

Biodiversity of aquatic and riparian zone within an urban ecosystem - Unkal nalla of Hubbli, Dharwad, Karnataka, India

Akshay Pandirkar^{*} and Alok Kumar

Environment & Ecology Department, Tata Consulting Engineers, Unit No. NB 1502 & SB – 1501, 15th floor, Empire Tower, Cloud City Campus, Kalwa Industrial Estate, Thane, Belapur Rd, Airoli, Navi Mumbai, Maharashtra 400708 ahpandirkar@tce.co.in

anpandirkai@tce.co.iii

Available online at: www.isca.in, www.isca.me Received 6th May 2020, revised 28th September 2020, accepted 13th October 2020

Abstract

There are very few Riparian zones in an Urban Ecosystem, which are fast dwindling and in extreme stress due to urban sprawl and environmental pollution. The present paper is about biodiversity study of Riparaian zone of Unkal Nalla of Hubbali city in Indian state of Karnataka. Riparian zones are the interface between terrestrial and aquatic ecosystem and act as a cross ecosystem flux for allochthonous resources. When compared with other habitats population density and diversity is higher in edge effect along the aquatic habitat created by ecological retort of riparian zone. Study has been conducted to understand biodiversity of the riparian zone of the Unkal Nalla. The Primary objective for this study is to study the biodiversity along Nalla at its current polluted state. Area of lake from where Nalla originates is considered as control area where influence of pollution is low and biodiversity is rich. Data is compared with control area to understand the possible improvement in biodiversity of Nalla area after interventions like cleaning, landscaping, plantation etc. The biodiversity study was undertaken by survey of 18 locations along the Nalla (Stretch of about 10km) and lake. Quadrate and transect method were used for assessment of flora and fauna of the locations. This has yielded in 72 species of plants and 53 species of birds. It can be seen that the Nalla with polluted water and low floral diversity have low faunal diversity. Authors also have proposed interventions to improve the quality of biodiversity in the study area.

Keywords: Urban Biodiversity, Riparian Zone, Nalla Aquatic ecosystem.

Introduction

Riparian zones have direct interaction between terrestrial and aquatic ecosystems 1⁻⁵ and act as a cross ecosystem flux for allochthonous resources 1. When compared with other habitats population density and diversity is higher in edge effect along the aquatic habitat created by ecological retort of riparian zone1. Resources from both the ecosystems get transferred through riparian zone and benefit organisms of either ecosystem i.e. leaf litter as a habitat for aquatic fauna, terrestrial insects as food, aquatic organisms as food, high organic content soil deposition etc. It is also a very significant ecosystem in terms of human wellbeing due to providing numerous services like improvement of water quality, mitigation of flood, opportunities for recreation, supporting fauna and improving fish habitat, filtering & retaining sediments and nutrients from upland runoff or out-of bank floods, reducing chemical inputs from uplands by immobilisation, storage and transformation, stabalising or forming stream banks, water storage and recharging aquifers, reduction in flood water runoff, regulation of microclimate, conservation of biological diversity, acting as biological indicators of healt 6^{-10} . It is said by Iankovoglou et. al.6, that human development in riparian areas can degrade its functionality. Healthy riparian areas may provide duel benefit by maintaining balance of nature and improving hedonic pricing

of the properties in that location. It is proved that though riparian areas occupy small area of the watershed but provide disproportionately larger number of ecosystem services9. Riparian zones are extremely fragile ecosystems affected by hydrology, geomorphology & human influence^{12,13}.

Urbanisation is considered as a major cause of habitat degradation and loss of biodiversity but in other way urban green features like gardens, parks, croplands provide habitat for wildlife¹⁴. It is also noted by Shiyi et. al.¹⁴ that well managed urban riparian areas provide habitat for bird including migratory ones.

Global trend shows degradation of freshwater ecosystem which results in depletion of ecosystem services allied with it. There is increasing awareness of the need to restore and manage freshwater ecosystem sustainably. As mentioned earlier this paper discuss the current status of the biodiversity affiliated with urban freshwater ecosystem i.e. Lake and nalla and ways to improvise it.

The Unkal Nalla originates at Unkal Lake as natural storm water drainage and flows through Hubli city. Unkal Nala is a storm water drain with inflow of sewage water at many places. The current condition of Nalla is much polluted and receives sewage and industrial waste from various inlets. Also solid-waste dumping including slaughter waste is being carried out at many locations of Nalla. This degrades state has necessitates the interventions to improve its overall status and to do that

understanding the current status becomes necessary. Hence this study has been undertaken.



Figure-1: Map Showing Study Area (Unkal Nalla, Hubali).



Figure-2: Map Showing Sampling Locations

Study Area: The nalla stretch under reference starts from north eastern part of the Unkal Lake (Lat, Long) and ends at Gabbur Nagar (Lat, Long). The core study area covered 8.5km stretch on both sides of the Unkal Nalla. Also, a 200 meter buffer area was selected for the study on either sides of the nalla. \Survey locations were set randomly to cover all the landuse i.e. Urban, Green Area, Wetland, Open Space etc. present in the area along the stretch of nalla.

Materials and methods

For assessment of floral diversity, 14 quadrates were laid in the study area. The quadrate method includes lying down of a square sample plot of suitable size for detailed analysis of vegetation. Quadrate size of 20mX20m for trees and within these, shrub species were counted in quadrat having area of 5m x5m, and 1mx1m area was used to count herbs. Faunal species were assessed by transect method by traversing a known distance and noting observed faunal species along the length. Survey was done by direct observation/visual encounter techniques and also through observation of indirect signs. Total

14 transects were laid in the study area. Shanon's index (H') and Simpson's index (D) was calculated for flora and fauna by using standard formulas and using 'Biodiversity Pro 2.0 softwere' for interpretation. To understand the local biodiversity of Hubli region various research papers and articles were studied¹⁵⁻¹⁸.

Fauna was checked for their IUCN 3.1 status and listing in the Schedules of Wildlife Protection Act, 1972. List of the quadrate locations is presented in Table-1.

Results and discussion

The study area consists of various habitats in the Urban parts of Hubali along the Nalla, which includes Scrub Areas, Wetlands, Urban Gardens/ Open Places, Agricultural Areas, Lake etc. Each habitat supports a specific flora and fauna which causes variation of species occurrence throughout the study area.

Total 37 tree species, 9 shrub species, 18 herb, 5 climers/ creepers & three species of grass were observed through primary survey.

Location	Latitude	Longitude	Landuse
L 1	15°21'18.81"N	75° 7'28.34"E	Urban/Open space
L 2	15°21'40.60"N	75° 7'6.50"E	Urban
L 3	15°21'54.15"N	75° 7'0.23"E	Urban
L 4	15°20'41.74"N	75° 7'41.41"E	Green area
L 5	15°22'31.14"N	75° 6'33.90"E	Lake
L 6	15°21'29.52"N	75° 7'18.70"E	Urban
L 7	15°21'27.18"N	75° 7'19.31"E	Urban/Open space
L 8	15°22'25.31"N	75° 6'40.48"E	Urban
L 9	15°22'30.48"N	75° 6'37.35"E	Wetland and green area
L 10	15°19'20.70"N	75° 8'28.33"E	Agriculture and scrub area
L 11	15°19'22.61"N	75° 8'22.07"E	Scrub area
L 12	15°19'12.84"N	75° 8'9.35"E	Urban

Table-1: Sampling Locations.

Location	Latitude	Longitude	Landuse
L 13	15°20'14.18"N	75° 8'6.54"E	Urban
L 14	15°20'45.29"N	75° 7'49.34"E	Urban







Figure-4 shows that compared to other quadrats L9, L4 and L6 shows more number of species. All the studied quadrats were calculated for various biodiversity indices, using floral data, the

details are mentioned in the following section. Figure-6 show that L 9 and L6 have higher number of faunal species.











Figure-8: Simpson's index for Fauna.

Simpson's Diversity Index measures the diversity by considering species richness and relative abundance of each species present in the sample. Increase in species richness and evenness results in increase of value of Simpson's diversity index. Simpson index for fauna shows highest readings at L 12

and L4 has least. It can be called as dominance index as it gives more weight to common or dominant species. As per the Graph L13 has high richness and evenness whereas L4 has lowest richness and evenness of flora.





Species richness is measured quantitatively by Shanon's index while considering even distribution of the species from the sample. It increases with the increase in evenness and richness. Shanon index of flora shows high values at L4 and L6 where as lowest at L 13. Index calculated for fauna shows High value at L9 and Low at L7.

Following graphs of species distribution shows positive relation in biodiversity.



Figure-11: Species Distribution of Flora.



Figure-12: Species distribution of Fauna.

Observations: The biodiversity indices show that the area is fairly rich in floral species. In trees *Ricinus communis, Samanea* (albezia) saman, and Azadirachta indica are found to be more common. Calotropis gigentia found to be a common shrub in the study area. Alternanthera sessilis is a most common herb along the nalla which is exotic and invasive in nature. This herb is reported to blog the drain network and irrigation channels. Out of observed species 35% are exotic in nature but most of them are naturalised. Lantana camara is one of the dominating invasive species found in the study area.

Faunal diversity of the area was found to be diverse, 53 birds, 6 mammals, 8 Reptiles and 12 butterflies were sighted observed in the area through primary survey. Two globally Near Threatened species (*Psittacula eupatria and Sterna aurantia*) were

observed. Two Species from Schedule I (*Pavo cristatus and Accipiter badius*) and two species from Schedule II (*Ptyas mucosa and Xenochrophis piscator*) as per Wildlife Protection Act, 1972 were observed during the study. One Near-Threatened species (*Psittacula eupatria*) as per IUCN list is recorded in the study area. Presence of Pavo Cristatus a Schedule I species was recorded through call in the vicinity of L1. Also birds like Northern Shoveler, Spot billed duck, River Terns, Purple heron, Brahminy Kite, Bronz winged Jacana, Purple Swamphen, Little grebe etc are present in the Unkal lake which is an originating point of the Nalla. A consolidated list of avifauna, mammals and butterflies is given in Table.

It can be seen that the study area harbours good biodiversity and the area L9 has an ecological importance by having wetland with reeds and wetland dependant fauna. It has also been seen that the number of scavenging birds especially Black kite is higher in the study area along with insectivorous birds. This is due to the dumping of slaughter waste in the Nalla which attracts scavenging birds and insectivorous birds which feeds on the insects harboured on the slaughter waste.

Recommendations for Policy Makers: In general, the area has rich biodiversity and requires to be conserved. Therefore biodiversity management plan is required details of which are as belows,

Biodiversity Management Plan: The objective of this biodiversity management plan is to: i. Cleaning of nalla water for enhancing its physical and chemical characteristics such as Dissolved Oxygen (DO), reduction in Biological Oxygen Demant (BOD) and Chemical Oxygen Demand (COD). Improvement in water quality will help in survival of aquatic flora and fauna. ii. Conserve Ecosystem, species and genetic diversity in the given area by enhancing the floral base, iii. Protection of Species found to be endemic to the region or are threatened to the region, iv. Conservation of migratory bird species, v. Reduction in loss of habitat, vi. Enhancing biodiversity of the region, vii. Sustainable development of the present component, viii. Reduction of threat due to proposed activities and further mitigating its impact.

Conservation of Floral Species: i. Conservation of floral species can be done by retaining the species in the area or if it is necessary to remove the tree it either should be transplanted or compensatory plantation is to be carried out. ii. Removal of Exotic and Invasive species. As mentioned in earlier section around 35% of the species recorded are exotic but most of them are naturalised in ecosystem but some like *Lantana camara* and *Alternantheria sesillis* are invasive and negatively impacting the ecosystem and hence measures to remove them should be taken up. iii. Plantation of Native plants.

Conservation of Faunal Species: i. Controlling population of stray pigs and dogs is essential to enhance the wild biodiversity as they often prey on the wild fauna. ii. Controlling population

of scavenging birds which compete with other bird of prey for shelter and food. In this case Black kite is high in numbers which may be the reason of absence of other large raptors in the area. Cleaning of nalla and over all solid waste management will be required to address this issue. iii. Installation and operation of the fountains and aerators in the lake and Nalla area should be strategically planned considering the movement of the birds like Terns, Coots, Ducks etc. Terns and Brahminey Kite prefers to fly over the water surface and look for the prey. Any structure like aerator/fountain will impact their movement. Operation time of these utilities should be planned avoiding dawn and dusk. iv. Development of butterfly garden – considering the number of butterflies in the biodiversity park development of butterfly garden can help improve their diversity. v. Frog pond – to improve diversity of frogs and toads

frog breeding ponds can be planned in the biodiversity park. There are smaller ditches with floating plants and smaller fisher. These provides shelter to frogs during breeding season. vi. Species like Indian Grey hornbill are found in the area of proposed biodiversity park. To improve their and other bird's diversity fruiting plants of wild nature can be planted i.e. Ficus trees¹⁹.

Conservation of Habitat: i. *Eichhornia crassipes and Ipomoea sp.* are found to be effective on removing pollution from aquatic system. Other aquatic plants also can utilise excessive nutrients from aquatic ecosystem. ii. Reeds (15°22'29.58"N, 75° 6'35.83"E) at should be preserved and integrated in the biodiversity park.



Figure-13: Biodiversity Management Plan.

International Research Journal of Biological Sciences _____ Vol. 9(4), 25-44, November (2020)



Figure-14: Current Situation of Nalla.



Figure-15: Wetland in riparian zone.



Figure-16: Ricinus communis.



Figure-17: Eichhornia crassipes.



Figure-18: Argemone Mexicana.



Figure-19: Typha domingensis.



Figure-20: Calotropis gigentia.



Figure-21: Calotropis procera.



Figure-22: Nymphaea pubescens.



Figure-23: Nymphoides cristata.



Figure-24: Ardea purpurea.



Figure-25: Haliastur Indus.



Figure-26: Egretta garzetta.



Figure-27: Amaurornis phoenicurus.



Figure-28: Halcyon gularis.



Figure-29: Ocyceros birostris.



Figure-30: Ptyas mucosa.



Figure-31: Xenochrophis piscator.

Table-2: Phyto-sociology Indicators & Status of Flora Observed.

English Common Name	Botanical Name	Family	Native/ Exotic	Endemic	Abundance	Relative Abundance	Frequency	Relative Frequency
Trees	·					•		
Rain Tree	Samanea (albezia) saman	Mimosaceae	Exotic	No	7	3.65	0.50	50.00
Neem	Azadirachta indica	Meliaceae	Native	No	7	3.65	0.50	50.00
Markhamia	Markhamia lutea	Bignoniaceae	Exotic	No	1	0.52	0.07	7.14
China Rose	Hibiscus rosa-sinensis	Malvaceae	Native	No	1	0.52	0.07	7.14
Coconut	Cocos nucifera	Arecaceae	Native	No	5	2.60	0.36	35.71
Peeple	Ficus religiosa	Moraceae	Native	No	5	2.60	0.36	35.71
Jamaica Cherry	Muntingia calabura	Muntingiaceae	Exotic	No	2	1.04	0.14	14.29
Indian Almond	Terminalia catappa	Combretaceae	Native	No	2	1.04	0.14	14.29
Babool	Vachellia (Acacia) nilotica	Mimosaceae	Native	No	6	3.13	0.43	42.86
Castor bean Plant	Ricinus communis	Euphorbiaceae	Native	No	9	4.69	0.64	64.29
Flame Tree	Delonix regia	Caesalpiniaceae	Exotic	No	2	1.04	0.14	14.29
Butterfly tree	Bauhinia purpurea	Caesalpiniaceae	Native	No	1	0.52	0.07	7.14
Arjun Tree	Terminalia arjuna	Combretaceae	Native	No	1	0.52	0.07	7.14
Pongam Tree	Millettia pinnata	Fabaceae	Native	No	1	0.52	0.07	7.14
Ziziphus	Ziziphus sp.	Rhamnaceae	Native	No	2	1.04	0.14	14.29
Peacock Flower	Caesalpinia pulcherrima	Caesalpiniaceae	Native	No	1	0.52	0.07	7.14
Eucalyptus	Eucalyptus sp.	Myrtaceae	Exotic	No	4	2.08	0.29	28.57

English Common Name	Botanical Name	Family	Native/ Exotic	Endemic	Abundance	Relative Abundance	Frequency	Relative Frequency
Copperpod	Peltophorum pterocarpum	Caesalpiniaceae	Exotic	No	3	1.56	0.21	21.43
Foxtail Palm	Wodyetia bifurcata	Arecaceae	Exotic	No	2	1.04	0.14	14.29
Tamarind	Tamarindus indica	Caesalpiniaceae	Exotic	No	1	0.52	0.07	7.14
Mango	Mangifera indica	Anacardiaceae	Native	No	2	1.04	0.14	14.29
False Ashok	Polyalthia longifolia	Annonaceae	Native	No	2	1.04	0.14	14.29
Madras Thorn	Pithecellobium dulce	Mimosaceae	Exotic	No	1	0.52	0.07	7.14
Drumstick Tree	Moringa oleifera	Moringaceae	Native	No	1	0.52	0.07	7.14
Teak	Tectona grandis	Verbenaceae	Native	No	3	1.56	0.21	21.43
Sapodilla plum	Manilkara zapota	Sapotaceae	Exotic	No	1	0.52	0.07	7.14
Guava	Psidium guajava	Myrtaceae	Exotic	No	1	0.52	0.07	7.14
Pomegranate	Punica granatum	Lythraceae	Native	No	1	0.52	0.07	7.14
Banyan tree	Ficus benghalensis	Moraceae	Native	No	3	1.56	0.21	21.43
Whistling Pine	Casuarina equisetifolia	Casuarinaceae	Native	No	1	0.52	0.07	7.14
Acasia	Acacia sp.	Mimosaceae	Exotic	No	2	1.04	0.14	14.29
Рарауа	Carica papaya	Caricaceae	Native	No	1	0.52	0.07	7.14
Sago Palm	Cycas sp.	Cycadaceae	Native	No	1	0.52	0.07	7.14
Ficus	Ficus sp.	Moraceae	Native	No	1	0.52	0.07	7.14
Wood Apple	Limonia acidissima	Rutaceae	Native	No	1	0.52	0.07	7.14
Java plum	Syzygium cumini	Myrtaceae	Native	No	1	0.52	0.07	7.14
Algaroba	Prosopis juliflora	Mimosaceae	Exotic	No	6	3.13	0.43	42.86
Shrubs				•	•			
Rubber Bush	Calotropis procera	Apocynaceae	Native	No	2	1.04	0.14	14.29
Crown Flower	Calotropis gigentia	Apocynaceae	Native	No	5	2.60	0.36	35.71
Lantana	Lantana camara	Verbenaceae	Exotic	No	6	3.13	0.43	42.86
Arabian Jasmine	Jasminum Sambac	Oleaceae	Native	No	1	0.52	0.07	7.14
Oleander	Nerium oliander	Apocynaceae	Native	No	1	0.52	0.07	7.14

English Common Name	Botanical Name	Family	Native/ Exotic	Endemic	Abundance	Relative Abundance	Frequency	Relative Frequency
Stinking Cassia	Cassia tora	Caesalpiniaceae	Native	No	2	1.04	0.14	14.29
Tanner's Cassia	Cassia auriculata	Caesalpiniaceae	Native	No	1	0.52	0.07	7.14
Needle Bush	Azima tetracantha	Salvadoraceae	Native	No	3	1.56	0.21	21.43
Marsh Barbel	Hygrophila auriculata	Acanthaceae	Native	No	1	0.52	0.07	7.14
Herbs								
Sessile Joyweed	Alternanthera sessilis	Amaranthaceae	Exotic	No	10	5.21	0.71	71.43
Mexican Prickly Poppy	Argemone mexicana	Papaveraceae	Exotic	No	4	2.08	0.29	28.57
Touch-me-not Plant	Mimosa pudica	Mimosaceae	Exotic	No	3	1.56	0.21	21.43
Cassia	Cassia sp.	Caesalpiniaceae	Native	No	2	1.04	0.14	14.29
Littoral bind weed	Cressa sp.	Convolvulaceae	Native	No	4	2.08	0.29	28.57
Rosy periwinkle	Catharanthus roseus	Apocynaceae	Exotic	No	1	0.52	0.07	7.14
Fragrant Flat Sedge	Cyperus sp.	Cyperaceae	Native	No	2	1.04	0.14	14.29
Water Hyacinth	Eichhornia crassipes	Pontederiaceae	Exotic	No	6	3.13	0.43	42.86
Lesser Indian Reed Mace	Typha domingensis	Typhaceae	Native	No	2	1.04	0.14	14.29
Malabar Nut	Justicia adhatoda	Acanthaceae	Native	No	1	0.52	0.07	7.14
Tridax Daisy	Tridax procumbens	Asteraceae	Exotic	No	3	1.56	0.21	21.43
Datura	Datura innoxia	Solanaceae	Exotic	No	4	2.08	0.29	28.57
Oval-Leaf Fan-Petals	Sida ovata	Malvaceae	Native	No	5	2.60	0.36	35.71
Basil	Ocimum sp.	Lamiaceae	Native	No	2	1.04	0.14	14.29
Floating Lace Plant	Aponogeton sp.	Aponogetonaceae	Native	No	2	1.04	0.14	14.29
Sicklepod	Cassia obtusifolia	Caesalpiniaceae	Exotic	No	2	1.04	0.14	14.29
Tall Reed	Phragmites sp.	Poaceae	Native	No	3	1.56	0.21	21.43
Elephant Ear	Colocasia sp.	Araceae	Native	No	1	0.52	0.07	7.14
Climbers and Creepers	•						·	
Stinking passionflower	Passiflora foetida	Passifloraceae	Exotic	No	3	1.56	0.21	21.43
Balloon Vine	Cardiospermum halicacabum	Sapindaceae	Native	No	3	1.56	0.21	21.43

English Common Name	Botanical Name	Family	Native/ Exotic	Endemic	Abundance	Relative Abundance	Frequency	Relative Frequency
Glory Flower	Ipomoea sp.	Convolvulaceae	Exotic	No	7	3.65	0.50	50.00
Leucas	Leucas sp.	Lamiaceae	Native	No	1	0.52	0.07	7.14
Bougainvillea	Bougainvillea glabra	Nyctaginaceae	Exotic	No	1	0.52	0.07	7.14
Grasses								
Indian Crowfoot Grass	Eleusine indica	Poaceae	Native	No	1	0.52	0.07	7.14
Bermuda Grass	Cynodon dactylon	Poaceae	Native	No	3	1.56	0.21	21.43
Indian Thorny Bamboo	Bambusa bambos	Poaceae	Native	No	2	1.04	0.14	14.29

Table-3: List of Fauna Observed in Study Area.

Sr. No.	English Common Name	Scientific Name	Order	Family	IUCN, 3.1 Status	WPA, 1972 (Schedule)	Endemic				
Avifau	Avifauna										
1	Common Myna	Acridotheres tristis	Passeriformes	Sturnidae	LC	IV	No				
2	Jungle Myna	Acridotheres fusus	Passeriformes	Sturnidae	LC	IV	No				
3	Indian House Crow	Corvus splendens	Passeriformes	Corvidae	LC	IV	No				
4	Large Billed Crow	Corvus macrorhynchos	Passeriformes	Corvidae	LC	IV	No				
5	Red Vented Bulbul	Pycnonotus cafer	Passeriformes	Pycnonotidae	LC	IV	No				
6	Black Kite	Milvus migrans	Accipitriformes	Accipitridae	LC	IV	No				
7	Common Tailor Bird	Orthotomus sutorius	Passeriformes	Cisticolidae	LC	-	No				
8	Purple Rumped Sunbird	Leptocoma zeylonica	Passeriformes	Nectariniidae	LC	IV	No				
9	White Breasted Waterhen	Amaurornis phoenicurus	Gruiformes	Rallidae	LC	IV	No				
10	Wire Tailed Swallow	Hirundo smithii	Passeriformes	Hirundinidae	LC	-	No				
11	Indian Robin	Saxicoloides fulicatus	Passeriformes	Muscicapidae	LC	-	No				

12	Grey wagtail	Motacilla cinerea	Passeriformes	Motacilla cinerea	LC	IV	No
13	Indian Peafowl	Pavo cristatus	Galliformes	Phasianidae	LC	Ι	No
14	Indian Pond Heron	Ardeola grayii	Pelecaniformes	Ardeidae	LC	IV	No
15	Common Sandpiper	Actitis hypoleucos	Charadriiformes	Scolopacidae	LC	IV	No
16	Little Egret	Egretta garzetta	Pelecaniformes	Ardeidae	LC	IV	No
17	Blue Rock Pigeon	Columba livia	Columbiformes	Columbidae	LC	-	No
18	Tickel's Blue Flycatcher	Cyornis tickelliae	Passeriformes	Muscicapidae	LC	IV	No
19	Ashy Prinia	Prinia socialis	Passeriformes	Cisticolidae	LC	-	No
20	Asian Koel	Eudynamys scolopaceus	Cuculiformes	Cuculidae	LC	IV	No
21	Greater Coucal	Centropus sinensis	Cuculiformes	Cuculidae	LC	IV	No
22	Oriental Magpie Robin	Copsychus saularis	Passeriformes	Muscicapidae	LC	-	No
23	Black Drongo	Dicrurus macrocercus	Passeriformes	Dicruridae	LC	IV	No
24	Alexandrine Parakeet	Psittacula eupatria	Psittaciformes	Psittacidae	NT	IV	No
25	Chestnut-tailed Starling	Sturnia malabarica	Passeriformes	Sturnidae	LC	IV	No
26	Indian Grey Hornbill	Ocyceros birostris	Bucerotiformes	Bucerotidae	LC	-	No
27	Coppersmith Barbet	Psilopogon haemacephalus	Piciformes	Megalaimidae	LC	IV	No
28	Indian Golden Oriole	Oriolus kundoo	Passeriformes	Oriolidae	LC	IV	No
29	Laughing Dove	Spilopelia senegalensis	Columbiformes	Columbidae	LC	IV	No
30	Shikhra	Accipiter badius	Accipitriformes	Accipitridae	LC	Ι	No
31	Cinereous tit	Parus cinereus	Passeriformes	Paridae	LC	IV	No
32	River Terns	Sterna aurantia	Charadriiformes	Laridae	NT	-	No
33	Brahminy kite	Haliastur indus	Accipitriformes	Accipitridae	LC	-	No

34	White-throated Kingfisher	Halcyon gularis	Coraciiformes	Alcedinidae	LC	IV	No
35	Common Kingfisher	Alcedo atthis	Coraciiformes	Alcedinidae	LC	IV	No
36	Indian Spot Billed Duck	Anas poecilorhyncha	Anseriformes	Anatidae	LC	IV	No
37	Grey Heron	Ardea cinerea	Pelecaniformes	Ardeidae	LC	IV	No
38	House Sparrow	Passer domesticus	Passeriformes	Passeridae	LC	-	No
39	Pied Bushchat	Saxicola caprata	Passeriformes	Muscicapidae	LC	IV	No
40	Large Gray Babbler	Turdoides malcolmi	Passeriformes	Leiotrichidae	LC	IV	No
41	Indian House Swift	Apus nipalensis	Caprimulgiformes	Apodidae	LC	-	No
42	Purple Heron	Ardea purpurea	Pelecaniformes	Ardeidae	LC	IV	No
43	Indian Palm Swift	Cypsiurus balasiensis	Caprimulgiformes	Apodidae	LC	-	No
44	Red Wattled Lapwing	Vanellus indicus	Charadriiformes	Charadriidae	LC	-	No
45	Common Iora	Aegithina tiphia	Passeriformes	Aegithinidae	LC	IV	No
46	White Browed Wagtail	Motacilla maderaspatensis	Passeriformes	Motacillidae	LC	IV	No
47	Pale Billed Flower Pecker	Dicaeum erythrorhynchos	Passeriformes	Dicaeidae	LC	IV	No
48	Barn Swallow	Hirundo rustica	Passeriformes	Hirundinidae	LC	-	No
49	Blyth's Reed Warbler	Acrocephalus dumetorum	Passeriformes	Acrocephalidae	LC	-	No
50	Red Whiskered Bulbul	Pycnonotus jocosus	Passeriformes	Pycnonotidae	LC	IV	No
51	Purple Sunbird	Cinnyris asiaticus	Passeriformes	Nectariniidae	LC	IV	No
52	Asian Green Bee-eater	Merops orientalis	Coraciiformes	Meropidae	LC	-	No
53	Cattle Egret	Bubulcus ibis	Pelecaniformes	Ardeidae	LC	IV	No
Mamm	als		-				
1	Three-striped palm squirrel	Funambulus palmarum	Rodentia	Sciuridae	LC	IV	No

2	Five-striped palm squirrel	Funambulus pennantii	Rodentia	Sciuridae	LC	IV	No
3	Indian Flying Fox	Pteropus giganteus	Chiroptera	Pteropodidae	LC	IV	No
4	Indian Pipistrelle bat	Pipistrellus coromandra	Chiroptera	Vespertilionidae	LC	-	No
5	House Rat	Rattus rattus	Rodentia	Muridae	LC	-	No
6	House Mouse	Mus musculus	Rodentia	Muridae	LC	IV	No
Reptile	s and Amphibians					•	
1	Indian Rat Snake	Ptyas mucosa	Squamata	Colubridae	-	II	No
2	Checkered Keel Back Snake	Xenochrophis piscator	Squamata	Colubridae	-	II	No
3	House Gecko	Hemidactylus frenatus	Squamata	Gekkonidae	LC	-	No
4	Bark Gecko	Hemidactylus leschenaultii	Squamata	Gekkonidae	-	-	No
5	Brahminy Skink	Eutropis carinata	Squamata	Scincidae	LC	-	No
6	Garden Lizard	Calotes versicolor	Squamata	Agamidae	-	-	No
7	Skittering Frog	Euphlyctis cyanophlyctis	Anura	Dicroglossidae	LC	-	No
8	Asian Common Toad	Duttaphrynus melanostictus	Anura	Bufonidae	LC	-	No
Butterf	lies		•			•	
1	Common Yellow Grass Butterfly	Eurema hecabe	Lepidoptera	Pieridae	-	-	No
2	Oriental Blue Tiger Butterfly	Tirumala limniace	Lepidoptera	Nymphalidae	-	-	No
3	Plain Tiger Butterfly	Danaus chrysippus	Lepidoptera	Nymphalidae	-	-	No
4	Striped Tiger Butterfly	Danaus genutia	Lepidoptera	Nymphalidae	-	-	No
5	Common Crow Butterfly	Euploea core	Lepidoptera	Nymphalidae	-	IV	No
6	Common Rose Butterfly	Pachliopta aristolochiae	Lepidoptera	Nymphalidae	-	-	No
7	Dark Grass Blue	Zizeeria karsandra	Lepidoptera	Papilionidae	LC	-	No

8	Common Four Ring	Ypthima huebneri	Lepidoptera	Nymphalidae	-	-	No
9	Psyche Butterfly	Leptosia nina	Lepidoptera	Pieridae	-	-	No
10	Lemon Pancy Butterfly	Junonia lemonias	Lepidoptera	Nymphalidae	-	-	No
11	White Orange Tip Butterfly	Ixias marianne	Lepidoptera	Pieridae	-	-	No
12	Chocolate Pansy	Junonia iphita	Lepidoptera	Nymphalidae	-	-	No

Conclusion

Biodiversity Assessment shows that the given area is good with biodiversity. Near Threatened and Scheduled species are observed during the survey. There will be increase in density of trees along the nalla if landscaping and new plantations are undertaken. As recommended biodiversity park, butterfly park and frog pond will help area to support biodiversity strongly. The implementation of recommended activities needs to be performed carefully and waste that will be generated should be handled properly avoiding discharge into the water body. It is very essential not to damage natural vegetation of the site by implementing appropriate management plan. This should include awareness generation and use of standard procedures.

Acknowledgment

The present study is carried out as part of Hubbali-Dharwad Smart City project (HDSCL). We acknowledge the project team of HDSCL for extending their support in collection of data and providing the necessary logistics during the study.

References

- 1. Xiang H., Zhang Y. & Richardson J. (2016). Importance of Riparian Zone: Effects of Resource Availability at Landwater Interface. *Riparian Ecology and Conservation*, 3, 1-17.
- Décamps H. & Naiman R.J. (1990). The Ecology and Management of Aquatic-Terrestrial Ecotones. 1st ed.; Taylor & Francis: London, UK. pp 1-136ISBN-10: 1850702713
- **3.** Ren, Q., Li, C., Yang, W., Song, H., Ma, P., Wang, C., ... & Morreale, S. J. (2018). Revegetation of the riparian zone of the Three Gorges Dam Reservoir leads to increased soil bacterial diversity. *Environmental Science and Pollution Research*, 25(24), 23748-23763.
- Arif, M., Zhang, S., Jie, Z., Charles, W., Sanelisiwe Mzondi, P., & Li, C. (2020). Evaluating the Effects of Pressure Indicators on Riparian Zone Health Conditions in

the Three Gorges Dam Reservoir. China. Forests, 11(2), 214.

- 5. Gregory S.V., Swansosn F.J., McKee W.A. and Cummins K.W., (1991). An ecosystem perspective of riparian zones: focus on links between land and water. *Bioscience*, 41(8). 540-551.
- V. Iakovoglou, G.N. Zaimes & D. Gounaridis. (2012). Managing Healthy Riparian Areas in Urban Settings of Greece to Improve Living Conditions' Conference for Protection and restoration of the environment XI: Sustainable architecture and planning. pp 2169-2178.
- Schultz R.C., Colletti J.P., Isenhart T.M., Marquez C.O., Simpkins W.W., Ball C.J. & Schultz O.L. (2000). Riparian Forest Buffer Practices. In North American Agroforestry – An integrated science and practice. WI: American Society of Agronomy. pp.189-281.
- 8. McDonell M.J. & Picket S.T.A. (1990). Ecosystem structure and function along urban-rural gradients An unexploited opportunity for ecology, *Ecology*, 71, PP. 1232-1237.
- **9.** Sunil C., Kalegowda R., Badenahally S. & Nagaraja Bc.. (2016). Diversity and composition of riparian vegetation across forest and agroeco system landscapes of river Cauvery, southern India. *Tropical Ecology*, 57(2), 343-354.
- Jisha K. & Nair M. C., (2018). Diversity Analysis of Angiosperms In Riparian System Along Thuppanad River, Southern Western Ghats, Kerala, India. *Int. J. Adv. Res.* 6(9), 531-539.
- **11.** Patten D.T. (1998). Riparian ecosyetems of semi-arid North America: diversity and human impacts. *Wetlands*, 18, 498-512.
- **12.** Wohl E. (2017). The significance of small streams. *Front. Earth Sci.* 11.
- Rodrigues, V.; Estrany, J.; Ranzini, M.; de Cicco, V.; Martín-Benito, J.M.T.; Hedo, J. and Lucas-Borja, M.E. (2018). Effects of land use and seasonality on stream water quality in a small tropical catchment: The headwater of

Córrego Água Limpa, São Paulo (Brazil). Sci. Total Environ., 622–623.

- 14. Shiyi G., Chang S., Kaoru S., Jiexin T. & Toru T. (2019). Bird Communities in Urban Riparian Areas: Response to the Local- and Landscape-Scale Environmental Variables. *Forests*, 10, 683.
- **15.** Karnataka Biodiversity Board (2010). Report on Biodiversity of Karnataka-At a Glance. Pp 1-91.
- 16. R. Parimala & G. R. Hegde. (2012). Grasses of Dharwad District. International Seminar on Multidisciplinary Approaches in Angiosperm Systematics. *Systematics of Flowering Plants*. pp 50-52.
- Nadaf R.M. and Ganesh C.B. (2016). A Study on Avifaunal Diversity Status in Lakes of Dharwad, Karnataka State. J. Ecophysiol. Occup. Hlth., 16 - 1&2, 13–21

- Ghorpadé, K. (2015). Birds in human habitations and the case in Dharwad, northern Karnataka. Indian Birds. 10 3&4. 71–84.
- **19.** Santhoshkumar E. & Balasubramanian P. (2014). Food Habits of Indian Grey Hornbill *Ocycerosbirostris* in Sathyamangalam forest Division, Eastern Ghats, India, *JBNHS*, V111i2. 71745.
- 20. McAleece, N., Gage J.D.G., Lambshead P.J.D. & Paterson G.L.J. (1997). Bio Diversity Professional statistics analysis software. V 2.0. Jointly developed by the Scottish Association for Marine Science and the Natural History Museum London. https://www.sams.ac.uk/science/ outputs/.1997.