modify their song and call structure to avoid masking in response to urbanization, a well-documented phenomenon. Urban birds are observed to be bolder and more tolerant of human and vehicular approaches, as they exhibit shorter Flight initiation distance (FID) [28].

2.8 Intervention Areas

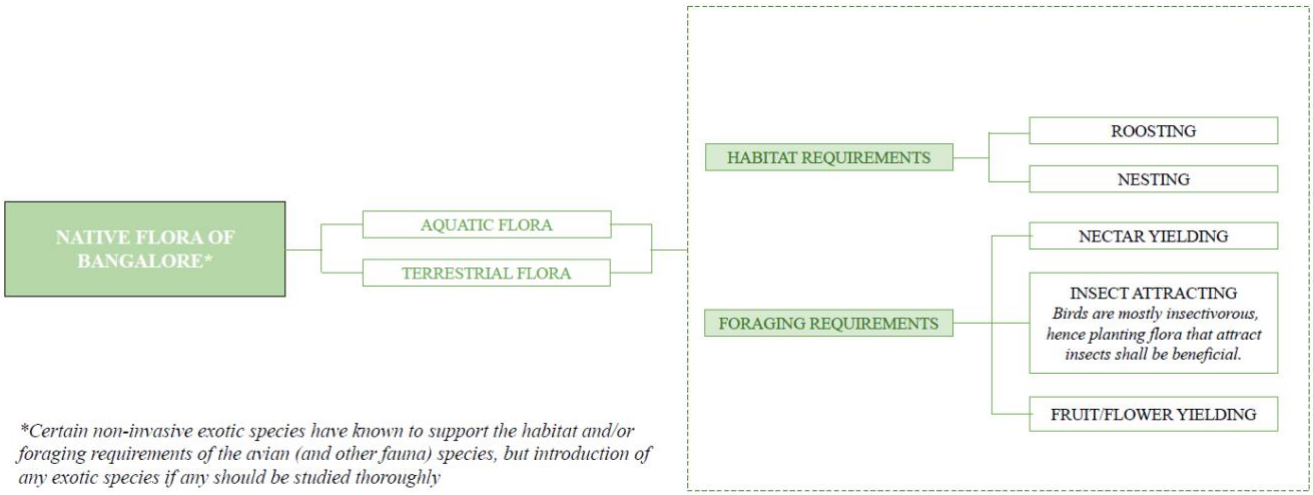

Fig. 2 Native Flora Selection Guide for Avian Inclusive Design

2.8.1 Green/ Ecological Corridors

Green corridors are essential for facilitating the dispersal of animals within urban environments [29]. These corridors offer critical habitats, shelter, sustenance, and security, enabling urban wildlife to persist and migrate between various green spaces. The strategic design and implementation of these corridors significantly enhance urban wildlife conservation efforts [30]. Identifying specific streets and areas within a city that have the potential to be transformed into multifunctional ecological corridors and parks—serving as confluence regions for both human and non-human users—is a crucial aspect of urban planning [31]. Additionally, incorporating eye-level hedges as buffers between roadways and footpaths can mitigate negative interactions between wildlife and human infrastructure. Attention to street lighting and building architecture design is also imperative, as it can substantially reduce avian mortality rates [15]. Ecological or green corridors should maintain a minimum width of 10 meters to ensure their effectiveness.

2.8.2 Wetland/ Lakes

The natural topography of the city, characterized by hills and valleys, naturally facilitates drainage, with small streams originating from ridges flowing down to form larger streams within the three main valleys: Hebbal, Vrushabhavathi, and Koramangala & Challaghatta. The natural streams were intercepted at appropriate places to create man-made lakes/tanks to capture the rainfall and meet the city's irrigation and drinking water needs. For Bangalore, its Lakes were supposed to be the source of water for agriculture and drinking but surface water runoff was so high that in 1985, the Government of Karnataka constituted an expert committee headed by Sri N.Lakshman Rau to examine all the aspects of the preservation, restoration or otherwise of the existing tanks in the metropolitan area of Bangalore- they were repurposed. The municipal body (Bruhat Bengaluru Mahanagara Palike- BBMP) manages 167 lakes, and the Lake Development Authority, Forest Development Authority, Bangalore Development Authority, and Bangalore Metro jointly manage 210 lakes. The city’s avian diversity majorly comprises waterbirds. Wetlands are the most productive and biologically diverse but fragile ecosystems [32]. Waterbirds play a crucial role in the majority of wetland ecosystems as they occupy various levels in the food chain and contribute to the nutrient cycles of wetlands [33]. But due to rapid urbanization, the lakes of Bangalore started facing a multitude of issues - untreated sewage in lakes,

encroachment and blockage of rainwater drains, dumping of solid waste due to a lack of surveillance, encroachment due to road construction, depleted oxygen levels, lack of underground drainage in new development, illegal earth and sand causing large craters, etc to name a few.

This has ultimately led to habitat loss for the species dependent on the wetland ecosystem. Multiple organizations and bodies are working together to improve the status of the lakes today. Lake preservation has to be integral to Layout Development by the respective development and Planning authorities (BDA, BIAPA, MICAPA, Nelamangala Planning Authority, Hosakote Planning Authority etc.) In designing urban or architectural developments in and around lakes, designers must prioritize the preservation of the fragile wetland ecosystem [34]. Peripheral lake development should incorporate a gradual sloping shoreline with a gradient no steeper than 1:6, as this supports wading birds and allows various species to easily access the water. Adhering to the established norm of maintaining a 30-meter buffer surrounding the legal boundaries of lakes is crucial for their preservation. When introducing aquatic vegetation, it is recommended that vegetation cover two-thirds of the lake area, leaving one-third of the lake open to maintain ecological balance.

Rather than constructing elevated jogging tracks that encircle the lakes, a more ecologically sensitive approach involves developing ground-level walkways made of packed mud or cobblestones, with a width not exceeding three meters. These walkways should be positioned around the lake perimeter, either beyond the high-water mark or close to the perimeter fence, ensuring they do not obstruct the inflow of runoff water from the surrounding catchment area. In areas of the lake that extend beyond the high-water mark and perimeter fence, the introduction of terrestrial vegetation that benefits birds, butterflies, and other biota is encouraged.

Each lake must be treated as a unique case during the site analysis phase of any project, taking into account its specific ecological characteristics and needs. Installing appropriate silt and waste-trapping structures at regular intervals along canals can help mitigate pollution and maintain water quality. To meet the foraging requirements of avian species, it is advisable to plant flora that yields nectar, fruit, and flowers. Given that many birds are insectivorous, including plants that attract insects would be particularly beneficial [35]. Additionally, using buffer flora can help shield birds from human disturbances, thereby protecting their ecologically designed urban habitats. These considerations are essential for ensuring that urban development around lakes is both sustainable and sensitive to the needs of the wetland ecosystem.

2.8.3 Gardens/ Parks/ Large Green Spaces

In the early 1600s, Bangalore was primarily covered by natural thorny forests. The introduction of green vegetation within the city began under Hyder Ali, ruler of Mysore, who established Lalbagh as his private garden spanning 100 hectares, now open to the public. Later, in 1831, the British furthered the city's greening efforts by creating Cubbon Park. These initiatives earned Bangalore the moniker of 'Garden City' due to the forward-thinking actions of its leaders. During the British era, the introduction of park culture brought a fresh perspective to the utilization of social spaces. Bangalore consists of multiple newly formed residential areas with pocket green spaces in the form of neighbourhood parks maintained by the municipality and mainly designed for recreation, neglecting that these spaces could be essential for biodiversity. The abundance and species richness of birds increased with the park's size, subject to habitat composition and landscape variables, making them a good intervention area for avian-inclusive design [36].

Designers can successfully improve the quality of a garden/large green space by incorporating several key considerations into their planning and design processes. One crucial aspect is the increase in vegetation structural complexity, which involves the creation of multiple vegetation layers. Large mature trees have more vertical vegetation structure than young trees, so it is essential to protect and plant large trees. Individual trees have less structural complexity than groups of trees and shrubs, so planting new trees and shrubs together will increase vegetation structure throughout the city. There

can be up to six distinct foliage heights or layers, including a ground cover, shrub, understory and canopy layer to maximize the amount of available bird habitat. Afforestation efforts should focus on planting local tree species with nectar, Flower & fruit-yielding capacities [17]. Allowing for the accumulation of leaf litter is also beneficial, as it promotes water seepage into the ground and encourages the presence of earthworms, which not only loosen the topsoil but also provide a food source for ground-feeding birds. Including sand and water baths, designed to be 2-3 inches deep, is another important design element, as birds require these features for dusting, drinking, and bathing. To prevent human disturbance to bird habitats, tall hedges can be strategically planted at or above human eye level to guide people away from sensitive areas. Vegetation should be arranged in a stepped pattern, with large trees placed at the back, shrubs in the middle, and ground cover plants in the front. The use of a variety of species is encouraged, with an emphasis on native flora, as they provide optimal support for native wildlife. Reducing lawned areas in favour of native grass species can also contribute to the ecological richness of the space. Diversifying the topography by adding slopes, bunds, and rocks can create a variety of microhabitats, further supporting biodiversity. Additionally, planting native shrubs near bird feeders can create a "staging" area where birds can wait their turn, and careful design of bird feeders can enhance their utility without disrupting the surrounding environment.

2.8.3 Building Level

The Intervention areas to facilitate birds' natural habitat would be the Gardens/Parks and lakes, and the Adaptive Habitat would be in the built environment (the human-avian confluence region). Intervention areas in building blocks as a whole mass would be most impactful at the transitional physical barrier of a building between the indoors (Humans) and outdoors (birds), the envelope - the facade. If designed well, the facade can be the region of the closest human-avian interaction without physical contact. Due to the tech industry's boom in Bangalore, infrastructure has increased, with glass facades leading to bird collisions. Careful attention to interior and exterior lighting design and building facade architecture is essential in preventing the deaths of millions of birds each year, particularly migratory birds [15]. A building facade design approach should ensure that structures are evident as physical barriers to birds, eliminating situations where reflections may confuse birds. Ensuring that the glass is non-reflective for existing glass facades is crucial. This can be achieved by replacing reflective glass with frosted or tinted glass or by adding patterned stickers to the exterior facade. Office and institutional buildings should consider employing nighttime personnel or installing automatic shutoff systems to prevent the reflectivity of light from within the building.

The bird collision threat rating for building materials should be below 15 to minimize risks to avian species. Additionally, outdoor building facade lights should be shielded to prevent direct light emission when positioned beyond a 90-degree angle [37]. Planters can be placed outside windows or beneath chajjas to collect bird droppings, further contributing to a bird-friendly environment.

Considering interior and exterior lighting requirements, alongside building material threat factors, is fundamental for designers aiming to reduce threats to birds. By implementing these strategies, the design of urban environments can be more harmonious with the needs of avian species, particularly during migration periods, thereby significantly reducing bird mortality rates.

3. Results

The framework developed serves as a vital tool for designers, enabling them to create designs inclusive of species beyond humans—in this case, avian species. Species selection is pivotal in harmonizing different stakeholders' conservation and planning efforts. Achieving an accurate understanding of the ideal degree of intervention that benefits both human and non-human interests necessitates meticulous documentation of existing design interventions of a similar nature and the exploration of innovative, experimental approaches. Crucially, post-construction monitoring is

essential to observe and document human-avian interactions, with the goal being positive or, at the very least, neutral interactions. Understanding the natural and adaptive habitats of Bangalore's birds and their ecological behaviours will equip stakeholders with the necessary information to devise site-specific design interventions and guidelines through landscape, urban, and architectural design.

In a world where every project, regardless of its environmental consciousness, contributes to some degree of environmental degradation, prioritizing intervention areas that align with the natural topography of a region is a step toward more conscious design. The guidelines emphasize sustaining the natural habitats of target avian species, recognizing that enhancing vegetation density, content, and diversity benefits avian species and supports a wide range of other fauna, including humans. When considering the building itself, this approach is more readily implemented in new construction than retrofitting projects, as the framework primarily addresses elements that should be considered during the pre-design stage.

The success of a framework such as this is significantly enhanced when it is integrated into zonal regulations, bylaws, and city planning efforts, with mandatory minimum standards and enforcement mechanisms. Given that the concept of inclusivity extending beyond humans is still in its nascent stages in India and globally, institutional support at the planning and regulatory levels is essential to ensure its effective implementation.

4. Conclusions

The study attempts to understand how designers can do their part in making design inclusive for human and non-human species, using the example of Avians in a multifaceted city going through rapid urbanisation through an avian-inclusive planning framework for the City of Bangalore. The research focuses on understanding the habitat requirements of prominent avian species to foster coexistence with humans, exploring the avian life cycles and ecological behaviours to inform design considerations, and investigating the historical relationship between humans and avian interaction. A tailored framework for Avian-inclusive design in Bangalore City has been created by identifying intervention areas.

In addition to the framework are recommendations for the intervention areas. These recommendations, however, need to be tested for evidence-based research to prove their feasibility in the design and construction industry, as there is a gap between research and practice in the architecture and urban design fraternity [10, 11]. The feasibility study would ensure it is beneficial to all stakeholders involved. This means the need for cross-disciplinary perspectives. This is necessary to make its implementation in the zonal regulations/bylaws easier. The pre-design process sets up the foundation for good design, and mock-ups during the construction phase allow designers to test experimental designs and/or new design approaches for feasibility. The paper draws attention to the pre-design phase, where the majority of the research and the site/contextual study happens, encouraging designers to be inclusive from the very inception of a project instead of as an afterthought.

The Framework is structured to be applied to projects of different scales and typologies; it can be tailored based on its context. The base can even be used by similar cities, and the next steps would involve developing similar frameworks to include other non-humans in design: Insects, Terrestrial Fauna, Aquatic Fauna, etc. Including fauna other than humans also ensures the organic incorporation of more flora in design. Since it would be done in the pre-design stage of any project, there would be sufficient time to test design iterations and mock-ups. It will also be essential to study and document the existing case studies for the methods employed in conceptualisation and execution to create a database designers can refer to.

Acknowledgement

This research was not funded by any grant. The authors thank M.B. Krishna, a Bangalore-based ecologist and ornithologist, for the recommendations provided, who enriches the paper by providing essential perspectives on the practical aspects of proposing, implementing, and executing guidelines and action plans in Bangalore. Also, extend thanks to the Bombay Natural History Society for assisting with the compilation of the target avian species and the additional data.

References

Citations and Readings

[1] Rahman, T., & Candolin, U. (2022).Linking animal behavior to ecosystem change in disturbed environments. Frontiers in Ecology and Evolution. [Online] Vol 10, Available: https://doi.org/10.3389/fevo.2022.893453

[2] Sun, B., Lu, Y., Yang, Y., Yu, M., Yuan, J., Yu, R., Bullock, J. M., Stenseth, N. C., Li, X., Cao, Z., Lei, H., & Li, J. (2022). Urbanization affects spatial variation and species similarity of bird diversity distribution. *Science advances*, *8*(49), eade3061. https://doi.org/10.1126/sciadv.ade3061

[3] Sudhira, H., & Nagendra, H. (2013). Local Assessment of Bangalore: Graying and Greening in Bangalore – Impacts of urbanization on ecosystems, ecosystem services and biodiversity. In *Springer eBooks* (pp. 75–91). https://doi.org/10.1007/978-94-007-7088-1_7

[4] Weisser, W., & Hauck, T., (2017). ANIMAL-AIDED DESIGN – using a species' life-cycle to improve open space planning and conservation in cities and elsewhere. *bioRxiv (Cold Spring Harbor Laboratory)*. https://doi.org/10.1101/150359

[5] Surya, S. (2016). Biodiversity and bird friendly design in urban areas for sustainable living. *Indian Journal of Science and Technology*, *9*(5). https://doi.org/10.17485/ijst/2016/v9i5/87224

[6] Gopinath, R., Begum, A. J., Joshi, G. D., & Anant, K. K. (2021). Impact of chaotic urbanisation on Bengaluru's (India) urban avian Diversity. *Transylvanian Review of Systematical and Ecological Research*, *23*(1), 81–94. https://doi.org/10.2478/trser-2021-0007

[7] Dutta, H. (2017). Insights into the impacts of four current environmental problems on flying birds. *Energy, Ecology and Environment (Online)*, *2*(5), 329–349. https://doi.org/10.1007/s40974-017-0075-6

[8] *THE 17 GOALS | Sustainable Development*. (n.d.). https://sdgs.un.org/goals

[9] *Bird conservation in India - India Bird watching*. (n.d.). India Bird Watching. https://www.indiabirdwatching.com/bird-conservation-in-india/

[10] Asaad, M., Khalifa, M., & Elrahman, A. S. A. (2019). Bridging the gap between theory and practice in the urban design process: towards Multidisciplinary Success Considerations. In *Advances in science, technology & innovation* (pp. 261–274). https://doi.org/10.1007/978-3-030-17308-1_25

[11] Sailer, K., Budgen, A., Lonsdale, N., & Penn, A. (2007). Effective workplaces – bridging the gap between architectural research and design practice. *ResearchGate*. https://www.researchgate.net/publication/309721127_Effective_workplaces_-_bridging_the_gap_between_architectural_research_and_design_practice

[12] Ramachandra, T. V., Aithal, B. H., Kulkarni, G., & Shivamurthy, V. (2017). GREEN SPACES IN BENGALURU: QUANTIFICATION THROUGH GEOSPATIAL TECHNIQUES. *ResearchGate*. https://www.researchgate.net/publication/315670439

[13] Ring, Z., Damyanovic, D., & Reinwald, F. (2021). Green and open space factor Vienna: A steering and evaluation tool for urban green infrastructure. *Urban Forestry & Urban Greening*, *62*, 127131. https://doi.org/10.1016/j.ufug.2021.127131

[14] Bird Count India. (2024, February 21). *About - Bird count India*. https://birdcount.in/about/

[15] State of India's Birds. (n.d.). *Comprehensive assessment of bird species found in India*. State of India's Birds. https://stateofindiasbirds.in/

[16] Hernández-Santín, C., Amati, M., Bekessy, S. A., & Desha, C. (2022). A review of existing ecological design frameworks enabling biodiversity inclusive design. *Urban Science*, *6*(4), 95. https://doi.org/10.3390/urbansci6040095

[17] Rajashekara, & Venkatesha, Melally. (2014). Eco-spatial and Temporal Variation in Waterbirds Composition and their relationship with Habitat Characteristics of Urban Lakes of Bengaluru city, India. International Journal of Advanced Research. 2. 60-80.

[18] Jambhekar, Ravi & Suryawanshi, Kulbhushansingh & Nagendra, Harini. (2021). Relationship between lake area and distance from the city centre on lake-dependent resident and migratory birds in urban Bangalore, a tropical mega-city in Southern India. *ResearchGate*. http://dx.doi.org/10.1093/jue/juab028

[19] Tanalgo, K. C., Pineda, J. A., Agravante, M. E., & Amerol, Z. M. (2015). Bird Diversity and Structure in Different Land-use Types in Lowland South-Central Mindanao, Philippines. *Tropical life sciences research*, *26*(2), 85–103.
[20] Swamy S, Nagendra H, Devy S (2019) Building biodiversity in neighbourhood parks in Bangalore city, India: Ordinary yet essential. *PLOS ONE 14(5)*: e0215525. https://doi.org/10.1371/journal.pone.0215525
[21] Bharadwaj, Akshay & Mhamane, Sarang & Bangal, Priti & Menon, Tarun & Isvaran, Kavita & Quader, Suhel. (2024). Assessment of long-term trends in a threatened grassland bird community using daily bird lists. *Bird Conservation International*. 34. 10.1017/S0959270923000357.
[22] Gedam, Endihnew Tessfa. "Behavioral Ecology of Forest Birds." J Biodivers Endanger Species 8 (2020): 241. doi: 10.37421/ JBES.2020.8.241
[23] Gültekın, H. (2009). Ecological Design And Retrieving The Environmental Meaning. In: Tymieniecka, AT. (eds) Memory in the Ontopoiesis of Life. Analecta Husserliana, vol 101. Springer, Dordrecht. https://doi.org/10.1007/978-90-481-2501-2_6
[24] Devaraju R., Mahaboob Basha P. (2021). Assessment of Breeding Status of Birds in Selected Urban Wetlands of Greater Bangalore, Karnataka. Environment and Ecology 39 (4) : 931—940. 10.5555/20220160387
[25] Møller, A. P., & Díaz, M. (2017, November 28). *Avian preference for close proximity to human habitation and its ecological consequences*. Current Zoology/Environmental Epigenetics/Current Zoology. https://doi.org/10.1093/cz/zox073
[26] Proctor, H., Carder, G., & Cornish, A. (2013, September 4). *Searching for Animal Sentience: A Systematic Review of the Scientific Literature*. Animals. https://doi.org/10.3390/ani3030882
[27] Batt, S. M. (2009, April 21). *Human attitudes towards animals in relation to species similarity to humans: a multivariate approach*. Bioscience Horizons. https://doi.org/10.1093/biohorizons/hzp021
[28] Patankar, S., Jambhekar, R., Suryawanshi, K. R., & Nagendra, H. (2021, January 20). *Which Traits Influence Bird Survival in the City? A Review*. Land. https://doi.org/10.3390/land10020092
[29] H A Aziz and M H Rasidi. (2014). The role of green corridors for wildlife conservation in urban landscape: A literature review. *IOP Conf. Ser.: Earth Environ. Sci.* 18 012093 DOI:10.1088/1755-1315/18/1/012093
[30] Zellmer, A. J., & Goto, B. S. (2022, October 14). *Urban wildlife corridors: Building bridges for wildlife and people*. Frontiers in Sustainable Cities. https://doi.org/10.3389/frsc.2022.954089
[31] Graviola, G. R., Ribeiro, M. C., & Pena, J. C. (2022). Reconciling humans and birds when designing ecological corridors and parks within urban landscapes. *Ambio*, *51*(1), 253–268. https://doi.org/10.1007/s13280-021-01551-9
[32] Gibbs, J. P. (1993, March 1). *Importance of small wetlands for the persistence of local populations of wetland-associated animals*. Wetlands. https://doi.org/10.1007/bf03160862
[33] Kushlan, J. A. (1992). Population Biology and Conservation of Colonial Wading Birds. *Colonial Waterbirds*, *15*(1), 1–7. https://doi.org/10.2307/1521348
[34] Patil, N. K. (2011, January 1). *Preservation of Lakes in the City of Bangalore*. ResearchGate. https://www.researchgate.net/publication/254412528_Preservation_of_Lakes_in_the_City_of_Bangalore
[35] Nyffeler, M., Şekercioğlu, Ç. H., & Whelan, C. J. (2018). Insectivorous birds consume an estimated 400-500 million tons of prey annually. *Die Naturwissenschaften*, *105*(7-8), 47. https://doi.org/10.1007/s00114-018-1571-z
[36] Swamy S, Nagendra H, Devy S (2019) Building biodiversity in neighbourhood parks in Bangalore city, India: Ordinary yet essential. PLOS ONE 14(5): e0215525. https://doi.org/10.1371/journal.pone.0215525
[37] *Bird collision deterrence | U.S. Green Building Council*. (n.d.). https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-data-41
[38] Apfelbeck, Beate & Jakoby, Christine & Hanusch, Maximilian & Steffani, Emanuel & Hauck, Thomas & Weisser, Wolfgang. (2019). A Conceptual Framework for Choosing Target Species for Wildlife-Inclusive Urban Design. Sustainability. 11. 6972. 10.3390/su11246972.
[39] *Birds as environmental indicators: raptor species a good proxy for agricultural bird diversity*. (2023, July 27). Environment. https://environment.ec.europa.eu/news/birds-environmental-indicators-raptor-species-good-proxy-agricultural-bird-diversity-2023-07-27_en#:~:text=Birds%20are%20excellent%20indicators%20of,land%20use%20and%20climate1
[40] Isaksson, C. (2018). Impact of urbanization on birds. In *Fascinating life sciences (Online)* (pp. 235–257). https://doi.org/10.1007/978-3-319-91689-7_13
[41] *Bird conservation in India - India Bird watching*. (n.d.-b). India Bird Watching. https://www.indiabirdwatching.com/bird-conservation-in-india/
[42] Amar, B. (2014). History paper of bangalore. *Rvce*. https://www.academia.edu/6649675/History_paper_of_bangalore
[43] INDIAN BIRDS IN THE IUCN RED LIST
https://www.birdsofindia.org/IUCN-Red-List
[44] *Karnataka High Court Report Promotes People Centre And Ecologically Sensitive Lake Rehabilitation In Bangalore | Environment Support Group*. (n.d.). https://esgindia.org/campaigns/press/karnataka-high-court-report-promotes-peo.html

[45] Dr. Patrick Mooney, Don Wuori Design. (2007). Urban Songbird Habitat: Landscape Design Guidelines. https://blogs.ubc.ca/greennetworks/files/2017/08/MooneyBarrs_Urban-Songbird-Landscape-Guidelines-FINAL-2007.08.09.pdf
[46] Michele Campbell. (2013). BIRD-FRIENDLY LANDSCAPE DESIGN GUIDELINES - City of Vancouver EXECUTIVE SUMMARY. https://sustain.ubc.ca/sites/default/files/2013-05_Bird-Friendly%20Landscape%20Design%20Guidelines_Campbell.PDF
[47] https://cob.org/wp-content/uploads/key-elements-when-landscaping-for-wildlife.pdf
[48] Garrard, G.E., Williams, N.S.G., Mata, L., Thomas, J. and Bekessy, S.A. (2018), "Biodiversity Sensitive Urban Design". *CONSERVATION LETTERS*, vol. 11 issue 2, e12411. https://doi.org/10.1111/conl.12411
[49] Apfelbeck, B., Snep, R. P., Hauck, T. E., Ferguson, J., Holy, M., Jakoby, C., MacIvor, J. S., Schär, L., Taylor, M., & Weisser, W. W. (2020). Designing wildlife-inclusive cities that support human-animal co-existence. *Landscape and Urban Planning*, *200*, 103817. https://doi.org/10.1016/j.landurbplan.2020.103817
[50]