Enhancing Biodiversity Conservation and Sustenance of Ecosystem Services in Environmentally Sensitive Areas (ESA) Project

BIODIVERSITY BASELINE SURVEY FOR THE ESA PROJECT

AMENDED FINAL REPORT

BASELINE BIODIVERSITY INFORMATION OF FAUNA AND FLORA SPECIES IN THE KALA OYA BASIN

November 2017

Table of Contents

Acronyms

ALG	Algae
BR	Breeding Resident
BS	Biodiversity Secretariat
BS	Black Sponge- Terpios
BBS	Biodiversity Baseline Survey
CAH	Chena & Associating Habitats
CH	Coastal Habitat
CM	Corallimorph
CR	Critically Endangered
CR	Coral Rubble
CR (PE)	Critically Endangered Possibly Extinct
DC	Recently Dead Coral
DD	Data Deficient
DF	Disturbed Forest
DMEF	Dry Mixed Evergreen Forests;
DS	District Secretariat
E	Endemic
EN	Endangered
ESA	Environmentally Sensitive Areas
GEF	Global Environment Facility
GIS	Geographic Information Systems
IAS	Invasive Alien Species
IBA	Important Bird Area
KOB	Kala Oya Basin
LC	Least Concern
LUPPD	Land Use Policy Planning Department -Sri Lanka
MMDE	Ministry of Mahaweli Development and Environment
M	Migrant
NT	Near Threatened
PMU	Project Managemnet Unit
RK	Rock or old dead coral
SA	Sand
SC	Soft Coral
SF	Scrub Forest
SI	Silt
SP	Sponge
TAH	Tank Associate Habitat
TOR	Terms of Reference
UM	Uncertain Migrant
UNDP	United Nations Development Programme
VCPs	Variable Circular Plots
VU	Vulnerable
PMU	Project Management Unit
MASL	Mahaweli Authority of Sri Lanka
ZO	Zoanthids

List of Tables

List of Figures

List of Annexures

Annex 01	Terms of Reference
Annex 02a	Kala Oya River Basin Map
Annex 02b	Client map of DS Divisions after discussion with LUPPD Oct 2016
Annex 02c	Kala Oya Basin Protected Area
Annex 02d	LUPPD protected Area Map provided on Feb 2017
Annex 02e	Map related information provided by BDS overlaid into Study Area Land use by GreenTech GIS Expert
Annex 03a	Kala OyaTransects1 - 5
Annex 03b	Kala Oya Transects 6- 8
Annex 03c	Kala Oya Transects 9-10
Annex 03d	Kala Oya Transects 11-12 Start
Annex 03e	Transect 11 End
Annex 03f	Kala Oya Transect 12 End
Annex 03g	Kala Oya Transect 13
Annex 03h	Kala Oya Transects 14- 16
Annex 03i	Kala Oya Transects 17- 20
Annex 03j	Kala Oya Transects 21- 22
Annex 03k	Kala Oya Transects 23- 24
Annex 04	Transects Surveyed (with Habitat Description
Annex 05	Checklist of the recorded Avifauna within Kala Oya basin and their distribution within the different sub-basins (1= present in VCP; P = Opportunistic observations)
Annex 06	Checklist of butterfly species recorded during the survey
Annex 07	Butterflies species recoded in the Kala Oya river basin during the last 5 years
Annex 08	Amphibian checklist and their representation in the Kala Oya River habitat types
Annex 09	Reptile checklist and their representation in the Kala Oya River habitat types
Annex 10	Reptile and Amphibian- Habitat types and status of the species
Annex 11	Marine Mammal Species recorded from Kalpitiya area
Annex 12	Sea bird Species recorded from Kalpitiya area
Annex 13	Sea turtle Species recorded from Kalpitiya area
Annex 14	Marine fish species recorded from the Bar-reef and surrounding area (with species recorded for sample sites included)
Annex 15	Stony Coral species recorded from the Bar-reef and surrounding area (with species recorded for sample sites included)
Annex 16	Marine Algae and Seagrass species recorded during the surveys
Annex 17	Marine Invertebrate species (non-coral) recorded during the surveys

ACKNOWLEDGEMENT

The Biodiversity Baseline Survey was conducted in 2016, as a component of the Environmentally Sensitive Area scheme proposed by UNDP, the Biodiversity Secretariat (BDS) and Ministry of Mahaweli Development and Environment. Members of the team are listed below and those who have contributed directly to the production of this document have been included under the respective taxonomic sections. It has been a pleasure to work with the staff of the Department of Wildlife Conservation, BDS and UNDP. The team is appreciative of the support received from the Park Wardens of Wilpattu National Park, Mr. Manoj Pradeep and Mr. Chamath, and officers of the Eluwankulama Ranger Station Mr Marasinghe and their staff who assisted with the field work. Special thanks to the Director of BDS, Ms. Padma Abeykoon and Cooridnator Ms. Pradeepa Ratnaweera. Thanks to the Director General and Assistant Director - Research & Training of the Department of Wildlife Conservation, Mr. Pathirathane and Dr. Luxman Peiris for their unstinted support. Ms, Sugandhi Samarasinge Technical Coordinator of the ESA Project of UNDP is mentined for her continuos support through the project.

Biodiversity Baseline Survey Team Members

Mammal Diversity Survey Team	U. K. G. K. Padmalal, D. M. Suratissa, Pubudu Weerarathne, Manaram Jayasooriya, Luxman Rathnayake
Avifauna Diversity Survey Team	Nishanthi Perera, Amila Sumanapala, Kasun Dayananda, Ruvinda de Mel, Rukmal Rathnayake, Nuwan Chaturanga, Tharidu Ranasinghe, Suneth Kanishka
Flora Diversity Survey Team	Himesh Jayasinghe, N.L. Dangampola, R.M.R. Rathnayake, K.A.N.C. Jayawardhane
Freshwater Diversity Survey Team	Sevvandi Jayakody, WMHK Wijenayake, Samantha Rajasinghe Gunasekara, Achini Wathsala Fernando, Sadun Nalaka Bandara, Janitha de Silva, Chandanie Wilson
Herpetofauna Diversity Survey Team	Roshan Rodrigo, M Roshan A. K. Peris, Amitha Bandara, P. Manamperi and A. V. Velauthem
Butterfly Diveristy Survey Team	Gamage Rajika Niroshan, Chetana Wimalarathne, Aruna Botheju
Dragonfly Diversity Survey Team	W.A Lasanthi Kanthika, M.Gayan Cooray, D.G.R.Sirimanna
Marine Diversity Survey Team	Prasanna Weerakody, Sajith Subhashana, K.Lakmal, Samantha Suranjan, Sevvandi Jayakody

1.0 INTRODUCTION TO THE PROJECT

"Enhancing Biodiversity Conservation and Sustenance of Ecosystem services in Environmentally Sensitive Areas" is a project initiative to be implemented in Sri Lanka by the UNDP with funding from the Global Environment Facility (GEF). The ESA project has the objective of operationalizing Environmentally Sensitive Areas (ESAs) as a mechanism for mainstreaming biodiversity management into development in areas of high conservation significance.

The project has two major components;

1. Enabling framework to designate and manage Environmentally Sensitive Areas (ESA)
2. Applying biodiversity friendly ESA management for long term integrity and resilience of ESAs

Under the ESA project, the area covering Kala Oya basin (downstream of Kala Wewa) and up to Gulf of Mannar along the coastal belt (including bar reef) and the terrestrial/aquatic landscape was identified as a potential ESA region, and the baseline survey was to be undertaken to provide a comprehensive understanding of the current situation with regard to the natural environment. The region includes high development areas as well as environmentally sensitive protected areas such as Wilpattu National Park.

Over the years, numerous measures have been taken to conserve biodiversity outside protected areas in Sri Lanka under different laws (Acts and Ordinances). This initiative, the management of Environmentally Sensitive Area (ESA) assigned by UNDP and BS will greatly strengthen such attempts under a different concept; a 'Landscape Approach'. The initiative will serve as an intermediary between the potential land use and land management by using the high conservation value of Kala Oya river basin (based on its significant biodiversity, even outside protected areas) as a parameter, especially in the deliberation and decision-making process involved in land use practices in Sri Lanka.

Following the Ecosystem Approach/Landscape Approach and using land-use planning and management framework as the entry point, the initiative aims to optimize multiple land management strategies to ensure the compatibility of land use practices across landscapes designated as ESAs with the biodiversity needs of the Kala Oya basin. Whilst several government policies and legislations provide the platform for the establishment of ESAs, there is the unmet need of operationalizing them. The survey project will provide baseline information necessary to put in place the framework for necessary governance at localized and national levels, including policy and enforcement systems.

This project, the Biodiversity Baseline Survey of the Kala Oya Basin, provides results of a three-month field survey on different taxonomic groups, specifically Dragonflies and Damselflies, Butterflies, Fish (Freshwater and Marine), Herpetofauna, Birds, Mammals and Flora (vascular plants) in their habitats which in turn elucidates the Kala Oya region's value as an ESA, the importance of its management, and the need for equilibrium between conservation efforts and development objectives. These include activities and mechanisms for land-use planning: protection of major habitat blocks and provision of structural and functional connectivity across

the landscape during the course of development. The project evidences the indirect impacts of development and their necessity to be factored into decision making which will subsequently deliver benefits at local level -immediate river basin- and national level while improving the long-term conservation prospects of the Kala Oya basin.

1.1 Scope of the Project

The ESA project of Biodiversity Secretariat stated that the Biodiversity Baseline Survey was initially to be carried out in two sites as indicated in the Terms of Reference for this assignment (Annex 01). However subsequent discussions held resulted in a request for the inclusion of the entire Kala Oya river basin including the Bar Reef without restricting to the two project sites of the ESA project, as initially agreed.

However, it must be noted that the time frame given was not sufficient to cover the entire extent of the basin with certain difficulties arising from this request being highlighted during discussions. Ultimately the BDS PMU requested the team to do the maximum possible work within the given time frame. Subsequently, the GreenTech team commenced surveying of biodiversity of the Kala Oya basin focusing on the following taxa: Plants, Mammals, Birds, Herpetofauna, Fish, Butterflies, Dragonflies, Damselflies and the Bar Reef.

The Kala Oya river basin map includes the watershed boundaries of Vanathavilluwa, Karuwalagaswewa in the Puttalam district, Kekirawa, Galnewa, Ipalogama, Palagala, and a portion of Nochchiyagama, Nachchaduwa, Thalawa, Thirappane, Palugaswewa in the Anuradhapura district, and a portion of Giribawa, Galgamuwa, Ehetuwewa, Polpithigama in the Kurunegala district and a portion of Galewela, Dambulla in the Matale district (Annex 02a). However, the survey conducted was confined to the boundaries within the Anuradapura and Puttalam districts.

For this particular study, the main objectives specified in the 'Terms of Reference' were as follows;

To carry out a biodiversity inventory of the ESA site of Kala Oya region to assess the current baseline information on biodiversity population and distribution, this will provide information for defining and conserving biodiversity
Identify the potential effects and impacts for monitoring purposes of project interventions on globally important ecosystems and species that are considered of global importance
Inventorying and developing a consistent long term database for knowing the identity and geographical distribution of its species, areas of endemism, threatened status are important for taking appropriate management decisions
Develop and carry out a training plan to fortify the skill sets of relevant stakeholder members for long term monitoring and evaluation

The inventorying and monitoring of biodiversity after successful completion of the study will provide guidance for immediate and long term management and conservation, policy and decision

making of the biodiversity in the area. Monitoring will allow assessments to understand the extent and degree of change that the recorded biodiversity in the area undergoes with time and will also allow for the crucial steps of continued sustainable management, using a landscape approach.

1.1.1 Outputs of the Study

The expected deliverables/ outputs for this study, as per the Terms of Reference are;

1. A work plan for this assignment, methodology including sampling and data collecting methods, indicative outline of each deliverable and a delivery schedule
2. Report and maps on ecosystem heterogeneity of the Kala Oya Region including terrestrial, coastal and aquatic ecosystems
3. Report on the threats and conservation issues in the region that functions as barriers to enhancing the biodiversity quality
4. Statistical Analysis of baseline biodiversity information of fauna and flora species in the ecosystems found in the two sites, to identify the endemism and the threaten status
5. A database for continual updating and long term monitoring and a distribution map of critical habitats displaying the threats and conservation status
6. A training plan to enhance capacities for monitoring and evaluation of biodiversity management in the project area




2.0 KALA OYA BASIN

The Kala Oya basin is the third largest river basin in Sri Lanka covering an area of 2,870 km^2, of which the major part is situated in the North-Western province, while the rest is situated in North Central and Central provinces of the island (Figure 1). Its elevation varies from sea level to 600 m above mean sea level at its headwaters, and this narrow basin is 150 km long and about 25 km wide on average (Perera et al, 2005). Kala Oya is not a perennial river as it dries out during some months of the year. However, due to the diversion of the Mahaweli water through Polgolla and Bowatenna, the riverine segment between Kala wewa and Rajangane gets adequate water. The basin can be divided into three regions: Upper region (the area above Kala wewa); Mid region (the area between Kalawewa and Rajangane Tank) and the Lower region (the area downstream of Rajangane) (Attigalle, 2002).

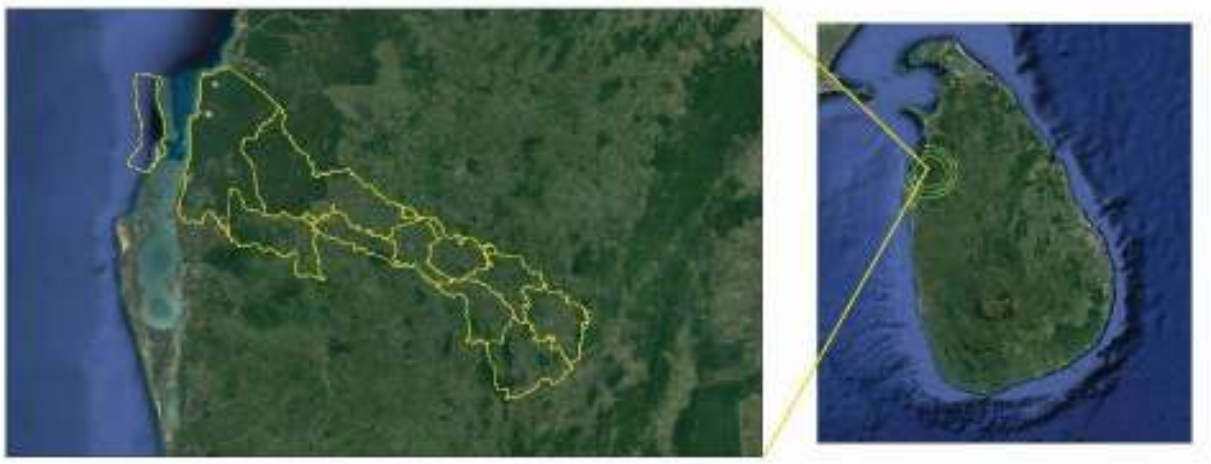


Figure 1 Location of the study area

Please refer to Annex 02b for the initial map provided by the LUPPD via the BDS outlining the District Secretariat Divisions for the corresponding maps of the study area.

Figure 2 Kala Oya observed from the bridge separating Anuradhapura and Puttalam districts

The Bar Reef is a coral reef system that is located offshore from Kalpitiya peninsula and is one of the more pristine and largest reef systems of the country. According to a study done in 2003[1], the Bar Reef is the habitat for 156 coral species and 283 fish species. The growth of coral reefs is predominantly influenced by the monsoons, which has a large impact on the level of turbidity and fresh water input into the coastal waters. The bar reef sanctuary (declared in 1992) covers an area of 306.7 km^2 and is governed by the Department of Wildlife Conservation.

Please refer to Annex 02c for a map of the Protected Areas of KOB, and a map of the protected areas provided by the LUPPD in Annex 02d. The final study area land use map compiled by the GIS Expert has been attached as Annex 02e.

The river basin covers many different types of ecosystems, valuable biodiversity resources and is characterized by conflicting user interests and serious degradation issues (Gunawardena, 2009). Nonetheless it is evident that such a vast array of resources and biodiversity is to be conserved in the most optimal manner, whilst ensuring sustainable development, with the cooperation of the various line agencies associated with the Ministry of Mahaweli Development and Environment.

2.1 Physical Features

KOB consists of most distinctive landform like Manawa, Ranawakanda, Kahallapallekele, Galpaya with quarts hills punctured at different locations. Streams drain mainly weststwards from these hills into Kala oya, dividing the area into sub-basins. The terrain is undulating, with occasional elevated outcrops of rock, and it is traversed by a series of stream gullies and small river valleys. An extensive peneplain stretches from the foothills of thses rocky out crops to the Kala oya.

A study conducted by Illangasinghe, 2016 indicates that in the KOB, 76% of land is situated in the dry zone and the rest in the intermediate zone. Most of the arable land is utilized for productive farming and rest is used for settlement, forest, pasture and non-agricultural activities. The main land use within the KOB includes forest (68, 271 ha), Paddy (61,895 ha), Scrub area (60,539 ha), Gardens (48, 777 ha), tanks (16,800 ha) and Chena cultivations (15,230 ha). The forests of the basin consist of around 59,857 ha of Dry Mixed Evergreen forests; 7,531 ha of Moist Monsoon Forests, 1,517 ha of Riparian forests and 4,345 ha of forest plantations (MASL, 2005).

Tanks are scattered throughout the landscape and there are also natural water holes, villus, which fill during the rainy season. Although the basin is located in the lowlands, there is a hill range especially in the upper basin, which is also the upper catchment of the Kala Oya River. Geologically, KOB is situated in the North-western lowlands and lies within a Dry zone. Soils include a variety of Reddish Brown Earths, Loams and Clays, derived from the weathering of residual parent materials, in upper catchments areas and alluviums in the flood plains, developed from materials that have been transported by water and deposited along the banks of the low areas of the Kala Oya. Geologically, KOB is underlain by protetozoic metamorphic rocks of the

[1] http://www.sarid.net/sarid-archives/03/031219-bar-reef-management.htm

Wannin complex and Miocene to quaternary aged sedimentary rocks. Most significant is the phosphate deposit at Eppawala and several other mineral reserves such as dolomite, topaz, mica etc occur within the KOB.

2.2 Climate & Rainfall

Kala Oya Basin area falls in to two agro-ecological regions that receive relatively low rainfall and comprise of high seasonal and spatial variations. The mean annual rainfall varies from 1700mm at high elevation in the south-eastern end of the basin and drops to 1200mm towards the north western part. More than two-third of the rainfall is received during the Maha season (October to March) and for this reason major reservoirs are built across Kala Oya and its major tributaries for regulation of surface water (MASL, 2003). Tanks in the basin play a major role in supplying water for the estuary to maintain its fresh water balance and to conserve biodiversity. The tanks also prevent large quantities of fresh water rushing in to inundate the estuary during rainy seasons. In the dry season, the controlled release of tank water for cultivation purposes is adequate to meet the fresh water requirements of the estuary.

The climate is characterized by a wide range of meteorological parameters, most commonly temperature, atmospheric pressures, precipitation, duration of sunshine and wind. The climate is generally tropical, and can be categorized into four climatic seasons: The first inter-monsoon season from March to April, Southwest monsoon season from May to September, Second inter-monsoon season from October to November and the Northeast monsoon season from December to February.

As the area lies within the dry zone of the country, the temperature varies between 30.4 –33.6^{0}C with an average monthly rainfall of 120 mm. The highest rainfall occurs from November to December (225 mm) while the driest periods are characterized by as little as 25 mm of rainfall per month. The estuarine system is very shallow, with depths of 1.5-3 m, except in the deep channels, where depths of 4-5 m have been recorded. The major sources of freshwater are the tanks in the Kala Oya basin.

There is a mean annual temperature varying between 26.5-28.5 degrees Celsius. Kala Oya is situated in the Dry Zone of Sri Lanka. Base river flow depends on water generated from the movement of groundwater into river channel during non-rainy seasons.

With increases in greenhouse gas emissions, anthropogenic activities that employ the burning of fossil fuels, changes in land-use patterns, decreasing tree cover, deforestation and environmental degradation, there has been an overall trend of increasing temperature. This has been caused by an enhanced greenhouse effect in lieu of an excess of greenhouse gases in the atmosphere. There are several issues pertaining to this specific region that are rooted in these anthropogenic activities, which exacerbate the current levels of degradation. These will be outlined under the Section of 'Threats and Conservation Issues' of this report.

2.3 Flora & Habitat

The Kala Oya River Basin represents a wide array of vegetation types covering terrestrial and aquatic ecosystems. Terrestrial ecosystems include many dry zone vegetation types. They have many special physiological and floristic characteristics and their distribution is influenced by soil, thermal hydrological and edaphic factors which induce more or less distinct assemblages: Vegetation types such as Dry mixed Evergreen Forest, Moist Monsoon forest, Riparian forest, Scrub forest, Thorn Scrub forest, Scrub on Food plains and Sands, Chena and abandoned Chena, Rocky out crops, Sand beaches, Home Gardens, Forest Plantation, (Teak and Eucalyptus.)

A study conducted by Illangasinghe in 2016 indicates that in the Kala Oya basin, 76% of land is situated in the dry zone and the rest in the intermediate zone. Most of the arable land is utilized for productive farming and rest is used for settlement, forest, pasture and non-agricultural activities. The main land use within the Kala Oya basin includes forests (68, 271 ha), paddy (61,895 ha), scrub area (60,539 ha), gardens (48, 777 ha), tanks (16,800 ha) and Chena cultivations (15,230 ha). The forests of the basin consist of around 59,857 ha of Dry Mixed Evergreen forests; 7,531 ha of Moist Monsoon forests, 1,517 ha of Riparian forests and 4,345 ha of forest plantations (MASL, 2005).

Coastal resources of the Kala Oya basin include varied biotopes such as mangroves, sea grass beds, sand dunes, the lagoon system, bar reef marine sanctuary, etc. The bar reef marine sanctuary (306 km^2) with very high biodiversity significance is situated at the sea mouth of the Kala Oya basin. It is of vast ecological and economic importance, as the reefs within the sanctuary function as an integral part of the larger economic system adjacent to coastal waters (Gunawardena, 2009, and Vidanage, 2005). A substantial portion (around 25%) of the Kala Oya basin comprises of Protected Areas managed by the Department of Wildlife Conservation (Wilpattu National Park, Kahala Pallekella Sanctuary, Sigiriya Sanctuary and Thabbowa Sanctuary). In addition, there are a number of reserved forests and plantation forests administered by the Forest Department (MASL, 2005). Weerakodicholi Forest Reserve was gazetted as of 2013 as well.

The distribution of vegetation types may be considered as broadly linked to the climate (mainly rainfall and temperature), topography and edaphic conditions. As Kala Oya is located in the dry zone, it is characterized by tropical dry mixed evergreen forests. This type of forest is the most abundant in the country, covering a majority of the dry zone. It is also characterized by a sparse canopy of about 20-25m in height, a sub-canopy of about 10-15 m and a well-developed shrub/ herb layer.

A total of 322 species of vascular plants have been recorded from the basin, with 262 indigenous species and 22 endemics. About 50 exotic species have also been recorded among them. Flora found in this basin include 08 nationally endangered and 15 nationally vulnerable species from the basin area.

The major trees have a deciduous component and an evergreen component. Rock outcrops are also found in many places. Ritigala is the highest peak in the dry zone, with a height of about 766m, where vegetation has been found to be unique. The grasslands are characterized as

'savannah' and 'damana talawa'. Situated at the extreme downstream end of the Kala Oya basin, the Wilpattu National Park, is the largest protected area in Sri Lanka, and contains significant biodiversity.

Figure 3 Various types of vegetation found around the Kala Oya Basin: (a) (b) Tropical dry mixed evergreen forests (c) (d) Agricultural areas and cultivations within the basin

The protection and enhancement of these forests and habitats, that serve as highly valuable carbon sinks is imperative. The sequestration of atmospheric carbon is an ecosystem service that can offset greenhouse gas emissions. These benefits include the conservation of soil from erosion, providing habitats and resources for surrounding biodiversity, regulation of climate, and providing raw materials.

Figure 4 Various types of habitats found around the Kala Oya Basin; (a) Stream (b) Salt Marsh (c) Fresh water aquatic plants (d) Seasonal marsh land

Sri Lanka has a unique assemblage of plant and animal communities, and is the most recent member of the 25 global hotspots with a significant center of endemism with its own characteristics and a rich and diverse range of flora including valuable timber species. Sri Lanka also has the highest species density per unit area for flowering plants, reptiles, mammals and possibly amphibians in the region.

Kala Oya estuary located in the western coast of North Western Province of Sri Lanka is one of the more biodiversity rich areas of the island. The mangrove and fisheries ecosystems in the lagoon area have been threatened by increased population pressure and industrial activities. The poor communities in the lagoon vicinity depend on the ecosystems for their livelihood activities and the pressure on ecosystems is believed to be exceeding sustainable levels.

Coastal resources of the Kala Oya basin include varied biotopes such as mangroves, sea grass beds, sand dunes, the lagoon system, Bar Reef Marine Sanctuary, etc. The Bar Reef marine sanctuary (306 km^2) with very high diversity significance is situated at the sea mouth of the Kala Oya basin. It is of vast ecological and economic importance as the reefs within the sanctuary function as an integral part of the larger economic system adjacent to coastal waters. The natural populations of many species are increasingly at risk, threatened by habitat loss, invasive species, and increasing degradation of natural environments. A substantial portion (around 25%) of the KOB comprise of Protected Areas managed by the Department of Wildlife Conservation (Wilpattu National Park, Kahala Pallekella Sanctuary, Sigiriya Sanctuary and Thabbowa Sanctuary). In addition, there are a number of Reserved Forests and plantation forests administered by the Forest Department (MASL, 2005).

Figure 5 Species of mature trees around the tropical dry mixed evergreen forest (*Commiphora caudate*- සිම්බිල්ල, එන්සෙළු)

2.4 Fauna

The high diversity of ecosystems in the country, combined with the zoogeographic history, diverse topography and climatic variations have resulted in a wide array of habitats occupied by a broad range of species, extending to mammals, birds, herpetofauna, freshwater fish, as well as several groups of invertebrate fauna. Sri Lanka Dry Zone tropical dry mixed evergreen forests harbour one of the largest elephant populations in Asia. The distinctive large mammal fauna include the leopard, bear, elephant, deer, and sambar deer.

A total of 35 species of butterflies, 15 species of dragonflies, 29 species of fishes including 22 native, 8 amphibians, 23 reptiles, 120 species of birds (106 native, and 14 migrants), 10 endemics and 31 species of mamals, 28 native and 4 endemics have been recorded from the basin.

The estuary harbours a variety of fish species, including freshwater and brackish water forms. Common species of economically important fish include *Anguilla bicolor* (Shortfin Eel), *Etroplus*

suratensis (Green Chromide), *Chanos chanos* (Milkfish), *Oreochromis mossambicus* (Mozambique tilapia), *Mugil cephalus* (Flathead grey mullet), *Sardinella* spp., and *Caranx* spp.

The estuary also supports fairly healthy populations of locally declining non-fish vertebrates such as colony-nesting water birds (i.e. *Pelecanus philippensis*- Spot billed pelican), reptiles (*Acrochordus granulatus* -Little file snake, *Crocodylus palustris* -Mugger crocodile, *Lissemys punctate* -Indian flapshell turtle) and mammals (i.e. *Lutra lutra*- Old World Otter). Crustaceans form an important component of invertebrate fauna associated with the mangals, including Portunid crabs such as *Scylla serrata* – Giant mud crab, *Portunus pelagicus* -Flower crab and *Macrophthalmus* spp. Additionally, penaeid shrimps and the mud lobster *Thalassina anomala* – Mud lobster are also present. A noteworthy mollusc is *Geloina coaxans* – Mud clam, which is an edible bivalve.

2.5 Water Resources

Aquatic Ecosystems include mangroves salt marshes, Paddy fields, Flood plains, fresh and brackish waterholes, Tanks (seasonal and Perennial) Rivers and Streams, Estuary and Lagoons, Bays, Coral reefs and Sea grass beds.

A majority of the Habitats such as Coastal, salt marsh, estuary and mangroves are confined to the lower basins of Kala Oya. In addition, monsoon forests are mainly confined to the upper basin where the terrain is punctured by hilly areas. Other vegetation types show basin wise distribution.

A large number of important wetlands including man-made and natural wetlands are situated in the Kala Oya basin. These wetlands are imperative for sustaining the livelihoods of the basin community, as they have a major role in maintaining water quality, biodiversity, water quantity regulation, fisheries, recreational activities, tourism, etc., depending on their strategic location within the basin. They are among the most important ecosystems on earth. They have significant direct and indirect economic value. Unfortunately, they are also the most-threatened class of habitats in the world, mainly anthropogenic in origin. Filling (due to the competitive demand for land) is the leading threat to wetlands, where poverty compels some people to illegally encroach into wetlands.

Figure 6 Kala Wewa as seen from a distance

Kala Oya estuary supports a healthy mangrove ecosystem distributed over a wide area along the banks of Kala Oya, Lunu Oya and other streams. This mangrove forest is the largest in the country and extends upstream about 2 km from the river mouth. As in many other mangrove ecosystems in the dry coastal regions of Sri Lanka, *Rhizophora mucronata* and *Avicennia marina* are the major constituent species.

Due to differences in depth, salinity and biodiversity, the estuarine system can be differentiated into two major parts, the outer estuary and the inner estuary. The area between the mouth of the estuary and the brackish water area of the Kala Oya is considered the inner estuary, while the Dutch bay and Puttalam estuary area is considered the outer estuary. Saltmarshes are situated behind the mangroves and the stability of this ecosystem depends on the salinity in the soil. Sea grass beds can be found in the Dutch bay.

Figure 7 Mangrove habitats near Uppu Aru Lagoon in Lunu Oya segment of river mouth

The distribution and abundance of the estuarine fauna is dependent on the tidal influences. About 55 fish species belonging to 33 families and 8 shellfish species belonging to 2 families have been recorded from the Puttalam estuarine area, including the Kala Oya estuary. The wetlands, particularly the flood plains, play an important role in minimizing flood damage to the adjacent land areas. They also serve as a breeding site for aquatic fauna such as prawns and fish, and support special assemblages of species.

Isolated flood plains are also present along the Kala Oya, which is connected to the river only during the rainy season and remains a flooded wetland during other times. A large number of reservoirs are also present within the flood plain area and although most of them are not in working condition, they fill up during the rainy season.

Other types of water resources in the Kala Oya basin include seasonal marshlands, tanks, seasonal water holes and streams. These are vital for the various species that depend on these for water, and habitats for breeding, shelter and other resources.

Figure 8 Various types of water resources found around the Kala Oya Basin; (a) Seasonal marsh land (b) Resevoir (c) Seasonal water hole

As livelihoods in the basin area largely depend on agriculture and related activities, there is a high demand for water for irrigation. A large proportion of regulated water in the lower valley of the basin is used in the irrigation sector. Domestic and industrial uses within the Kala Oya basin are relatively low, as most of the domestic uses are non-consumptive and the industrial demand is negligible. Rural livelihood is tied up with tanks, as the main supplier of resources to the people in the village. The tanks provide water for their main income generation activities, i.e. cultivation of paddy and other field crops. In addition, it provides water for other crops in home gardens through sub surface water.

The average annual releases for Kala Oya Basin amount to 1,150 MCM. This figure includes return flows from upper irrigation areas and excludes releases from approximately 600 minor tanks spread over the basin. The tanks which have less than 80 ha of a command area outside 'System H' are managed by the Agrarian Services Department (ASD) in association with the relevant farmer organizations. Both MASL and ASD conduct meetings ("Kanna Resweem") prior to each season to inform farmers regarding water availability, expected rainfall, suitable crops for the season and the proper management of water and irrigation.

2.6 Ecosystems Covered under Present Study

The primary task of this study was to conduct a biodiversity inventory within a stipulated area of the KOB to assess the current baseline information on biodiversity population and distribution which will provide information for defining and conserving the biodiversity to understand the potential effects and monitor the impacts of project interventions on globally important ecosystems and species that are considered of global importance. Due to time and monitoring constrains the biodiversity survey was mainly done outside the existing protected areas (20 Transects) and 4 transects were undertaken within Wilpattu National Park. As each 1km transect included four 100m quadrat, they too covered different habitats. The main ecosystems

surveyed during this study included the following: Dry Mixed Ever Green Forests, Disturbed Forest, Scrub forest, Tank associate habitats, Chena associating habitats and Coastal habitats. Further dragonflies were also recorded within associated tank beds, rock pool and streams. The photographs given below provide some examples of these ecosystems.

Dry Mixed Evergreen Forests

Figure 9 Adjacent to Eluwankulama tank (5TQD); Forest at Manawa Kanda (T17QD) Wilpattu National Park (T24Q2)

Figure 10 [Left] Slopy forest at Hingurwalpitiya (T13QB); [Center] Riparian forests at Puliyankulama (T9QB); [Right] Forests at Nisala Arana (T16QA-D)

Disturbed Forests and Scrub Jungles

Figure 11 [Left] Abandoned quarry site in Gangewadiya (T3QA); [Center] Scrub jungles Associated with rocky outcrops (T24Q2);

Figure 12 Scrub forest associated with Tank catchment (T14QA-D)

Chena Cultivation Associated Habitats

Figure 13 [Left] Chena at Wilangoda (T10QC); [Right]Chena associated with Rukada Tank (T11QC)

Tank Associated Habitats

Figure 14 [Left] Aily Tank (T2QC); [Center] Eluwankulama Tank (T5QB); [Right] Tank associated forest (T14QB)

Coastal Habitats

Figure 15[Left] Dried up Salt marshes and [Right] Inland mangrove forests at Gangewadiya (T$QC and D)

Manewakanda is an isolated hill surrounded by settlements and chena cultivations. Therefore, the hill serves as refugia for many plant and animal species. Although the foothill regions of the site are heavily disturbed due to human activities, the upper forested area still support a good patch of Lowland dry forest which are the typical forests of this region. Since human disturbances are relatively low in the upper regions of the hill, most of the mammal species which are sensitive to disturbances have moved to these upper regions of the hill, thus making this area the only refugia for the survival of these species. Therefore, these isolated hills should be protected from anthropogenic disturbances to conserve the remaining biological diversity in the area (Attygalle, Ranawana & De Silva, 2012).

3.0 SAMPLING METHODOLOGY

Full details of the methodology developed and utilized for the Biodiversity Baseline Survey under PA and WM project can be found as a separate Field Manual (the 'Biodiversity Baseline Survey: Field Manual, DWC (2008); and Biodiversity Baseline Survey: Field Manual: Revised version- Department of Wildlife Conservation, Ministry of Environment and Natural Resources, Sri Lanka.'). A brief overview is provided below, together with details specific to the survey of the Kala Oya river basin such as the time of survey being during the height of the dry season in the months from January to March 2017 over a period of approximately 12 weeks.

3.1 Protocols used in the Biodiversity Baseline Survey of the Kala Oya Basin

The Biodiversity Baseline Survey has been designed in accordance with the following protocol:

1. All major habitats in each protected area/or outside area were sampled in a standard manner that was acceptable to international refereed scientific journals. The approach was designed to enable comparison of species richness and diversity between different habitats
2. The locations of the survey were guided by habitat maps produced during field visits
3. Sampling techniques used were not destructive to any habitat, population or individual
4. Sampling methods, while necessarily differing between taxonomic groups generated quantifiable, verifiable and repeatable results in accordance with the criteria for sampling as specified below
5. The same survey personnel were used throughout the Survey to minimize observer biases in species richness and abundance arising from differences in the competencies of field staff. Observer consistency was checked in the field during the course of the Survey.

The time frame provided to study and survey the extent of the area was a constraint and imposed limitations.

3.2 Criteria for Sampling and Collection of Field Data

Site selection was done to exclude protected areas within the basin as requested by the BDS. The number of sampling site in each cluster or sub basin based on the availability of time and extent of the area. Each sampling point was geo referenced in order to ensure repeatability of the data in the future if necessary

3.3 Description of Sampling Units

3.3.1 Transects – 1 km in length

Transects of 1 km in length were marked out in at least four replicates of the broadly defined habitat (i.e. vegetation) types within a protected area. They were positioned to cover a single vegetation type (the area was determined by taking in to account a discernible measurement based on available maps). In areas comprising of a mosaic of highly fragmented habitats, a transect may cover more than one vegetation type and encompass ecotones. Where necessary or appropriate, transects were extended from 1km to cover several vegetation types along a major environmental gradient, such as altitude. Such transects conform to gradsects.

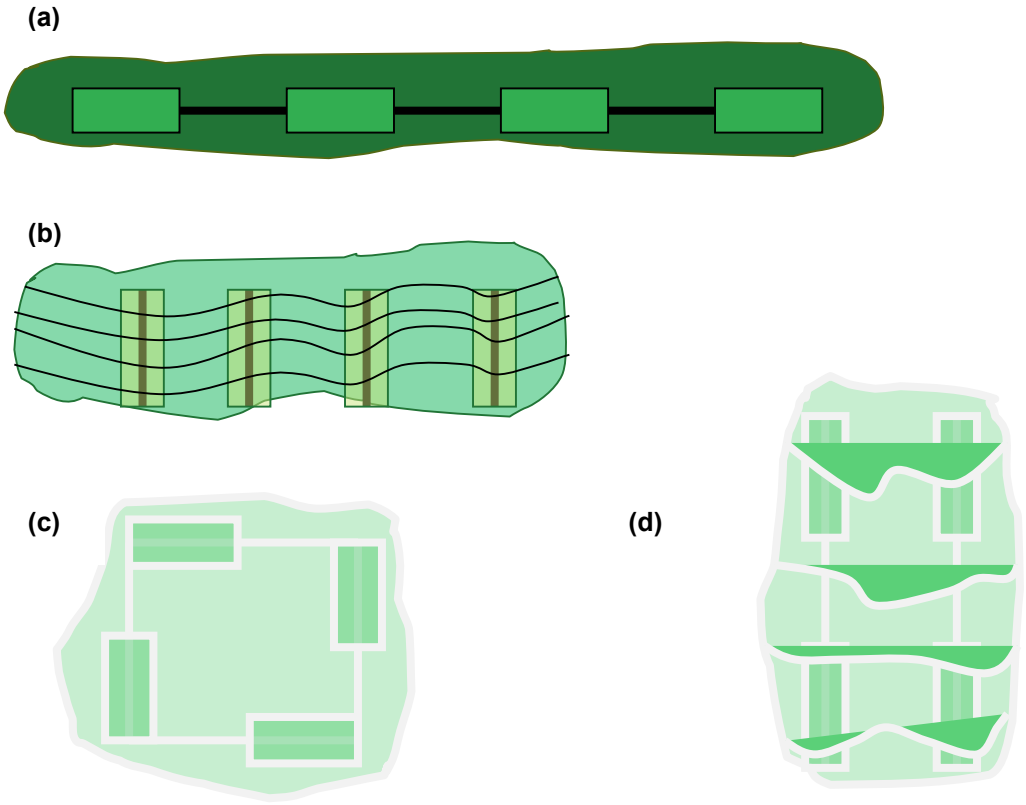


Figure 16 Transects are aligned in a single line (a), in parallel (b, d) or in a square, depending on the distribution of the habitat, access to it and sampling logistics. They should also be aligned perpendicular to environmental gradients, such as altitude (b, (b, c) to maximise sampling of biological diversity. (*not to scale*) DWC 2007

3.3.2 Quadrats –100m × 5m

The length of the quadrat used during the sampling period (four days) was demarcated using a centre line of highly visible nylon cord, marked at every 10m interval by tape. A thin pole of 2.5m in length was aligned perpendicular to the central cord in order to determine the width of the quadrat. Cords were removed at the end of the sampling period of four days. The position at each

100m point of the quadrat line was georeferenced using a GPS and marked using a coloured plastic wrap tied loosely around a branch of vegetation (not applicable in grasslands), which were removed upon completion of the surveying.

Quadrats were aligned along a single straight line 1 km in length, or in a square (250m × 250m) or rectangle (350m × 150m). Regardless of the transect shape, quadrats must be 150m apart. This criterion is particularly important with respect to mobile taxa, such as birds, to minimize the potential for recording the same individual in adjacent quadrats. Sometimes, where access is very restricted (e.g. either side of a footpath) or where the habitat is very linear in its distribution, it may be necessary to establish four parallel quadrats, spaced at least 150m apart.

3.3.3 Plots – 10m × 5m

The subdivision of quadrats into plots is critical. It enabled the Quadrat Clearing Technique to be applied at 20m intervals for reptile/amphibian incidence, small mammal traps to be positioned at 10m intervals and most importantly it provided the basis for examining potential relationships between plant and animal species (amphibian, reptile or small mammal) and assemblages.

3.4 Sampling and Preparation

The distribution and abundance of most faunal species varies temporally in relation to daily, seasonal or longer-term cycles or fluctuations in their environments. This variation reflects on the genetic diversity of species as well as the diversity of communities of which they form a part. Thus, sampling of the different faunal groups was undertaken at times of day or night and during seasons of greatest activity. In the case of plants, sampling is best done during the flowering seasons or, at least, avoiding the driest times of year to facilitate the ready identification of species.

A baseline environmental framework of information with details such as the geography, topography, ecology including diversity and spread, hydrology and socio-economy was compiled through an in-depth review of available secondary information wherever possible. A preliminary reconnaissance survey was done to identify sensitive areas, preserved ecosystems, threatened ecosystems, base data on species abundance, climate change effects, and pollution. On-going community discussions also provided additional information not readily available through reports, documents etc.

3.4.1 Sampling of Identified Habitats

The Biodiversity Baseline Survey of Kala Oya basin covered both terrestrial and aquatic habitats (i.e. water holes, mangroves, salt marshes, rivers, streams, tanks and villus). Terrestrial habitats were identified using land use maps of the area and were principally based on the vegetation types. Terrestrial habitats were systematically sampled for plants, butterflies, dragonflies, amphibians, reptiles, birds and mammals using quadrats (100m × 5m) positioned at different distances/ intervals along transects. Four replicate transects were positioned within each habitat type. Opportunistic observations were also recorded along transects, between quadrats, and elsewhere taking the habitat's heterogeneity into consideration. Freshwater habitats were treated as a single type, which was sampled systematically for fish diversity and opportunistically for other taxonomic groups. The head, mid and lower reaches of streams of each sub-basin were sampled for fish.

Habitat maps that were available for this purpose from the Land Use Policy Planning Working Group and were created by the GIS team from overlays of a suite of geographic and environmental variables that include geology, soil, altitude, aspect, land use and vegetation. These maps were used as the baseline demarcations and layers to build upon during the field surveying. Identification of species diversity was one of the main objectives, along with the identification of the threats and statuses of these species.

Figure 17 The biodiversity baseline surveying team reviewing the maps of the Kala Oya Basin

The sampling of the taxa groups and preparation of inventories were proposed after considering the following factors;

- Methodological/ sampling constraints depending on the taxonomic group
- Timing and duration of the surveying
- Experience of the surveyors in carrying out the sampling techniques
- Weather conditions

Figure 18 The team collecting samples and taking photographic evidence

The detection of faunal species is highly variable and dependent on the complex relationship between an animal's behaviour and its environment. Consequently, there is a high degree of variation in determining the composition of species in faunal assemblages.

3.4.2 Quantitative Integrated Sampling Design

Transects of 1 km in length were marked out in at least four replicates of the broadly defined habitat (i.e. vegetation- this was accordance with the vegetation types identified by the botanist) types within a proposed sampling area. In areas that comprised of a mosaic of highly fragmented habitats, some transects covered more than one type of vegetation and also included ecotones. The 1 Km transects were divided and named as quadrat A, B, C and D.

There were different transects lined up for the different taxa groups in the same habitat but they were of the same length and width and in other components. For instance, terrestrial habitats were systematically sampled for butterflies using quadrats (100 m x 5 m) aligned at 150 m intervals along transects (1 km length). Moreover, two quadrats were randomly placed along a transect line and the percentage recorded for each butterfly species found within the frame was recorded.

Figure 19 (a) The Biodiversity Survey team conducting field sampling (b) Marking the sampling points within the transects; The red colour tape indicates a sampling site, a Sherman trap is visible to the bottom left (c) A ring-tailed Civet captured with a Tomahawk; (d) Study and subsequent release of the civet

Sampling of Aquatic Habitats

The habitat maps/land used for the river basin were prepared and included a layer that defines river sub-basins. These maps were used to identify river sub-basins and plan the sampling of rivers and other water bodies. In order to maintain consistency with the survey of terrestrial habitats, replicates were sampled within each river sub-basin.

3.4.3 Qualitative Sampling Design

The presence of any additional species encountered along the transects between quadrats or elsewhere within the protected area were also recorded separately. Visual Encounter Surveys were carried out at night for some taxonomic groups such as herpetofauna and mammals, with a similar amount of time spent searching each habitat over the surveyed period. The proposed methods were alternated depending on the actual field conditions.

Direct observations

were utilized to classify habitat conditions and conservation statuses of the identified sampling locations, and these locations were geo-referenced for subsequent monitoring to be undertaken by the Biodiversity Secretariat if deemed necessary.

Georeferencing was undertaken during the field surveying and all the locations were given an identifier and produced in map formats. The consolidated surveying points for all taxonomic groups were provided upon completion of the baseline survey.

Sampling Design for Vascular Plants

Quantitative: All vascular plant species were recorded on a plot-by-plot basis (10m × 5m) within every quadrat (100m × 5m) of a transect. The number, estimated height (with the exception of climbers) and DBH (Diameter at Breast Height) of individuals exceeding 5cm DBH was also recorded. Any herbaceous species within a quadrat was recorded as present (but individuals were not counted).

Qualitative: The presence of additional species encountered along a transect, between quadrats, were recorded separately. Any other additional species encountered elsewhere within the protected area were also recorded.

3.5 Sampling Methods

The Biodiversity Baseline Survey of Kala Oya basin covered both terrestrial and aquatic habitats (i.e. water holes, mangroves, salt marshes, rivers, streams, tanks and villus). Terrestrial habitats were identified using land use maps of the area and were based principally on the vegetation types. The key design elements of this integrated, quantitative approach to sampling terrestrial taxonomic groups (i.e. not freshwater fish) were as follows.

1. Each habitat type, as defined by the type of vegetation, was sampled by a minimum of four replicate transects of 1km, taking into account as much of the environmental variation (notably in geology, soil, aspect and altitude) as practicable given constraints of time and access to the area (note: it may be necessary to increase the number of replicates, depending on the size and shape of the protected area, and its range in environmental variables).
2. Quadrats, measuring 100m × 5m, were positioned at 150m intervals along the 1km transects (i.e. 4 quadrats per 1 km transect).
3. Each quadrat was divided into 10m × 5m plots, within which each taxonomic group was sampled
4. Vascular plants were recorded in every plot of each quadrat; vertebrate taxonomic groups were recorded within certain plots in either all quadrats (birds) or alternate quadrats (amphibians, reptiles and mammals). This sampling design provided the basis for examining relationships between plant and animal species or assemblages.

Figure 20 (a) Surveying in the forest (b) Marking the transect paths with blue tape markers (c) Marking the transect line (a tagged red rope was used as the measurement)

The logistic units for planning and undertaking of field work were based on sampling a total of 4km of transects within a 20-day period. The duration of field sessions was governed by the minimum period considered necessary to effectively sample (trap) small mammals and plants at a given location: it was considered to be four days/nights. Given that plants can be sampled at a rate of four quadrats (1 km) in a span of 2-3 days, equating to 4 km of transects per 20-day period, sampling intensities for the faunal taxonomic groups were adjusted accordingly.

Figure 21 (a) The team adding bait (Maldive fish) to the Sherman traps used to capture small mammals such as rodents (b) Sherman trap inside a tree hollow, the blue colour tape indicates the path of the transect (c) Tomahawk trap for larger species of mammals

1. Plants: 2-4 quadrats over 4 days (i.e. 4 km for 20 days)
2. Amphibians and reptiles: 5 alternate plots within each of the two quadrates set per day (i.e. 1 km per day). Any other additional species encountered elsewhere within the area/habitats were also recorded, especially around water holes and other aquatic habitats.

3. Birds: 2 Variable Circular Plots (VCPs) at the beginning and end of each of the four quadrats surveyed early morning and evening (i.e. 1 km per day)
4. Mammals: 11 traps for small mammals (e.g. rodents) at 10m intervals and 2 traps for small carnivorous mammals at the beginning and end of each of the two quadrats along the four transects set per day (i.e. 1 km per day, repeated over four days/nights).
5. Butterfly and dragonfly fauna: 2 Variable Circular Plots (VCPs) at the beginning and end of each of the four quadrats surveyed early morning and evening (i.e. 1 km per day).

However visual encounter surveys in between plots and dragonfly and butterfly fauna associated with waterholes and other aquatic habitats were surveyed using circular plot methods. The presence of additional species encountered along a transect, between quadrats and outside areas, were also recorded separately. Any other additional species encountered elsewhere within the area/habitats were also recorded, especially around waterholes and other aquatic habitats for dragonflies.

Note that the two quadrats sampled for mammals alternated with those sampled for herpetofauna. The level of sampling intensity achieved during the Biodiversity Baseline Survey over the 3-month period, involved a total of some 60 days in the field and on average two 10-day trips per month.

Table 1 Additional survey methods used (as and when appropriate)

Taxonomic Group	Method	Description
Vascular plants	Between quadrats	Additional species recorded as present
Herpetofauna	Visual encounters	Along roadsides, footpaths and by water bodies, both at daytime and night. Number of individuals and were search time recorded
Birds	Opportunistic observations	Species recorded along ecotones (e.g. roadsides) while travelling to and from the field
Mammals	Road counts	Direct and indirect observations were recorded along roads/tracks travelled on foot or by vehicle early morning, towards dusk and with flashlights at night.
	Waterhole counts	Total count of individuals observed with flashlights at night-time was recorded
Freshwater fish	Nets	A range of fish nets and traps and snorkeling was used to catch fish in streams and water bodies. Number of individuals and sampling efforts were record.
Dragon flies and Damsel flies	Visual encounter	Water holes around the habitats

Figure 1. 1 (a) Scenic Kala Wewa (b) Survey teams setting up Tomahawk traps for small mammals (c) Survey team observing a possible dragonfly habitat

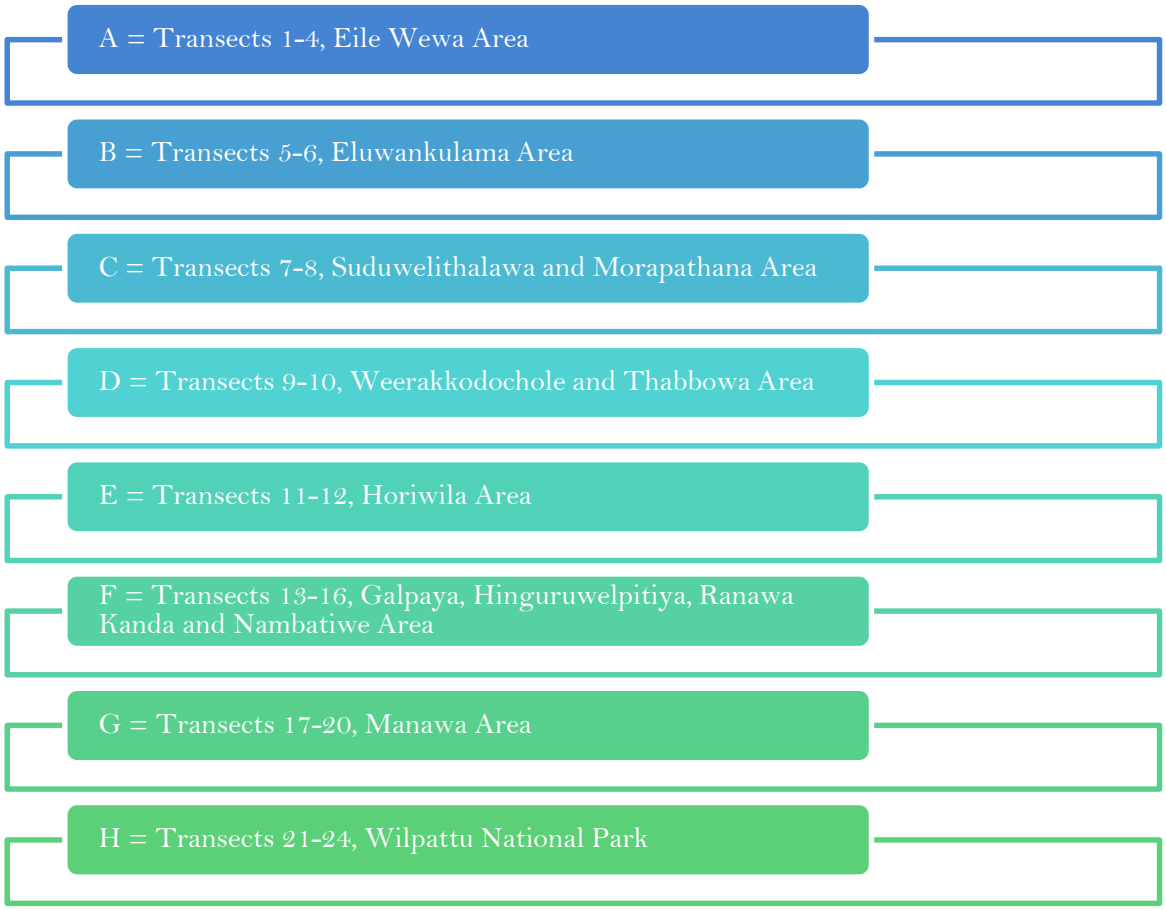
3.6 Habitats/Ecosystems Surveyed

The primary task of this survey was to conduct a biodiversity inventory within a stipulated area of the Kala Oya basin (please refer to maps in Annexure) to provide current baseline information on biodiversity, population and distribution which was needed to define conservation efforts and help understand the potential effects of interventions and monitor the impacts of such interventions on ecosystems and species considered to be of global importance.

Due to time constrains (as explained prior) the biodiversity survey was mainly done outside existing protected areas (20 transects) with 4 transects being positioned inside the Wilpattu National Park. As each 1km transect included four 100m quadrats they too covered different

habitats. The main ecosystems surveyed included the following: Dry Mixed Ever Green Forests, Disturbed Forests, Scrub forests, Tank associated habitats; Chena associated habitats and Coastal habitats. Furthermore, dragonflies were also recorded within associated tank beds, rock pools and streams. The photographs given below provide some examples of these ecosystems.

All 24 transect were categorized or grouped into the following areas for analysis.



Please refer to Annex 03a-3k for maps of the transects that were surveyed for the above areas. The geographic coordinates of all sampling locations including a description of habitat were obtained (please refer to Annex 04).

3.6.1 Freshwater stream habitats

A total of 14 sampling stations within the sub-basins of Kala Oya were sampled for mangroves, and 9 sampling locations for the sampling of freshwater fish.

Limitations in Data Collection

Biodiversity is a complex concept that cannot be measured by a single indicator. There are many influencing factors that may limit data collection, and some of these are listed below.

Sampling was mostly dominated in the dry season due to the timing of this survey. Some species counts will be affected due to this reason, and predictably few sampling was done wet season made a significant change to the total checklist of the herpetofauna. Some species such as burrowing frogs Sphaerotheca breviceps & Sphaerotheca rolandae were only recorded at the onset of rainy season. Thus, it is recommended to carry out the field sampling in the wet season as well to have a comprehensive survey and sample of species from all taxonomic groups.

The type of survey technique utilized for each survey may have an influence on the results. A lack of coverage of the geographic and environmental variations will also affect the distribution of organisms found in the surveyed areas. In terms of survey techniques and their respective efficiencies, the results from this survey show that opportunistic walks along forest ecotones, using footpaths and wildlife trails generated the most information about species diversity, and that for specific taxonomic groups such as herpetofauna, night time was more productive than day time sampling of plots.

It was found that identification of conservation area boundaries was difficult as there were no clear demarcations. Also, there were access issues in some sampling locations due to a lack of motable roads. In addition, the survey field work was restricted because of lack or none of available wildlife officers from the relevant line institutions such as the Forest Department and Department of Wildlife Conservation. The marine survey team found that there were no officers from the DWLC who were conversant with marine surveying techniques or familiar with the marine survey methods, scuba diving, snorkling etc. which was a limitation for the engagement of relevant officers during the marine survey.

The survey team found several illegal tap guns along the foot pathways, which made an unsafe situation in sampling sites. There was also the risk of being attacked by wild elephants during sampling.

4.0 FLORA DIVERSITY ANALYSIS

4.1 Methodology

The basic methodology used was in accordance with 'Biodiversity Baseline Survey – Field Manual' (DWC 2007). Selection of the transects was not random and were selected after an initial site identification visit to cover various habitat and micro habitat types. Some transects represented more than one habitat type within their four quadrats.

All the woody plants above 15cm GBH (Girth at Breast Height) (approx. 5cm DBH Diameter at breast height,) within the 100m × 5m quadrat were measured and their height was record by eye estimation. All non-woody angiosperm species within each quadrat were recorded for their existence. A considerable number of 'hard to identify' Cyperaceae species were not recorded quadrat-vise since it was a time-consuming task, though they were reported as opportunistic observations to represent their existence. Less attention was given to the family Poaceae since identification of them up to species level is impossible in the field. All other angiosperm families both terrestrial and aquatic (fresh water) were thoroughly studied. Even though aquatic habitats were not selected as quadrats, plants in aquatic habitats nearby the quadrats were reported as opportunistic observations. No herbarium specimens were collected as there were no special permits to do so.

All unidentified plants were photographed in a detailed manner and later identified using references given and field notes. Canopy cover was measured at 0m, 50m and 100m of each quadrat using a spherical crown densiometer. Field work was carried out during the months of January, February and March 2017. All field data gathered were compiled electronically and analyzed using MS Excel.

Nomenclature & classification used in this document is based on The Plant List – 2013 ver. 1.1. Note that there are some variations from the Red Data List – 2012. Conservation status is completely in accordance with the Red Data List – 2012.

4.2 Habitat Heterogeneity

The surveyed area of the Kala Oya basin lies completely within the dry zone of the country. Though the area surveyed belongs to a single climatic zone, floristic species and their composition gradually changes along the river basin even within the same habitat type. Forests were taller and denser upstream of the basin. A total of 96 quadrats distributed among six major habitat types were sampled.

4.2.1 Dry Mixed Evergreen Forests

This was the most frequently encountered habitat type during this survey, found in a total of 41 quadrats in varying locations (42.7% of the total). The canopy cover, ranging between 50-90%, had an average of 73.34% for this type of habitat. The average canopy height varied between 10m to 15m while some emergent trees appeared sporadically. Canopy cover as well as the canopy height gradually increased towards upstream areas of the main river catchment. Under-shrubs

and ground vegetation was usually less with ground cover almost consisting of only leaf litter in some quadrats (17C, 17D). Occasionally woody lianas were found which reached up to the canopy.

Figure 22 Dry mixed evergreen forest habitat at Eluwankulama cluster

Canopy of the upstream quadrats consisted mainly of *Drypetes sepiaria* (Weera), while in lower reaches it was dominated by *Mischodon zeylanicus* (Tammenna). *Lepisanthes senegalensis* showed a gradual increment in density towards the upstream area. *Diospyros ebenum* (Ceylon Ebony), *Diospyros ovalifolia*, *Psydrax dicoccos*, *Chloroxylon swietenia* (Ceylon satinwood), *Pleiospermium alatum*, *Pleurostylia opposita*, *Diplodiscus verrucosus*, *Grewia helicterifolia* and *Pterospermum suberifolium* were also found as canopy trees. *Commiphora caudata* (Hill mango) and tall *Euphorbia antiquorum* (Antique spurge) trees were present in the canopy when the habitat reached towards hill tops.

In the riparian habitats, the canopy was dominated by *Terminalia arjuna* (Arjun tree/ Kumbuk) together with some riparian species such as *Diospyros malabarica* (Malabar ebony). *Manilkara hexandra* (Palu) and *Stereospermum tetragonum* (Yellow snake tree) were usually found as emergent trees. *Mallotus eriocarpus*, *Mallotus philippensis* (Kamala tree), *Suregada lanceolata*, *Premna tomentosa*, *Hibiscus platanifolius* (Maple leaved mallow), *Memecylon capitellatum*, *Ochna lanceolata*, *Ixora pavetta* and *Psydrax dicoccos* represented the sub canopy layer. *Cissus latifolia*, *Ziziphus oenoplia* (Jackal jujube), *Derris parviflora* and *Hugonia serrata* were the main liana species found in this habitat.

Under-shrubs were dominated by *Glycosmis mauritiana* and *Stenosiphonium cordifolium* together with sporadic appearances of *Clausena indica*, *Murraya koenigii* (Curry tree) and *Murraya paniculata*. Ground vegetation was not abundant and was represented by herbs such as *Andrographis alata*, *Crossandra infundibuliformis* (Firecracker flower), *Ecbolium ligustrinum*, *Elytraria marginata*, *Eranthemum capense*, *Lepidagathis fasciculata*, *Psilotrichum elliottii*,

Commelina undulata (Long-leaved dayflower), *Pseudarthria viscida*, *Glinus lotoides*, *Habenaria plantaginea*, *Malaxis versicolor*, *Oldenlandia ovatifolia* and *Oldenlandia biflora*.

Figure 23 *Panicum* invaded habitat and dry mixed evergreen forest habitat at Manewa kanda cluster

4.2.2 Disturbed forests

Only 8 quadrates of disturbed forests were sampled during the survey. Clear distinction between this forest type and the previous type was quite hard to be determined since almost all forests were disturbed to at least a small degree. These quadrats were considered as disturbed forests considering the overall appearance of the habitat. The canopy cover of this habitat, which ranged from 40% to 75%, averaged at 65.60 %. The average height of the canopy ranged between 5m to 10m with some emergent trees of *Manilkara hexandra*. Some trees were covered with non-woody lianas. Lower vegetation was denser than in the previous habitat type and no distinct stratification were found. Ground layer was more exposed to sunlight and some areas were covered with grasses and small sun-loving herbs.

Figure 24 Disturbed Forest Habitat at Weerakkodichole cluster

There were no dominant species in the canopy which consisted of a mixture of species such as *Cordia monoica, Cordia dichotoma* (Indian cherry), *Trema orientalis* (Pigeon wood), *Bauhinia racemosa, Premna tomentosa, Azadirachta indica* (Neem tree), *Drypetes sepiaria, Mitragyna parvifolia* and *Mischodon zeylanicus*.

In the median vegetation, *Diospyros vera* (Narrow-leaved ebony), *Croton aromaticus, Grewia helicterifolia, Tarenna asiatica, Trema orientalis, Phoenix pusilla* (Ceylon date palm), *Senna auriculata* (Ranawara) and *Benkara malabarica* were found. *Ipomoea marginata, Merremia umbellata* (Yellow merremia), *Coccinia grandis* (Ivy gourd), *Mikania cordata* (Heartleaf hempvine), *Ichnocarpus frutescens* (Black creeper), *Asparagus racemosus* (Wild asparagus/Hathawariya) were some liana species found in this habitat.

4.2.3 Scrub forests

Figure 25 Scrub Forest Habitat at Eilie cluster

18 quadrates surveyed belonged to this habitat type. Most of these habitats were regenerating eco-systems which were heavily disturbed by anthropogenic activities. Few other scrub forest quadrats appeared to be natural and were found in and around rocky outcrops. These outcrops were not much elevated above the existing ground level (i.e. not outcrops in hill tops). The soil layer was very thin in these quadrats.

A special microhabitat was found in quadrats 6A, 6B, 6C and 6D - a sand dune situated a considerable distance from the sea. Some unique plant species were found in this location. Generally, the canopy level of this main habitat varied between 4m to 8m, but there were some trees reaching up to 12m-15m, which play a key role in regenerating eco-systems. In natural scrub forests, the canopy level was low and scrubs appeared sparsely than in regenerating eco-systems.

The canopy cover of this habitat type which varied between 10% to 60%, averaged at 32.9%. Most of the plants found in this habitat were thorny shrubs which were entangled in each other and overlaid by various species of lianas. Scrubs covered the entire strata from its top to the ground level by their branches. In the remaining ground, various species of herbs and grasses were found.

Figure 26 Scrub Forest habitat at Suduweli thalawa (Eluwankulama cluster)

Dominant and the taller trees species in this habitat included *Bauhinia racemosa, Manilkara hexandra, Diplodiscus verrucosus, Grewia damine* (Salvia-leaved crossberry), *Sapindus emarginatus, Azadirachta indica* and *Syzygium cumini* (Java plum).

Scrub species and lower trees found in this vegetation were *Morinda coreia* (Indian mulberry), *Ziziphus oenoplia* (Jackal jujube), *Catunaregam spinosa* (Mountain Pomegranate), *Gmelina asiatica, Ehretia laevis, Chromolaena odorata* (Siam weed), *Carissa spinarum* (Conkerberry), *Ochna lanceolata, Flueggea leucopyrus, Cordia curassavica* (Black sage), *Ehretia microphylla* (Fukien tea tree), *Croton tiglium* (Purging Croton), *Dichrostachys cinerea* (Sicklebush) and *Streblus asper. Asystasia gangetica* (Creeping foxglove), *Barleria prionitis* (Porcupine flower), *Blepharis maderaspatensis, Dipteracanthus prostratus, Dyschoriste litoralis, Justicia procumbens* (Water willow), *Achyranthes aspera* (Chaff-flower), *Aerva lanata* (Mountain knotgrass), *Acmella paniculata* (Panicled spot flower), *Ageratum conyzoides* (Goatweed), *Cyanthillium cinereum* (Little ironweed), *Ocimum americanum* (Hoary basil) were some of the various herbaceous species found in this habitat.

4.2.4 Tank associated habitats

Figure 27 Tank associate habitat (downstream) at Manewa kanda cluster

Since ancient times, the northern dry zone was used as a cultivation ground where people made reservoirs to regulate the water availability throughout the year across different weather conditions. Some of these tanks still remain and new tanks have also been built in the recent past. Hence, tank associated habitats were present in a considerable extent of the land in the dry zone and can be recognized as a unique habitat type. This habitat can be divided in to three microhabitats namely tank upstream, water retaining section and tank downstream. Only the tank upstream and tank downstream sections were selected as quadrates in this survey. Wet and boggy soil was a common feature for both these microhabitats. In the tank upstream habitats, the location of the boggy section varied to a considerable extent within the year according to the water level of the reservoir, but in downstream habitats it varied to a very little extent. Usually the tank upstream habitats were less disturbed by anthropogenic activities than the tank downstream habitats. Due to these reasons there were a few differences in plant species and their composition between these two microhabitats. Calculations were done by only considering the main habitat type.

Figure 28 Tank associate habitat (upstream) at Ranawakanda cluster

Altogether 16 quadrats were surveyed and it was found that the average canopy cover of this habitat was 40.1%. It varied between 10% and 80% with lesser values being found in tank downstream sections. Canopy height varied between 5m to 15m depending on the quadrat.

Dominant as well as the tallest tree species in this habitat were *Terminalia arjuna* (Kumbuk). *Mitragyna parvifolia, Margaritaria indica, Barringtonia acutangula* (Freshwater mangrove), *Syzygium cumini* (Java plum), *Diospyros malabarica* (Malabar ebony) and *Vitex leucoxylon* (Whitewood chaste tree) were the other distinct tree species found in this habitat.

Water associated herbs whose abundance varied within the year were dominant in this habitat. These plants that bear flowers during the first three months of the year, which was after the north-east monsoon, were the most common. These herbs included many Cyperaceae species, *Hygrophila auriculata*, *Hygrophila ringens*, *Justicia procumbens*, *Alternanthera sessilis* (Sessile joyweed), *Crinum viviparum* (Spider lily), *Blumea obliqua*, *Ammannia baccifera* (Monarch redstem), *Eclipta prostrata* (False daisy), *Epaltes divaricata*, *Neptunia oleracea* (Water mimosa), *Hydrolea zeylanica*, *Grangea maderaspatana* (Madras Carpet) and *Sphaeranthus africanus* (East Indian Globe Thistle).

Some of the distinct vine species were *Oxystelma esculentum*, *Pentatropis capensis*, *Ipomoea marginata*, *Ipomoea aquatica* (Swamp morning-glory) and *Pentapetes phoenica*.

Aquatic and partially aquatic plants found in adjacent areas included *Najas minor* (Brittle waternymph), *Ottelia alismoides* (Waterplaintain Ottelia), *Nymphoides hydrophylla*, *Nymphaea nouchali* (Blue lotus), *Limnophila indica* (Indian marshweed) and *Dopatrium junceum* (Rushlike Dopatrium).

4.2.5 Coastal Habitats

Only 4 quadrats of coastal habitats were surveyed. Two of them were saltwater marshes and the other two were a mixture of saltwater marsh and mangrove. In the two saltwater marshes, canopy cover was zero as they had no tree species. Although the number of species found in this habitat was very low, plants unique to this habitat were found.

The habitat consisted of *Suaeda maritima* (Seepweed), *Suaeda monoica*, *Najas marina*, *Aerva javanica* (Desert cotton), *Pouzolzia zeylanica* and *Sauropus bacciformis*. Mangroves were dominated by *Avicennia marina* (Grey mangrove) together with *Lumnitzera racemosa* (Black mangrove), *Excoecaria agallocha* and *Rhizophora mucronata* (Red mangrove). Canopy cover of the dense mangrove was 74.1%. Marginal vegetation consisted of *Volkameria inermis* (Glory bower), *Premna serratifolia*, *Thespesia populnea* (Portia tree), *Grewia tenax* (White crossberry), *Azima tetracantha* (Needle bush) and *Salvadora persica* (Mustard tree).

4.2.6 Chena and associated habitats

Figure 29 Chena associate habitat at Manewa kanda cluster

This was a highly disturbed habitat, which was cleared for Chena cultivation. Chena is a cultivation practice that entails the clearing of the forest and cultivatation for 3-4 seasons, followed by abandoning it to allow for regeneration of the forest. Only one season per year is available for these farms since its water requirement depends directly on the Northeast monsoonal rains. After the harvesting, which takes place between February–March, the remaining crops are left idle and serve as a good food source for some wild animals such as elephants. Abandoned Chena and its marginal vegetation were assessed in this survey in 9 quadrats. Working Chena was not selected within the quadrats.

Canopy cover of this habitat which varied from 5% to 40% averaged at 26.9%. There were no distinct canopy trees except remnants of the destroyed forest, which were used as shading trees during cultivation.

Bauhinia racemosa, *Grewia helicterifolia*, *Azadirachta indica* (Neem tree), *Grewia damine* and *Sapindus emarginatus* were the dominant pioneer tree species in these regenerating habitats. Most sun-loving herbs and shrubs described prior in other habitats types were also available in this habitat.

4.3 Plant Species Diversity at Different Clusters

Eili Cluster

Eili cluster consisted of transect no. 1 to 4, which are the transects that have the lowest elevation, studied in the survey. This cluster is situated near the sea outfall of Kala Oya, and contains the only coastal habitats that were surveyed. Transect 4 consisted of upper reaches of mangrove forests, salt water marshes and their ecotones with scrublands and forests. The main component of the mangrove forest is the *Avicennia marina*, which is the mangrove species that typically grows

in the seasonally inundated, flat terrain mangroves at higher elevations during the flooding season. In the pockets of depressions, *Lumnitzera racemosa* and *Rhizophora mucronata* were found. Although the species diversity is low in these mangroves and salt water marshes, species found in this habitat is unique to the micro habitat. Tank associate habitat at transect 2 is almost merged with the nearby salt marsh, hence the plants of this habitat was a mixture of high ground species as well as low ground species that tolerate salty conditions in the soil. Dry mixed ever green forest habitat of this cluster has the sparsest vegetation as well as the lowest canopy level out of the studied transects.

Eluwankulama Cluster

Transect 5 of this cluster mainly consisted of man-made environment, which is still regularly maintained for irrigation and cultivation purposes. Although this habitat is good for aquatic and water associated fauna, the plant diversity is quite low. The specialty of this cluster is the presence of many water-associated herbaceous species, which were not considered for calculations. The major finding of this cluster is a growth of *Hibiscus panduriformis*, a plant that was considered as a 'possibly extinct" species in the red data list – 2012. A detailed description of this finding is discussed here under 'threatened species'. Quadrat 5-D is the only area that survives without anthropogenic activities. It contained some economically valued trees such as *Diospyros ebenum*. Transect 6 is a unique micro habitat, which consisted of a sand dune as in some areas of Wilpattu National Park. This area had a stunt vegetation and its canopy is not much higher than 3 meters. *Diospyros vera* is the dominant tree species in this special habitat. This is a small area and highly disturbed by sand mining and clearing the forest for 'Kadju tree' cultivation.

Morapathana Cluster

This cluster consists of a dense forest that was dominated by *Mischodon zeylanicus*, *Drypetes sepiaria*, *Pleurostylia opposita*, *Dimorphocalyx glabellus* and *Diospyros ebenum*. Undershrub also densely covered *Stenosiphonium cordifolium*, which was in mass flowering during the surveyed period. The rare, endemic under shrub *Abutilon subumbellatum* was a special finding of this cluster. One of the mysterious genus of ground orchids was found in quadrat 8-c under dense shade of *Stenosiphonium* shrubs on a sandy soil. It was a *Nervilia* species, and a poorly known genus of the country, due to its cryptic nature. This genus is growing by a tuber, which bear flowers only for few days at the onset of the monsoon rains. Only after the flowering, it produces one or two leaves for few months and then again hides under the ground only with the living tuber. In this survey, we could find some plants with leaves. In the present Sri Lankan check list, there is only one species under this genus, but we have found quite a few species with different types of leaves. It was observed that lot of illegal tree felling in this cluster. The main threat was observed for *Diospyros ebenum* and *Manilkara hexandra*. In some situations, big trees were cut down for a small portion of timber. Not only the tree felling, but also sizing of the timber was also done at the location. Tractor road were made by clearing the undergrowth for transportation.

Weerakkodichole Cluster

This habitat cluster consisted of various types of forests, mainly interfered by human activities. Some ongoing chena cultivations, recently abandoned chena cultivations, scrublands and forests which are re-generated after abandoning chena cultivations are present in this cluster. The chena associated habitat mostly consisted of pioneer vegetation of dry zone and some remnants of partially burnt tree species. Scrubland habitats of this area are much thicker than the naturally

occurring scrublands and show a gradual transition in to secondary forest habitats. It is evident that this area is a re-generating forest due to less number of trees recorded in this cluster, and now it is at an intermediate level of disturbance due to its comparatively high species diversity than the prime habitats in the KOB.

Horiwila cluster

This cluster consisted of both prime habitats as well as disturbed habitats. Prime habitats consisted of a dense canopy cover with a thick under growth of Rutaceae species including *Atalantia monophylla*, *Clausena indica*, *Glycosmis mauritiana*, *Murraya koenigii* and *Murraya paniculata*. The canopy of this habitat consisted of another Rutaceae species *Chloroxylon swietania* together with *Grewia helicterifolia* and *Sapindus emerginatus*. The only tank associated habitat predominantly consisted of *Vitex leucoxylon*, which has an exceptional number of trees and a vastly extended single *Ficus microcarpa* tree with many still roots. Diversity in this quadrat is very low due to this reason. Conditions of the secondary habitats within this cluster were the same as described in the Weerakkodichole cluster.

Ranawa kanda Cluster

Transect 13 & 16 of this cluster consisted of prime forest, which were in two small hills. Quadrats of these clusters were laid to cover the level gradient of this terrain. These were much taller forests compared to forests in Eilie cluster. *Drypetes sepiaria* which was found in both these clusters were much taller and had a more DBH compared to trees at Eili cluster. *Lepidagathis senegalensis* was a dominant tree, which was a rare species in the downstream transects of the KOB. Under layer is not much thick in this forest, which has a much visibility than the prime habitats in Horiwila cluster. Ground layer had some orchid species and some prime herbaceous species, which requires dense shade and wetness. Towards the top of the hills, some trees species were found which were not found in lower levels. Ie. *Commiphora caudata* and *Euphorbia antiquorum*. Surrounding area of this habitat is highly disturbed by rock blasting for floor tiles. Two other transects were secondary habitats which was mainly due to chena cultivation and tree felling.

Manewa kanda Cluster

Features of transect 17 & 20 are almost like the features of prime habitats in the Ranawa kanda cluster except the ground dwelling herbaceous species. Adjacent area of the cluster consisted with some rock pools and their associating vegetation. That includes some rock dwelling herbaceous species such as *Plectranthus barbatus*, *Orthosiphon thymiflorus* and trees such as *Ficus mollis*. But the quadrat 20 D, which is in a flat terrain is almost infested by the invasive tall grass species *Panicum maximum*. This representative habitat is extended in to a considerable extent along the base of the hill. Remnants of this area indicates that it was burnt recently. Only very few trees as well as herbaceous species were found in this quadrat due to the thickness of *Panicum* growth. The forested area is an archaeological site, which has a protection status. Transect 18 & 19 are secondary habitats which were situated around Manewa Wewa. Tank upstream sections consisted of trees such as *Terminalia arjuna* and *Vitex leucoxylon* and many Cyperaceae species. Disturbed forest quadrat was a small strip between two tanks which consisted of some trees covered by many lianas and vines.

Wilpattu Cluster

Most of the surveyed clusters of this habitat were thick forests and this cluster is ranked as the first in highest number of trees, which exceed 1000 in number. This habitat is dominated by the typical dry zone forest species *Drypetes sepiaria* together with *Mischodon zeylanicus*. Canopy cover is mostly in between 80% to 90%. Sub canopy is mainly consisted of *Diospyros ovalifolia*. Under layer is moderately thick, which doesn't allow freely movement across the forest. Scrublands in this cluster have evolved due to the physical conditions of the environment, irrespective of human involvement. This habitat was found adjacent to rock outcrops, which have a thin soil layer mainly in sand. Shrub species that were evolved to harsh conditions were found in this area. Also, it had many herbaceous species which lives only for few wet months of the year and gives a pleasant sight in their flowering. This includes *Platostoma menthoides*, *Chamaecrista mimosoides*, *Evolvulus alsinoides* and *Hybanthus enneaspermus* which has white, yellow, blue and rose colored flowers respectively. The orchid species *Vanda spathulata* is a unique species for this micro habitat in Wilpattu National Park.

4.4 Species Diversity

A total of 609 species belonging to 107 families were recorded during this survey (Please refer to Report on 'Database for Habitat Monitoring' for a list of all species that were surveyed during this BBS). The highest number of species were reported from the family Fabaceae while Malvacea and Acanthaceae were the second and third highest. 42 families were represented by only one species and another 16 families were represented by only two species. The top 15 families have been given below.

Table 2 Number of angiosperm species represented by each family in Kala Oya Basin

Rank	Family	No. of species
1	Fabaceae	82
2	Malvaceae	41
3	Acanthaceae	29
4	Asteraceae	27
5	Euphorbiaceae	26
6	Rubiaceae	26
7	Cyperaceae	24
8	Lamiaceae	20
9	Amaranthaceae	17
10	Convolvulaceae	17
11	Phyllanthaceae	16
12	Apocynaceae	14
13	Rutaceae	14
14	Boraginaceae	11
15	Commelinaceae	11

511 species of the total reported plants (83.91%) are native to Sri Lanka while a further 26 species (4.27%) are endemic. 72 species (11.82%) are exotic species where most of them have naturalized

in Sri Lankan eco-systems. Very few species of these exotics were cultivated species, which were recorded only when they were present in a considerable extent of the surveyed quadrats.

Among the indigenous plants, 61 species reported in KOB are considered as 'threatened' species by Red Data List - 2012. A summary of the conservation statuses of the species recorded can be found in Table 3 below.

Table 3 Number of angiosperm species belonging to each conservation category

Conservation Status (Red Data List – 2012)	No. of species
CR(PE) [1]	1
CR [2]	3
EN [3]	15
VU [4]	42
NT [5]	63
LC [6]	403
NE [7]	75
DD [8]	7

[1]CR(PE) – Critically Endangered (Possibly Extinct); [2]CR – Critically Endangered; [3]EN – Endangered; [4]VU – Vulnerable; [5]NT – Near threatened; [6]LC – Least Concerned; [7]NE – Not Evaluated; [8]DD – Data Deficient

Species belonging to CR(PE), CR, EN and DD categories have been given below.

Table 4 : Threatened and data deficient angiosperm species surveyed in KOB

Family	Species	Common Name	Distribution Status	Conservation Status
Malvaceae	*Hibiscus panduriformis* Burm.f.		Native	CR(PE)
Amaranthaceae	*Aerva javanica* (Brum. f.) Juss. ex Schult.	පොල්කුඩු පළා, පොල්පළා	Native	CR
Fabaceae	*Macrotyloma axillare* (E. Meyer) Verdc.		Native	CR
Phyllanthaceae	*Sauropus quadrangularis* (Willd.) Müll.Arg.		Native	CR
Acanthaceae	*Hygrophila polysperma* (Roxb.) T.Anderson		Native	EN
Acanthaceae	*Monothecium aristatum* (Nees) T. Anderson		Native	EN
Amaranthaceae	*Achyranthes diandra* Roxb.		Endemic	EN
Cyperaceae	*Cyperus cephalotes* Vahl		Native	EN
Cyperaceae	*Cyperus clarkei* T. Cooke		Native	EN
Dioscoreaceae	*Dioscorea trimenii* Prain & Bukill	දෙහිය අල	Endemic	EN

Family	Species	Common Name	Distribution Status	Conservation Status
Ebenaceae	*Diospyros ebenum* J.Koenig ex Retz.	කළුවර	Native	EN
Euphorbiaceae	*Croton caudatus* Geiseler	වැල් කැප්පෙටියා	Native	EN
Fabaceae	*Ormocarpum sennoides* (Willd.) Brenan & J. Leonard	සුදු අවරිය	Native	EN
Fabaceae	*Teramnus mollis* Benth.	වල් කොල්ලු	Native	EN
Fabaceae	*Vigna aconitifolia* (Jacq.) Marechal	මකුශ්ඨ	Native	EN
Malvaceae	*Abutilon subumbellatum* Philcox		Endemic	EN
Rubiaceae	*Diyaminauclea zeylanica* (Hook.f.) Ridsdale	දිය මී	Endemic	EN
Rubiaceae	*Oldenlandia ovatifolia* (Cav.) DC.		Native	EN
Vitaceae	*Cissus adnata* Roxb.		Native	EN
Fabaceae	*Alysicarpus bupleurifolius* (L.) DC.		Native	DD
Fabaceae	*Alysicarpus monilifer* (L.) DC.		Native	DD
Fabaceae	*Alysicarpus scariosus* (Spreng.) Thwaites		Native	DD
Fabaceae	*Crotalaria juncea* L.	හණ	Native	DD
Hydrocharitaceae	*Najas marina* L.		Native	DD
Menispermaceae	*Tinospora sinensis* (Lour.) Merr.	ඛූ කිඳ, වල් කිඳ, රස කිඳ	Native	DD
Solanaceae	*Physalis minima* L.	හීන් මොට්ටු, ලිං මොට්ටු, නළල් මොට්ටු	Native	DD

Hibiscus panduriformis – This shrub species has been found only in very few locations in Sri Lanka and its last record was in 1932. It has been reported in Thunkama in Atakalan Korale, Anuradhapura and near Giant's tank in Murunkan. During this survey, 6 plants of this species were found in a single quadrat (quadrat 5A) on 27th January 2017. The site was a muddy area situated between a canal embankment and paddy fields, which received lot of sunlight. These plants were in bloom in the morning and some of them had capsules. In the evening, flowers had faded. A subsequent visit to the site on 10th February 2017 revealed that all the six plants were destroyed due to land preparation for paddy cultivation for the upcoming season. However, a nearby location was found to have this species distributed abundantly. This location was situated in the flood plain of Kala Oya (8.2896 N, 79.8850 E), near the Eluwankulama causeway. This was also a seasonal muddy place with direct exposure to sunlight. As this species was not found in the nearby shady forest habitats, it could be a highly microhabitat-specific species.

Aerva javanica – This plant was reported in the quadrats 1A, 1B, 1D, 2D, 3D, and 4B. This herbaceous species is very much similar in appearance to the much commoner Aerva lanata and both species grow together. Hence the abundance of this herb in these quadrats is hard to asses without a thorough study.

Macrotyloma axillare – This vine was recorded only in quadrat 6A. Only a single plant was observed with pods and flower buds.

Sauropus quadrangularis – This herb was observed only twice in quadrats 9A and 10A. The total number of plants was not exceeding 10. They were growing under shades of trees and shrubs.

Hygrophila polysperma – This species was not found within a quadrat, but found at a dried-up tank bed near transect 16. Few plants were growing together with other common tank bed species such as *Coldenia procumbens* and *Glinus oppositifolius*.

Monothecium aristatum – This herb was not found within a quadrat. Instead it was found in ground vegetation of a riparian habitat at the boundary of the Sewa Lanka institute at 8.2284 N, 80.1005 E. It was quite an abundant species at the location.

Achyranthes diandra – This herbaceous species was reported only in quadrat 13D, in the shady ground layer of a dry mixed evergreen forest. About 10 plants were observed.

Cyperus cephalotes – This species was found in two tanks outside the quadrats. The locations were a tank near transect 16 and Manewa wewa near transect 19. This plant had made dense mats on thin water layers at tank edges. It was quite an abundant species in this marginal vegetation.

Figure 30 [Left] *Cyperus cephalotes*; [Right] *Cyperus clarkei*

Cyperus clarkei – This herbaceous species was reported in quadrat 7B. About 10 plants were recorded at a seasonal stream edge within a dry mixed evergreen forest. They were growing in sandy soil that had collected due to water flow.

Dioscorea trimenii – This was reported in quadrat 21D, within the Wilpattu National Park. Only one vine was observed.

Figure 31 [Left] *Dioscorea trimenii*; [Right] *Diospyros ebenum*

Diospyros ebenum – This hardwood tree was reported in quadrats 5D, 6B, 6D, 7A, 7C, 10A, 10B, 10D, 13A, 13C, 14A, 15C, 16A, 16D, 17B, 17D, 20B, 21B, 21C, 21D, 22A, 23A, 23B, 23C, 24B and 24D. A total of 50 trees were counted during the survey. Most of these trees had grown as canopy trees.

Croton caudatus – This large shrubby plant was recorded in quadrats 21C, 11B,9B, 5A and 5B. It was mostly found near aquatic habitats and flood plains.

Figure 32 [Left] *Croton caudatus*; [Right] *Ormocarpum sennoides*

Ormocarpum sennoides – This was found in quadrats 5D, 8D, 10C and 13D. It was an undershrub in dry mixed evergreen forests. About 30 plants were found during the entire survey.

Teramnus mollis – This vine was reported in quadrat 11D and at a tank embankment near transect 6. In the latter location, it was found growing together with the much commoner Teramnus labialis. Only about 5 vines were recorded.

Vigna aconitifolia – This ground dwelling vine was recorded at the edge of a gravel road near transect 8. Only one cluster was observed.

Abutilon subumbellatum – This lax shrub species was found in quadrats 8C, 8D and 16D. This species was always found growing under the dense shade of dry mixed evergreen forests. About 10 plants were observed during the survey.

Diyaminauclea zeylanica – This small tree was recorded in quadrats 7C, 7D and at a place nearby to transect 6. The tree at the latter location was in bloom and carried a lot of flowers making it a pleasant sight. About 5 trees were found in all these locations.

Oldenlandia ovatifolia – This was reported in quadrats 3C, 8A, 8B, 8C, 8D and 13D. This herbaceous plant was present in good numbers in the shady ground layer within these quadrats.

Cissus adnata – This species was reported in quadrats 10D, 11C and 12D. It was a liana that grew up to the canopy of the forest.

Figure 33 [Left to Right] *Macrotyloma axillare, Monothecium aristatum, Sauropus quadrangularis, Vigna aconitifolia*

Table 5 Endemic angiosperm species found in Kala Oya Basin

Family	Species	Common Name	Conservation Status
Acanthaceae	*Dicliptera neesii* (Trimen) L.H. Cramer		NT
Acanthaceae	*Rhinacanthus flavovirens* Amaras. & Wijes.	අනිවිට	VU
Acanthaceae	*Rhinacanthus polonnaruwensis* L.H. Cramer		LC
Achariaceae	*Hydnocarpus venenata* Gaertn.	මකුළු, මකුල, මකුල්ල, මකිටිය	LC
Amaranthaceae	*Achyranthes diandra* Roxb.		EN
Annonaceae	*Uvaria sphenocarpa* Hook. f. & Thomson		LC
Asteraceae	*Vernonia zeylanicum* (L.) Less.	හීන් බෝටිය, පුපුල, වල් පුපුල	LC
Celastraceae	*Cassine balae* Kosterm.	නෙරළු	LC
Commelinaceae	*Murdannia spirata* (L.) G.Brückn.		LC
Dioscoreaceae	*Dioscorea trimenii* Prain & Bukill	දෙහිය අල	EN
Euphorbiaceae	*Mallotus eriocarpus* (Thwaites) Müll. Arg.	බුළු පෙත්ත, වැල් කැප්පෙටියා	LC
Fabaceae	*Derris parviflora*	කල වැල්, සුදු කල වැල්	LC

Family	Species	Common Name	Conservation Status
	Benth.		
Fabaceae	*Painteria nitida* (Vahl) Kosterm.	දිය මාර	VU
Lamiaceae	*Premna procumbens* Moon	ලේ කොළ පළා	LC
Loganiaceae	*Strychnos benthami* C.B. Clarke		NT
Loranthaceae	*Dendrophthoe ligulatus* (Thwaites) Tiegh.		VU
Malvaceae	*Abutilon subumbellatum* Philcox		EN
Malvaceae	*Diplodiscus verrucosus* (Thwaites) Kosterm.	දික්වැන්න, දික් ඇන්ද	LC
Malvaceae	*Triumfetta glabra* Spreng.		VU
Melastomataceae	*Memecylon capitellatum* L.	දැදි කහ, දොඩන්කහ, වැල් කහ, වැලි කහ, ඉදල් ගහ, අඳුන්, කායම්	LC
Oleaceae	*Chionanthus albidiflorus* Thwaites	ඇඹුල් කොරකහ, තක්කඩ ගස්	VU
Putranjiavaceae	*Drypetes gardneri* (Thwaites) Pax & Hoffm.	ගල් වීර, ඇට වීර, යකිල්ද	NT
Rubiaceae	*Diyaminauclea zeylanica* (Hook.f.) Ridsdale	දිය මී	EN
Rubiaceae	*Pavetta gleniei* Thwaites ex Hook.f.	ගල් හැඹැල්ල, එළ තෙරන	NT
Rutaceae	*Micromelum minutum* Wight & Arn.	වල් කරපිංචා	LC
Rutaceae	*Murraya glenieii* Thwaites ex Oliv.		NT

A total of 4,139 plants were measured in 4.8 hectares (96 100m×5m quadrats) during this survey. All species diversity calculations were done using these measured trees. A summary of the diversity calculations has been given in the following table (Table 6).

Figure 34 [Left to Right] *Abutilon subumbellatum, Achyranthes diandra, Aerva javanica, Hibiscus panduriformis*

Table 6 Angiosperm diversity indices for different habitats

Habitat type	Total	D.M.E. Forest	D. Forest	Scrub Forest	T. a. habitats	Coastal habitats	C.a. habitats
No. of quadrats	96	41	8	18	16	4	9
Species Richness [s] (including non-woody species)	609	388	227	340	349	42	246
Species Richness [s] (only woody species)	149	116	62	74	53	5	47
Shannon Entropy [exp(H)]	5.75	5.26	4.96	5.07	4.24	1.65	4.65
Simpson's Index of Diversity [1-D]	0.96	0.94	0.94	0.95	0.90	0.64	0.94
Simpson's Reciprocal Index [1/D]	26.82	17.47	18.11	19.71	10.49	2.75	15.61
Chao 2 Estimator [S2]	151.97	120.00	66.84	81.67	58.06	14.00	51.98

D.M.E. Forest – Dry mixed evergreen forest; D. Forest – Disturbed forest; T.a. habitats – Tank associated habitats; C.a. habitats – Chena & associated habitats

Table 7 Stem density, Species richness & Shannon Entropy for transect clusters

	Eili	Eluwan kulama	Mora pathana	Weerakko dichole	Horiwila	Ranawa Kanda	ManawaKanda	Wilpattu
Total number of woody plants	**385**	**187**	**469**	**251**	**307**	**840**	**636**	**1046**
Stem Density	**0.048**	**0.046**	**0.117**	**0.063**	**0.077**	**0.105**	**0.079**	**0.131**
Species Richness	**51**	**41**	**39**	**52**	**47**	**68**	**78**	**65**
Shannon Entropy	**4.577**	**4.326**	**4.094**	**5.001**	**4.636**	**4.525**	**5.133**	**4.183**

The most abundant woody plant species within the surveyed area was *Drypetes sepiaria*. 86.8% of these plants were reported in dry mixed evergreen forest habitats while 10.6% was reported in scrub forests. Interestingly, only 5 plants were reported in disturbed forests. The top 20 abundant species have been given below in Table 8.

Table 8 Most abundant woody plant species within Kala Oya Basin

Rank	Family	Species	No. of trees
1	Putranjiavaceae	*Drypetes sepiaria*	537
2	Picrodendraceae	*Mischodon zeylanicus*	382
3	Euphorbiaceae	*Mallotus eriocarpus*	152
4	Ebenaceae	*Diospyros ovalifolia*	138
5	Combretaceae	*Terminalia arjuna*	137

Rank	Family	Species	No. of trees
6	Rubiaceae	*Psydrax dicoccos*	118
7	Fabaceae	*Bauhinia racemosa*	113
8	Rubiaceae	*Mitragyna parvifolia*	98
9	Lamiaceae	*Vitex leucoxylon*	91
10	Malvaceae	*Grewia helicterifolia*	90
11	Malvaceae	*Grewia damine*	89
12	Meliaceae	*Azadirachta indica*	83
13	Fabaceae	*Dichrostachys cinerea*	78
14	Sapindaceae	*Lepisanthes senegalensis*	77
15	Euphorbiaceae	*Mallotus philippensis*	65
16	Sapotaceae	*Manilkara hexandra*	65
17	Rutaceae	*Limonia acidissima*	63
18	Ebenaceae	*Diospyros vera*	59
19	Malvaceae	*Diplodiscus verrucosus*	59
20	Euphorbiaceae	*Excoecaria agallocha*	55

Table 9 Most abundant woody plant species within each habitat

Habitat type	Most abundant species	No. of trees
DME forest	*Drypetes sepiaria*	466
Disturbed forest	*Grewia damine*	61
Scrub forest	*Mischodon zeylanicus*	83
Tank associated habitats	*Terminalia arjuna*	82
Coastal habitats	*Avicennia marina*	25
Chena & associated habitats	*Bauhinia racemosa*	32

The following is the ranking of transects for the most number of species recorded during the survey (**Error! Reference source not found.**). This includes both woody and non-woody species.

Table 10 Number of Angiosperm species in transects

Rank	Transect number	Cluster	Number of species
1	5	Eluwankulama	174
2	14	Ranawa Kanda	168
3	2	Eilie	167
4	18	Manewakanda	165
5	10	Weerakkodichole	156
6	11	Horiwila	152
7	21	Wilpattu	150
8	9	Weerakkodichole	147
9	15	Ranawa Kanda	143
10	22	Wilpattu	135
11	6	Eluwankulama	134
12	8	Morapathana	134
13	12	Horiwila	127
14	17	Manewakanda	123

Rank	Transect number	Cluster	Number of species
15	1	Eili	122
16	7	Morapathana	117
17	19	Manewakanda	113
18	3	Eili	110
19	20	Manewakanda	104
20	16	Ranawakanda	100
21	24	Wilpattu	90
22	13	Ranawakanda	81
23	23	Wilpattu	64
24	4	Eili	41

5.0 HERPETOFAUNA DIVERSITY ANALYSIS

5.1 Introduction

Sri Lanka is particularly rich with herpetofauna, with 38 of the 56 species of amphibians being endemic. Sri Lanka's amphibians are important for both their species richness and their representation of ancient lineages.

Figure 35 Oligodon arnensis, Common Name: The common kukri snake or banded kukri

Herpetofauna constitute a significant biomass, often exceeding that of all other vertebrates. They form important linkages in the ecosystem by providing dispersal mechanisms for plants, form an important link in the tropic structure through predation, form a potential prey- base themselves, contribute to environmental heterogeneity, have keystone functions in maintaining ecosystem structure and forests, and also form important symbiotic associations with an array of organisms.

Sri Lanka ranks as a great herpetological paradise in the world. It is blessed with not only high amphibian and reptile diversity and endemism, but also relatively high densities of individuals interested in herpetology and publications, especially when compared with other countries in South Asia. Sri Lanka supports a high species richness and endemicity in herpertofauna, with 111 described species of amphibians and 211 described species of reptiles. Among them there are 92 amphibians and 125 reptiles species are endemic.

Figure 36 [Left]: Lissemys ceylonensis, Common Name: Sri Lankan flapshell turtle [Right]: Melanochelys trijuga, Common Name: The Indian black turtle

At present large scale conversion of forest areas for agriculture, plantation and settlements has put great stress on the remaining tropical forests of the country. Changing land use patterns,

habitat fragmentation and habitat destruction have caused severe threats to the amphibian and reptiles. Also, a combination of other factors including use of organoclorine pesticides and herbicides may have caused declining populations of once abundant herpetofauna of Sri Lanka.

Therefore it is of critical importance to comprehensively identify the Herpetofauna of Sri Lanka in order to develop conservation measures which may help in encouraging ecotourism, building biodiversity database, land use planning and the production of regional and international Red Data Books of threatened species.

Figure 37 Varanus salvator, Common Name: Water Monitor

5.2 Herpetofauna Diversity in Kala Oya Basin

5.2.1 Quantitative Integrated Sampling Design

Transects of 1 km in length were marked out in at least four replicates of the broadly defined six habitats (Dry Mixed Evergreen Forest, Disturbed Forest, Scrub forest, Tank associated habitat, Coastal habitat, Chena & Associating Habitats) types within 24 sampling sites covering length 24,000 m and an area of 120, 000 m^2 in total in Kala Oya river basin.

Furthermore, the 24 sampling sites were included in eight sub-river basin areas;

- Eile (transects 1,2,3 & 4)
- Eluwankulama (transects 5 & 6)
- Suduweli Tahala- Morapathana (transects 7 & 8)
- Werakkodichole- Tahabbbowa (transects 9 & 10)
- Horiwila –Ambagahawewa (transects 11 & 12)
- Galpaya- Hinguruwelpitiya- Ranva kannda- Nambatiwewa (transects 13, 14,15 & 16)
- Manawa (transects 17, 18 19 & 20)
- Wilpattu National Park- Thelbipuwewa (transects 21, 22, 23 & 24)

These areas comprised of a mosaic of highly fragmented habitats, some of transects were covered more than one vegetation type and also encompassed ecotones. 1km transects were further divided and named as quadrat A, B, C & D. Herpetofauna was sampled only in A and C quadrats.

Within the quadrat 5 m x 5 m (Day) / 20 m x 5 m (night) plots were cleared at 20 m intervals and time spent 15 minutes. Following summarises the sampling effort.

Figure 38 [Left]: Calotes versicolor, Common Name: Oriental Grgen Lizard; [Right]: Sphaerotheca rolandae, Common Names: Sri Lanka bullfrog, Roland's burrowing frog, southern burrowing frog, marble sand frog

Table 11 Quantitative sampling effort in Kala Oya River basin for herpetofauna

Description Of The Method	Sampled Plots Details	
	No. of plots sampled in total 24 Km	Total time
Plot clearing (daytime): 4 plots (5m x 5m) cleared in each of 2 quadrats (100m x 5m)	192 plots (4 x 2 x 24)	48 hrs [(192 x 15min.) /60 min.]
Plot clearing (night time): 1 plot (20m x5m) cleared in single quadrat (100m x 5m)	48 plot (1 x 2 x 24)	12 hrs [(48 x 5min.)/60min.]

5.2.2 Qualitative Sampling Design

The presence of additional species encountered along the transect, between quadrats, or elsewhere within the sampling area were recorded separately. Visual Encounter Surveys were carried out at day and night, with a similar amount of time spent (15min.) searching each habitat over the surveyed period. Grey literature, expert evidence and local knowledge were considered for total species diversity in the Kala Oya River basin. Sampling was carried out in 01 January to 31 March 2017.

5.2.3 Species Diversity

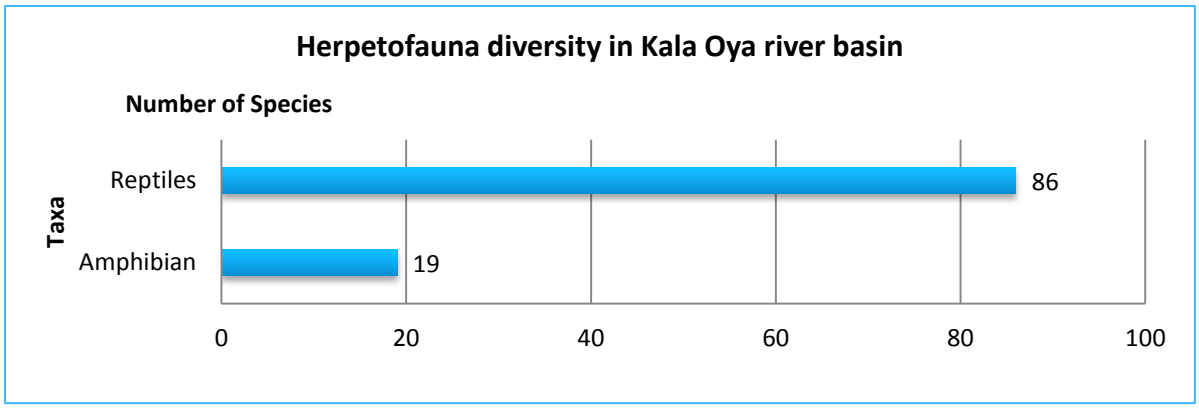


Figure 39 Herpetofauna diversity in Kala Oya River Basin

Nineteen species of amphibian species recorded and which included 5 families (Bufonidae, Microhylidae, Dicroglossidae, Rhacophoridae and Ranidae) and 12 generas (*Duttaphrynus, Kaloula, Microhyla, Ramanella, Uperodon, Euphlyctis, Zakerana, Hoplobatrachus, Sphaerotheca, Pseudophilautus, Polypedates* and *Hylarana*) (Figure 39).

Eighty six species of reptiles were recorded in the Kala Oya basin. Out of the 86 species of reptiles recorded 38 were tetrapod reptiles and 48 were snakes. All recorded reptile species belong to 20 families and 59 genera.

Figure 40 (a) *Hylarana gracilis* - Gravenhorst's frog, a species endemic to Sri Lanka (b) *Euphlyctis hexadactylus*- Green pond frog

5.2.4 Species status and their conservation status

4 amphibian & 20 reptiles endemic species respectively were found during the sampling period in Kala Oya River basin, as well as other species were indigenousFurthermore, according to the IUCN Sri Lankan Red Data Book 2012 which comprises of 01 Near Threatened, 15 Least Concern, 02 Data Deficient & 01 Vulnerable amphibian species. Also 11 Near Threatened, 54 Least Concern, 01 Data Deficient, 10 Vulnerable, 09 Endangered & 01 critically endangered reptiles species were recorded (Table 11, Annexes 08 & 09).

Table 12 Status of the herpetofauna recorded in the Kala Oya river basin

Taxa	Species Status		Conservation Status					
	Endemic	Indigenous	NT	LC	VU	DD	EN	CR
Amphibian	4	15	1	15	1	2	0	0
Reptiles	20	66	11	54	10	1	9	1

Note: EN-Endemic, IN-Indigenous, NT-Near Threatened, LC- Least Concern, VU-Vulnerable, DD-Data Deficient, EN- Endangered, CR-Critically Endangered.

Considering amphibian species diversity recorded in the 8 sub basing regions Eile area, Horiwila-Ambagahawewa and Manawa areas recorded high diversity (Table 13) and generally reptiles diversity were high is 7 areas except Eluwankulama.

Table 13 Distribution of amphibian species in Kala Oya river sub basins and their species status and conservation status according to the IUCN red list 2012

Sub-basin	# of habitat types	# Species & status		Conservation Status					
		Amphibian	Status	NT	LC	VU	DD	EN	CR
Eile area	4	18	EN 4, IN14	1	14	1	2	0	0
Eluwankulama	3	16	EN 3, IN13	1	13	0	2	0	0
Suduweli Tahala, Morapathana	1	10	EN 3, IN7	1	8	0	1	0	0
Werakkodichole, Thabbowa	4	9	EN 2, IN7	1	6	1	1	0	0
Horiwila, Ambagahawewa	4	18	EN 4, IN14	1	15	1	2	0	0
Galpaya Hinguruwelpitiya Ranva kannda, Nambatiwewa	5	12	EN 2, IN10	1	9	1	1	0	0
Manawa	4	18	EN 4, IN14	1	14	1	2	0	0
Wilpattu NP	3	13	EN 4, IN09	1	11	0	1	0	0

Note: EN-Endemic, IN-Indigenous, NT-Near Threatened, LC- Least Concern, VU-Vulnerable, DD-Data Deficient, EN- Endangered, CR-Critically Endangered.

Figure 41 [Left]: *Sitana devakai*, Common name: Devaka's fan-throated lizard; [Right]: *Otocryptis nigristigma*, Common Name: black-spotted kangaroo lizard or black-patched kangaroo lizard

Table 14 Distribution of reptiles' species in Kala Oya River sub basins and their species status and conservation status according to the IUCN red list 2012

Sub-basin	# of habitat types	# Species & status		Conservation Status					
		Reptiles	Status	NT	LC	VU	DD	EN	CR
(A). Eile area	4	43	END 7, IN36	5	29	6	0	3	0
(B). Eluwankulama	3	19	END 3, IN16	3	14	0	0	2	0
(C). Suduweli Tahala, Morapathana	1	43	END 10, IN31	8	27	6	0	1	1
(D). Werakkodichole, Thabbowa	4	39	END 13, IN26	4	28	4	0	2	1
(E). Horiwila, Ambagahawewa	4	31	END 8, IN23	5	23	3	0	0	0
(F). Galpaya Hinguruwelpitiya, Ranva Kannda, Nambatiwewa	5	45	END 14, IN31	8	30	5	0	1	1
(G). Manawa	4	57	END 19, IN38	10	37	7	0	2	1
(H). Wilpattu NP	3	49	END 16, IN33	7	29	8	0	4	1

Note: EN-Endemic, IN-Indigenous, NT-Near Threatened, LC- Least Concern, VU-Vulnerable, DD-Data Deficient, EN- Endangered, CR-Critically Endangered.

Figure 42 [Left]: Geochelone elegans, Common Name: The Indian star tortoise, [Right]: Hemidactylus frenatus, Common Names: The common house gecko,Pacific house gecko, the Asian house gecko

5.3 Herpetofauna diversity in Kala Oya river sub-basin areas and its importance

5.3.1 Eile area

The area is located at the end of the Kala Oya river basin which meets the Indian Ocean. Generally it is comprised of 4 major ecosystem types; Dry Mixed Evergreen Forest, Scrub Forest, Tank Associate Habitats and Coastal Habitats. A total of 61 herpetofauna species were recorded (Table 03 & 04) among them 11 species were endemic to the area. The major threats to the

herpetofauna were identified as vegetation clearing for Chena cultivation, sand mining, limestone mining and cattle farming.

5.3.2 Eluwankulama

Comparatively this area was highly modified by human activities such as cashew, coconut plantations and paddy cultivations. But mainly 3 ecosystem types were found; Dry Mixed Evergreen Forest, Scrub Forest and Tank Associate Habitats. Out of 35 species of herpetofauna found 6 species were endemic to the area. The main threat to the herpetofauna in the area is clearing of natural vegetation, as this leads to loss of amphibian and reptiles micro habitat in main ecosystems.

5.3.3 Suduweli Tahala-Morapathana

53 herpetofauna species were recorded in this sub basin area and it included the endangered skink species *Eutropis beddomii* (Beddome's skink) and critically endangered skink species *Nessia hickanala* (Shark-headed Snake Skink) in transect number 8A and 7C respectively (Table 03 & 04). Therefore conservation of these habitats should be of high concern. The main threat to these populations is the loss of micro habitat by clearing of forest for Chena cultivations.

5.3.4 Weerakkodichole- Thabbowa

48 herpetofauna species were recorded in this area and it included 2 endangered species; *Cnemaspis kumarasinghei* (Kumarasinghe's day gecko), *Eutropis beddomii* and 1 critically endangered *Nessia hickanala* (Table 03 & 04). Those species were recorded in the transect 9C and 10C which were located in the eco tone of the dry mixed evergreen forest. This indicates that the protection of the forest is very important as these species are roaming to the edge of the ecosystem. These areas are legally protected by Thabbowa sanctuary but illegal Chena cultivations were observed during surveying.

5.3.5 Horiwila-Ambagahawewa

The area is surrounded by the agricultural lands and it is highly disturbed by the human movement. But some of the isolated forest patches were observed and in these forested areas, 49 herpetofauna species were found which included 12 endemics. Conservation of these areas will be helpful to protect *Geochelone elegans* (Indian star tortoise) population as their preferred vegetation types existed among the forest patches.

5.3.6 Galpaya-Hinguruwelpitiya-Ranva Kannda-Nambatiwewa

Hilly isolated forest patches is found in this sub-region and its included 5 ecosystems types which harbors 57 herpetofauna species. It included 16 species of amphibians (2) and reptiles (14). This included 1 endangered species of skink *Eutropis beddomii*, and 1 critically endangered *Nessia hickanala*. These rocky habitats make some of the best habitats for skink and gecko species that live in this sub basin. Unfortunately these rocky habitats were being destroyed by quarry activities even during the survey period.

5.3.7 Manawa

A total of 75 herpetofauna species were recorded in this sub region. It comprised of 4 and 19 amphibian and reptile species respectively. It included 2 endangered species, a gecko- *Cnemaspis kumarasinghei*, a skink- *Eutropis beddomii* and 1 critically endangered *Nessia hickanala*. There is a high diversity of herpetofauna concentrated in four types of eco systems in the area.

5.3.8 Wilpaththu National Park

In Wilpathu national park sub-region area, the species diversity comprised of 62 species of herpetofauna which included 4 amphibians and 16 reptile species. It included 4 endangered species, a gecko- *Cnemaspis kumarasinghei*, a skink- *Eutropis beddomii*, a Chameleon- *Chamaeleo zeylanicus* (Indian chameleon), a crocodile- *Crocodylus porosus* (Estuarine crocodile) and 1 critically endangered *Nessia hickanala*.

Figure 43 [Left]: Ptyas mucosa, Common Names: oriental ratsnake, Indian rat snake, [Right]: Eutropis carinata, Common Names: Many-keeled Grass Skink or (ambiguously) "golden skink"

5.4 Habitat heterogeneity, species diversity and distribution

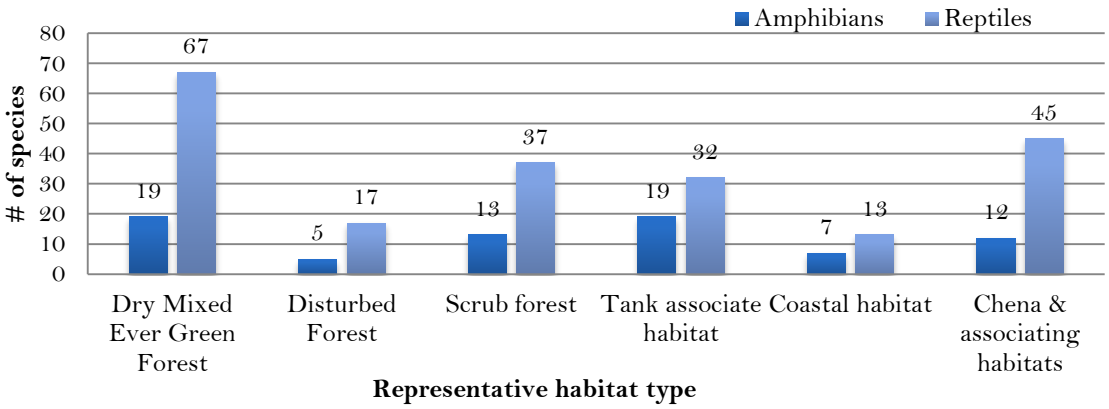


Figure 44 Herpetofauna diversity vs habitat in Kala Oya River basin

High species diversity of herpetofauna was recorded in 4 habitat types; Dry mixed evergreen forest, scrub forest, tank associate habitats and Chena & associate. Four species of amphibians and 20 species of reptiles were recorded in all of above 4 habitats.

Figure 45 (a) *Dendrelaphis tristis* – Common bronzeback tree snake (b) *Lankascincus fallax* - Peter's Lanka Skink, an endangered skink that is also endemic to Sri Lanka

6.0 AVIFAUNA DIVERSITY ANALYSIS

6.1 Introduction

Sri Lanka supports a rich avifauna that stands at 453 species, which includes 240 bird species who are known to breed in the island. Of the breeding residents 33 are endemic species, 213 species are migrants of which 72 species are encountered rarely and therefore considered as vagrants (Weerakoon, 2012). The main reason for this high number of migratory species is due to Sri Lanka's geographical position and dimensions. The island state is positioned at the end point of the Central Asian Flyway. The numerically largest migratory groups are the waders, ducks and coastal birds. In the family Charadridae, 42 of 47 species are migrants, while in the family Anatidae. 11 of 14 are migrants (Kotagama and Ratnavira, 2010). Recent taxonomic changes adopted by BirdLife International (2015) affected 56 species present in the island and as a result scientific names and in some cases the common names as well as their status had to be changed (Dayananda and Kaluthota, 2016). Most of these changes are yet to be in operatedincoperated in to presently available literature. Trees are essential for nesting and roosting of water birds, while the dead tree stumps in the reservoirs are used as feeding and roosting perches.

Sri Lanka is divided into six Avifaunal Zones based on the distribution patterns of the resident bird species. These include the Northern or Indian zone that shares many similarities with the South Indian avifauna; Low country wet zone, Mid country wet zone and Hill country wet zone that contain most of the endemic and threatened species; Dry zone and the Uva zone, which contain mostly common bird species as well as few rare species that are restricted to these zones (Kotagama, 1989). Kala Oya river basin (KOB) is the third largest river basin in Sri Lanka, and 76% of land of KOB is situated in the dry zone and the rest in the intermediate zone. Therefore, the majority of birds encountered in KOB fall within the Dry zone avifaunal zones. In depth avifaunal studies from the KOB are scarce, and a biodiversity survey conducted in 2005 reported the highest number of bird diversity in scrub forests (117) and mixed evergreen forests (103). Riparian forests hosted the lowest bird diversity (21 species), followed by thorn scrub and plantation forests with 54 species. 71 bird species were recorded from chena and chena regrowth. Perennial large tanks and Seasonal small tanks supported numerous aquatic birds (MASL, 2005).

A survey carried out in Wilpattu National Park recorded 149 species of birds belonging to 53 families, which included 3 endemic and 7 nationally threatened species. There were 24 species of migratory winter visitors. Wetlands such as villus and tanks provide ideal habitats for migratory waterfowl and

other aquatic birds. Wilpattu is a popular destination for a large number of migratory avifauna from late September to late March, since it is located along the western migratory fly way. In the forested areas, *Pycnonotus luteolus* and *Aegithina tiphia* were the most abundant species, while *Halcyon smyrnensis* and *Phalacrocorax fuscicollis* were the most abundant in wetland habitats (IUCN, 2006).

According to the latest national Red list, one in every five species of birds in Sri Lanka are currently facing the risk of becoming extinct in the wild. Nearly one third of all the resident birds in Sri Lanka are forest birds including all the endemic species. Therefore, loss of forest cover and fragmentation of forests are the main threats faced by the birds of Sri Lanka. Wetlands are also an important bird habitat in Sri Lanka with nearly 25% of the resident birds and more than 75% of the migrants depend on such habitats. Many of these wetland habitats are adversely impacted due to conversion, changes in salinity and hydrology, pollution of water ways, spread of invasive species, expansion of prawn farming and salt production. As a result, species richness and the carrying capacity of many wetland habitats have declined rapidly. Even though land use change has impacted most bird species in a detrimental manner, some species such as *Lonchura* spp., *Psittacula kramerii*, *Stigmatopelia chinensis*, *Corvus splendens*, *Centropus chinensis* have shown a marked increase in their range and numbers (Weerakoon, 2012).

6.2 Sampling Methodology

The main sampling method used to record terrestrial bird diversity within the Kala Oya basin was the Variable Circular Plots (VCPs). A total of 192 VCPs were sampled within the 24 transects within the basin. As indicated in Figure 46, VCPs were established at the beginning and end of each quadrat within a transect to record birds directly or indirectly from their calls over a period of 10 minutes in duration, once early morning and once in the evening. The VCP is divided into quarters, each of which is recorded for 21/2 minutes.

Any bird seen or heard outside the quarter (> 20 m in distance) is record as outside and as opportunistic observations. Similarly, birds observed while travelling along a transect between VCPs are recorded as opportunistic observations.

The presence of additional species encountered elsewhere within the area is recorded separately. Also, records were taken at water bodies adjacent to transects from one or more recording stations as necessary, preferably on more than a single occasion. Mist netting was not undertaken.

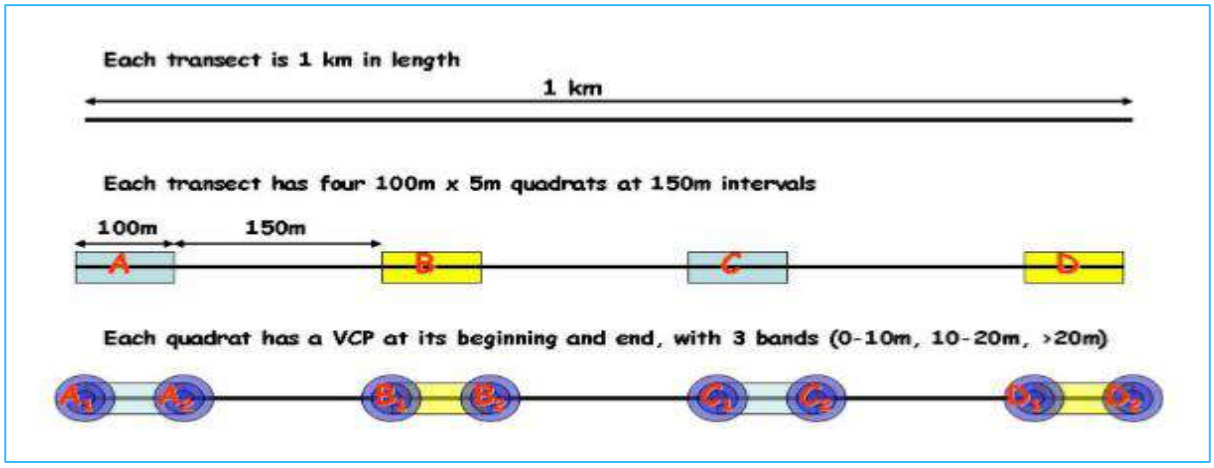


Figure 46 Location of quadrats within a transect and Variable Circular Plots within a quadrat

Further, a literature survey was undertaken to gather the state of knowledge of the existing species and their distribution range within Kala Oya Basin. Field work was carried out from January to April 2017. Field identification guides - Local and international bird guide books (Harrison, 2011; Kotagama and Ratnavira, 2010; Henry, 1998) were used as a reference for bird identification.

6.3 Results

6.3.1 Overall Avifaunal Diversity within the Basin

A total of 188 species of birds belonging to 59 families were recorded during the survey period. This included nine endemic species, one proposed endemic and 46 migrant species (of which in nine species breeding populations also has been observed in other parts of the country).

The nine endemics were *Galloperdix bicalcarata* (Sri Lanka Spur fowl) *Gallus lafayetii* (Sri Lanka Jungle fowl), *Ocyceros gingalensis* (Sri Lanka Grey Hornbill), *Treron pompadora* (Sri Lanka Green-pigeon), *Megalaima rubricapillus* (Sri Lanka Small Barbet), *Pellorneum fuscocapillum* (Sri Lanka Brown-capped Babbler) *Dinopium psarodes* (Sri Lanka Lesser Flameback), *Tephrodornis affinis* (Sri Lanka Wood shrike) and *Pycnonotus melanicterus* (Sri Lanka Black-capped Bulbul). The proposed Endemic recorded was *Hirundo hyperythra* (Red-rumped Swallow). Of the nine endemic species, *T. pompadora* had the largest presence within the Kala Oya basin. A complete check list of bird species observed during the survey is available in Annex 05.

Of the total birds, 70 can be considered as wetland associated species. Among them, the most commonly occurring families are: Scolopacidae (13 species including sandpipers and curlews); Ardeidae (11 species that includes herons and egrets); Charadriidae (8 species including Plovers and Lapwings); Rallidae (six species that includes coots and hens) and Anatidae (five species consisting of ducks). 30 of the migrant species were found mainly associated with wetlands. Few commonly occurring aquatic birds are given in Figure 47.

Figure 47 Some common aquatic birds recorded from Kala Oya basin

The total birds observed included four nationally threatened species (other than breeding migrants) all of whom fell into the category "vulnerable": *Porzana fusca* (Ruddy-breasted Crake), *Leptoptilos javanicus* (Lesser Adjutant), *Chrysocolaptes* festivus (White-naped Woodpecker) and *Lonchura malabarica* (White-throated Munia).

Further two globally threatened species were recorded: *Ciconia episcopus* (Woolly-necked Stork) and *Leptoptilos javanicus* (Lesser Adjutant). As per the IUCN Red List of threatened species 2016, both species are considered as "vulnerable" globally as their overall populations seem to be in a rapid decline mainly due to loss and degradation of wetlands and loss of nesting tress and hunting. Yet nationally only *L. javanicus* is considered as vulnerable, while *C. episcopus* status is near threatened (MoE, 2012), indicating its population is more stable in Sri Lanka. During the present survey, records of *C. cepiscopus* was high with eight individuals being observed in a dried up tank within Manawakanda area (Figure 48).

A single individual of *L. Javanicus* was observed near Eluwankulama Tank (Transect 6). A recent study on *L. javanicus* in the country indicated that the species' distribution is restricted to dry lowlands (rainfall <2200mm, elevation <300m). The bird showed preference for savannah/woody savannahs, dry mixed evergreen forests, permanent wetlands, and croplands, and was prominently found within protected areas. Habitat loss and fragmentation, hunting pressure, agricultural intensification, and development projects were identified as potential threats faced by the species, which varied in magnitude across the country (de Silva et al, 2015).

Figure 48 Gathering of *C. cepiscopus* in a dried up tank bed in Manawa Kanda area (near Transect 20).

6.3.2 Diversity within Habitats

Of the 188 bird species, only 111 were recorded in the VCPs during the sampling time frame within a 20m distance and therefore were subject to further analysis (Table 15). The balance could be treated as opportunistic observations.

The highest species diversity was recorded from transects that included a variety of habitats including both aquatic and terrestrial: Nabatayagama Tank and associated forests (Transect 14) located adjacent to Namal Uyana Conservation Forest recorded the highest diversity followed by Manawa tank associated habitats (Transect 19).

Of the Dry mixed evergreen forests, highest bird diversity was recorded from Manawakanda forests (Transect 17) followed by Higuruwelpitiya (Transect 13) and Eile tank associated DMEF (Transect 1). Least diversity was observed from DMEF of Suduwelithalawa (Transects 7 & 8) and this might be due to high density of the forest cover. The most commonly found bird species with highest population densities within the transects were *Pycnonotus luteolus* (White-browed Bulbul), *Stigmatopelia chinensis* (Spotted Dove), *Pycnonotus cafer* (Red-vented Bulbul), *Nectarinia zeylonica* (Purple-rumped Sunbird), *Acrocephalus dumetorum* (Blyth's Reed Warbler) and *Aegithina tiphia* (Common Iora). Nationally threatened *C. festivus* was recorded from Transect 18 while *L malabarica* was recorded from Transects 6 and 12. Few of the common bird species observed are given in Figure 49.

Figure 49 Few common bird species of the Kala Oya basin

Table 15 Avifaunal diversity within the transects

Transect	Sub basin	Main Habitat	# of species	Endemics	Threatened species		Shannon Wiener
					National	Global	
1	Eile Tank and the coastal wetland	DMEF	39	1			3.089263457
2		SF and Tank	37	2			2.86802819
3		Disturbed SF & abandoned quarry	22	1			2.404241532
4		SWM and mangroves	37	1			2.837637881
5	Eluwankulama Area	Tank associated	39	2			3.362404167
6		SF	33	5	1 (VU)		2.720507655
7	Suduwelithalawa and Morapathana Area	DMEF	21	1			2.620364374
8		DMEF	23	3			2.613919832
9	Werakkodichole & Tahabbbowa Area	SF, aband. Chena	38	3			2.912685518
10		Chena & Dis. Forests	31	4			2.773988299
11	Horiwila area	Dis. Forest & tank catch.	21	1			2.740915389
12		DMEF & Chena	35	4	1 (VU)		2.715507563
13	Galpaya, Hinguruwelpitiya, Ranawa Kanda & Nambatiwewa area	DMEF	39	4			3.362049512
14		SF & Tank associated	51	5			3.52172657
15		SF & Dist. Forests	31	2			3.126275154
16		DMEF	31	3			3.260144361
17	Manawa Kanda area	DMEF	42	5			3.355627183
18		Dist. Forests and Tank ass.	33	3	1 (VU)		3.134277433
19		Tank associated	48	4			3.43915158
20		DMEF & abnd. Chena	34	4			3.189920661

Transect	Sub basin	Main Habitat	# of species	Endemics	Threatened species		Shannon Wiener
					National	Global	
21	Wilpattu National Park	DMEF & Villu	37	4			3.017458927
22		SF	24	5			2.698676389
23		DMEF	21	4			2.304498065
24		DMEF & SF	29	5			2.698424615

DMEF- Dry Mixed Evergreen Forests; SF- Scrub Forests

6.3.3 Avifaunal Diversity within the Eight Sub-Basins

For the analysis of the avifauna within the eight sub-basins, the opportunistic birds encountered are also taken in to consideration. Table 16 provides a brief summary of the same. As indicated in the table, the number of bird species observed within VCPs were highest in sub basin 6 (Galpaya) while in two sub-basins opportunistic bird encountered were high (Eluwankulama and Suduwelithalawa). The main reason for these high opportunistic observations was the inclusion of birds observed in small tanks in the vicinity, adding a considerable number of aquatic birds to the list.

Table 16 Summary information for Sub-basins

	Sub basin/Clusters							
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***
Total number Sp.	105	140	71	89	88	90	102	89
Within VCPs	64	54	29	48	48	64	67	48
Opportunistic obs.	41	86	42	41	40	16	35	41
No. of Families	43	57	43	41	43	43	43	38
No. of Endemic Species	04	07	06	07	05	06	07	08
No of Migrant Species	27	23	11	10	9	13	10	13
No. of Nationally threatened species	-	03	-	-	02	-	01	-
No. of Globally threatened species	-	01	-	-	01	-	01	01
Shannon wiener Index	3.00126	3.34323	2.71843	2.85772	2.96343	3.75677	3.5677	2.93287

Sub-Basin 1 (Elie Tank and the Associated Coastal Wetlands)

Of the 105 Species recorded, 41 were opportunistic observations, consisting mainly of migrant wader species that occupied transect 4 and the adjoining salt marsh and mangrove area indicating the importance of this transect as a feeding ground for migratory waders. None of the nationally or globally threatened species were encountered from this sub-basin and the number of endemics encountered (4) was less compared to the other sub-basins.

During the survey, the main threat to the area was the lack of water due to the dry weather conditions. However, this area is also prone to flooding, especially during North-East monsoons. Sand mining was taking place in the upstream of Lunu Oya. Animal husbandry (cattle and goat)

was prominent in this area and the dung of the animals had led to eutrophication of the tanks. Haphazard tourism development and land degradation due to lime quarrying also affect the biological wealth. This area is also prone to flooding.

Figure 50 Elie Tank and Associated Coastal Wetlands

Sub Basin 2: Eluwankulama Area

Of the 8 sub basins, the highest species number was recorded from this sub basin, and this can be accounted to the presence of Eluwankulama Tank (Transect 5), adjoining riverine and scrub vegetation as well as vast areas of paddy fields. Seasonal water holes appeared with rain and this attracted large numbers of aquatic birds, mainly species belonging to family Ardeidae and Phalacrocoracidae, It should be noted that although only 54 species were within its VCPs, a separate detailed study of the area indicated presence of 140 species, indicating the importance of protecting this habitat which is located adjacent to Wilpattu National Park boundary and directly receives water from the Kala Oya.

Nationally and globally threatened *L. javanicus* was only observed from this area and that was a single opportunistic record. *C. festivus* (White-naped Woodpecker) was also recorded from this sub-basin. Seven endemic species were found in this sub basin.

Main threats included the heavy use of agrochemicals in the paddy fields, removal of trees for tank rehabilitation and siltation. This area is prone to flooding.

Figure 51 Eluwankulama Area

Sub Basin 3: Suduwelithalawa and Morapathana Area

The least number of bird species (71) was encountered from this sub basin and could be accounted to human interventions including abandoned cultivations (cashew) and thick forests. The opportunistic observations (42) were mainly of the birds that flew above the transects or were encountered within small tanks in the area. Six endemic species represented the avifaunal assemblage of this sub-basin while no nationally or globally threatened species were observed. Main threats in the area include sand mining and tree felling.

Sub Basin 4: Weerakkodichole & Tahabbbowa Area

This sub basin mainly consisted of Chena (abandoned and cultivated) and a few disconnected forest patches. There was a seasonal stream dissecting Transect 9, as well as vast paddy area that adjoined the sub basin, which provided habitats for several aquatic birds. The area bordered the Tabbowa Sanctuary as well as the Weerakkodicholai Reserve Forests. As a result, a considerable number of forest birds, including the endemic Grey Hornbill were observed from this area. 89 bird species that included seven endemic species were recorded from this sub-basin. No nationally or globally threatened species were observed during the study period.

Major threats include the highly fragmented nature of the forest patches that were disappearing fast due to human interference such as clearing for Chena cultivation and housing construction.

Figure 52 Werakkodichole & Tahabbbowa Area

Sub Basin 5: Horiwila area

The vegetation in this sub basin was highly fragmented and degraded, predominantly due to Chena land use. Yet the presence of small tanks (include Abaga wewa) increased the areas potential to habour 88 Bird species. 40 species are of opportunistic observations recorded mainly from the two tanks. Five endemic species and two nationally threatened (*Porzana fusca* - Ruddy breasted Crake (VU); and *Lonchura malabarica* - White-throated Munia (VU) was recorded from the sub basin. A colony of *Phalacrocorax niger* (Little Cormorant) and Indian Night Heron was observed at Abagaha wewa, and there was indications that these two bird species together with few other aquatic birds use the trees in this tank for breeding purposes.

The globally threatened C. episcopus together with several migrant waders were observed in a small tank with receding waters.

The small forest patch which is an important watershed to Abagahawewa tank should be protected with community participation for the continuation of the nesting and roosting facilities. Main threats include forest clearing for Chena cultivation and use of high concentrations of agrochemicals that ended in the tank systems. Furthermore, clearing and burning of tank beds for agricultural purposes is practiced.

Figure 53 Birds and Habitat observed in Horiwila area

Sub Basin 6: Galpaya, Hinguruwelpitiya, Ranawa Kanda & Nambatiwewa area

Galawala DS Division contains a higher proportion of forest areas and rocky outcrops. The only water body in this sub-basin was the Nambatiwewa Tank, which was located adjacent to Namal Uyana Conservation Forest and most of this tank bed area was dried up, limiting the encounter of water birds. In total 90 bird species were recorded of which only 16 were opportunistic observations. The bird list included six endemic species, and no nationally or globally threatened species were encountered during the study period.

The forests in the area are fragmented and threatened due to quarrying for different varieties of stones. Immediate attention should be given to quarrying industry in the area as it had already led to many environmental and social issues. Furthermore, sand mining in seasonal streams is affecting the water table.

Figure 54 Habitat and avifauna observed in Galpaya, Hinguruwelpitiya, Ranawa Kanda & Nambatiwewa area

Sub Basin 7: Manawa Kanda area

This sub-basin includes a variety of habitats and hence a higher number of bird species (102) were present. Manawa tank is an important habitat for aquatic birds, while the dry mixed forest patches associated with Manawakanda provides habitats for forest birds. 67 bird species were encountered within the 20 m of the VCPs, including seven endemic birds. Largest concentration of globally threatened *C. episcopus* was observed from this area. Presence of the nationally threatened *Chrysocolaptes festivus* (White-naped Wood pecker) added to the importance of this site. Forest clearing for Chena cultivation and the spread of invasive gini grass are the major threats.

Figure 55 Habitat and avifauna Manawa Kanda area

Sub Basin 8: Wilpattu National Park

Mixed habitats including tank beds, rock outcrops and dry mixed evergreen forests were sampled within the 4 transects set in Wilpattu National Park. The total number of birds recorded was 89 and the rainy conditions prevailed during the sampling period might have reduced the species numbers. Seven migrant species including *Galloperdix bicalcarata* (Sri Lanka Spurfowl) was recorded. Globally threatened *C. episcopus* was observed outside the transects. No nationally threatened species were observed.

Figure 56 Habitat and avifauna observed around Wilpattu National Park

6.3.4 Feeding, Roosting and Nesting Concentrations

Large concentrations of feeding/roosting birds were observed on several occasions, especially adjacent to in association with Eluwankulam tank and adjacent seasonal water holes (SB2), salt march wetlands in Gange wadiya (SB1), Abagaha wewa tank (SB5) and at Kala wewa and Rajanganaya tanks where no sampling was undertaken during the present study. It has been reported that during the dry months of the year (June –September) a large area of the Kala wewa shores are exposed by the receding waters. The habitat created by the shallow waters and the dead trees is conducive for the fresh water bivalves which attracts thousands of Open bills to the area (Gunawardena, 2010).

Picivorous nesting birds, other than the White bellied Sea Eagle (one nest at SB1) were not recorded during the survey. Nesting of the Sri Lanka Grey Hornbill was observed at the Hinguruwelpitiya forest – SB6.

6.3 Discussion, Threats & Issues

The survey revealed the presence of a rich avifaunal diversity within the Kala Oya basin including few nationally and globally threatened species. Yet their survival is threatened by many anthropogenic as well as climate change related issues. The sub basins that need priority in terms of conserving the bird diversity are Eluwankulama, Manawa kanda and Galpaya sub-basins as well as Eilie sub basin as it is important feeding ground for migratory waders. . It should be noted that other than the Puttalam lagoon no other areas in the KOB has been designated as an important bird area. Therefore inclusion of these sites as Important Birda Areas (IBAs) is recommended and also continuous monitoring of the bird populations should be undertaken. Attention should be given to maintain adequate tree cover consisting of tree species required for feeding and nesting requirements, while when allocating water, the importance of wetlands for maintaining the rich biological wealth should kept in mind.

7.0 MAMMAL DIVERSITY ANALYSIS

7.1 Introduction

The large mammals are the best-known group among Sri Lanka's vertebrates, with a high level of subspecies diversity and endemism. In addition, hoofed mammals, small carnivores such as members of the mongoose and civet family, leopards, fishing cats, jungle cats, rusty spotted cats, sloth bears, jackals, otters and leopards – the largest wildcat in Sri Lanka, can be found in the dry zone of Sri Lanka. Bats and rodents are more commonly found. Unfortunately the ranges of these species have been diminished over time due to habitat destruction and human activities

Existing Sri Lankan Mammals can be categorized into 12 orders. The following table (Table 7.1) illustrates the orders, number of genera, number of species and percentage endemism of present day Sri Lankan Mammals.

Table 17 : The orders, number of genera, number of species and percentage endemism of present day Sri Lankan Mammals.

Order	No. Of Genera	No. Of Species	No.of Endemic genera	No. Of Endemic Species
Sirenia	1	1	0	0
Proboscidia	1	1	0	0
Primates	3	5-7	0	3-5 (60-71%)
Rodentia	14	23	1 (7%)	7 (30%)
Lagomorpha	1	1	0	0
Eulipotyphla	4	10-11	1 (25%)	7-8 (70-73%)
Chiroptera	16	30	0	0
Carnivora	10	17	0	4 (23%)
Pholidota	1	1	0	0
Artiodactyle	6	9	0	3 (33%)
Perisodactyla	2	1	0	0
Cetacea	20	27	0	0

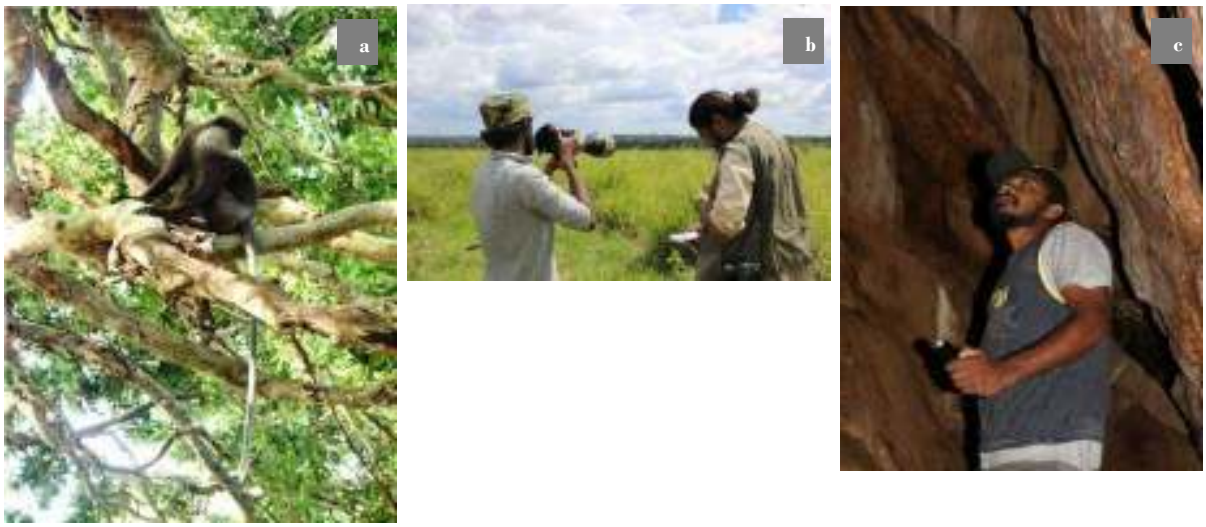


Figure 57 (a) The purple-faced langur (*Trachypithecus vetulus*), also known as the purple-faced leaf monkey, is a species of Old World monkeys that is endemic to Sri Lanka (b) Collecting photographic evidence during surveying (c) Field teams surveying bats in cave

Approximateley 125 species (77 Genera) of Mammals are available in Sri Lanka (Yapa & Rathnavira 2013).Six habitat types identified in the Kala Oya basin were surveyed for mammals: Dry Mixed evergreen forest, Disturbed Forest, Scrub Forest, Tank Associated Area, Coastal habitat and Chena Associated Area.

Thus, atotal of 48 quadrets (100 M X 5 M) were sampled for small medium and large sized mammals. A total of 96 quadrets were aligned along 24 Km transects and surveyed during the surveying phase of the project in the following manner to investigate the diversity of mammals. Some of the habitats were found disturbed due to anthropogenic actvities such as agricultural practices. In this study we studied the mammalian diversity using many methods as described below.

- Identify mammals available in this area using Tracks, Signs and Scat by setting 100X5m quadrets along the 1km line transects across various habitats
- Using Traps
- Opportunistic Survey
- Personnel Communication (Socio-ecological Survey)

7.1.1 Tracks

- A familiarity with the basic track patterns allowed the identification of mammals by the tracks they have left behind
- Tracks can state whether or not a certain species is present in the area and roughly their behaviour
- This thechniques was mainly used to identify mammalian species by using their fore and hind limb avarage paws size and the shape/pattern of the Paws.

7.1.2 Signs

- Mammals often leave signs of their presence that act ikeclues that aid trackers in Wild identification, allowing them to record presence of that species
- These signs include nests, dens, browse marks, food scraps and tree trunk rubs

7.1.3 Scat

- The identification and analysis of scat is a common method for identifying the presence of a species in an area
- Scat may contain hairs of a mammal thatexcreted which may helpthe identification.Scat can also contain hairs from pray that has been consumed. Size and Shape of the scat used for species identification

7.1.4 Trap Time

- Traps are laid at early evening times for five consecutive days, and subsequently examined and baited during morning hours.

7.2 Survey Methodology

Within 100 X 5 m quadrets, we placed 10 traps in each alternative quadrets for five consecutive nights.

Choosing an Appropriate Site

- All potential habitats were covered.
- Each habitat types are having 4 quadretst within 1Km (150m distance each). Quadret number 2 and 4 (B and D) sampled for mammals while the other quadrates were dedicated for other faunal groups.

Setting Traps

- For a small mammals, 40 Shermans traps were used
- For a intermediate Size Mammals, 2 Tomahawk Traps were used
- Normally traps were placed around areas of fresh signs where possible (runays, burrows, fresh scat,grass clippings, and water loged areas).
- Traps were tagged or marked for the identification of the place
- Traps were tethered to a bush or stone in areas where scavengers are common.

Baiting Traps

- Each traps was baited with a piece of burnt coconut and roasted dry fish for small rodents like animals
- For intermediate size mammals, traps were baited using banana for herbivorous and raw fish for carnivorous

Checking Traps

- Traps were checked once a day, early in the morning.If an animal was caught, collected the animal to record the time, station number, habitat,species, age and sex
- Rebaited and reset the trap

7.2.1 Opportunistic Observations

Casual observations done in all habitats outside sampling quadrats generate information about rare and restricted species that are difficcult to capture. These observaions were done both day and night. At night search lights were used to facilitate the observations.

7.2.2 Socio-ecological Survey

Having informal conversation with villagers to find out the presence or absence of certain wildlife species was done throughout the survey. Such personal communication resulted in the information gathered about important species present in different habitats such as leopard, flying squirrels, elephants,etc.

7.3 Results

7.3.1 Diversity within Habitats

For the convenience of the comparisons of diversity, 24 km line transects were clustered to 8 areas. Out of 24, 4 transects lines were plotted inside the Wilpattu National park to give a better comparison of distribution of mammals near the protected areas and to provide some indication of the home ranges of some mammals.

A total of 39 species (22 families and 32 Genera) were recorded during the survey; 7 species of bats, 4 species of cat family members, 3 species of deer, 3 species of herpestids, 2 viverrids, 2 species of squirrels, 4 muridae members, 3 cercopithicidae members and so on. All the mammals identified in those 8 areas are shown in Table 18.

Table 18 Observed fauna in different localities of Kala oya Basin

Species Name	Conservation Status	Clusters of Transects in Different Locations							
		A	B	C	D	E	F	G	H
Bubalusbubalis					*	*	*	*	*
Canisaureus	LC	*			*	*	*	*	*
Macacasinica	LC	*	*	*	*	*	*	*	*
Semnopithecuspriam	LC	*	*	*	*	*	*	*	*
Semnopithicusvetulus	EN	*	*					*	
Axis axis	LC	*	*	*	*	*	*	*	*
Rusaunicolour	NT		*		*		*	*	*
Elephasmaximus	EN	*	*	*	*		*	*	*
Felischaus	NT	*	*	*	*	*	*	*	*
Prionailurusrubiginosus	EN	*							
Prionailurusviverrinus	EN	*	*				*	*	*
Pantherapardus	EN	*	*				*		*
Herpestesedwardsii	LC	*	*	*	*	*	*	*	*
Herpestessmithii	LC	*		*	*		*	*	*
Herpestesbrachyurus	LC	*		*					
Paradoxurushermaphoditus	LC	*			*		*	*	*
Hystrixindica	LC	*	*	*	*	*	*	*	*
Lepusnigricollis	LC	*	*	*	*	*	*	*	*
Mus booduga	LC		*	*	*	*	*	*	*
Rattusrattus	LC	*	*	*	*	*	*	*	*
Bandicotaindica	LC	*							
Tateraindica	LC	*	*	*	*	*	*	*	*
Lutralutra	VU	*	*		*	*	*	*	*
Pteropusgiganteus	LC		*	*	*	*	*	*	*
Funambuluspalmarum	LC	*	*	*	*	*	*	*	*
Ratufamacroura	LC	*	*	*	*	*	*	*	*
Loris lydekkerianus	NT				*	*			

Species Name	Conservation Status	Clusters of Transects in Different Locations							
		A	B	C	D	E	F	G	H
Susscrofa	LC	*	*	*	*	*	*	*	*
Moschiolameminna	LC	*	*	*	*	*	*	*	*
Muntiacusmuntjak	NT	*			*				*
Melursusursinus	EN				*				*
Viverriculaindica	LC	*	*	*	*	*	*	*	*
Maniscrassicaudata	NT	*	*		*	*	*	*	*
Hipposiderosspeoris	LC								*
Kerivaulapicta	NT						*		*
Hipposiderosgaleritus	VU								*
Megadermaspasma	VU								*
Pipistrelluscoromandra	VU								*
Cynopterus sphinx	LC								*
Total Number of Species		**27**	**23**	**20**	**27**	**21**	**27**	**26**	**34**

Note: A= Transect 1-4, EileWewa Area
B= Transect 5-6, Eluwankulama Area
C= Transect 7-8, Suduwelithalawa and Morapathana Area
D= Transect 9-10, Weerakkodochole and Thabbowa Area
E= Transect 11-12, Horiwila and Ambagaswewa Area
F= Transect 13-16, Galpaya, Hinguruwelpitiya, Ranawa Kanda and Nambatiwearea
G= Transect 17-20, Manawa Area
H= Transect 21-24, Wilpatthu National Park

33 species of indigenous mammals were recorded from the 48 quadrates and another 6 species were recorded opportunistically in the Wilpattu National park. All those six species belong to Chiropterans. Statuses of the identified species at Kala Oya Basin are shown in Table 18. Mammals Diversity and its Estimates for habitats, based on quadrates sampling are shown in Table 19 and Figure 58. Levels of Diversity and Endemism together with Endangered, Near Threatened and Vulnerability of recorded mammalian species in different localities at Kala Oya Basin are summarized in Figure 59.

- Eile Wewa area (Locality A) had 27 species of mammals and out of which 3 were endemics, 5 endangered, 3 near threatened and 1 vulnerable. The area is comprised of Dry Mixed Evergreen Forest, Scrub Forest, Tank Associated and Coastal Habitats which are most favourable to mammalian life.
- Eluwankulama Area (Locality B) was having 23 species of mammals including 3 Endemics, 4 Endangered, 3 Near Threatened and 1 Vulnerable. This locality has Dry Mixed Evergreen Forest, Scrub Forest and Tank Associated Habitats like Eile Wewa areas, which are suitable for the abundance of mammals.
- The Lowest numbers of mammalian species were recorded from Suduwelithalawa and Morapathana Area (Locality/ cluster C) which is 20, of which 2 are endemic, 1 endangered and 1 threatened. This region consists of scrubbed and tank associated habitats which are not suitable for many species of mammals.

- Locality D (Weerakkodichole and Thabbowa Area) is comprised of Dry Mixed Evergreen Forest and Disturbed Forest with 27 species of mammals (2 Endemic, 2 Near Threatened and 1 Vulnerable). There are agricultural lands nearby and small domesticated populations of goat, cattle and chicken which disturb wild fauna species. Also it was observed that illegal timber cutting was happened in this area.
- Horiwila and Ambagaswewa Area (Locality E) was having second lowest number of mammals; 21. 2 Endemic, 2 Near Threatened and 1 vulnerable species were identified within the habitat of Dry Mixed Evergreen, Disturbed Forest, Scrub and Chena associated habitats. This area has low species richness due to high levels of anthropogenic activity.
- Locality F (GalaPaya) sub basin was having 27 number of identified mammal species distributed in four type of habitats namely Dry Mixed Evergreen, Disturbed, Scrub and Tank. 2 endemics, 3 endangered, 4 near threatened and 1 vulnerable species were observed at this locality.
- Locality G is having 26 species of mammals; 3 endemics, 3 endangered 3 near threatened and 1 vulnerable within the habitats of Dry Mixed Evergreen Forest, Tank Associated and Chena Associated.
- Locality H belongs to Wilpatthu National park which recorded 2 Endemics, 4 Endangered, 5 near threatened and 4 vulnerable mammal species.

Table 19 Status of the Identified Species at Kala Oya Basin

Categories	Clusters of Transects in Different Locations							
	A	B	C	D	E	F	G	H
Total Species Richness								
Quadrates & Opportunistic	32	35	24	31	25	39	36	44
Quadrates only	27	23	20	27	21	27	26	34
Number of Genera	22	21	18	26	21	26	23	32
Number of Families	15	14	13	19	17	18	17	20
Number of Endemics	03	03	02	02	02	02	03	02
Number of Endangered	05	04	01	02	00	03	03	04
Number of Near Threatened	03	03	01	05	03	04	03	05
Number of Vulnerable	01	01	00	01	01	01	01	04

Table 20 Distribution of Mammalian Fauna in an identified six habitats at Kala Oya Basin

Clusters of Transects	Number of Species	Habitat Types					
		P	Q	R	S	T	U
1-4 (A)	27	24	00	15	22	12	00
5-6 (B)	23	20	00	15	15	00	00
7-8 (C)	20	18	00	00	00	00	00
9-10 (D)	27	26	20	00	00	00	00
11-12 (E)	21	11	14	00	00	00	15
13-16 (F)	27	25	11	14	14	00	00
17-20 (G)	26	23	00	00	21	00	20
21-24 (H)	34	2	00	22	00	00	00

Habitat Types: P = Dry Mixed Evergreen Forest, Q= Disturbed, R= Scrub forest, S= Tank associate habitat, T= coastal habitat, U= Chena & associating habitats

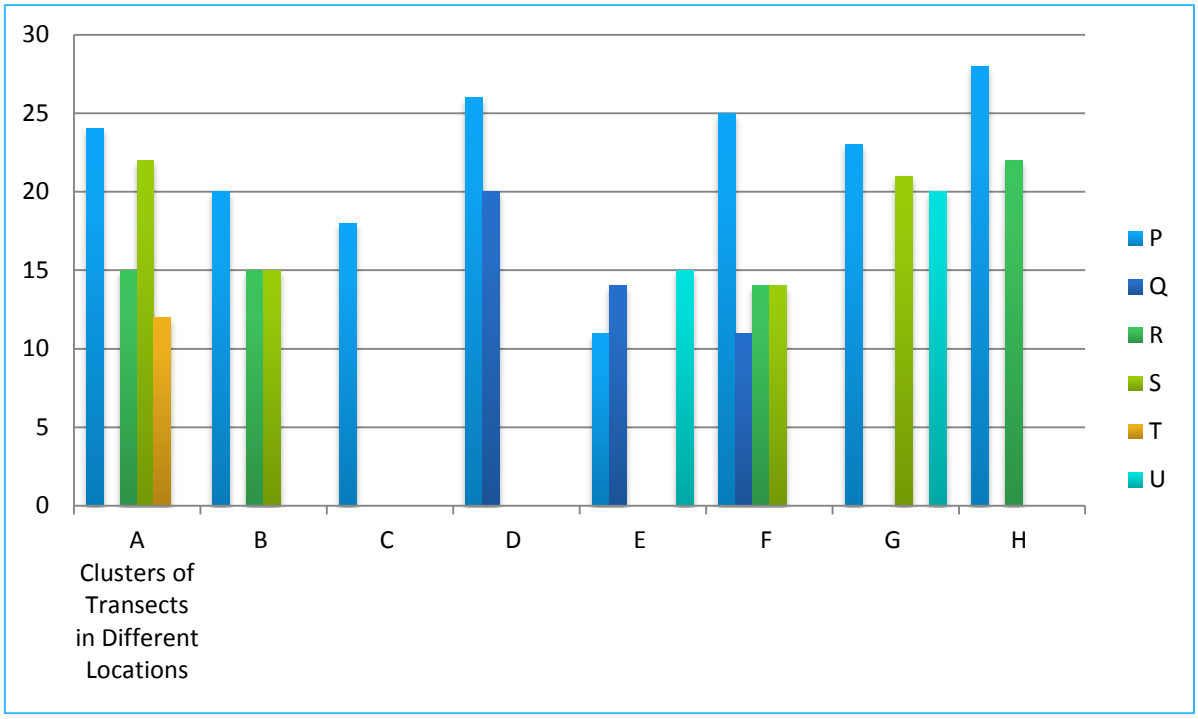


Figure 58 Mammalian Distribution in different habitat types within the Kala Oya Localities (Habitat Types: P = Dry Mixed Evergreen Forest, Q= Disturbed, R= Scrub forest, S= Tank associate habitat, T= Coastal Habitat, U= Chena & associating habitats)

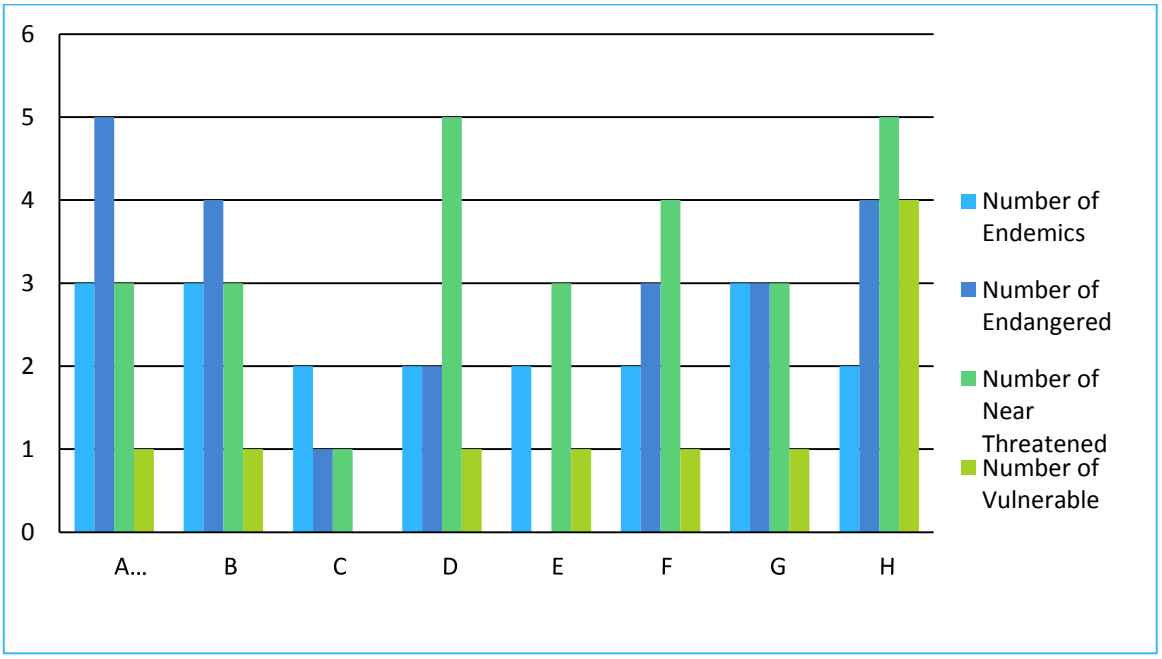


Figure 59 Status of Identified Mammals at Kala Oya basin localities

7.4 Discussion

According to the observations, 3 species (*Macaca sinica, Semnopithecus vetulus hartii, Moschiola meminna*) are endemic. Considering National conservation status of Sri Lankan mammals,

surveying area consisted of 6 species of Endangered (EN), 6 species of Near Threatened (NT), and 4 species of Vulnerable (VU).

Species	IUCN Status
Semnopithicus vetulus	EN
Elephas maximus	EN
Prionailurus rubiginosus	EN
Prionailurus viverrinus	EN
Panthera pardus	EN
Melursus ursinus	EN
Kerivaula picta	NT
Manis crassicaudata	NT
Muntiacus muntjak	NT
Loris lydekkerianus	NT
Felis chaus	NT
Rusa unicolour	NT
Lutra lutra	VU
Hipposideros galeritus	VU
Megaderma spasma	VU
Pipistrellus coromandra	VU

According to the Figure 58, most of the identified species were distributed in Dry Mixed Evergreen Forest habitats compared to the other identified habitats followed by Scrub and Tank Associated habitats. All 8 locality areas comprise of dry mixed evergreen forest habitats; this gives an idea about large number of Ecological Niches for mammals existing within this Dry Mixed Evergreen Forest and species richness is highest in Dry Mixed Evergreen Forests.

During the surveying period, many of the water bodies/streams within the selected localities at Kala Oya Basin were totally dry, but otter scat was found on a several places of rocky surfaces next to dry water bodies.

Ratufa macroura (Grizzled giant squirrel) were recorded in all localities at Kala Oya basin including Wilpatthu National park is categorized as a Least Concern (LC) species Nationally; but Globally it is a Near Threatened (NT) species.

All 3 species of muridae were trapped and also some of them were directly observed. 15 species were commonly recorded in all 8 localities. The Rusty Spotted Cat and Bandicoot Rat were observed only in locality area "A"; EilebWewa.

Compared to Wilpatthu National Park localities (transect 21 – 24), Species Richness and type of Habitats are more or less similar in Locality A, B, E and F.

Also those four localities are very specific due to high endemism, near threatened species, endangered and vulnerable species compared to species distribution and species richness of other localities.

Therefore, these four localities should further be investigated in the long term and it is suggested to declare these as protected areas.

7.4.1 Human Elephant Conflict

Conservation of elephants in Sri Lanka is a major problem faced by the Department of Wildlife Conservation. The increase in human population and expansion of areas for agriculture and irrigation settlement projects has resulted in areas available to elephants as habitats diminishing over time. The existing protected areas are insufficient for year-round requirements of elephant inhabitants and are continuing to be degraded due to on-going human activity. Moreover, the range of a large portion of existing elephants is outside the protected area networks set aside for elephant conservation. This has resulted in high levels of human-elephant conflicts in the form of crop and property damage and human and elephant deaths. This is inevitable when humans and elephants compete for common resources; however around 150 elephants are killed every year as a result of this conflict.

There are numerous options for the mitigation of Human-Elephant Conflict (HEC). Some of these include:

- Implementation of habitat enrichment programs to enhance the carrying capacity of the protected areas and provide connectivity between remaining forests and wildlife reserves.
- Animal Rescue and Translocation Programs
- Maintenance of elephant corridors
- Electric fences including regular maintenance, monitoring systems, training of relevant personnel and communities, introduction of user-friendly equipment, awareness of the implications of malfunctioning electric fences, fences designed with concepts such as "free roaming area", solar powered electric fences, biological fences such as growing thorny plant species, bee-hive fences, and pragmatic use of current fences in place
- Elephant drives: The objective is to drive the elephants into an area, usually a National Park, and establish a barrier to prevent them from returning. Electric fences are sometimes used to contain elephants driven into a particular area and temporary electric fences are used as an aid to the drive
- Integration of surrounding communities and initiatives to

ensure HEC is minimized, through raising awareness, educating the communities on the habitats required for elephants and the reasons behind the conflicts

Efficient and collaborative institutional arrangements among the relevant Ministry of Environment, Ministry of Land, Land Use Policy Planning Department, Department of Wildlife Conservation, Forest Department Archaeology Department and other relevant agencies is vital for the protection of natural reserves and conservation sites including buffer zones in between protected areas.

In addition, effective land use planning plays a vital role in minimizing disruptions to the surrounding biodiversity and resulting habitat fragmentation from haphazard developments in rural areas. This coordination among the relevant agencies is the most important factor that can categorically consider all the aforementioned strategies and ensure that HEC is mitigated.

8.0 FRESHWATER FAUNA AND FLORA DIVERSITY ANALYSIS

Mangroves of Kala Oya river mouth

Mangrove Ecosystems

The sea is a hostile environment to animals and plants. High salinity, wave action, and fluctuating water levels present problems that are rarely experienced in terrestrial or freshwater habitats. Few angiosperms have specialised to live in such environments and one such ecosystem that is created by such tolerant plants is mangroves. Mangroves are dicotyledonous woody shrubs or trees that are virtually confined to the tropics. They often form dense forests that dominate intertidal muddy shores, frequently consisting of monospecific patches or bands. Mangroves stabilize the soil and create a habitat which is exploited by a host of other organisms: through this, and in their role as photosynthetic primary producers, they are the basis of a complex and productive ecosystem. The mangrove trees themselves, and the other inhabitants of the mangrove ecosystem, are adapted to their unpromising habitat, and can cope with periodic immersion and exposure by the tide, fluctuating salinity, low oxygen concentrations in the water, and—being tropical—frequently high temperatures. They are most extensive where there is a low shore gradient, and occupy a broader belt on shorelines which have a large tidal range (Walsh, 1974). Sheltered habitats are essential for mangrove development, and on coasts which are exposed, mangroves are localised in the lee of other coastal landforms (Davies, 1972). Associated with the concept of species replacement through time is the belief that the seaward species has an ability to prograde into shallow water. The viviparous nature of seedlings of many species of mangroves appears to support this contention and several early workers regarded mangroves as 'makers of land' (Davis, 1938; Stephens, 1962).

Mangroves are defined as woody trees and shrubs which flourish in mangrove habitats (or mangals). True, or exclusive, mangroves are those which occur only in such habitats, or only rarely elsewhere. There is in addition a loosely defined group of species often described as mangrove associates, or non-exclusive mangrove species. These comprise a large number of species typically occurring on the landward margin of the mangal, and often in non-mangal habitats such as rainforest, salt marsh, or lowland freshwater swamps. Many epiphytes also grow on mangrove trees: these include an assortment of creepers, orchids, ferns, and other plants, many of which cannot tolerate salt and therefore grow only high in the mangrove canopy. True mangroves comprise some 55 species in 20 genera, belonging to 16 families. They are taxonomically diverse.

Amongst different ecosystems in Sri Lanka mangroves represent a unique assemblage of specialized fauna and flora adopted to survive in brackish water conditions and intertidal zones. At present, an estimated range of 12,000 to 15,668 ha of land is covered with mangroves but the exact cover is unknown. In Sri Lanka 22 true mangrove and several mangrove associate floras have been identified. Most importantly, this represents one third of the world mangrove species diversity and in terms of land, 0.001 % of the world mangrove cover.

Mangroves perform a crucial role in maintaining the ecological integrity of the coastal zone, and the services provided are provisioning, regulatory, supportive as well as cultural services. Being in between coastal and inland ecosystems, they act as filters from both sides. From the landward side, upland sediment and other organic and inorganic matter uploads are deposited within mangrove ecosystems, preventing direct release of sediments and nutrients to sensitive coastal ecosystems such as sea grass beds and coral reefs. From seaward side, effects of tides, storm surges, tsunamis and salt wedges to fresh water ecosystems are ameliorated hence; salt-water sensitive ecosystems, lives of people and their properties are protected. Additionally, the role played by mangrove ecosystems as carbon sinks, that mitigate climate change is globally highlighted as a prime need for conserving mangroves. Biologically, mangrove ecosystems provide feeding and breeding habitats for species that permanently inhabit such ecosystems as well as for those temporarily immigrate as a part of their life cycle requirements. Economically, mangroves provide livelihood opportunities for the coastal people through fisheries and ecotourism opportunities in mangrove areas. The fish, shellfish and other food items obtained from mangroves play a vital role in food and nutritional security of the coastal people.

However, mangroves cover less than 0.1 % of land area of Sri Lanka. These are the areas that have also seen fierce human competition for commercial exploitation, urban development, recreational uses, and waste disposal. Underlying this competition is the fact that the vast majority of megacities and fastest-growing cities are located in (or very close to) coastal zones. The trend for rural populations to migrate to coastal urban areas has greatly accelerated in recent years; this is of particular concern in developing countries, where urban areas often have poor infrastructure, planning, and resources. Another threat to coastal zones has emerged in the last two decades – global warming and the attendant rise in sea level. Some of the recent scientific predictions on accelerated sea-level rise as a result of anthropogenically induced global warming are, indeed, alarming.

Kala Oya Mangrove Ecosystem

Part of Kala Oya mangrove ecosystem is protected as it forms the Southern boundary of Wilpattu National Park. However, a large portion of it mainly the Lunu Oya segment of the river is currently unprotected though Department of Forest has identified the area as a proposed forest patch.

This mangrove ecosystem is also one of the largest remaining mangrove ecosystems in the country with relatively undisturbed patches scattered across islands formed in river mouth. Kala Oya segments in to several branches towards the mouth, and the meandering river has formed many islands. Here three main segments are identified, Kala Oya proper, Henakachchi Oya and Lunu Oya. Amongst the three segments Lunu Oya has mangroves extended further into inland (Figure 46).

Figure 60 Kala Oya river mouth

Methodology for Sampling Mangroves

Flora was identified by bank counts and transects. A boat was used in bank counts and GPs locations of start and end were recorded. Four observers and two note takers recorded the species occurring in the banks along with the number of each species. Only the species occurring in banks were noted. Bank counts were done from river mouth to inland, in all three segments of the river.

In randomly selected islands outside the boundary of Wilpattu National Park transects were laid from fringing mangroves to inland. At least four transects were laid per island. Each transect was 50 m in length and 1 m in width. The gap between two transects were minimally over 5 m. Depending on the size of the island further 50 m transects were laid until the entire composition of the island was known (Figure 61).

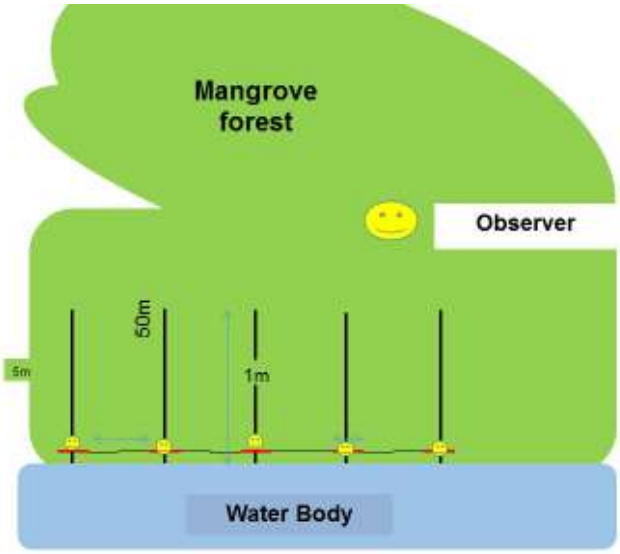


Figure 61 Schematic diagram depicting data collection procedure

Two diversity indices were used to find the species richness in each location.

Margalef diversity index

$D_{mg} = (S - 1)/ LnN$
D_{mg} = Margalef's diversity index

N= total number of individuals in the sample
S = the number of species recorded

Shannon Wiener Diversity Index

$H = - \sum p_i \ln p_i$
H = Shannon's diversity index
p_i = The proportion of species *i* relative to the total number of species

Results

Table 21 provides the list of true mangroves found in the area and their conservation status. A total of 14 true mangroves were found.

Table 21 True mangrove species recorded from the area

Family	Scientific name	Common names	IUCN Status
Avicenniaceae	*Avicennia marina* (Forsk.) Vierh.	E : Grey mangrove/White mangrove S : Manda T : Kanna/Venkandal	LC
	Avicennia officinalis L.	E : Indian mangrove S : Manda T : Kanna/Upu attha	NT
Combretaceae	*Lumnitzera racemosa* Willd.	E : Teruntum bunga puteh S : Sudu beriya T : Thipparethai	NT
Euphorbiaceae	*Excoecaria agallocha* L.	E : Buta-buta/Blind-your-eyes S : Thelakeeriya T : Thillai	LC
Lythraceae	*Pemphis acidula* Forst.	S : Muhudu wara T :Kiri maram	NT
Meliaceae	*Xylocarpus granatum*	E : Mangrove cannonball S : Mutti kadol T : Kadal manga/Somuntheri	EN
Myrsinaceae	*Aegiceras corniculatum* (L.) Blanco	E : Black mangrove/River mangrove S : Heen kadol/Awari kadol T : Vettilaikanna/Narikandal	LC
Rhizophoraceae	*Bruguiera cylindrica* (L.) Blume	E : Bakau Putih S : Mal kadol T : Sirukandal	EN
	Bruguiera gymnorrhiza (L.) Lamk.	E : Oriental mangrove S : Rath kadol	VU
	Ceriops tagal (Perr.) C.B. Robinson	E : Tengar S : Punkanda T : Chirukandal	NT
	Rhizophora apiculata BL.	S : Rana kadol T : Kandal	NT
	Rhizophora mucronata Lamk.	E : Asiatic Mangrove S : Murunga kadol T : Kandal	LC
Rubiaceae	*Scyphiphora hydrophyllacea* Gaertn.f.	S :Kalu kadol	VU
Sonneratiaceae	*Sonneratia alba* J. Smith	S : Sudu mal kirala/Gal kirala T : Vellai-kinnai	EN

Species typical to dry zone riverine forests and dry deciduous forest were found as associates (Table 222).

Table 22 The checklist of mangrove associate species and other plant species recorded from Kala Oya-Pomparippu area

Family	Scientific name	Common names	IUCN Status
Acanthaceae	*Acanthus ilicifolius* (L.)	E : Holly-leaved acanthus S : Katu ekiliya	LC
Aizoaceae	*Sesuvium portulacastrum* (L.) L.	E : Shoreline purslane/sea purslane S : Mahasarana T : Vankiruvilai	NT
Amaranthaceae	*Suaeda monoica* Forssk. Ex J.F.Gmelin	E : Jambl/Jambolan T : Umiri	NT
Amaryllidacea	*Crinum asiaticum* L.	E : Poison bulb S : Tolabo T : Vichamunkil	LC
Arecaceae	*Phoenix zeylanica*	S : Wal indi	
Asclepiadaceae	*Calotropis gigantea (L.) W.T.Aiton*	S : Wara	
Asteraceae	*Mikania micrantha* Kunth	S : Wathu palu	
Bignoniaceae	*Dolichandrone spathacea* (L.f)	S : Diyadanga	NT
Celastraceae	*Pleurostylia opposita* (Wall.) Alston	S : Panakka/Piyari T : Chiru/Piyari	LC
Combretaceae	*Terminalia arjuna* (Roxb.) Wight & Arn.	E : Arjuna/Arjun tree S : Kumbuk	LC
	Terminalia catappa L.	E : Indian Armand S : Kottamba	
Fabaceae	*Derris trifoliata* Lour.	S : Kalawel T : Pungai	LC
	Cassia auriculata(L)	S : Ranawara E : Matara tea T : Avarai	LC
	Tamarindus indica	S : Siyabala T : Puli	
	Acacia cornigera (L.)Willd.	E : Bullhorn acacia S : Katu andara	LC
	Caesalpinia bonduc(L)	S : Kumburu E : Grey nicker T : Punaikkalaichchi	LC
Lamiaceae	*Premna latifolia*	S : Wal midi T : Erumaimulla	LC
Lamiaceae	*Clerodendron inerme(L)*	E : Glorybower/Bagflower S : Wal gurenda T : Pichuvilathi	LC
Malvaceae	*Hibiscus tiliaceus* L.	S : Wal beli: T : Vellai	LC
	Thespesia populnea (L.) Sol. ex Correa	E : Portia tree S: Gan suriya	LC
	Berrya cordifolia	S : Halmilla	LC

Family	Scientific name	Common names	IUCN Status
		E : Tricomalee wood T : Chavandalai	
Melastomataceae	*Memecylon umbellatum* Burm.f.	S: Korakaha E : Blue mist	LC
Meliaceae	*Azadirachta indica* A. Juss., 1830	S : Kohomba E : Margosa	
Moraceae	*Ficus hispida L.f*	S : Kata Dimbula	LC
Myrtaceae	*Syzygium cumini* (L.) Skeels.	S : Madan	LC
Pteridaceae	*Acrostichum aureum* (L.)	E : Golden leather fern S : Karan koku T : Minni	LC
Rubiacea	*Nauclea orientalis* (L)	S : Bakme T : Vammi/Atuvangi	LC
Salvadoraceae	*Azima tetracantha* Lam.	S : Katu niyanda	LC
Sapotaceae	*Manilkara hexandra* (Roxb.) Dubard	S : Palu	
Sterculiaceae	*Pterospermum suberifolium* (L.) Willd.	S : Velan	
Teliaceae	*Muntingia calabura*	E : Jam tree	
Verbenaceae	*Lantana camara* L.	S : Gandapana E : Lantana	

Sampling Stations and Recorded Mangrove Species

Location 01

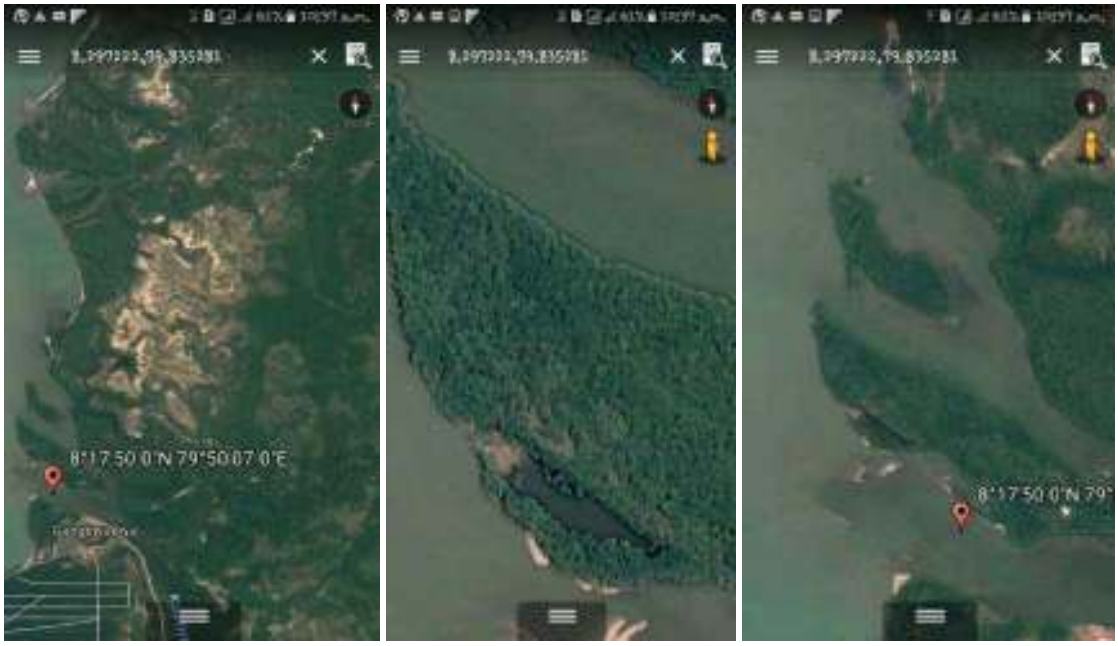


Figure 62 Satellite images of the sampling station 01

Figure 62 indicates the location with longitude and latitude. Location 1 was open to sea at the river mouth. Figure 62 provides the species found in each transect. A total of five 50 m transects were laid. Table 23 provides the density of each species and the density data were depicted as a percentage. *Ceriops tagal* was the plant with highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.9218 and 2.7304 respectively (Table 24).

Table 23 Recorded true mangrove and mangrove associate species (Transect – 50 m to the forest)

Species	Transect 01 (50 m)				
	1	2	3	4	5
Avicennia marina	2	4	9	2	2
Avicennia officinalis	1	1			2
Bruguiera cylindrical	1		9	24	11
Bruguiera gymnorrhiza		7	4	38	
Ceriops tagal	43	6	9	15	1
Excoecaria agallocha	5	5	2	2	
Lumnitzera racemosa	3	1	1	3	4
Pemphis acidula	1	1		2	1
Rhizophora apiculata				3	8
Rhizophora mucronata	22	10	11	5	12

Scyphiphora hydrophyllacea	1	1			
Aegiceras corniculatum	1				1
Thespesia populnea	1		2		1
Premna serratifolia	2				1
Clerodendrum inerme	2		1	2	2
Azima tetracantha					1
Sesuvium portulacastrum				1	
Derris trifoliate	3		1	1	2
Syzygium cumini			1		
Phoenix zeylanica					2

Table 24 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m-2)					Mean Density (m-2)
	1	2	3	4	5	
Avicennia marina	0.04	0.08	0.18	0.04	0.04	0.076
Avicennia officinalis	0.02	0.02	0	0	0.04	0.016
Bruguiera cylindrical	0.02	0	0.18	0.48	0.22	0.18
Bruguiera gymnorrhiza	0	0.14	0.08	0.76	0	0.196
Ceriops tagal	0.86	0.12	0.18	0.3	0.02	0.296
Excoecaria agallocha	0.1	0.1	0.04	0.04	0	0.056
Lumnitzera racemosa	0.06	0.02	0.02	0.06	0.08	0.048
Pemphis acidula	0.02	0.02	0	0.04	0.02	0.020
Rhizophora apiculata	0	0	0	0.06	0.16	0.044
Rhizophora mucronata	0.44	0.2	0.22	0.1	0.24	0.240
Scyphiphora hydrophyllacea	0.02	0.02	0	0	0	0.008
Aegiceras corniculatum	0.02	0	0	0	0.02	0.008
Thespesia populnea	0.02	0	0.04	0	0.02	0.016
Premna serratifolia	0.04	0	0	0	0.02	0.012
Clerodendrum inerme	0.04	0	0.02	0.04	0.04	0.028
Azima tetracantha	0	0	0	0	0.02	0.004
Sesuvium portulacastrum	0	0	0	0.02	0	0.004
Derris trifoliate	0.06	0	0.02	0.02	0.04	0.028
Syzygium cumini	0	0	0.02	0	0	0.004
Phoenix zeylanica	0	0	0	0	0.04	0.008

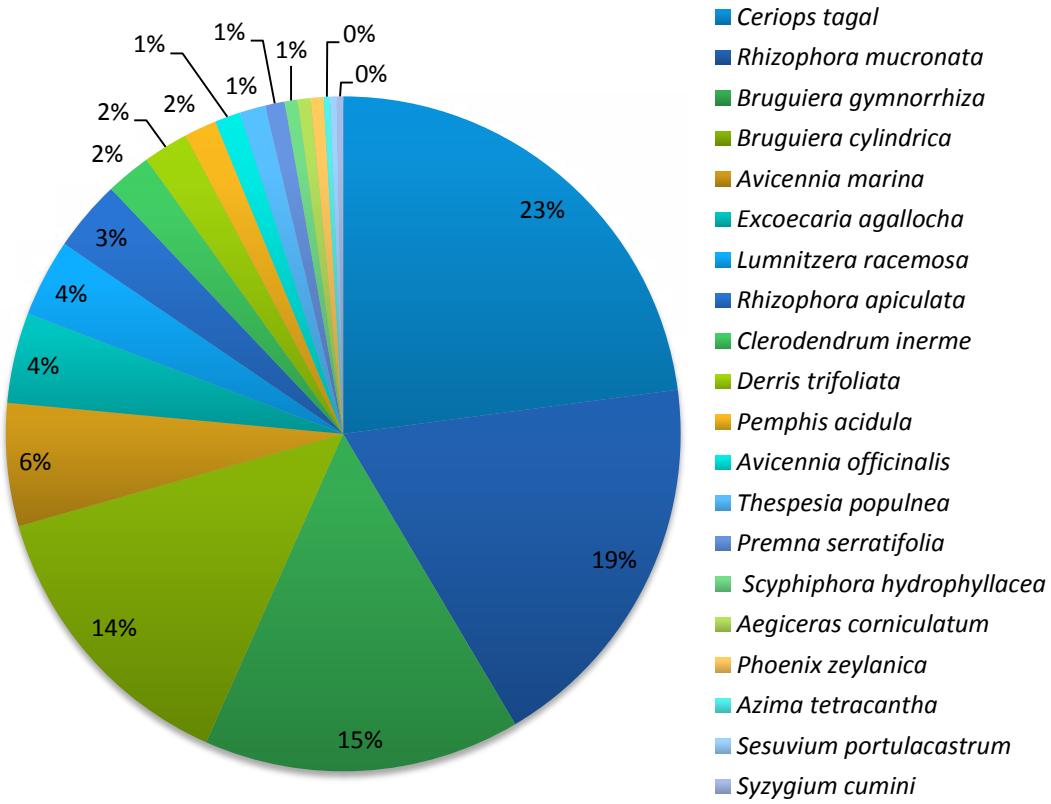


Figure 63 Pie chart indicating the percentage of true mangrove & mangrove associates (L 1)

Table 25 Species Richness Indices (L 1)

Margalef Species Richness Index	Shannon Wiener Index
2.7304	1.9218

Location 02

Figure 64 Sampling station 02

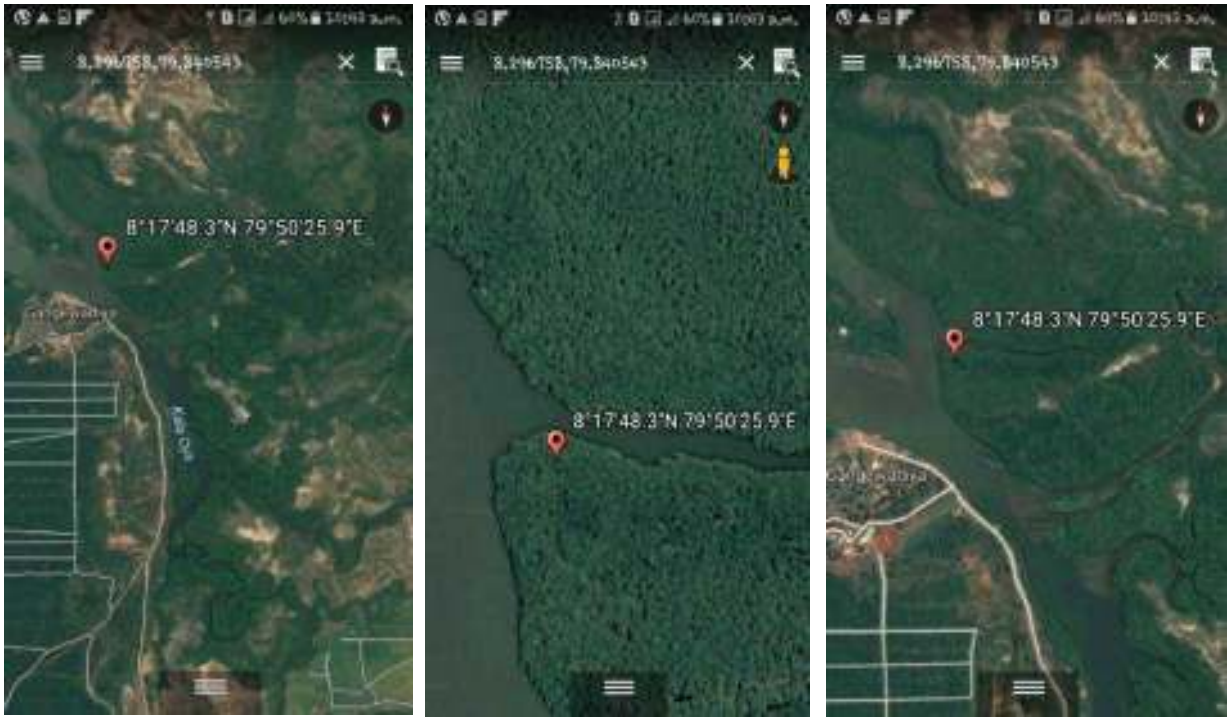


Figure 65 Satellite images of the sampling station 02

Figure 64 indicates the typical mangal composition of site 2. Figure 65 indicates the location with longitude and latitude. Location 2 was open to river proper. Table 26 provides the species found in each transect. A total of ten 50 m transects were laid. It also provides the density of each species and the desity data were depeicted as a percentage in Figure 66. *Ceriops tagal* was the plant with highest density in this location. The Margalef and Shannon Wiener species richness indices were 0.9061 and 1.2341 respectively (Table 28).

Table 26: Recorded True mangrove and mangrove associate species (Transect – 100 m to the forest)

Species	Transect 01 (50 m)					Transect 02 (50 m)				
	1	2	3	4	5	1	2	3	4	5
Avicennia marina	17	10	16	20	51	14	10	11	21	65
Bruguiera cylindrica	4									
Bruguiera gymnorrhiza			1						3	
Ceriops tagal	23	21	20	55	10	30	45	32	33	6
Excoecaria agallocha	3		3							2
Lumnitzera racemosa	3		1			1				2
Rhizophora mucronata	23	42	30	15	50	4	26	6	23	15
Xylocarpus granatum						4				
Aegiceras corniculatum	9	18	18		4		5	3		14
Clerodendrum inerme	4	4								

Table 27: Densities of true mangrove and mangrove associate species in each transect

Species	Density (m^{-2})										Mean Density (m^{-2})
	1	2	3	4	5	1	2	3	4	5	
Avicennia marina	0.34	0.2	0.32	0.4	0.51	0.28	0.2	0.22	0.42	0.65	0.354
Bruguiera cylindrica	0.08	0	0	0	0	0	0	0	0	0	0.008
Bruguiera gymnorrhiza	0	0	0.02	0	0	0	0	0	0.06	0	0.008
Ceriops tagal	0.46	0.42	0.4	1.1	0.1	0.6	0.9	0.64	0.66	0.06	0.534
Excoecaria agallocha	0.06	0	0.06	0	0	0	0	0	0	0.02	0.014
Lumnitzera racemosa	0.06	0	0.02	0	0	0.02	0	0	0	0.02	0.012
Rhizophora mucronata	0.46	0.84	0.6	0.3	0.5	0.08	0.52	0.12	0.46	0.23	0.411
Xylocarpus granatum	0	0	0	0	0	0.08	0	0	0	0	0.008
Aegiceras corniculatum	0.18	0.36	0.36	0	0.04	0	0.1	0.06	0	0.14	0.124
Clerodendrum inerme	0.08	0.08	0	0	0	0	0	0	0	0	0.016

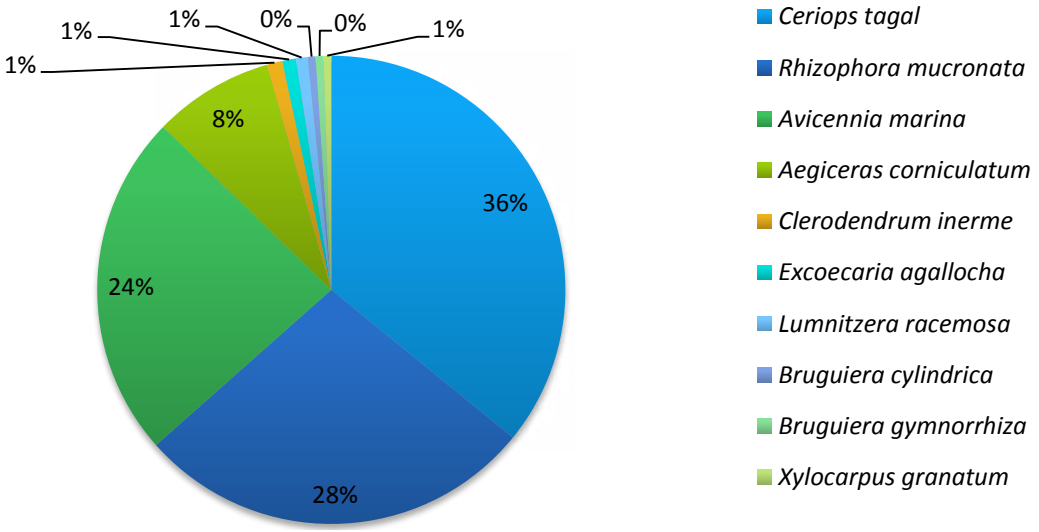


Figure 66 Pie chart indicating the percentage of true mangrove & mangrove associates (L 2)

Table 28 Species Richness Indices (L 2)

Margalef Species Richness Index	Shannon Wiener Index
0.9061	1.2341

Location 03

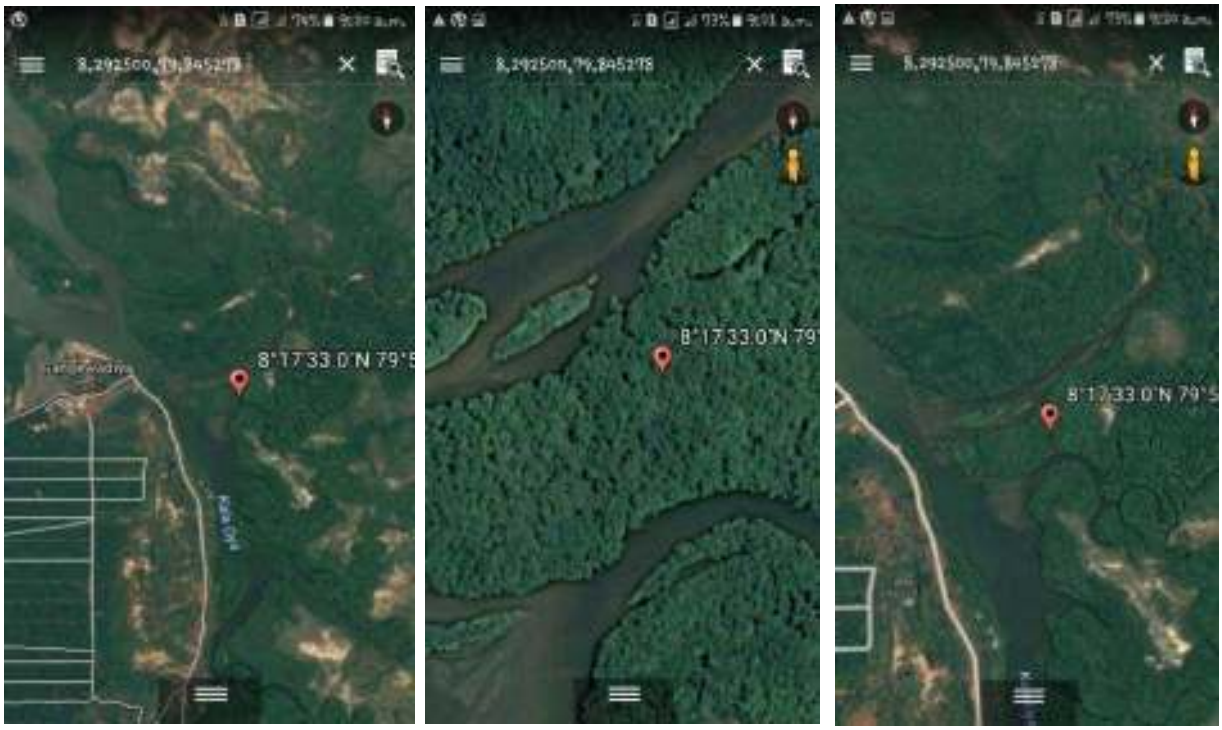


Figure 67 Satellite images of the sampling station 03

Figure 67 indicates the location with longitude and latitude. Location 3 was open to river proper. Figure 68 provides the species found in each transect. A total of seven 50 m transects were laid. Table 28 provides the density of each species and the desity data were depeicted as a percentage in Table 29. Acrostichum aureum was the plant with highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.2257 and 1.3744 respectively (Table 31).

Table 29 Recorded True mangrove and mangrove associate species (Transect – 100 m to the forest)

Species	Transect 01 (50 m)				Transect 02 (50 m)		
	1	2	3	4	1	2	3
Avicennia marina	**1**						
Ceriops tagal						**10**	
Excoecaria agallocha	**15**	**7**	**25**	**20**	**7**		**11**
Rhizophora mucronata	**5**		**4**				
Aegiceras corniculatum			**1**	**5**			
Premna serratifolia	12		22	7	2		11
Clerodendrum inerme		3					
Derris trifoliata	6	3	7	10		1	
Acanthus ilicifolius	55	20	17	11	14	6	10
Acrostichum aureum	53	47	57	40	46	55	42

Species	Transect 01 (50 m)				Transect 02 (50 m)		
	1	2	3	4	1	2	3
Caesalpinia bonduc	4	9		5			
Terminalia arjuna		1					
Mikania micrantha	9	4		2	5		
Berrya cordifolia		1					

Table 30 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m^{-2})				Density (m^{-2})			Mean Density (m^2)
	1	**2**	**3**	**4**	**1**	**2**	**3**	
Avicennia marina	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0.003**
Ceriops tagal	**0**	**0**	**0**	**0**	**0**	**0.2**	**0**	**0.029**
Excoecaria agallocha	**0.3**	**0.14**	**0.5**	**0.4**	**0.14**	**0**	**0.22**	**0.243**
Rhizophora mucronata	**0.1**	**0**	**0.08**	**0**	**0**	**0**	**0**	**0.026**
Aegiceras corniculatum	**0**	**0**	**0.02**	**0.1**	**0**	**0**	**0**	**0.017**
Premna serratifolia	0.24	0	0.44	0.14	0.04	0	0.22	0.154
Clerodendrum inerme	0	0.06	0	0	0	0	0	0.009
Derris trifoliata	0.12	0.06	0.14	0.2	0	0.02	0	0.077
Acanthus ilicifolius	1.1	0.4	0.34	0.22	0.28	0.12	0.2	0.380
Acrostichum aureum	1.06	0.94	1.14	0.8	0.92	1.1	0.84	0.971
Caesalpinia bonduc	0.08	0.18	0	0.1	0	0	0	0.051
Terminalia arjuna	0	0.02	0	0	0	0	0	0.003
Mikania micrantha	0.18	0.08	0	0.04	0.1	0	0	0.057
Berrya cordifolia	0	0.02	0	0	0	0	0	0.003

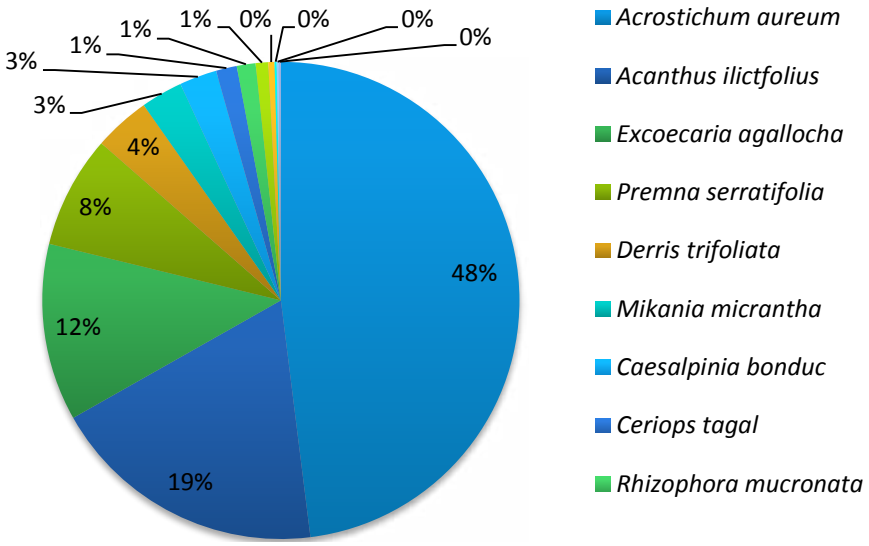


Figure 68 Pie chart indicating the percentage of true mangrove & mangrove associates (L 3)

Table 31 Species Richness Indices (L 3)

Margalef Species Richness Index	Shannon Wiener Index
1.2257	1.3744

Location 04

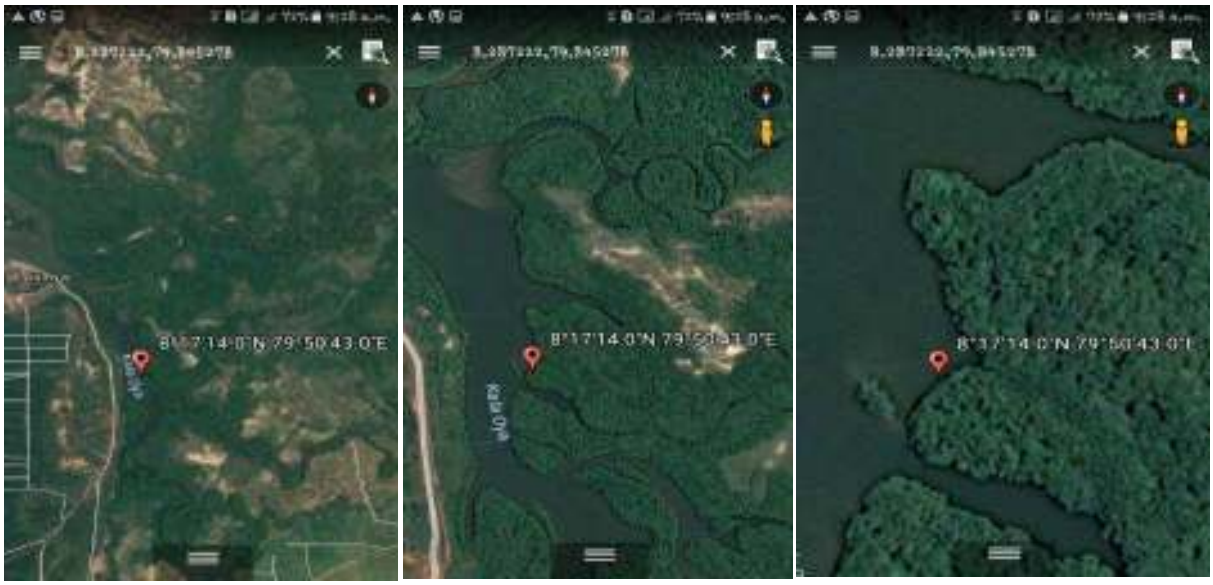


Figure 69 Satellite images of the sampling station 04

Figure 69 indicates the location with longitude and latitude. Table 32 provides the species found in each transect. A total of nine 50 m transects were laid. Figure 70 provides the density of each species and the desity data were depicted as a percentage in Table 33. Acrostichum aureum was the plant with highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.6673 and 1.6637 respectively (Table 344).

Table 32 Recorded true mangrove and mangrove associate species (Transect – 150 m to the forest)

Species	Transect 01 (50 m)			Transect 02 (50 m)			Transect 03 (50 m)		
	1	2	3	1	2	3	1	2	3
Avicennia marina								**2**	
Bruguiera cylindrica		**2**			**1**			**7**	**5**
Ceriops tagal		**5**	**3**		**3**	**7**		**1**	**2**
Excoecaria agallocha	**7**	**17**	**10**	**3**	**1**		**4**	**4**	**10**
Lumnitzera racemosa			**12**			**2**	**3**	**9**	
Pemphis acidula		**1**							
Rhizophora mucronata	**15**	**45**	**5**	**21**	**22**	**21**	**5**	**4**	**7**
Aegiceras corniculatum		**2**					**1**	**4**	**1**
Premna serratifolia		2	6		3			3	
Derris trifoliata		10	2			1		1	2
Acanthus ilicifolius	8	2	30	2		16	13	5	17
Acrostichum aureum	26	20	6	27	13	8	30	20	22
Caesalpinia bonduc	5	18	11	4	4	6	4	4	12
Terminalia arjuna		1							

Table 33 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m^{-2})			Density (m^{-2})			Density (m^{-2})			Mean Density (m^2)
	1	2	3	1	2	3	1	2	3	
Avicennia marina	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.04**	**0**	**0.004**
Bruguiera cylindrica	**0**	**0.04**	**0**	**0**	**0.02**	**0**	**0**	**0.14**	**0.1**	**0.033**
Ceriops tagal	**0**	**0.1**	**0.06**	**0**	**0.06**	**0.14**	**0**	**0.02**	**0.04**	**0.047**
Excoecaria agallocha	**0.14**	**0.34**	**0.2**	**0.06**	**0.02**	**0**	**0.08**	**0.08**	**0.2**	**0.124**
Lumnitzera racemosa	**0**	**0**	**0.24**	**0**	**0**	**0.04**	**0.06**	**0.18**	**0**	**0.058**
Pemphis acidula	**0**	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.002**
Rhizophora mucronata	**0.3**	**0.9**	**0.1**	**0.42**	**0.44**	**0.42**	**0.1**	**0.08**	**0.14**	**0.322**
Aegiceras corniculatum	**0**	**0.04**	**0**	**0**	**0**	**0**	**0.02**	**0.08**	**0.02**	**0.018**
Premna serratifolia	0	0.04	0.12	0	0.06	0	0	0.06	0	0.031
Derris trifoliata	0	0.2	0.04	0	0	0.02	0	0.02	0.04	0.036
Acanthus ilicifolius	0.16	0.04	0.6	0.04	0	0.32	0.26	0.1	0.34	0.207
Acrostichum aureum	0.52	0.4	0.12	0.54	0.26	0.16	0.6	0.4	0.44	0.382
Caesalpinia bonduc	0.1	0.36	0.22	0.08	0.08	0.12	0.08	0.08	0.24	0.151
Terminalia arjuna	0	0.02	0	0	0	0	0	0	0	0.002

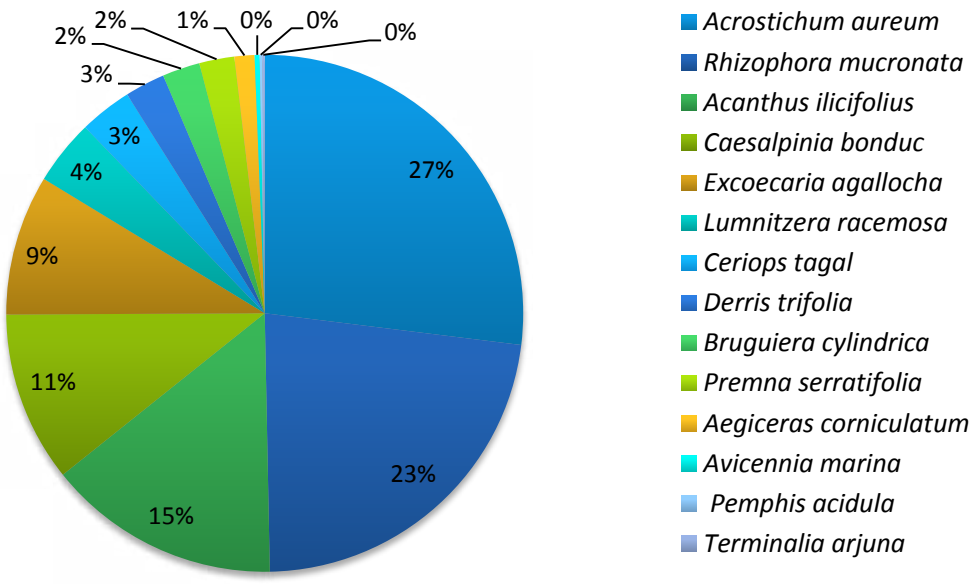


Figure 70 Pie chart indicating the percentage of true mangrove & mangrove associates (L 4)

Table 34 Species Richness Indices (L 4)

Margalef Species Richness Index	Shannon Wiener Index
1.6673	1.6637

Location 05

Figure 71 Satellite images of the sampling station 05

indicates the location with longitude and latitude. Location 5 was open to sea at the river mouth. Table 35 provides the species found in each transect. A total of six 50 m transects were laid. Table 35 provides the density of each species and the desity data were depeicted as a percentage in Figure 72. *Avicennia marina* was the plant with highest density in this location. The Margalef and Shannon Wiener species richness diversity indices were 1.4319 and 1.3011 respectively (Table 377).

Table 35 Recorded true mangrove and mangrove associate species (Transect – 100 m to the forest)

Species	Transect 01 (50 m)				Transect 02 (50 m)		
	1	2	3	4*	1	2	3
Avicennia marina	**4**	**12**	**12**	**33**	**21**	**7**	**21**
Avicennia officinalis	**3**		**3**	**3**			
Bruguiera cylindrica		**1**		**1**	**2**		
Bruguiera gymnorrhiza				**2**			
Ceriops tagal		**1**	**5**	**3**	**5**	**1**	**7**
Excoecaria agallocha	**16**	**7**	**9**	**6**	**11**		**3**
Lumnitzera racemosa	**5**	**3**		**5**	**8**	**2**	
Pemphis acidula	**21**			**1**	**8**		
Rhizophora apiculata				**3**			
Rhizophora mucronata	**12**		**2**	**10**	**4**	**12**	**12**
Aegiceras corniculatum	**2**			**1**			
Thespesia populnea		2					

Species	Transect 01 (50 m)				Transect 02 (50 m)		
	1	2	3	4*	1	2	3
Premna serratifolia	7		3	5		3	5
Azima tetracantha			3				

*numbers for 100 m

Table 36 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m^{-2})				Density (m^{-2})			Mean Density (m^{-2})
	1	**2**	**3**	**4**	**1**	**2**	**3**	
Avicennia marina	**0.08**	**0.24**	**0.24**	**0.33**	**0.42**	**0.14**	**0.42**	**0.267**
Avicennia officinalis	**0.06**	**0**	**0.06**	**0.03**	**0**	**0**	**0**	**0.021**
Bruguiera cylindrical	**0**	**0.02**	**0**	**0.01**	**0.04**	**0**	**0**	**0.010**
Bruguiera gymnorrhiza	**0**	**0**	**0**	**0.02**	**0**	**0**	**0**	**0.003**
Ceriops tagal	**0**	**0.02**	**0.1**	**0.03**	**0.1**	**0.02**	**0.14**	**0.059**
Excoecaria agallocha	**0.32**	**0.14**	**0.18**	**0.06**	**0.22**	**0**	**0.06**	**0.140**
Lumnitzera racemosa	**0.1**	**0.06**	**0**	**0.05**	**0.16**	**0.04**	**0**	**0.059**
Pemphis acidula	**0.42**	**0**	**0**	**0.01**	**0.16**	**0**	**0**	**0.084**
Rhizophora apiculata	**0**	**0**	**0**	**0.03**	**0**	**0**	**0**	**0.004**
Rhizophora mucronata	**0.24**	**0**	**0.04**	**0.1**	**0.08**	**0.24**	**0.24**	**0.134**
Aegiceras corniculatum	**0.04**	**0**	**0**	**0.01**	**0**	**0**	**0**	**0.007**
Thespesia populnea	0	0.04	0	0	0	0	0	0.006
Premna serratifolia	0.14	0	0.06	0.05	0	0.06	0.1	0.059
Azima tetracantha	0	0	0.06	0	0	0	0	0.009

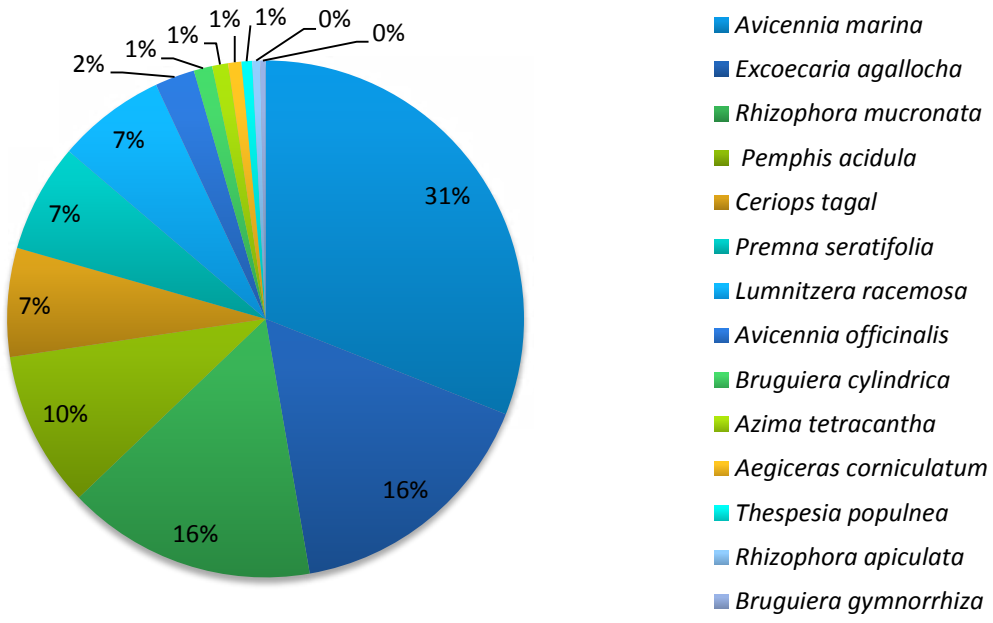


Figure 72 Pie chart indicating the percentage of true mangrove & mangrove associates (L 5)

Table 37 Species Richness Indices (L 5)

Margalef Species Richness Index	Shannon Wiener Index
1.4319	1.3011

Location 06

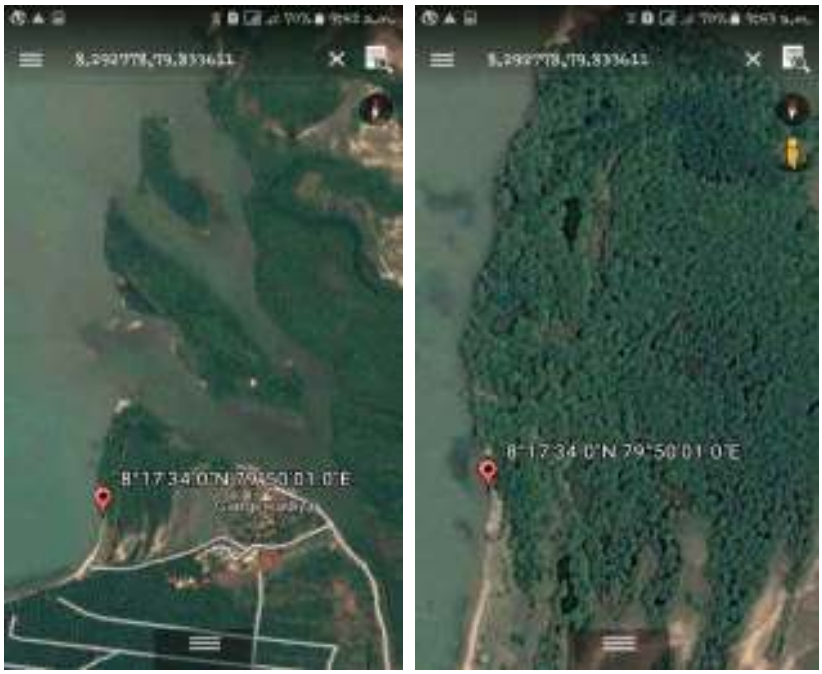


Figure 73 Satellite images of the sampling station 06

Figure 73 indicates the location with longitude and latitude. Location 6 was open to sea. Table 388 provides the species found in each transect. A total of twenty-five 50 m transects were laid. Table 39 provides the density of each species and the desity data are depeicted as a percentage in Figure 67. *Avicennia marina* was the plant with highest density in this location. The Margalef and Shannon Wiener species richness indices were 0.1609 and 0.2134 respectively (Table 40).

Table 38 Recorded true mangrove and mangrove associate species (Transect – 285 m to the forest)

Species	Transect 01 (50 m)					Transect 02 (50 m)					Transect 03 (50 m)					Transect 04(50 m)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Avicennia marina	43	23	19	34	21	24	17	25	38	37	31	31	41	34	32	34	15	29	14	36
Avicennia officinalis		4																		
Bruguiera gymnorrhiza	1																			
Ceriops tagal	1																			
Excoecaria agallocha	17	1		16		5														
Lumnitzera racemosa	4	4	21	6	7	9														
Aegiceras corniculatum	1																			
Premna serratifolia				1																

Species	Transect 05 (50 m)					Transect 06 (35 m)
	1	**2**	**3**	**4**	**5**	**1**
Avicennia marina	**25**	**16**	**23**	**68**	**17**	**11**
Avicennia officinalis						
Bruguiera gymnorrhiza						
Ceriops tagal						
Excoecaria agallocha						
Lumnitzera racemosa						**32**
Aegiceras corniculatum						
Premna serratifolia						

Table 39 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m^{-2})					Density (m^{-2})					Density (m^{-2})				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Avicennia marina	**0.86**	**0.5**	**0.4**	**0.7**	**0.42**	**0.48**	**0.5**	**0**	**0.5**	**0.76**	**0.74**	**0.6**	**0.6**	**0.6**	**0.8**
Avicennia officinalis	**0**	**0.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Bruguiera gymnorrhiza	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Ceriops tagal	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Excoecaria agallocha	**0.34**	**0**	**0**	**0.3**	**0**	**0.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Lumnitzera racemosa	**0.08**	**0.1**	**0.4**	**0.1**	**0.14**	**0.18**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Aegiceras corniculatum	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Premna serratifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Species	Density (m^{-2})					Density (m^{-2})					Density (m^{2})	Mean Density (m^{2})
	1	2	3	4	5	1	2	3	4	5	1	
Avicennia marina	**0.68**	**0.6**	**0.7**	**0.7**	**0.3**	**0.58**	**0.3**	**1**	**0.5**	**0.32**	**0.31**	**0.557**
Avicennia officinalis	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.003**
Bruguiera gymnorrhiza	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.001**
Ceriops tagal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.034**
Excoecaria agallocha	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.081**
Lumnitzera racemosa	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.91**	**0.001**
Aegiceras	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.001**

Species	Density (m^{-2})					Density (m^{-2})					Density (m^2)	Mean Density (m^2)
	1	2	3	4	5	1	2	3	4	5	1	
corniculatum												
Premna serratifolia	0	0	0	0	0	0	0	0	0	0	0	0.001

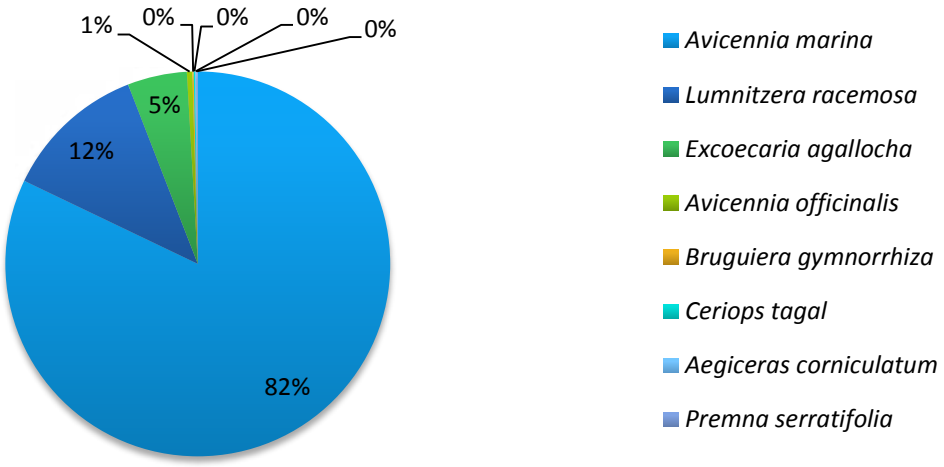


Figure 74 Pie chart indicating the percentage of true mangrove & mangrove associates (L 6)

Table 40 Species Richness Indices (L 6)

Margalef Species Richness Index	Shannon Wiener Index
0.1609	0.2134

Location 07

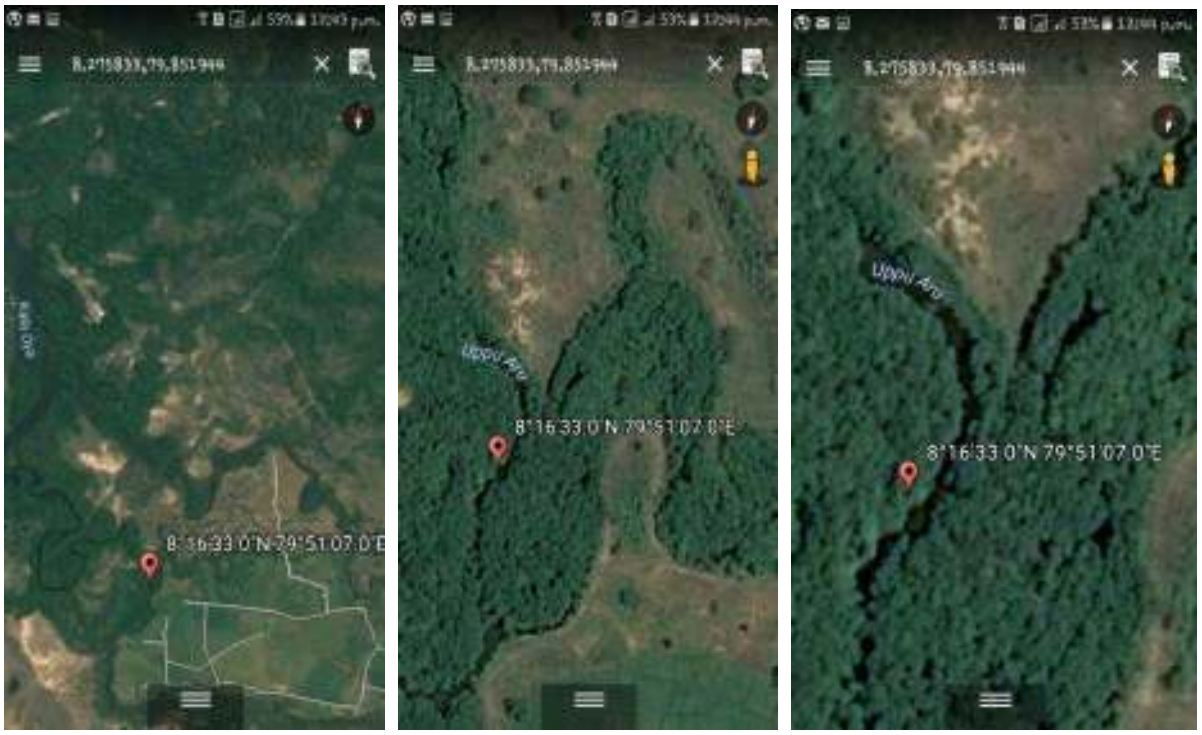


Figure 75 Satellite images of the sampling station 07

Figure 75 indicates the location with longitude and latitude. Location 7 was open to Uppu Aru (Lunu oya). Table 41 provides the species found in each transect. A total of three 50 m transects were laid. Table 42 provides the density of each species and the desity data were depeicted as a percentage in Figure 76. *Acanthus ilicifolius* was the plant with highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.6237 and 1.4378 respectively (Table 43).

Table 41 Recorded true mangrove and mangrove associate species (Transect – 50 m to the forest)

Species	Transect 01 (50 m)

	1	2	3
Avicennia marina	1		7
Bruguiera cylindrica	1	3	
Bruguiera gymnorrhiza			1
Excoecaria agallocha	5	21	11
Lumnitzera racemosa	1		
Rhizophora mucronata	5	6	
Thespesia populnea		1	
Premna serratifolia	4	1	4
Azima tetracantha	6		
Acanthus ilicifolius	68	37	
Acrostichum aureum	12	39	17
Phoenix zeylanica	1	1	
Mikania micrantha		20	
Azadirachta indica		1	

Table 42 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m-2)			Mean Density (m-2)
	1	2	3	
Avicennia marina	0.02	0	0.14	0.053
Bruguiera cylindrica	0.02	0.06	0	0.027
Bruguiera gymnorrhiza	0	0	0.02	0.007
Excoecaria agallocha	0.1	0.42	0.22	0.247
Lumnitzera racemosa	0.02	0	0	0.007
Rhizophora mucronata	0.1	0.12	0	0.073
Thespesia populnea	0	0.02	0	0.007
Premna serratifolia	0.08	0.02	0.08	0.060
Azima tetracantha	0.12	0	0	0.040
Acanthus ilicifolius	1.36	0.74	0	0.700
Acrostichum aureum	0.24	0.78	0.34	0.453
Phoenix zeylanica	0.02	0.02	0	0.013
Mikania micrantha	0	0.4	0	0.133
Azadirachta indica	0	0.02	0	0.007

Figure 76 Pie chart indicating the percentage of true mangrove & mangrove associates (L 7)

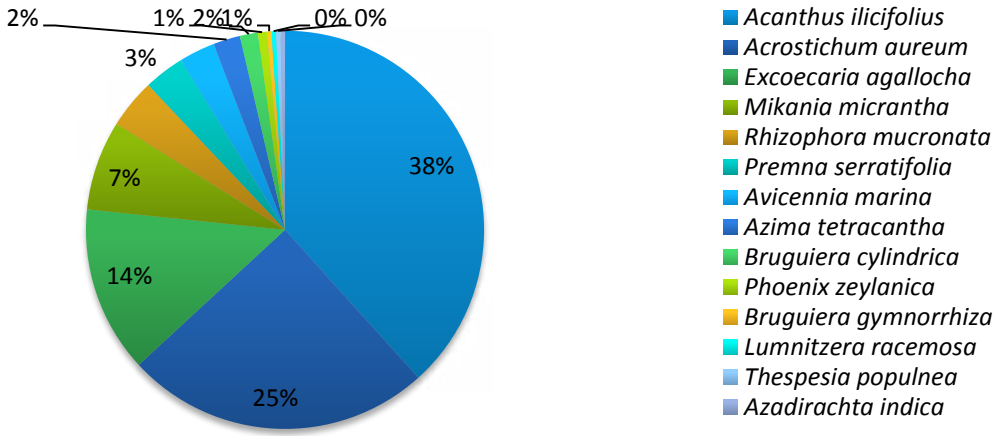


Table 43 Species Richness Indices (L 7)

Margalef Species Richness Index	Shannon Wiener Index
1.6237	1.4378

Location 08

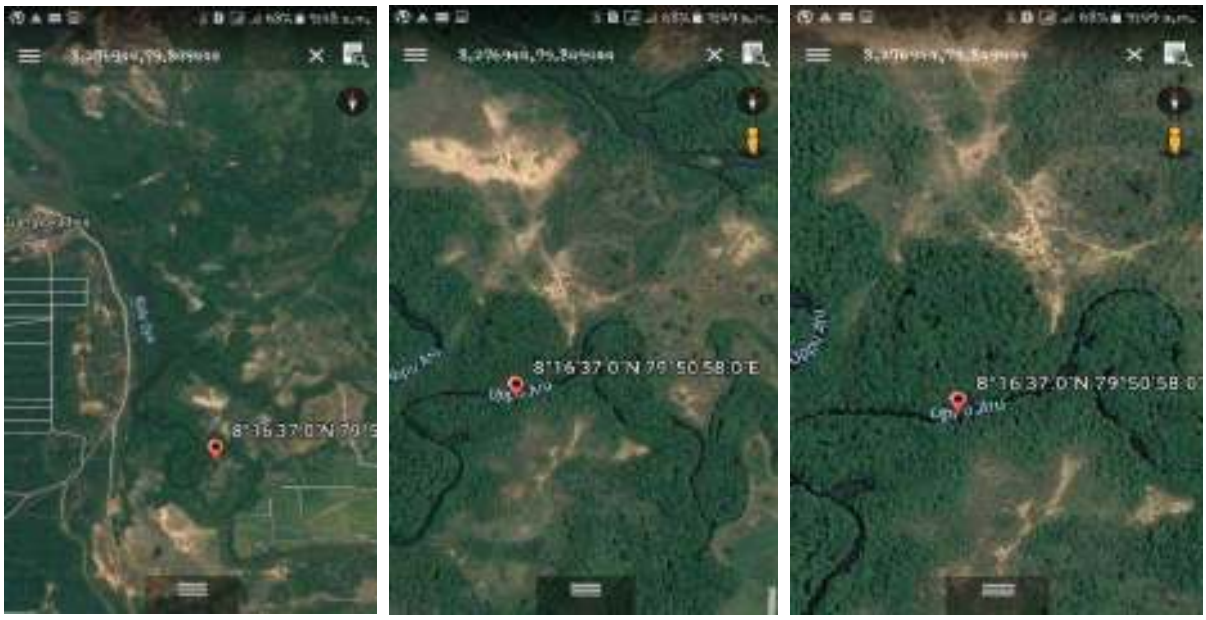


Figure 77 Satellite images of the sampling station 08

Figure 77 indicates the location with longitude and latitude. Location 8 was open to Uppu Aru (Lunu Oya). Table 45 provides the species found in each transect. A total of five 50 m transects were laid. Table 46 provides the density of each species and the desity data were depeicted as a percentage in Figure 70. *Acrostichum aureum* was the plant with highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.8647 and 1.7116 respectively (Table 47).

Table 44 Recorded true mangrove and mangrove associate species (Transect – 50 m to the forest)

Species	Transect 01 (50 m)				
	1	2	3	4	5
Avicennia marina					2
Bruguiera cylindrica	4	9	3	1	
Bruguiera gymnorrhiza					10
Excoecaria agallocha	3	8	8	5	24
Lumnitzera racemosa				1	
Rhizophora mucronata	15	2	4	9	14
Thespesia populnea		2			
Premna serratifolia	5	7	10	2	4
Clerodendrum inerme					1
Derris trifoliata	1	5	2		
Acanthus ilicifolius		21	42		
Acrostichum aureum	27	31	16	16	40
Terminalia arjuna	2	6	3		1
Phoenix zeylanica	1		1		
Mikania micrantha		11	11		25
Azadirachta indica		1			
Ficus hispida			4		
Unknown grass			60		
Lantana camara					3

Table 45 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m-2)					Mean Density (m2)
	1	2	3	4	5	
Avicennia marina	0	0	0	0	0.04	0.008
Bruguiera cylindrica	0.08	0.18	0.06	0.02	0	0.068
Bruguiera gymnorrhiza	0	0	0	0	0.2	0.040
Excoecaria agallocha	0.06	0.16	0.16	0.1	0.48	0.192
Lumnitzera racemosa	0	0	0	0.02	0	0.004
Rhizophora mucronata	0.3	0.04	0.08	0.18	0.28	0.176
Thespesia populnea	0	0.04	0	0	0	0.008
Premna serratifolia	0.1	0.14	0.2	0.04	0.08	0.112
Clerodendrum inerme	0	0	0	0	0.02	0.004
Derris trifoliata	0.02	0.1	0.04	0	0	0.032
Acanthus ilicifolius	0	0.42	0.84	0	0	0.252
Acrostichum aureum	0.54	0.62	0.32	0.32	0.8	0.520
Terminalia arjuna	0.04	0.12	0.06	0	0.02	0.048
Phoenix zeylanica	0.02	0	0.02	0	0	0.008
Mikania micrantha	0	0.22	0.22	0	0.5	0.188
Azadirachta indica	0	0.02	0	0	0	0.004
Ficus hispida	0	0	0.08	0	0	0.016
Unknown grass	0	0	1.2	0	0	0.240
Lantana camara	0	0	0	0	0.06	0.012

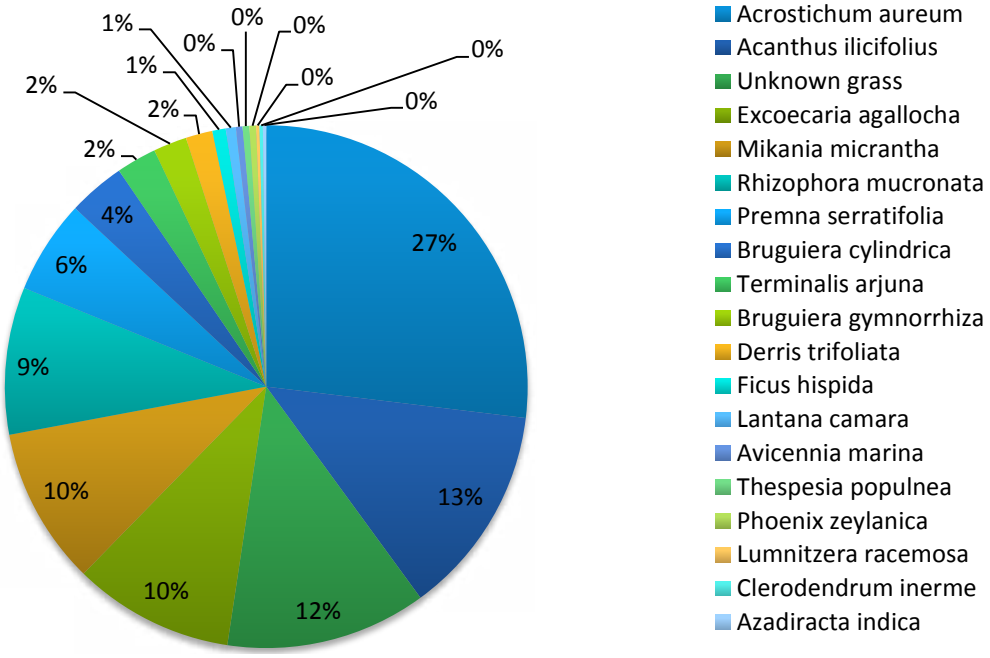


Figure 78 Pie chart indicating the percentage of true mangrove & mangrove associates (L 8)

Table 46 Species Richness Indices (L 8)

Margalef Species Richness Index	Shannon Wiener Index
1.8647	1.7116

Location 09

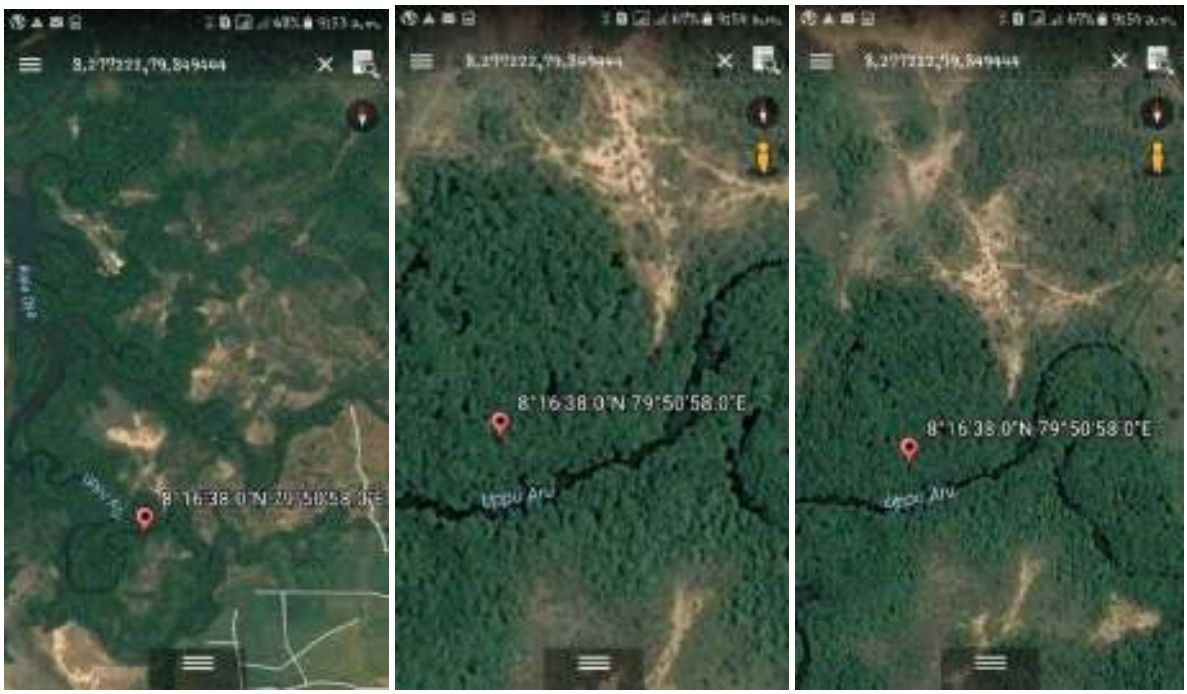


Figure 79 Satellite images of the sampling station 09

Figure 79 indicates the location with longitude and latitude. Location 9 was open to Uppu Aru (Lunu Oya). Table 48 provides the species found in each transect. A total of ten 50 m transects were laid. Table 49 provides the density of each species and the desity data were depeicted as a

percentage in Figure 80. *Acrostichum aureum* was the plant with highest density in this location. The Margalef and Shannon Wiener species richness indices were 0.9947 and 1.0181 respectively (Table 50).

Table 47 Recorded true mangrove and mangrove associate species (Transect – 100 m to the forest)

Species	Transect 01 (50 m)					Transect 02 (50 m)				
	1	2	3	4	5	1	2	3	4	5
Avicennia marina						1				
Avicennia officinalis		2			8	3	2		1	2
Bruguiera cylindrica	20	5	10	10		25	11	11		15
Bruguiera gymnorrhiza					5					6
Lumnitzera racemosa	2					2				
Pemphis acidula			3							
Rhizophora mucronata	8	2	3	3	4					4
Aegiceras corniculatum			3							
Thespesia populnea							4			1
Clerodendrum inerme							2			
Azima tetracantha										6
Premna serratifolia	1	4			2					
Acrostichum aureum	25	30	18	33			11	5		
Caesalpinia bonduc			2					6		1
Mikania micrantha			2		68					2
Crinum asiaticum					1					

Table 48 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m-2)					Density (m-2)					Mean Density (m-2)
	1	2	3	4	5	1	2	3	4	5	
Avicennia marina	0	0	0	0	0	0.02	0	0	0	0	0.002
Avicennia officinalis	0	0.04	0	0	0.16	0.06	0.04	0	0.02	0.04	0.036
Bruguiera cylindrica	0.4	0.1	0.2	0.2	0	0.5	0.22	0.22	0	0.3	0.214
Bruguiera gymnorrhiza	0	0	0	0	0.1	0	0	0	0	0.12	0.022
Lumnitzera racemosa	0.04	0	0	0	0	0.04	0	0	0	0	0.008
Pemphis acidula	0	0	0.06	0	0	0	0	0	0	0	0.006
Rhizophora mucronata	0.16	0.04	0.06	0.06	0.08	0	0	0	0	0.08	0.048
Aegiceras corniculatum	0	0	0.06	0	0	0	0	0	0	0	0.006
Thespesia populnea	0	0	0	0	0	0	0.08	0	0	0.02	0.010
Clerodendrum inerme	0	0	0	0	0	0	0.04	0	0	0	0.004
Azima tetracantha	0	0	0	0	0	0	0	0	0	0.12	0.012
Premna serratifolia	0.02	0.08	0	0	0.04	0	0	0	0	0	0.014
Acrostichum aureum	0.5	0.6	0.36	0.66	0	0	0.22	0.1	0	0	0.244
Caesalpinia bonduc	0	0	0.04	0	0	0	0	0.12	0	0.02	0.018
Mikania micrantha	0	0	0.04	0	1.36	0	0	0	0	0.04	0.144
Crinum asiaticum	0	0	0	0	0.02	0	0	0	0	0	0.002

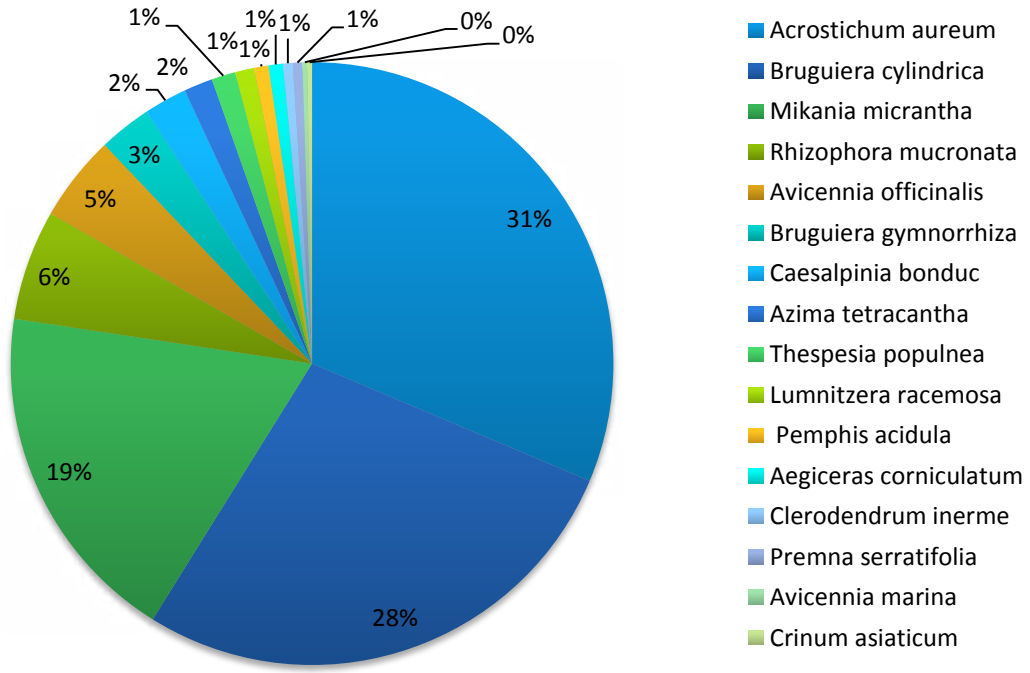


Figure 80 Pie chart indicating the percentage of true mangrove & mangrove associates (L 9)

Table 49 Species Richness Indices (L 9)

Margalef Species Richness Index	Shannon Wiener Index
0.9947	1.0181

Location 10

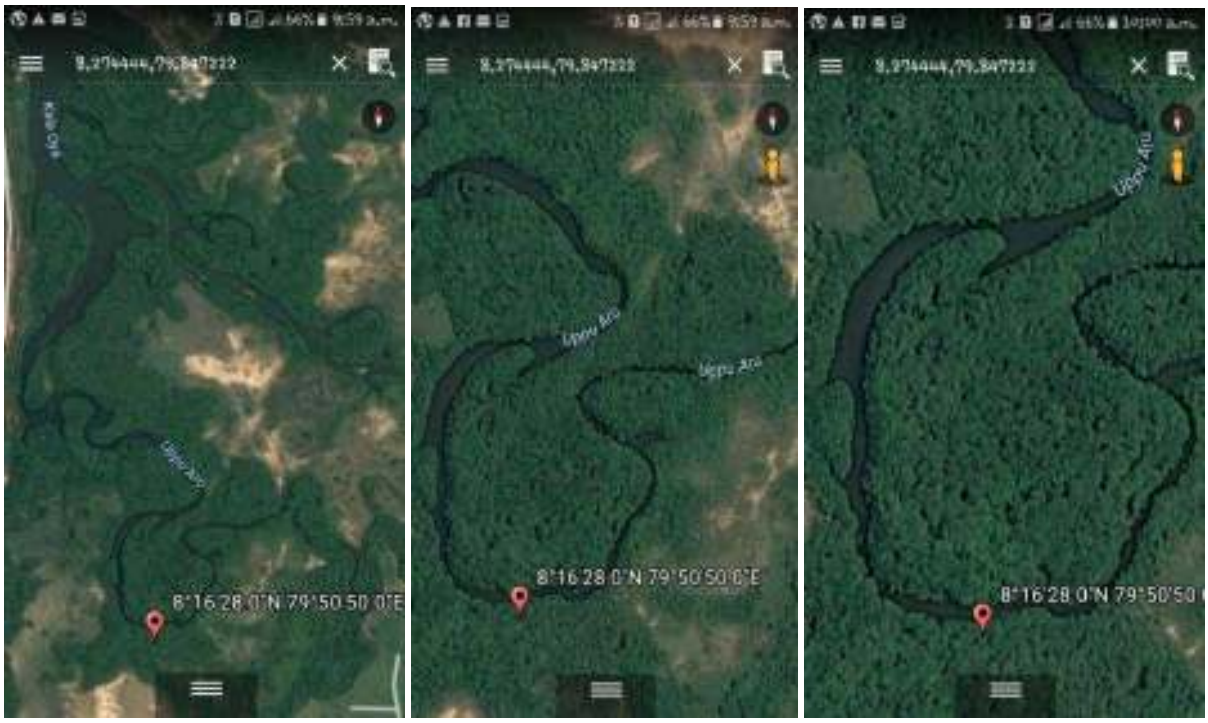


Figure 81 Satellite images of the sampling station 10

Figure 81 indicates the location with longitude and latitude. Location 10 was open to Uppu Aru (Lunu Oya). Table 51 provides the species found in each transect. A total of five 50 m transects were laid. Table 52 provides the density of each species and the desity data were depeicted as a percentage in Figure 82. *Bruguiera cylindrica* was the plant with highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.3073 and 1.3576 respectively (Table 53).

Table 50 Recorded true mangrove and mangrove associate species (Transect – 50 m to the forest)

Species	Transect 01 (50 m)				
	1	2	3	4	5
Avicennia marina		12		1	
Bruguiera cylindrica	8	20	7	89	10
Excoecaria agallocha	7	18	5	5	2
Lumnitzera racemosa		2		1	
Pemphis acidula				1	
Aegiceras corniculatum	1		1		
Thespesia populnea		3		4	3
Premna serratifolia	5				
Azima tetracantha		11	11	22	13
Acanthus ilicifolius	35				
Acrostichum aureum	18	5	20		
Suaeda monoica		3			

Species	Transect 01 (50 m)				
	1	2	3	4	5
Phoenix zeylanica			1		
Mikania micrantha					1

Table 51 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m-2)					Mean Density (m-2)
	1	2	3	4	5	
Avicennia marina	0	0.24	0	0.02	0	0.052
Bruguiera cylindrica	0.16	0.4	0.14	1.78	0.2	0.536
Excoecaria agallocha	0.14	0.36	0.1	0.1	0.04	0.148
Lumnitzera racemosa	0	0.04	0	0.02	0	0.012
Pemphis acidula	0	0	0	0.02	0	0.004
Aegiceras corniculatum	0.02	0	0.02	0	0	0.008
Thespesia populnea	0	0.06	0	0.08	0.06	0.040
Premna serratifolia	0.1	0	0	0	0	0.020
Azima tetracantha	0	0.22	0.22	0.44	0.26	0.228
Acanthus ilicifolius	0.7	0	0	0	0	0.140
Acrostichum aureum	0.36	0.1	0.4	0	0	0.172
Suaeda monoica	0	0.06	0	0	0	0.012
Phoenix zeylanica	0	0	0.02	0	0	0.004
Mikania micrantha	0	0	0	0	0.02	0.004

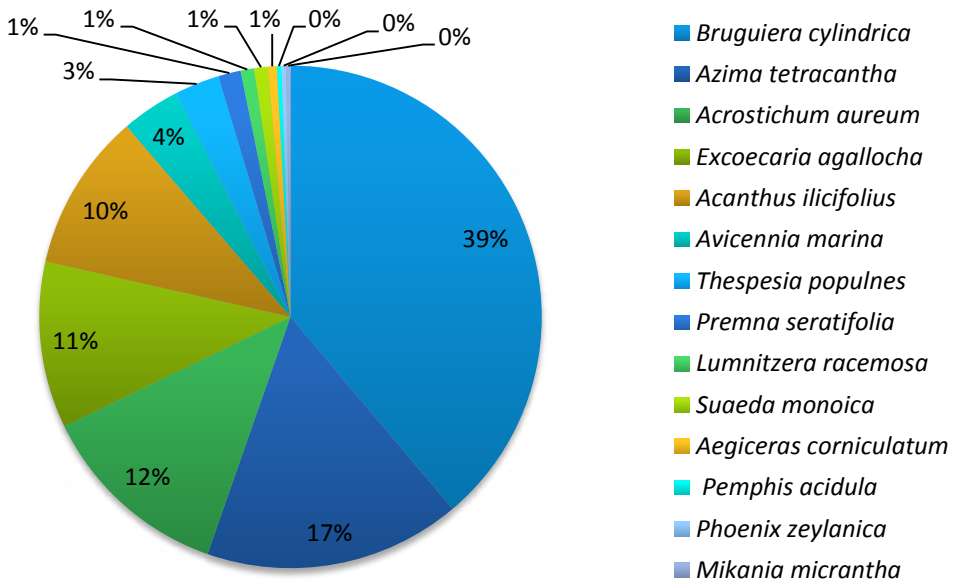


Figure 82 Pie chart indicating the percentage of true mangrove & mangrove associates (L 10)

Table 52 Species Richness Indices (L 10)

Margalef Species Richness Index	Shannon Wiener Index
1.3073	1.3576

Location 11

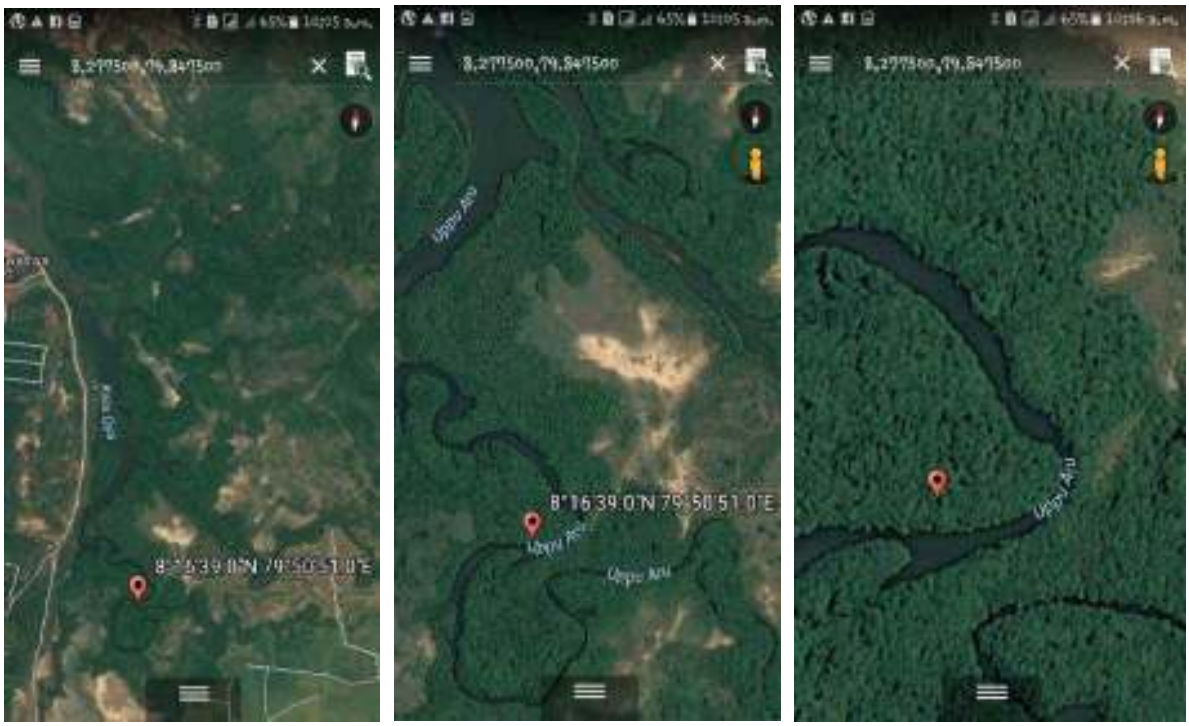


Figure 83 Satellite images of the sampling station 11

Figure 83 indicates the location with longitude and latitude. Location 11 was open to Uppu Aru (Lunu oya). Table 54 provides the species found in each transect. A total of six 50 m transects were laid. Table 55 provides the density of each species and the desity data were depeicted as a percentage in Figure 84. *Acanthus ilicifolius* was the plant with highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.2435 and 1.269 respectively (Table 56).

Table 53 Recorded true mangrove and mangrove associate species (Transect – 50 m to the forest)

Species	Transect 01 (50 m)					
	1	2	3	4	5	6
Avicennia marina				1		
Avicennia officinalis	1				2	
Bruguiera cylindrica	12	37	37	13	14	6
Excoecaria agallocha	9	22	1	13	9	6
Lumnitzera racemosa	1			2		
Pemphis acidula			1			
Rhizophora mucronata	7	1	6	7	6	4
Aegiceras corniculatum			2			
Premna serratifolia	1	14		12		4
Acanthus ilicifolius	18	33	154		100	197
Acrostichum aureum	28	15	20	54	74	23
Caesalpinia bonduc		5				1
Phoenix zeylanica			1			

Table 54 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m2)						Mean Density (m-2)
	1	2	3	4	5	6	
Avicennia marina	0	0	0	0.02	0	0	0.003
Avicennia officinalis	0.02	0	0	0	0.04	0	0.010
Bruguiera cylindrica	0.24	0.74	0.74	0.26	0.28	0.12	0.397
Excoecaria agallocha	0.18	0.44	0.02	0.26	0.18	0.12	0.200
Lumnitzera racemosa	0.02	0	0	0.04	0	0	0.01
Pemphis acidula	0	0	0.02	0	0	0	0.003
Rhizophora mucronata	0.14	0.02	0.12	0.14	0.12	0.08	0.103
Aegiceras corniculatum	0	0	0.04	0	0	0	0.007
Premna serratifolia	0.02	0.28	0	0.24	0	0.08	0.103
Acanthus ilicifolius	0.36	0.66	3.08	0	2	3.94	1.673
Acrostichum aureum	0.56	0.3	0.4	1.08	1.48	0.46	0.713
Caesalpinia bonduc	0	0.1	0	0	0	0.02	0.020
Phoenix zeylanica	0	0	0.02	0	0	0	0.003

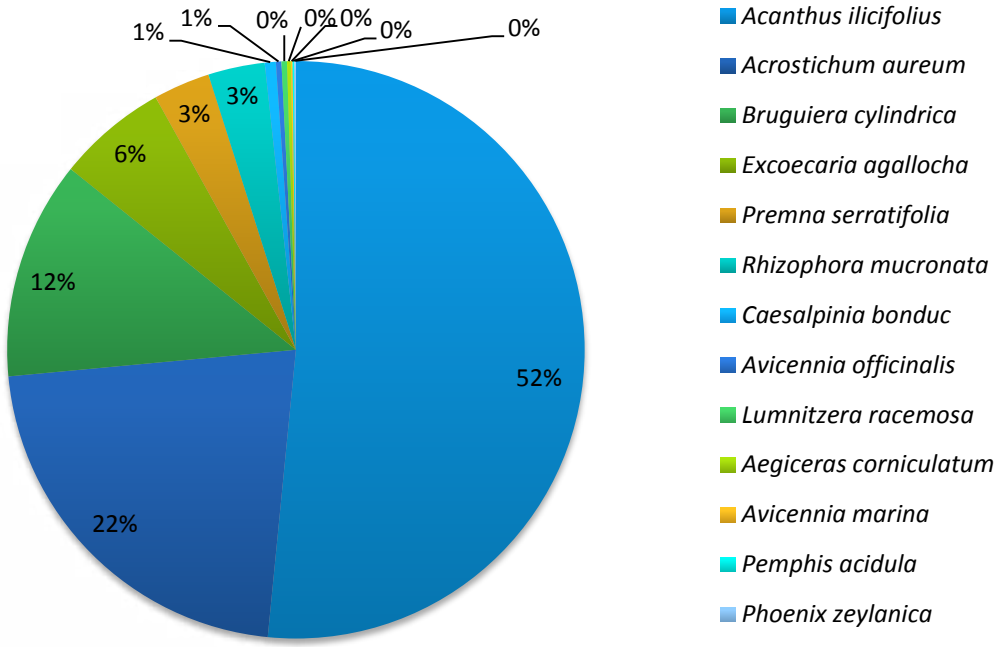


Figure 84 Pie chart indicating the percentage of true mangrove & mangrove associates (L 11)

Table 55 Species Richness Indices (L 11)

Margalef Species Richness Index	Shannon Wiener Index
1.2437	1.269

Location 12

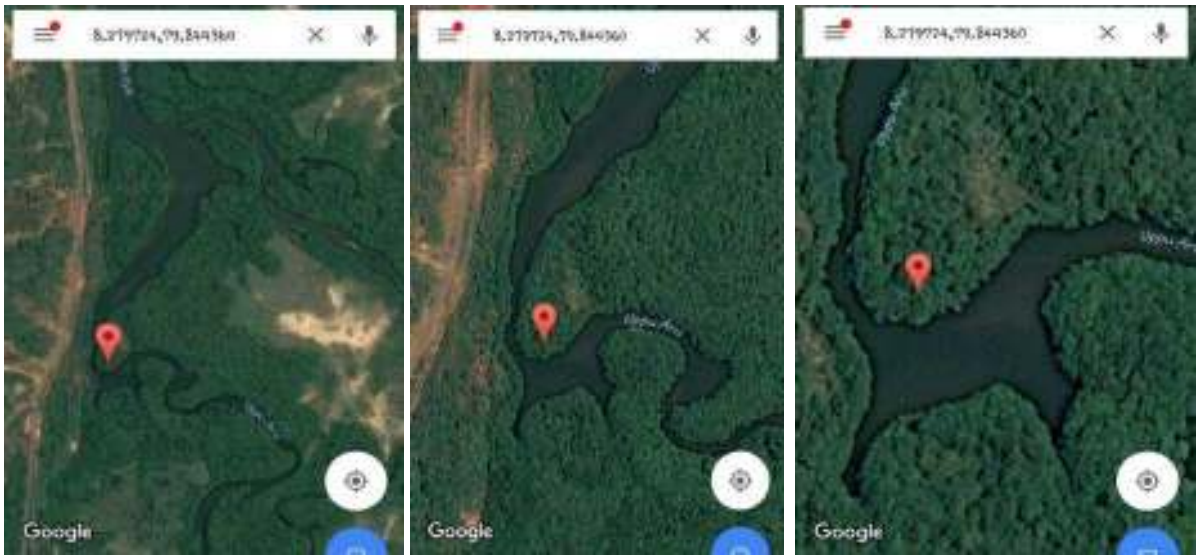


Figure 85 Satellite images of the sampling station 12

Figure 85 indicates the location with longitude and latitude. Location 12 was open to Uppu Aru (Lunu Oya). Table 57 provides the species found in each transect. A total of two 50 m transects were laid. Table 58 provides the density of each species and the density data were depicted as a percentage in Figure 86. *Acrostichum aureum* was the plant with highest density in this location. The Margalef and Shannon Wiener species richness diversity indices were 1.7639 and 1.3239 respectively (Table 59).

Table 56 Recorded true mangrove and mangrove associate species (Transect – 50 m to the forest)

Species	Transect 01 (50 m)	
	1	2
Avicennia officinalis		3
Bruguiera cylindrica	15	8
Bruguiera gymnorrhiza		1
Ceriops tagal	2	3
Excoecaria agallocha	66	
Lumnitzera racemosa	6	7
Rhizophora apiculata	10	4
Rhizophora mucronata	70	8
Thespesia populnea	2	
Premna serratifolia	4	3
Azima tetracantha		2
Acrostichum aureum	8	106
Terminalia arjuna	2	
Dolichandrone spathacea	1	

Table 57 Densities of true mangrove and mangrove associate species in each transect

	Density (m-2)		Mean Density (m-2)
	1	2	
Avicennia officinalis	0	0.06	0.03
Bruguiera cylindrica	0.3	0.16	0.23
Bruguiera gymnorrhiza	0	0.02	0.01
Ceriops tagal	0.04	0.06	0.05
Excoecaria agallocha	1.32	0	0.66
Lumnitzera racemosa	0.12	0.14	0.13
Rhizophora apiculata	0.2	0.08	0.14
Rhizophora mucronata	1.4	0.16	0.78
Thespesia populnea	0.04	0	0.02
Premna serratifolia	0.08	0.06	0.07
Azima tetracantha	0	0.04	0.02
Acrostichum aureum	0.16	2.12	1.14
Terminalia arjuna	0.04	0	0.02
Dolichandrone spathacea	0.02	0	0.01

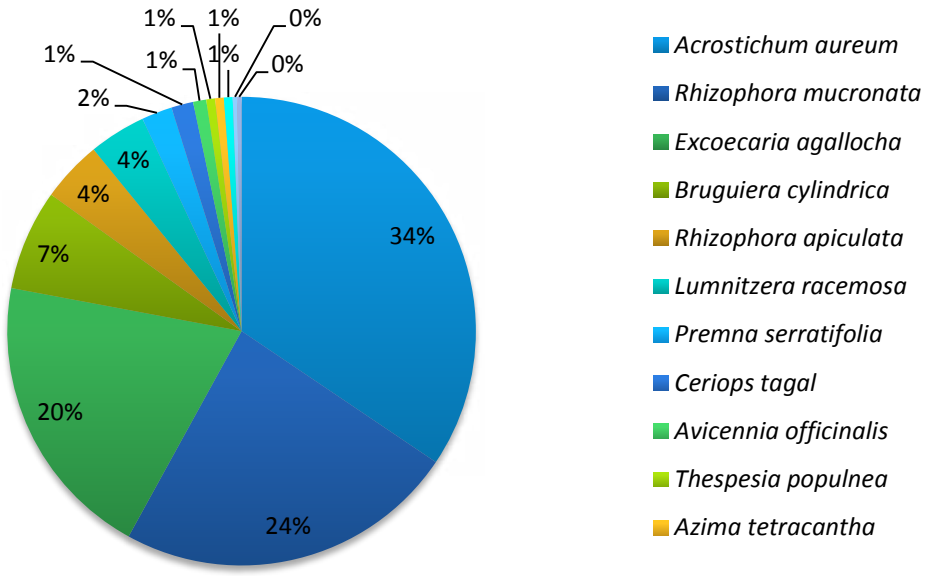


Figure 86 Pie chart indicating the percentage of true mangrove & mangrove associates (L 12)

Table 58 Species Richness Indices (L 12)

Margalef Species Richness Index	Shannon Wiener Index
1.7639	1.3239

Location 13

Figure 87 Sampling station 13

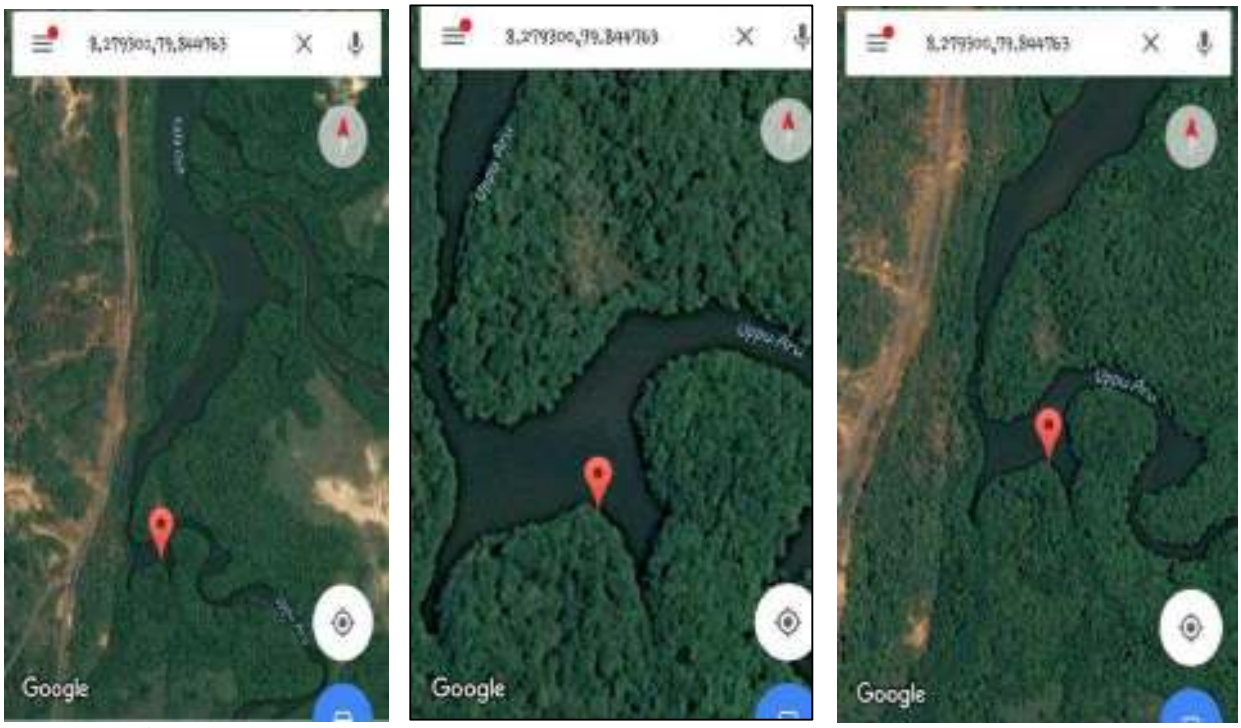


Figure 88 Satellite images of the sampling station 13

Figure 87 indicates the typical mangal composition of site 13. Figure 88 indicates the location with longitude and latitude. Location 13 was open to Uppu Aru (Lunu Oya). Table 59 provides the species found in each transect. One 50 m transect was laid. Table 60 provides the density of each species and the desity data were depicted as a percentage in Figure 89. *Rhizophora mucronata*

was the plant with the the highest density in this location. The Margalef and Shannon Wiener species richness diversity indices were 1.0448 and 1.3704 respectively (Table 61).

Table 59 Recorded true mangrove and mangrove associate species (Transect – 50 m to the forest)

Species	Transect 01 (50 m)
Bruguiera cylindrica	10
Bruguiera gymnorrhiza	2
Excoecaria agallocha	13
Rhizophora mucronata	18
Acrostichum aureum	3

Table 60 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m^{-2})
Bruguiera cylindrica	0.2
Bruguiera gymnorrhiza	0.04
Excoecaria agallocha	0.26
Rhizophora mucronata	0.36
Acrostichum aureum	0.06

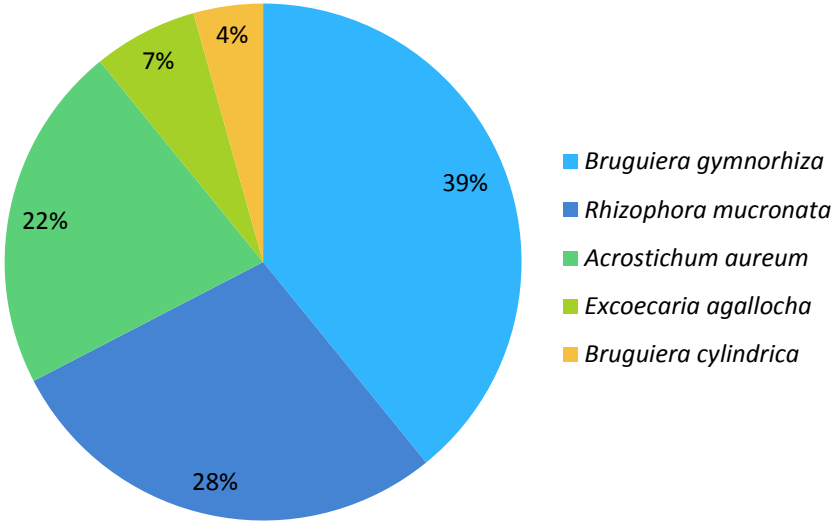


Figure 89 Pie chart indicating the percentage of true mangrove and mangrove associates (L 13)

Table 61 Species Richness Indices (L 13)

Margalef Species Richness Index	Shannon Wiener Index
1.0448	1.3704

Location 14

Figure 90 Sampling station 14

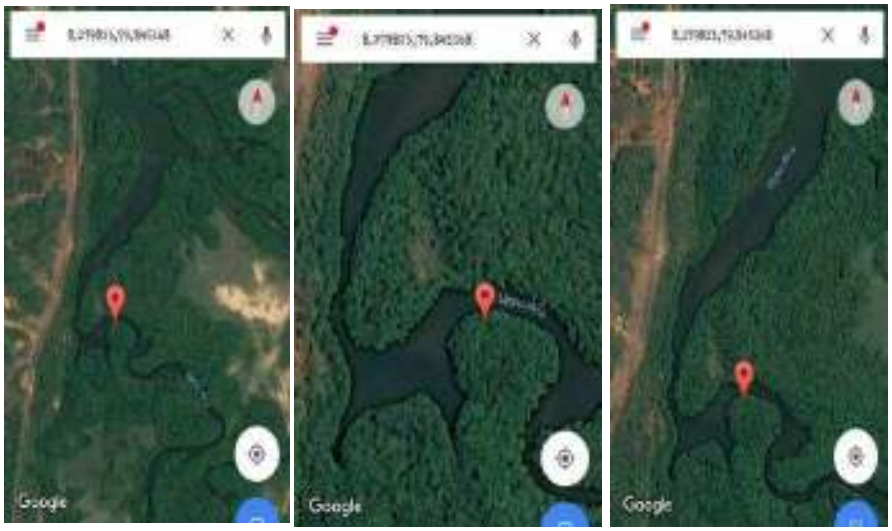


Figure 91 Satellite images of the sampling station 14

Figure 90 indicates the typical mangal composition of site 14. Figure 91 indicates the location with longitude and latitude. Location 14 was open to Uppu Aru (Lunu Oya). Table 62 provides the species found in each transect. One 50 m transect was laid. Table 63 provides the density of each species and the desity data were depicted as a percentage in Figure 92. *Acanthus ilicifolius* was the plant with the the highest density in this location. The Margalef and Shannon Wiener species richness diversity indices were 1.4627 and 1.5594 respectively (Table 44).

Table 62 Recorded true mangrove and mangrove associate species (Transect – 50 m to the forest)

Species	Transect 01 (50 m)	
	1	2
Avicennia marina	13	33
Bruguiera cylindrica	11	5
Bruguiera gymnorrhiza		17
Ceriops tagal	4	10
Excoecaria agallocha	5	2
Lumnitzera racemosa		3
Rhizophora mucronata	5	13
Aegiceras corniculatum	8	6
Acanthus ilicifolius	80	114
Acrostichum aureum	57	93

Table 63 Densities of true mangrove and mangrove associate species in each transect

Species	Density (m^{-2})		Mean Density (m^{-2})
	1	2	
Avicennia marina	0.26	0.66	0.46
Bruguiera cylindrica	0.22	0.1	0.16
Bruguiera gymnorrhiza	0	0.34	0.17
Ceriops tagal	0.08	0.2	0.14
Excoecaria agallocha	0.1	0.04	0.07
Lumnitzera racemosa	0	0.06	0.03
Rhizophora mucronata	0.1	0.26	0.18
Aegiceras corniculatum	0.16	0.12	0.14
Acanthus ilicifolius	1.6	2.28	1.94
Acrostichum aureum	1.14	1.86	1.50

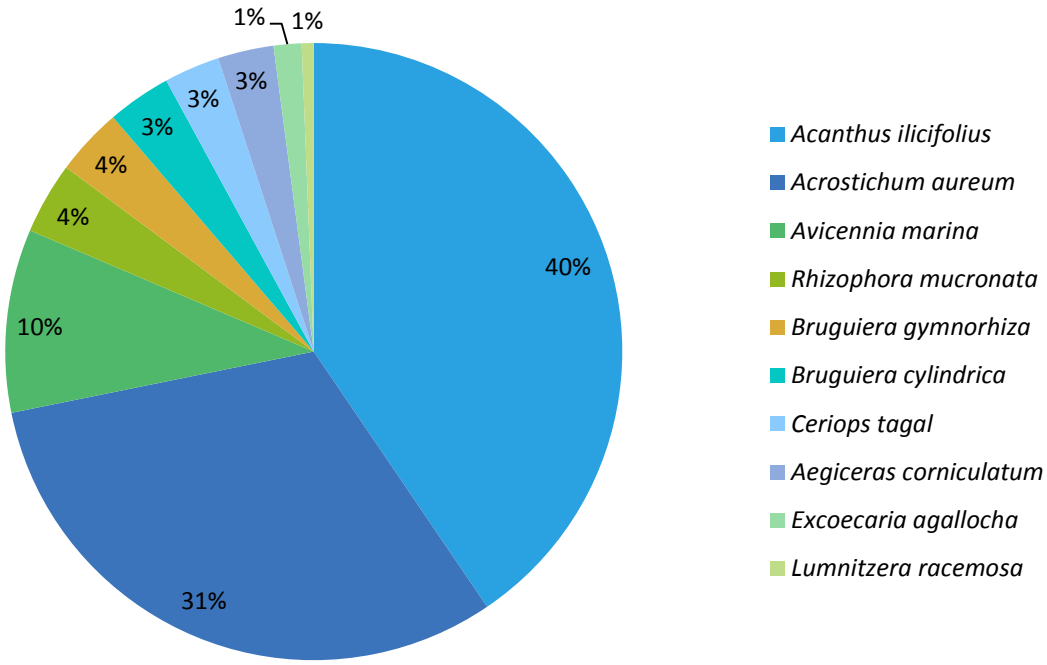


Figure 92 Pie chart indicating the percentage of true mangrove and mangrove associates (L 14)

Table 64 Species Richness Indices (L 14)

Margalef Species Richness Index	Shannon Wiener Index
1.4627	1.5594

Bank Counts (Sampling stations and recorded mangrove species)

Location 01

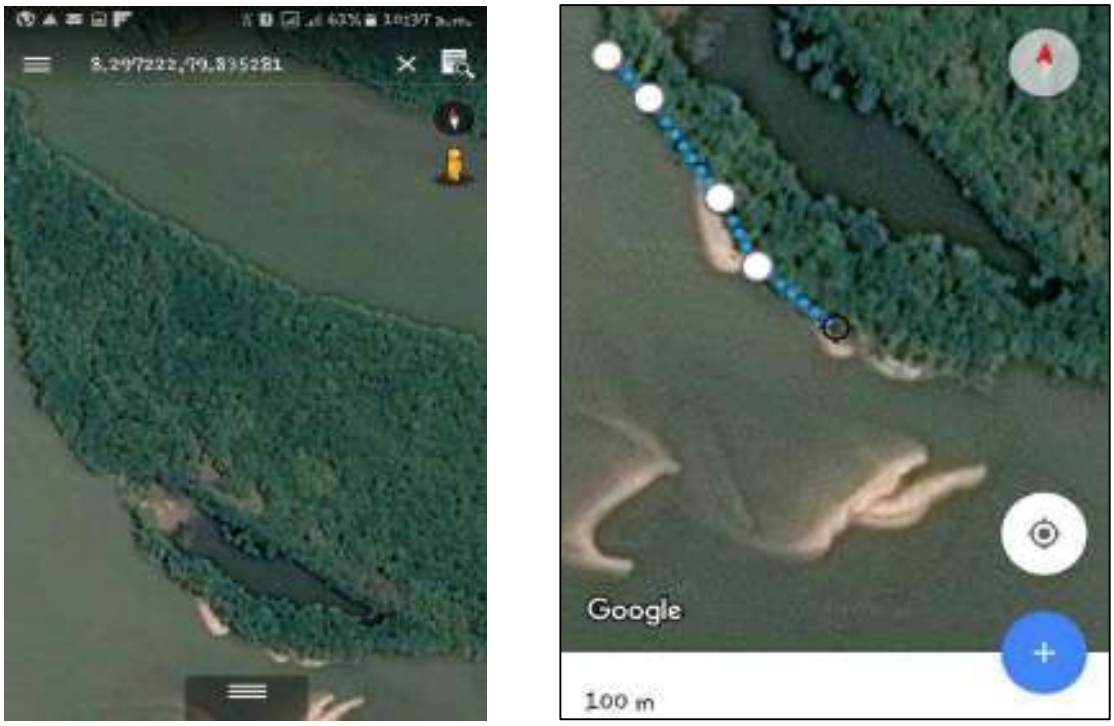


Figure 93 Satellite image (left) and distance covered (right) (BCL 01)

Figure 93 indicates the location of bank count 1 (BCL 01) with longitude and latitude. Table 65 provides the species found in this transect (100 m). Number of species recored were depicted as a percentage in Figure 94. *Lumnitzera racemosa* was the plant with the the highest density in this location. The Margalef and Shannon Wiener species richness diversity indices were 2.1797 and 1.7337 respectively (Table 46).

Table 65 Recorded true mangrove and mangrove associate species (Transect – 100 m along the coastline

Species	Transect (100 m)
Avicennia marina	16
Avicennia officinalis	4
Ceriops tagal	2
Excoecaria agallocha	70
Lumnitzera racemosa	97
Pemphis acidula	12
Rhizophora apiculata	2
Rhizophora mucronata	7
Thespesia populnea	2
Clerodendrum inerme	9
Sesuvium portulacastrum	2
Terminalia catappa	1
Derris trifoliata	22

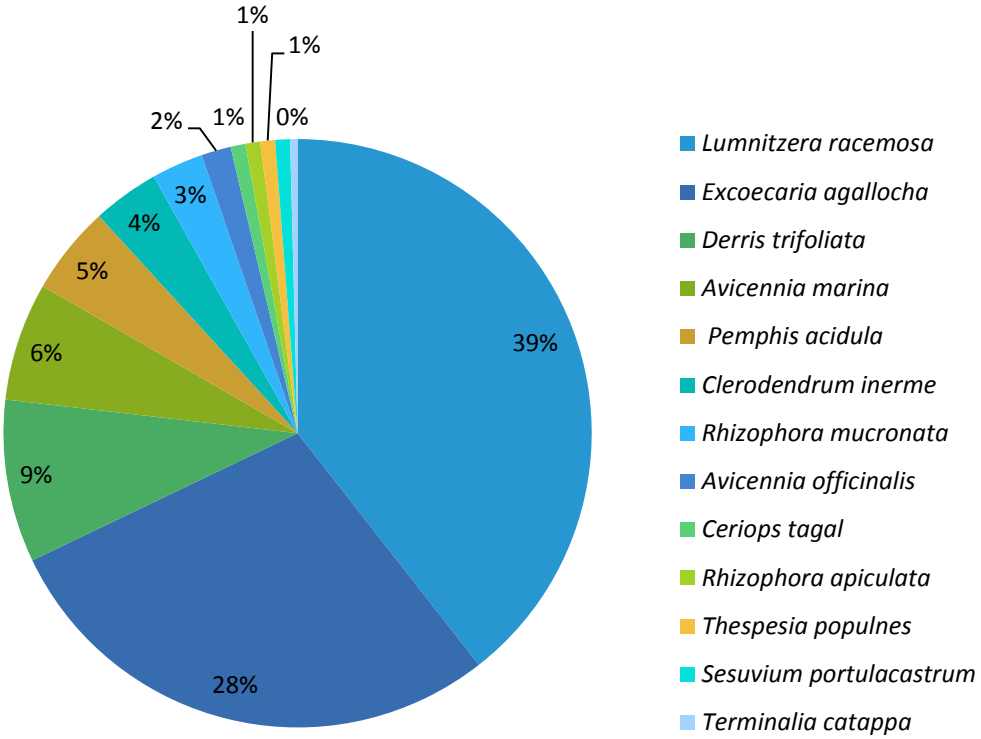


Figure 94 Pie chart indicating the percentage of true mangrove and mangrove associates (BCL 01)

Table 66 Species Richness Indices (BCL 01)

Margalef Species Richness Index	Shannon Wiener Index
2.1797	1.7337

Location 02

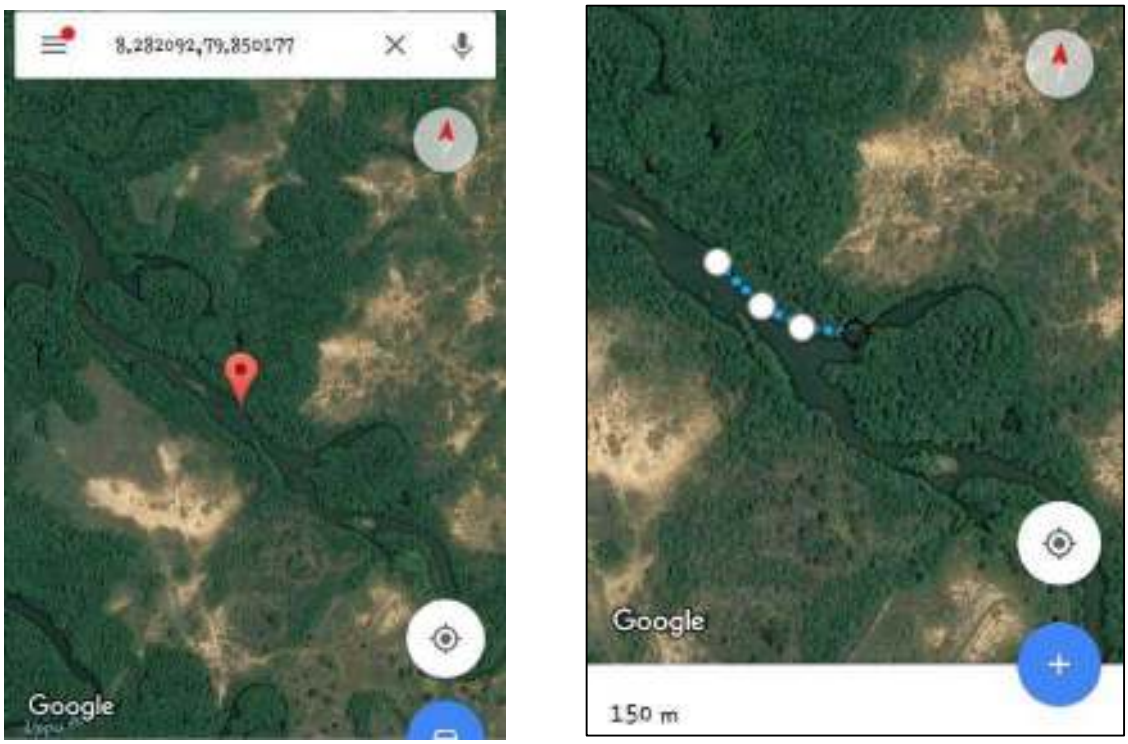


Figure 95 Satellite image (left) and distance covered (right) (BCL 02)

Figure 95 indicates the location of bank count 2 (BCL 02) with longitude and latitude. Table 67 provides the species found in this transect of 150 m. Number of species recored were depicted as a percentage in Figure 96. *Rhizophora mucronata* was the plant with the the highest density in this location. The Margalef and Shannon Wiener species richness diversity indices were 2.1862 and 1.020 respectively (Table 68).

Table 67 Recorded true mangrove and mangrove associate species (Transect – 150 m along the bank)

Species	Transect (150 m)
Avicennia officinalis	1
Excoecaria agallocha	11
Lumnitzera racemosa	4
Pemphis acidula	1
Rhizophora mucronata	182
Thespesia populnea	1
Clerodendrum inerme	7
Terminalia catappa	1
Derris trifoliata	1
Calotropis gigantea	1
Acanthus ilicifolius	23
Acrostichum aureum	8
Terminalia arjuna	1

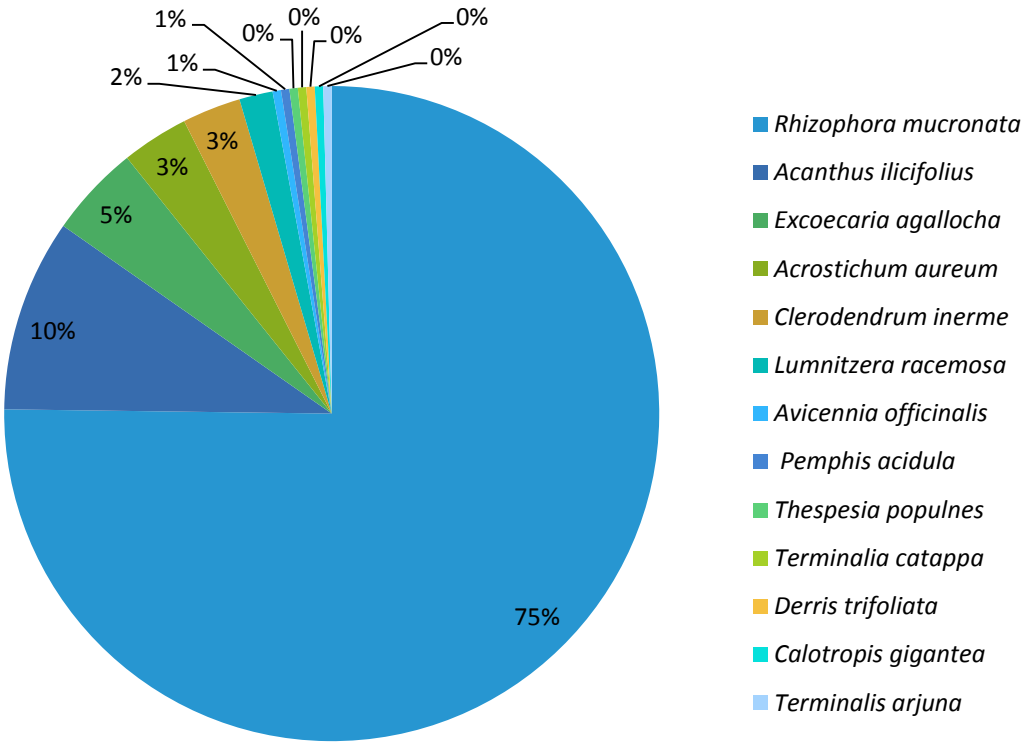


Figure 96 Pie chart indicating the percentage of true mangrove and mangrove associates (BCL 02)

Table 68 Species Richness Indices (BCL 02)

Margalef Species Richness Index	Shannon Wiener Index
2.1862	1.0202

Location 03

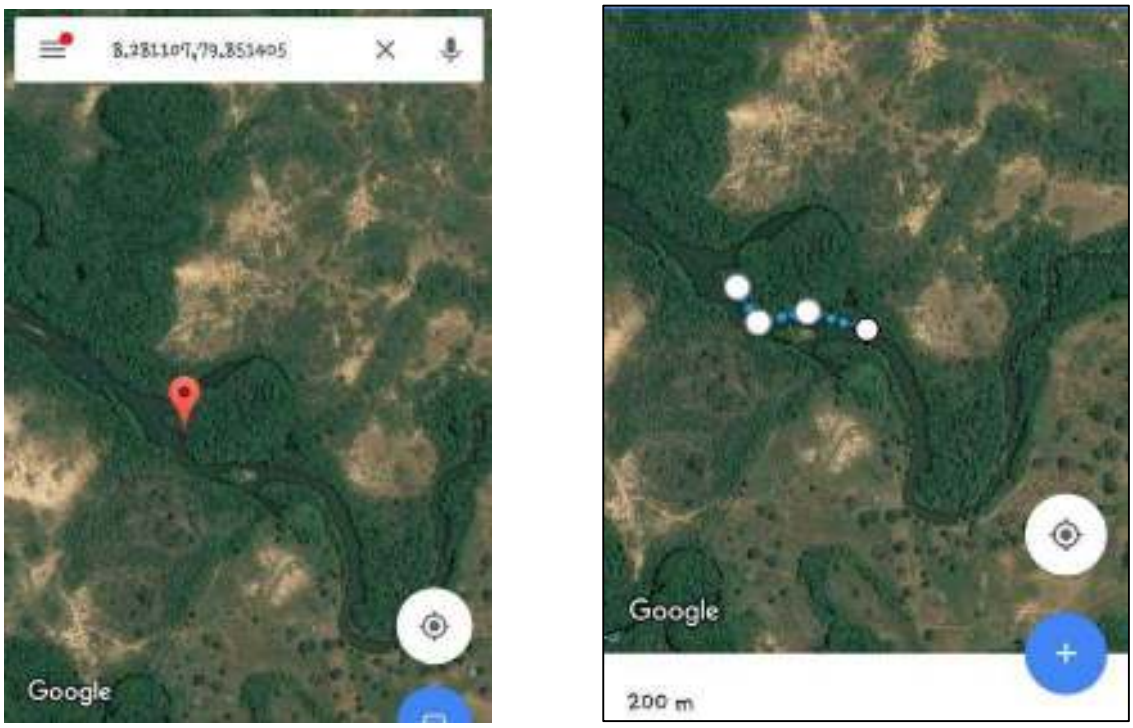


Figure 97 Satellite image (left) and distance covered (right) (BCL 03)

Figure 97indicates the location of bank count 3 (BCL 03) with longitude and latitude. Table 69 provides the species found in this transect of 200 m. Number of species recored were depicted as a percentage in Figure 98. *Acrostichum aureum* was the plant with the the highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.7872 and 2.0307 respectively (Table 70).

Table 69 Recorded true mangrove and mangrove associate species (Transect – 200 m along the bank)

Species	Transect (200 m)
Avicennia officinalis	2
Ceriops tagal	12
Excoecaria agallocha	20
Lumnitzera racemosa	82
Pemphis acidula	18
Rhizophora mucronata	100
Aegiceras corniculatum	30
Thespesia populnea	3
Clerodendrum inerme	10
Derris trifoliata	15
Acrostichum aureum	178
Caesalpinia bonduc	1

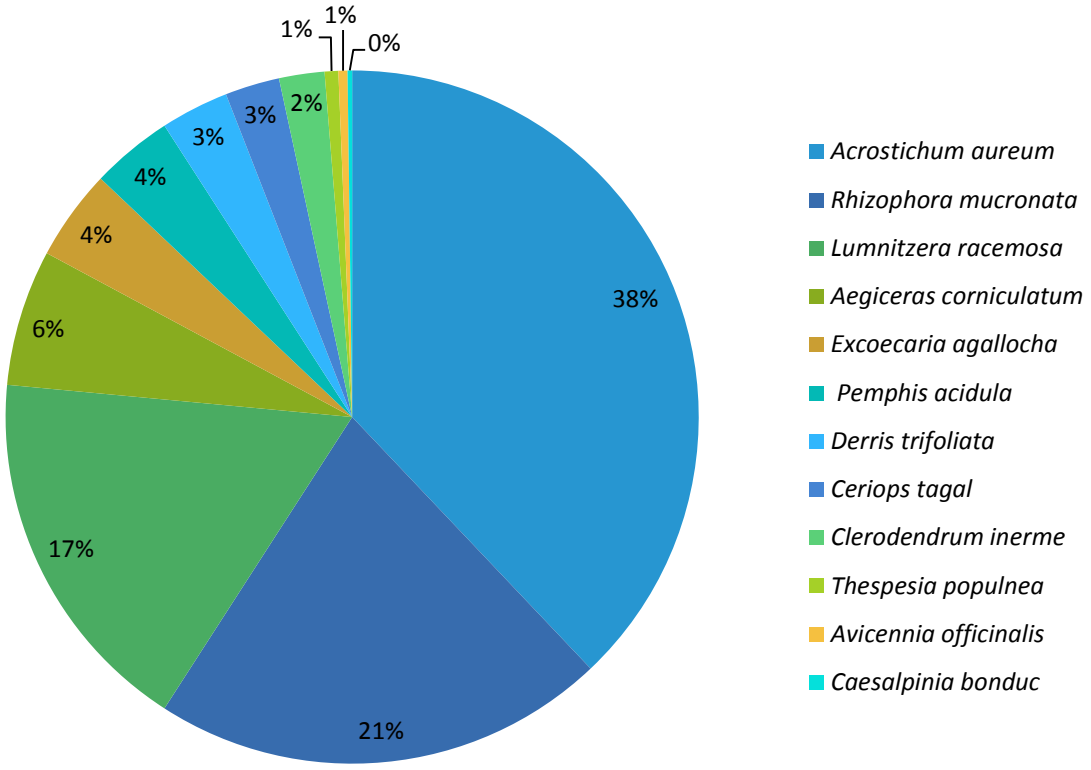


Figure 98 Pie chart indicating the percentage of true mangrove and mangrove associates (BCL03)

Table 70 Species Richness Indices (BCL 03)

Margalef Species Richness Index	Shannon Wiener Index
1.7872	2.0307

Location 04

Figure 99 Satellite image (left) and distance covered (right) (BCL 04)

Figure 99 indicates the location of bank count 4 (BCL 04) with longitude and latitude. Table 71 provides the species found in this transect of 102 m. Number of species recored were depicted as a percentage in Figure 100. ***Rhizophora mucronata*** was the plant with the the highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.5231 and 1.4154 respectively (Table 72).

Table 71Recorded true mangrove and mangrove associate species (Transect – 102 m along the bank)

Species	Transect (102 m)
Avicennia marina	1
Avicennia officinalis	1
Excoecaria agallocha	40
Lumnitzera racemosa	17
Rhizophora mucronata	103
Premna serratifolia	12
Clerodendrum inerme	7
Derris trifoliata	6
Acrostichum aureum	4

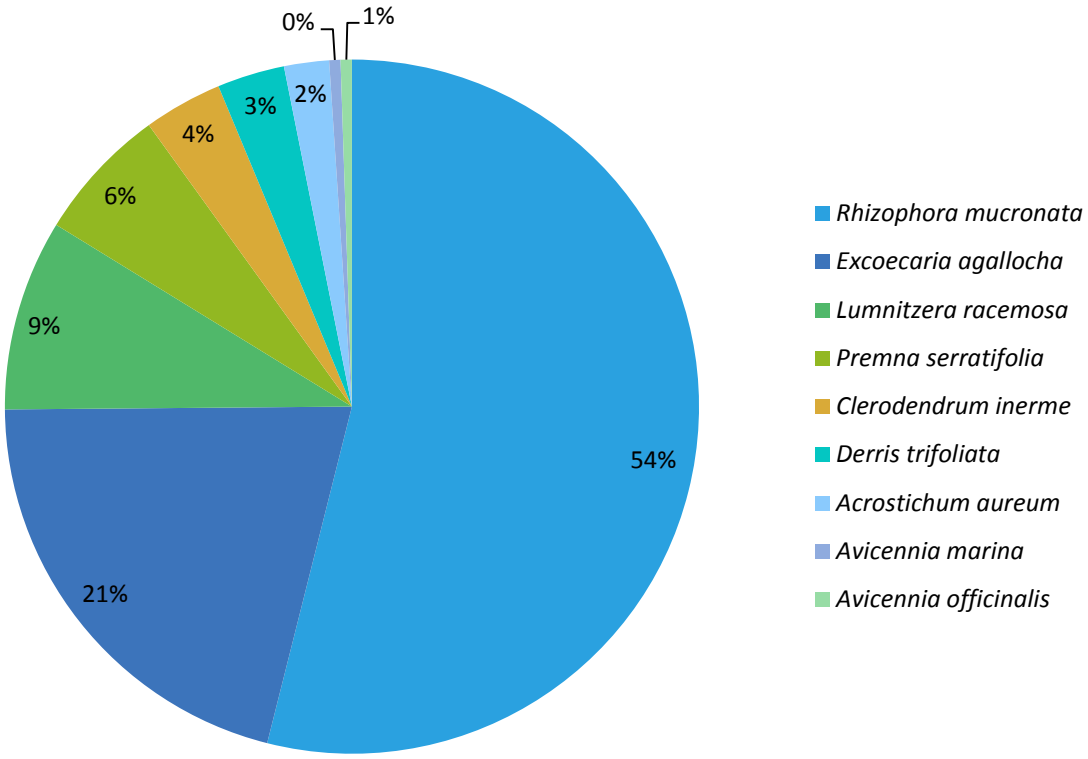


Figure 100 Pie chart indicating the percentage of true mangrove and mangrove associates (BCL 04)

Table 72 Species Richness Indices (BCL 04)

Margalef Species Richness Index	Shannon Wiener Index
1.5231	1.41545

Location 05

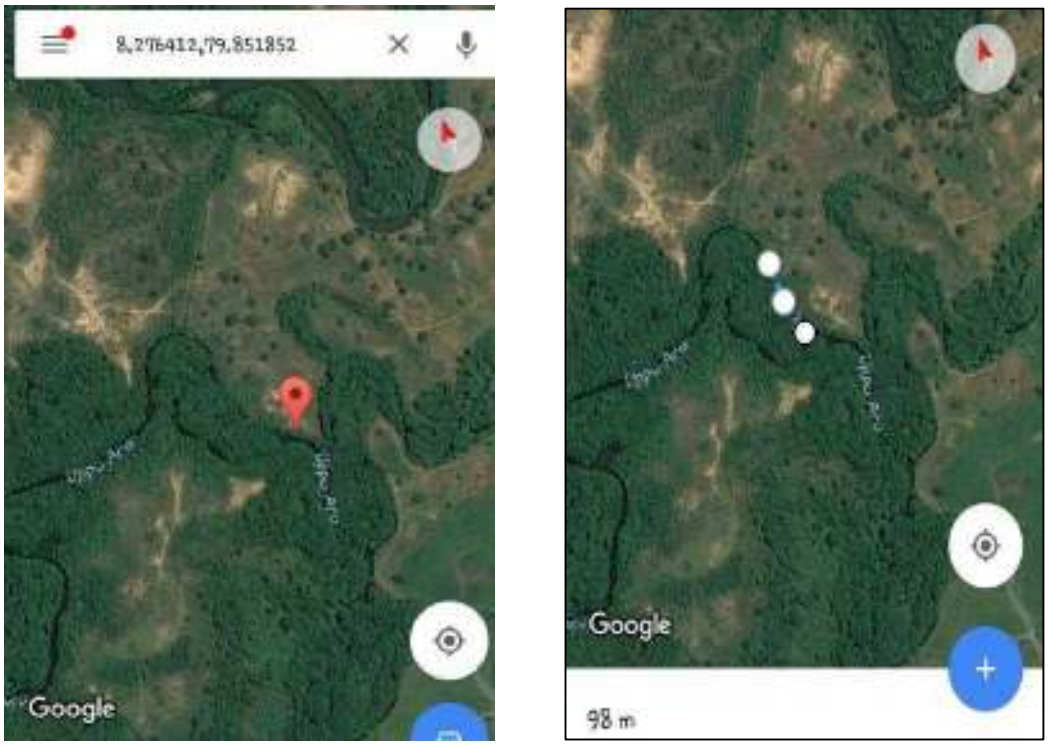


Figure 101 Satellite image (left) and distance covered (right) (BCL 05)

Figure 101 indicates the location of bank count 5 (BCL 05) with longitude and latitude. Table 73 provides the species found in this transect of 98 m. Number of species recored were depicted as a percentage in Figure 102. *Rhizophora mucronata* was the plant with the the highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.9222 and 1.5570 respectively (Table 74).

Table 73 Recorded true mangrove and mangrove associate species (Transect – 98 m along the bank)

Species	Transect (98 m)
Avicennia officinalis	1
Excoecaria agallocha	9
Rhizophora mucronata	46
Thespesia populnea	2
Premna serratifolia	1
Clerodendrum inerme	6
Derris trifoliata	10
Acanthus ilicifolius	31
Acrostichum aureum	1
Terminalia arjuna	1

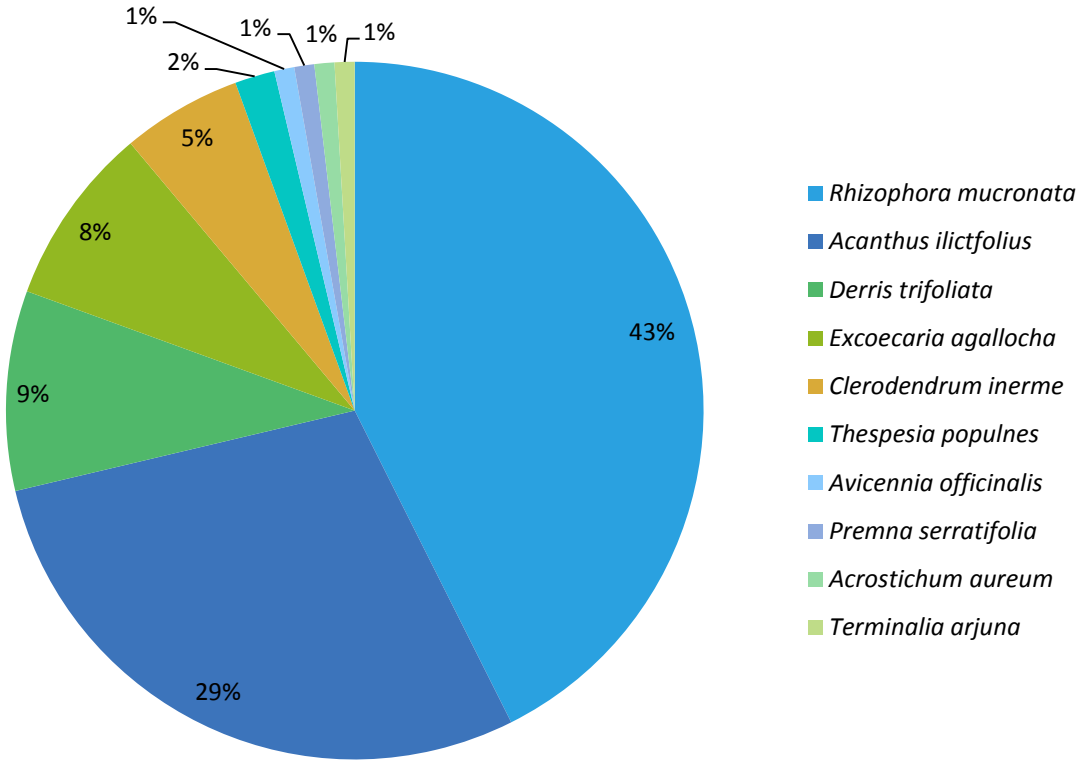


Figure 102 Pie chart indicating the percentage of true mangrove and mangrove associates (BCL 05)

Table 74 Species Richness Indices (BCL 05)

Margalef Species Richness Index	Shannon Wiener Index
1.9222	1.5570

Location 06

Figure 103 Satellite image (left) and distance covered (right) (BCL 06)

Figure 103 indicates the location of bank count 6 (BCL 06) with longitude and latitude. Table 75 provides the species found in this transect of 132 m. Number of species recored were depicted as a percentage in Figure 22. *Excoecaria agallocha* was the plant with the the highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.3269 and 1.4695 respectively (Table 56).

Table 75 Recorded true mangrove and mangrove associate species (Transect – 132 m along the bank)

Species	Transect (132 m)
Excoecaria agallocha	36
Acrostichum aureum	9
Terminalia arjuna	23
Berrya cordifolia	1
Nauclea orientalis	20
Caesalpinia bonduc	1
Muntingia calabura	1

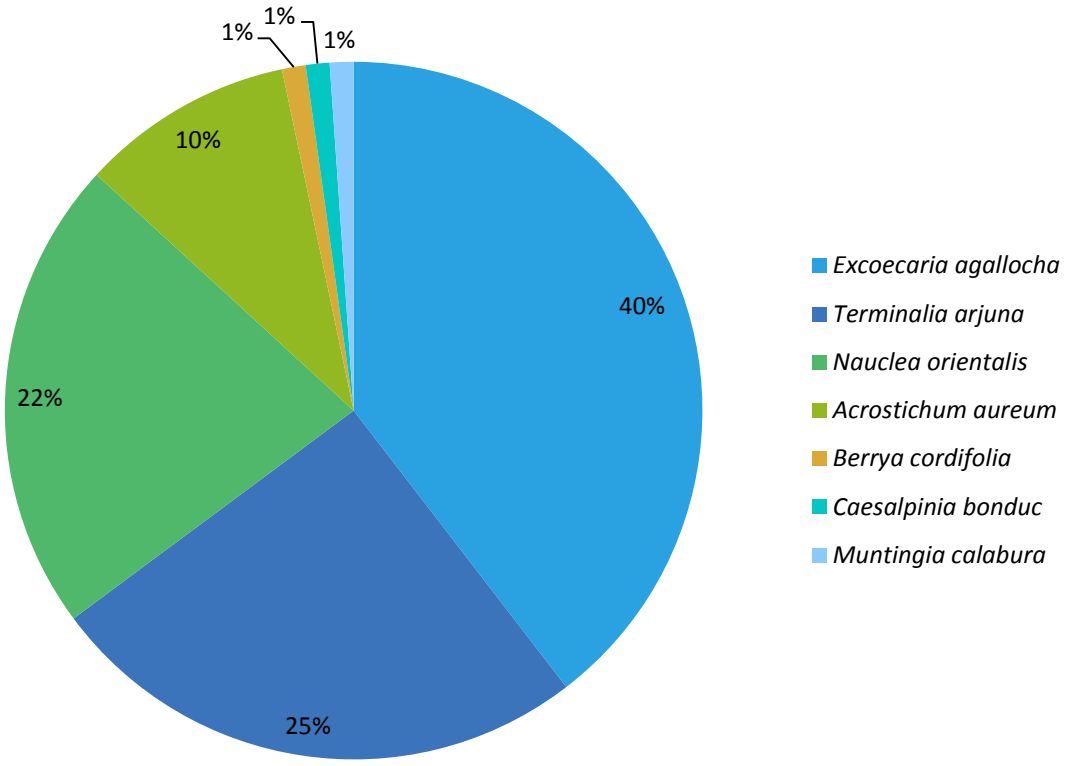


Figure 104 Pie chart indicating the percentage of true mangrove and mangrove associates (BCL 06)

Table 76 Species Richness Indices (BCL 06)

Margalef Species Richness Index	Shannon Wiener Index
1.3269	1.4694

Location 07

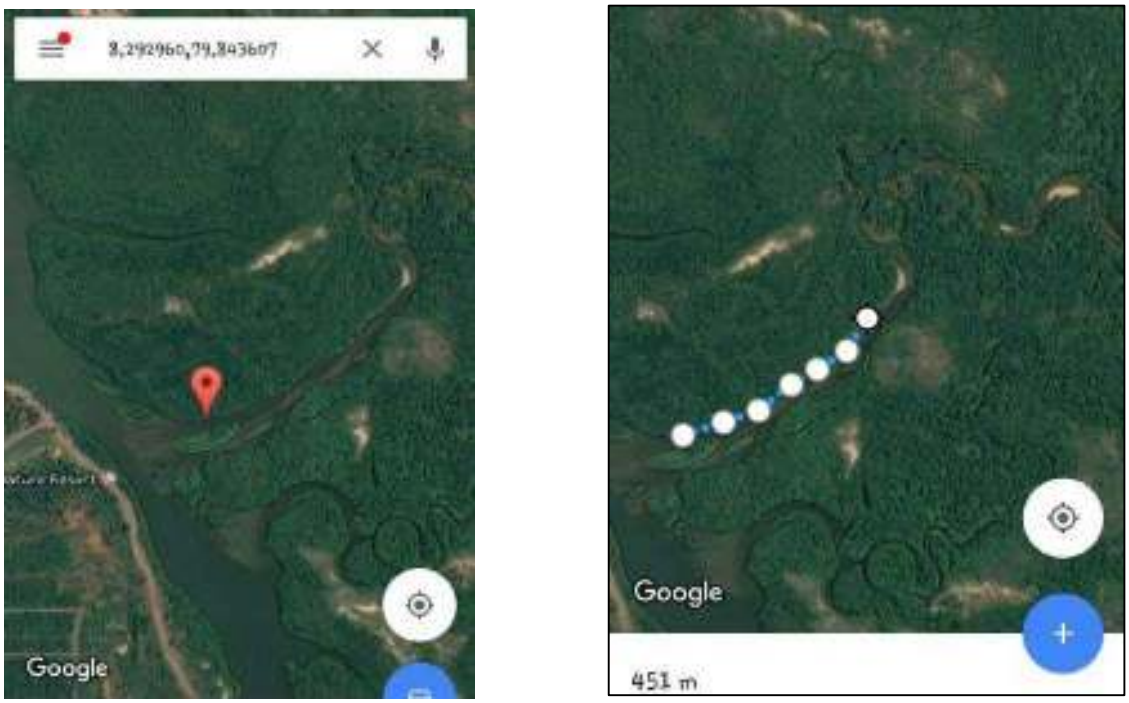


Figure 105 Satellite image (left) and distance covered (right) (BCL 07)

Figure 105 indicates the location of bank count 7 (BCL 02) with longitude and latitude. Table 77 provides the species found in this transect of 451 m. Number of species recored were depicted as a percentage in Figure 106. *Acrostichum aureum* was the plant with the the highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.862 and 1.6460 respectively (Table 78).

Table 77 Recorded true mangrove and mangrove associate species (Transect – 451 m along the bank)

Species	Transect (451 m)
Avicennia officinalis	1
Excoecaria agallocha	180
Rhizophora mucronata	11
Derris trifoliata	4
Premna serratifolia	19
Acanthus ilicifolius	148
Acrostichum aureum	201
Terminalia arjuna	24
Berrya cordifolia	9
Manilkara hexandra	1
Nauclea orientalis	26
Muntingia calabura	1
Thespesia populnea	3

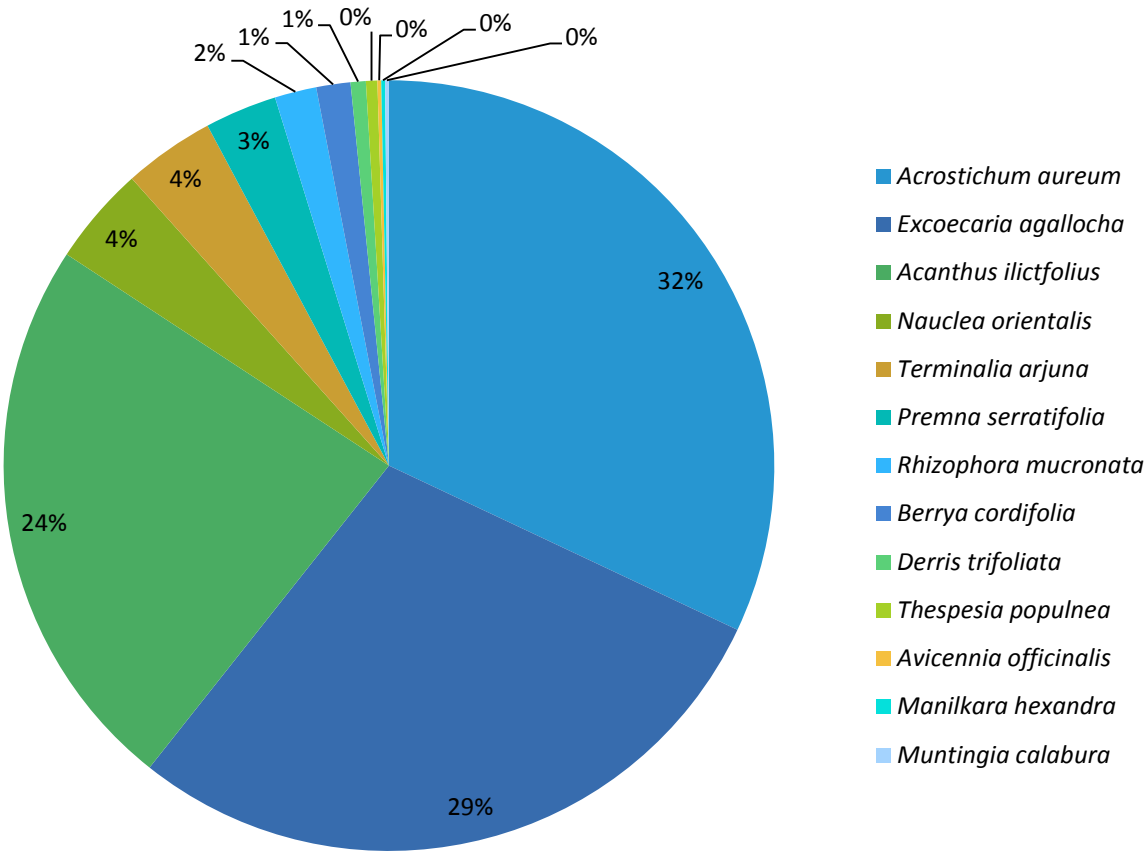


Figure 106: Pie chart indicating the percentage of true mangrove and mangrove associates (BCL 07)

Table 78 Species Richness Indices (BCL 07)

Margalef Species Richness Index	Shannon Wiener Index
1.8626	1.6460

Location 08

Figure 107 Satellite image (left) and distance covered (right) (BCL 08)

Figure 107 indicates the location of bank count 8 (BCL 08) with longitude and latitude. Table 79 provides the species found in this transect of 610 m in both the banks. Number of species recored were depicted as a percentage in Figures 108 and 109. *Rhizophora mucronata* was the plant with the the highest density in both the banks. The Margalef and Shannon Wiener species richness diversity indices were (L-1.5873 and R-1.6433) and (L-1.3028 and R-1.7714) respectively (Table 80).

Table 79 Recorded true mangrove and mangrove associate species (Transect – 610 m along the bank)

Species	Transect (610 m)	
	1(left)	2(right)
Avicennia officinalis	3	
Bruguiera cylindrica	25	29
Excoecaria agallocha	26	40
Lumnitzera racemosa	10	9
Rhizophora mucronata	185	88
Scyphiphora hydrophyllacea		3
Thespesia populnea		5
Premna serratifolia	26	15
Clerodendrum inerme	1	5
Derris trifoliata	3	1
Acrostichum aureum	9	44
Manilkara hexandra	2	

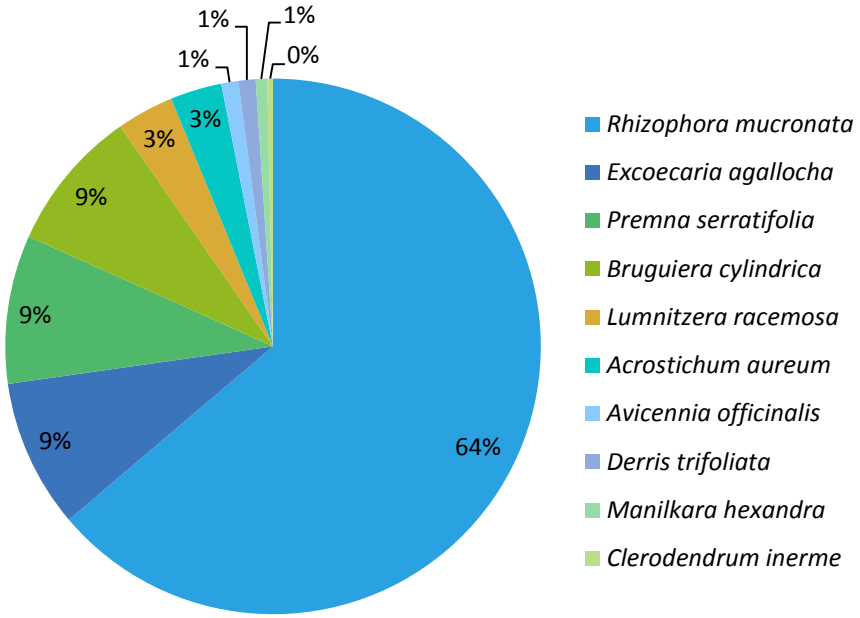


Figure 108 Pie chart indicating the percentage of true mangrove and mangrove associates (BCL 08)-Left

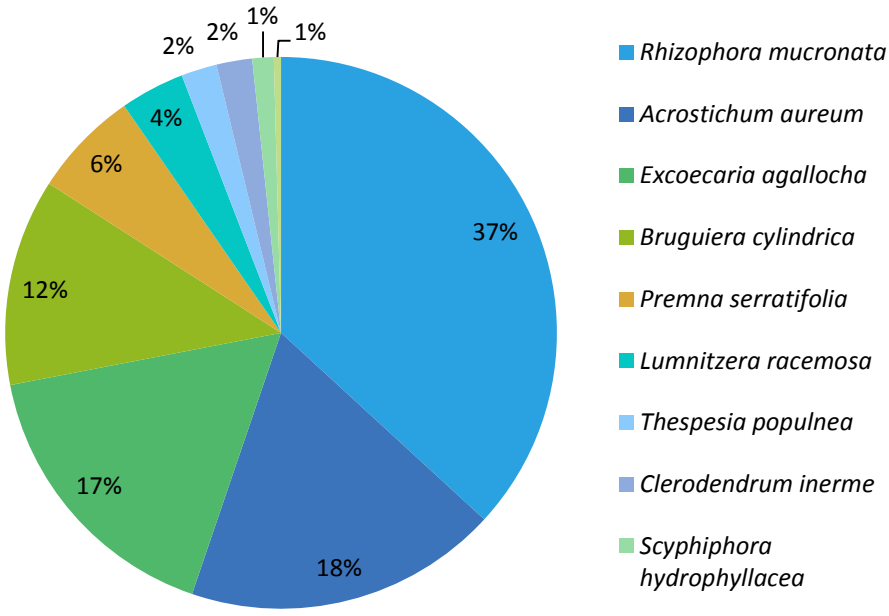


Figure 109 Pie chart indicating the percentage of true mangrove and mangrove associates (BCL 08)-Right

Table 80 Species Richness Indices (BCL 08)

Side	Margalef Species Richness Index	Shannon Wiener Index
Bank (Left)	1.5873	1.3029
Bank (Right)	1.6433	1.7714

Location 09

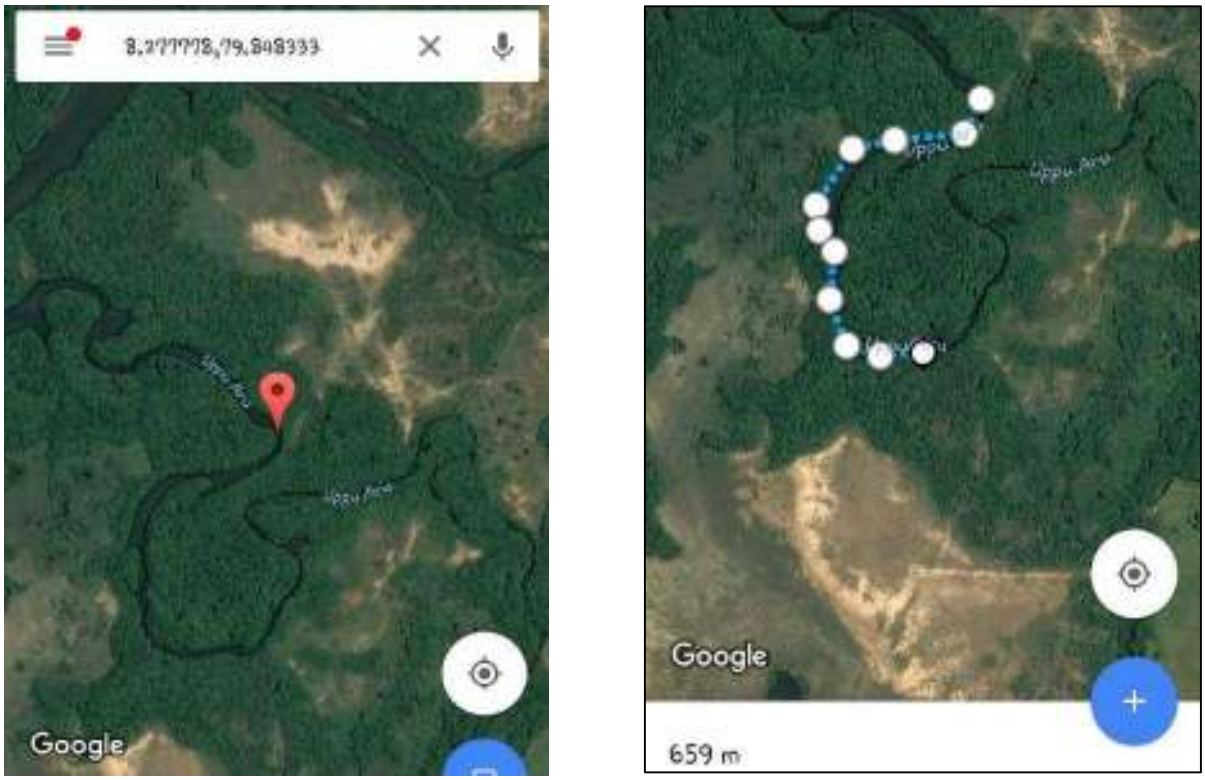


Figure 110 Satellite image (left) and distance covered (right) (BCL 09)

Figure 110 indicates the location of bank count 9 (BCL 09) with longitude and latitude. Table 81 provides the species found in this transect of 659 m. Number of species recored were depicted as a percentage in Figure 111. *Rhizophora mucronata* was the plant with the the highest density in this location. The Margalef and Shannon Wiener species richness indices were 1.9524 and 1.9962 respectively (Table 82).

Table 81 Recorded true mangrove and mangrove associate species (Transect – 659 m along the bank)

Species	Transect (659 m)
Bruguiera cylindrica	**19**
Excoecaria agallocha	**71**
Lumnitzera racemosa	**19**
Rhizophora mucronata	**135**
Thespesia populnea	6
Premna serratifolia	24
Clerodendrum inerme	5
Derris trifoliata	11
Acrostichum aureum	67
Terminalia arjuna	93
Phoenix zeylanica	13
Manilkara hexandra	3
Tamarindus indica	1

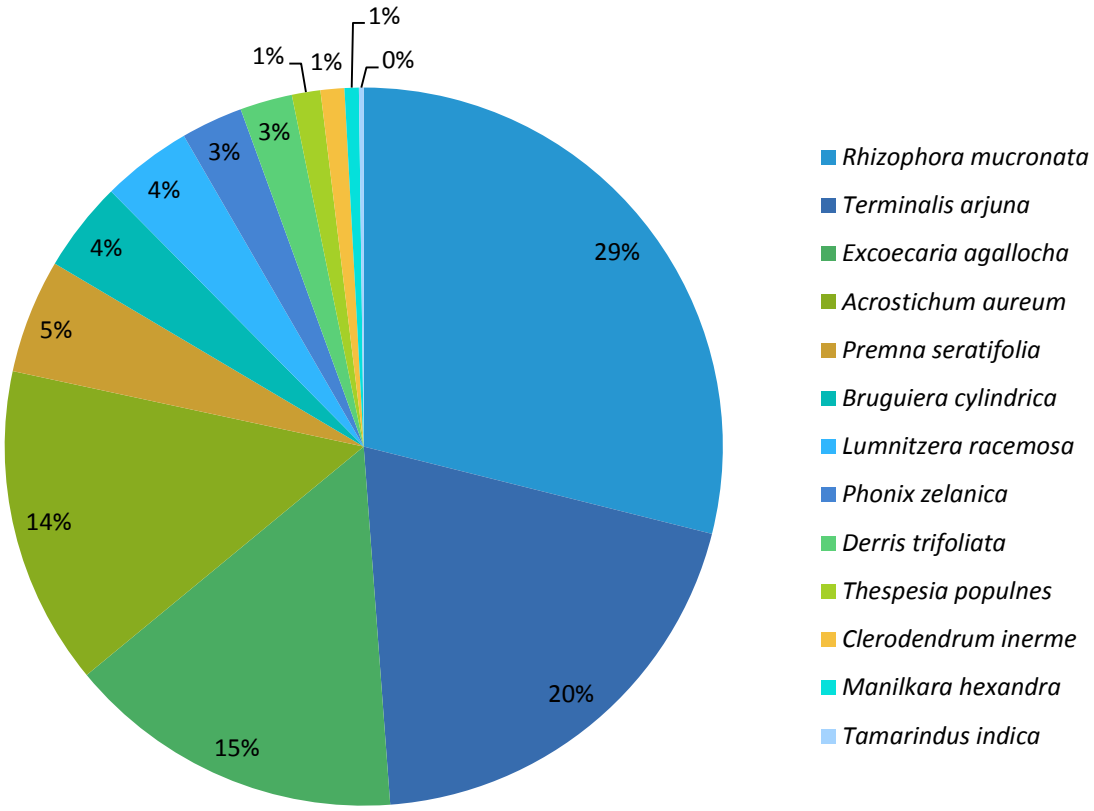


Figure 111 Pie chart indicating the percentage of true mangrove and mangrove associates (BCL 09)

Table 82 Species Richness Indices (BCL 09)

Margalef Species Richness Index	Shannon Wiener Index
1.9524	1.9963

Birds of study area

The following birds (Table 83) were recorded during the field studies in estuary (in blue) and river (in black).
(RL Categories - Red List Categories: VU – Vulnerable; EN – Endangered; CR – Critically Endangered; NT – Near Threaten; LC – Least Concerned; DD – Data Deficient) (Source: IUCN, 2012) M – Migrant Species; R – Residential; S – Sinhala Name; E – English name; T – Tamil Name

*RL Categories of migrant species were not indicated

Table 83 The checklist of bird species recorded from the study area

Family	Scientific name	Common names	RL Categories
Accipitridae	*Haliaeetus leucogaster* (Gmelin, 1788)	E : White-Bellied Sea-eagle S : Kusa alli muhudukussa T : Ven vayitru kadat kaluhu	LC
	Ichthyophaga ichthyaetus (Horsfield, 1821)	E : Grey-Headed Fish-eagle S : luhis masukussa/Wewa rajaliya T : Siriya sambalthalai meen Kaluhu	NT
	Accipiter badius (Gmelin, 1788)	E : Shikra S : Kurulugoya T : Valooru	LC
	Spilornis cheela (Latham, 1790)	E : Crested Serpent-eagle S : Silu sarapakussa T : Kondai paambu kaluhu	LC
	Haliastur indus (Boddaert, 1783)	E : Brahminy Kite S : Bamunu piyakussa/Ukussa T : Sem parunthu	LC
	Pernis ptilorhyncus (Temminck, 1821)	E : Oriental Honey- Buzzard S : Silu bambarakussa/ Rajaliya T : Then parunthu	NT

Family	Scientific name	Common names	RL Categories
	Circus aeruginosus(Linnaeus, 1758) (M)	E: Western marsh harrier	
Aegithinidae	*Aegithina tiphia* (Linnaeus, 1758)	E : Common Iora S : Podu iorava T : Manjal chittu	LC
Alcedinidae	*Alcedo atthis* (Linnaeus, 1758)	E : Common Kingfisher S : Mal Pilihuduwa T : Siriya neela meen kothi	LC
Alcedinidae	*Pelargopsis capensis* (Linnaeus, 1766)	E : Stork-billed Kingfisher S : Manathudu maha pilihuduwa T : Parutha alahu meen koth	LC
	Ceryle rudis (Linnaeus, 1758)	E : Pied Kingfisher S : Gomara pilihuduwa T : Siriya karuppu vellai meen Kothi	LC
	Halcyon smyrnensis (Linnaeus, 1758)	E : White-Throated Kingfisher S : Gelasudu medi-pilihuduwa T : Venmarabu meen kothi	LC
Anhingidae	*Anhinga melanogaster* Pennant, 1769	E : Oriental Darter S : Ahikava T : Paambu thara	LC
Anatidae	*Dendrocygna javanica* (Horsfield, 1821)	E : Lesser Whistling-duck S : Heen thamba seruwa T : Siriya seelkani siravi	LC
Apodidae	*Cypsiurus balasiensis* (Gray, 1829)	E : Asian Palm-swift S : Asia thal-thurithaya T : Panai ulavaaran	LC
	Apus affinis (Gray, 1830)	E : Little Swift S : Punchi thurithaya T : Naadu ulavaaran	LC
Ardeidae	*Ardea cinerea* Linnaeus, 1758	E : Grey Heron S : Alu kokka T : Sambal kokku	LC

Family	Scientific name	Common names	RL Categories
	Ardeola grayii (Sykes, 1832)	E : Indian Pond-heron S : Kana kokka T : Mudaiyan	LC
	Ixobrychus sinensis (Gmelin, 1789)	E : Yellow Bittern S : Kaha meti-kokka T : Manjal kuruhu	NT
	Ixobrychus flavicollis (Latham, 1790)	E : Black Bittern S : Kalu meti-kokka T : Karung kuruhu	LC
	Ardea purpurea Linnaeus, 1766	E : Purple Heron S : Karaval kokka T : Senneela kokku	LC
	Casmerodius albus (Linnaeus, 1758)	E : Great Egret S : udu- maha kokka T : Periya kokku	LC
	Egretta garzetta (Linnaeus, 1766)	E : Little Egret S : Punchi anu-koka/Sudu kokka T : Sinna kokku	LC
	Mesophoyx intermedia (Wagler, 1829)	E : Intermediate Egret S : Sudu medi-kokka T : Naduthara kokku	LC
	Bubulcus ibis (Linnaeus, 1758)	E : Cattle Egret S : Gerikokka/Harak kokka T : Unnik kokku	LC
	Ardeola grayii (Sykes, 1832)	E : Indian Pond-heron S : Kana kokka T : Mudaiyan	LC
	Butorides striata (Linnaeus, 1758)	E : Striated Heron S : Palakokka T : Siriya pachchai kokku	LC
	Ardea cinerea Linnaeus, 1758	E : Grey Heron S : Alu Kokka	LC

Family	Scientific name	Common names	RL Categories
		T : Sambal kokku	
	Nycticorax nycticorax (Linnaeus, 1758)	E : Black-Crowned Nightheron S : Rekana-kokka T : Irak kokku	NT
Artamidae	*Artamus fuscus* Vieillot, 1817	E : Ashy Woodswallow S : Alu vanalihiniya T : Sambal kaatu thakai vilaan	LC
Bucerotidae	*Ocyceros gingalensis* (Shaw, 1811)	E : Sri Lanka Grey Hornbill S : Sri Lanka Alu Kandetta T : Ilankai naarai irattai chondu kuruvi	LC
	Anthracoceros coronatus (Boddaert, 1783)	E : Malabar Pied Hornbill S : Poru Kandetta T : Malabar karuppuvellai Iruvaayan	LC
Caprimulgidae	*Caprimulgus asiaticus* Latham, 1790	E : Indian Nightjar S : Indu Bimbassa T : Siru pakki	LC
Campephagidae	*Coracina macei* (Lesson, 1830)	E : Large cuckoo shrike	LC
	Tephrodornis pondicerianus (Gmelin, 1789)	E : Common wood shrike	
Ciconiidae	*Ciconia episcopus* (Boddaert, 1783)	E : Wooly-Necked Stork S : Padili manava T : Venkaluthu naarai	NT
	Anastomus oscitans (Boddaert, 1783)	E : Asian Openbill S : Vivarathuduwa T : Naththai-kuththi-narai	LC
	Mycteria leucocephala (Pennant,1769)	E : Painted Stork S : Lathuvakiya T : Manjalmooku naarai	LC
Cisticolidae	*Prinia inornata* Sykes, 1832	E : Plain Prinia S : Sarala prinia	LC

Family	Scientific name	Common names	RL Categories
		T : Kathir kuruvi	
	Prinia socialis Sykes, 1832	E : Ashy Prinia S : Alu prinia T : Sambal kathir kuruvi	LC
Charadriidae	*Vanellus indicus* (Boddaert, 1783)	E : Red-Wattled Lapwing S : Rath yatimal kirala T : Sihappu mooku aart kaati	LC
	Charadrius dubius Scopoli, 1786	E : Little Ringed Plover S : Punchi mala oleviya T : Sinna pattani uppuk kothi	VU
Columbidae	*Treron bicinctus* (Jerdon, 1840)	E : Orange-breasted Green-pigeon S : Layaran batagoya T : Orange maarbu Pachai Puraa	LC
	Ducula aenea (Linnaeus, 1766)	E : Green Imperial-Pigeon S : Nil Mahagoya T : Pachai arasa Puraa	LC
	Stigmatopelia chinensis (Scopoli, 1786)	E : Spotted Dove S : Alu-kobeiya T : Pulli Puraa	LC
Cuculidae	*Phaenicophaeus viridirostris* (Jerdon, 1840)	E : Blue-faced Malkoha; S : Wathanil malkoha T : Neela muha malkoha	LC
Dicruridae	*Dicrurus caerulescens* (Linnaeus, 1758)	E : White-bellied Drongo S : Kavuda T : Venvayittru karichaan	LC
Estrildidae	*Lonchura punctulata* (Linnaeus, 1758)	E : Scaly Breasted Munia S : Laya kayuru Weekurulla T : Pulli sillai	LC
	Lonchura striata (Linnaus, 1766)	E : White Rumped Munia S : Nithamba sudu Weekurulla T : Ven muthuhu sillai	LC

Family	Scientific name	Common names	RL Categories
Hirundinidae	Hirundo rustica (Linnaeus, 1758) **(M)**	E : Barn swallow	
Laridae	*Sterna nilotica* Brehm,1830	E : Gull-billed Tern S : Galuthudu muhudulihiniya	CR
	Chroicocephalus brunnicephalus Jerdon 1840 **(M)**	E : brown-headed gull	
	Chroicocephalus ridibundus Linnaeus, 1766 **(M)**	E : Black-headed gull	
	Sterna albifrons Pallas, 1764	E : Little Tern S : Punchi muhudulihiniya	VU
	Chlidonias hybrid Pallas 1811 **(M)**	S : Whiskered tern	
	Sterna caspia Pallas, 1770	E : Caspian Tern S : kaspiya muhudulihiniya	CR
	Thalasseus bengalensis (Lesson, 1831) **(M)**	E : Lesser crested tern	
Meropidae	*Merops philippinus* Linnaeus, 1766	E : Blue-tailed Bee-eater S : Nilpenda binguhariya	CR
Monarchiidae	*Terpsiphone paradisi* (Linnaeus, 1758)	E : Asian Paradise Flycatcher S : Asia rahanmara/Redi hora T : Arasavaal eepidipaan	LC
Motacillidae	*Anthus rufulus* Vieillot, 1818	E : Paddyfield Pipit S : Keth waratichcha T : Vayal nettaikkaadi	LC
Muscicapidae	*Saxicoloides fulicatus* (Linnaeus, 1766)	E : Indian Robin S : Kalukichcha, Kalu polkichcha T : Karunj chittu	LC
	Copsychus malabaricus (Scopoli, 1788)	E : White Rumped Shama S : Vana Polkichcha T : Solanippaadi	LC

Family	Scientific name	Common names	RL Categories
Nectariniidae	*Nectarinia asiatica* (Latham, 1790)	E : Purple Sunbird S : Dam sutikka T: Ootha thenchittu	LC
Oriolidae	*Oriolus xanthornus* (Linnaeus, 1758)	E:Black Hooded Oriole S:Kahakurulla T : Karunthalai maangkuyil	LC
Pelecanidae	*Pelecanus philippensis* Gmelin, 1789	E : Spot-billed Pelican S : Thithhota pasthuduwa T : Pullialahu koolikkada	LC
Phalacrocoracidae	*Phalacrocorax niger* (Vieillot, 1817)	E : Little cormorant T : Siriya neerkaham	LC
	Phalacrocorax fuscicollis Stephens, 1826	E : Indian Cormorant S : Indu diyakava T : Naduthoura neerkaaham	LC
Phasianidae	*Pavo cristatus* Linnaeus, 1758	E : Indian Peafowl S : Monara T : Neela mayil	LC
Podicipedidae	*Tachybaptus ruficollis* (Pallas, 1764)	E : Little Grebe S : Punchi gembithuruva T : Sinna mookulippan	LC
Rallidae	*Amaurornis phoenicurus* (Pennant, 1769)	E :White-breasted Waterhen S : Layasudu korawakka T : Ven maarbu kaanaang koli	LC
	Fulica atra Linnaeus, 1758	E : Common Coot S : Podu kithala T : Nama koli	LC
	Porphyrio porphyria (Linnaeus, 1758)	E : Purple Swamphen S : Dam madi-kithala T : Neela thodai koli	LC
Recurvirostridae	*Himantopus himantopus* (Linnaeus, 1758)	S : E: Black-Winged Stilt S : Kalupiya ipalpava/Kalapu-kirala T : Nedungkaal ullaan	LC

Family	Scientific name	Common names	RL Categories
Scolopacidae	*Actitis hypoleucos* (Linnaeus, 1758)	E : Common sandpiper	
	Limosa lapponica (Linnaeus, 1758)	E : Bartailed godwit	
	Limnodromus semipalmatus (Blyth, 1848)	E : Asian Dowitcher	
	Totanus totanus (Linnaeus, 1758)	E : Common red shank	
	Tringa stagnatilis (Bechstein, 1803)	E : Marsh sandpiper	
Sturnidae	*Sturnia pagodarum* (Gmelin, 1789)	E : Brahmini staring	
Sylviidae	*Orthotomus sutorius* (Pennant, 1769)	E : Common Tailorbird S : Battichcha T : Thaiyat kaara kathir kuruvi	LC
Threskiornithidae	*Threskiornis melanocephalus* (Latham, 1790)	E : Black-headed Ibis S : Hisakalu dekettha T : Vellai arivaal mookan	LC
Timaliidae	*Turdoides affinis* (Jerdon, 1845)	E : Yellow Billed Babbler S : Demalichcha T : Manjal alahu silamban	LC

Summary of the results

Tables 65 and 66 summerise the species richness, diversity and species compositin of Kala Oya river mouth. As evident from the results, it is clear that diversity and richness varies from location to location. Also this is an indecation of habitat heterogeneity in this estuary. Overall this estuary can be considered as a nationally important estuary due to its unique composition of species in different islands.

Table 84 Summary of species richness indices (Shannon Wiener and Margalef), number of true mangroves and total number of species in each sampling location

Site No.	GPS Coordination	Margalef Species Richness Index	Shannon Wiener Index	Number of True mangrove Species	Total Number of Species (True mangrove, mangrove associates and other)
Site 01	8.300131, 79.832904	2.7304 ± 0.53	1.9218 ± 0.23	12	20
Site 02	8.296565, 79.84011	0.9061 ± 0.35	1.2341 ± 0.26	9	10
Site 03	8.292629, 79.844963	1.2257 ± 0.46	1.3744 ± 0.38	5	14
Site 04	8.287065, 79.845270	1.6673 ± 0.55	1.6637 ± 0.31	8	14
Site 05	8.295674, 79.833748	1.4319 ± 0.25	1.3011 ± 0.56	11	14
Site 06	8.294462, 79.833481	0.1609 ± 0.32	0.2134 ± 0.37	7	8
Site 07	8.276288, 79.851641	1.6237 ±0.47	1.4378 ± 0.21	6	14
Site 08	8.276916, 79.849532	1.8647 ±0.31	1.7116 ± 0.27	6	19
Site 09	8.277123, 79.850121	0.9947 ±0.54	1.0181 ± 0.49	8	16

Site No.	GPS Coordination	Margalef Species Richness Index	Shannon Wiener Index	Number of True mangrove Species	Total Number of Species (True mangrove, mangrove associates and other)
Site 10	8.27444, 79.847222	1.3073 ±0.19	1.3576 ± 0.33	6	14
Site 11	8.277211, 79.847535	1.2437 ±0.22	1.2690 ± 0.37	8	13
Site 12	8.27901, 79.8444374	1.7639 ±0.12	1.3239 ± 0.39	9	14
Site 13	8.279300, 79.844763	1.0448	1.3704	4	5
Site 14	8.279898, 79.845163	1.4627 ±0.17	1.5594 ± 0.09	8	10

Table 85 Summary of species richness indices (Shannon Wiener and Margalef), number of true mangroves and total number of species in each bank count

Site No.	GPS Coordination	Margalef Species Richness Index	Shannon Wiener Index	Distance of the transect (m)	Number of True mangrove Species	Total Number of Species (True mangrove, mangrove associates and other)
Site 01	8.297222, 79.835281	2.1797	1.7337	100 m	8	13
Site 02	8.282092, 79.850177	2.1862	1.0202	150 m	5	13
Site 03	8.281107, 79.851405	1.7872	2.0307	200 m	7	12
Site 04	8.277124, 79.850231	1.523	1.4154	102 m	5	9

Site No.	GPS Coordination	Margalef Species Richness Index	Shannon Wiener Index	Distance of the transect (m)	Number of True mangrove Species	Total Number of Species (True mangrove, mangrove associates and other)
Site 05	8.276412, 79.851852	1.9222	1.5570	98 m	3	10
Site 06	8.276412, 79.851852	1.3269	1.4695	132 m	1	7
Site 07	8.292960, 79.843607	1.862	1.6460	451 m	3	13
Site 08	8.280024, 79.845243	1.5873	1.3028	610 m	5	10
		1.6433	1.7714	610 m	6	10
Site 09	8.27778, 79.84833	1.9524	1.9962	659 m	4	13

Discussion and Conclusions

Although never looked at from an angle of catchment, Kala Oya river basin harbours one of the best if not the best mangrove ecosystem in Sri Lanka. Associated with it are the other important ecosystems, namely seagrass beds and coralreefs off Kalpitiya, salt marshes off Lunu Oya thus completing the typical tropical ecosystems associated with a lower course of a catchment. Due to remoteness and the war that prevailed most of the above-mentioned habitats have remained intact and in good condition. Thus, the dynamics and interactions between different ecosystems are maintained and as such, goods and services from lower course have remained unaffected to a certain level. The challenge is maintaining this habitat connectivity, heterogeneity as well as the dynamics between them.

As evident fromTables 84 and 85 above, which summarise the diversity and species richness of each sampling site, the uniqueness of this mangrove ecosystem lies on the fact that each island has a different plant profile, distribution as well as maturity stages. Hence, no two islands are the same and in certain locations, two banks of the river are not the same. Some species like *Aegiceras corniculata* and *Bruguiera cylindrica* have developed heights and girths that is unusual for the said species. Additionally, presence of threated species such as *Scyphiphora hydrophyllacea*, *Bruguiera cylindrica* in good numbers in some islands indicate the need for greater conservation.

However, the end of war and the rapid development has now affected the lower course of this river. Kalpitiya attracts national and international tourists, which has led to some developments in coastal areas. Additionally, quarrying at a large scale in Gange Wadiya area and intensifying fisheries activities coupled with new settlements should be closely monitored and strategically managed with all stakeholder participation.

A larger portion of the lower catchment is already protected as Wilpattu National Park. However Southern bank of the river proper, Henakachchi and Lunu Oya should be given a greater protection to ensure that entire catchment is given due protection. This area is already declared as Wilpattu Ramsar site hence international recognition has been provided.

All threats and recommendations to address them have been proposed above. A strategic management regime, which should be implemented by all key stakeholders and led, by DWC and the Forest Department is timely and such a plan should focus on the lower course of the river exclusively, thus the system is managed as one unit.

Fish fauna of Kala Oya basin

Introduction of Fish Fauna of Kala Oya

Island Sri Lanka is well known for its rich biodiversity where fish fauna is an important taxonomic component. Geographical isolation, climate, rainfall, temperature are the main factors which responsible for this rich biodiversity. The diverse drainage system of the island with 103 riverss has greatly influenced the diversity of fish fauna of the country. Though the number of fresh water fish keeps changing at present there are about 90 fresh water fish species.

Kala Oya basin is one of the largest river basins in the dry zone which originates northern end of Knuckles range and flows through intermediate, dry and arid zones of the island. Kala Oya ends up with Lunu Ganga estuary and carries a larger volume of water and other materials to the sea thereby connecting with Gulf of Mannar.

Due to those above factors, Kala Oya consist of diverse fish faunal habitats resulting in a wide range of fish species. The flood plains of the river act as important breeding grounds for fresh water fish.

Kala Oya estuary is a refuge place for several marine and brackish water fish species. Diversity of habits formed by the river through its journey including pools, riffles, gravel and sandy substrates and swamps provide protective habitats and favourable environment to maintain the rich diversity of fish fauna in Kala Oya basin. Cascading small reservoirs connected to tributaries of the Kala Oya also significantly contribute the diversity of freshwater fish fauna.

It is noted that two invasive fish species; *Trichogaster pectoralis* and *Pterygoplichthys multiradiatus* (or *Pterygoplichthys* spp.) were invading in several locations of the study area. *Pterygoplichthys* spp. population has been well established at the habitats of Kala oya basin including the riverine sections and reservoirs.

Methodology for collecting data on fish fauna of Kala Oya basin

Fish fauna of Kala Oya basin were sampled first by dividing the basin into two main categories, namely river proper and reserviours. Selected reserviours of the basin were sampled to collect data. Additionally, all the historical records of fish in the reserviours of Kala Oya basin collected by team members and other researchers were compiled.

River proper was segmented into sub basins and in selected sub basins locations were decided considering the river continuum concept. Accordingly, first, second, third and fouth order streams were selected for sampling.

Sampling gear included hand nets of various mesh sizes, cast nets, gill nets and fish traps. In shallow clear water bank counts were conducted. Additionally, diving and snorkeling were done in deeper water where the water is clear. Fish drives were done in areas of boulders with gill nets drawn right acrosss the river.

Addionally, fish catch of fishermen from the area were reguarly inspected and landing sites were visited to obtain fish samples from the area. We also followed fishermen when they clear nets to obtain discarded fish at source as well as at landing sites. Fishermen and villagers were interviewed to obtain further information about the inhabiting fish fauna in the Kala Oya basin. Identification of the fish samples were done with published updated literature.

No counts of fish were taken as sampling techniques varied from site to site.

Results

(RL Categories - Red List Categories: VU – Vulnerable; EN – Endangered; En: Endemic; Ex: Exotic; CR – Critically Endangered; NE: Not Evaluated NT – Near Threaten; LC – Least Concerned; DD – Data Deficient) (Source: IUCN, 2012) S – Sinhala Name; E – English name; TR – Threatened

Table 86 The recorded fish species during the field survey and their taxonomic, conservation status (Freshwater fish – Blue; Marine and brackish water – black; Crustaceans – Red)

Family	Scientific name	Common names	RL Categories
Adrianichthyidae	*Oryzias dancena* (Hamilton, 1822)	E : Indian Ricefish S : Handi Handaya	DD
	Oryzias carnaticus (Jerdon,1849)	E : Spotted Ricefish S : Handi Handaya	DD
Anabantidae	*Anabas testudineus* (Bloch,1795)	E : Climbing Perch S : Kaavaiya	LC
Anguilllidae	*Anguilla bicolor* (Mc Clelland,1844)	E : Level-finned Eel S : Mada Anda	LC
	Anguilla nebulosa (Gray, 1831)	E : Mottled Eel S : Polmal Anda	LC
Aplocheilidae	*Aplocheilus parvus* (Raj, 1916)	E : Dwarf Panchax S : Uda Handaya	LC
Arridae	*Arius maculatus* (Thunberg, 1792)	E : Spotted catfish S : Anguluwa	NE
Bagridae	*Mystus vittatus* (Blotch,1794)	E : Striped Dwarf Catfish S.: Iri Ankutta	LC
	Mystus zeylanicus (Ng and Pethiyagoda, 2013)	E.: Yellow Catfish S.: Path Ankutta	NE/En
Belontiidae	*Trichogaster pectoralis* (Regan, 1910)	E : Snakeskin Gouramy S : Vel Gurami	Ex/LC
Carangidae	*Caranx sexfasciatus* Quoy and Gaimard, 1825	E : Bigeye Trevally S : Parawa	NE
Chanidae	*Chanos chanos* (Forsskal, 1775)	E : Milkfish S : Wekkaya	NE
Channidae	*Channa striata* (Bloch,1793)	E : Murrel S : Loola	LC
	Channa punctata (Bloch, 1793)	E : Spotted snakehead S : Mada Kanaya	LC
Cichlidae	*Etroplus suratensis* (Bloch,1785)	E : Green Chromid S : Mal koraliya	LC
	Pseudoetroplus maculatus (Bloch, 1785)	E : Orange Chromid S : Kaha Koraliya	LC
	Oreochromis niloticus (Lin.,1758)	E : Nile Tilapia S : Sudu Batta	Ex/LC
	Oreochromis mossambicus (Peters, 1864)	E : Mozambique Tilapia S : Sudu Batta	Ex/LC

Family	Scientific name	Common names	RL Categories
Claridae	*Clarias brachysoma* (Günther, 1864)	E : Walking Catfish S : Magura	En /T
Clupeidae	*Amblygaster clupeoides* Bleeker, 1849	E : Bleeker's smoothbelly sardinella S : Gal hurulla	NE
	Anadontosoma chacunda (Hamilton-Buchanun,1822)	E : Chacunda gizzard shad	NE
	Ehirava fluviatilis (Deraniyagala, 1929)	E : Malabar Sprat S : Ahirawa	NE
Cyprinidae	*Labeo dussumieri* (Valenciennes,1842)	E : Common Labeo S : Hiri Kanaya	LC
	Puntius bimaculatus (Bleeker, 1863)	E : Redside Barb S : Ipilli kadaya	LC
	Puntius thermalis (Valenciennes, in Cuvier and Valenciennes, 1844)	E : Swamp barb S : Kota Pethiya	LC/En
	Puntius dorsalis (Jerdon, 1849)	E : Long Snouted Barb S : Katu Pethiya	LC
	Rasbora microcephalus (Jerdon, 1849)	E : Narrow line Rasbora S : Kiri Dandiya	LC
	Rasbora dandia (Valenciennes, in Cuvier and Valenciennes, 1844)	E : Common Rasbora S : Dandiya	LC
	Laubuca lankensis (Deraniyagala, 1960)	E : Sri Lankan blue Laubuca S : Nil Kara-Adaya	VU/En
	Puntius vittatus (Day, 1865)	E : Silver Barb S : Bandi titteya	LC
	Pethia melanomaculata (Deraniyagala, 1956)	E : Sri Lanka tic tac toe barb S : Thith petiya	VU/En
	Dawkinsia singhala (Dunker,1912)	E : Sri Lanka filamented Barb S : Damkola Pethiya	LC/En
	Devario malabaricus (Jerdon,1849)	E : Giant Danio S : Damkola Salaya	LC
	Amblypharyngodon melattinus (Valencinnes, 1844)	E : Silver carplet S : Soraya	LC
	Esomus thermoicos (Valenciennes, 1842)	E : Flying Barb S : Revul Dandiya	LC/En
	Garra ceylonensis Bleeker, 1863	E : Stone Sucker S : Gal Paandiya	VU/En
	Horadandia atukorali Deraniyagala, 1943	S : Hora Dandia	VU/En
	Labeo rohita (Hamilton,1822)	E : Rohu S : Rohu	NE/Ex
Echeneidae	*Echeneis naucrates* Linnaeus, 1758	E : Live sharksucker	LC
Engraulidae	*Thryssa baelama* (Forsskål, 1775)	E : Baelama anchovy	NE

Family	Scientific name	Common names	RL Categories
Gerreidae	*Gerres setifer* Hamilton, 1822)	E : Small Bengal silver-biddy	LC
Gobiidae	*Stenogobius malabaricus* (Day, 1865)	E : Malabar Goby	NE
	Glossogobius giuris (Hamilton,1822)	E : Bar Eyed Goby S : Maha Weligowwa	LC
	Awaous melanocephalus (Bleeker, 1849)	E : Large Snout Goby	LC
Haemulidae	*Plectorhinchus gibbosus* (Lacepède, 1802)	E : Harry hotlips	LC
Heteropneustidae	*Heteropneustes fossilis* (Bloch,1797)	E : Stiging Catfish S : Hunga	LC
Hemiramphidae	*Hyporhamphus limbatus* (Valenciennes, 1846)	E : Congaturi Halfbeak S : Moralla	NE
	Zanarchopterus dispar (Valenciennes, 1847)	E : Halfbeak S : Moralla	NE
Latidae	*Lates calcarifer* (Bloch, 1790)	E : Barramundi S : Moda	NE
Leiognathidae	*Leiognathus brevirostris* (Valencinnes, 1835)	E : Short nose pony fish	NE
Loricariidae	*Pterygoplichthys pardalis* (Castelnau, 1855)	E : Leopard pleco S : Tanki sudda	Ex/NE
Lutjanidae	*Lutjanus argentimaculatus* (Forsskal, 1775)	E : Mangrove Jack S : Thambalaya	NE
Mastacembelidae	*Mastacembelus armatus* (Lacepede, 1803)	E : Marbled Spiny Eel S : Gan Theliya	LC
Monodactylidae	*Monodactylus argenteus* (Linnaeus, 1758)	E : Silver moony S : Kapu handa	NE
Mugilidae	*Mugil cephalus* (Linnaeus, 1758)	E : Gray Mullet S : Godaya	NE
Penaeidae	*Penaeus semisulcatus* (De Haan, 1844)	E : Green tiger prawn	NE
Platycephalidae	*Thysanophrys chiltonae* Schultz, 1966	E : Longsnout flathead	NE
Portunidae	*Scylla serrata* (Forsskål, 1775)	E : Mangrove crab	NE
Sciaenidae	*Dendrophysa russelii* (Cuvier, 1829)	E : Goatee croaker	NE
Siganidae	*Siganus javus* (Linnaeus, 1766)	E : Streaked spinefoot	NE
Sillaginidae	*Sillago sihama* (Forsskål, 1775)	E : Silver sillago	NE
Siluridae	*Ompok bimaculatus* (Blotch, 1794)	E : Butter Catfish S : Walapotta	LC
Soleidae	*Euryglossa orientalis* (Bloch and Schneider, 1801)	E : Oriental sole S : Pathamadiya	NE
Terapontidae	*Terapon jarbua* (Forsskal,1775)	E : Crescent Perch S : Iri Bataya	LC

Family	Scientific name	Common names	RL Categories
Tetradontidae	*Chelonodon patoca* (Hamilton, 1822)	E : Puffer fish S : Peththaya	NE

Fish species recorded during the sampling

Monodactylus argentius

Amblygaster clupeoides

Arius maculatus

Gerres setifer

Siganus javus

Thysanophrys chiltonae

Amblypharyngodon melattinus

Anadontosoma chacunda

Arius maculatus

Awaous melanocephalus

Carynx sexfasciatus

Chanos chanos

Chelonodon patoca

Dawkinsia singhala

Dendrophysa russelii

Devario malabaricus

Echeneis naucrates

Etroplus suratensis

iEuryglossa orientalis

Garra ceylonensis

Horadandia atukorali

Labeo dussumier

Labeo rohita

Laubuca lankensis

Leiognathus brevirostris

Lutjanus argentimaculatus

Mastacembelus armatus

Mugil cephalus

Mystus vittatus

Mystus zeylanicus

Oreochromis mossambicus

Oreochromis niloticus

Oryzias dancena

Plectorhinchus gibbosus

Pseudoetroplus maculatus

Puntius bimaculatus

Puntius dorsalis

Puntius thermalis

Rasbora microcephalus

Siganus javus

Sillago sihama

Stenogobius malabaricus

Terapon jarbua

Thryssa baelama

Figure 112 Photographs of fish species recorded during the sampling

9.0 BUTTERFLY DIVERSITY ANALYSIS

9.1 Introduction

Sri Lanka is home to 245 species of butterflies (Order Lepidoptera: superfamily Papilionoidae) which twenty-six species are endemic to the country. Based on this current classification and they comprise 6 families: Papilionidae, Pieridae, Riodinidae, Lycaenidae, Hesperiidae and Nymphalidae (which includes the sub-families Satryinae, Danainae, Libytheinae, Limenitidinae, Apaturinae, Biblidinae, Charaxinae and Heliconiinae).

Distribution pattern of butterflies, classified into six butterfly zones based on rainfall, elevation; temperature and vegetation. Those are Wet Zone Low land, Wet Zone Montane, Dry & Intermediate Zone, Arid Zone (North & North West), Arid Zone (South), Wet Coastal Zone.
Butterflies are living organisms that are an integral part of our ecosystems and provide a valuable environmental service as pollinators. They play a significant role in the food chain by being a source of food to other organisms within all stages of their development. The larval stages are particularly important food sources for birds including their young. Butterflies are used as indicators of environmental quality and are invaluable for their aesthetic appeal and have considerable economic value to the tourism Sector, particularly in ecotourism.

The sampling for this group also followed the protocol outlined in the Biodiversity Survey Field Manual endorsed by the Department of Wildlife Conservation. All collection practices were according the Field Manual and to ensure minimal damage to the particular species and after identification they released in to same natural habitat.

9.2 Sampling Methodology

During the survey, 84 species of butterflies belonging to 5 families were recorded. This represented about 34.42 % of the island's total butterfly fauna.

There were three endemic species- *Troides darsius,* Sri Lanka Birdwing, *Mycalesis subdita*, Sri Lanka Tamil Bush Brown, *Appias galena,* Sri Lanka Lesser Albatross. Moreover, there are 7 nationally threatened species found in the Kala Oya river basin, out of which five are Vulnerable (VU)**:** *Papiliocrino* - Banded Peacock, *Ariadne merione* - Common Caster, *Bybliai lithyia* - Joker (Figure 113),*Virachola perse* - Large Guava Blue, *Spindasis lohita* - Long-banded Silverline, and two are Near Threatened (NT) *Iraota timoleon* - Silver Streak Blue, *Pelopidas agna* - Little Branded Swift.

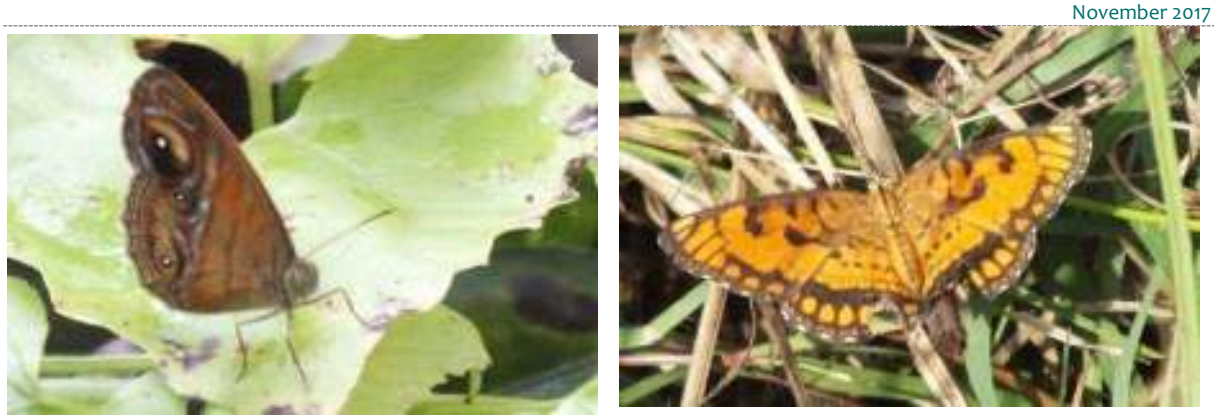


Figure 113 [Left] Gladeye Bush Brown (*Mycalesis subdita*); [Right] Joker (*Byblia ilithyia*)

When considering the distribution of endemic species, the Sri Lanka Birdwing - *Troides darsius*, was found in Dry Mixed Evergreen Forest, the Sri Lanka Tamil Bush Brown - *Mycalesis subdita* was found in Chena associated habitats, Disturbed Forest areas and Dry Mixed Evergreen Forest, the Sri Lanka Lesser Albatross - *Appias galena*, was found in tank associated habitats and Dry Mixed Evergreen Forests (Table 87).

Figure 115Lesser Albatross (*Appiasgalene*)

Table 87 Endemic butterfly species found in transects surveyed

Genus	Species	Common Name	Red List status	T9	T12	T13	T15	T17	T19	T22	T23	T24
Appias	*galene*	Lesser Albatross	LC			11	4	2	9	3	12	27
Troides	*demoleus*	Sri Lanka Birdwing	LC			1		2				
Mycalesis	*subdita*	Tamil Bush Brown	LC	1	3		12					

The nationally threatened Joker - *Bybliai lithyia* which is Vulnerable, was found only in meadows with seasonal flooding on coastal habitats T1 and T2. These areas belong to the North and North West butterfly zones. The Common Caster - *Ariadne merione*, was recorded only once in this habitat (T2). The Banded Peacock - *Papilio crino* mainly found in Dry Mixed Evergreen Forest areas was found in T9, T17, T19, T20. The Large Guava Blue - *Virachola perse* mainly found in Scrub Forests was observed in T21. The Long-banded Silverline - *Spindasis lohita* found in Dry Mixed Evergreen Forests was observed in T16.

Two species falling in the Near Threatened category, the Little Branded Swift - *Pelopidas agna* and the Silver Streak Blue - *Iraota timoleon* were recorded in Scrub Forests in T6 and tank associated habitats in T18 respectively.

Table 88 Nationally threatened species found in transects

Genus	Species	Common Name	Red List Status	T1	T2	T6	T9	T 16	T 17	T 18	T 19	T 21
Papilio	crino	Banded Peacock	VU				1		1		1	1
Ariadne	merione	Common Caster	VU		1							
Byblia	ilithyia	Joker	VU	3	9							
Virachola	perse	Large Guava Blue	VU									1
Pelopidas	agna	Little Branded Swift	NT			1						
Spindasis	lohita	Long-banded Silverline	VU					1				
Iraota	timoleon	Silver Streak Blue	NT							1		

According to the different habitats, the transects of the Kala Oya were categorized to seven different sub basins. However, only the distribution in the sub basins in Kala Oya with relevance to the respective transect is discussed here. Annex 04outlines the geographic coordinates of the transects.

A. Eile area sub basin (Transect 1, 2, 3, 4)

Dry Mixed Evergreen Forest was the prominent habitat type in this area along with Scrub forest. (Figure 116). In addition, tank associated habitats, Salt water marshes, Mangroves, abandon quarries with Disturbed scrub and meadows with seasonal flooding were also habitat types found in the transects.

The Joker - *Bybliai lithyia* (Figure 81), a characteristic species confined to seasonal flooding habitats (Gamage, R. 2014, Redlist 2012) was found only in meadows with seasonal flooding.

.

Figure 116 (a) (b) Elie area sub-basin and associated habitats - Transect 1 (c) (d) Elie area sub-basin and Associated habitats - Transect 2

This nationally threatened species which falls under the Vulnerable (VU) category was found only in T1 and T2 (IUCN Redlist 2012). The Common Caster, *Ariadne merione*, a Vulnerable species, was recorded only once- in habitat T2 (Shannon Index 3.68, Simpson Index 0.1084). According to density values, the Dark Grass Blue shows the highest density (Table 89).

Figure 117 (a) Abandoned quarry in Aruwakkalu - Transect 3 (b) Disturbed scrub in Aruwakkalu- Transect 3

Figure 118 Mangroves in Gagewadiya - Transect 4

Table 89 List of Butterfly species recorded from the Eile area (Transects 1,2,3,4,) and their status and population density (m^2)

	Genus	Species	Common Name	Red List status	No. butter flies	Status	Population density (m^2)
1	*Azanus*	*jesous*	African Babul Blue	LC	3	Indigenous	0.0001875
2	*Ariadne*	*ariadne*	Angle Castor	LC	53	Indigenous	0.0033125
3	*Tirumala*	*limniace*	Blue Tiger	LC	1	Indigenous	0.0000625
4	*Ampittia*	*dioscorides*	Bush hopper	LC	1	Indigenous	0.0000625
5	*Lambrix*	*salsala*	Chestnut Bob	LC	2	Indigenous	0.000125
6	*Ariadne*	*merione*	Common Caster	VU	1	Indigenous	0.0000625
7	*Eurima*	*Hecabe*	Common Grass Yellow	LC	33	Indigenous	0.0020625
8	*Cepora*	*Cepora*	Common Gull	LC	7	Indigenous	0.000875
9	*Prosotas*	*nora*	Common Line Blue	LC	8	Indigenous	0.0005
10	*Danaus*	*genutia*	Common Tiger	LC	6	Indigenous	0.00075
11	*Pachliopta*	*hector*	Crimson rose	LC	1	Indigenous	0.0000625
12	*Hypolimnas*	*misippus*	Danaid Eggfly	LC	1	Indigenous	0.0000625
13	*Zizeeria*	*Karsandra*	Dark Grass Blue	LC	73	Indigenous	0.0045625
14	*Delias*	*eucharis*	Jezebal	LC	11	Indigenous	0.0005
15	*Byblia*	*ilithyia*	Joker	VU	12	Indigenous	0.00075
16	*Catopsilia*	*pomona*	Lemon Emigrant	LC	1	Indigenous	0.0000625
17	*Junonia*	*lemonius*	Lemon Pansy	LC	20	Indigenous	0.00125
18	*Lampides*	*boeticus*	Pea Blue	LC	1	Indigenous	0.0000625
19	*Junonia*	*almanac*	Peacock Pansy	LC	1	Indigenous	0.0000625
20	*Danaus*	*chrysippus*	Plain Tiger	LC	55	Indigenous	0.0034375
21	*Leptosia*	*nina*	Psyche	LC	6	Indigenous	0.000375
22	*Clotis*	*amata*	Small Salmon Arab	LC	38	Indigenous	0.002375

	Genus	Species	Common Name	Red List status	No. butter flies	Status	Population density (m^2)
23	*Appias*	*libythea*	Striped Albetross	LC	5	Indigenous	0.0003125
24	*Acraea*	*violae*	Tawniy Coster	LC	2	Indigenous	0.000125
25	*Zizula*	*hylax*	Tiny Grass Blue	LC	11	Indigenous	0.0006875
26	*Potanthus*	*confucius*	Tropic Dart	LC	1	Indigenous	0.000125
27	*Ypthima*	*ceylonica*	White Four Ring	LC	4	Indigenous	0.00025
28	*Ixias*	*pyrere*	Yellow Orange tip	LC	1	Indigenous	0.0000625
29	*Leptotus*	*Plinius*	Zebra Blue	LC	6	Indigenous	0.000375

Figure 119 Some butterfly species (a) Danaid Eggfly (*Hypolimnas misippus*) (b) White Orange Tip; (*Ixias marianne*) (c) Angled Castor (*Ariadne ariadne*) (d) Tawny Coster (*Acraea violae*)

B. Eluwankulama sub basin (Transect 5 and 6)

This area consisted mainly of two different habitats- tank associated habitat and Dry Mixed Evergreen Forest (Figure 120). The results indicate that the Eluwankulama ecosystem contained 23 species of butterflies (Table 90). However, no endemic species were recorded. The species richness according to the Shannon index was 3.88, showing fairly high diversity.

Figure 120 Some butterfly species from Eluwankulama sub basin (a) White Four-ring (*Ypthima ceylonica*) (b) Gram Blue (*Euchrysops cnejus*)

The Little Branded Swift, *Pelopidas agna*, falling under the Near Threatened (NT) category was recorded within Scrub Forest habitats of the area. According to the density values, the Common Jezebel showed the highest density values (Table 90).

Figure 121 (a) Tank associated habitat in Eluwankulama - Transect 5 (b) (c) Eluwankulama sub basin Transect 6

Table 90 List of butterfly species recorded from the Eluwankulama area (Transect 5 and 6)

	Family name	Species name	Common Name	Red List status	No. of butterflies	Status	Population density (m^2)
1	*Tirumala*	*limniace*	Blue Tiger	LC	12	Indigenous	0.0015
2	*Ampittia*	*dioscorides*	Bush hopper	LC	2	Indigenous	0.00025
3	*Euploea*	*core*	Common Crow	LC	14	Indigenous	0.00175
4	*Eurima*	*Hecabe*	Common Grass Yellow	LC	28	Indigenous	0.0035
5	*Danaus*	*genutia*	Common Tiger	LC	7	Indigenous	0.000875
6	*Pachliopta*	*hector*	Crimson rose	LC	7	Indigenous	0.000875
7	*Hypolimnas*	*misippus*	Danaid Eggfly	LC	2	Indigenous	0.00025
8	*Zizeeria*	*Karsandra*	Dark Grass Blue	LC	15	Indigenous	0.001875

	Family name	Species name	Common Name	Red List status	No. of butterflies	Status	Population density (m^2)
9	*Euchrysops*	*cnejus*	Gram Blue	LC	2	Indigenous	0.00025
10	*Delias*	*eucharis*	Jezebel	LC	16	Indigenous	0.002
11	*Zizina*	*otis*	Lesser Grass Blue	LC	2	Indigenous	0.00025
12	*Junonia*	*lemonius*	Lemon Pansy	LC	9	Indigenous	0.001125
13	*Pelopidas*	*agna*	Little Branded Swift	NT	1	Indigenous	0.000125
14	*Orsotriaena*	*medus*	Medus Brown	LC	3	Indigenous	0.000375
15	*Catopsilia*	*pyrantha*	Mottled Emigrant	LC	8	Indigenous	0.001
16	*Lampides*	*boeticus*	Pea Blue	LC	21	Indigenous	0.002625
17	*Danaus*	*chrysippus*	Plain Tiger	LC	32	Indigenous	0.004
18	*Anthene*	*lycaenina*	Pointed Cilite Blue	LC	1	Indigenous	0.000125
19	*Leptosia*	*nina*	Psyche	LC	3	Indigenous	0.000375
20	*Acraea*	*violae*	Tawney Coster	LC	3	Indigenous	0.000375
21	*Potanthus*	*confucius*	Tropic Dart	LC	1	Indigenous	0.000125
22	*Ypthima*	*ceylonica*	White Four Ring	LC	4	Indigenous	0.0005
23	*Leptotus*	*Plinius*	Zebra Blue	LC	4	Indigenous	0.0005

C. Suduweli Tahalawa, Morapathana sub basin (Transects 7 and 8)

Dry Mixed Evergreen Forest was the prominent habitat type with open dunes in some areas.

Figure 122 (a) Suduweli Talawa sub basin - Transect 7 (b) (c) (d) Suduweli Talawa sub basin- Transect 8

Figure 123 Mottled Emigrant; (*Catopsilia pyranthe*) (b) Chocolate Soldier (*Junonia iphita*)

During the period of survey, 22 species were observed in this habitat. The Shannon index (H') was 2.758. According to the density values, the White Four Ring -Ypthima ceylonica shows the highest density value (Table 91).

Table 91 List of butterfly species recorded from the Suduweli Tahalawa, Morapathana area (Transect 7 and 8) with their status and population density (m2)

	Family name	Species name	Common Name	Red List status	No. butter flies	Status	Population density (m^2)
1	*Ariadne*	*ariadne*	Angle Castor	LC	4	Indigenous	0.0005
2	*Junonia*	*iphita*	Chocolate Soldier	LC	5	Indigenous	0.000625
3	*Mycalesis*	*perseus*	Common Bushbrown	LC	2	Indigenous	0.00025
4	*Jamides*	*celeno*	Common Cerulean	LC	1	Indigenous	0.000125
5	*Euploea*	*core*	Common Crow	LC	9	Indigenous	0.001125
6	*Eurima*	*Hecabe*	Common Grass Yellow	LC	2	Indigenous	0.00025
7	*Cepora*	*Cepora*	Common Gull	LC	4	Indigenous	0.0005
8	*Castalius*	*rosimon*	Common Pierrot	LC	2	Indigenous	0.00025
9	*Neptis*	*hylas*	Common Sailor	LC	5	Indigenous	0.000625
10	*Spindasis*	*vulcanus*	Common Silverline	LC	1	Indigenous	0.000125
11	*Pachliopta*	*hector*	Crimson rose	LC	3	Indigenous	0.000375
12	*Euchrysops*	*cnejus*	Gram Blue	LC	2	Indigenous	0.00025
13	*Freyeria*	*putli*	Grass Jewel	LC	1	Indigenous	0.000125
14	*Spialia*	*galba*	Indian Skipper	LC	2	Indigenous	0.00025
15	*Delias*	*eucharis*	Jezebel	LC	4	Indigenous	0.0005
16	*Zizina*	*otis*	Lesser Grass Blue	LC	2	Indigenous	0.00025
17	*Junonia*	*lemonius*	Lemon Pansy	LC	3	Indigenous	0.000375
18	*Orsotriaena*	*medus*	Medes Brown	LC	9	Indigenous	0.001125
19	*Catopsilia*	*pyrantha*	Mottled Emigrant	LC	9	Indigenous	0.001125
20	*Graphiun*	*agamemnon*	Tailed Jay	LC	1	Indigenous	0.000125
21	*Acraea*	*violae*	Tawney Coster	LC	1	Indigenous	0.000125
22	*Ypthima*	*ceylonica*	White Four Ring	LC	16	Indigenous	0.002

D. Weerakkodichole, Tahabbbowa sub basin (Transect 9, 10)

Dry Mixed Evergreen Forests dominated this area. Disturbed Forest, Scrub Forest, abandoned Chena and Riparian forest are other habitat types found within this area.

Figure 124 Werakkodichole, Tahabbbowa sub basin - Transect 9

The results indicated that the habitat showed 29 species of butterflies. The Shannon index (H') was 2.71. The Banded Peacock -*Papilio crino*, a Vulnerable (VU) species was recorded in this area.

According to the density values, the Plain Tiger – *Danaus chrysippus* showed the highest density values (Table 92).

Figure 125 (a) Plain Tiger (*Danaus chrysippus*) (b) Crimson Rose (*Pachliopta aristolochia*)

Table 92 List of butterfly species recorded from Werakkodichole, Tahabbbowa area (Transect 9 and 10) with their status and population density (m^2)

	Family name	Species name	Common Name	Red List status	No. of butter flies	Status	Population density (m^2)
1	*Ariadne*	*ariadne*	Angle Castor	LC	6	Indigenous	0.00075
2	*Papilio*	*crino*	Banded Peacock	VU	1	Indigenous	0.000125
3	*Tirumala*	*limniace*	Blue Tiger	LC	4	Indigenous	0.0005
4	*Badamia*	*exclamationis*	Brown Awl	LC	1	Indigenous	0.000125
5	*Lambrix*	*salsala*	Chestnut Bob	LC	7	Indigenous	0.000875
6	*Jamides*	*celeno*	Common Cerulean	LC	2	Indigenous	0.00025
7	*Euploea*	*core*	Common Crow	LC	21	Indigenous	0.002625
8	*Eurima*	*Hecabe*	Common Grass Yellow	LC	13	Indigenous	0.001625
9	*Cepora*	*Cepora*	Common Gull	LC	3	Indigenous	0.000375
10	*Castalius*	*rosimon*	Common Pierrot	LC	1	Indigenous	0.000125
11	*Pachliopta*	*hector*	Common Rose	LC	1	Indigenous	0.000125
12	*Neptis*	*hylas*	Common Sailor	LC	12	Indigenous	0.0015
13	*Spindasis*	*vulcanus*	Common Silverline	LC	1	Indigenous	0.000125
14	*Danaus*	*genutia*	Common Tiger	LC	10	Indigenous	0.00125
15	*Pachliopta*	*hector*	Crimson Rose	LC	15	Indigenous	0.001875
16	*Zizeeria*	*Karsandra*	Dark Grass Blue	LC	16	Indigenous	0.002
17	*Pareronia*	*ceylanica*	Dark Wanderer	LC	2	Indigenous	0.00025
18	*Euchrysops*	*cnejus*	Gram Blue	LC	5	Indigenous	0.00625
19	*Everes*	*lacturnus*	Indian Cupid	LC	1	Indigenous	0.000125
20	*Delias*	*eucharis*	Jezebal	LC	18	Indigenous	0.00225
21	*Zizina*	*otis*	Lasser Grass Blue	LC	4	Indigenous	0.0005
22	*Catopsilia*	*pomona*	Lemon	LC	2	Indigenous	0.00025

	Family name	Species name	Common Name	Red List status	No. of butter flies	Status	Population density (m^2)
			Emigrant				
23	*Junonia*	*lemonius*	Lemon Pansy	LC	4	Indigenous	0.0005
24	*Junonia*	*almanac*	Peacock Pansy	LC	1	Indigenous	0.000125
25	*Danaus*	*chrysippus*	Plain Tiger	LC	52	Indigenous	0.0065
26	*Leptosia*	*nina*	Psyche	LC	6	Indigenous	0.00075
27	*Mycalesis*	*subdita*	Tamil Bush Brown	LC	1	Endemic	0.000125
28	*Zizula*	*hylax*	Tiny Grass Blue	LC	2	Indigenous	0.00025
29	*Ypthima*	*ceylonica*	White Four Ring	LC	42	Indigenous	0.00525

E. Horiwila / Ambagahawewa sub basin (Transect 11 and 12)

Disturbed Forest, Scrub Forest, abandoned Chena, Riparian forest, Tank associated habitats, Dry Mixed Evergreen Forest are habitat types found within this area. The results indicated that the habitat had 18 species of butterflies.

The Shannon index (H') was 2.472. One endemic species, the Sri Lanka Tamil Bush Brown – *Mycalesis subdita*, was found in Dry Mixed Evergreen Forest habitat. According to the density values, the Common Crow - *Euploea core*, showed the highest density values (Table 93).

Figure 126 (a) Common Crow; (*Euploea core*) (b)Common Grass Yellow (*Eurema hecabe*) (c) Blue Tiger (*Tirumala limniace*) (d) Common Sailor (*Neptis hylas*)

Table 93 List of butterfly species recorded from Horiwila/ Ambagahawewa (Transect 11 and 12) with their status and Population density (m^2)

	Family name	Species name	Common Name	Red List status	No. of butter flies	Status	Population density (m^2)
1	*Tirumala*	*limniace*	Blue Tiger	LC	11	Indigenous	0.001375
2	*Ampittia*	*dioscorides*	Bush hopper	LC	2	Indigenous	0.00025
3	*Lambrix*	*salsala*	Chestnut Bob	LC	4	Indigenous	0.0005
4	*Euploea*	*core*	Common Crow	LC	29	Indigenous	0.003625
5	*Melanitis*	*leda*	Common Evening Brown	LC	1	Indigenous	0.000125
6	*Eurima*	*Hecabe*	Common Grass Yellow	LC	11	Indigenous	0.001375
7	*Cepora*	*Cepora*	Common Gull	LC	4	Indigenous	0.0005
8	*Neptis*	*hylas*	Common Sailor	LC	1	Indigenous	0.000125
9	*Danaus*	*genutia*	Common Tiger	LC	2	Indigenous	0.00025
10	*Pachliopta*	*aristolochia*	Crimson Rose	LC	7	Indigenous	0.000875
11	*Euchrysops*	*cnejus*	Gram Blue	LC	4	Indigenous	0.0005
12	*Delias*	*eucharis*	Jezebel	LC	5	Indigenous	0.000625
13	*Catopsilia*	*pyrantha*	Mottled Emigrant	LC	3	Indigenous	0.000375
14	*Lampides*	*boeticus*	Pea Blue	LC	3	Indigenous	0.000375
15	*Danaus*	*chrysippus*	Plain Tiger	LC	8	Indigenous	0.001
16	*Mycalesis*	*subdita*	Tamil Bush Brown	LC	3	Endemic	0.000375
17	*Ypthima*	*ceylonica*	White Four Ring	LC	20	Indigenous	0.0025
18	*Leptotus*	*Plinius*	Zebra Blue	LC	3	Indigenous	0.000375

F. Galpaya Hinguruwelpitiya Ranva kannda, Nambatiwewa, sub basin (Transect 13, 14, 15, 16)

During the study period, 55 species of butterflies including 3 endemic species- Sri Lanka Birdwing - *Troides darsius*, Sri Lanka Tamil Bush Brown – *Mycalesis subdita* and the Sri Lanka Lesser Albatross, *Appias galena* were recorded in this area. Among them 1 nationally threatened species was identified.

The results indicated that this area as a habitat showed the highest butterfly diversity (55 species). The Shannon index (H') was 3.39. According to the density values, the Common Grass Yellow – *Eurima hecabe* and Pea Blue – *Lampides boeticus* showed the highest density values (Table 65).

Figure 127 (a) (b) Galpaya, Hinguruwelpitiya, Ranva kannda, sub basin- Transect 13; (c) (d) Nambatiwewa, sub basin - Transect 14

Table 94 List of butterfly species recorded from Galpaya, Hinguruwelpitiya, Ranva kannda, Nambatiwewa (Transect 13, 14, 15, and 16) with their status and Population density (m^2)

	Family name	Species name	Common Name	Red List status	No. of butterflies	Status	Population density (m^2)
1	*Azanus*	*jesous*	African Babul Blue	LC	3	Indigenous	0.000188
2	*Ariadne*	*ariadne*	Angle Castor	LC	3	Indigenous	0.000188
3	*Papillio*	*polymnestor*	Blue Mormon	LC	2	Indigenous	0.000125
4	*Tirumala*	*limniace*	Blue Tiger	LC	18	Indigenous	0.001125
5	*Ampittia*	*dioscorides*	Bush hopper	LC	2	Indigenous	0.000125
6	*Tagiades*	*japetus*	Ceylon Snow	LC	1	Indigenous	0.0000625

	Family name	Species name	Common Name	Red List status	No. of butterflies	Status	Population density (m^2)
			Flat				
7	*Lambrix*	*salsala*	Chestnut Bob	LC	4	Indigenous	0.00025
8	*Junonia*	*iphita*	Chocolate Soldier	LC	7	Indigenous	0.000438
9	*Hasora*	*chromus*	Common Banded Awl	LC	1	Indigenous	0.0000625
10	*Mycalesis*	*perseus*	Common Bushbrown	LC	24	Indigenous	0.0015
11	*Jamides*	*celeno*	Common Cerulean	LC	3	Indigenous	0.000188
12	*Euploea*	*core*	Common Crow	LC	18	Indigenous	0.001125
13	*Eurima*	*Hecabe*	Common Grass Yellow	LC	52	Indigenous	0.00325
14	*Cepora*	*Cepora*	Common Gull	LC	5	Indigenous	0.000625
15	*Papilio*	*polytes*	Common Mormon	LC	2	Indigenous	0.000125
16	*Castalius*	*rosimon*	Common Pierrot	LC	1	Indigenous	0.0000625
17	*Pachliopta*	*aristolochia*	Common Rose	LC	11	Indigenous	0.001375
18	*Neptis*	*hylas*	Common Sailor	LC	24	Indigenous	0.0015
19	*Danaus*	*genutia*	Common Tiger	LC	4	Indigenous	0.00025
20	*Pachliopta*	*hector*	Crimson rose	LC	23	Indigenous	0.001438
21	*Mycalesis*	*mineus*	Dark Brand Bushbrown	LC	2	Indigenous	0.000125
22	*Jumides*	*bochus*	Dark Cerulean	LC	6	Indigenous	0.000375
23	*Mycalesis*	*patnia*	Gladeye Bush Brown	LC	7	Indigenous	0.000438
24	*Parantica*	*aglea*	Glassy Tiger	LC	1	Indigenous	0.0000625
25	*Hypolimnas*	*bolina*	Grate Eggfly	LC	3	Indigenous	0.000188
26	*Hebomoia*	*glaucippe*	Great Orangetip	LC	1	Indigenous	0.0000625
27	*Junonia*	*atlites*	Grey Pansy	LC	8	Indigenous	0.0005
28	*Everes*	*lacturnus*	Indian Cupid	LC	3	Indigenous	0.000188
29	*Spialia*	*galba*	Indian Skipper	LC	4	Indigenous	0.00025
30	*Curetis*	*thetis*	Indian Sunbeam	LC	1	Indigenous	0.0000625
31	*Delias*	*eucharis*	Jezebel	LC	10	Indigenous	0.000625
32	*Zizina*	*otis*	Lesser Grass Blue	LC	11	Indigenous	0.001375
33	*Junonia*	*lemonius*	Lemon Pansy	LC	1	Indigenous	0.0000625
34	*Phalanta*	*phalantha*	Leopard	LC	4	Indigenous	0.00025
35	*Appias*	*galene*	Lesser Albatross	LC	15	Endemic	0.001875
36	*Chilades*	*lajus*	Lime Blue	LC	5	Indigenous	0.000313
37	*Papilio*	*demoleus*	Lime Butterfly	LC	4	Indigenous	0.00025
38	*Spindasis*	*lohita*	Long-banded Silverline	VU	1	Indigenous	0.0000625
39	*Orsotriaena*	*medus*	Medus Brown	LC	12	Indigenous	0.00075
40	*Rathida*	*amor*	Monkey Puzzle	LC	1	Indigenous	0.0000625
41	*Catopsilia*	*pyrantha*	Mottled Emigrant	LC	23	Indigenous	0.001438
42	*Lampides*	*boeticus*	Pea Blue	LC	52	Indigenous	0.00325
43	*Junonia*	*almanac*	Peacock Pansy	LC	2	Indigenous	0.000125

	Family name	Species name	Common Name	Red List status	No. of butterflies	Status	Population density (m^2)
44	*Tajuria*	*cippus*	Peacock Royal	LC	1	Indigenous	0.0000625
45	*Danaus*	*chrysippus*	Plain Tiger	LC	3	Indigenous	0.000188
46	*Leptosia*	*nina*	Psyche	LC	3	Indigenous	0.000188
47	*Troides*	*darsius*	Sri Lanka Birdwing	LC	1	Endemic	0.0000625
48	*Graphiun*	*agamemnon*	Tailed Jay	LC	2	Indigenous	0.000125
49	*Mycalesis*	*subdita*	Tamil Bush Brown	LC	15	Endemic	0.000938
50	*Acraea*	*violae*	TawniyCoster	LC	5	Indigenous	0.000313
51	*Zizula*	*hylax*	Tiny Grass Blue	LC	33	Indigenous	0.002063
52	*Potanthus*	*confucius*	Tropic Dart	LC	4	Indigenous	0.00025
53	*Borbo*	*cinnara*	Wallace's Swift	LC	2	Indigenous	0.000125
54	*Ypthima*	*ceylonica*	White Four Ring	LC	40	Indigenous	0.0025
55	*Leptotus*	*Plinius*	Zebra Blue	LC	18	Indigenous	0.001125

Figure 128 (a) (b) Hinguruwelpitiya sub basin -Transect 15 (c) Galpaya basin (d) (e) Galpaya - Transect 16 (f) Indigollagama wawa - Transect 16

Figure 129 Some butterflies found this sub basin (a) Lesser Albatross (*Appias galene*) (b) Monkey-puzzle (*Rathinda amor*) (c) Lime Blue; (*Chilades lajus*)

G. Manawa area sub basin (Transect 17, 18 19 20,)

Figure 130 (a) (b) Manawa area sub basin - Transect 18 (c) (d) Transect 19

During the study period, 42 species of butterflies including 2 endemic species, the Sri Lanka Birdwing, Troides darsius and the Sri Lanka Lesser Albatross, Appias galena were recorded in this area. Amongst the butterflies recorded during the survey, the nationally threatened Banded Peacock, Papilio crino, and Silver Streak Blue, Iraota timoleon were also recorded. The Shannon index (H') was 4.27. According to the density values, the Common Crow showed the highest density values (Table 95).

Figure 131 Some butterfly species found in this sub basin (a) Lesser Albatross (*Appias galene*) (b) Indian Cupid (*Everes lacturnus*)

Table 95 List of butterfly species recorded from the Manawa area (Transect 17, 18, 19, and 20) with their status and population density (m^2)

	Family name	Species name	Common Name	Red List status	No. of butter flies	Status	Population density (m^2)
1	*Papilio*	*crino*	Banded Peacock	VU	2	Indigenous	0.000125
2	*Papillio*	*polymnestor*	Blue Mormon	LC	3	Indigenous	0.000188
3	*Tirumala*	*limniace*	Blue Tiger	LC	50	Indigenous	0.003125
4	*Ampittia*	*dioscorides*	Bush hopper	LC	1	Indigenous	0.0000625
5	*Junonia*	*iphita*	Chocolate Soldier	LC	7	Indigenous	0.000438
6	*Mycalesis*	*perseus*	Common Bushbrown	LC	11	Indigenous	0.001375
7	*Euploea*	*core*	Common Crow	LC	122	Indigenous	0.007625
8	*Taractrocera*	*maevius*	Common Grass Dart	LC	4	Indigenous	0.00025
9	*Eurima*	*hecabe*	Common Grass Yellow	LC	66	Indigenous	0.004125
10	*Papilio*	*polytes*	Common Mormon	LC	3	Indigenous	0.000188
11	*Castalius*	*rosimon*	Common Pierrot	LC	1	Indigenous	0.0000625
12	*Pachliopta*	*aristolochia*	Common Rose	LC	2	Indigenous	0.000125
13	*Neptis*	*hylas*	Common Sailor	LC	5	Indigenous	0.000313
14	*Danaus*	*genutia*	Common Tiger	LC	44	Indigenous	0.00275
15	*Pachliopta*	*hector*	Crimson rose	LC	17	Indigenous	0.001063
16	*Jumides*	*bochus*	Dark Cerulean	LC	1	Indigenous	0.0000625
17	*Euchrysops*	*cnejus*	Gram Blue	LC	11	Indigenous	0.001375
18	*Junonia*	*atlites*	Grey Pansy	LC	1	Indigenous	0.0000625
19	*Everes*	*lacturnus*	Indian Cupid	LC	6	Indigenous	0.000375
20	*Spialia*	*galba*	Indian Skipper	LC	4	Indigenous	0.00025
21	*Curetis*	*thetis*	Indian Sunbeam	LC	2	Indigenous	0.000125
22	*Delias*	*eucharis*	Jezebal	LC	2	Indigenous	0.000125
23	*Zizina*	*otis*	Lesser Grass Blue	LC	48	Indigenous	0.003
24	*Catopsilia*	*pomona*	Lemon Emigrant	LC	13	Indigenous	0.000813
25	*Junonia*	*lemonius*	Lemon Pansy	LC	15	Indigenous	0.000938
26	*Appias*	*galene*	Lesser Albatross	LC	11	Endemic	0.001375
27	*Papilio*	*demoleus*	Lime Butterfly	LC	7	Indigenous	0.000438
28	*Orsotriaena*	*medus*	Medus Brown	LC	3	Indigenous	0.000188
29	*Catopsilia*	*pyrantha*	Mottled Emigrant	LC	7	Indigenous	0.000438
30	*Lampides*	*boeticus*	Pea Blue	LC	78	Indigenous	0.004875
31	*Danaus*	*chrysippus*	Plain Tiger	LC	34	Indigenous	0.002125
32	*Neopithecops*	*zalmora*	Quaker	LC	1	Indigenous	0.0000625
33	*Talicada*	*nyseus*	Red Pierrot	LC	5	Indigenous	0.000313
34	*Dophla*	*evelina*	Red Spot Duke	LC	1	Indigenous	0.0000625
35	*Iraota*	*timoleon*	Silver Streak Blue	NT	1	Indigenous	0.0000625
36	*Clotis*	*amata*	Small Salmon Arab	LC	1	Indigenous	0.0000625
37	*Troides*	*darsius*	Sri Lanka Birdwing	LC	2	Endemic	0.000125
38	*Appias*	*libythea*	Striped Albatross	LC	13	Indigenous	0.000813
39	*Acraea*	*violae*	Tawny Coster	LC	16	Indigenous	0.001
40	*Zizula*	*hylax*	Tiny Grass Blue	LC	11	Indigenous	0.000688

	Family name	Species name	Common Name	Red List status	No. of butter flies	Status	Population density (m^2)
41	*Ypthima*	*ceylonica*	White Four Ring	LC	32	Indigenous	0.002
42	*Leptotus*	*plinius*	Zebra Blue	LC	47	Indigenous	0.002938

H. Wilpattu NP area, sub basin (Thelbipuwewa) (Transect 22, 23, 24)

This area dominated by Dry Mixed Evergreen Forest also contained Scrub Forest, Tank associated habitats. During the study period, 40 species of butterflies including 1 endemic species, the Sri Lanka Lesser Albatross, *Appias galena*, was recorded.

Figure 132 Wilpattu NP area sub basin

Additionally, 2 nationally threatened species, the Banded Peacock, *Papilio crino* and the Large Guava Blue, *Virachola perse* were also found. The Shannon index (H') was 3.54. According to the density values, the Common Crow showed the highest density values (Table 96).

Table 96 List of butterfly species recorded from Wilpattu NP area (Transect 21, 22,23, and 24) with their status and population density (m^2)

	Family name	Species name	Common Name	Red List status	No. of butter flies	Status	Population density (m^2)

	Family name	Species name	Common Name	Red List status	No. of butter flies	Status	Population density (m^2)
1	*Ariadne*	*ariadne*	Angle Castor	LC	2	Indigenous	0.000125
2	*Papilio*	*crino*	Banded Peacock	VU	1	Indigenous	0.0000625
3	*Papillio*	*polymnestor*	Blue Mormon	LC	2	Indigenous	0.000125
4	*Tirumala*	*limniace*	Blue Tiger	LC	4	Indigenous	0.00025
5	*Ampittia*	*dioscorides*	Bush hopper	LC	2	Indigenous	0.000125
6	*Cethosia*	*nietneri*	Ceylon Lace Wing	LC	3	Indigenous	0.0001875
7	*Junonia*	*iphita*	Chocolate Soldier	LC	17	Indigenous	0.0010625
8	*Euploea*	*core*	Common Crow	LC	278	Indigenous	0.017375
9	*Taractrocera*	*maevius*	Common Grass Dart	LC	4	Indigenous	0.00025
10	*Eurima*	*Hecabe*	Common Grass Yellow	LC	31	Indigenous	0.0019375
11	*Cepora*	*Cepora*	Common Gull	LC	8	Indigenous	0.0005
12	*Graphiun*	*agamemnon*	Common Jay	LC	11	Indigenous	0.001375
13	*Papilio*	*polytes*	Common Mormon	LC	1	Indigenous	0.0000625
14	*Castalius*	*rosimon*	Common Pierrot	LC	4	Indigenous	0.00025
15	*Pachliopta*	*aristolochia*	Common Rose	LC	2	Indigenous	0.000125
16	*Danaus*	*genutia*	Common Tiger	LC	17	Indigenous	0.0010625
17	*Pachliopta*	*hector*	Crimson rose	LC	3	Indigenous	0.0001875
18	*Spialia*	*galba*	Indian Skipper	LC	2	Indigenous	0.000125
19	*Virachola*	*perse*	Large Guava Blue	VU	1	Indigenous	0.0000625
20	*Zizina*	*otis*	Lasser Grass Blue	LC	15	Indigenous	0.0009375
21	*Catopsilia*	*pomona*	Lemon Emigrant	LC	8	Indigenous	0.0005
22	*Junonia*	*lemonius*	Lemon Pansy	LC	4	Indigenous	0.00025
23	*Appias*	*galene*	Lesser Albatross	LC	42	Endemic	0.002625
24	*Chilades*	*lajus*	Lime Blue	LC	30	Indigenous	0.001875
25	*Papilio*	*demoleus*	Lime Butterffly	LC	9	Indigenous	0.0005625
26	*Orsotriaena*	*medus*	Medus Brown	LC	1	Indigenous	0.0000625
27	*Catopsilia*	*pyrantha*	Mottled Emigrant	LC	5	Indigenous	0.0003125
28	*Junonia*	*almanac*	Peacock Pansy	LC	2	Indigenous	0.000125
29	*Belenois*	*aurota*	Pioneer	LC	2	Indigenous	0.000125
30	*Danaus*	*chrysippus*	Plain Tiger	LC	24	Indigenous	0.0015
31	*Anthene*	*lycaenina*	Pointed Ciliate Blue	LC	1	Indigenous	0.0000625
32	*Neopithecops*	*zalmora*	Quaker	LC	10	Indigenous	0.000625
33	*Eurema*	*brigitta*	Small Grass Yellow	LC	46	Indigenous	0.002875
34	*Clotis*	*amata*	Small Salmon Arab	LC	9	Indigenous	0.0005625
35	*Appias*	*libythea*	Striped Albatross	LC	15	Indigenous	0.0009375
36	*Acraea*	*violae*	Tawney Coster	LC	3	Indigenous	0.0001875

	Family name	Species name	Common Name	Red List status	No. of butter flies	Status	Population density (m^2)
37	*Zizula*	*hylax*	Tiny Grass Blue	LC	2	Indigenous	0.000125
38	*Ypthima*	*ceylonica*	White Four Ring	LC	49	Indigenous	0.003
39	*marianne*	*Pieridae*	White Orange Tip	LC	1	Indigenous	0.0000625
40	*Ixias*	*pyrere*	Yellow Orange tip	LC	1	Indigenous	0.0000625

Figure 133 Some of the butterfly species found in the Wilpattu National Park sub basin (a) Small Salmon Arab; (*Colotis amata*) (b) Small Grass Yellow (*Eurema brigitta*) (c) Peacock Pansy (*Junonia almana*) (d) Lemon Pansy (*Junonia lemonias*)

Table 97 Species richness and diversity of butterflies in different sub basin in the Kala Oya river basin

Sub basins	Richness (Species)	Shannon Index (H)	Simpson Index (1-D)
Eile area	29	2.551	0.8891
Eluwankulama	23	2.694	0.9.126
Suduweli Tahala	22	2.758	0.9168
Werakkodichole, Tahabbbowa	30	2.71	0.9015
Horiwila/Ambagahawewa	18	2.472	0.8829
Galpaya,Hinguruwelpitiya,Ranvakannda, Nambatiwewa	55	3.39	0.9516
Manawa area	42	2.962	0.9241
Wilpattu NP area area (Thelbipuwewa)	40	2.457	0.8058

9.3 Constraints of the field survey

The field survey was conducted during the drought period which is not a suitable time to monitor animal activity. Therefore, this has resulted in low counts in species diversity and abundance. Additionally, the time of day the survey was conducted compounded by extreme drought conditions may have been another causative factor. Furthermore, the recorded species' populations were also low and in order to gain a clear picture of the butterfly diversity, the survey should be conduct for at least a period of one year. Seasonal variation was also not reflected in the data recorded. A three-month period is not sufficient to cover the entire basin and consequentially adequate sampling could not be done.

The Large Salmon Arab, *Colotis fausta*, the Crimson Tip, *Colotis danaeare*, the Yellow Pansy, *Junonia hierta*, and the Bright Babul Blue, *Azanus ubaldus*, only inhabit the coastal thorn scrubs of the North and North East butterfly zones. Despite the expectation of occurrence of these 4 species in transects T1 of N8.2718, E79.8501 and T2 of N8.2672 E79.8514, our findings revealed zero occurrence; possibly due to the afore-mentioned unsuitable environmental conditions.

During the survey period, the checklist of observed species was at 84 species while past observations recorded within the last five years recorded a 117 species.

Tank associated habitats can be very rich in butterflies, especially counting the Common Crow- *Euploea core*, Plain Tiger- *Danaus chrysippus*, Common Tiger- *Danaus genutia*, and Blue Tiger- *Tirumala limniace*. These butterflies are attracted to the *Heliotropium indicum* plant which is powerful enough to attract these butterflies from long distances away. Large gatherings of these species were found in Manawa wewa and Thelbipuwewa.

Very few butterfly species were observed inside the thick forests and *Panicum maximum* (Guinea grass)-invaded habitats. *Panicum maximum* was the most common alien invasive in the Kala Oya river basin.

9.4 Discussion

Butterflies have short life cycles and thus react immediately to environmental changes. Their limited dispersal ability, larval food plant specialization and close reliance on the weather and climate make many butterfly species sensitive to fine-scale changes. Butterflies are indicators of a healthy environment and healthy ecosystems.

Out of the five habitats selected for this study in the Kala Oya river basin, Scrub forest and Tank associated habitats stand out as the best sites for butterflies. The current study shows that the Galpaya Hinguruwelpitiya Ranva kannda, Nambatiwewa, Manawa area supports butterfly diversity including endemic butterfly species.

The Eile area – transects T1 and T2 - is an ideal habitat for the Joker- *Byblia ilithyia*, a characteristic species of this area found only in Meadows with seasonal flooding. When considering the North West butterfly region, it is typically home to and the preferred habitat for the Large Salmon Arab- *Colotis fausta*, Crimson Tip- *Colotis danaeare*, Yellow Pansy- *Junonia*

hierta, and Bright Babul Blue- *Azanus ubaldus*. However, these species were not encountered despite previous records of their existence in these habitats indicating inadequate sampling or lack of time to carry out sampling.

Additionally, the total number of species recorded during the last five years, 117 species, was in stark contrast to the number of species recorded during the survey; 84 species (Annex 07). It must be also noted that though the study was confined to the lower levels of habitats no canopy butterflies were observed.

10.0 DRAGONFLY DIVERSITY ANALYSIS

10.1 Introduction

The dragonflies of Sri Lanka can be divided into two suborders – damselflies (Zygoptera) and dragonflies (Anisoptera), but the broadly applied term "dragonflies" applies to both suborders. Dragonflies are generally larger, with compound eyes that cover almost the entire head.
Members of the order Odonata are characteristically acrobatic aerial predators. Individual Odonata species have a wide range of environmental tolerances, and are good indicators of ecosystem health, particularly for wetlands. Odonata are also known to be highly responsive to ecosystem conditions in relation on to broad-scale factors such as climate and urbanization. Damselflies are important bio-control agents especially in the control of Dipteran larvae. Both larvae and adults are predators near the top of food chains in their ecosystems, and some species feed on mosquitoes and their larvae.

Many species of Odonates that inhabit agro ecosystems play a crucial role in controlling pest populations and can be considered as pollution indicators. Previous studies have pointed out that Odonates may also serve as good indicators for complex changes in landscapes. Most Odonate species are included in data deficient category and are in the 'Red Data List' of Sri Lanka. Nonetheless, there are huge knowledge gaps on habitat preferences of Odonate species, and the factors that influence their distribution and diversity and ecological services. 124 species Odonates have been recorded from Sri Lanka. 58 species are belonging to sub order Zygoptera a 66 to sub order Anisoptera 49.2% of Odonate fauna or 61 taxa are endemic. Most of endemic taxa are distributed in wet zone of the country.(Bedjanic at al. 2014)

10.2 Methodology

Odonates are considered as wetland associate species because a major part of its lifecycle is spent in aquatic habitats (Sylsbi, 2001). Therefore, the sample areas were mainly confined to habitats associated with aquatic environments. A total of 33 circular sample plots with a radius of 30m were observed during the study. Additional observations were also recorded in between sample points. Sampled locations were as shown below in Figure 134. Sampled locations were grouped into sub basins for analytical purposes. The population density and species diversity were calculated in each sub basin using recorded circular plot data. Species diversity was calculated using Shanon Weigner index.

10.3 Habitats

Different types of habitats associated with stagnant and running water bodies were identified, observed and sampled during the field survey. Among them were fresh water tanks , seasonal water ponds , streams and canals , salt marshes , rocky pools and agricultural lands (paddy or Chena).

Figure 134 Map of sample points in the Kala Oya river basin

10.4 Results

A total of 1,202 individual dragonflies and damselflies belonging to 7 families, 31 genera and 40 species were observed during the period of the survey. Among recorded species, *Pseudagrion rubiceps* (Orange-faced Sprite) (Figure 135) and *Prodasineura sita* (Stripe-headed Threadtail) are endemic to Sri Lanka. Among the recorded species, 30 species were in the category of Least Concern (LC), 8 in the Near Threatened (NT) and 2 species in the Vulnerable (VU) category (IUCN 2012).

Figure 135 [Left]: *Prodasineura sita* (Stripe-headed Threadtail) [Right]: *Pseudagrion rubiceps* (Orange-faced Sprite)

Figure 136 (a) *Brachythemis contaminata* (Orange-winged Groundling) and *Orthetrum Sabina* (Green Skimmer)

10.3.1 Species distribution according to the sub-basin/cluster level

1. Eile area (Transect 1-5) - Cluster A

The Eile area is located in Gagewadiya which consisted mainly of salt marshes and seasonal water holes. A total of 349 individuals from 26 species with a diversity index value of 2.367 (Shanon index value) were recorded from this area. The most abundant species was *Ceriagrion coromandelianum*. Despite the high salinity of the water, dragonflies were found to be breeding in the area.

Exuviae of *Brachythemis contaminata* were also observed within the pencil roots of mangrove plants (Figure 137). Seasonal flooding and cattle grazing was noted as threats to these habitats of Odonate fauna.


Figure 137 [Left] *Ceriagrion coromandelianum*; [Right] Exuvia of *Brachythemis contaminata* observed in pencil roots on mangroves

2. Eluwankulama area - Cluster B

Man-made tanks, streams and paddy fields were noted as dragonfly habitats in this sub basin (B). Most sampling points were shady places with riverine vegetation. 112 individuals of 17 species were recorded and the species diversity index value was 2.317. Populations of 2 endemic species, *P.rubiceps* (Orange-faced Sprite) and *Prodasineura sita* (Stripe-headed Threadtail) were recorded in this area.

3. Morapathana, Sudu walitheeruwa area - Cluster C

Sampling points in this area were seasonal water holes and agricultural lands. Habitual areas were noted to have been destroyed for Chena cultivation and waterlogged areas were dried at the time of the survey. 37 individuals belong to 13 species were recorded with a diversity index value of 2.466.

4. Thabbova, Weerakkodichole area (Point 13, 14, 15) - Cluster D

Seasonal water holes, rocky pools and natural ponds were considered as sampling points. Point 14 in the Wilandagoda temple (Figure 138) was identified as a point with high species richness where a total number of 18 species were recorded. *Lathrecista asiatica* and *Rhodothemis rufa*, two Nearly Threatened species, were found in seasonal water holes. A total number of 115 individual Odonates belonging to 22 species were recorded with diversity index value of 2.716.

Figure 138 [Top left and right] Wilangoda temple (Point 14); [Bottom left] *Lathrecista asiatica*

5. Horiwila/Ambagaha Wewa area (Point 16, 17, 18) - Cluster E

Man-made tanks, seasonal water holes and Chena lands were the available sampling points in this area. Addition of agrochemicals to the water was noted to be a major threat to the habitats.

Figure 139 Addition of agrochemicals to water sources

Brachythemis contaminata and *Orthetrum sabina* were the most abundant species in the area and these species are usually considered to be pollution indicators (Bedjanic at al, 2014). 97 individuals from 13 species were observed and diversity index value was 1.717.

Figure 140 *Brachythemis contaminata* [Left] and *Orthetrum sabina* [Right]

6. Galpaya area (Point 19-25) - Cluster F

Rocky pools, ponds and man-made tanks were the available habitats to observe for Odonate fauna. Most rocks in the area have been exploited by metal crushers which has led to vast habitat destruction of *Tramea limbata* (Sociable glider) as well as *Bradinopyga geminate* (Indian rock-dweller), a rock dwelling species. 125 individuals belonging to 21 species were observed with a diversity index value of 2.683.

Figure 141 *Bradinopyga geminate* (Indian rock-dweller) [Left]; *Tramea limbata* (Sociable glider) [Right]

7. Manaewa area (Point 26-29) - Cluster G

This area consisted mainly of tanks and rocky pools. 181 individual Odonates belonging to 23 species were recorded with diversity index value of 2.4.

8. Wilpattu National Park (Point 30-33) - Cluster H

The highest diversity index value, 2.703, and species richness, 32 species, were recorded from the Wilpattu National Park. 185 individual animals were observed. The species *Aethriamanta brevipennis* was record only at 30th point during the survey. *Indothemis carnatica, Rhodothemis rufa* and *Indothemis limbata sita*, species categorized as Nearly Threatened, were recorded at the same sampling point. Invasive plant species in aquatic habitats such as *Pistia* and *Salvinia* were identified as a threat to the habitats.

Figure 142 *Aethriamanta brevipennis* (Scarlet marsh hawk)

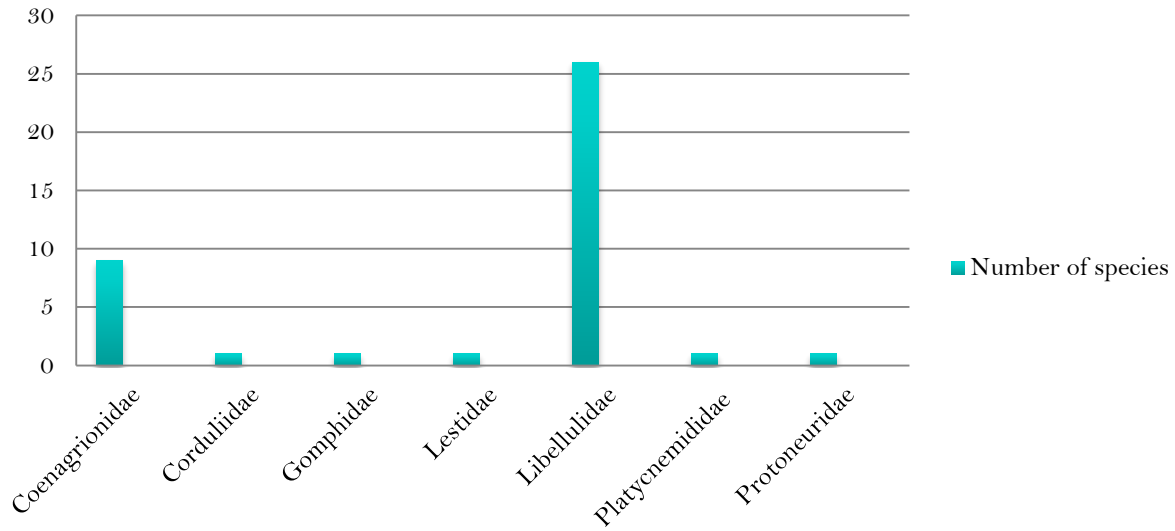


Figure 143 Number of species representing different families

Figure 144 Wilpattu National Park [Left]; Invasive *Pistia* species [Right]

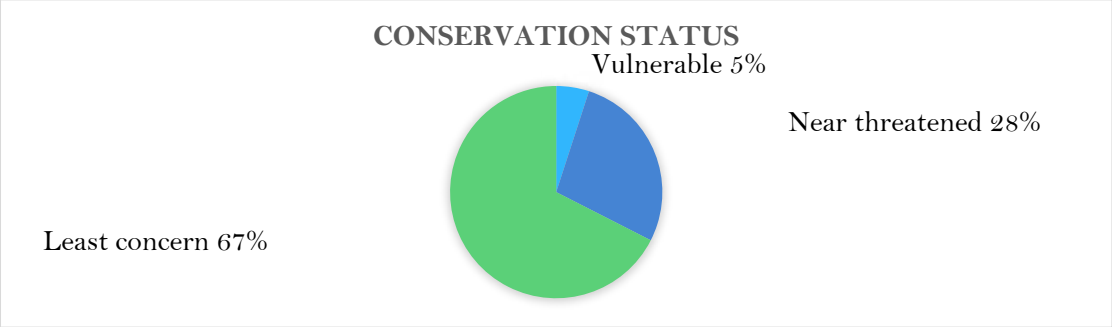


Figure 145 Conservation status of Odonata species based on IUCN Red List 2012

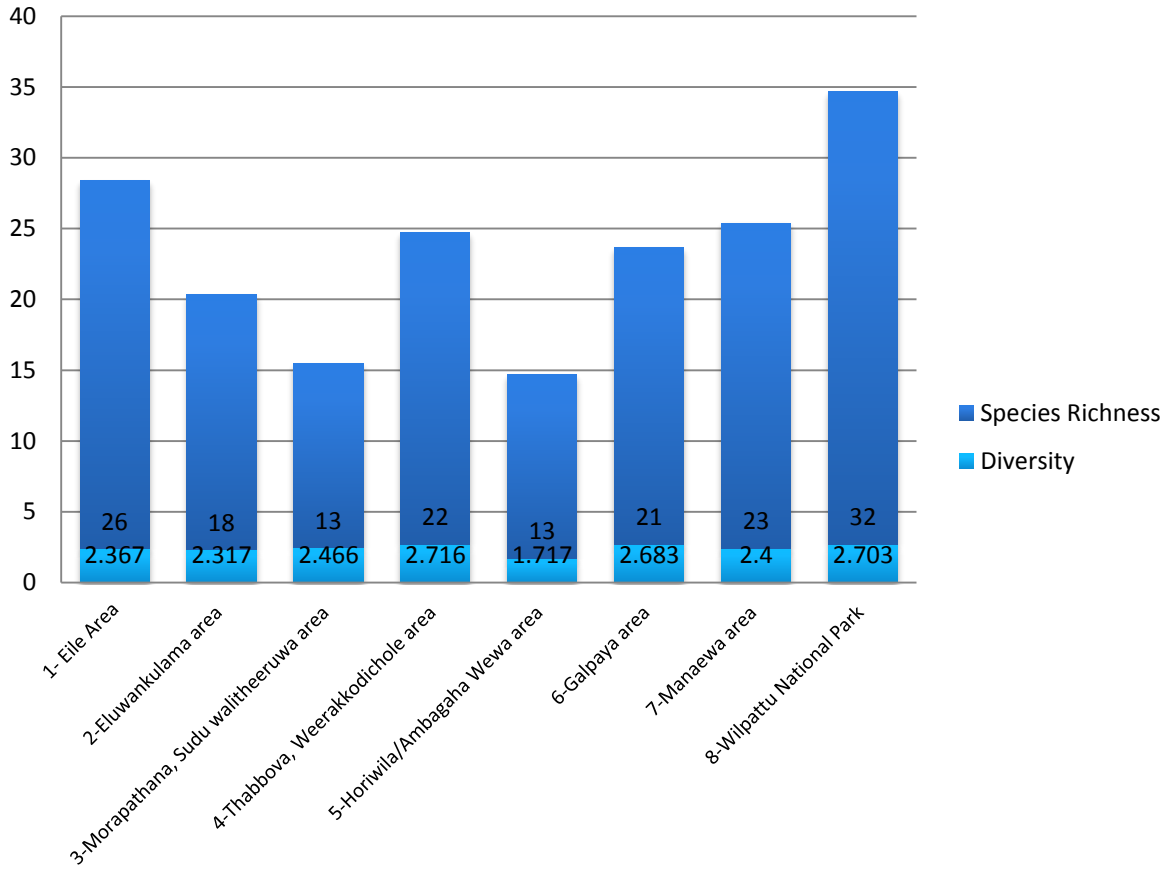


Figure 146 Species richness and diversity index values (Shannon–Wiener diversity index S = -Σ (Pi ln Pi)) in each sub basin

Table 98 Species abundance in the sub-basins of Kala Oya Basin

	Family	Species	Conservation status	Eile	Eluwankulama	Morapahana	Weerakkodichole, Thabbowa	Ambagahawewa	Galpaya,, Hinguruwelpitiya Manaewa	Wilpaththu
1	Coenagrionidae	*Aciagrion occidentale*	VU	9	0	0	4	0	0	0	4
2	Coenagrionidae	*Agriocnemis pygmaea*	LC	15	1	4	0	0	1	1	22
3	Coenagrionidae	*Ceriagrion coromandelianum*	LC	127	25	4	18	40	10	21	10
4	Coenagrionidae	*Ischnura aurora*	NT	6	0	0	1	0	0	0	1
5	Coenagrionidae	*Ischnura senegalensis*	LC	15	2	0	4	0	2	2	2
6	Coenagrionidae	*Paracercion malayanum*	LC	9	2	0	2	0	0	0	0
7	Coenagrionidae	*Pseudagrion malabaricum*	LC	12	4	0	18	3	2	3	8
8	Coenagrionidae	*Pseudagrion rubiceps**	LC	1	11	2	0	4	8	3	0
9	Coenagrionidae	*Pseudagrion microcephalum*	LC	21	5	0	7	2	4	7	4
10	Corduliidae	*Epophthalmia vittata*	NT	0	0	0	0	0	0	1	1
11	Gomphidae	*Ictinogomphus rapax*	LC	1	0	0	0	0	0	1	5
12	Lestidae	*Lestes elatus*	LC	54	1	0	0	0	0	0	0
13	Libellulidae	*Acisoma panorpoides*	LC	0	0	0	0	0	2	10	3
14	Libellulidae	*Aethriamanta brevipennis*	LC	0	0	0	0	0	0	0	8
15	Libellulidae	*Brachydiplax sobrina*	LC	2	2	0	1	1	0	1	1
16	Libellulidae	*Brachythemis contaminata*	LC	16	28	4	14	31	26	65	54
17	Libellulidae	*Bradinopyga geminata*	LC	0	0	0	3	0	19	4	3
18	Libellulidae	*Crocothemis servilia servilia*	LC	9	10	0	3	3	2	6	0
19	Libellulidae	*Diplacodes nebulosa*	NT	1	0	0	0	0	0	0	7
20	Libellulidae	*Diplacodes trivialis*	LC	13	4	2	5	2	6	11	19
21	Libellulidae	*Hydrobasileus croceus*	NT	2	0	0	0	0	0	0	1
22	Libellulidae	*Indothemis carnatica*	NT	0	0	0	0	0	4	0	1
23	Libellulidae	*Indothemis limbata sita*	NT	0	0	0	0	0	0	0	1
24	Libellulidae	*Lathrecista asiatica*	NT	0	0	0	1	0	0	0	1
25	Libellulidae	*Neurothemis intermedia*	NT	0	1	0	0	0	0	2	2
26	Libellulidae	*Neurothemis tulia*	LC	11	7	0	0	4	0	10	4

	Family	Species	Conservation status	Eile	Eluwankulama	Morapahana	Weerakkodichole, Thabbowa	Ambagahawewa	Galpaya,, Hinguruwelpitiya	Manaewa	Wilpaththu
27	Libellulidae	*Orthetrum glaucum*	NT	0	0	0	0	0	0	0	1
28	Libellulidae	*Orthetrum sabina*	LC	9	0	3	5	3	6	6	3
29	Libellulidae	*Pantala flavescens*	LC	1	0	2	3	3	4	6	4
30	Libellulidae	*Potamarcha congener*	LC	0	0	0	4	0	6	1	0
31	Libellulidae	*Rhodothemis rufa*	NT	0	1	0	2	0	0	1	2
32	Libellulidae	*Rhyothemis variegata variegata*	LC	4	0	0	4	0	2	7	2
33	Libellulidae	*Tholymis tillarga*	LC	1	0	2	0	0	0	0	0
34	Libellulidae	*Tramea limbata*	LC	2	0	0	1	0	3	2	2
35	Libellulidae	*Tramea basilaris*	VU	0	0	1	0	0	0	0	1
36	Libellulidae	*Trithemis pallidinervis*	NT	3	4	0	0	0	3	0	0
37	Libellulidae	*Trithemis aurora*	LC	2	1	1	1	1	4	10	1
38	Libellulidae	*Urothemis signata signata*	LC	3	0	3	5	0	0	0	5
39	Platycnemididae	*Copera marginipes*	LC	0	0	5	9	0	8	0	2
40	Protoneuridae	*Prodasineura sita**	LC	0	3	4	0	1	3	0	0
	Total count			**349**	**112**	**37**	**115**	**98**	**125**	**181**	**185**
	Number of species			**26**	**18**	**13**	**22**	**13**	**21**	**23**	**32**
	Diversity			**2.367**	**2.317**	**2.466**	**2.716**	**1.717**	**2.683**	**2.4**	**2.703**

*Endemic species

Table 99 Species density (m^2)

Family	Species	Conservation status	Eile	Eluwankulama	Morapahana	Weerakkodichole, Thabbowa	Ambagahawewa	Galpaya	Manaewa	Wilpaththu
Coenagrionidae	*Aciagrion occidentale*	VU	0.000637	0	0	0.000472	0	0	0	0.000354
Coenagrionidae	*Agriocnemis pygmaea*	LC	0.001062	0.000118	0.000354	0	0	5.06E-05	8.85E-05	0.001946
Coenagrionidae	*Ceriagrion coromandelianum*	LC	0.008988	0.002949	0.000354	0.002123	0.004718	0.000506	0.001858	0.000885
Coenagrionidae	*Ischnura aurora*	NT	0.000425	0	0	0.000118	0	0	0	8.85E-05
Coenagrionidae	*Ischnura senegalensis*	LC	0.001062	0.000236	0	0.000472	0	0.000101	0.000177	0.000177
Coenagrionidae	*Paracercion malayanum*	LC	0.000637	0.000236	0	0.000236	0	0	0	0
Coenagrionidae	*Pseudagrion malabaricum*	LC	0.000849	0.000472	0	0.002123	0.000354	0.000101	0.000265	0.000708
Coenagrionidae	*Pseudagrion rubiceps**	LC	7.08E-05	0.001297	0.000177	0	0.000472	0.000404	0.000265	0
Coenagrionidae	*Pseudagrion microcephalum*	LC	0.001486	0.00059	0	0.000826	0.000236	0.000202	0.000619	0.000354
Corduliidae	*Epophthalmia vittata*	NT	0	0	0	0	0	0	8.85E-05	8.85E-05
Gomphidae	*Ictinogomphus rapax*	LC	7.08E-05	0	0	0	0	0	8.85E-05	0.000442
Lestidae	*Lestes elates*	LC	0.003822	0.000118	0	0	0	0	0	0
Libellulidae	*Acisoma panorpoides*	LC	0	0	0	0	0	0.000101	0.000885	0.000265
Libellulidae	*Aethriamanta brevipennis*	LC	0	0	0	0	0	0	0	0.000708
Libellulidae	*Brachydiplax sobrina*	LC	0.000142	0.000236	0	0.000118	0.000118	0	8.85E-05	8.85E-05
Libellulidae	*Brachythemis contaminata*	LC	0.001132	0.003303	0.000354	0.001651	0.003657	0.001314	0.00575	0.004777
Libellulidae	*Bradinopyga geminata*	LC	0	0	0	0.000354	0	0.00096	0.000354	0.000265
Libellulidae	*Crocothemis servilia servilia*	LC	0.000637	0.00118	0	0.000354	0.000354	0.000101	0.000531	0
Libellulidae	*Diplacodes nebulosa*	NT	7.08E-05	0	0	0	0	0	0	0.000619
Libellulidae	*Diplacodes trivialis*	LC	0.00092	0.000472	0.000177	0.00059	0.000236	0.000303	0.000973	0.001681
Libellulidae	*Hydrobasileus croceus*	NT	0.000142	0	0	0	0	0	0	8.85E-05
Libellulidae	*Indothemis carnatica*	NT	0	0	0	0	0	0.000202	0	8.85E-05
Libellulidae	*Indothemis limbata sita*	NT	0	0	0	0	0	0	0	8.85E-05

Family	Species	Conservation status	Eile	Eluwankulama	Morapahana	Weerakkodichole, Thabbowa	Ambagahawewa	Galpaya	Manaewa	Wilpaththu
Libellulidae	*Lathrecista asiatica*	NT	0	0	0	0.000118	0	0	0	8.85E-05
Libellulidae	*Neurothemis intermedia*	NT	0	0.000118	0	0	0	0	0.000177	0.000177
Libellulidae	*Neurothemis tulia*	LC	0.000778	0.000826	0	0	0.000472	0	0.000885	0.000354
Libellulidae	*Orthetrum glaucum*	NT	0	0	0	0	0	0	0	8.85E-05
Libellulidae	*Orthetrum sabina*	LC	0.000637	0	0.000265	0.00059	0.000354	0.000303	0.000531	0.000265
Libellulidae	*Pantala flavescens*	LC	7.08E-05	0	0.000177	0.000354	0.000354	0.000202	0.000531	0.000354
Libellulidae	*Potamarcha congener*	LC	0	0	0	0.000472	0	0.000303	8.85E-05	0
Libellulidae	*Rhodothemis rufa*	NT	0	0.000118	0	0.000236	0	0	8.85E-05	0.000177
Libellulidae	*Rhyothemis variegata variegata*	LC	0.000283	0	0	0.000472	0	0.000101	0.000619	0.000177
Libellulidae	*Tholymis tillarga*	LC	7.08E-05	0	0.000177	0	0	0	0	0
Libellulidae	*Tramea limbata*	LC	0.000142	0	0	0.000118	0	0.000152	0.000177	0.000177
Libellulidae	*Tramea basilaris*	VU	0	0	8.85E-05	0	0	0	0	8.85E-05
Libellulidae	*Trithemis pallidinervis*	NT	0.000212	0.000472	0	0	0	0.000152	0	0
Libellulidae	*Trithemis aurora*	LC	0.000142	0.000118	8.85E-05	0.000118	0.000118	0.000202	0.000885	8.85E-05
Libellulidae	*Urothemis signata signata*	LC	0.000212	0	0.000265	0.00059	0	0	0	0.000442
Platycnemididae	*Copera marginipes*	LC	0	0	0.000442	0.001062	0	0.000404	0	0.000177
Protoneuridae	*Prodasineura sita**	LC	0	0.000354	0.000354	0	0.000118	0.000152	0	0

*Endemic species

Table 72 presents Odonate species previously recorded in the area by separate studies and surveys but were not observed during this survey (note that species recorded by and included in this survey have been excluded) (Bedjanick at al, 2014).

Table 100 Checklist of Odonate species previously recorded but were not observed during the survey

Family	Species	Common Name	CS
Chlorocyphidae	*Libellago adami**	Sri Lanka Adam's Gem	VU
Lestidae	*Lestes praemorsus*	Scalloped Spreadwing	NT
Protoneuridae	*Elattoneura centralis**	Sri Lanka Dark-glittering Threadtail	VU
Aeshnidae	*Anax gutattus*	Pale-spotted Emperor	LC
	Anax indicus	Elephant Emperor	LC
	Gynacantha dravida	Indian Duskhawker	NT
	*Cyclogomphus gynostylus**	Sri Lanka Transvestite Clubtail	CR
Libellulidae	*Zyxomma petiolatum*	Dingy Duskflyer	NT
	Macrodiplax cora	Costal Pennant	VU
Gomphidae	*Paragomphus campestris**	Lowland hooktail	VU
	*Macrogomphus lankanensis**	Sri Lanka Forktail	EN

*Endemic species
CS = Conservation Status

10.4 Discussion

Damselflies and dragonflies belong to the ancient insect order Odonata under the sub-order Anisoptera and Zygoptera. Members of the order Odonata are characteristically acrobatic aerial predators. Individual Odonata species have a wide range of environmental tolerances, and are good indicators of the health of an ecosystem, particularly for wetlands. Odonates are also known to be highly responsive to ecosystem conditions in relation to broad-scale factors such as climate and urbanization. Damselflies are important bio-control agents, especially in the control of Dipteran larvae. Many species of Odonata inhabiting agro-ecosystems play a crucial role in controlling pest populations and can be considered a pollution indicator. Previous studies have pointed out that Odonates may also serve as a good indicator for complex changes in landscapes.

Most Odonata species are included in the data deficient and east concern categories in the Red Data List for Sri Lanka and there is a great deficit in the knowledge on habitat preference of Odonate species, factors that influence their distribution and diversity and ecological services etc.

In the present study, the area to be surveyed was divided in to 8 sub basins. Although species richness was different in the sub basins, species diversity has not a shown significant difference. Most adult forms of Odonata species in Sri Lanka emerge from their larval stage in between July and August. Hence it is generally recommended to survey Odonata species in during this period (July-August) to record more species and report abundance.

It was noticed that habitats in proximity to agricultural fields such as Chena lands have a very low dragonfly species composition. The few species that have the ability to tolerate harsh

environments such as *Brachythemis contaminate* (Orange-winged Groundling) and *Orthetrum sabina* (Green Skimmer) were recorded at those sampling points.

Some species show territorial behaviours and if their habitats are destroyed, competition amongst individuals may be increased which might lead to a decrease in the population of that particular species. For instance, *Tramea limbata* (Sociable glider), is a highly territorial species seen mostly at seasonal water holes formed on rocks. Therefore, usually one rocky pool is inhabited by one individual animal (i.e. one specimen per habitat/territory). The highest abundance of these species was recorded in the Hinguruwelpitiya, Galpaya region. It was observed that unfortunately most rocks in the area have been exploited by metal crushers that has led to vast habitat destruction of *Tramea limbata* (Sociable glider) as well as *Bradinopyga geminate* (Indian rockdweller) , a rock dwelling species.

Endemic species such as *Prodasineura sita* (Stripe-headed Threadtail) and *Pseudagrion rubriceps* (Orange-faced sprite) were observed near riverine areas with a canopy cover. Therefore, alteration of the vegetation and environmental conditions will lead to the disappearance of such species from the area. The following table displays areas with high species richness from all sub-basins surveyed.

Table 101 Areas with a high dragonfly/ damselfly species richness and their corresponding species richness

Species Richness	Cluster
12	Gage wadiya
14	Wilandagoda
26	Manaewa
30	Wilpattu National Park

11.0 MARINE FLORA AND FAUNA DIVERSITY ANALYSIS

11.1 Marine environments and Biodiversity

The Marine environments of Kala Oya basin includes the northern area of the Kalpitiya Lagoon, which contains significant areas of Sea grass habitats and sea floor areas that are important fishery grounds for prawns and finfish. The sea area adjacent to the lagoon, off Uchchimune, contains extensive coral and sandstone reefs of the Bar-reef complex. The area is also one of the most important habitat hot spots in the country, which periodically becomes a focal point for some of the largest gatherings of marine mammals in Sri Lanka. The area also is important as a transitional area for migrating turtles and sea birds.

The survey area includes the northern part of the Puttalam lagoon and extends to include the Bar-reef Marine Sanctuary up to the continental shelf edge which is important as an area of high diversity and abundance of marine mammals and other off shore fauna.

The submarine geography/ bathymetry of the Kalpitiya seas is key to the high abundance and diversity of Marine Mammals in the area. On one side, the carving in of the continental shelf in-between the South Indian headland and North West Sri Lanka terminating below the Mannar land bridge brings in an effective deep oceanic water cove close to kalpitiya and Mannar area. The predominant oceanic currents during the south west monsoon would drive against the walls of this bathymetric formation resulting in formation of an up-welling area in the sea that feeds a key food chain and may also be the focus of many marine life aggregations observed in the area at that time; including whales, sea birds and fishes. The Continental shelf is very narrow around Talawila and Kandakuliya headland, reaching in as close as 5km from shore. The continental slope is also very steep in the area, causing a sudden drop off allowing most whales and marine mammals to approach close to the coast while still staying in the safety of the deep oceans, and make quick forays over the shelf to feed in shallower seas. The steep continental slope walls cause up-welling of nutrient rich waters and food sources which may be an additional attraction for marine mammals, oceanic sea birds and marine animals.

Beyond the Kudiramale headland and Battalangundu Island, the continental shelf widens abruptly and joins with the Indian sub-continent shelf causing a vast plateau of shallow seas expanding throughout the Palk-straight and Gulf of Mannar extending past Jaffna and along the Eastern Sea board of India. The vast shallow sea areas which ranges at around 10-meter depth contain extensive sea grass habitats dominated by Sea grass genera *Cymodoce, Halophila, Syringodium*, etc. These extensive seagrass beds provide important habitats for sea turtles, rays, and other rare species and the last remnant populations of endangered Dugong and Saw-fishes.

The study area contains several nationally important ecosystems and critical habitat areas including the coral and other reef areas of the Bar-reef Marine Sanctuary. The area is currently in a conservation crisis due to the recent coral bleaching and mortality event. The sea of Kalpitiya is considered a global hotspot for marine mammals including some of the largest aggregations of

Sperm whales globally. The area is also of importance for the migratory sea turtles contributing to the Arribada' in orissa India and also seasonal sea bird migrations during months of April and August. The sea grass areas consist of a natural extension of the vast northern sea grass beds, composing of a significant lagoon sub-area which differs in species composition from the more marine northern areas with species types like Enhalus becoming dominant.

Figure 147 (a) Risso's Dolphins (*Grampus griseus*) spotted during marine mammal survey (b) Spinner Dolphin pod (*Stenella longirostris*)

11.2 Bar Reef and Reef Habitats

Established in 1992 and located on the north-western coast of Kalpitiya peninsular- Bar Reef Marine Sanctuary (BRMS) covers an area of sea 30,669 (ha) in extent. The area extends from the coast up to a distance of 6-9 km off shore and reaching beyond the 10m depth contour. The Buffer zone of the BRMS reaches beyond the continental shelf edge and into the continental drop off area. The area includes a wide variety of marine habitats from soft sandy floors to coral and sandstone reefs and sea grass beds.

The focal point in the BRMS is the once lush shallow coral habitats that existed in the core area of the sanctuary. Before the 1998 coral mortality event, Bar Reef Marine Sanctuary was composed of a series of extensive coral patch reefs which was critically affected by the event. Only two primary sections of the reef made recovery of coral cover and reef function from the aftermath of the event, which reduced the live coral cover from around 80% to less than 1%. (Rajasuriya et al., 1998). The recovered reef changed in structure into a table coral (*A. cytheria*) dominated habitat from the previous Staghorn coral (*A. formosa*) dominated habitats. The surviving coral areas were observed to reach mature status nearly 20 years after the 1998 coral mortality event, with re-colonization of significant areas with Staghorn corals and changing of the reef from a monotypic coral habitat to a richer species assembly.

Beyond the bar reef, the sea area contains extensive areas of scattered rock/sandstone reefs ranged at different depths and other allied habitats including sea grass beds. The year 2016 brought in the most severe El-nino related coral bleaching event on record in Sri Lanka after the 1998 event. The survey also aimed to document the level of damage to the Bar-reef complex as a result of this event and the post event status of reefs.

The main coral areas which had shown recovery from the 1998 event was observed to have suffered severely during the 2016 event with almost total coral mortality on the reef areas. The live coral cover was observed to be less than 1% of the reef surfaces. The inshore section of the reef was observed to be heavily overgrown with a diverse assemblage of algae dominated by algal genera *Padina, Stoechospermum, Caulerpa, Halimeda, Asperogopis* and *Dictyota* etc.

The sampling of the reef areas were planned to include the two main sections of the Bar-reef that recovered from the 1998 bleaching/ coral mortality event, which were affected significantly by the coral bleaching event of 2016 and was found to have suffered critical damage. Additional sampling were carried out on an area of old coral reef that had not recovered from the 1998 event which comprised of a significant area of the sea floors of the area, and a deeper reef at 10m depth and a sand stone reef areas adjacent to the Bar-reef to increase the diversity of the sample.

The two main sections of the reef to survive the 1998 coral bleaching event was surveyed to observe the impact of the 2016 coral bleaching event. These sections are also used for tourism where many whale watching tour boats would bring their guests to snorkel on the reef. The sections are also subjected to significant fishing pressure.

The majority of the once abundant coral reef patches in the area were killed off during the previous coral bleaching event in 1998. These areas are now degraded in to mare patches or mounds of coral rubble over grown with varying amounts of algae. Live coral cover is very low and consist of later recruits mostly of encrusting or sub-massive type coral colonies of smaller size. Fish life was also very low and mostly consisted of Parrot fishes, Sturgeon fish, Rabbit fishes, Damselfishes and wrasses. The coral rubble is eroded, and of relatively small sized ones forming a moving unstable substrate that is not conducive for re-settlement by new coral larval recruits. The coral restoration potential of these areas is low. One dead reef site was included in the survey sites as it consists of the significantly extensive habitat within the survey area.

Additional sites were included in the survey to sample the deeper sandstone reef habitats which were less impacted by the recent climatic events. Though not true coral reefs, these reefs at present contain higher abundance of live coral compared to the two primary coral reef sites. These reefs range from 3-30m or more in depth and extend out to the end of the continental shelf area. The reefs range from scattered rocky areas to large hard reef structures and formed by non-coral hard substrates. These reefs support significant populations of fish and invertebrates and are subject to fishing using both traditional methods as well as by divers engaged in collection of marine fauna export trades including ornamental exotic species, sea cucumber and spiny lobsters. The deeper reef sites at 10m depth sampled was an extensive area of low flat scattered coral and fragmented rocky/sandstone terrain interspaced with high coral "bommies" which would have a relief of over 2m from the substrate the area. This area contained a high abundance of algae (38%) mainly consisting of *Asperogopsis taxiformis*. The site also contained the highest surviving live coral cover (15%) as well as the highest abundance of fish, of all the sample sites.

11.3 Survey Methodology

Coral reef areas were surveyed using modified GCRMN/AIMS Rapid coral reef survey methodologies (Methods for Ecological Monitoring of Coral reefs - A resource for Managers- Jos Hill and Clive Wilkinson- AIMS/ GCRMN).

The sites were initially monitored using swims to collect qualitative information on the reef including species observed, threats and general condition of the reef.

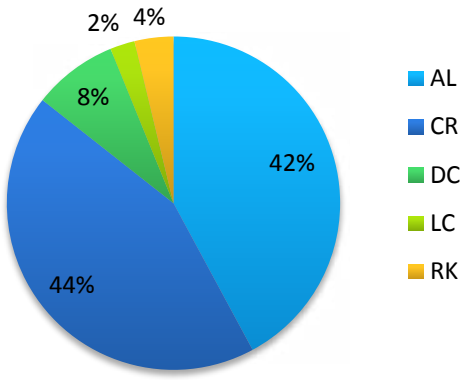
The reef sites were sampled using 25m Point transects (0.5m interval) carried out for substrate composition and 25m.x 5m Belt transects out for fishes and large sessile benthic invertebrates. The substrate categories used are listed in Table 102.

Table 102 Reef Substrate survey point transect category types

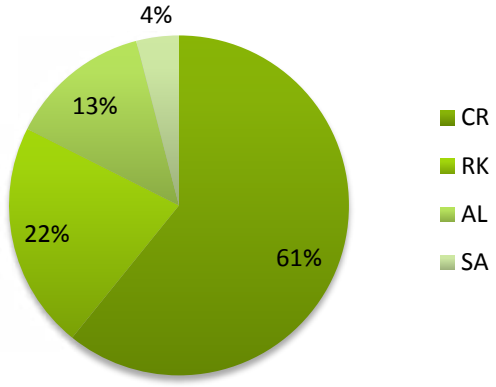
Abbreviation	Category	Description
DC	Recently dead coral	Dead standing coral - indicates recent mortality events and rate of mortality
RK	Rock or old dead coral	Old dead coral and other stable substrates- indicate neutral areas and potential substrates available for re-colonization by new coral recruits
CR	Coral Rubble	Old dead and fragmented coral forming a loose sessile matrix as substrates. Smaller quantities will feed sand supply on the reef. High quantities are a negative as it does not provide a stable substrate for new coral recruits for re-colonization
SA	Sand	heavier grained Sand that does not float and do not contribute significantly for siltation

Abbreviation	Category	Description
SI	Silt	Fine grained silty sand - easily suspended with rough sea conditions and can contribute to smothering of corals
ALG	Algae	Algae- high numbers would indicate invasive events or post coral mortality event substrate take over.
SC	Soft coral	
CM	Corallimorph	High numbers may indicate invasive events
SP	Sponge	High numbers may indicate invasive events
BS	Black sponge -Terpios	High numbers may indicate invasive events
ZO	Zoanthids	High numbers may indicate invasive events

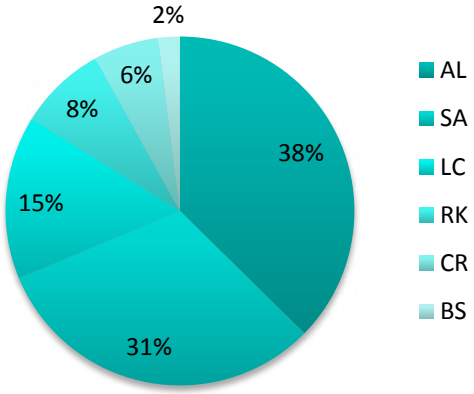
Bar-reef inner reef crest



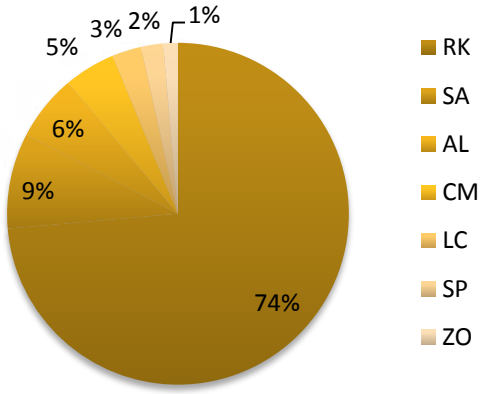
Bar reef outer reef crest



10m. Deep reef



Deeper sandstone ridge



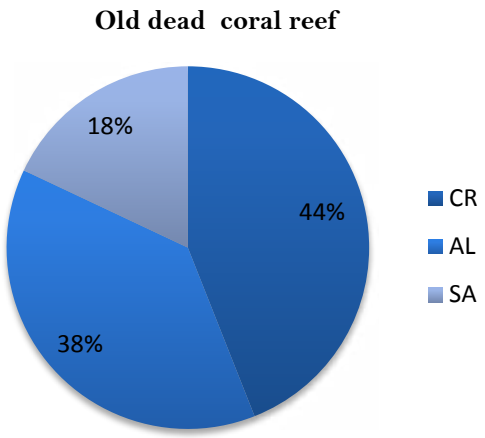


Figure 148 Substrate compositions of sample sites

11.3.1 Fish and Invertebrate counts

25m belt counts were carried out to survey the densities of indicator groups of reef fauna including both fish and larger benthic invertebrates.

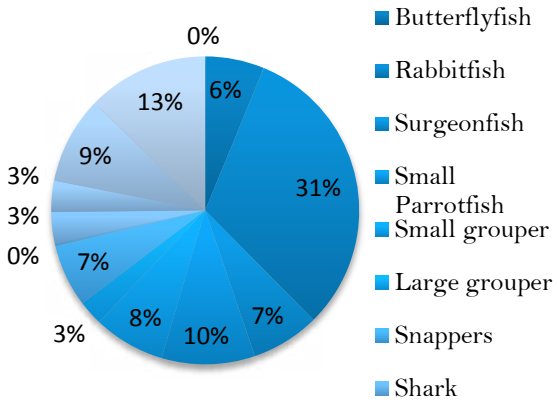
Table 103 Reef Fish and macro Invertebrate survey Belt Transect Categories used

Category	Description
Predators	
Large grouper	Large predators that are indicators of heavy fishing pressure on the reef
Small grouper	smaller benthic predators
Barracuda	Large predators that are indicators of heavy fishing pressure on the reef
Shark	Apex predators
Lionfish	medium sized predators indicative of ornamental fishing pressure
Snappers	smaller mid water predators
Grazers and Herbivores	
Small Parrotfish	Important reef Grazers
Large Parrotfish	Important reef Grazers
Rabbitfish	Important reef Grazers
Surgeonfish	Important reef Grazers
Habitat diversity /reef health indicator species	
Butterflyfish	Indicator for habitat diversity and reef health
Invertebrates	
Urchins	Important reef Grazers
Crown of Thorn Seastar	- (Invasive species)
other Seastars	
Sea cucumber	Commercially important species
Large shells	
Sea Hares	Important reef Grazers

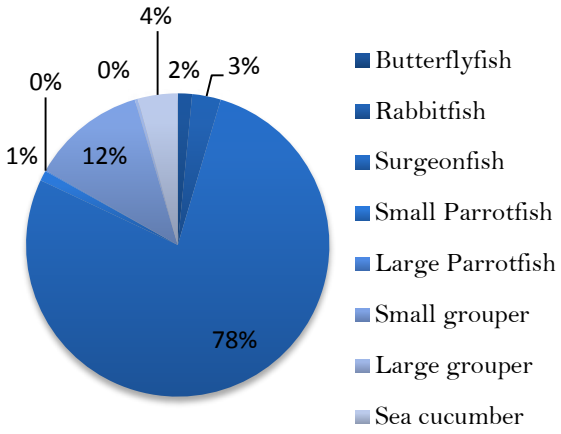
Table 104 Shannon's Wiener diversity index for coral reef sample sites

	Transect	Index
T1	Bar reef site 1A	H=0.99466
T2	Bar reef site 1B	H=1.22149
T3	10m.reef	H= 1.46936
T4	Bar reef site 2	H = 1.03403
T5	Deep Sandstone ridge	H = 1.0025
T6	Old dead reef	H = 1.03758

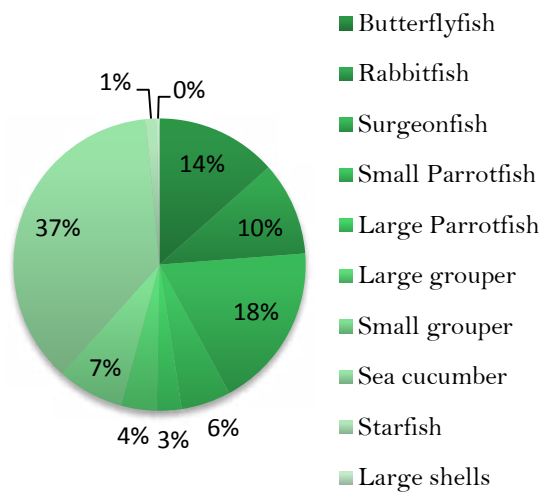
Bar-reef inner reef crest



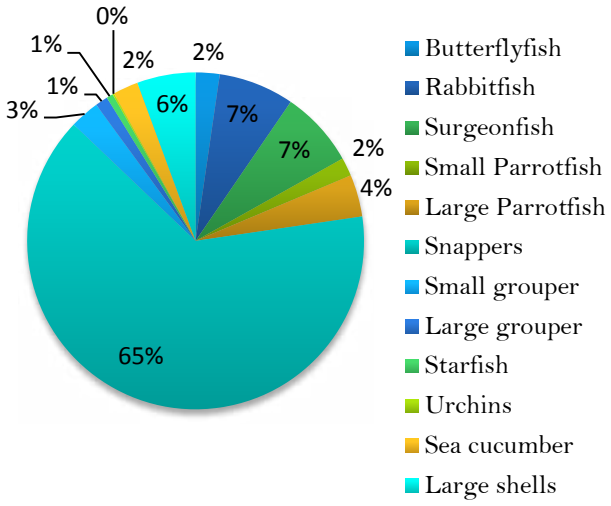
Bar-reef outer reef crest



10m. deep reef



Deeper sandstone ridge



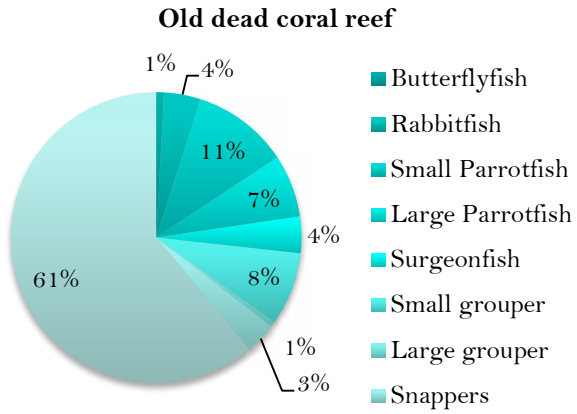


Figure 149 Fish and Benthic Invertebrate Belt counts at survey sites

The highest numbers of Butterfly-fishes were recorded from the deeper sandstone patch reef site while the Inner section of the Bar-reef still contained significant numbers of Butterfly-fishes though mainly restricted to the deeper section to the north of the reef where many of the old populations of the reef fish seem to have found refuge from the loss of habitats.

The two bar reef sections both suffered extensive mortality from the coral bleaching event. The section 1 still contain high level of algal cover over the reef surfaces and the algal grazers populations have still not reached high enough numbers to bring the algae in to control. The percentage of grazing fish species on site one was 48% with an additional 13% included as Sea hares to increase the count of grazers to 61%. The algal cover still remains at 47% of reef substrates. At Bar-reef site 2, the grazer populations have increased to 82% with a corresponding reduction of algal cover to 13% of substrates.

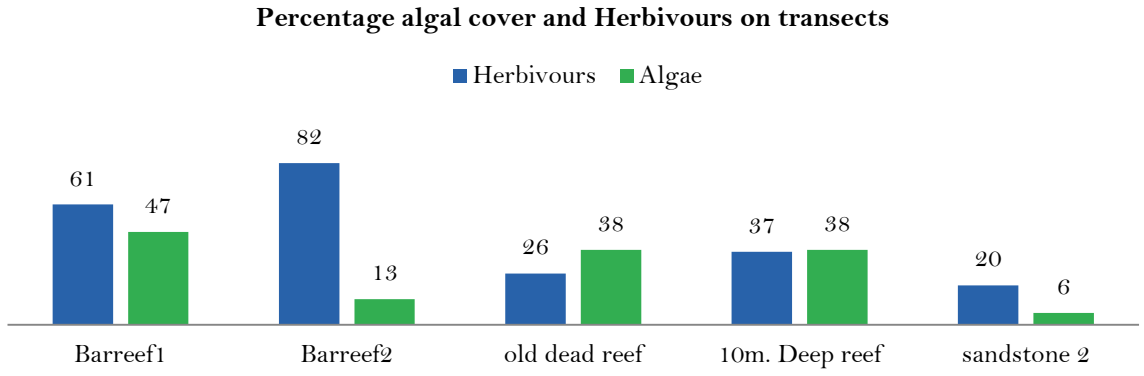


Figure 150 Percentage algal cover and herbivores on transects

11.4 Sampling sites

Bar Reef crest section 1 day 1 - N8 22.214 E79 44.799
Bar Reef crest section 1 day 2 - N8 22.308 E79 44.822

First of the two primary sections of the Bar-reef to make a significant recovery from the 1998 coral bleaching event is heavily visited by local tour boat operators for snorkel diving.

The reef consists of a reef ranging from about 4m to almost intertidal. The reef had suffered heavily in the 2016 coral bleaching /mortality event and also show signs of heavy mechanical damage at a scale which would most likely be due to heavy surf/ storm action. Most of the dead coral has been broken and has already turned into coral rubble. The area is still in post mortality event stage 1 where the reef is being heavily overgrown with algae.

The shallower reef crest areas are overgrown with macro-algae including *Ulva lactuca, Ulva sp.* Stoechospermum polypodioides, *Padina spp., Dictyota spp., Asperogopsis taxifomis, Caulerpa racemosa, Caulerpa verticilliata, Halimeda spp.*, etc. Fish life was very low except on the deeper areas of North East corner of the reef where large aggregations of fish were observed including a diversity of species. The herbivore fish population on the reef was observed very low and the observed grazing on the algae low. Large numbers of Sea hares *Aplysia* sp. were observed on some sections of the reef crest which was the only significant grazer observed on the reef. The reef recovery needs the reef fish populations to change in to a herbivour (Sturgeon fishes, Parrotfish etc.) before Algal cover is brought under control to allow clearing of reef surfaces for re-settlement of coral larvae.

6 nos 25m. Point transects (0.5m. interval) carried out for substrates and 6 nos. 25m.x 5m. Belt transects were carried out for fishes and large sessile benthic invertebrates.

Bar Reef crest section 2 - N8 22.777 E79 44.147

The second and outer of the two main areas of the Bar-reef that had recovered from the 1998 bleaching event was also affected by the 2016 coral bleaching event and the coral mortality has been devastating and complete.

The reef was composed entirely of dead coral and coral rubble with live coral cover less than 1% of substrates, which included mostly small colonies of Acroporid corals that had re-settled and less than 6-months in age. The reef was observed to be in secondary stage of post mortality recovery, where the populations of herbivorous fishes have increased into large shoals increasing the grazing down of algae to low levels again. The abundance of Herbivorous fish on the reef had increased to 82% with a corresponding reduction of algal cover to 13% of substrates, which allows the resettlement of coral larvae on to the reef. The reef shows very low level of algal cover compared to the other sections of the Bar-reef and also indicates some level of recent coral recruits settling in among the rubble zones.

The fish diversity was very low with only 62 species recorded. The abundance of Grazers including Surgeonfishes and Parrotfishes was high with large shoals of 200-300 surgeonfish frequent, with large shoals of mid water feeding Planktivorous damselfishes including chromids and Pomacentrids. There were notably high numbers of Queenfish *(Scomberoides sp.)* in the seaward end of the reef.

Several instances of fishing operations involving large nets deployed by two boats each using up to 4 SCUBA divers were observed laying and operating the nets on the Bar-reef. The Boats were observed to travel in and towards Battalangundu Islands.

6 nos. 25m Point transects (0.5m. interval) carried out for substrates and 6 nos. 25m.x 5m. Belt transects were carried out for fishes and large sessile benthic invertebrates.

Bar reef dead section - N8 22.268 E79 43.954

Part of the extensive patch reefs which was killed off by the 1998 Coral bleaching event. The site is composed of a large patch of old degraded coral rubble with some algal cover. Low fish diversity and abundance present.

Deeper "Bommie" reef - N8 21.082 E79 43.242

The area is composed of small rocky boulders scattered over the sandy sea floor creating a rough low relief terrain. The area is interspersed with larger rock/coral outcrops "Bommies" which form centers of high diversity and abundance of fish life. Significant, though not exert, algal cover was observed on the low relief areas dominated by algae *Asperogopsis*.

The live coral cover at the site was significantly higher than surviving in the Bar-reef area though it consisted mostly of Poritid and Mussid corals. Two transects were carried out at the site.

Deep sandstone ridge - N8 19.055 E79 41.661

The site is a high relief sand stone ridge over 50m long and 10m wide, located at a depth of 12-15m. Representative of deeper non-coral reef habitats, the reef contains good diversity of fish life and abundance. The reef is in general good health with low level of pollution in some areas with minor aggregations of Corallimorphs observed. The Corallimorphs do not seem to be aggressive or pose a threat to live coral areas on the reef. The reef contained healthy fish assemblages including large Groupers and Napoleon wrasses indicating that the reef is not heavily fished.

11.5 Marine fauna recorded in Kalpitiya sea area

The continental shelf of the west coast of Sri Lanka makes a sharp turn close to Kalpitiya as it joins the Indian shelf, forming a large bay like structure with forming a terminus to the Northward flow of currents in the deeper sea regions. This feature allows creation of conditions for the formation of up-welling currents from the deep sea which feeds a system that include migration of many species of animals including marine mammals and sea birds to visit this part of the shores. Seas around Kalpitiya include areas with narrow continental shelf as well as areas that have steep shelf slopes which also help to bring many species of marine mammals to areas closer to the shore.

The area is considered a Cetacean hotspot in Sri Lanka, with 20 species of marine mammals recorded from the area; including 19 species of Cetaceans and one species of Sirenian. There are

also additional unconfirmed records of the possible presence of Irrawadi dolphins and finless porpoise and the Hump-backed Whale in the area based on several recent kill records within the bay.

11.5.1 Spinner Dolphins (Stenella longirostris)

The Spinner Dolphins (*Stenella longirostris*) pods in the area are estimated to be about 5000 in number, which are usually divided in to several smaller pods. These pods join together on occasion to form a super pod of dolphins. The spinner dolphins usually inhabit the area of the continental shelf edge, ranging a little inshore at times. There seem to be a general North South Diurnal movement travelling along the shelf edge ranging as far south as Norochchole and moving north up to Bar-reef area. There is also another pod of Spinner Dolphins that are observed north of Bar-reef which may be distinct from the Southern pods based on the observation of community tour boat operators.

The pod size and direction of movement is often based on many environmental factors including sea conditions and pressure from tourist boats etc. The spinner dolphins are regularly observed in the presence of large schools of Yellow fin Tuna (Kenda/ Kelawalla) engaging in hunting together on the same fish aggregations. The local fishermen regularly use the dolphin pods to locate the yellow fin tuna which are caught using trolling lines. Bryde's whales are observed on occasion to feed among the dolphin pods as well.

Figure 151 [Left] Spinner dolphins; [Right] Risso's dolphins

In addition to the Spinner Dolphins; other small cetaceans recorded in the area include Bottle-nose Dolphins, Risso's Dolphins (*Grampus griseus*), Rough toothed Dolphin (*Steno bredanensis*), Fraser's Dolphin (*Lagenodelphis hosei*), Pilot Whale, False Killer Whales (*Pseudorca crassidens*), Pigmy/Dwarf sperm whales, and the Killer whales (*Orcinus orca*).

11.5.2 Killer whales (*Orcinus orca*)

Killer Whales seem to be recorded regularly during months of March-April and tend to come closer to the shore in the sea area closer to Talawila. They are also encountered further off shore beyond the shelf edge in deeper waters. Usually encountered in small pods of 2 to 10 animals, records exist of large pods of up to 50 animals in the area on occasion. These include family groups of both males and females, or all male groups. They have been observed to actively hunt and kill Spinner Dolphins in the Kalpitiya area and the boatmen report that the arrival of Killer whales are often predicted by excited erratic movement of Spinner Dolphin pods which tend to leave the

area. On occasion, Killer whales were reported by local tour boat operators to attack pods of Sperm whales. The marine surveying team observed over 30 Killer whales (on 10th March 2017) corralling and repeatedly attacking a pod of about 100 sperm whales about 20km off the coast of Kandakuliya.

11.5.3 Sperm Whale

Sperm whales are regularly observed in the area; individually or as small groups. Seas of Kalpitiya are unique as there are recorded super pods of Sperm whales aggregating off Kandakuliya area. These large aggregations, ranging from 50 -200 animals, usually in the months of March-April occur before the onset of the South Western monsoon conditions. The sperm whales are usually found further off shore and tend to stay in deeper waters beyond the shelf edge and further 5-7 km away from shore than the area frequented by Spinner Dolphins.

11.5.4 Bryde's Whale

A small group of Bryde's Whales are regularly seen in the outer area of the Bar-reef complex consisting of up to 6-7 animals. Bryde's whales are encountered throughout the year which may indicate a resident group, and unlike the other larger whales they are known to hunt in shallower waters ranging on to the continental shelf areas.

Though less common, the Blue Whales (*Balaenoptera musculus*), Minke Whales and Humpback Whales (*Megaptera novaeangliae*) are also documented in the area.

A high diversity of marine mammal species are recorded in the sea area off shore sea area beyond the shelf edge in deeper water including records of Risso's Dolphins, Rough-toothed Dolphins, Fraser's Dolphins, False Killer whales, Dwarf Sperm whales, Bottle nosed Dolphins, Pilot whales, Melon headed whales, Spotted Dolphins, Striped Dolphins, and the Common Dolphins.

11.5.5 Indo-pacific Hump-backed Dolphin (*Sousa chinensis*)

A pod of Indo-pacific Hump-backed Dolphins (*Sousa chinensis*) are regularly observed within the lagoon and are believed to be residents within the lagoon and adjacent sea area. Though the original pod is dwindling in number with only about 8-10 individuals surviving, one juvenile dolphin was observed among the pod during the current surveys indicating that the population may be breeding. They venture deep inside the lagoon and can sometimes be observed feeding as close as 1km from the Kalpitiya town. The average depths in these lagoon areas can be as low as 2m.

In addition to the available anecdotal evidence, there are possible presences of Irrawaddy Dolphins based on 2 reported kills within the lagoon and reports of a small dolphin could possibly be Finless Porpoise.

11.5.6 Dugong

Though a population of Dugong are still surviving in the sea areas between Battalangundu Island and Jaffna peninsula, the Dugong populations in Sri Lanka are considered to be highly threatened. The once significant population of Dugong in the Kalpitiya area have been decimated by hunting and by the increasing pressure from humans.

Though many records of Dugong entering the Puttalam Lagoon could be found several decades ago, presently very few records of Dugongs are verifiable within the lagoon; with many of the claimed records attributable to other species of marine mammals including the Indo-pacific humpback dolphin. There is a surviving population of Dugongs recorded in the area of Sea North of Battalangundu Island and Kudiramalai point. The area contains vast sea grass beds which form the primary habitat for the Dugongs. The greatest threat to the Dugong is the use of Gill-nets set for Rays which contribute to the majority of Dugong kills in Sri Lanka.

11.5.7 Other marine fauna encountered during surveying

During the surveys, other groups of marine fauna were regularly observed. These include Sea turtles (Olive Ridley Turtle/ *Lepidochelys olivacea* (VU), Hawksbill turtle/ *Eretmochelys imbricata* (CE), Green turtle/ *Chelonia mydas* (EN)) and sea birds including Little tern (*Sternula albifrons*), Gull billed tern (*Gelochelidon nilotica*), Lesser crested tern (*Thalasseus bengalensis*), Common tern (*Sterna hirundo*) and Sooty tern (*Onychoprion fuscatus*). The area also is known to contain large aggregations of oceanic sea birds during months of April- August in the outer sea areas beyond the continental shelf edge.

The most significant numbers of sea turtles recorded were of Olive-Ridley turtles encountered near and on the outer side of the Continental shelf area. They rarely venture inshore and tend to be more pelagic in habit. On several occasions, the turtles were observed to feed on the floating mats

of sea grass (*Syringodium isoetifolium*) washed down from the sea grass meadows to the North of Kalpitiya. Hawks bill turtles and Green Turtles are uncounted close to reef habitats in the inshore areas.

11.6 Marine flora recorded in Kalpitiya sea area

A survey was carried out along the Puttalam lagoon in the Portugal bay and Dutch Bay areas between Aruwakkalu and Battalangundu to identify habitats and to sample sea grass ecosystems. The sea floor was monitored using side scan sonar to observe bottom features and to separate sand/mud floors with sea grass and other possible habitats. Spot sampling was carried out by a snorkel diver at sites based on sonar tracings of the lagoon floor. The sampling was highly limited as underwater visibilities at most sites were 0.3-0.6m, and divers had to resort mostly to grabbing up samples in very turbid waters. Where sea grass samples were found with a workable setting, sampling was carried out using a 0.5m x0.5m quadrat.

The northern most area of the lagoon in Portugal Bay between Battalangundu Island and Kudiramale point contained large tracts of thick sticky greenish muddy floors. The area is heavily fished by Bottom trawlers. 14 Bottom trawlers were observed trawling the sea floor area. The primary fishery is for prawns and shrimp with by catch of fin-fish species. The rich fishery grounds of the area were confirmed by significant number of sonar traces of fish/prawn shoals.

There are significant sea grass beds lining the inner shores of most of the islands from Kalpitiya to Battalangundu. Several quadrate samples were carried out in these areas. (Quadrats Q2, Q3, Q4, Q5). The land ward shore closer to Gangewadiya contained few and much smaller sea grass areas sheltered within cove areas of the shore, which may indicate heavy action of waves entering the bay from the Uchchimune entrance. This may restrict growth of sea grass on this part of the coast line. Two samples were carried out on sea grass areas on the land side of the Lagoon (Quadrats Q6, Q7).

A sea grass habitat was also sampled in the sea area between Uchichimune and Bar-reef (Quadrats Q1) to provide a reference to the transition of habitat types and species composition of sea grass habitats from marine to lagoon habitats. This sea grass area was composed primarily of *Halophila ovalis* (Paddle weed) and *Halodule uninervis*. The area contained a high level of dead detached fronds of sea grass floating among the living sea grass patches. The die back is suspected to have resulted from the extreme cold water event which lasted from December 2016 to February 2017. The sea grass areas seem to have made good recovery and were observed not to be significantly affected by the event. Fish life at the site was very low despite being located very close to the Bar-reef complex with Goat fishes *Mulloidichthys* sp., juvenile Parrot fish *Calotomus* sp., few juvenile *Lethrinids* and one clown fish observed.

The middle area of the lagoon consisted mainly of sandy floors with a maximum depth of 5.0-5.5 m. The area contained some pink Hydorid colonies, *Astropecten indicus* -sea stars, fine algae, oyster and cockle shells. It must be noted that the sampling is highly restricted due to very low underwater visibility.

The shore ward coast south of the Kala Oya estuary contained a large tract of green clay mud with significant surface texturing observed on sonar. *Astropecten indicus* sea stars, cockles, window-pane oyster and large quantities of algae *Codium geppiorum* were observed in the area.

The pod of Indo pacific Hump-backed Dolphins (*Sousa Chinensis*) was observed close to the Uchchimune Island in the mid lagoon area. About 8-10 animals were observed including one juvenile. The behaviour was relaxed and indicated feeding while moving southwards. The pod is believed to be resident in the lagoon though they are seen sporadically; which may indicate that they may foray in to the sea areas as well. The area where the Dolphins were seen was about 2.2-2.5m in depth and contained only sand.

Several Islands contained large roosts of sea birds and many of these birds were observed resting and feeding in the lagoon areas as well. The roosts were composed of Heuglin's Gulls (*Larus fuscus heuglini*), Pallas's Gull (*Ichthyaetus ichthyaetus*), Brown headed gulls (*Chroicocephalus brunnicephalus*), Caspian Terns (*Hydroprogne caspia*), Lesser Crested Terns (*Thalasseus bengalensis*), Greater crested terns (Thalasseus bergii), Common Terns, Little Terns, Gull-billed Terns (*Gelochelidon nilotica*), Spot-billed pelicans and Gray Herons.

Many sea snakes were observed in the area, though the observation time was not sufficient to make an ID. Very little other fauna was observed except for few colonies of hydroids.

11.6.1 Sampling methodology for marine fauna

Sampling was carried out based on globally accepted sea grass survey methodologies adopted by the "seagrass watch" (http://www.seagrasswatch.org/Methods/Manuals/SeagrassWatch_Rapid_Assessment_Manual.pdf) methodologies. Surveys were carried out using 0.5m quadrats with 3 replicates per plot and data was collected on the species cover at each site.

The collected data was analysed by generating mean values for each site for all vegetation cover values. Species composition of sea grass species are shown as pie charts for each site and species similarity of the sites were analysed by using non-metric multi-dimensional scaling method. Prior to analysis, data was calculated to squareroot and bray-curtis similarity method using primer 6 software.

11.6.2 Marine fauna sampling results

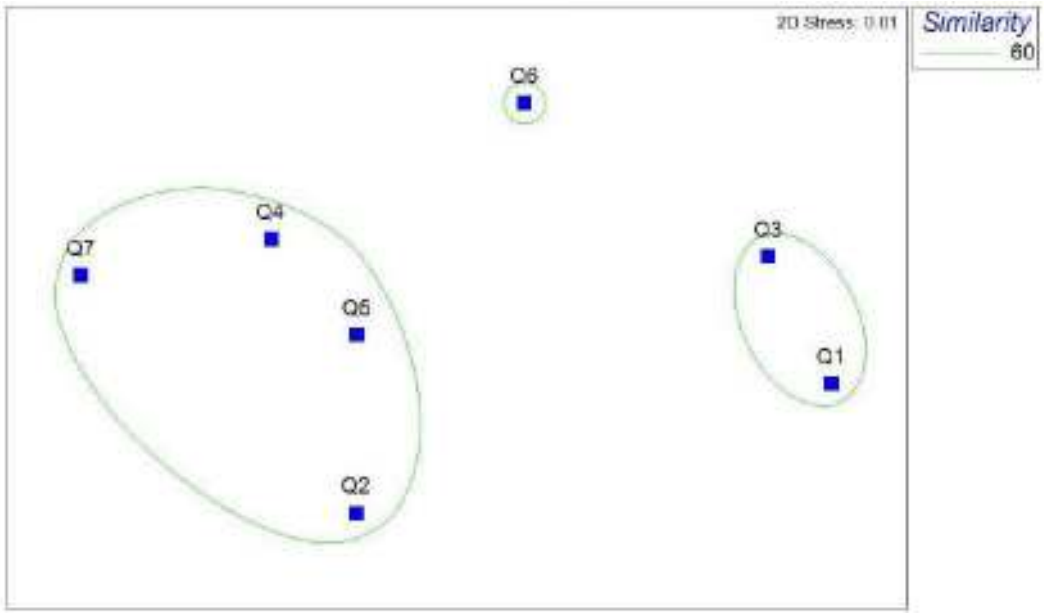


Figure 152 Non-metric multidimensional scaling ordination for seagrass sampling sites

Non-metric multidimensional scaling ordination shows results for 7 sampling sites (stress level 0.01) with the lines showing 60% of similarity of species composition. The ordination indicates that the two sites, Bar-reef inshore (Q1) located in a fully marine environment and Palliyawatta sea grass seaward end Q3, shows more similarity than other sites (which are the only sites containing Seagrass *Halophila ovalis*).

Figure 153 [Left] Sea star *Pentaceraster affinis* on sea grass; [Right] *Halopila* dominant Seagrass at Palliyawatta

11.6.2.1 Bar-reef inner SG- N8 22.304 E79 45.071 [Q1]

An extensive marine sea grass area located inshore of the Bar reef complex at a depth of about 5 m. The area extends North in discontinuous patches to link with the large sea grass areas North of Battalangundu.

The area was composed primarily of a mixed sea grass bed of *Halophila ovalis* and *Halodule uninervis* with some *Syringodium* found in places. It is to be noted that very large quantities of dead decomposing seagrass litter was found, indicating a recent mortality event of a significant

scale from which the sea grass seem to have recovered. Sea grass beds extend north of Battalangundu Island as well. It is presumed that this may have been due to the extreme cold sea conditions experienced during the last months of 2016 and first two months of 2017.

11.6.2.2 Paliiyawatta shallow- N8 26.939 E79 48.844 [Q3]

A large tract of sea grass on the inshore side of the Palliyawatta Island was observed at very shallow 0.5-1.5m depth, with crest formed about 1km east of the Island and running parallel to the Island in a North-South direction. The shallower more northern sections contain *Halophila ovalis* and *Halodule uninervis* dominated areas, with patch areas of *Enhalus acroides* encountered. Small quantities of *Syringodium* was observed while the deeper sections areas are dominated by *Enhalus acroides* dominated environments

The sites Q2, Q4, Q5, Q7 show similarity and are all located in sheltered locations on the coast and containing high levels of *Cymodocea serrulata, Enhalus acroides* and *Halodule uninervus* which are co-dominant.

Figure 154 Mixed sea grass undergrowth on *Enhalus* beds- *Cymodoce serrulata, Halodule uninervis*

11.6.2.3 Battalangundu Island-N8 29.859 E79 47.507 [Q2]

A moderate sized sea grass area on the lower inshore area of Battalangundu Island at 2m depth is dominated by *Cymodoce serrulata, Halodule uninervis* and *Halophila decipens,*

11.6.2.4 Palliyawatta outer SG- N8 25.967 E79 49.101 [Q4]

This is an extension of the same sea grass bed as in Q3, but at a site close to the outer end of sea grass bed and about 2km south of the first site. The area was structurally different to the first, in having a denser growth of *Enhalus* and *Cymodoce serrulata* interspersed with *Halodule uninervis* and *Thalassia hemprichi* and small quantities of *Syringodium isoetifolium*.

11.6.2.5 Ippanthivu inner shore- N8 19.417 E79 48.839 [Q5]

Sea grass area on the Inner shore of Ippanthivu Island Southern end is located in 0.5m shallow waters. This is primarily composed of *Cymodoce serrulata* and *Halodule uninervis* dominated environment, interspersed with *Enhalus acroides*, *Halophila ovalis*, *Thalassia hemprichi,* algae including *Padina* and a fine filament un-identified brown species. The northern sections of the sea grass area in Ippanthivu changes to a more *Enhalus acroides* dominant environments.

11.6.2.6 Wilpattu coast- N8 20.934 E79 50.438 [Q6]

The coast on the landward shore of Puttalam lagoon contains less prolific growth of sea grass than the seaward shore areas. In the area North of the Gangewadiya / Kala Oya outfall, the shore shows signs of heavy exposure to waves entering from the sea openings at Uchchimune. The sea grass areas are restricted to pockets contained within smaller sheltered coves on the coastline and are limited in extent compared to the sea grass areas on the inner shores of the Islands.

The location contained a sea grass patch enclosed in a cove on the beach on the shores of Wilpattu forest area. Thick muddy floors dominated by *Enhalus acroides, Halodule uninervus, had scattered growths of* other species including *Halophila ovalis, Halophila decipens, Thalassia* and few *Cymodoce*; Algae *Codium geppiorum* was common.

The shore line north of Gangewadiya contains extensive mangrove areas with heavy wave washing on the coast. No sea grasses were observed in the shores adjacent to the mangroves.

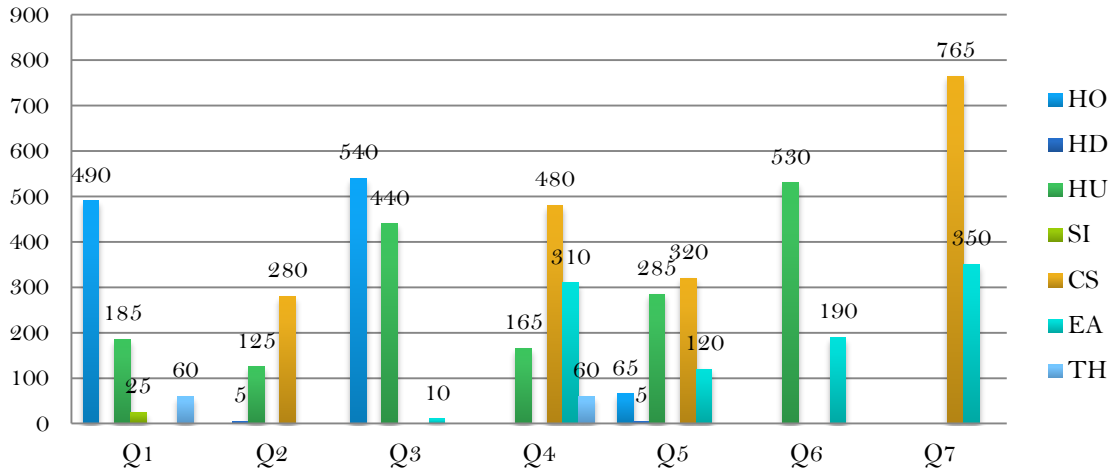
The Q6 is indicated as an outlier from other plots and contained only *Cymodoce serrulata* and *Enhalus acroides*. The site is muddier than other sites and is located further south within the Puttalam bay in more sheltered waters.

Figure 155 *Enhalus* dominated sea grass beds

Aruwakkalu coast- N8 14.843 E79 48.716 [Q7]

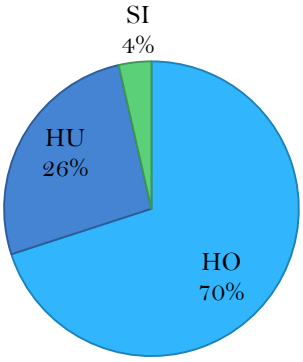
Few small patches of Seagrass are found on the landward coast of Puttalam lagoon between Gangewadiya and Kalpitiya. These are small in extent and are usually located in small sheltered sections of the coast. The water is extremely turbid and sampling was difficult. The site is shallow with 1.3m depth and the location only contained *Enhalus* and *Cymodoce serrulata*.

Seagrass species composition at sites

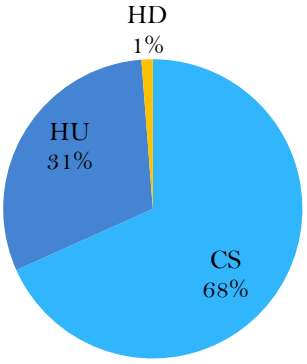


HU	*Halodule*	*uninervis*
HP	*Halodule*	*pinifolia*
CR	*Cymodoce*	*rotundata*
CS	*Cymodoce*	*serrulata*
HO	*Halophila*	*ovalis*
HD	*Halophila*	*decipens*
SI	*Syringodium*	*isoetifolium*
EA	*Enhalus*	*acroides*
TH	*Thalassia*	*hemprichii*

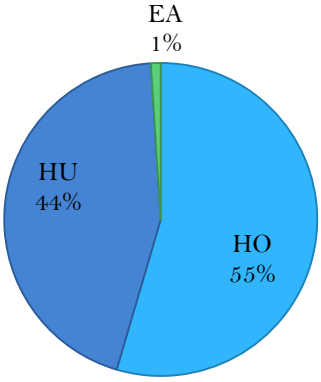
Bar-reef inshore Q1



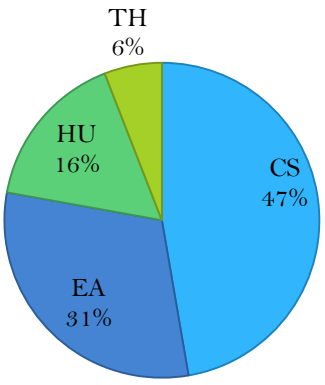
Battalangundu Is. Q2



Palliyawatta shallow Q3



Palliyawatta outer Q4



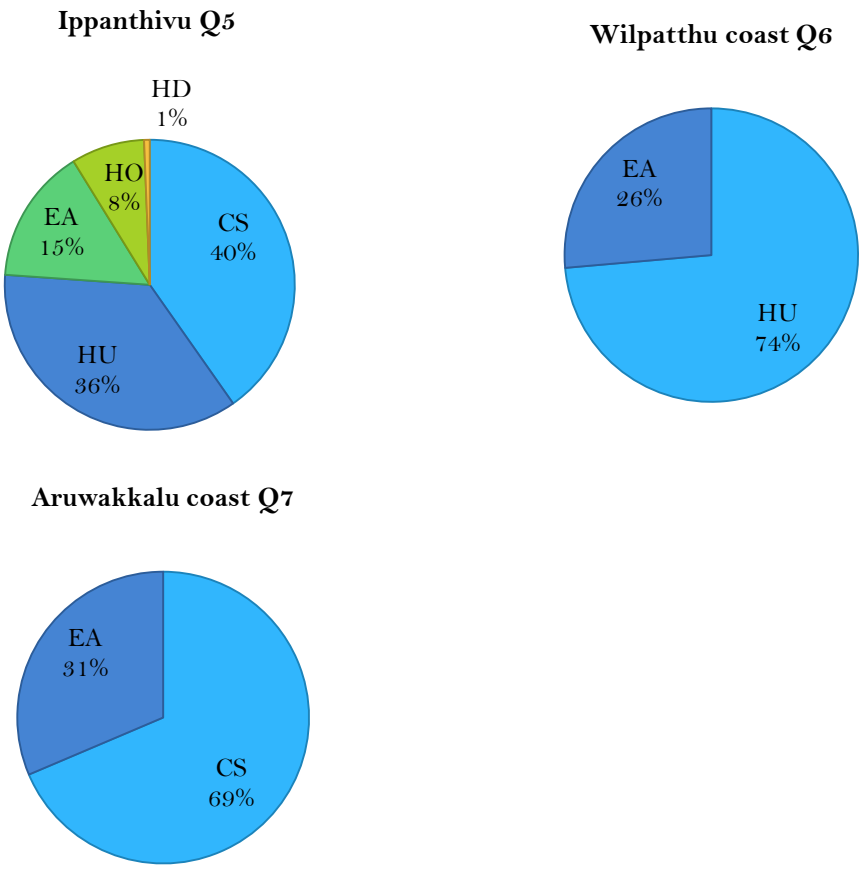


Figure 156 Seagrass species compositions in samples areas

Table 105 Shannon's Wiener diversity index for Sea grass sample sites

	Transect	Index
Q1	Bar reef SG	H = 0.72037
Q2	Battalangundu	H = 0.67633
Q3	Palliyawatta 1	H = 0.73745
Q4	Palliyawatta 2	H = 1.1789
Q5	Ippanthivu	H = 1.25607
Q6	Wilpattu coast	H= 0.57709
Q7	Aruwakkalu coast	H= 0.62219

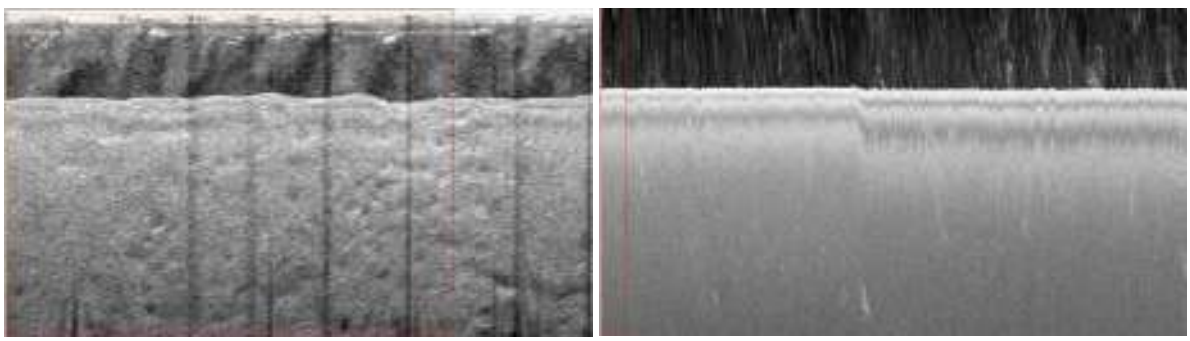


Figure 157 [Left] Sonar image of a flat sand/mud floor; [Right] Sonar image of a muddy floor with rough surface texturing south of Kala Oya estuary

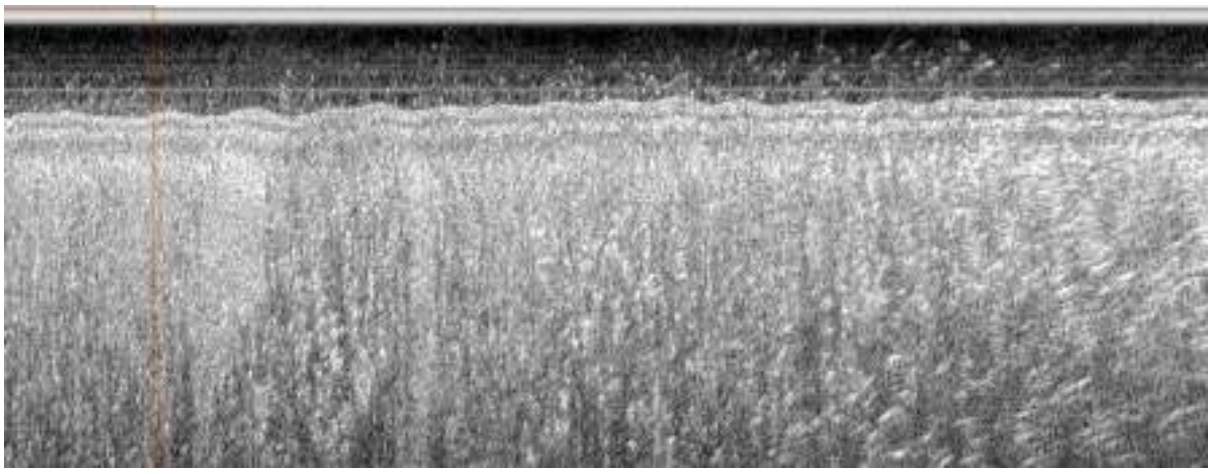


Figure 158 Sonar images of a sea grass bed dominated by *Enhalus acoroides*

12.0 CONCLUSIONS AND RECOMMENDATIONS

The Kala Oya basin represents a wide spectrum of ecosystem and habitats and is currently a biodiversity hotspot in the country. Ecosystems encountered here can be broadly categorized into terrestrial, aquatic and coastal and marine categories. These ecosystems can be further categorized into specific sub-ecosystem types based on their biological features. During the study 16 major terrestrial ecosystems and 9 major aquatic and marine ecosystems were identified by the survey teams.

12.1. Overview of Issues Identified in Kala Oya Basin

12.1.1. Habitat Fragmentation

Clearing and burning of tank beds, scrub forests and grasslands for cultivation purposes lead to the loss of grass cover/ reed beds/ mudflats for birds, and also contribute to increased pollution and siltation of the water bodies during the rainy seasons. During a field visit it was observed that chena cultivations take place legally as well as illegally. The farmers clear large tracks of jungle envisaging plentiful of rainwater, yet lack of rains led to poor returns, resulting in wastage, economic and massive environmental losses.

Figure 159 (a) Burnt tank bed in Kukul katuwa area (b) Chena cultivation in Pulliyankulam area

Clearance of mangrove forests in the inner part of the Kala Oya estuary for fuel and timber is a growing concern. This is clearly evident in the area bordering the Gangewadiya fisheries village, where part of the southern border of the estuary is devoid of mangroves. Use of detrimental fishing practices (i.e. push nets, blast fishing) affects aquatic biodiversity in the estuary. Excessive sediment loading during the rainy season is also a concern, and Gange wadiya is increasingly becoming unsuitable for brackish water fisheries due to the silting of the river. This has caused the river mouth area to decrease from 15 ft to 2 ft within a 30-year span. Sand mining and unsustainable harvesting of bivalves from the mangrove areas are also threatens the estuary. Although this area escaped destruction due to the civil unrest in the area, the increased access after the end of the civil war in 2009 has led to an increase in the number of visitors interested in hunting and camping.

Habitat destruction and fragmentation have also resulted in increased threats to the surrounding biodiversity. Since the animals are unable to have safe passage across such roads and constructed infrastructure, they often end up on the roads and result in being run-over by motor vehicles. There is a high prevalence of animal deaths due to road construction and encroachment of their habitats by human settlement.

In addition, the use of illegal tap guns along the foot pathways were noticed by the survey team, which are indicators of hunting and a lack of monitoring of these areas as was evidenced.

Figure 160 Road kill: Pregnant Ring tailed civet in the road adjacent to Kahala Pallakale Sanctuary

12.1.2. Excessive usage of agro-chemicals and fertilizers

Chemicals are washed into the streams and tanks leading to pollution and eutrophication. High levels of nitrates and phosphates released from fertilizer application of the relevant catchments in the agricultural zones or from wastes released from urbanized areas cause nutrient enrichments in stagnant waters. Animal husbandry including cattle and goat rearing are popular in certain areas and excretion of these livestock also leads to eutrophication of reservoirs. Eutrophication increases the growth of nuisance algae, which release toxic substances to water during their degeneration, resulting in health problems to humans and disruption of the entire ecosystem. Eutrophication in water bodies also affects the larval stages of species such as dragonflies (Odonata).

Figure 161 (a) Spread of Salvinia in small reservoir (b) Agrochemical use in Eluwankulama area

Fertilizers applied by the farmers are many times higher than recommended standard application rate of the Department of Agriculture (DOA); due to over application of fertilizers by farmers neglecting or unawareness of the standard recommended application rates by the DOA.

"Dieback", a condition in which a tree or shrub begins to die from the tip of its leaves or roots backwards, owing to disease or an unfavourable environment has been observed in the Kala Oya basin. Dieback of Kumbuk trees was observed, and this might be due to increasing chemical pollution of water from agriculture activities. A good example in this regard is the Abagas wewa tank in Kukul katuwa area.


Figure 162 Dieback of Kumbuk trees

12.1.3. Solid waste dumping

Dumping of waste also causes nutrient enhancements in catchment areas. The release of heavy loads of organic substances, and waste via surface runoff is a major issue. This disrupts the overall water quality and contaminates the entire network of interconnected water bodies.

Other indirect implications include increase in potential for diseases, promotion of breeding grounds for mosquitos, disruption to the ecosystem, higher likelihood for surrounding biodiversity to be affected, ingestion of waste and toxins by fish resulting in bioaccumulation of toxins in the food chain.


Figure 163 Mismanagement of waste disposal have resulted in water pollution and have other indirect implications

12.1.4. Siltation of water ways and wetlands

There is a high level of biodiversity in natural and man-made wetland areas, with significant ecological and biological importance in the ancient tank systems in particular. A key issue in the Kala Oya Basin is seasonality and duration of water retention in these traditional tanks, which has a significant influence on their biodiversity and ecology.

Water levels are very low during the dry season due to natural processes and many tanks dry out completely before being filled again in the rainy season. Their use for grazing cattle during the dry season maintains high levels of nutrients in the tanks.

Siltation is referred to as both to the increased concentration of suspended sediments, and to the increased accumulation (temporary or permanent) of fine sediments in the bottom of water bodies, where they are undesirable. Siltation is most often caused by soil erosion or sediment spill. Wetlands in the Kala Oya Basins are currently under a threat of siltation and sedimentation, arising from unsustainable land use practices in the catchments. The erosion source is typically soil degradation due to intensive or inadequate agricultural practices, leading to soil erosion.

Siltation has reduced the water holding capacity of tanks and resulted in excess water overflow to the sea during the rainy season and the period of Mahaweli water releases.

12.1.5. Salinity

Escalations in levels of salinity pose a threat to the environment and agricultural production in the Kala Oya Basin. Irrigated lands with inadequate drainage and insufficient irrigation management in the dry zones of the country can cause a rise in salinity levels. There is a limited amount of data and studies conducted on this subject.

Studies have indicated that low lying lands have the propensity to become waterlogged in the instances where the groundwater table has risen to less than one meter below the soil surface. These waterlogged areas are vulnerable to salinization with adverse effects on the surrounding areas including losses of wet and dry season crops.

In addition to crop loss, other potential negative impacts following salinization involve ecosystem degradation, diminished surface water quality, and increased public health risk.

12.1.6. Invasive Species

Spread of invasive alien aquatic plants such as *Hydrilla verticillata*, *Najas marina*, *Eichhornia crassipes* and *Salvina molesta* and invasive alien fish such as *Oreochromis mossambicus* could cause problems to the endemic aquatic biodiversity, especially in Villus.

Figure 164 (a) Invasive Plants- Common water hyacinth- *Eichhornia crassipes* (b) Guinea grass species spreading in an abandoned agricultural land

12.1.7. Quarrying

Another significant environmental issue taking place within the Kala Oya basin is the quarrying of rock stone/granite, especially within the Palagala Divisional Secretariat area in Anuradhapura district, where a number of such quarries that has been haphazardly established were observed during the field visits. This highly lucrative business, which also has a political backing, has significant adverse impacts on the surrounding environment, with many long-term disadvantages. As indicated in the below diagrams, the most prominent impact is the destruction and segmentation of forest patches leading to disruption of elephant migratory routes as well as to loss of general biodiversity.

Figure 165 Forest fragmentation due to quarrying of stone at Higuruwalpitiya forest (Transect No.13)

This land belongs to Mahaweli Authority of Sri Lanka and presently MASL has granted permits for seven quarries and stone crushes to operate within this area. DWC identifies this forest patch as an important area for elephants and is in the view of incorporating the forest to existing Kahalapallakale Sanctuary, which is going to be upgraded into a National Park status soon

Figure 166 The granite quarry operated by a private company (Alle Weerashinge Pvt Limited) for the past 26 years adjoining to the Dematagollagama forest (Transect No.15)

The company has obtained a 99 year lease of a 30 acre land plot and good quality granite are directly exported while the rejects are piled within the site. The annual permission for quarrying is granted by the Government Agent. The adjoining forest patch belongs to the Forest Department. This site is with high educational potential and could be utilized to educate the school children and general public about geology of the area as well as of quarrying industry

Figure 167 Quarrying will also completely or destroy or disrupt the follow of seasonal small streams that traverse these forest patches.

Further siltation and pollution will also led to loss of good quality water for general public as well as for wildlife

Figure 168 Noise pollution and vibrations from the blasting of rocks as well the machinery operation can disturb the fauna as well as the life styles of communities living in adjoining villages

Figure 169 Soil erosion from cleared lands and excavated soils as well as slope instabilities in hill slopes take place. Loss of the stability of fractured and loosed rock slabs within the hill slopes of dam abutments

These environmental issues are inherently also a social dispute as the surrounding communities are also affected by the presence of these industries. There has been an on-going difference of opinions between the local communities, local authorities, relevant line agencies, and the individuals running these quarries.

A good example would be the Galpaya area where the villagers have been clashing with the local authorities for about 10 years for protecting the archeological heritage adjoining to the Nisala Aranya Senasanaya. It is believed that these granite rocks are from a hermitage where Arahath theros lived during pre-Dutugemunu era according to the villagers. There are 13 caves believed to have been offered to Arahath by Buddhist devotee during pre-Dutugamunu era. There are rock inscriptions in several caves and these have been declared as archaeological monuments on July 22, 2011 by the Archaeological Department through as extraordinary gazette notification no: 1716. The surrounding area is under the jurisdiction of the Forest Department.

The outraged locals have staged protests, blocking the machinery and tried to prevent the extraction of granite. Some were arrested under the clause of "obstruction of government service". They have handed over letters to several high level officials, including the President, requesting to intervene in stopping the destruction of the ancient caves by quarrying.

Figure 170 (a) Blocks of granite that have been taken from blasting the caves around the hermitage (b) The hermitage built for monks to meditate (c) Local villagers and the monk showing the team the sites where blasting has taken place, and machinery has been trying to remove the blasted granite pieces; (d) The Galpaya temple

Some of the impacts of quarrying include;

- Soil erosion from cleared lands and excavated soils,
- *Pollutants run-off into the surrounding water bodies and also siltation in minor stream paths, possible accidental drains of fuels from machinery used, and these pollutants also impact the soil and subsoil.*
- *Slope instabilities in hill slopes,*
- *Noise pollution from the blasting that can disturb the surrounding fauna and also cause ground vibration*

- *Dust generation during transportation of earth, affects human health and also has environmental implications*
- *Loss of the stability of fractured and loosed rock slabs within the hill slopes of dam abutments*
- *Damages to Archaeological sites*
- *Land Degradation due to Cutting of Trees / Vegetation Removal, and deforestation result in habitat loss and fragmentation which have adverse short and long-term effects on the surrounding biodiversity and overall ecosystem health*

It is evident that the operation of borrow pits and quarry sites would degrade the existing vegetation in the site.

Figure 171 (a) Black stone quarry at Hinguruwelpitiya (Transect No.13); (b) Field team discussing the quarrying issue at Galpaya

The particular case of the quarries brings attention to the implementing agencies and decision makers to take an initiative to look at the realistic situation of how policies and regulatory guidelines are applied within protected areas. There is a clear requirement for the new political and administration leadership to take initiatives to ensure that current legislature to protect these conservation areas are applied correctly in the best interest of conserving the natural resources within the gazetted boundaries with no exceptions to private sector intruders as observed in the villages in Anuradhapura.

12.1.8. Lack of Coordination among Implementing Agencies

Policy decisions at higher official levels without consideration or awareness of the ground level realities lead to confusion in managing the protected areas. A lack of coordination among relevant implementing agencies results in inefficient management, and insufficient communication. Issues at the ground level are not brought to the level where policies and legislative measures can be implemented. An example of the unawareness of the ground level situation was the declaration of Weerakkodicholi Forest Reserve in 2013 with the inclusion of some lands within the Thabbowa Sanctuary.

12.2. Conservation Issues & Threats for each Taxonomic Group Surveyed

Among the threats, habitat destruction is the major threat to KOB. This is mainly due to the illicit human activities. Introduction of invasive species, conversion of habitats to other land uses, resources extractions, Chena cultivation, encroachments, grazing by domestic animals, salt intrusion in coastal areas, disturbances to water flow were other major threats observed.

Illicit timber felling, especially selective felling of rare plant species such as ebony, satin wood, etc are continuing threats in the area. Use of forest land for agriculture and settlement is also a prevailing issue in the KOB. Hunting and mining are emerging major threat to the biodiversity along with increasing timber felling, chena cultivation and poaching.

Use of varying new crops played a major role in affecting biodiversity of the area. Farmers use large quantities of pesticides and weedicide for crops, and this adversely affects species distribution, survival, and pollination/spawning.

12.2.1. Flora

It was found that many of the remaining areas in between these sections of the river basin have been cleared up for development, apart from the forests around Wilpattu National Park at the downstream areas and fragmented forests around Kahalla Pallekele at the lower upstream areas.

Although there are forest reserves shown in some maps, they no longer exist in this area. The area that belongs to Lunu Oya forest reserve, (just downstream of the Rajangana reservoir) is presently a vast paddy and banana cultivation. Some protected areas containing monoculture plantations (ie. Teak) has a less significance in biodiversity. Loss of habitats and the spread of monoculture plantations are a major threat to flora of this area.

Monoculture planatations have significant negative implications some of which are:

1. Elimination of biological controls: eliminates all the functions that nature provides to plants and the soil. It means that there is no range of insect species in a location to ensure that a single population does not get too large and damage too many plants. This results in a fewer species of microorganism and bacteria on the soil as there are fewer nutrients available for them to survive on, and it undermines the integrity of the soil by not having a variety of plants with different root depths.
2. Increase of synthetic material use: Large quantities of synthetic herbicides, insecticides, bactericides and fertilizers are generally used in order to maintain the crops, prevent damage by weeds and insects etc. Furthermore, such chemical substances kill indiscriminately, meaning that all manner of wildlife, beneficial insects and native plants are affected by their use, depleting the vibrancy and diversity of neighboring ecosystems as well.
3. Soil degradation: Besides the negative impact the overuse of chemical fertilizers has on the soil, monocultures are detrimental to soil health in other ways. Ground cover crops are eliminated, meaning there is no natural protection for the soil from erosion by wind and rain.There is a loss leaf litter mulch to replenish the topsoil, which would be eroded.

Eight invasive plant species and two other potential invasive plant species were found within the study area. Invasive species - *Eichhornia crassipes* (Japan Jabara), *Panicum maximum* (Gini Thana), *Typha angustifolia* (Hambu Pan), *Lantana camara* (Gandapana), *Leucaena leucocephala* (Ipil Ipil), *Pennisetum polystachion* (Rila Waliga), *Salvinia molesta, Colocasia esculenta* (Ala kola). Potential invasive species - *Acacia auriculiformis, Muntingia calabura* (Jam). Many of these species were found in less densities or in less numbers within the natural habitats of surveyed transects. But *Panicum maximum* was extensively growing in edges of cultivated areas and in abandoned lands within the study area. Canal embankment of Neela Bemma irrigation system is such a location. Gravel road edges in cultivated areas are also infested by this species. A considerable amount of remnants of died *Salvinia molesta* was observed at Manewa Wewa. Since the tank is dried up at the time of observation, area of extent of this floating invasive plant couldn't determine. No any other distinct boosts of aquatic weed species were observed during the survey as both manmade and natural water bodies were in shortage of water due to lack of monsoonal rains in the previous season. Although *Acacia nilotica* is not listed in present IAS list, this species is significantly invading the habitats of Tabbowa Sanctuary, its surroundings and extending into Wanathawillu area together with highly invasive species *Prosopis juliflora*.

Figure 172 Dry mixed evergreen forest habitat at Wilpattu cluster

Alterations in the weather pattern due to climate change also make a negative impact on plants of this river basin. The usual North East monsoonal rains in November to January were not received during the last season, while there are now rains in February.

During this survey, flowers were observed in *Manilkara hexandra* (Palu) and *Drypetes sepiaria* (Weera), the two dominant fruiting tree species in the dry zone, which usually bear fruits at the beginning of the dry spell (around May & June). Due to the unexpected rains, many flowers are falling off, leading to a poor fruiting season, which will ultimately make an impact on fauna. Short lived herbaceous species which are surviving as a seed bank on dry soil in the drought

months (July to October) suffered from 'no rains' in November. Also, the annual cycle of aquatic plants has been altered since many water bodies including irrigation tanks and streams are deficient in water. No floods occurred during this season in flood plains of the river basin, which is a required incident for the restoration of fertilizers.

Considerable amount of tree felling was observed in transect 7 & 8. It has been observed that large trees of two hard wood species *Manilkara hexandra* (Palu) and *Diospyros ebenum* (Kaluwara) are selectively cut down and only a portion of the tree was removed from the site while the remaining portion is abandoned. Temporary tractor roads to the trees also make damages to the habitat by removing understory vegetation.

Suduwelipitiya (transect 6) was a unique habitat since its soil comprises of a thick sand layer. It has a stunt forest and bare many herbaceous species that are not found in other locations. Some extent of this habitat was converted in to a cashew plantation some time ago. The remaining natural habitat is now threatened by sand mining.

New settlements within the forested areas adversely effect the continuation of forest as well as make harsh conditions to settlers. Such a settlement was observed at Thuththaneriya within Weerakkodicholei forest reserve. This village was established some decades back and it is now abandoned. Another such ongoing settlement was observed at Ihala Puliyankulama (near transect 9). Up to now more than 20 houses are being built along the road within the forest.

12.2.2. Herpetofauna

The island is particularly rich with herpetofauna, with 38 of the 56 species of amphibians being endemic. Sri Lanka's amphibians are important for both their species richness and their representation of ancient lineages.

Figure 173 Hemidactylus leschenaultia, Common Name: Leschenault's leaf-toed gecko

The main conservation issues identified include habitat losses and fragmentation that have negative direct and indirect implications on all biodiversity. Expansion of human settlements and clearing of land for agriculture, plantations, etc. disrupt the existing balance. The diminishing availability of natural habitats have pushed herpetofauna to adapt to live in home gardens, plantations and degraded habitats. Furthermore, human consumption of the flesh and eggs of some reptiles such as sea and fresh water turtles has also increased. The killing and trade/collection of reptiles has also been evident with the increases in human settlements.

Another consequence of human encroachment into natural habitats is the high incidence of road kill observed. Excessive uses of pesticides and

agrochemicals have dire consequences for herpetofauna, which are sensitive to their surroundings. Forest fires also have detrimental effects as their eggs are generally laid on leaf litter.

Climatic changes such as increasing temperatures and decreasing rainfall has been a trend seen in Sri Lanka in the recent past, and this may have adverse effects on reptiles that require moist and cool habitats.

12.2.3. Avifauna

Some of the specific issues affecting avifauna in the Kala Oya basin have been outlined below.

Diminishing tree cover within and surrounding tank/reservoir areas leading to reduction in nesting, roosting and perching sites for birds. Trees are essential for nesting and roosting of water birds, while the dead tree stumps in the reservoirs are used as feeding and roosting perches. Yet for safe operation of dams as well for disaster risk reduction it is required to keep spillway channels free of debris and bund free of trees and brushes.

Presently when a new reservoir is constructed, trees are uprooted completely before flooding the area and no stumps are left. These actions had led to loss of suitable perching options as well as food availability within and the surrounding areas of the reservoir, leading to loss of bird diversity in the water bodies.

Lack of dead tree stumps will also affect the fish diversity as it reduces the suitable surfaces for algal growth. Therefore, it is essential to undertake a thorough scientific study in this regard and provide suitable recommendations to improve the present situation, especially when constructing new reservoirs. It was also observed the Kala Oya banks are also lacking tree cover in certain locations. The stretch of Kala Oya that divides Anuradhapura and Kurunagala districts are lacking tree cover and bank erosion was also noticeable.

Figure 174 Spot billed pelicans and Indian Cormorants perched on dead tree trumps at Rajanganaya reservoir ; Kala Oya observed from the bridge separating Anuradhapura and Puttalam districts

Prolonged droughts leading to reduction in mudflat areas for waders, while high rain fall results in the inundation of the mudflats and other bird habitats. In the recent past there has been an increase of flooding in the lower reaches of the Kala Oya and discussions with the Divisional Secretary of Wanathawillu lead to the understanding that Gangewadiya and Eluwankulam areas get flooded twice a year and is under water for around nine days.

Figure 175 Dried up mudflats within a mangrove forest in Gangewadiya area and a dried up tank bed

The survey reveals the presence of a rich avifaunal diversity within the Kala Oya basin including few nationally and globally threatened species. However, their survival is threatened by many anthropogenic as well as climate change related issues.

The sub basins that need priority in terms of conserving the bird diversity are Eluwankulama, Manawa kanda and Galpaya sub-basins as well as Eilie sub basin as it is important feeding ground for migratory waders.

It should be noted that other than the Puttalam lagoon no other areas in the Kala Oya basin has been designated as an Important Bird Area (IBA). Therefore inclusion of these sites as IBAs is recommended and also continuous monitoring of the bird populations should be undertaken. Attention should be given to maintain adequate tree cover consisting of tree species required for feeding and nesting requirements, while when allocating water, the importance of wetlands for maintaining the rich biological resources should kept in mind.

12.2.4. Mammals

The major threats that are faced by mammals in the kalaoya basin are due to human influences. Hunting by individuals and poaching by organized gangs, habitat destruction due to encroachment by villagers are major threats to medium and large sized mammals. It was evident that trap guns are a common method to hunt large mammals such as Wild boar and species of deer while snares and pit falls are used to capture medium size mammals such as Mouse deer. Old trap guns set for hunting were found during the survey while evidence for other methods were obtained based on casual conversations with villagers. Small mammals are affected by occasional fire that resulted from anthropogenic acitvities and during prolonged droughts. Awareness programmes would help

reduce hunting by villagers. Also, proper law enforcement is necessary to reduce poaching and habitat destruction due to encroachment.

12.2.5. Freshwater Flora and Fauna

Mangrove swamps are significant habitats and play an important role with regard to microscopic and mescocopic fauna. The micro relief of mangrove swamps produces food and shelter and provides nursery grounds for birds, fishes, reptiles and crustaceans. Although mangrove habitats help preserve the natural balance, they have been significantly damaged by anthropogenic activities, human settlements, industrial activities, tourism etc.

Mangrove species have also been degraded by changes in freshwater runoff, salinity regime and tidal flow patterns. In addition, excessive siltation and discharge of toxic substances and the in-flow of polluted water contribute to further habitat and ecosystem disruption. The depletion and degradation of mangroves have direct and indirect influences on livelihoods of the surrounding communities, and ecological health of surrounding biodiversity and ecosystem.

The paucity of the island's freshwater fish is notable. Freshwater fish have also been exploited by the ornamental fish trade.

12.2.6. Butterflies

An important step in practical conservation is to identify processes that threaten butterfly populations and to determine the severity and extent of these processes.

Habitat destruction and fragmentation is one of the predominant threats to butterflies, as these result in elimination of vital resource bases for the species and changes the environments necessary for the survival of butterfly populations, creating pressures on ecosystems. This stems from anthropogenic activities such as urbanization, pollution, reclamation of wetlands and mangroves, and related development activities that infringe upon rural land that includes butterfly habitats. These also include illegal felling of trees for firewood, timber and other uses, which affects their sources of food and breeding sites.

Spread of invasive species of plants that displaces native flora and are a major threat to all biota. Moreover, establishment of monocrop agricultural plantations including the use of pesticides and weedicides have direct and indirect impacts by killing entire populations of species or destroying the larval host plants that result in larval death. Indirect impacts on butterfly populations include soil degradation which affects larval food plants and nectar plants growth.

The issue of over-grazing and excessive trampling of vegetation by domesticated animals such as cattle and buffalo are very destructive to butterfly habitats since it completely eliminates or diminishes all sources of larval food and adult nectar sources.

There are several species of butterflies that depend entirely on riparian habitats for their survival because larval food plants grow almost exclusively along streams and rivers. Human activities result in disturbances to soil and changes to surrounding habitats. It may also result in certain species of grasses and plants to grow in an aggressive manner and take over the original, native habitats. This alteration in the established landscape causes diminished diversity of plant species that serve as sources of larval food plants and nectar sources.

Climate change is a factor that has wide-spread effects on all species of biodiversity including humans. Changes in weather patterns have an impact on all butterfly populations, and the high rainfall experienced in the early part of 2016 coupled with the drought toward the end of 2016 to date have had significant adverse effects.

Encroachment and Habitat Destruction

As many of the forest habitats were surrounded by human habitations, and the extent of land subject to Chena cultivation, which can be identified as the major cause to a diminished diversity of butterflies.

Impact of Invasive Species

Spreading of invasive plants, specifically *Panicum maximum* (Guinea grass), found commonly in the Kala Oya basin (Figure 176) was a leading threat to butterfly fauna. This tall, dense grass displaces native flora which butterflies use as host and nectar plants while also affecting their microhabitats.

Figure 176 (Left) *Panicum maximum* (Guinea grass) invaded habitat; (Right) Land cleared for chena cultivation

Cattle Grazing around the Habitats

Commercial cattle and goat rearing activities and their subsequent grass and plant grazing in scrub lands may cause butterfly diversity loss due to the changes in their habitats.

12.2.7 Dragonflies

Dragonflies are indicators of watershed quality and are sensitive to disturbances in terrestrial and freshwater habitats. High species diversity is a reflection of favourable conditions in the wider wetland ecosystem (Bedjanic, 2006). The main threats to this taxonomic group are anthropogenic factors such as habitat loss and the rapid destruction of primary rainforests. Extraction for irrigation, cattle grazing, over-use of pesticides, insecticides, weedicides, and pollution of rivers and stream and other water bodies have had devastating effects on the population of dragonflies. Eutrophication of water bodies that serve as breeding grounds for dragonflies and as a habitat for larvae to grow have negative impacts on the development of Odonata larval stages. Other weather phenomena that have stemmed from climate change such as flooding also destroys larval stages and habitats.

The growth of invasive plant species such as *Eichhornia* spp. also alters habitat requirements, with indirect impacts on the dragonfly lifecycle. Moreover, high population growth resulting in urbanization, and related development activities such as building infrastructure, mining, and soil erosion causes additional habitat loss with direct and indirect impacts.

Odonates have been used as biological indicators of water quality and environmental quality for conservation work due to their sensitivity towards environmental changes.

Such changes can affect their lifecycle. Several threats were identified in the areas surveyed. In addition to habitat degradation which was the major threat other threats can be as follows;

- Eutrophication in water bodies which affect larval stages of Odonata species
- Cattle grazing has been observed to reduce their preferred habitat
- Flooding which destroys both larval stages and habitats
- Addition of agrochemicals and insecticides to water bodies inhabited which affect Odonata larvae and freshwater fauna consumed by the larvae
- Breeding of invasive plants such as Eichornia, Salvinia and Pistia alter habitats which in turn affect their requirements

12.2.8 Marine Flora and Fauna (Bar Reef)

The Bar Reef, off the western coast of the Putlam district, is the largest and most bio-diverse coral formation in Sri Lanka, being home to 156 species of coral and 283 of fish. It is also one of the few remaining in a pristine condition. However, as evidenced by our marine survey team, this status is changing rapidly.

It is made up of a complex of reefs which stretch parallel to the coast of the northern end of the Kalpitiya peninsular and to the islands in Portugal Bay. There have been 5 surveys have been carried out to date under the Marine component of the Kala Oya Survey.

Figure 177 Tourist boats chasing dolphin pods, causing high levels of stress for the dolphins

The trade in marine mammal tourism is still insufficiently regulated and especially on holidays times occur where more than 30 boats could be observed to chase a single pod of dolphins for hours. The boats do not approach the mammals in an orderly manner and do not comply with

whale watching guidelines. The practice will make the dolphins stressed and prevent them from engaging in their normal lifestyles.

Bleaching events and Recovery

The Bar-reef has shown that it is very susceptible to coral bleaching events driven by global climatic events. The reef was critically damaged on at least two of the major bleaching events recorded in recent times, 1998 and 2016. The reef was also affected by several other coral bleaching events which were less severe in intensity or duration of the event, and managed to survive and recover. The scale of these events prevents any human interventions that could reduce the impact of these events on coral reefs.

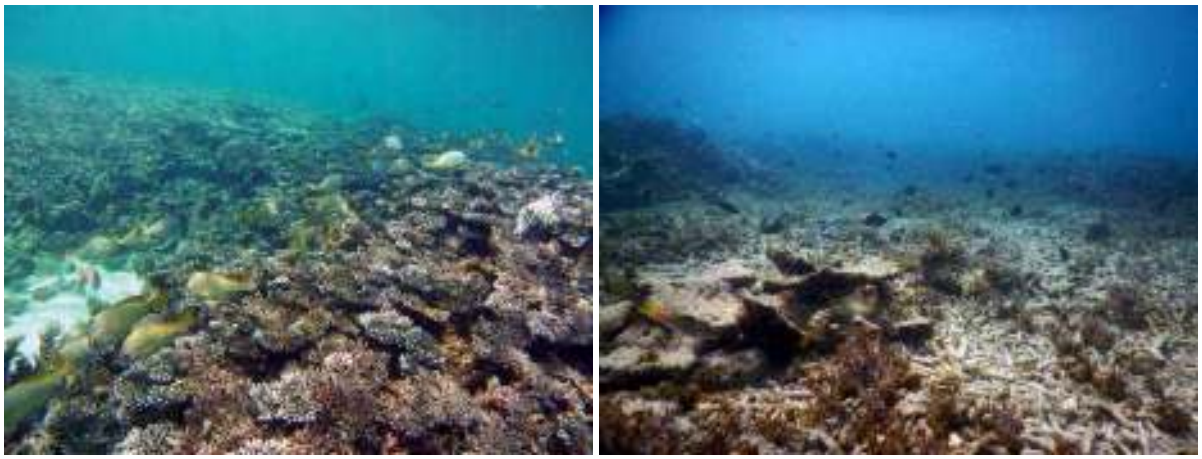


Figure 178 [Left] Bar reef before bleaching event; [Right] Bar reef after 1998 bleacihing event

The main shallow coral sections of the Bar-reef have been impacted heavily by the 2016 coral bleaching/mortality event. The coral cover over most shallow areas have been reduced to 1-2 % and with most of the remaining corals found in the deeper sections of the reef. While the inshore section of the reef is still heavily overgrown with algae (47%) with low potential for new recruitment of coral from planktonic larvae, the outer section of the reef seems to be moving in to the secondary phase. In this area, herbivorous fish numbers have increased significantly and the grazing levels have reduced the algal cover to 13% of the reef surfaces, making it sufficiently open to allow settlement of new coral recruits. Observations indicate at least some recent recruitment have already taken place.

The prognosis for recovery of the coral reef is dependent on the ability to control the human impacts on the reef. The presence of significant populations of surviving coral in adjacent coral reefs at Silawathura Arrippu reef complexes and in the deeper sandstone reef areas would ensure availability of larval coral for resettlement of reef surfaces.

The level of secondary non-algal invasive reef organisms on the reef is currently not significant and is not expected to pose a significant threat to corals. The presence of excessive quantities of coral rubble over the reef surfaces is a major setback in the long term recovery process of the reef as the unstable substrate provided by the coral rubble for recruitment of corals. This makes coral larvae prone to being displaced or rolled over reef surfaces during rough weather causing harm or significantly reducing the survival potential of the coral recruits till they reach sufficient colony

size and colony density, to stabilize the ground by re-cementing coral rubble in to a more stable substrate.

It is believed that the main reason for the recovery of the Bar-reef from the previous coral bleaching event was due to the inaccessibility of the reef to most human activities during security restrictions. In the current situation, the reef is impacted by fishing practices including use of bottom-set nets, purse-seine nets (leila and surukku), blast fishing or combination of techniques used together. Local tour boats also bring tourists in to the Bar-reef where they would swim and snorkel on the reef causing coral breakage due to trampling, souvenir collection and on occasion angling within the BRMS.

Pollution- solid waste/ water

Solid debris on the reef primarily include discarded fishing nets, line and material of terrestrial origin from plastics, organic debris washed in through currents or discarded by fishermen/ tour boats visiting the reef. The off shore sea area between Battalangundu Island and along the continental shelf edge and along the boundary with India, contains high densities of floating debris which may originate from India. Some of this debris contributes to the solid waste over the reef in addition to the waste from local origins.

The reef is subject to pollution from solid waste as well as effluents, including agricultural runoff, which may be responsible for several algal blooms events that were observed on the reef post to heavy rains on land. The Kala Oya plume can periodically washes over the Bar-reef area, bringing in agricultural runoff and siltation through Kala Oya system and Puttalam lagoon during heavy flood conditions. Some significant invasive events involving algal blooms on the reef may attribute to excessive nutrient runoff from fertilizer use upstream.

Fisheries

The Kalpitiya area contains 247km of lagoon and sea coastline with a population of more than 15,600 fishermen registered within the area working from 72 fishing villages and "harbors"

40 Purse seine nets including the Laila and the Surukku nets are registered in Kandakuliya and 53 in Kalpitiya. These nets range from a net eye size of 1 1/4inch to 2 1/4 inch in size. Though legally operated, the nets are believed to be destructive and un-sustainable in operation with many fishermen modifying the fishing practices using explosives within the net and using SCUBA divers to drive fish and collect the catch. Many fishermen would use these nets in sensitive areas including the Bar-reef Marine sanctuary over coral areas and there are instances on record when they had been used to encircle pods of spinner dolphins to target the Yellow-fin tuna schools which regularly travel with the Spinner Dolphins causing significant deaths among the encircled Dolphins.

63 Multiday boats are registered in the area which would usually fish in off shore areas; in addition many other fishing craft from other areas of the coastline would visit and carry out fishing activities within this area as well.
About 18 fishing craft using bottom trawl nets were regularly observed in the upper end of the bay in the Portugal bay area in Puttalam lagoon between Battalangundu Island and Kudiramale

point. The fishery is primarily targeting the shrimps and includes by catch of fin-fishes. The fishery is conducted throughout the year with the best catches recorded from the period between October and April. 23 Bottom trawl boats are operating in the area.

280 boats are registered for the fishery of Sea cucumbers, Chanks and Spiny Lobsters, which are operated using locals employed as SCUBA divers. Most of the collectors receive minimal training in SCUBA and operate without adhering to any dive safety rules and working

The main fisheries in the sea area include long-line fishery for Yellow-fin Tuna, are some gill net fisheries are practiced for Flying fish and demersals. Main target species in the area include Rays, scombrids, Claupid, Exocoitids and Squid.

Direct impacts of fisheries on the sea grass beds of the northern section of the lagoon are low as the areas are larger and difficult to access. There is some trap netting being carried out over the sea grass as well as small scale push net operations.

Figure 179 [Left] A mixed fish catch in the lagoon; [Right] Bottom trawl nets in action (Portugal Bay)

The use of destructive fishery practices pose a significant threat to the reefs, the use of "Leila" and "Surukku" Purse seine nets over reef areas, the use of explosives and SCUBA divers in conjunction with the nets causes excessive damage to reefs and reef fauna. The use of blast fishing is documented and the damage of the blasts on the reef surfaces is observed regularly. The illegal use of bottom set nets on reefs is significant and nets are often lost due to entanglement and abandonment on the reef which is proven true by ghost nets observed.

Figure 180 [Left] Surukku net in operation over Bar-reef; [Right] Schools of Herbivorous Surgeonfish

The fishery for ornamental aquarium trade and the export trade including Sea cucumber, Chank and Spiny lobster is carried out mainly in the area adjacent to the Bar-reef proper and deeper sandstone reefs. This is not sufficiently regulated, and can deplete target species in the areas where the divers would fish one area till it is depleted of the target species and move on to other areas. Spear fishing which is now an illegal activity is carried out regularly as there are no monitoring of boats out at sea. This activity is highly destructive on the reefs as the divers target the sensitive species and also selectively kills the largest and dominant members of a population on the site.

Tourism

Marine Mammal Tourism was initiated in Kalpitiya area, post to the ending of the war in the period 2010-11. Currently there are 97 boats registered for Marine mammal tourism in the area, though the number of boats in actual operation is about 30-40 boats. The largest numbers of boats are operating from Kudawa while the rest operate from Kandakuliya and Alankudawa. Few other boats carry out operations from Kalpitiya and Anawasala where they tend to offer excursions to Gangewadiya, Wilpattu, Islands and the Bar-reef

The Dolphins and Marine Mammal watching has become a major trade in the area with a number of tourist boats currently registered to carry out tourism in the seas. These boats operate primarily from Kandakuliya, and Kudawa and each boat is equipped with basic facilities to carry 6 tourists per boat. Most boat trips are aimed at encountering the resident coastal pod of spinner dolphins that range 5-8km from the shore along the continental shelf edge area, while some would venture out in to the deeper sea areas and offer encounters with Sperm whales and other species of dolphins and whales.

Whale watching tour boats regularly provide an additional trip to tourist by allowing them to snorkel at Bar-reef. This activity is unregulated and involves alighting of tourists who have minimal skills in snorkeling. While there is a high risk to the non-diver tourists in alighting at a location at a significant distance from the shore, it also causes significant damage to the reef as the non-divers tend to gather at shallowest sections of the reef crest and stand and walk on the reef causing significant trampling damage to the reef corals.

Invasive species

Many marine reef species can become invasive over reef areas when their natural densities on the reef are significantly increased. Reef organism invasive events can take two forms where they may be seasonal (or activate as short term events triggered by an external cue), or be long term takeovers of reef substrates due to a more significant change in reef ecology.

These include algae *Halimeda spp. Ulva spp. Asperogopsis taxiformis,* Stoechospermum polypodioides, *Padina spp., Dictyota spp., Caulerpa racemosa, Caulerp averticilliata* etc. and reef invertebrates including encrusting black sponge (*Terpios* sp.) Corallimorphs, Green Ascidians (*Didemnum sp.)* and Crown of thorn sea stars etc. Most of these species are present on the Bar-reef complex and have shown to be locally invasive on occasion. The invasive events are believed to be linked to human activity including pollution/eutrophication and selective removal of adult or larval predators of the species.

Coral rubble

The dead standing coral colonies degrade and break up due to wave action with time to form coral rubble. The major coral mortality events result in massive accumulations of coral rubble that dominate most of the reef surfaces making the reef substrates unstable and prone to dislodging and shifting during rough sea conditions. Poor management of fisheries have also resulted in discarded bottom set nets on the bottom of the ocean bed, several pits around live areas which occurred by blast fishing, cyanide fishing, and scattered live coral particles which have been destroyed by ornamental fish and lobster collectors and boat anchoring. Coral mining and overuse of reef resources also result in declining fish stocks, as these serve as vital habitats for breeding and are diverse ecosystems which harbor a multitude of organisms. These fragile ecosystems are highly sensitive to water temperature and are already seeing the effects of global warming, climate change, and oceanic acidification.

Figure 181 Dead coral reef with remnant fish populations

New re-colonization of reefs over coral rubble substrates are rarely viable as any new recruits tend to be rolled over during storms and end killed or damaged due to abrasion or smothering. Colonies established on firmer substrates within coral rubble dominated habitats are prone to damage as storms tend to float rubble pieces and cause damage to any live coral. This is a major setback for the restoration of live coral cover of the reef.

Figure 182 [Left] Dead standing coral; [Right] Reef overgrown with macro algae

The future challenges in coral reef restoration include possible removal of significant quantities of loose coral rubble off reef areas to facilitate stabilization of reef substrates and recovery of live coral cover. This is a topic that needs to be given consideration and may need formulation of new policies in coral reef conservation as coral, including rubble, is currently regulated by Coast conservation act.

Figure 183 [Left] Dead coral reduced to rubble Bar-reef; [Right] Coral rubble overgrown with algae

There are un-regulated instances of snorkelers getting off boats to swim with whales as well, though currently it is not a significant threat. But if the practice increases, it could become problem for the whales and could raise visitor safety issues as well.

Though the DWC and Navy regularly monitor the boats leaving for whale watching and each tourist boat is issued with a ticket, virtually no monitoring or enforcement of regulations or best practice guideline are carried out at sea.

The main setback preventing effective enforcement of marine conservation issues including tourism is monitoring and enforcement of regulations on the boats at sea and at the BRMS, which is virtually non-existent at present.

Inadequate capacity of the DWC staff in handling marine environments is also a prevailing issue. The DWC staff at the marine protected areas need to be provided comprehensive training on

swimming, snorkelling, SCUBA diving, boat handling and safety at sea in order to be comfortable and capable of working out at sea. There is also need for additional equipment including boats and diving gear etc. and sufficient running expenses to be able to run boat excursions out to see regularly.

12.3. Critical Species

Critical Species can be defined as any species that is, (i) Critically Endangered or Endangered (ii) Endemic and (iii) or a Restricted range species. The table below provides a summary of critical species found in the Kala Oya basin. By the given definition, the table indicates the importance of different clusters in terms of taxonomic and conservation considerations.

Table 106 No of Critical Species in Each Habiatat Cluster or Sub Basin (No of Species in each Habiat)

Taxonomic Group	Total no of species	A	B	C	D	E	F	G	H	Total no of critical species
Plants	609	09	12	13	11	07	18	09	15	41
Mammals	39	11	10	04	09	05	09	09	11	15
Birds	188	04	11	06	07	08	06	09	09	14
Herperto Fauna	105	11	6	13	15	12	16	23	20	29
Fish (cluster wise species categorization not possible for aquatic fauna)	64									8 (all EDN of which 4 are VUL
Dragonflies	40	2	2	2	2	2	2	3	2	05
Butterflies	84	02	01	00	01	00	01	02	02	07
Mangroves (cluster wise species categorization not possible for aquatic fauna)	14									10 (5NT,3 EDN 2 VUL)
TOTAL	**1129**	**39**	**42**	**38**	**45**	**34**	**52**	**55**	**59**	**129**

Cluster F: Galpaya sub-basin is an important area in terms of terrestrial flora, while Cluster B: Eluwankulama is a key sub-basin in terms of avifauna diversity. Cluster G: Manawa is important for dragonflies while the mouth of the Kala Oya is a crucial area for diversity of of fish and mangroves as it forms the estuary that creates a critical habitat. Although parts of this estuary is already under conservation, a considerable part of the Lunu Oya and Henakachchi segments of the estuary along with associated salt marshes are essential environments for the survival of mangroves, salt marsh associated fauna and flora as well as migratory birds.

Other critical habitat clusters include the entirety of Kala Oya estuary and associated salt marshes in landward side. In terms of freshwater fauna, remaining flood plains of the river still preserved at Wilpattu and Eluwankulama areas should be given needed legislative and institutional protection.

Compared to Wilpatthu National Park localities (transect 21 – 24), Species Richness and type of Habitats are more or less similar in Locality A: Eile area sub-basin, B: Eluwakulama sub-basin, E: Horiwila/ Ambagahawewa sub-basin and F: Wilpattu NP area. Additionally, these four localities are very significant due to high levels of endemism, near threatened species, endangered and vulnerable species compared to species distribution and species richness of other localities in the adjacent areas.

Avifauna observed during the study period included four nationally threatened species (other than breeding migrants) all of whom fell into the category "vulnerable": *Porzana fusca* (Ruddy-breasted Crake), *Leptoptilos javanicus* (Lesser Adjutant), *Chrysocolaptes* festivus (White-naped Woodpecker) and *Lonchura malabarica* (White-throated Munia). Further two globally threatened species were recorded: *Ciconia episcopus* and *Leptoptilos javanicus*. As per the IUCN Red List of threatened species, 2016, both species are considered as "vulnerable" globally as their overall populations are seems to be in rapid decline mainly due to loss and degradation of wetlands and loss of nesting tress as well as hunting. Yet nationally, only *L. javanicus* is considered as vulnerable, while *C. episcopus* status is near threatened, indicating its population is more stable in Sri Lanka. During the present survey, records *C. cepiscopus* was high with eight individuals being observed in a dried up tank within Manawakanda area. Single individual of *L. Javanicus* was observed near to Eluwankulama Tank (Transect 6). A recent study on *L. javanicus* in the country indicated that the species' distribution was restricted to dry lowlands (rainfall <2200mm, elevation <300m). The bird showed preference for savannah/woody savannahs, dry mixed evergreen forests, permanent wetlands, and croplands, and was prominently found within protected areas. Habitat loss and fragmentation, hunting pressure, agricultural intensification, and development projects were identified as potential threats faced by the species, which varied in magnitude across the KOB.

The highest avifaunal species diversity was recorded from transects that included a variety of habitats including both aquatic and terrestrial: Nabatayagama Tank and associated forests (Transect 14) located adjacent to Namal Uyana Conservation Forest recorded the highest diversity followed by Manawa tank associated habitats (Transect 19). Of the Dry mixed evergreen forests, highest bird diversity was recorded from Manawakanda forests (Transect 17) followed by Higuruwelpitiya (Transect 13) and Aily tank associated DMEF (Transect 1). Least diversity was observed from DMEF of Suduwelithalawa (Transects 7 & 8) and this might be due to high density of the forest cover.

Out of the habitats selected in the Kala Oya river basin, Scrub forest and Tank associated habitats stand out as the best sites for butterflies. The current study shows that the Galpaya, Hinguruwelpitiya, Ranva kannda, Nambatiwewa, Manawa area supports high levels of butterfly diversity including endemic butterfly species. The Eile area – transects T1 and T2 - is an ideal habitat for the Joker, *Byblia ilithyia,* a characteristic species of this area found only in Meadows with seasonal flooding. When considering the North West butterfly region, it is typically home to and the preferred habitat for the Large Salmon Arab- *Colotis fausta*, Crimson Tip- *Colotis danae*are, Yellow Pansy- *Junonia hierta*, and Bright Babul Blue- *Azanus ubaldus*. However, these species were not encountered despite previous records of their existence in these habitats indicating inadequate sampling or lack of time to carry out sampling.

12.4. Discussion & Recommendations

Biodiversity baseline survey indicates that species compositions and communities vary from cluster to cluster. Therefore, the selection of ESA cluster/Are should be based on the criteria adopted and objectives of establishing them

12.4.1 Critical Species

Critical Species can are, (i) Critically Endangered or Endangered (ii) Endemic and (iii) or a Restricted range species. The table below provides a summary of critical species found in the Kala Oya basin. By the given definition, the table indicates the importance of different clusters in terms of taxonomic and conservation considerations.

Cluster F: Galpaya sub-basin is an important area in terms of terrestrial flora, while Cluster B: Eluwankulama is a key sub-basin in terms of avifauna diversity. Cluster G: Manawa is important for dragonflies while the mouth of the Kala Oya is a crucial area for diversity of fish and mangroves as it forms the estuary that creates a critical habitat. Although parts of this estuary is already under conservation, a considerable part of the Lunu Oya and Henakachchi segments of the estuary along with associated salt marshes are essential environments for the survival of mangroves, salt marsh associated fauna and flora as well as migratory birds.

Other critical habitat clusters include the entirety of Kala Oya estuary and associated salt marshes in landward side. In terms of freshwater fauna, remaining flood plains of the river still preserved at Wilpattu and Eluwankulama areas should be given needed legislative and institutional protection.

Compared to Wilpatthu National Park localities (transect 21 – 24), Species Richness and type of Habitats are more or less similar in Locality A: Eile area sub-basin, B: Eluwakulama sub-basin, E: Horiwila/ Ambagahawewa sub-basin and F: Wilpattu NP area. Additionally, these four localities are very significant due to high levels of endemism, near threatened species, endangered and vulnerable species compared to species distribution and species richness of other localities in the adjacent areas.

Avifauna observed during the study period included four nationally threatened species (other than breeding migrants) all of whom fell into the category "vulnerable": *Porzana fusca* (Ruddy-breasted Crake), *Leptoptilos javanicus* (Lesser Adjutant), *Chrysocolaptes* festivus (White-naped Woodpecker) and *Lonchura malabarica* (White-throated Munia). Further two globally threatened species were recorded: *Ciconia episcopus* and *Leptoptilos javanicus*. As per the IUCN Red List of threatened species, 2016, both species are considered as "vulnerable" globally as their overall populations are seems to be in rapid decline mainly due to loss and degradation of wetlands and loss of nesting tress as well as hunting. Yet nationally, only *L. javanicus* is considered as vulnerable, while *C. episcopus* status is near threatened, indicating its population is more stable in Sri Lanka. During the present survey, records *C. cepiscopus* was high with eight individuals being observed in a dried up tank within Manawakanda area. Single individual of *L. Javanicus* was observed near to Eluwankulama Tank (Transect 6). A recent study on *L. javanicus* in the country indicated that the species' distribution was restricted to dry lowlands (rainfall <2200mm,

elevation <300m). The bird showed preference for savannah/woody savannahs, dry mixed evergreen forests, permanent wetlands, and croplands, and was prominently found within protected areas. Habitat loss and fragmentation, hunting pressure, agricultural intensification, and development projects were identified as potential threats faced by the species, which varied in magnitude across the KOB.

The highest avifaunal species diversity was recorded from transects that included a variety of habitats including both aquatic and terrestrial: Nabatayagama Tank and associated forests (Transect 14) located adjacent to Namal Uyana Conservation Forest recorded the highest diversity followed by Manawa tank associated habitats (Transect 19). Of the Dry mixed evergreen forests, highest bird diversity was recorded from Manawakanda forests (Transect 17) followed by Higuruwelpitiya (Transect 13) and Aily tank associated DMEF (Transect 1). Least diversity was observed from DMEF of Suduwelithalawa (Transects 7 & 8) and this might be due to high density of the forest cover.

Out of the habitats selected in the Kala Oya river basin, Scrub forest and Tank associated habitats stand out as the best sites for butterflies. The current study shows that the Galpaya, Hinguruwelpitiya, Ranva kannda, Nambatiwewa, Manawa area supports high levels of butterfly diversity including endemic butterfly species. The Eile area – transects T1 and T2 - is an ideal habitat for the Joker, *Byblia ilithyia,* a characteristic species of this area found only in ***Meadows with seasonal flooding.*** When considering the North West butterfly region, it is typically home to and the preferred habitat for the Large Salmon Arab- *Colotis fausta*, Crimson Tip- *Colotis danae*are, Yellow Pansy- *Junonia hierta*, and Bright Babul Blue- *Azanus ubaldus*. However, these species were not encountered despite previous records of their existence in these habitats indicating inadequate sampling or lack of time to carry out sampling.

Taxonomic Group	Total no of species	A	B	C	D	E	F	G	H	Total no of critical species
Plants	609	09	12	13	11	07	18	09	15	41
Mammals	39	11	10	04	09	05	09	09	11	15
Birds	188	04	11	06	07	08	06	09	09	14
Herperto Fauna	105	11	6	13	15	12	16	23	20	29
Fish (cluster wise species categorization not possible for aquatic fauna)	64									8 (all EDN of which 4 are VUL
Dragonflies	40	2	2	2	2	2	2	3	2	05
Butterflies	84	02	01	00	01	00	01	02	02	07
Mangroves (cluster wise species categorization not possible for aquatic fauna)	14									10 (5NT,3 EDN 2 VUL)
TOTAL	**1129**	**39**	**42**	**38**	**45**	**34**	**52**	**55**	**59**	**129**

The main ecosystems surveyed included Dry Mixed Ever Green Forests, Disturbed Forests, Scrub forests, Tank associated habitats; Chena associated habitats and Coastal habitats. Furthermore, dragonflies were also recorded within associated tank beds, rock pools and streams.

12.4.2 Flora

A total of 609 species of plants belonging to 107 families were recorded during this survey (Please refer to Report on 'Database for Habitat Monitoring' for a list of all species that were surveyed during this BBS). The highest number of species were reported from the family Fabaceae while Malvacea and Acanthaceae were the second and third highest. 42 families were represented by only one species and another 16 families were represented by only two species.

511 species of the total reported plants during the survey (BBS Kala oya (83.91%) are native to Sri Lanka while a further 26 species (4.27%) are endemic. 72 species (11.82%) are exotic species where most of them have naturalized in Sri Lankan eco-systems. Very few species of these exotics were cultivated species, which were recorded only when they were present in a considerable extent of the surveyed quadrats.

Among the indigenous plants, 61 species reported in KOB are considered as 'threatened' species by Red Data List - 2012.

The most abundant woody plant species within the surveyed area was *Drypetes sepiaria*. 86.8% of these plants were reported in dry mixed evergreen forest habitats while 10.6% was reported in scrub forests. Interestingly, only 5 plants were reported in disturbed forests.

12.4.3 Mangroves

It was evident that Kala Oya river basin harbours one of the best if not the best mangrove ecosystem in Sri Lanka. Associated with it are the other important ecosystems, namely seagrass beds and coral reefs off Kalpitiya, salt marshes off Lunu Oya thus completing the typical tropical ecosystems associated with a lower course of a catchment. Due to remoteness and the war that prevailed most of the above-mentioned habitats have remained intact and in good condition. Thus, the dynamics and interactions between different ecosystems are maintained and as such, goods and services from lower course have remained unaffected to a certain level. The challenge is maintaining this habitat connectivity, heterogeneity as well as the dynamics between them.
The uniqueness of this mangrove ecosystem lies on the fact that each island has a different plant profile, distribution as well as maturity stages. Hence, no two islands are the same and in certain locations, two banks of the river are not the same. Some species like *Aegiceras corniculata* and *Bruguiera* cylindrica have developed heights and girths that are unusual for the said species. Additionally, presence of threated species such as *Scyphiphora hydrophyllacea*, *Bruguiera cylindrica* in good numbers in some locations indicates the need for greater conservation.

12.4.4 Herpetofauna

Nineteen species of amphibian species recorded and which included 5 families (Bufonidae, Microhylidae, Dicroglossidae, Rhacophoridae and Ranidae) and 12 genera (*Duttaphrynus, Kaloula, Microhyla, Ramanella, Uperodon, Euphlyctis, Zakerana, Hoplobatrachus, Sphaerotheca, Pseudophilautus, Polypedates* and *Hylarana*)

Eighty six species of reptiles were recorded in the Kala Oya basin. Out of the 86 species of reptiles recorded 38 were tetrapod reptiles and 48 were snakes. All recorded reptile species belong to 20 families and 59 genera. 4 amphibian & 20 reptiles endemic species respectively were found during the sampling period in Kala Oya River basin, as well as other species were indigenous. Furthermore, according to the IUCN Sri Lankan Red Data Book 2012 which comprises of 01 Near Threatened, 15 Least Concern, 02 Data Deficient & 01 Vulnerable amphibian species. Also 11 Near Threatened, 54 Least Concern, 01 Data Deficient, 10 Vulnerable, 09 Endangered & 01 critically endangered reptiles species were recorded.

Considering amphibian species diversity recorded in the 8 sub basing regions Eile area, Horiwila-Ambagahawewa and Manawa areas recorded high diversity and generally reptiles diversity were high is 7 areas except Eluwankulama

High species diversity of herpetofauna was recorded in 4 habitat types; Dry mixed evergreen forest, scrub forest, tank associate habitats and Chena & associate. Four species of amphibians and 20 species of reptiles were recorded in all of above 4 habitats.

12.4.5 Avifauna

A total of 188 species of birds belonging to 59 families were recorded during the survey period. This included nine endemic species, one proposed endemic and 46 migrant species (of which in nine species breeding populations also has been observed in other parts of the country).

The nine endemics were *Galloperdix bicalcarata* (Sri Lanka Spur fowl) *Gallus lafayetii* (Sri Lanka Jungle fowl), *Ocyceros gingalensis* (Sri Lanka Grey Hornbill), *Treron pompadora* (Sri Lanka Green-pigeon), *Megalaima rubricapillus* (Sri Lanka Small Barbet), *Pellorneum fuscocapillum* (Sri Lanka Brown-capped Babbler) *Dinopium psarodes* (Sri Lanka Lesser Flameback), *Tephrodornis affinis* (Sri Lanka Wood shrike) and *Pycnonotus melanicterus* (Sri Lanka Black-capped Bulbul). The proposed Endemic recorded was *Hirundo hyperythra* (Red-rumped Swallow). Of the nine endemic species, *T. pompadora* had the largest presence within the Kala Oya basin.

Of the total birds, 70 can be considered as wetland associated species. Among them, the most commonly occurring families are: Scolopacidae (13 species including sandpipers and curlews); Ardeidae (11 species that includes herons and egrets); Charadriidae (8 species including Plovers and Lapwings); Rallidae (six species that includes coots and hens) and Anatidae (five species consisting of ducks). 30 of the migrant species were found mainly associated with wetlands

The survey revealed the presence of a rich avifaunal diversity within the Kala Oya basin including few nationally and globally threatened species. Yet their survival is threatened by many anthropogenic as well as climate change related issues. The sub basins that need priority in terms of conserving the bird diversity are Eluwankulama, Manawa kanda and Galpaya sub-basins as well as Eilie sub basin as it is important feeding ground for migratory waders. . It should be noted that other than the Puttalam lagoon no other areas in the KOB has been designated as an important bird area. Therefore inclusion of these sites as Important Birda Areas (IBAs) is recommended and also continuous monitoring of the bird populations should be undertaken.

Attention should be given to maintain adequate tree cover consisting of tree species required for feeding and nesting requirements, while when allocating

12.4.6Mammals

A total of 39 species (22 families and 32 Genera) were recorded during the survey; 7 species of bats, 4 species of cat family members, 3 species of deer, 3 species of herpestids, 2 viverrids, 2 species of squirrels, 4 muridae members, 3 cercopithicidae members and so on. 33 species of indigenous mammals were recorded from the 48 quadrates and another 6 species were recorded opportunistically in the Wilpattu National park. All those six species belong to Chiropterans.

Eile Wewa area (Locality A) had 27 species of mammals and out of which 3 were endemics, 5 endangered, 3 near threatened and 1 vulnerable. The area is comprised of Dry Mixed Evergreen Forest, Scrub Forest, Tank Associated and Coastal Habitats which are most favourable to mammalian life.

Eluwankulama Area (Locality B) was having 23 species of mammals including 3 Endemics, 4 Endangered, 3 Near Threatened and 1 Vulnerable. This locality has Dry Mixed Evergreen Forest, Scrub Forest and Tank Associated Habitats like Eile Wewa areas, which are suitable for the abundance of mammals.

The Lowest numbers of mammalian species were recorded from Suduwelithalawa and Morapathana Area (Locality/ cluster C) which is 20, of which 2 are endemic, 1 endangered and 1 threatened. This region consists of scrubbed and tank associated habitats which are not suitable for many species of mammals.

Locality D (Weerakkodichole and Thabbowa Area) is comprised of Dry Mixed Evergreen Forest and Disturbed Forest with 27 species of mammals (2 Endemic, 2 Near Threatened and 1 Vulnerable). There are agricultural lands nearby and small domesticated populations of goat, cattle and chicken which disturb wild fauna species. Also it was observed that illegal timber cutting was happened in this area.

Horiwila and Ambagaswewa Area (Locality E) was having second lowest number of mammals; 21. 2 Endemic, 2 Near Threatened and 1 vulnerable species were identified within the habitat of Dry Mixed Evergreen, Disturbed Forest, Scrub and Chena associated habitats. This area has low species richness due to high levels of anthropogenic activity.

Locality F (Gal Paya) sub basin was having 27 number of identified mammal species distributed in four type of habitats namely Dry Mixed Evergreen, Disturbed, Scrub and Tank. 2 endemics, 3 endangered, 4 near threatened and 1 vulnerable species were observed at this locality.

Locality G is having 26 species of mammals; 3 endemics, 3 endangered 3 near threatened and 1 vulnerable within the habitats of Dry Mixed Evergreen Forest, Tank Associated and Chena Associated.

Locality H belongs to Wilpatthu National park which recorded 2 Endemics, 4 Endangered, 5 near threatened and 4 vulnerable mammal species

12.4.7 Butterfly

During the survey period, 84 species of butterflies were recorded while past observations recorded within the last five years recorded a 117 species. Tank associated habitats can be very rich in butterflies, especially counting the Common Crow- *Euploea core*, Plain Tiger- *Danaus chrysippus*, Common Tiger- *Danaus genutia*, and Blue Tiger- *Tirumala limniace*. These butterflies are attracted to the *Heliotropium indicum* plant which is powerful enough to attract these butterflies from long distances away. Large gatherings of these species were found in Manawa wewa and Thelbipuwewa.

Very few butterfly species were observed inside the thick forests and *Panicum maximum* (Guinea grass)-invaded habitats. *Panicum maximum* was the most common alien invasive in the Kala Oya river basin.

Out of the five habitats selected for this study in the Kala Oya river basin, Scrub forest and Tank associated habitats stand out as the best sites for butterflies. The current study shows that the Galpaya Hinguruwelpitiya Ranva kannda, Nambatiwewa, Manawa area supports butterfly diversity including endemic butterfly species.

The Eile area – transects T1 and T2 - is an ideal habitat for the Joker- *Byblia ilithyia*, a characteristic species of this area found only in Meadows with seasonal flooding. When considering the North West butterfly region, it is typically home to and the preferred habitat for the Large Salmon Arab- *Colotis fausta*, Crimson Tip- *Colotis danaeare*, Yellow Pansy- *Junonia hierta*, and Bright Babul Blue- *Azanus ubaldus*. However, these species were not encountered despite previous records of their existence in these habitats indicating inadequate sampling or lack of time to carry out sampling.

Additionally, the total number of species recorded during the last five years, 117 species, was in stark contrast to the number of species recorded during the survey; 84 species. It must be also noted that though the study was confined to the lower levels of habitats no canopy butterflies were observed. Butterflies have short life cycles and thus react immediately to environmental changes. Their limited dispersal ability, larval food plant specialization and close reliance on the weather and climate make many butterfly species sensitive to fine-scale changes. Butterflies are indicators of a healthy environment and healthy ecosystems.

12.4.8 Dragonflies

A total of 1,202 individual dragonflies and damselflies belonging to 7 families, 31 genera and 40 species were observed during the period of the survey. Among recorded species, *Pseudagrion rubiceps* (Orange-faced Sprite) and *Prodasineura sita* (Stripe-headed Threadtail) are endemic to Sri Lanka. Among the recorded species, 30 species were in the category of Least Concern (LC), 8 in the Near Threatened (NT) and 2 species in the Vulnerable (VU) category (IUCN 2012).

It was noticed that habitats in proximity to agricultural fields such as Chena lands have a very low dragonfly species composition. The few species that have the ability to tolerate harsh environments such as *Brachythemis contaminate* (Orange-winged Groundling) and *Orthetrum sabina* (Green Skimmer) were recorded at those sampling points.

Some species show territorial behaviours and if their habitats are destroyed, competition amongst individuals may be increased which might lead to a decrease in the population of that particular species. For instance, *Tramea limbata* (Sociable glider), is a highly territorial species seen mostly at seasonal water holes formed on rocks. Therefore, usually one rocky pool is inhabited by one individual animal (i.e. one specimen per habitat/territory). The highest abundance of these species was recorded in the Hinguruwelpitiya, Galpaya region. It was observed that unfortunately most rocks in the area have been exploited by metal crushers that has led to vast habitat destruction of *Tramea limbata* (Sociable glider) as well as *Bradinopyga geminate* (Indian rockdweller), a rock dwelling species.

Endemic species such as *Prodasineura sita* (Stripe-headed Threadtail) and *Pseudagrion rubriceps* (Orange-faced sprite) were observed near riverine areas with a canopy cover. Therefore, alteration of the vegetation and environmental conditions will lead to the disappearance of such species from the area. Gangewadiya had the lowest diversity and Wilpattu National Park showed the highest species diversity among the surveyed habitats of the area.

12.5 Recommendations

Existence of Sensitive forest patches with sensitive species, threats to their survival, habitat fragmentation are the predominant issues encountered by all taxonomic groups that have been surveyed area.

It is recommended that these areas need immediate protective measures to prevent and mitigate adverse impacts by establishing ESA policy incorporating existing laws before incorporating/ producing new laws. EPA under NEA act, MER under FFPO are some of the possible mechanisms that can be recommended for immediate consideration. Biodiversity Secretariat of the Environmental Ministry needs to play a major role in coordinating these activities with other agencies concerned.

It is evident that habitat fragmentation is one of the predominant issues faced by all taxonomic groups that have been surveyed. This issue has been on-going due to human population growth and expansion of urban spaces, building of roads and construction of infrastructure that encroach into natural habitats. Inefficient urban planning, that do not consider natural ecosystems, coupled with lack of coordination among relevant institutions result in haphazard settlements with significant long-term impacts on the surrounding biodiversity, environment, and human health are the main causes. An increase in the already established method of establishing 'Important Bird Areas' (IBAs) for conservation using faunal species as indicators would be advantageous in the efforts to conserve the populations of avifauna, which are increasingly also under threat from habitat loss and fragmentation.

Effective nature conservation measures in declared protected areas, non-protected areas, and buffer zones is of utmost importance, and further encroachment of habitats should be prevented. Taking the existing forest patches and ranging behavior into consideration, it is recommended to establish corridors/linkages with sensitive areas connecting the different habitats and protected areas is one definite method of conserving biodiversity that rely on interconnectedness of the ecosystem. Elephant ranging areas can be used as one important criteria to link forest patches using FFPO managed Elephant Range (MER) area concept as an Environmental Sensitive Area. These networks will minimize habitat fragmentation that causes a high level of stress to the surrounding biodiversity, with long-term direct and indirect effects that extend to human populations as well.

12.5.1 Recommendation to initiate surveying covering temporal and special variation with adequate time

Duration of the sampling (three months), time of the sampling (January to March) given to the consultant is not a suitable season for sampling as; 1. Heavy dry season prevailed 2. Breeding and nesting of birds were not in line with the seasons 3 Time given was not adequate to sample the entire area given. Thus some important areas may have been left out, and especially human dominated land use areas. It is also noted that high habitat destructions has been inevitable due to high development pressures to meet the needs of the local communities living in the basin.

Immediate actions need to be taken to conserve Sensitive Areas outside PA network in the Kala oya basin. Critical species, proxy species, critical habitats, degrees of threats can be considered as criterion for establishment of Environmental Sensitive Areas. Field observations and baseline survey revealed that diverse ecosystems are present with high sensitivity/ Critical habitats, critical species, and proxy species such as long ranging animals within the Kala oya basin. Wilpattu Cluster, Manawa cluster and Galpaya cluster, Weerakkodichale Cluster, etc, all sampling locations are placed on the areas outside the existing protected area network where disturbances were minimal but with high sensitivity.

It is import to use different approaches and legislation for different clusters depending on proximity to existing protected areas, long ranging species requirements, critical habitat requirements (especially with riverine vegetation considering the amount of rivers and streams). Different clusters play an important with respect to the species and other proxy species conservation that are of concern.

These outside areas are vital to the long term maintenance of biological diversity of physical landscape features, natural processes at multiple scales within the human dominated land scape. (Refer the Land use map and important Critical clusters of the Basin.). A number of protected areas have been established in the Kala Oya basin to safeguard the biodiversity. These biodiversity areas offer legal protection to the flora and fauna species. **It is recommended that ESA concept needs to operationalize and develop a mechanism for mainstreaming biodiversity management of those Environmental Sensitive Areas with the involvement of local people.**

However, questions will arise with the identification and establishment of important biodiversity areas located outside the existing protected rea network. The sensitivity and importance depends on the objectives and threats imposed on those systems.

However, field observation revealed that ESA concept will bring another sensitives area under protected area system with certain limitations to local communities and with the need to face challenges. Thus existing policies need to be developed to establish Environment Sensitive Areas within the existing policies in Kala oya basin as a model which can be used in other areas of the country. But criterion for establishing ESA can vary from location to location. **It is recommended that strategies are developed with mechanisms for identifying and declaring ESA area under existing laws and regulations for management of the ESAs. Biodiversity Secretariat can play an important role in coordinating and monitoring aspects.**

It is recommended that the concept needs to be looked at with the purpose to protect its value (ESA Biodiversity or land form) and regulate certain activities in the area with communities actively participating in the conservation efforts.

It is also suggested that biodiversity baseline survey has focused on pockets of unprotected areas and proved the importance of its value as ESAs that require protection through proper legislation without further delay and with adequate resources for management.
Discussion with local communities has revealed that conservation of these areas are not simply a process to preserve species but an active process that requires an integrated approach. The

purpose of conservation is to provide the appropriate habitat and resources to maintain it for the future.

The Bar reef needs immediate protection for its recovery after the bleaching event. More than 90% of the reef is dead. As such sufficient time and protection for recovery and immediate interventions are needed from authorities. Urgent consideration must be given to declare the reef a NO GO zone for all human activities preventing all fishing and tourist boats from approaching or traversing close to the reef.

The bar reef is currently under heavy pressure from fisheries activities, pollution and visitation by tourists. It is imperative that these stresses are significantly reduced or stopped for a time period to allow the reef to naturally recover its bio-diversity and natural functions. The availability of large populations of live healthy coral in both the deeper reef sections and at adjacent coral reef sites including the Silavathura-Arippu reef complexes increases the potential of larval recruitment of coral for the long term restoration of coral cover over the reef.

It is recommended to have regular monitoring and law enforcement activity with trained offices of the relevant agencies to conserve Bar Reef and sea areas with adequate equipment.

No regular monitoring of human activity or enforcement of law was observed on the sea at the reef site. The main set back is due to the primary enforcement agencies including Department of Wildlife Conservation being ill-equipped and untrained to carry out regular operations out at sea. The distance from the shore to the offshore reef site becomes a primary obstacle in enforcement as it is about 15 km from the nearest DWC point at Kudawa and 30 minutes to one hour boat ride depending on engine power and sea conditions. It may also be not practical to maintain a boat "on location" on a daily basis due to the costs of running the boats and physical challenges.

It is recommended to develop a team of officers and staffs within DWC who are better geared and equipped for marine operations with a proper mental attitude towards the sea. This is key to making a positive change in the situation.

There is a need to set up a coastal watch point at a site closer to the reef, preferably at Uchchimune, as the distance from the shore to the reef at this site is about 4- 5.5km from shore. A look out on a high platform with a scope could monitor fishing and other non-legal activities on the reef. A closer distance to the reef will make it more convenient and less expensive for staff to be deployed and visit the reef for monitoring or for responding to detection.

It is recommended to bring in the SL Navy and Coast Guard to assist regulating agencies as they are better geared to handle sea conditions and have a regular presence in the area.

There is a Navy coastal point at Uchchimune and any operations in that area can be conducted jointly. Several Navy facilities with support from inshore patrol craft are available in the area from bases including Kalpitiya, Battalangundu and Mollikulam. Training and awareness activities must be carried out to sensitize and build capacity among the Navy officers and seamen as well.

It recommended that training of relevant staff and resource personnel in the implementing agencies is a priority need.

The trainings need to include skills in snorkelling, SCUBA diving, boat handling, basic sea-craft, marine ecology, identification of marine fauna and flora and their distribution, reef survey techniques, reef habitat maintenance and identification and management of illegal fishing gear and practices etc. This is a specialized set of training to be conducted for selected individuals with a commitment to be posted in marine protected areas. Steps need to be taken to retain trained individuals within the Marine Park/ coastal marine management areas.

It is recommended that the fishery practices in the area are regulated at least within the BRMS boundary areas which include netting operations, collection of marine organisms for food and ornamental export trades and illegal spear fishing activities by divers.

It is recommended that management of water pollution also necessitates an interdisciplinary approach. It should be a collective effort including government/ non-government organizations, politicians, experts of the field, village heads/ clergy, and the public mass.

All pesticides approved for release in Sri Lanka should be assessed for any impacts on non-target organisms and the environment in general in the context of Environmental Sensitive Area Approach. This will help all sensitive wetlands in the country be conserved in an efficient manner. All pesticides approved for release in Sri Lanka should be assessed for any impacts on non-target organisms and the environment in general, with appropriate labelling and information on environmental safeguards.

Finally, the promotion of sustainable forest management practices, afforestation and reforestation, and promotion of sustainable forms of agriculture and land use to ensure that future generations may also benefit from these resources is imperative in the long-term, landscape conservation approach.

Ecological goods and services provided by these ESAs are very diverse and of great ecological, socio-cultural and economic value. The legal and illegal over-exploitation of natural resources such as felling of trees, trade of exotic species, coral mining, and corresponding activities such as clearing of land for monocultures all contribute to the degradation of habitats and reserves.

12.5.2 Policy recommendations proposed for consideration

The government policy on (proposed) on ESA shall be:-

12.5.2.1 Policy Statement 1

1. To ensure the establishment and protection of ESAs outside the existing protected areas for biodiversity conservation, management and sustainable use.

Note: ESAs are landscapes located outside the existing Protected Areas (PAs) managed by the Department of Wildlife Conservation (DWC) and forests managed by Forest Department (FD), coastal areas Managed by the Cost Conservation Department(CCD) and EPA Managed the Central Environmental Authority (CEA) where sensitive features will be conserved. ESA indicate management options adopted on the part of the legal authority to managed it by their respective legislation/ regulations (such as the establishment EPA, MER, Sanctuary, Nature Reserve Jungle corridor, riverine forest, soil conservation areas etc.).

The demarcation of ESA boundaries should be based primarily with reference to the sensitivity criterion adopted by this policy. ESA will limit and allow thresholds on anthropogenic activities in the Critical Core areas of ESA (Critical Core area are that excludes human settlements). The action of recognizing ESAs will bring a rational land use approach to lands proximate to EPAs MER, Sanctuaries, Nature Reserves, etc. and to areas where sensitivity is established through this policy. It should be effective to regulate or reduce the impacts on critical core areas and other bad land use practices that contribute to the sensitivity of the area.

a. Strategy 1.1: Identification of possible and viable ESA areas in Sri Lanka based on a combination of criteria established for the purpose of ESA policy.
b. Strategy 1.2: Establish an inter-agency committee comprising of heads of departments of above ministries in the steering committee
c. Strategy 1.3: Establishment of ESA and demarcating the zones
d. Strategy 1.4: Establish high powered **Inter-Ministerial** Steering Committee under the leadership of the Ministry of Environment with **BDS act as the coordinating body**. Ministries responsible NEA, FFPO, FD, CCD, Archeology, Land and Public Administration and Provincial need to be members in addition to opted ministries by the Committee.

12.5.2.2 Policy Statement 2

2. To adopt regulatory mechanisms for establishment and management within available laws/ policies of Sri Lanka

a. Strategy: 2.1. Management ESAs Based on Evidence Based management practices.

Once the ESAs have been identified, any existing land use patterns within an ESA needs to be revised and accustomed if need be, to allow the management of biodiversity within the ESA. Both sensitive habitats and other land uses within the ESAs need to be managed. Anthropological

activities in the ESA will also have to be regulated in such a way as to cater to the needs of the local people while meeting the purpose and objectives for which individual ESAs are established.

12.5.2.3 Policy Statement 3

3. To promote scientific/traditional research as the basis for identifying and managing ESA with involvement of local communities

12.5.2.4 Policy Statement 4

4. To develop mechanisms to derive benefits to the communities through ESA management processes/ mechanisms while maintaining environmental services. Or to derive socio-economic benefits from establishing ESA by introducing environmentally livelihood services such as eco-tourism.

13.0 REFERENCES

APG III [Bremer, B., Bremer K., Chase M. W., Fay M. F., Reveal J. L., Soltis D. E., Soltis P. S., and Stevens P. F. (comp.)] (2009). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society* 161: 105–121.

Asoka Yapa and Gamini Rathnavira (2013), The Mammals of Sri Lanka, Field Ornithology Group of Sri Lanka

Bio Diversity Secretariat, Ministry of Environment (2012), The National Red List 2012 of Sri Lanka

Biodiversity Baseline Survey (2008), Field Manual, Wildlife Department

Dassanayake, M. D. (Ed.) (1980). *A revised handbook to the flora of Ceylon, Vol. 1.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1980). *A revised handbook to the flora of Ceylon, Vol. 1.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1981a). *A revised handbook to the flora of Ceylon, Vol. 2.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1981a). *A revised handbook to the flora of Ceylon, Vol. 2.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1981b). *A revised handbook to the flora of Ceylon, Vol. 3.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1981b). *A revised handbook to the flora of Ceylon, Vol. 3.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1983). *A revised handbook to the flora of Ceylon, Vol. 4.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1983). *A revised handbook to the flora of Ceylon, Vol. 4.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1985). *A revised handbook to the flora of Ceylon, Vol. 5.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1985). *A revised handbook to the flora of Ceylon, Vol. 5.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1987). *A revised handbook to the flora of Ceylon, Vol. 6.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1987). *A revised handbook to the flora of Ceylon, Vol. 6.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1991). *A revised handbook to the flora of Ceylon, Vol. 7.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1991). *A revised handbook to the flora of Ceylon, Vol. 7.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1994). *A revised handbook to the flora of Ceylon, Vol. 8.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1994). *A revised handbook to the flora of Ceylon, Vol. 8.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1995). *A revised handbook to the flora of Ceylon, Vol. 9.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1995). *A revised handbook to the flora of Ceylon, Vol. 9.* Amerind Publishing Co. Pvt. Ltd., New Delhi.

Dassanayake, M. D. (Ed.) (1996). *A revised handbook to the flora of Ceylon, Vol. 10.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1996). *A revised handbook to the flora of Ceylon, Vol. 10.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1997). *A revised handbook to the flora of Ceylon, Vol. 11.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1997). *A revised handbook to the flora of Ceylon, Vol. 11.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1998). *A revised handbook to the flora of Ceylon, Vol. 12.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1998). *A revised handbook to the flora of Ceylon, Vol. 12.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1999). *A revised handbook to the flora of Ceylon, Vol. 13.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (1999). *A revised handbook to the flora of Ceylon, Vol. 13.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (2000). *A revised handbook to the flora of Ceylon, Vol. 14.* Oxford & IBH Publishing Co., New Delhi.

Dassanayake, M. D. (Ed.) (2000). *A revised handbook to the flora of Ceylon, Vol. 14.* Oxford & IBH Publishing Co., New Delhi.

de Silva Thilina N., Fernando Sumudu, de Silva Haritha B. & Tennakoon Parami (2015): Lesser Adjutant Leptoptilos javanicus Horsfield, 1821 (Ciconiiformes: Ciconiidae) in the dry lowlands of Sri Lanka: distribution, ecology, and threats. Journal of Threatened Taxa www.threatenedtaxa.org | 26 November 2015 | 7(14): 8089–8095

de Silva, Anslem. 2009. Amphibians of Sri Lanka: A Photographic Guide to common frogs Toads and caecilians. Published by the author.

de Vlas, J. & J. de Vlas (2014). *Illustrated field guide to the flowers of Sri Lanka, volume 2.* J & J de vlas, The Netherlands.

de Vlas, J. & J. de Vlas (2014). *Illustrated field guide to the flowers of Sri Lanka, volume 2.* J & J de vlas, The Netherlands.

de Vlas, J. & J. de Vlas-de Jong (2008). *Illustrated field guide to the flowers of Sri Lanka.* Mark Booksellers and Distributors (pvt) Ltd, Kandy.

de Vlas, J. & J. de Vlas-de Jong (2008). *Illustrated field guide to the flowers of Sri Lanka.* Mark Booksellers and Distributors (pvt) Ltd, Kandy.

DWC (2008). Biodiversity Baseline Survey: Field Manual. Revised version. Consultancy Services Report prepared by Green, M.J.B. (ed.), De Alwis, S.M.D.A.U., Dayawansa, P.N., How, R., Padmalal, U.K.G.K., Singhakumara, B.M.P., Weerakoon, D., Wijesinghe, M.R. and Yapa, W.B. Infotechs IDEAS in association with GREENTECH Consultants. Sri Lanka Protected Areas Management and Wildlife Conservation Project (PAM&WCP/CONSULT/02/BDBS), Department of Wildlife Conservation, Ministry of Environment and Natural Resources, Colombo. 49 pp. [http://203.143.23.34/BBS/bbs.html]

Europeana collections (2016). http://www.europeana.eu/portal/en Accessed on 02 April 2017

Europeana collections (2016). http://www.europeana.eu/portal/en Accessed on 02 April 2017

Fernando, S. S., L.J.M Wickramasingha & R.K. Rodirigo. 2007. A new species of endemic frog belonnging to genus Nannophrys Gunther, 1869 (Anura: Dicroglossinae) From Sri Lanka. Zootaxa 1403:55-68

Gunawardena K (2010): Kalawewa. In Ceylon Bird Club Notes. Pp124

IUCN Sri Lanka & the Ministry of Environmental and Natural Resources. 2007. The 2007 Red List of Threatened Fauna and Flora of Sri Lanka. Colombo.

Kotagama S.W (1989); Wildlife Conservation and the development off the South East Dry Zone. Proceedings of a Symposium on the South East Dry zone of Sri Lanka. Agrarian Research and Tranining Institute. Pp 103-130

Madhava Meegaskumbura, Suyama Meegaskumbura, Gayan Bowatte, Kelum Manamendra-Arachchi, Rohan Pethiyagoda, James Hanken & Christopher J. Schneider 2010. Taruga

(Anura: Hacophoridae), A New Genus of foam-nesting tree frogs endemic to Sri Lanka. Cey. J. Sci. (Bio. Sci.) 39 (2): 75-94.

Manamendra-Arachchi K. & Meegaskumbura M. 2012. The Taxonomy and Conservation Status of Amphibians in Sri Lanka In: The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora. Weerakoon, D.K. & S. Wijesundara Eds., Ministry of Environment, Colombo, Sri Lanka. 88-99 pp

Manamendra-Arachchi, K. & Pethiyagoda, R. (1998) A synopsis of the Sri Lankan Bufonidae (Amphibia: Anura) with description of new species. Journal of South Asian Natural History, 3, 213–248

Manamendra-Arachchi, K. & R. Pethiyagoda. 2006. Sri Lankawe ubayajeewin (Texi in Sinhala) .WHT publication 9pvt) Ltd. Colombo.

Manamendra-Arachchi, K.; Pethiyagoda, R. 2005: The Sri Lankan shrub frogs of the genus Philautus Gistel, 1848 (Ranidae: Rhacophorinae), with description of 27 new species. Raffles bulletin of zoology, supplement 12: 163–303.

Meegaskumbura M., K. Manamendra-Arachch, C.J. Schneider & R. Pethiyagoda. 2007. New species amongst Sri Lanka's extinct shrub frogs (Amphibia : Rhacophoridae: Philautus). Zootaxa 1397:1-15

Meegaskumbura M., K. Manamendra-Arachchi & R. Pethiyagoda 2009. Two new species of shrub frogs (Rhacophoridae: Philautus) from the lowlands of Sri Lanka. Zootaxa, 2122: 51-68

Meegaskumbura M., K. Manamendra-Arachchi 2011. Two new species of shrub frogs (Rhacophoridae: Pseudophilautus) from Sri Lanka Zootaxa, 2747: 1–18

Meegaskumbura M., Manamendra-Arachchi K., Bowatte G. & Meegaskumbura S. 2012 Rediscovery of Pseudophilautus semiruber, a diminutive shrub frog (Rhacophoridae: Pseudophilautus) from Sri Lanka Zootaxa 3229: 58–68pp.

Meegaskumbura, M. & K. Manamendra-Arachchi (2005). Descriptions of eight new species of shrub frogs (Ranidae: Rhacophorinae: Philautus) from Sri Lanka. Raffles Bulletin of Zoology, Supplement 12: 305–338.

Meegaskumbura, M., F. Bossuyt, R. Pethiyagoda, K. Manamendra-Arachchi, M. Bahir, M.C. Milinkovitch & C.J. Schneider, 2002. Sri Lanka: an amphibian hotspot. Science, 298:379.

MOE 2012. The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora. Ministry of Environment, Colombo, Sri Lanka. viii + 476pp

Pethiyagoda R., K. Mamamendra-Arachchi, M.M. Bahir & M. Meegaskumbura. 2006. Sri lankan Amphibians: diversity, uniqueness and conservation. IN: The fauna of Sri lanka: status of taxonomy, research and conservation. IUCN, Sri lanka: 125-133

Sarath Kotagama (2004), Mammals in Sri Lanka, Field Ornithology Group of Sri Lanka

The IUCN Red List of Threatened Species 2016: e.T22693855A93427510. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22693855A93427510.en. Downloaded on 14 April 2017.

The Plant list: ver. 1.1 (2013). http://www.theplantlist.org. Accessed on 02 April 2017

The Plant list: ver. 1.1 (2013). http://www.theplantlist.org. Accessed on 02 April 2017

Thwaites, G.H.K. (1864). *Enumeratio Plantarum Zeylaniae*. Dulau & Co., London.

Thwaites, G.H.K. (1864). *Enumeratio Plantarum Zeylaniae*. Dulau & Co., London.

Trimen, H. (1885). *Flowering plants and ferns indigenous to or growing wild in Ceylon*. George J.A. Skeen, Government Printer, Ceylon.

Trimen, H. (1885). *Flowering plants and ferns indigenous to or growing wild in Ceylon*. George J.A. Skeen, Government Printer, Ceylon.

Trimen, H. (1893). *A hand book to the flora of Ceylon, Part 1*. Dulau & Co., London.

Trimen, H. (1893). *A hand book to the flora of Ceylon, Part 1*. Dulau & Co., London.

Trimen, H. (1894). *A hand book to the flora of Ceylon, Part 2*. Dulau & Co., London.

Trimen, H. (1894). *A hand book to the flora of Ceylon, Part 2*. Dulau & Co., London.

Trimen, H. (1895). *A hand book to the flora of Ceylon, Part 3*. Dulau & Co., London.

Trimen, H. (1895). *A hand book to the flora of Ceylon, Part 3*. Dulau & Co., London.

Trimen, H. (1898). *A hand book to the flora of Ceylon, Part 4.* Dulau & Co., London.

Trimen, H. (1898). *A hand book to the flora of Ceylon, Part 4.* Dulau & Co., London.

W.W.A. Phillips (1981) , Manual of the Mammals of Sri Lanka, Wildlife and Nature Protection Society of Sri Lanka

Wickramasinghe M.L. J., Vidanapathirana D.R. & Wickramasinghe N., 2012. Back from the dead: The world's rarest toad Adenomus kandianus rediscovered in Sri Lanka Zootaxa, 3347: 63–68

Wickramasinghe, L. J. M., Munindradasa, D. A. I. & Fernando, P., (2012). A new species of Polypedates Tschudi (Amphibia, Anura, Rhacophoridae) from Sri Lanka. Zootaxa, 3498, pp.63–80.

Wickramasinghe, L.J.M., D.R. Vidanapathirana, M.D.G. Rajeev, S.C. Ariyarathne, A.W.A. Chanaka, L.L.D. Priyantha, I.N. Bandara & N. Wickramasinghe (2013). Eight new species of Pseudophilautus (Amphibia, Anura, Rhacophoridae) from Sripada World Heritage Site (Peak Wilderness), a local amphibian hotspot in Sri Lanka. Journal of Threatened Taxa 5(4): 3789–3920; doi:10.11609/JoTT.o3099.3789-920

Wijesundara, S., H.S. Kathriarachchi, S.W. Ranasinghe &G. Hapuarachchi(2012). Analysis of seed plants of Sri Lanka, pp. 205-345. In: Weerakoon, D.K. &S. Wijesundara (eds.). *The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora.* Ministry of Environment, Colombo.

Wijesundara, S., H.S. Kathriarachchi, S.W. Ranasinghe &G. Hapuarachchi(2012). Analysis of seed plants of Sri Lanka, pp. 205-345. In: Weerakoon, D.K. &S. Wijesundara (eds.). *The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora.* Ministry of Environment, Colombo.