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**An Assessment of the Status of Biodiversity
in the Muthurajawela Wetland Sanctuary**

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Summary

Sri Lanka has a wide array of inland and coastal wetland ecosystems that harbor a rich biological diversity. One such urban wetland in Sri Lanka is Muthurajawela, the largest coastal peat bog of the island located on the West coast. At present, the biodiversity of Muthurajawela is threatened by unplanned development activities and a growing human population. Therefore, IUCN Sri Lanka designed and implemented a six-month ecological survey in order to assess the present status of biodiversity in Muthurajawela, and also to identify critical habitats for the conservation of biodiversity. Field monitoring of fauna and flora was carried out at fortnightly intervals, in a systematic manner, using scientifically accepted biodiversity assessment techniques. A zoning exercise was carried out according to ecological significance and threats to biodiversity, using appropriate indicators.

The study enabled to identify 192 species of flora, distributed over seven major vegetation communities at Muthurajawela: marsh, lentic flora, reed swamp, short grassland, shrubland, stream bank flora and mangrove swamp. The vertebrate fauna documented included 40 species of fish, 14 species of amphibians, 31 species of reptiles, 102 species of birds and 22 species of mammals. Among the total vertebrate species documented, 17 are endemic, while 26 are nationally threatened. A total of 36 species of vertebrates are new records to Muthurajawela. The selected invertebrate species documented consisted of 48 species of butterflies and 22 species of odonates. The latter was a useful indicator of habitat quality. The threats documented included direct exploitation (poaching, cutting of trees), habitat degradation/modification (land reclamation, dumping of garbage, clearing of natural vegetation, pollution and eutrophication) and the spread of several invasive alien species (including unmanaged domestic animals). The northern part of the marsh served as an ecotone, with a mixture of the above plant communities/habitat types which were in a relatively undisturbed condition. Ground truthing of vegetation maps, supported with results of the vegetation survey showed that the composition of dominant flora has changed over a period of 10 years, in most places in the Muthurajawela wetland, as a result of human disturbances. Data on the avifauna also highlighted a considerable decrease in migrant birds at Muthurajawela, possibly due to habitat deterioration. The findings of the survey will be of vital use for wildlife managers, who could focus their conservation and management efforts on the critical areas of the marsh.

Key Words: Wetland, Biodiversity, Assessment , Species, Critical habitats, Threats.

1. Introduction

Muthurajawela is the largest saline coastal peat bog in Sri Lanka, located on the west coast (70°3'N, 79°55'E) between the Negombo lagoon and Kelani river and spreading inland upto Ragama and Peliyagoda in the Gampaha District (Figure 1). The marsh, together with the Negombo lagoon forms an integrated coastal wetland ecosystem (6,232 ha in total extent). The marsh-lagoon complex is estimated to have originated about 5000 years BC (CEA/Euroconsult, 1994). The main water source to the marsh is Dandugan Oya which drains a catchment of 727 km² and discharges at the interface of the lagoon and the marsh, while the marsh is traversed by a navigational canal constructed during the Dutch colonial period. The area receives an annual average rainfall of 2000-2500mm, while the average annual temperature is 27°C (Samarakoon and Renken, 1999). According to historical evidence, Muthurajawela was subjected to extensive cultivation of paddy, more than 500 years ago (GCEC/Euroconsult, 1991).

The Muthurajawela marsh-Negombo lagoon wetland system has served multiple uses including fishery, agriculture, trade and shipping and habitation since historical times. Furthermore, previous studies carried out in the area clearly highlight the ecological significance of the Muthurajawela marsh, which covers 3068 ha (Samarakoon & Van Zon, 1991). Scott and Pools (1989) have listed it as one of the 12 priority wetlands of Sri Lanka, in a status overview of Asian wetlands. Upon recognizing the ecological significance of Muthurajawela, the Government of Sri Lanka declared the northern section of the marsh covering an area of 1777 ha as a sanctuary in July 1996, under the Fauna and Flora Protection Ordinance, which is administered by the Department of Wildlife Conservation (DWLC).

The location of the Muthurajawela wetland in a rapidly developing urban area, makes it an extremely vulnerable ecosystem. At present, this wetland is being rapidly degraded by inadequately planned development activities and other detrimental activities related to growing human population pressure. Therefore, IUCN Sri Lanka undertook a systematic survey to document the present status of biodiversity in this coastal wetland, for the purpose of safeguarding the ecological functions, resources and values of the Muthurajawela Wetland Sanctuary. This paper intends to highlight the biodiversity values of Muthurajawela, and provide scientific knowledge in a simplified manner to facilitate future initiatives to conserve this valuable coastal wetland ecosystem.

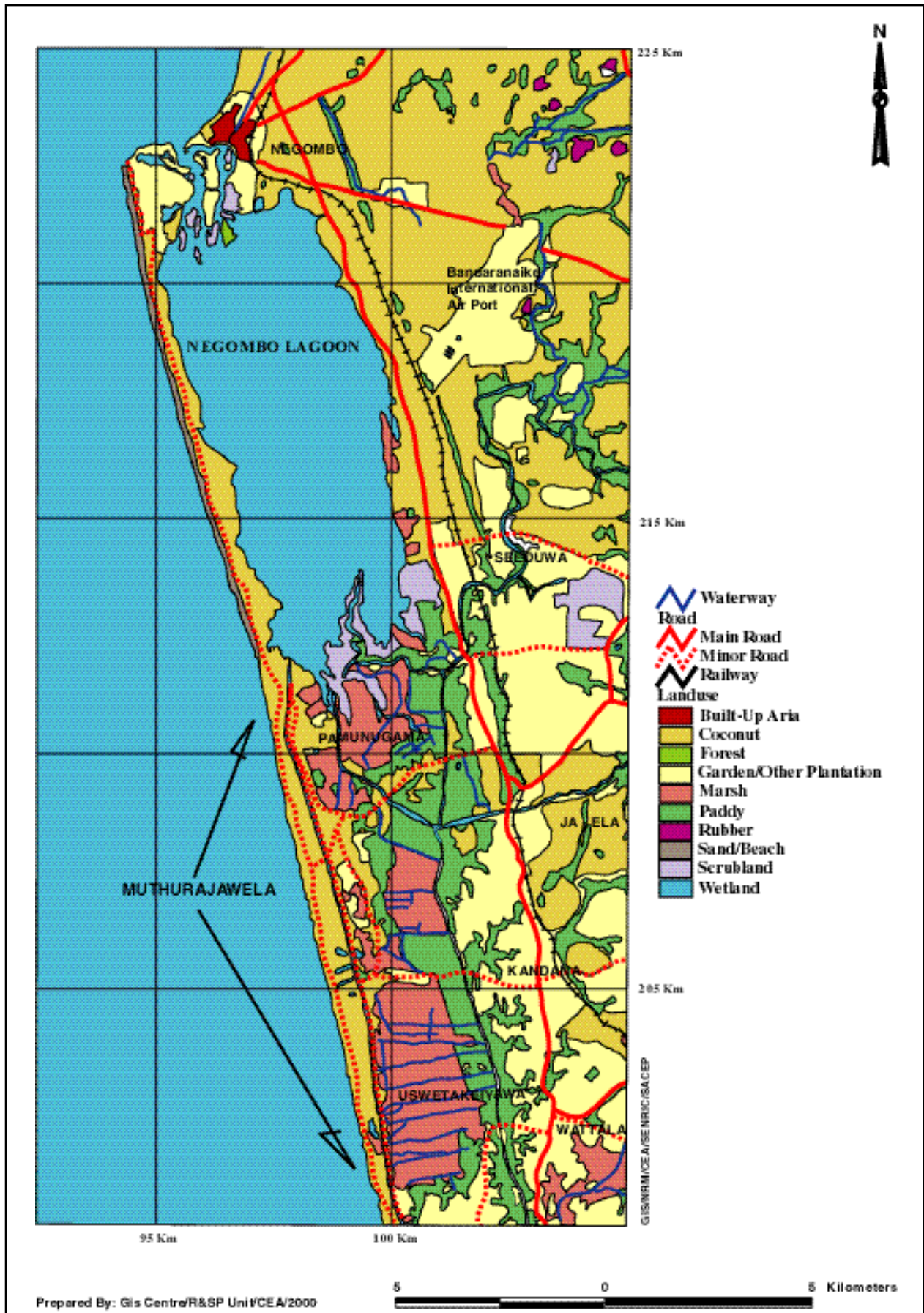


Figure 1.
Location of Muthurajawela wetland sanctuary

2. Methodology

Period of field survey, sampling frequency and time

The field survey commenced at the beginning of November, 1999 and was completed by the end of April, 2000 (six months duration). Field sampling was carried out at fortnightly intervals, each sampling session spanning over six continuous days. Each selected sampling site was covered at different times of the day, including nocturnal visits, in order to avoid a time bias for a particular sampling site when recording fauna.

Sampling sites

After an initial reconnaissance survey, the Muthurajawela Sanctuary was divided into five major strata, based on a North-South salinity and human disturbance gradient. The sampling sites within each strata were selected in a partially random manner considering the accessibility, and spatial distribution of habitats/vegetation types. The base maps on vegetation and land-use types of the Muthurajawela marsh prepared by the Central Environmental Authority (CEA) in 1990 were used for this purpose. These representative sampling sites located from North to South are indicated in Table 1 and Figure 2.

Table 1
Selected sampling sites in the Muthurajawela Sanctuary

Sampling Strata	Site
Northern area	Danduganoya-lagoon transition zone; Nona-ela - Matiwalabokke; Wahatiyagama West; Wahatiyagama East
North-central	Lenus Bund; Kadola
Central	Minuwambemma; Bopitiya
South-central	Ambahiti-ela; Nugape
Southern area	Mudiyanse-ela; Farmwatte

Field sampling techniques

Sampling methods were designed to identify and quantify all groups of vertebrates, some selected groups of invertebrate taxa, and floral communities in different habitats/locations within the sanctuary. The sampling sites in the extreme North of the Sanctuary were accessed by a motorized boat, while the other areas were covered on foot.

Sampling of flora: Distinct vegetation types were identified according to the vegetation structure and composition. For the enumeration of plant species, two or more plots were laid in a locality to accommodate the floristic variations within a site. Size of the plots was either 10m

x 2m or 20m x 5m, depending on the vertical stratification of the vegetation. In general, smaller plots (10m x 2m) were used to sample low stature communities. Abundance of each plant species in a given plot was recorded according to Braun-Blanquet method (cited in Sutherland, 1996), using the following scale:

<1% plant cover-F, 1-5% plant cover-E, 6-25% plant cover-D, 26-50% plant cover-C, 51-75% plant cover-B, 76-100% plant cover-A.

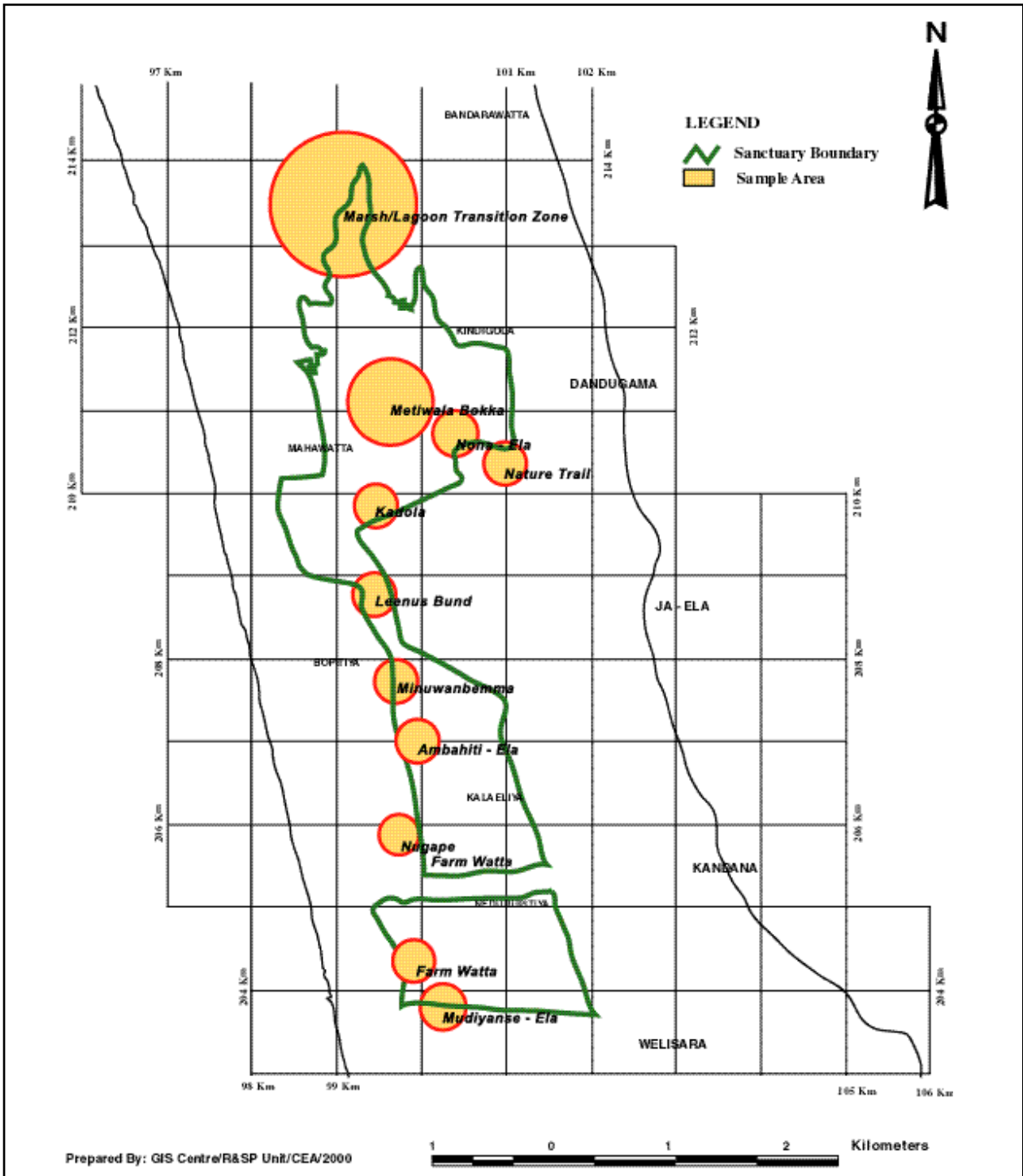


Figure 2
Sampling sites in Muthurajawela sanctuary

Sampling of fauna: The fauna sampled regularly included all groups of vertebrates and 2 groups of invertebrates (butterflies and dragonflies) for which there is adequate information in Sri Lanka. Standard sampling techniques specified in Sutherland (1996) were adopted, with slight modifications to suit the existing field conditions. Fish were sampled by cast netting (10 random casts/site) and observing the commercial catch. Herpetofauna were sampled along transects (50m x 5m) and placing pitfall traps. Birds were documented along 100m x 50m transects. Mammals were documented in a qualitative manner, using direct observations and indirect methods (defecation, tracks). Butterflies and dragonflies were documented along 50m x 5m transects.

Identification and nomenclature of flora and fauna

The fauna and flora of Muthurajawela were identified and classified using the published guides stated in Table 2 below:

Table 2
Guides used for the identification and taxonomy of flora and fauna

Group	Source
Flora	Dassanayake, M. D. & Fosberg, F. R. (eds.) (1980 - 1991); Dassanayake, M. D., Fosberg, F. R. and Clayton, W. D. (eds.) (1994 -1995) Dassanayake, M. D., and Clayton, W. D. (eds.) (1996 - 1999).
Fish	Pethiyagoda (1991); De Bruin et al. (1994).
Amphibians	Dutta & Manamendra-Aarachchi (1996).
Reptiles	Deraniyagala (1953); De Silva (1990); De Silva (1996).
Birds	Harrison & Worfolk (1999).
Mammals	Phillips (1980).
Butterflies	D' Abrera (1998).
Odonates	De Fonseka (2000).

Physico-chemical measurements

Certain physico-chemical parameters that would enable predictions on the quality of water in different habitats of the sanctuary were measured during two different time intervals, based on relative rainfall at Muthurajawela: high rainfall (December - January, 2000) and low rainfall (April - May, 2000) period. Field measurements were obtained, using a portable electrode kit. Two replicate samples were obtained from a particular location. The average measurements of pH, DO, BOD5 and COD were compared with standard values for these parameters specified by the CEA for fish and aquatic life.

Preparation of maps

The vegetation and land-use map prepared by CEA in 1990 was subjected to ground-truthing by visiting all accessible locations within the sanctuary. Coordinates of the different locations/habitats within the sanctuary were obtained using a GPS (Global Positioning System) monitor. With the aid of GIS (Global Information System) techniques, the information gathered through ground-truthing of vegetation maps, and the results of the data were used to produce digitized maps of the sanctuary. The maps included areas of high ecological importance (critical habitats), threat zones and new areas that should be incorporated into the existing wetland sanctuary. As it was not possible to obtain the latest aerial photographs of the sanctuary, demarcation of the different zones was done in a qualitative manner.

Ecological Zoning

The Muthurajawela Sanctuary was zoned according to ecological significance, as low, moderate and high using the following ecological criteria:

- Biodiversity - the variety or richness of habitats, communities and species (the latter was assessed using species richness of flowering plants and birds as surrogates of biodiversity).
- Naturalness and habitat quality - extent to which the area has been protected from, or has not been subjected to, human-induced destruction, degradation or modification (assessed using species richness of odonates; quality of water for aquatic life in terms of pH, DO, BOD5 and COD; status of habitat deterioration; and spread of invasive alien plants).
- Representativeness - the degree to which the area represents a habitat type, ecological process, biological community or other natural characteristic within the Muthurajawela Sanctuary (assessed by the number of representative habitat and vegetation types/communities).
- Dependency/uniqueness in terms of providing habitat for endemic and/or threatened species of fauna and flora (assessed by the number of species of endemic and/or threatened plants and animals present in a strata).
- Functional Integrity - the degree to which the area is an effective, self-sustaining ecological entity in terms of time and space within the Muthurajawela Sanctuary (assessed by the overall status of the above criteria, and the degree of connectivity with other neighboring habitats).

The 12 sampling sites under the five major strata surveyed were assessed for each of the above ecological criteria, using a set of scores ranging from 1-5; the highest score being given to the higher significance of each criteria. The sampling sites that received a cumulative score of 20

and above were considered areas of high ecological significance in the Muthurajawela Sanctuary which are critical habitats that need priority conservation attention. Those that received a cumulative score between 10-19 were considered areas of moderate ecological significance, while those with a cumulative score below 10 were considered areas of low ecological significance.

Assessment of threats

The threats were categorized under habitat deterioration/degradation, direct exploitation of species and spread of invasive alien species. The factors that contribute to the above threat categories in different sampling sites were assessed at three levels of significance: low, moderate and high, using appropriate indicators. The overall threat status of each site was determined according to the frequency of threat significance levels.

3. Flora of Muthurajawela

Vegetation types, floristic composition and abundance of species.

The Muthurajawela wetland sanctuary consists of a mosaic of seven major vegetation types: marsh, lentic flora, shrubland, reed swamp, grassland, stream bank and mangrove forest (Table 3). Edaphic factors such as physiography, land form, soils, salinity, hydrological conditions etc., appear to be the primary factors which govern the organisation of different vegetation types within the Muthurajawela wetland. Climatic factors play a secondary role in determining the plant life at Muthurajawela. In addition to edaphic and climatic factors, human disturbances and the spread of invasive alien species have also determined the structure and composition of vegetation types at a local level.

A total of 194 species belonging to 66 families were recorded from the study area, and these included one endemic species, three nationally threatened species and 11 invasive alien species (Appendix 1). *Phoenix zeylanica* (Family Palmae) is the sole endemic species recorded. Of the total number of species documented, 30 were woody plant species. Among the different vegetation types, the shrubland harbored the highest number of species (115), while the

Table 3

Vegetation types and dominant plant species in the Muthurajawela Wetland Sanctuary

Vegetation Types	Description	Dominant Species ¹ and Families
Marsh	Aquatic and semi-aquatic herbs and some woody plants	<i>Eleocharis dulcis</i> (Cyperaceae) <i>Acrostichum aureum</i> (Pteridaceae)
Lentic flora	Aquatic vegetation associated with static or slow-flowing aquatic habitats	<i>Pistia stratiotes</i> (Araceae) <i>Nymphaea stellata</i> (Nymphaeaceae) <i>Eleocharis dulcis</i> (Cyperaceae) <i>Eichhornia crassipes</i> (Pontederiaceae) <i>Salvinia molesta</i> (Salviniaceae)
Reed swamp	Aquatic or semi-aquatic tall reeds rooted in soil.	<i>Phragmites karka</i> (Poaceae) <i>Typha angustifolia</i> (Typhaceae)
Short grassland	Herbaceous grasses	<i>Ischaemum rugosum</i> (Poaceae) <i>Eragrostis</i> spp. (Poaceae)
Shrubland	Broad-leaved shrub	<i>Annona glabra</i> (Annonaceae) <i>Lygodium microphyllum</i> (Schizaeaceae)
Stream bank/Riparian	Broad-leaved flora bordering streams and canals	<i>Annona glabra</i> (Annonaceae) <i>Pandanus tectorius</i> (Pandanaeaceae) <i>Cerbera manghas</i> (Apocynaceae) <i>Syzygium caryophyllatum</i> (Myrtaceae)
Mangrove Forest	Broad-leaved trees and shrubs which are adapted to grow under saline and anaerobic conditions, along or near sea shores and estuaries	<i>Rhizophora mucronata</i> (Rhizophoraceae) <i>Avicennia marina</i> (Verbenaceae)

¹ Based on % cover (Braun-Blanquet method)

mangrove forest and stream bank/riparian type consisted of the lowest number of species (23 each) (Figure 3). In addition, 27 species of plants were documented as common flora occurring in home gardens within the sanctuary (Appendix 2). Based on the percentage of cover, the most abundant/dominant plant species under different vegetation types within each sampling site are presented in Table 4. The table shows that the species richness (no. of plant species / area) of different vegetation types increases with the advancing seral stages (ie., from aquatic lentic type to terrestrial shrubland type), as expected in the natural hydrophytic succession.

Table 4
Plant communities, dominant species, their abundance and species richness in the different sampling sites of the Muthurajawela wetland sanctuary.

Site	Vegetation type	Dominant species	Abundance	No. of species/area
Mudiyanse-ela	Reed Swamp	<i>Phragmites karka</i>	A	20-29/100m ²
	Shrub	<i>Annona glabra</i>	B-C	28-30/100m ²
Farmwatte	Reed Swamp	<i>Phragmites karka</i>	C	20-22/20m ²
	Shrub	<i>Annona glabra</i>	B-C	25-27/20m ²
Nugape	Reed Swamp Lentic flora	<i>Typha angustifolia</i>	A-B	12-13/20m ²
		<i>Acrostichum aureum</i>	C	12-15/20m ²
		<i>Ceratophyllum demersum</i>	C	
		<i>Eichhornia crassipes</i>	C	
	Shrub	<i>Nymphaea nauchali</i> <i>Annona glabra</i> <i>Lygodium microphyllum</i>	C B B	24-30/100m ²
Ambahiti-ela	Grassland Lentic flora	<i>Ischaemum rugosum</i>	B	9-11/20m ²
		<i>Pistia stratiotes</i>	A-C	5-18/20m ²
		<i>Nymphaea stellata</i>	B-C	
	Reed swamp Marsh Shrub	<i>Typha angustifolia</i>	B	6-11/20m ²
		<i>Eleocharis dulcis</i> <i>Annona glabra</i>	B A	3-4/20m ² 17-19/100m ²
Minuwanbema	Grassland	<i>Desmodium</i> spp.	C	20-25/20m ²
		<i>Eragrostis</i> spp.	C	
		<i>Ischaemum</i> spp.	C	
		<i>Digitaria</i> spp.	C	
	Marsh Shrub	<i>Eleocharis dulcis</i> <i>Annona glabra</i>	B A	12-16/20m ² 22-28/100m ²
Bopitiya	Grassland Lentic flora	<i>Ischaemum rugosum</i>	A	14-17/20m ²
		<i>Nymphaea stellata</i>	A	8-10/20m ²
		<i>Panicum repens</i>	B	
	Reed swamp Marsh Shrub	<i>Typha angustifolia</i>	A	15-22/20m ²
		<i>Acrostichum aureum</i> <i>Annona glabra</i>	A A	22-24/20m ² 9-14/100m ²
Lenus bund	Lentic flora	<i>Nymphaea stellata</i>	A-B	5-20/20m ²
	Reed swamp	<i>Phragmites karka</i>	A	20-22/100m ²
	Shrub	<i>Annona glabra</i>	A	22-27/100m ²
Kadola	Reed swamp	<i>Phragmites karka</i>	A	15-22/20m ²
	Marsh	<i>Eleocharis dulcis</i>	A-B	9-15/20m ²
	Shrub	<i>Annona glabra</i>	A	15-21/100m ²
Wahatiyagama West	Lentic flora	<i>Nymphaea stellata</i>	A	6-9/20m ²
		<i>Eleocharis dulcis</i>	B-C	

Site	Vegetation type	Dominant species	Abundance	No. of species/area
Wahatiyagama East	Reed swamp	<i>Typha angustifolia</i>	B	12-16/20m ²
	Marsh	<i>Acrostichum aureum</i>	B	12-16/20m ²
	Shrub	<i>Annona glabra</i>	B	12-17/100m ²
	Lentic flora	<i>Pistia stratiotes</i>	C	8 - 11 / 20 m ²
	Shrub	<i>Annona glabra</i>	A-B	18-25/100m ²
Nona-ela	Reed swamp	<i>Pandanus tectorius</i>	A-B	4-7/100m ²
	Shrub	<i>Annona glabra</i>	B	14-20/100m ²
Digana-ela	Lentic flora	<i>Ipomoea aquatica</i>	A	5-7/20m ²
	Reed swamp	<i>Typha angustifolia</i>	C	1-16/20m ²
		<i>Pandanus tectorius</i>	C	
Matiwala-bokke Wein-ela	Shrub	<i>Annona glabra</i>	A	7-9/20m ²
	Reed swamp	<i>Phragmites karka</i>	A	13-15/20m ²
	Mangrove	<i>Rhizophora mucronata</i> <i>Avicennia marina</i>	B B	19-23/100m ²

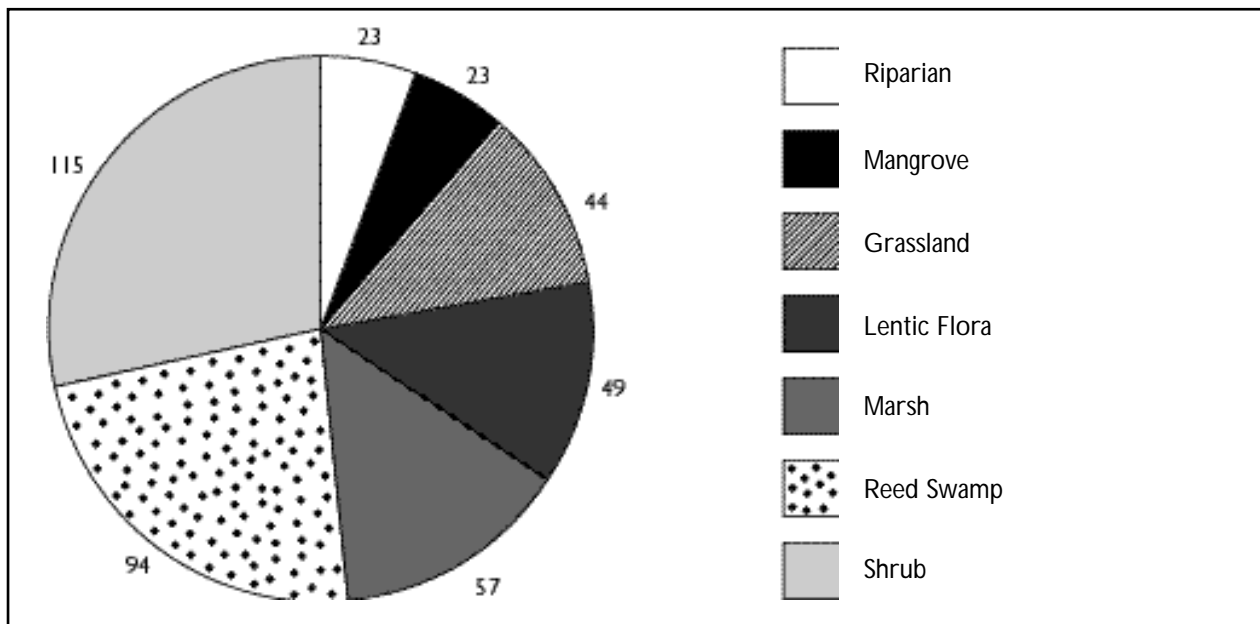


Figure 3
Species richness of flora in different vegetation types of the Muthurajawela wetland sanctuary

The study carried out in 1990 by CEA had recorded 140 species of plants (including mangroves) from Muthurajawela (Samarakoon & van Zon, 1991). The present study has enabled the documentation of an additional 50 species of plants, increasing the total to 190 species. Two endemic species that were documented in 1990 as rare sedges in Muthurajawela - *Eleocharis lankana* and *Fimbristylis zeylanica*, were not observed during the present survey. In addition, a major finding of the present survey was the significant change in the composition of dominant plant species, over a period of 10 years (Appendix 3). Drastic changes in species composition of flora was clearly observed especially in the southern part of the sanctuary, which is severely disturbed by human activities. These changes in the composition of vegetation could be attributed partly to the natural succession in a marsh, but the major causative factor seems to be the high level of human disturbance in most areas.

4. Fauna of Muthurajawela

Species composition and relative abundance of vertebrate fauna

A total of 209 species of vertebrate fauna, belonging to 96 families were recorded from Muthurajawela. Of the total number of species recorded, 17 (9 %) are endemic, while 26 (12 %) are nationally threatened (IUCN Sri Lanka, 2000). Among the endemic vertebrate species at Muthurajawela, 60% are nationally threatened. A comparison of inland native vertebrate fauna of Sri Lanka and in the Muthurajawela wetland sanctuary is shown in Figure 4. The native vertebrate fauna of Muthurajawela represents 30% of Sri Lanka's native inland vertebrate species. This is a significant proportion, when considering the size of this wetland. Of the total vertebrate species recorded, a majority (35%) were uncommon, while 13% were very common, and 5% were very rare.

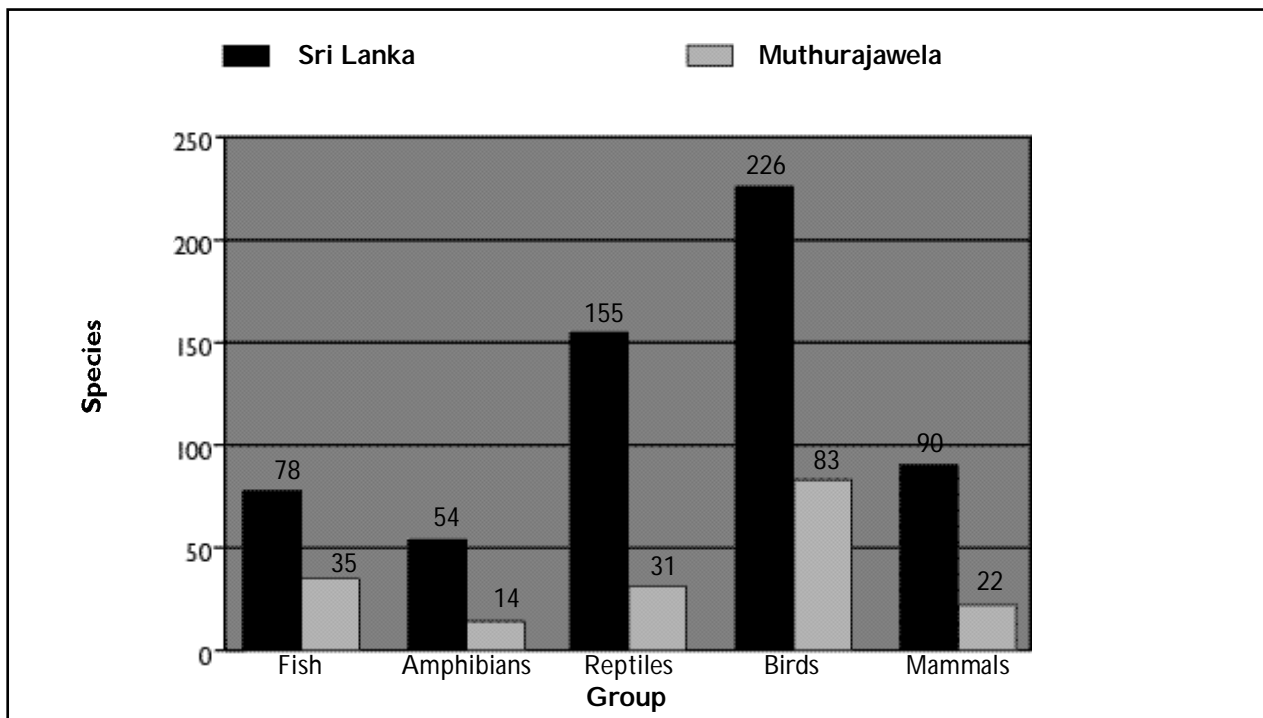


Figure 4

Comparison of inland native vertebrate species of Sri Lanka with those in the Muthurajawela wetland.

The fish consisted of 40 species (5 endemics) belonging to 23 families (Appendix 4), representing approximately 45% of Sri Lanka's native inland fishes. Among them, 5 species are nationally threatened, while 4 are exotic. These were distributed in lentic (ie., ponds, marshes) and lotic (ie., canals, streams, rivers) habitats, as well as the transition area of the marsh-lagoon complex, which is subjected to daily tidal influence. The Tilapia (*Sarotherodon mossambicus*), Pearl Spot (*Etroplus suratensis*) and the Dwarf Panchax (*Aplocheilichthys parvus*) were very common species of fish at Muthurajawela. The fish also included freshwater and marine migratory species, which were mainly observed in the Dandugam Oya and the marsh-lagoon transition zone. For instance, the "catadromous" species (Species that migrate from

fresh to marine habitats for reproduction) included the Level-finned Eel (*Anguilla bicolor*). The “anadromous” species (marine species which move into brackish/fresh water for spawning or to spend their juvenile period) included the Red Snapper (*Lutjanus argentimaculatus*), Big-eye Trevally (*Caranx sexfasciatus*), Common Glass fish (*Ambassis commersoni*), Tarpon (*Megalops cyprinoides*), and the Silver Bleddy (*Gerres* spp.).

The amphibians consisted of 14 species (4 endemics) belonging to 4 families (Appendix 5), including toads, narrow-mouthed frogs, aquatic frogs and tree frogs. These represented approximately 26% of the total amphibian species in the island. Among them, 5 species are nationally threatened. The Common Toad (*Bufo melanostictus*) and the Six-toed Green Frog (*Euphlyctis hexadactyla*) are very common species of amphibians at Muthurajawela. The latter was particularly abundant in areas with the semi-aquatic plant ‘Kan-Kun’ (*Ipomoea aquatica*), on which it is known to feed.

The reptiles consisted of 31 species (6 endemics) belonging to 18 families (Appendix 6), covering 20% of the island’s reptilian fauna. These included 15 species of tetrapod reptiles and 16 species of serpents. Among the total species, 9 are nationally threatened. The Water Monitor (*Varanus salvator*), Common Garden Lizard (*Calotes versicolor*), and two species of geckos (*Hemidactylus frenatus* and *Gehyra mutilata*) were very common reptiles at Muthurajawela. The occurrence of the Star Tortoise (*Geochelone elegans*) is of particular interest, as this species is known to occur naturally only in the lowland dry and intermediate zones in the island. This species may have been introduced to Muthurajawela through individuals brought in as pet animals. A breeding population of the Estuarine Crocodile (*Crocodylus porosus*), the largest reptile in the Muthurajawela Sanctuary, occurs in the northern area. Among the other reptiles, the Indian Python (*Python molurus*), the largest serpent in Sri Lanka, also occurs in Muthurajawela.

Birds appeared to be the dominant group of vertebrates at Muthurajawela, consisting of 102 species (1 endemic) belonging to 42 families (Appendix 7). These represented approximately 37% of Sri Lanka’s native avifauna. Among the total species were 19 winter migrants, while 3 species are nationally threatened. The mixture of vegetation types and aquatic habitats in Muthurajawela has made it an ideal ecotone for a variety of birds. About half of the bird species recorded were those associated with wetland ecosystems, such as herons, egrets, cormorants, teals, waders, kingfishers and terns which feed on aquatic organisms. The northern and central parts of the Muthurajawela Sanctuary are an important breeding habitat of native birds. This area, together with the Negombo lagoon, is also a preferred feeding and resting habitat of the winter migrants.

The mammals of Muthurajawela consist of 22 species (1 endemic) belonging to 14 families (Appendix 8), representing approximately 25% of the island’s mammalian fauna. Among them, 4 species are nationally threatened. The murids (rats and mice) were the most common types. The Slender Loris (*Loris tardigradus*) is an extremely rare primate at Muthurajawela, and it is considered globally threatened. The marsh is also an important refuge for the carnivorous Fishing Cat (*Prionailurus viverrinus*). Apart from these mammals that were identified, a few

other species of insectivorous bats (micro-chiroptera) and shrews were frequently observed, but these evaded capture and hence could not be identified.

The present survey enabled the documentation of 36 species of vertebrates that are new records for Muthurajawela (Table 5). However, a total of 60 vertebrates that were recorded during the previous survey carried out by the CEA in 1990 were not observed during the present survey. A considerable reduction was observed amongst the migrant bird species, although both surveys (present and previous) were conducted during the bird migratory season. However, some of the vertebrates that were not documented (especially birds) may be present in the northern part of the Negombo lagoon.

Table 5
Comparison of the numbers of vertebrate faunal species recorded during the previous ecological survey (1990/91; CEA) and the present survey (1999/2000; IUCN).

Group	Previous Survey (CEA)	Present Survey (IUCN)	Species not recorded during present survey	New species recorded during present survey
Fish	26	40	6	20
Amphibians	15	14	3	2
Reptiles	37	31	8	2
Birds	125 (40 WM) ¹	102 (19 WM)	13 Natives; 22 WM	10 Natives; 2 WM
Mammals	30	22	8	-

¹WM: Winter Migrants

Species composition and relative abundance of selected invertebrate fauna

Only two invertebrate groups - the butterflies (Lepidoptera) and the dragonflies (Odonata) were studied in detail, as these two groups are well documented in Sri Lanka. The butterflies recorded consisted of 48 species (in 8 families) and these represented approximately 20 % of the total butterfly species in the island (Appendix 9). None of them are endemic, but 6 species are nationally threatened (IUCN Sri Lanka, 2000). Among the butterfly species, 40% were common. The Blue Glassy Tiger (*Ideopsis similis*), Glassy Tiger (*Parantica aglea*) and the Tailed Jay (*Graphium agamemnon*) were very common species in Muthurajawela. The larvae of the latter species feed on the leaves of *Annona glabra*, the dominant plant in the scrub habitat of Muthurajawela.

The odonates (dragonflies and damselflies) consists of 22 species (in 4 families), representing approximately 19 % of the total odonate species in Sri Lanka (Appendix 10). Among them, only one is endemic, while 2 are nationally threatened. Among the odonate species, 36% were common. The dragonfly *Rhyothemis variegata* and the damselfly *Agriocnemis pygmaea* were abundant. Interestingly, the former was more common in degraded/disturbed habitats. The survey clearly highlighted that odonates could be used as indicators of habitat quality in wetland ecosystems.

Among the aquatic molluscs, *Pila globosa* was the most common species. Other common aquatic species included *Indoplanorbis exustus*, *Melanoides tuberculata* and *Lymnaea luteola*. Among the terrestrial molluscs, the alien invasive Giant African Snail (*Achatina fulica*) was commonly observed throughout the Sanctuary. Several species of crustaceans were also observed, including the Giant Freshwater Prawn (*Macrobrachium rosenbergii*).

It is alarming to note considerable reductions in species composition amongst the butterflies and dragonflies, in comparison to the 1990 survey conducted by the CEA (Table 6). This provides another clear indication of habitat degradation that has taken place over the past decade in the Muthurajawela Sanctuary.

Table 6
Comparison of the numbers of Butterfly species and Dragonfly species recorded from Sri Lanka and from the Muthurajawela wetland sanctuary.

Group/Family	Species in Sri Lanka	Species in Muthurajawela	
		1990/1991 (CEA)	1999/2000 (IUCN)
Butterflies (Lepidoptera)	248	67	48
Lycaenidae	85	14	5
Hesperiidae	51	6	4
Nymphalidae	37	17	7
Pieridae	27	9	10
Satyridae	16	4	7
Papilionidae	15	9	6
Daneidae	12	8	8
Libythidae	2	-	-
Acraeidae	1	-	1
Amathusiidae	1	-	-
Riodinidae	1	-	-
Dragonflies (Odonata)	117	34	22
Calopterygidae	2	-	-
Chlorocyphidae	4	2	-
Euphaeidae	1	-	-
Lestidae	6	-	-
Coenagrionidae	14	12	7
Platycnemididae	1	1	-
Platystictidae	17	2	-
Protoneuridae	7	3	1
Gomphidae	14	1	1
Aeshnidae	6	-	-
Corduliidae	3	-	-
Libellulidae	42	13	13

5. Water Quality

Water quality measurements

The average measurements of eight water quality parameters that were obtained from different areas/aquatic habitats of the Muthurajawela wetland sanctuary during the high rainfall (higher water flow) and low rainfall (lower water flow) periods are presented in Table 7. The average pH values of all sampling areas falls within the standard pH range (6 - 8.5) for fish and aquatic life. Interestingly, the average dissolved oxygen (DO) levels in all sampling areas were below the mean standard DO (6 mg/l) for fish and aquatic life. However, the average DO levels in the majority of the areas were above the standard daily minimum level (3 mg/l) for fish and aquatic life. In general, the lower levels of DO in the Muthurajawela wetland sanctuary could be attributed to the decomposition of peat matter, which results in de-oxygenation. The DO levels in the canal and marsh habitats of the Wahatiyagama (West) area were very low, possibly due to the proliferation of the alien invasive floating plant *Salvinia molesta* (in the canal) and the higher decomposition of peat (in the marsh) respectively.

In general, the average BOD5 and COD levels in the different sampling locations were much higher than the average standard levels of BOD5 (4 mg/l) and COD (15 mg/l). Although this situation could be normal for a peat bog ecosystem, it is alarming to note that the level of COD in certain areas (especially in the Negombo lagoon and the transition zone) was very high, indicating organic loading/pollution. This is further evident when considering the ratio between averages of COD and BOD5 for most areas, which is higher than twice the average value of BOD5, a condition that clearly depicts pollution by organic substances of natural origin (domestic sewage, farm wastes etc.).

The average values of water temperature, pH, conductivity, salinity, BOD and COD showed an increase from the wet to the dry season, which is related to the reduction of water flow towards the dry season. On the other hand, the DO of water in rivers, streams and canals showed a reduction towards the low rain period, as a result of low water flow, while such changes were not observed in marshy areas and ponds. As the flow of water in the Dandugan-oya, Ja-Ela canal and Hamilton canal is reduced during the low rain period, saline water penetrates into the marsh area, resulting in an increase in salinity, which also contributes to an increase in water pH. The considerable increase in conductivity especially in the Negombo lagoon and the transition zone could be attributed to increase in salinity (Sodium Chloride accumulation), as well as to the accumulation of ions from other sources (run-off from garbage dumps, discharge of chemicals from industrial areas etc.). The COD in most areas showed a considerable increase towards the dry period, owing to the accumulation of organic matter. The accumulation of organic material provides a substrate for the proliferation of micro-organisms, which contributes to an increase in BOD towards the dry period, and this may be another factor which contributes to lowering of DO.

Table 7
Assessment of water quality in different areas of the Muthurajawela Wetland Sanctuary

Location	Habitat	Season*	Temperature (C°)	pH	Conductivity ms/cm	Salinity %	Turbidity NTU	DO mg/l	BOD ₅ mg/l	COD mg/l
Negombo Lagoon	Lagoon	Wet	26.1	7.0	1.58	0.07	36	4.82	10	29
		Dry	30.4	7.1	11.1	0.63	03	4.73	15	330
Transition zone	Marsh-Lagoon Transition	Wet	26.5	6.7	0.062	0	10	5.7	10	49
		Dry	31.0	7.1	1.27	0.05	04	3.78	15	140
Matiwalabokke	River-Transition	Wet	25.9	7.1	0.185	0	10	5.48	10	29
		Dry	30.2	7.5	1.93	0.09	01	4.23	10	90
Dandugam-Oya	River	Wet	26.2	6.6	0.051	0	10	4.33	20	98
		Dry	30.2	7.9	0.135	0.0	06	4.51	10	30
Nona-Ela	Stream	Wet	25.5	7.0	0.382	0.01	10	4.2	20	29
		Dry	30.3	7.1	0.495	0.03	07	4.5	10	30
Canal	Marsh	Wet	29.3	6.9	0.396	0.01	10	4.39	5	39
		Dry	32.7	7.2	1.05	0.04	09	5.9	10	100
Marsh	Marsh	Wet	26.5	6.3	0.395	0.01	10	1.13	5	29
		Dry	30.8	6.9	1.22	0.05	13	2.5	15	140
Kadola	Marsh	Wet	27.0	6.4	0.332	0.01	10	5.36	10	20
		Dry	32.8	6.6	2.38	0.115	15.5	4.38	10	95
Lenus Bund	Marsh	Wet	27.7	6.8	0.70	0.03	10	5.55	7.5	50
		Dry	34.6	7.0	2.22	0.09	10	5.8	7.5	95
Bopitiya	Pond	Wet	26.8	6.6	0.601	0.02	10	3.71	7.5	60
		Dry	32.4	7.0	1.61	0.07	35	4.01	15	85
Minuwambemma	Marsh	Wet	30.5	6.8	0.402	0.01	10	4.28	12.5	39
		Dry	35.1	6.8	1.21	0.05	10	4.33	12.5	80
Ambahiti-Ela	Canal	Wet	30.0	6.6	0.383	0.01	10	5.31	10	95
		Dry	34.1	7.2	0.49	0.015	10	5.68	17.5	65
Nugape	Marsh	Wet	29.0	6.6	0.321	0.01	10	5.05	7.5	65
		Dry	33.3	6.7	0.77	0.03	10	3.42	35	65
Ja-Ela	Canal	Wet	27.8	6.6	0.073	0	10	3.27	10	20
		Dry	33.1	6.9	0.46	0.015	10	4.95	30	40
Old Dutch Canal	Canal	Wet	29.1	6.5	0.229	0.01	10	1.77	7.5	10
		Dry	32.7	7.2	1.16	0.055	10	5.17	55	65
Farmwatte	Canal	Wet	28.2	6.9	0.331	0	10	3.10	14.5	45
		Dry	31.5	7.0	1.05	0.01	12	2.15	30	95
Mudiyanse-Ela	Canal	Wet	29.3	6.6	0.235	0.01	10	3.92	12	25
		Dry	30.8	7.1	1.12	0.015	12	3.42	18.5	80

*Wet Season - December-January, 2000 (higher flow); Dry Season sampling - April - May, 2000 (Lower flow)

6. Zonation of Muthurajawela based on ecological significance

A summary of the assessment of ecological zones is presented in Table 8. Areas of high, moderate and low ecological significance in the Muthurajawela wetland sanctuary are shown in Figure 5. Based on the overall assessment of the predetermined ecological criteria, the northern (including the marsh-lagoon transition zone) and the central (Lenus bund, Bopitiya and Minuwambemma area) parts of the Muthurajawela wetland sanctuary, clearly stand out as areas of high ecological significance, which are critical habitats for the conservation and sustenance of biodiversity. The northern part of the Muthurajawela wetland sanctuary (including the mangrove ecosystem in the marsh-lagoon transition zone) is a key area that contributes to the future sustenance of the Muthurajawela marsh - Negombo lagoon complex wetland system. This area is essential to maintain a balance in the ecological processes pertaining to this complex wetland system, and is also vital for the future sustenance of the commercial fishery carried out in the Negombo lagoon.

Table 8
Assessment of sites based on ecological significance

Strata ¹	1				2		3		4		5	
Location ¹	1.1	1.2	1.3	1.4	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2
Biodiversity	5	5	5	3	2	4	3	5	3	2	2	2
Naturalness & Habitat Quality	5	5	4	3	1	3	2	4	3	2	1	1
Representativeness	5	5	4	3	2	5	2	4	2	3	1	1
Dependency/Uniqueness	5	5	4	3	2	5	3	4	3	3	1	1
Functional Integrity	4	4	4	3	1	3	3	4	2	3	1	1
Cumulative Score	24	24	21	15	8	20	13	21	13	13	6	6
Ecological Significance	H	H	H	M	L	H	M	H	M	M	L	L

¹ **Sampling Strata and locations:**

1 - Northern Area: 1.1 - Danduganoya-lagoon transition zone; 1.2 - Nona-ela to Matiwalabokke; 1.3 - Wahatiyagama West; 1.4 - Wahatiyagama East.

2 - North-central area: 2.1 - Lenus Bund; 2.2 - Kadola

3 - Central area: 3.1 - Minuwambemma; 3.2 - Bopitiya

4 - South-central: 4.1 - Amnahiti-ela; 4.2 - Nugape

5 - Southern area: 5.1 - Mudiyanse-ela; 5.2 - Farmwatte

Ecological Significance: H - high, M - Moderate, L - Low.



Figure 5
Zonation of Muthurajawela according to ecological significance

7. Major threats to biodiversity in Muthurajawela

The location of the Muthurajawela wetland sanctuary in a rapidly developing urban area makes it an extremely vulnerable ecosystem. As clearly evident from the findings of the present survey, considerable changes have taken place in relation to the biodiversity of Muthurajawela, over a period of 10 years. These changes could be attributed to a combination of various anthropogenic factors, that have a negative impact on biodiversity. The major threats that affect the biodiversity of the Muthurajawela wetland sanctuary can be summarized under 3 major categories: habitat deterioration/degradation; direct exploitation of species and impact of exotic species. The different factors that contribute to these threat categories are given below:

Factors resulting in deterioration/degradation of habitats

The major factors that lead to the deterioration and degradation of habitats in Muthurajawela include land reclamation (filling of the marsh), clearing of vegetation, deliberate fire, dumping of garbage, discharge of agro-chemicals and organic pollution. Illegal reclamation and filling is a severe problem in Muthurajawela, which has contributed to a change in vegetation and habitat types within the sanctuary. Marshy areas are being filled with soil, and foreign material such as rubber refuse, polythene and garbage. Filling of land is mainly for construction of new houses and access roads/pathways, while the established residents also fill their backyards illegally, in order to widen their existing land space. Filling of land has also resulted in the fragmentation of natural habitats and affected the free movement of water between different aquatic habitats. It has also contributed to the siltation of aquatic habitats, including the marsh-lagoon transition zone.

Clearing of natural vegetation is evident mainly around residential areas. Certain areas of scrubland have also been set on fire by the residents, and this seems to be a regular practice, to get rid of serpents entering home gardens. Large scale dumping of garbage is a serious problem in Muthurajawela. This has led to the accumulation of nutrients in aquatic habitats, and poses a severe health hazard as well. It has also decreased the scenic value of this wetland. Furthermore, garbage dumps have also resulted in a proliferation of native opportunistic faunal species such as cattle egrets, common crows, jungle crows and the water monitor. These species, together with the domestic cats and dogs which also gather near garbage dumps, pose a threat to native faunal species in Muthurajawela.

Agro-chemicals (pesticides, chemical fertilisers) are heavily used in leafy vegetable cultivation lands, especially in the Minuwambemma area. Clear signs of eutrophication are evident in aquatic habitats close to this area, as a result of nutrient accumulation. These chemical residues pose a serious threat to the aquatic organisms. The illegal breweries that produce local alcohol ('kasippu') also contribute to the degradation of aquatic habitats, as they release various chemicals (including urea - N fertiliser) into the water. In addition, small animals such as amphibians, reptiles and small mammals are also used for this process, and hence it poses a threat to these organisms.

The water quality measurements clearly highlight that certain areas of the Muthurajawela wetland sanctuary are subjected to high levels of organic pollution. The major sources of organic pollution at Muthurajawela include domestic sewage, garbage disposal, urban run-off, industrial effluents and farm wastes. The residential areas inhabited by poor settlers (ie., Kadola, Lenus bund etc.) release domestic waste and sewage into nearby aquatic habitats. Several pig and poultry farms are scattered in and around the Muthurajawela wetland sanctuary and these release large quantities of farm waste material into nearby aquatic habitats. Decomposing organic material from garbage dumps are also washed off into aquatic habitats. In addition, patches of oil were observed in the marsh-lagoon transition zone and in certain parts of the Dandugan-oya, probably as a result of being released/dumped from motorized boats used for fishing. The poor quality of water will have negative impacts on aquatic organisms, while organic pollution contributes to eutrophic conditions, as clearly evident in several localities of the Muthurajawela wetland sanctuary.

Factors contributing to direct exploitation of species

Poaching of animals (ie., waterfowl, hare, mouse deer, terrapins etc.) takes place in certain parts of the sanctuary, especially in areas inhabited by poor settlers. A few traditional fishing families are involved in small-scale commercial/subsistence fishery, in the canals, Dandugan-oya and marsh-lagoon transition zone. The fishery is mainly dependant on the cichlid species (Tilapia, Orange Chromide and the Pearl Spot). These fishermen are dependent on traditional fishing methods, such as the use of hook and rod, drift nets, cast nets and brush-piles and these could be considered as sustainable practices. However, organised groups are involved in the large-scale harvesting of fish species for the ornamental fish trade, from various parts of the Sanctuary. Major fish species that are captured for the aquarium trade includes the Blue-eye (*Oryzias melastigma*), Day's Killifish (*Aplocheilus dayi* - Endemic & Threatened), Dwarf Panchax (*A. parvus*), Horadandiya (*Horadandiya atukorali* - Threatened), Flying Barb (*Esomus thermoicos* - Endemic & Threatened), Striped Rasbora (*Rasbora daniconius*), Filamented Barb (*Puntius sinhalaya* - Endemic) and the Mono (*Monodactylus argenteus*). Trees are cut in an unsustainable manner by the producers of illegal liquor, to use as fuel-wood for the distillery process.

Impacts of exotic species

Several species of invasive alien plants and animals, including unmanaged domestic animals pose a serious threat to the biodiversity of Muthurajawela. Eleven species of invasive alien plants appear to dominate the total plant biomass of the Muthurajawela Sanctuary. These species have invaded into all vegetation types within the sanctuary (Appendix 11). The shrubland is the most affected vegetation type, dominated by the invasive *Annona glabra*. In addition, floating invaders such as *Eichhornia crassipes* and *Salvinia molesta* thrive in lentic habitats and slow-flowing canals. The spread of *Annona glabra*, *Eichhornia crassipes* and *Salvinia molesta* is of particular concern, as these species have the ability to convert wetlands into terrestrial ecosystems, by enhancing the process of natural succession of wetlands. The aquatic invasive plants have formed dense mats in several aquatic habitats, leading to low levels of dissolved oxygen, hence affecting the native aquatic organisms. Some of the indigenous

lentic flora such as *Nymphaea* spp., and *Utricularia australis* are gradually being replaced by the above floating alien invaders and also due to the shrinkage of open water bodies. These indigenous species contribute towards the scenic value of wetlands (due to their attractive flowers) and their reduction is therefore a matter of concern for purposes of eco-tourism. The interaction of various human related disturbances such as fire, grazing by domestic cattle, soil disturbances (land fills, domestic pigs), nutrient inputs (garbage dumps, fertiliser run-off, sewage etc.) and habitat fragmentation have facilitated the spread of invasive alien plant species throughout the Muthurajawela sanctuary.

The invasive alien fauna documented include 4 species of fish (Tilapia - *S. mossambicus*, Snake-skin Gouramy - *Trichogaster pectoralis*, Tank Cleaner - *Hypostomus plecostomus* and the Kissing Gouramy - *Helostoma temminckii*), 2 species of molluscs (Giant African Snail - *Achatina fulica* and the slug - *Laevicaulis alte*) and the Common House Rat (*Rattus rattus*). These invasive alien faunal species affect the native biodiversity as direct exploiters (predators, disease vectors) and superior competitors for resources. In addition, several species of unmanaged domestic animals (Water buffalo, cattle, pigs, goats, dogs and cats) pose a serious threat to native fauna and flora. The unmanaged domestic pigs serve as reservoirs of harmful pathogens, while they also contribute to changes in vegetation, due to their feeding behavior and wallowing habits. Similarly, buffalo and cattle are brought into the Sanctuary and let loose in grassland areas, until they are butchered. This practice may have contributed to the introduction of exotic weeds from other areas into Muthurajawela. The domestic cats and dogs attack native fauna such as reptiles, birds and small mammals. This is a grave problem especially around residential areas.

Table 9
Assessment of sites based on threats to biodiversity

Strata ¹	1				2		3		4		5	
Location ¹	1.1	1.2	1.3	1.4	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2
Reclamation	L	L	L	H	H	H	M	M	H	H	H	H
Habitat clearing	L	L	L	M	H	H	M	M	M	H	H	H
Fire	L	L	L	M	M	M	L	L	L	L	H	H
Garbage disposal	L	L	L	M	M	M	L	M	M	M	H	H
Agrochemical discharge	L	L	L	L	L	L	H	M	L	L	L	L
Effluent discharge	M	L	L	M	M	M	M	M	M	M	M	M
Poaching	L	L	L	M	H	M	L	L	M	M	L	L
Over exploitation	L	L	L	M	M	H	L	L	M	M	M	M
Spread of IAS	L	M	M	M	H	H	M	M	H	H	M	M
Unmanaged domestic animals	L	L	L	H	H	H	M	M	H	M	H	H
Overall Level of Threats	L	L	L	M	H	H	M	M	M	M	H	H

¹Sampling strata and locations:

1 - Northern Area: 1.1 - Danduganoya-lagoon transition zone; 1.2 - Nona-ela to Matiwalabokke; 1.3 - Wahatiyagama West; 1.4 - Wahatiyagama East.

2 - North-central area: 2.1 - Lenus Bund; 2.2 - Kadola

3 - Central area: 3.1 - Minuwambemma; 3.2 - Bopitiya

4 - South-central: 4.1 - Amnahiti-ela; 4.2 - Nugape

5 - Southern area: 5.1 - Mudiyanse-ela; 5.2 - Farmwatte

Overall level of threats: H - High, M - Moderate, L - Low

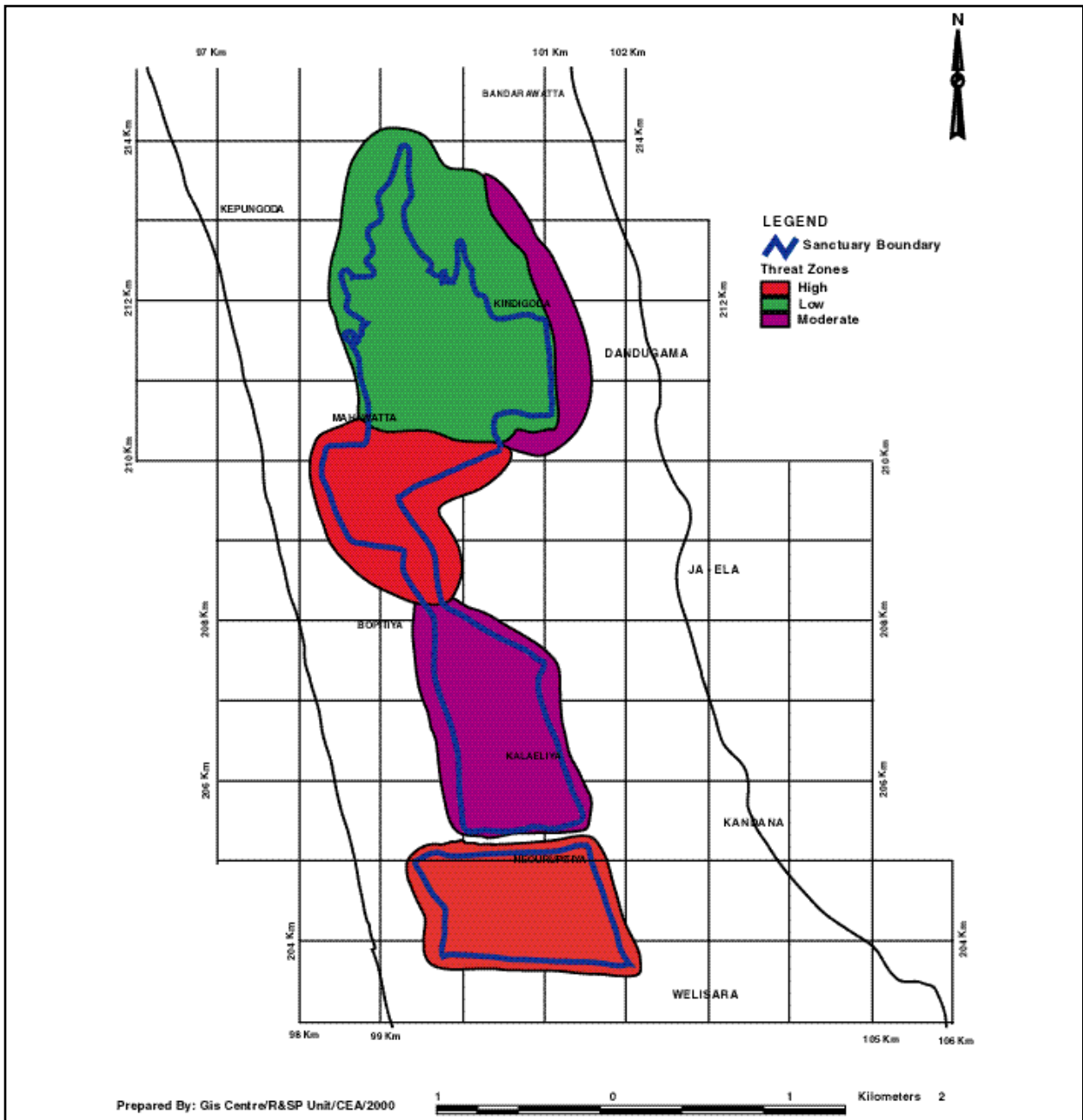


Figure 6
Zonation of Muthurajawela based on threats to biodiversity

Zonation of Muthurajawela Wetland based on severity of threats

The threats discussed above were assessed at the different sampling sites of the Muthurajawela wetland sanctuary, and the results are presented in Table 9. It is evident that residential areas with high human population pressure (ie., Kadola, Lenus Bund, Mudiyanse-ela, Jayasooriya Bund) are the highly threatened regions of the Muthurajawela wetland sanctuary, while the northern part seems to be the least threatened area (Figure 6). It is alarming to note that the central part of the Muthurajawela Wetland Sanctuary (ie., Bopitiya, Minuwambemma, Lenus Bund) which is of high ecological significance is also under moderate to high level of threat due to various detrimental factors. Therefore, the central part of the Muthurajawela Wetland Sanctuary needs attention for immediate conservation measures.

8. Recommendations for conservation of the Muthurajawela Wetland Sanctuary

The present survey has clearly revealed that the biodiversity of this important wetland has changed over the past decade. It enabled not only the identification of areas of high ecological significance, which are critical for biodiversity conservation, but also the documentation of threats to biodiversity, in different parts of the sanctuary. The following recommendations are made to facilitate future management of this unique urban wetland.

I. Upgrade the Muthurajawela Wetland Sanctuary to a higher conservation status.

The northern part of the Sanctuary, which is an area of high ecological significance, should be promoted to a higher protected area category, so that it could be afforded increased protection and management by the DWLC. Some adjoining areas of the north-western and north-eastern part of Muthurajawela Sanctuary (figure 7) should also be incorporated into this proposed upgraded PA. A permanent range office of the DWLC should be established in a suitable location at Muthurajawela.

II. Document the legal status of land within the Muthurajawela Wetland Sanctuary.

A major constraint to overcome the illegal reclamation of land at the Muthurajawela Wetland Sanctuary is the lack of information on the legal status of land. It was clearly observed that the existing households also reclaim land in their backyards. Therefore, the legal status of land should be clarified immediately through a joint survey conducted by the DWLC and local administrators.

III. Initiate studies to document the current socio-economic status related to resource use in Muthurajawela, as well as the physico-chemical and hydrological status of Muthurajawela Wetland Sanctuary.

Information gathered from the above studies would facilitate better management of the Muthurajawela Sanctuary.

IV. Initiate prompt action against practices that degrade the wetland.

Legal action will have to be strictly implemented to mitigate detrimental practices (especially the dumping of garbage and illegal reclamation) that threaten the biodiversity in the Muthurajawela Wetland Sanctuary. The temporary access pathways which have resulted in the fragmentation of natural habitats (ie., Lenus bund area, Nugape area) will have to be cleared immediately.

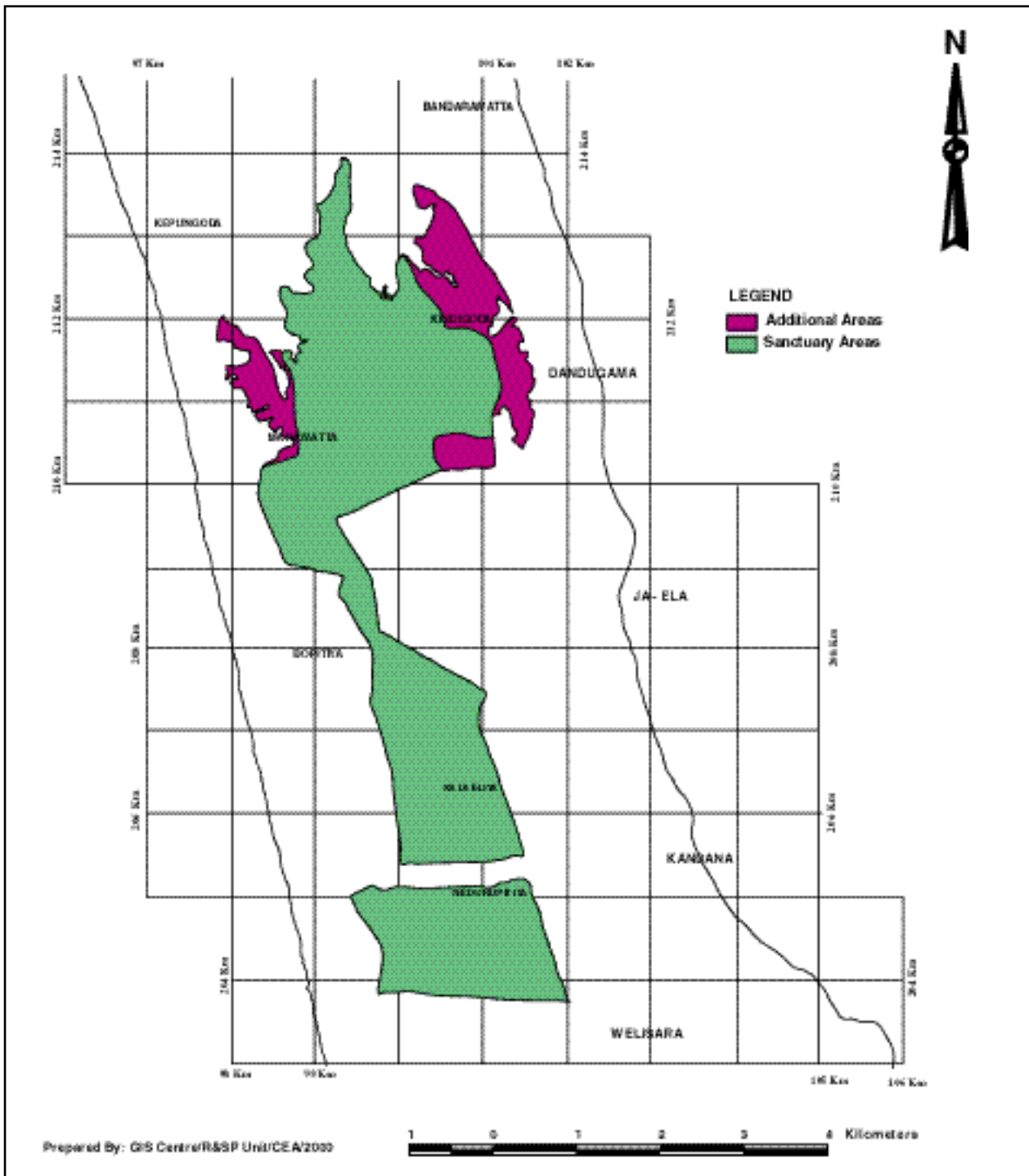


Figure 7
Additional areas that should be incorporated into the existing sanctuary

V. *Initiate restoration activities to enhance degraded habitats.*

The restoration activities will have to be initiated in a scientific manner, with regular monitoring. The local schools and CBO's can actively contribute in these initiatives, and also help to maintain the restored areas in a natural state. The Lenus Bund (north-central area) and Ambahiti-ela (south-central) are two areas that need immediate attention for restoration.

VI. *Initiate programmes to manage the spread of invasive alien species*

Scientifically planned management programmes should be implemented to manage the spread of three species of invasive alien plants in Muthurajawela: *Annona glabra*, *Salvinia molesta* and *Eichhornia crassipes*. The removal of *Annona glabra* should be simultaneously accompanied by replanting of native scrub species such as *Cerbera manghas*, *Syzigium* spp, and *Pandanus* spp.

VII. *Promote eco-tourism.*

The Muthurajawela Wetland Sanctuary is being visited regularly by local and foreign tourists, to view its biodiversity. However, this will have to be systematically regulated by the DWLC, in order to ensure that it is carried out in a sustainable manner. Furthermore, the local communities should also be able to benefit from eco-tourism initiatives.

VIII. *Establish a joint steering committee for the management of the Muthurajawela marsh-Negombo lagoon wetland complex.*

A steering committee that comprises of all line agencies and major stakeholders should be formulated, under the Chairmanship of the DWLC. Such a steering committee can give guidance to the formulation of an action plan for conservation of this complex wetland, and also contribute to participatory management of its resources.

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Appendix 1

Species composition of flora of Muthurajawela Wetland Sanctuary.

(E - Endemic species, IAS - Invasive Alien Species, T - Threatened species)

Family	Botanical Name	Family	Botanical Name
Acanthaceae	<i>Acanthus ilicifolius</i>		<i>Cyperus exaltatus</i>
Amaranthaceae	<i>Alternanthera sessilis</i>		<i>Cyperus pangorei</i>
	<i>Alternanthera</i> sp.		<i>Cyperus rotundus</i>
	<i>Amaranthus viridis</i>		<i>Cyperus stoloniferous</i>
Amaryllidaceae	<i>Crinum zeylanicum</i>		<i>Cyperus tenniculmis</i>
Annonaceae	<i>Annona glabra</i> ^{IAS}		<i>Eleocharis dulcis</i>
Apocynaceae	<i>Cerbera manghas</i>		<i>Eleocharis geniculata</i>
Aponogetonaceae	<i>Aponogeton natans</i> ^T		<i>Fimbristylis cinnamometorum</i>
Araceae	<i>Lagenandra ovata</i>		<i>Fimbristylis dipsacea</i>
	<i>Pistia stratiotes</i> ^{IAS}		<i>Fimbristylis ferruginea</i>
Aristolochiaceae	<i>Pentatropis capensis</i>		<i>Fimbristylis littoralis</i>
Asparagaceae	<i>Asparagus falcatus</i>		<i>Fimbristylis schoenoides</i>
Asteraceae	<i>Acanthospermum hispidum</i>		<i>Fimbristylis tetragona</i>
	<i>Ageratum conyzoides</i>		<i>Fimbristylis triflora</i>
	<i>Blainvillea acmella</i>		<i>Fimbristylis umbellaris</i>
	<i>Eleautherantha ruderalis</i>		<i>Lepironia articulata</i>
	<i>Elephantopus scaber</i>		<i>Pycreus polystachyos</i>
	<i>Eupatorium odoratum</i> ^{IAS}		<i>Rhynchospora corymbosa</i>
	<i>Mikania cordata</i> ^{IAS}		<i>Schenoplectus juncooides</i>
	<i>Synedrella nodiflora</i>		<i>Schoenoplectes littoralis</i>
	<i>Tridax procumbens</i>		<i>Schoenoplectus grossus</i>
	<i>Vernonia cinera</i>	Droseraceae	<i>Drosera indica</i>
	<i>Vicoa indica</i>	Elantinaceae	<i>Bergia capensis</i>
	<i>Wedelia</i> sp. ^{IAS}	Eriocaulaceae	<i>Eriocaulon quinquangulare</i>
Avicenniaceae	<i>Avicennia marina</i>		<i>Eriocaulon thwaitesii</i>
Azollaceae	<i>Azolla</i> sp.		<i>Eriocaulon truncatum</i>
Bignoniaceae	<i>Dolichandrone spathacea</i>	Euphorbiaceae	<i>Excoecaria agallocha</i>
Ceratophyllaceae	<i>Ceratophyllum demersum</i>		<i>Glochidion zeylanicum</i>
Combretaceae	<i>Lumnitzera racemosa</i>		<i>Macaranga peltata</i>
	<i>Terminalia catappa</i>		<i>Phyllanthus debilis</i>
Commelinaceae	<i>Commelina benghalensis</i>	Fabaceae	<i>Abrus precatorius</i>
	<i>Commelina diffusa</i>		<i>Caesalpinia crista</i> ^T
	<i>Commelina attenuata</i>		<i>Calopogonium</i> sp.
	<i>Murdannia spirata</i>		<i>Centrosema pubescens</i>
Convolvulaceae	<i>Ipomoea aquatica</i>		<i>Clitoria ternatea</i>
	<i>Erycibe paniculata</i>		<i>Derris trifoliata</i>
	<i>Ipomoea carnea</i>		<i>Desmodium dichotomum</i>
	<i>Ipomoea obscura</i>		<i>Desmodium heterophyllum</i>
	<i>Ipomoea</i> sp.		<i>Desmodium triflorum</i>
	<i>Jacquemontia paniculata</i>		<i>Mimosa pudica</i>
	<i>Merrimia tridentata</i>		<i>Pycnospora lutescens</i>
Cucurbitaceae	<i>Trichosanthes cucumerina</i>		<i>Rhynchosia suaveolens</i>
Cyperaceae	<i>Cyperous haspan</i>		<i>Tephrosia purpurea</i>
	<i>Cyperus corymbosus</i>	Flagellariaceae	<i>Flagellaria indica</i>
		Haloragaceae	<i>Myriophyllum indicum</i>

Family	Botanical Name	Family	Botanical Name
Hydrocharitaceae	<i>Hydrilla verticillata</i> ^{IAS}		<i>Isachne globosa</i>
Hydrophyllaceae	<i>Hydrolea zeylanica</i>		<i>Ischaemum indicum</i>
	<i>Hydrophylla ariculata</i>		<i>Ischaemum rugosum</i>
Lamiaceae	<i>Anisomeles indica</i>		<i>Isachne kunthiana</i>
	<i>Hyptis suaveolens</i>		<i>Leersia hexandra</i>
	<i>Ocimum sanctum</i>		<i>Leptochloa chinensis</i>
Lauraceae	<i>Cassytha filiformis</i>		<i>Panicum repens</i>
Lemnaceae	<i>Lemna minima</i>		<i>Paspalidium flavidum</i>
Lentibulariaceae	<i>Utricularia flexuosa</i>		<i>Paspalidium punctatum</i>
Limnocharitaceae	<i>Limnocharis flava</i>		<i>Paspalum scrobiculatum</i>
Lythraceae	<i>Rotala indica</i>		<i>Paspalum vaginatum</i>
Malvaceae	<i>Hibiscus tiliaceus</i>		<i>Phragmites karka</i> ^{IAS}
	<i>Sida veronicifolia</i>		<i>Pseudoraphis spinescens</i>
	<i>Urena lobata</i>		<i>Sacciolepis indica</i>
Melastomataceae	<i>Osbeckia aspera</i>	Polygonaceae	<i>Antigonon leptopus</i>
Meliaceae	<i>Xylocarpus granatum</i>	Pontederiaceae	<i>Eichhornia crassipes</i> ^{IAS}
Menyanthaceae	<i>Nymphoides hydrophylla</i>		<i>Monochoria hastata</i>
Molluginaceae	<i>Mollugo disticha</i>	Potamogetonaceae	<i>Potamogeton filiformis</i>
	<i>Mollugo oppositifolia</i>	Pteridaceae	<i>Acrosticum aureum</i>
Myrsinaceae	<i>Ardisia humilis</i>	Rhizophoraceae	<i>Bruguiera sexangula</i>
	<i>Aegiceras corniculata</i>		<i>Ceriops tagal</i>
Myrtaceae	<i>Syzygium caryophyllatum</i>		<i>Rhizophora apiculata</i>
Nyctaginaceae	<i>Boerhavia diffusa</i>		<i>Rhizophora mucronata</i>
Nymphaeaceae	<i>Nymphaea nouchali</i>	Rubiaceae	<i>Dentella repens</i>
Oleaceae	<i>Jasminum</i> sp.		<i>Hedyotis fruticosa</i>
Onagraceae	<i>Ludwigia decurrens</i>		<i>Ixora</i> sp.
	<i>Ludwigia hyssopifolia</i>		<i>Knoxia corymbosa</i>
	<i>Ludwigia perennis</i>		<i>Mitracarpus villosus</i>
	<i>Ludwigia peruviana</i>		<i>Spermacoe hispida</i>
Palmae	<i>Nypa fruticans</i> ^T	Salviniaceae	<i>Salvinia molesta</i> ^{IAS}
	<i>Phoenix zeylanica</i> ^F	Schizaeaceae	<i>Lygodium microphyllum</i>
Pandanaceae	<i>Pandanus tectorius</i>	Scrophulariaceae	<i>Bacopa monnieri</i>
Parkeriaceae	<i>Ceratopteris</i> sp.		<i>Centranthera indica</i>
Passifloraceae	<i>Passiflora foetida</i>		<i>Lindernia rotundifolia</i>
Poaceae	<i>Alloteropsis cimicina</i>		<i>Scoparia dulcis</i>
	<i>Aristida setacea</i>	Sonneratiaceae	<i>Sonneratia caseolaris</i>
	<i>Axonopus affinis</i>	Sterculiaceae	<i>Heritiera littoralis</i>
	<i>Axonopus compressus</i>	Thelypteridaceae	<i>Cyclosorus</i> sp.
	<i>Brachiaria ramosa</i>	Tiliaceae	<i>Corchorus aestuans</i>
	<i>Cirtococcum trigonum</i>		<i>Corchorus tridens</i>
	<i>Cynodon dactylon</i>		<i>Triumfetta rotundifolia</i>
	<i>Dactyloctenium aegyptium</i>	Typhaceae	<i>Typha angustifolia</i> ^{IAS}
	<i>Digitaria ciliaris</i>	Verbenaceae	<i>Clerodendrum inerme</i>
	<i>Digitaria longiflora</i>		<i>Lantana camara</i> ^{IAS}
	<i>Dimeria fuscescens</i>		<i>Premna latifolia</i>
	<i>Echinochloa frumentacea</i>		<i>Premna serratifolia</i>
	<i>Eleusine indica</i>		<i>Stachytarpheta jamaicensis</i>
	<i>Eragrostis japonica</i>	Vitaceae	<i>Cayratia trifolia</i>
	<i>Eragrostis riparia</i>	Xyridaceae	<i>Xyris indica</i>
	<i>Eragrostis unioides</i>		

Appendix 2

Common plants associated with home gardens within Muthurajawela Sanctuary.

Botanical Name	Local Name	Family
<i>Albizia lebbbeck</i>	Kabal mara	Fabaceae
<i>Annona muricata</i>	Anoda	Annonaceae
<i>Areca catechu</i>	Puwak	Palmae
<i>Artocarpus altilis</i>	Del	Moraceae
<i>Artocarpus heterophyllus</i>	Kos	Moraceae
<i>Averrhoa bilimbi</i>	Bilinch	Oxalidaceae
<i>Azadirachta indica</i>	Kohomba	Meliaceae
<i>Ceiba pentandra</i>	Kotta	Bombacaceae
<i>Cocos nucifera</i>	Coconut	Palmae
<i>Coffea arabica</i>	Kopi	Rubiaceae
<i>Filicium decipiens</i>	Pihimbiya	Sapindaceae
<i>Gliricidia sepium</i>	Weta hira	Fabaceae
<i>Macaranga peltata</i>	Kenda	Euphorbiaceae
<i>Mangifera indica</i>	Amba	Anacardiaceae
<i>Moringa oleifera</i>	Murunga	Moringaceae
<i>Musa paradisiaca</i>	Kesel	Musaceae
<i>Nephelium lappaceum</i>	Rambutan	Sapindaceae
<i>Persea americana</i>	Alipera	Lauraceae
<i>Polyalthia longifolia</i>	Weeping willow	Annonaceae
<i>Psidium guajava</i>	Pera	Myrtaceae
<i>Swietenia macrophylla</i>	Mahogani	Meliaceae
<i>Syzygium jambos</i>	Jambu	Myrtaceae
<i>Tamarindus indica</i>	Siyambala	Fabaceae
<i>Tectona grandis</i>	Thekka	Verbenaceae
<i>Terminalia catappa</i>	Kottamba	Combretaceae
<i>Thespesia populnea</i>	Gan suriya	Malvaceae

Appendix 3

Comparison of dominant flora of the Muthurajawela marsh in different habitats/study sites, recorded during the previous survey (1990 – CEA) and the present survey (2000 – IUCN, SL).

Area	Major Flora in year 1990	Sampling site & Human impact	Habitat	Major flora in year 2000	Braun-Blanquet Cover Codes
1. Extreme North Dandugan-oya area	Grasses	Wahatiyaynma west 1	Reed Swamp	<i>Typha angustifolia</i>	B
	Sedges		Marsh	<i>Acrostichum aureum</i>	B
	Mangrove		Shrub	<i>Annona glabra</i>	B
				<i>Phragmites karka</i>	C
		Nona-ela 1	Reed Swamp	<i>Pandanus tectorius</i>	A-C
			Shrub	<i>Annona glabra</i>	B
				<i>Acrostichum aureum</i>	C
		Matiwala-bokka 1	Reed Swamp	<i>Phragmites karka</i>	A
			Weinela	Mangrove	<i>Avicennia marina</i>
					<i>Rhizophora mucronata</i>
				<i>Rhizophora apiculata</i>	C
2. North of Ja-ela – Tudella/South Mahawatte	<i>Acrostichum aureum</i>	Lenus Bund 3	Lentic flora	<i>Nymphaea stellata</i>	A-B
	<i>Annona glabra</i>		Shrub	<i>Annona glabra</i>	A
	<i>Flagellaria indica</i>		Reed Swamp	<i>Phragmites karka</i>	A
	<i>Ischaemum rugosum</i>				
	Grasses				
	Sedges				
		Kadola 4	Shrub	<i>Annona glabra</i>	A
			<i>Acrostichum aureum</i>	C	
	Reed swamp		<i>Phragmites kirka</i>	A	
	Marsh		<i>Eleocharis dulcis</i>	A-D	

Area	Major Flora in year 1990	Sampling site & Human impact	Habitat	Major flora in year 2000	Braun-Blanquet Cover Codes	
3. North of Ambahiti-ela – Ja-ela canal	<i>Acrostichum aureum</i> <i>Cyperus spiralis</i> <i>Schoenoplectus grossus</i>	Minuwambemma 2	Marsh	<i>Eleocharis dulcis</i>	B	
					<i>Panicum repens</i>	C
					<i>Ischaemum spp.</i>	C
			Short grassland	<i>Desmodium heterophyllum</i>	C	
					<i>Digitaria ciliaris</i>	C
					<i>Eragrostis spp.</i>	C
				<i>Ischaemum spp.</i>	C	
				Shrub	<i>Annona glabra</i>	A-B
			Bopitiya (1) 2	Shrub	<i>Annona glabra</i>	A
				Reed Swamp	<i>Typha angustifolia</i>	A
				Marsh	<i>Acrostichum aureum</i>	A
				Lentic flora	<i>Eleocharis dulcis</i>	B
			Bopitiya (2) 2	Lentic flora	<i>Nymphaea stellata</i>	A
			<i>Panicum repens</i>	B		
		Short grassland	<i>Ischaemum rugosum</i>	A		
			<i>Eleocharis dulcis</i>	C		
4. North of J'suriya Rd – Ambahiti-ela	<i>Carex indica</i> <i>Isachne globosa</i> <i>Furena umbellata</i>	Nugape 3	Shrub	<i>Annona glabra</i>	B	
					<i>Lygodium microphyllum</i>	B
					<i>Cerbera manghas</i>	C
					<i>Syzygium caryophyllatum</i>	C
					<i>Typha angustifolia</i>	C
				Lentic flora	<i>Acrostichum aureum</i>	C
					<i>Ceratophyllum demersum</i>	C
					<i>Nymphaea nouchali (N. stellata)</i>	C
					<i>Eichhornia crassipes</i>	C
				Reed swamp	<i>Typha angustifolia</i>	A-B
			<i>Ipomoea aquatica</i>	C		
			<i>Lagenandra ovata</i>	C		

Area	Major Flora in year 1990	Sampling site & Human impact	Habitat	Major flora in year 2000	Braun-Blanquet Cover Codes	
5. Extreme South Mudiyansela – Jayasuriya Rd		3	Reed swamp	<i>Nymphaea stellata</i>	C	
				<i>Typha angustifolia</i>	B	
				<i>Nymphaea stellata</i>	C	
				Lentic flora	<i>Pistia stratiotes</i>	A
				<i>Nymphaea stellata</i>	B-C	
				<i>Ceratophyllum demersum</i>	C	
			Marsh	<i>Typha angustifolia</i>	C	
				<i>Eleocharis dulcis</i>	B	
				<i>Nymphaea stellata</i>	C	
			Shrub	<i>Annona glabra</i>	A	
				Short grassland	<i>Ischaemum rugosum</i>	B
			Mudiyanse-ela	3	Shrub	<i>Annona glabra</i>
Reed swamp	<i>Phragmites karka</i>	A				
Sedges	Farmwatte	Shrub			<i>Annona glabra</i>	B-C
					<i>Cayratia trifolia</i>	C
					<i>Lygodium microphyllum</i>	C
Reed swamp	<i>Phragmites karka</i>	C				

Human impact (Disturbance): 1 – Very low; 2 – marginal; 3 – moderate; 4 – high; 5 – Very high.

Braun-Blanquet scale for visual estimation of plants: 76%-100% cover (A); 51%-75% cover (B); 26%-50% cover (C); 6%-25% cover (D); 1%-5% cover (E); <1% cover (F)

Abbreviations used in Appendices 4-10

Status: E - Endemic; T - Nationally Threatened (IUCN Sri Lanka, 2000)

Ex - Exotic species; WM - Winter migrant.

Abundance: VC - Very Common; C - Common; UC - Uncommon; R - Rare

Appendix 4

List of Fish recorded at Muthurajawela

Family	Species	Status	Abundance	Habitat
Anguillidae	Level-finned Eel - <i>Anguilla bicolor</i>		R	C,R,L,M
Cyprinidae	Striped Rasbora - <i>Rasbora daniconius</i>		C	P,C,R,S,M
	Filamented Barb - <i>Puntius sinhalaya</i>	E	C	P,C,R,S,M
	Redside Barb - <i>Puntius bimaculatus</i>		C	P,C,R,S,M
	Silver Barb - <i>Puntius vittatus</i>		UC	C,R,S,M
	Olive Barb - <i>Puntius sarana</i>		R	P,C,R,S,M
	Scarlet-banded Barb - <i>Puntius amphibius</i>		C	P,C,R,S,M
	Long-snouted Barb - <i>Puntius dorsalis</i>		UC	P,C,R,S,M
	Common Labeo - <i>Labeo dussumieri</i>		R	C,R,S
	Silver Carplet - <i>Amblypharyngodon melettinus</i>		C	P,C,R,S,M
	Flying Barb - <i>Esomus thermoicos</i>	E;T	R	P,C,R,S,M
	Horadandiya - <i>Horadandiya atukorali</i>	T	UC	P,C,R,S,M
	Clupeidae	Malabar Sprat - <i>Ehirava fluviatilis</i>		UC
Heteropneustidae	Stinging Catfish - <i>Heteropneustes fossilis</i>		UC	P,C,R,S
Hemiramphidae	Halfbeak - <i>Zenarchopterus dispar</i>		UC	L,R
Oryziidae	Blue-eye - <i>Oryzias melastigma</i>		C	P,C,R,S,M
Aplocheilidae	Day's Killifish - <i>Aplocheilus dayi</i>	E;T	C	P,C,R,S,M
	Dwarf Panchax - <i>Aplocheilus parvus</i>		VC	P,C,R,S,M
Centropomidae	Common Glassfish - <i>Ambassis commersoni</i>		UC	L,R,C,S
Kuhliidae	Spotted Flagtail - <i>Kuhlia marginata</i>		R	L
Carangidae	Big-eye Trevally - <i>Caranx sexfasciatus</i>		UC	L
Monodactylidae	Mono - <i>Monodactylus argenteus</i>		UC	L
Cichlidae	Orange Chromide - <i>Etroplus maculatus</i>		C	C,R,S
	Pearl Spot - <i>Etroplus suratensis</i>		VC	C,R,S
	Tilapia - <i>Sarotherodon mossambicus</i>	Ex	VC	P,C,R,S,M,L
Gobiidae	Bar-eyed Goby - <i>Glossogobius giuris</i>		UC	C,R,S
Anabantidae	Climbing Perch - <i>Anabas testudineus</i>		UC	M,C,P
Belontiidae	Paradise Fish - <i>Pseudosphromenus cupanus</i>		R	C,S
	Snakeskin Gouramy - <i>Trichogaster pectoralis</i>	Ex	C	M,C,P,R,S
Helostomiidae	Kissing Gourami - <i>Helostoma temminckii</i>	Ex	UC	C,S
Channidae	Smooth-breasted Snakehead - <i>Channa orientalis</i>	E;T	UC	C,S,R,M
	Murrel - <i>Channa striata</i>		UC	C,S,R,M
Hypostomidae	Tank Cleaner - <i>Hypostomus plecostomus</i>	Ex	UC	R,S,P
Tetraodontidae	Common Puffer - <i>Tetraodon fluviatilis</i>		R	L
Lutjanidae	Red Snapper - <i>Lutjanus argentimaculatus</i>		UC	L
Clariidae	Walking Catfish - <i>Clarias brachysoma</i>	E;T	UC	C,S,R,M,P
Cobitidae	Spiny Loach - <i>Lepidocephalichthys thermalis</i>		UC	C,S,P

Family	Species	Status	Abundance	Habitat
Megalopidae	Tarpon - <i>Megalops cyprinoides</i>		C	L
Theraponidae	Target Fish - <i>Therapon jabua</i>		C	L
Gerridae	Silver Bleddy - <i>Gerres abbreviatus</i>		UC	L
	Silver Bleddy - <i>Gerres oyana</i>		C	L,C

Habitats: P - Ponds; C - Canals; S - Streams; R - River; M - Marsh; L - Lagoon (Transition area)

Appendix 5

List of Amphibians recorded at Muthurajawela

Family	Species	Status	Abundance
Bufonidae	Common Toad - <i>Bufo melanostictus</i>		VC
	Athokorale's Dwarf Toad - <i>Bufo atukoralei</i>	E;T	R
Microhylidae	Common Bull Frog - <i>Kaloula taprobanica</i>		UC
	Red Narrow-mouthed Frog - <i>Microhyla rubrum</i>		R
Ranidae	Common Paddy field Frog - <i>Limnonectes limnocharis</i>		C
	Corrugated Water Frog - <i>Limnonectes corrugatus</i>	E;T	R
	Small Wood Frog - <i>Rana aurantiaca</i>	T	UC
	Sri Lanka Wood Frog - <i>Rana gracilis</i>	E;T	UC
	Six-toed Green Frog - <i>Euphlyctis hexadactyla</i>		VC
	Skipper Frog - <i>Euphlyctis cyanophlyctis</i>		C
	Indian Bull Frog - <i>Hoplobatrachus crassus</i>		UC
Rhacophoridae	Striped Pygmy Tree Frog - <i>Philautus leucorhinus</i>		UC
	Hour-glass Tree Frog - <i>Polypedates cruciger</i>	E;T	R
	Chunam Tree Frog - <i>Polypedates maculatus</i>		UC

Appendix 6

List of Reptiles recorded at Muthurajawela

Family	Species	Status	Abundance
Crocodylidae	Estuarine Crocodile - <i>Crocodylus porosus</i>	T	UC
Trionychidae	Flapshell Turtle - <i>Lissemys punctata</i>	T	R
Bataguridae	Parker's Black Turtle - <i>Melanochelys trijuga</i>	T	UC
Testudinidae	Star Tortoise - <i>Geochelone elegans</i>	T	R
Varanidae	Water Monitor - <i>Varanus salvator</i>		VC
	Land Monitor - <i>Varanus bengalensis</i>		UC
Agamidae	Green Garden Lizard - <i>Calotes calotes</i>		C
	Common Garden Lizard - <i>Calotes versicolor</i>		VC
	Sri Lanka Kangaroo Lizard - <i>Otocryptis wiegmanni</i>	E; T	R
Gekkonidae	Common House Gecko - <i>Hemidactylus frenatus</i>		VC
	Spotted House Gecko - <i>Hemidactylus brookii</i>	E	C
	Fourclaw Gecko - <i>Gehyra mutilata</i>		VC
Scincidae	Common Lanka Skink - <i>Lankascincus fallax</i>	E	UC
	Bronze-green Little Skink - <i>Mabuya macularius</i>		C
	Common skink - <i>Mabuya carinata</i>	E	UC
Colubridae	Green vine snake - <i>Ahaetulla nasutus</i>		UC
	Dog-faced Water Snake - <i>Cerberus rhynchops</i>		R
	The Olive Keelback - <i>Atretium schistosum</i>		UC
	Rat Snake - <i>Ptyas mucosus</i>		C
	Common Bronzeback - <i>Dendrelaphis tristis</i>		UC
	Common Pond Snake - <i>Xenochrophis asperrimus</i>	E;T	UC
	Checkered Keelback - <i>Xenochrophis piscator</i>		C
	Buff-striped Keelback - <i>Amphiesma stolata</i>		C
	Common Kukri Snake - <i>Oligodon arnensis</i>		UC
	Dumeril's Kukri Snake - <i>Oligodon sublineatus</i>	E;T	VR
Wolf Snake - <i>Lycodon aulicus</i>		UC	
Elapidae	Cobra - <i>Naja naja</i>		UC
Viperidae	Russell's Viper - <i>Daboia russellii</i>		UC
	Merrem's Hump-nosed Viper - <i>Hypnale hypnale</i>		UC
Boidae	Indian Python - <i>Python molurus</i>	T	VR
Achrochordidae	Wart Snake - <i>Achrochordus granulatus</i>	T	R

Appendix 7

List of Birds recorded at Muthurajawela

Family	Species	Status	Abundance
Phalacrocoracidae	Little Cormorant - <i>Phalacrocorax niger</i>		C
	Indian Cormorant - <i>Phalacrocorax fuscicollis</i>		UC
Ardeidae	Intermediate Egret - <i>Mesophoyx intermedia</i>		C
	Little Egret - <i>Egretta garzetta</i>		C
	Large Egret - <i>Casmerodius albus</i>		R
	Cattle Egret - <i>Bubulcus ibis</i>		C
	Purple Heron - <i>Ardea purpurea</i>		UC
	Indian Pond Heron - <i>Ardeola grayii</i>		VC
	Little Green Heron - <i>Butorides striatus</i>		UC
	Night Heron - <i>Nycticorax nycticorax</i>		R
	Yellow Bittern - <i>Ixobrychus sinensis</i>		R
	Chestnut Bittern - <i>Ixobrychus cinnamomeus</i>		UC
	Black Bittern - <i>Dupetor flavicollis</i>		R
Ciconiidae	Asian Openbill - <i>Anastomus oscitans</i>		C
Threskiornithidae	White Ibis - <i>Threskiornis melanocephalus</i>		R
Jacanidae	Pheasant-tailed Jacana - <i>Hydrophasianus chirurgus</i>		R
Rallidae	White-breasted Waterhen - <i>Amaurornis phoenicurus</i>		VC
	Ruddy-breasted Crake - <i>Porzana fusca</i>	T	VR
	Purple Coot - <i>Porphyrio porphyrio</i>		UC
	Watercock - <i>Gallinula cineria</i>		VR
	Common Moorhen - <i>Gallinula chloropus</i>		UC
Anatidae	Lesser Whistling Teal - <i>Dendrocygna javanica</i>		VC
Recurvirostridae	Black-winged Stilt - <i>Himantopus himantopus</i>		R
Scolopacidae	Whimbrel - <i>Numenius phaeopus</i>	WM	R
	Eurasian Curlew - <i>Numenius arqueta</i>	WM	R
	Common Sandpiper - <i>Actitis Hypoleucos</i>	WM	UC
	Curlew Sandpiper - <i>Calidris ferruginea</i>	WM	R
	Marsh Sandpiper - <i>Tringa stagnatilis</i>	WM	VR
	Pintail Snipe - <i>Gallinago stenura</i>	WM	R
Rostratulidae	Greater Painted-Snipe - <i>Rostratula benghalensis</i>	T	VR
Burhinidae	Eurasian Thick-Knee - <i>Burhinus oedicephalus</i>		VR
Charadriidae	Red-wattled Lapwing - <i>Vanellus indicus</i>		C
Laridae	Gull-billed Tern - <i>Gelochelidon nilotica</i>	WM	C
	Whiskered Tern - <i>Chlidonias hybridus</i>	WM	VC
	Lesser Crested Tern - <i>Sterna bengalensis</i>	WM	C
	Little Tern - <i>Sterna albifrons</i>		UC
Podicipedidae	Little Grebe - <i>Tachybaptus ruficollis</i>		UC

Family	Species	Status	Abundance
Alcedinidae	White-breasted Kingfisher - <i>Halcyon smyrnensis</i>		VC
	Black-capped Kingfisher - <i>Halcyon pilcata</i>	WM	VR
	Stork-billed Kingfisher - <i>Pelargopsis capensis</i>		R
	Common Kingfisher - <i>Alcedo atthis</i>		C
	Pied Kingfisher - <i>Ceryle rudis</i>		UC
Accipitridae	Shikra - <i>Accipiter badius</i>		UC
	Brahminy Kite - <i>Haliaster indus</i>		C
	Western Marsh Harrier - <i>Circus aeruginosus</i>	WM	UC
	Pale Harrier - <i>Circus macrourus</i>	WM	R
Columbidae	Spotted Dove - <i>Streptopelia chinensis</i>		VC
	Rock Pigeon - <i>Columba livia</i>		UC
	Pompadour Green Pigeon - <i>Treron pompadora</i>		R
Meropidae	Blue-tailed Bee-eater - <i>Merops philippinus</i>	WM	VC
Cuculidae	Common Coucal - <i>Centropus sinensis</i>		C
	Blue-faced Malkoha - <i>Phaenicophaeus viridirostris</i>		VR
	Asian Koel - <i>Eudynamys scolopacea</i>		C
	Pied Crested Cuckoo - <i>Oxylophus jacobinus</i>		UC
Psittacidae	Rose-ringed Parakeet - <i>Psittacula kramerii</i>		C
	Alexandrine Parakeet - <i>Psittacula eupatria</i>		R
Hirundinidae	Barn Swallow - <i>Hirundo rustica</i>	WM	VC
	Red-rumped Swallow - <i>Hirundo daurica</i>		UC
Apodidae	White-browed Swift - <i>Apus affinis</i>		UC
	Alpine Swift - <i>Tachymarptis melba</i>	T	R
	Asian Palm Swift - <i>Cypsiurus balasiensis</i>		UC
	Indian Swiftlet - <i>Collocalia unicolor</i>		UC
Corvidae	House Crow - <i>Corvus splendens</i>		VC
	Jungle Crow - <i>Corvus macrorhynchos</i>		VC
Coraciidae	Indian Roller - <i>Coracias benghalensis</i>		UC
Capitonidae	Brown-headed Barbet - <i>Megalaima zeylanica</i>		C
	Small Barbet - <i>Megalaima rubricapilla</i>	E	UC
Pycnonotidae	Red-vented Bulbul - <i>Pycnonotus cafer</i>		VC
	White-browed Bulbul - <i>Pycnonotus luteolus</i>		C
Sturnidae	Common Mynah - <i>Acridotheres tristis</i>		VC
Laniidae	Brown Shrike - <i>Lanius cristatus</i>	WM	UC
Oriolidae	Black-headed Oriole - <i>Oriolus xanthornus</i>		UC
Picidae	Red-backed Woodpecker - <i>Dinopium benghalense</i>		UC
Muscicapidae	Common Tailorbird - <i>Orthotomus sutorius</i>		VC
	White-browed Prinia - <i>Prinia inornata</i>		C
	Great Reed Warbler - <i>Acrocephalus stentoreus</i>		C
	Fantail Warbler - <i>Cisticola juncidis</i>		C
	Large Prinia - <i>Prinia sylvatica</i>		UC

Family	Species	Status	Abundance
	Ashy Prinia - <i>Prinia socialis</i>		UC
	Black Robin - <i>Saxicoloides fulicata</i>		C
	Magpie Robin - <i>Copsychus saularis</i>		C
	Common Babbler - <i>Turdoides affinis</i>		VC
	Asian Paradise Flycatcher - <i>Terpsiphone paradisi</i>		UC
	Brown Flycatcher - <i>Muscicapa daurica</i>	WM	R
Motacillidae	Grey Wagtail - <i>Motacilla cinerea</i>	WM	C
	Forest Wagtail - <i>Dendronanthus indicus</i>	WM	R
	Indian Pipit - <i>Anthus rufulus</i>		UC
Nectariniidae	Purple Sunbird - <i>Nectarinia asiatica</i>		UC
	Purple-rumped Sunbird - <i>Nectarinia zeylonica</i>		VC
	Loten's Sunbird - <i>Nectarinia lotenia</i>		UC
Dicaeidae	Pale-billed Flowerpecker - <i>Dicaeum erythrorhynchos</i>		C
Ploceidae	White-rumped Munia - <i>Lonchura striata</i>		C
	Spotted Munia - <i>Lonchura punctulata</i>		C
	Black-headed Munia - <i>Lonchura malacca</i>		UC
Dicruridae	White-vented Drongo - <i>Dicrurus caerulescens</i>		C
Strigidae	Collared Scops Owl - <i>Otus bakkamoena</i>		UC
	Brown Fish Owl - <i>Ketupa zeylonensis</i>		UC
Alaudidae	Oriental Skylark - <i>Alauda gulgula</i>		R
Irenidae	Common Iora - <i>Aegithina tiphia</i>		UC
Artamidae	Ashy Swallow-Shrike - <i>Artamus fuscus</i>		R
Campephagidae	Little Minivet - <i>Pericrocotus cinnamomeus</i>		R
Pittidae	Indian Pitta - <i>Pitta brachyura</i>	WM	R

Appendix 8

List of Mammals recorded at Muthurajawela

Family	Species	Status	Abundance
Cercopithecidae	Toque Macaque - <i>Macaca sinica</i>	E	C
Loridae	Slender Loris - <i>Loris tardigradus</i>	T	VR
Leporidae	Black-naped Hare - <i>Lepus nigricollis</i>		C
Sciridae	Palm squirrel - <i>Funambulus palmarum</i>		VC
Hystericidae	Indian Crested Porcupine - <i>Hystrix indica</i>		UC
Muridae	Indian Bandicoot - <i>Bandicota bengalensis</i>		VC
	House Rat - <i>Rattus rattus</i>		VC
	House Mouse - <i>Mus musculus</i>		VC
	Brown Mouse - <i>Mus cervicolor</i>		VC
Soricidae	Musk Shrew - <i>Suncus murinus</i>		C
Pteropidae	Flying-Fox - <i>Pteropus giganteus</i>		C
	Fruit Bat - <i>Rousettus seminuodus</i>		C
Rhinolophidae	Horse-shoe Bat - <i>Rhinolopus</i> spp.		C
Hipposiderosidae	Leaf-nosed Bat - <i>Hipposideros</i> spp.		C
Viverridae	Brown Mongoose - <i>Herpestes fuscus</i>		UC
	Ruddy Mongoose - <i>Herpestes smithii</i>		R
	Indian Palm-Cat - <i>Paradoxurus hermaphrodites</i>		UC
	Small Civet-Cat - <i>Viverricula indica</i>		UC
Mustellidae	Eurasian Otter - <i>Lutra lutra</i>	T	UC
Felidae	Indian Fishing Cat - <i>Prionailurus viverrinus</i>	T	UC
	Rusty-spotted Cat - <i>Felis rubiginosa</i>	T	VR
Tragulidae	Mouse Deer - <i>Tragulus meminna</i>		R

Appendix 9

List of Butterflies recorded at Muthurajawela

Family	Species	Status	Abundance
Lycaenidae	Lesser Grass Blue - <i>Zizina otis</i>		C
	Large Oak Blue - <i>Arhopala amantes</i>	T	R
	Dark Grass Blue - <i>Zizeeria karsandra</i>	T	UC
	Tiny Grass Blue - <i>Zizula hylax</i>	T	UC
	Dark Cerulean - <i>Jamides coruscans</i>		UC
Satyridae	Common Evening Brown - <i>Melanitis leda</i>		C
	Dark Evening Brown - <i>Melanitis phedima</i>		UC
	Dark-Brand Bush Brown - <i>Mycalesis mineus</i>		UC
	Common Bush Brown - <i>Mycalesis perseus</i>		UC
	White Four-Ring - <i>Ypthima ceylonica</i>		C
	Common Palm Fly - <i>Elymnias hypermnestra</i>		C
	Nigger - <i>Orsotriaena medus</i>		C
Danaidae	Blue Glassy Tiger - <i>Ideopsis similis</i>		VC
	Glassy Tiger - <i>Parantica aglea</i>		VC
	Dark Blue Tiger - <i>Tirumala septentrionis</i>		R
	Plain Tiger - <i>Danaus chrysippus</i>		R
	Common Tiger - <i>Danaus genutia</i>		R
	Common Crow - <i>Euploea core</i>		C
	Brown King Crow - <i>Euploea klugii</i>		UC
	Great Crow - <i>Euploea phaenareta</i>		R
Nymphalidae	Leopard - <i>Phalanta phalantha</i>		R
	Great Egg Fly - <i>Hypolimnias bolina</i>		R
	Danaid Egg Fly - <i>Hypolimnias misippus</i>		UC
	Common Sailor - <i>Neptis hylas</i>		C
	Grey Pansy - <i>Junonia atlites</i>		UC
	Peacock Pansy - <i>Junonia almana</i>		UC
	Tamil Lacewing - <i>Cethosia nietneri</i>		R
Acraeidae	Tawny Coster - <i>Acraea violae</i>		R
Pieridae	Psyche - <i>Leptosia nina</i>		C
	Jezebel - <i>Delias eucharis</i>		UC
	Chocolate Albatross - <i>Appias lycinda</i>		UC
	Striped Albatross - <i>Appias libythea</i>	T	R
	Common Albatross - <i>Appias albina</i>		C
	Lemon Emigrant - <i>Catopsilia pomona</i>		C
	African immigrant - <i>Catopsilia pyranthe</i>		UC
	Small Grass Yellow - <i>Eurema brigitta</i>		C
	Three-spot Grass Yellow - <i>Eurema blanda</i>		UC
Common Grass Yellow - <i>Eurema hecabe</i>		C	

Family	Species	Status	Abundance
Papilionidae	Blue Mormon - <i>Papilio polymnestor</i>		R
	Common Mormon - <i>Papilio polytes</i>		UC
	Common Rose - <i>Pachliopta aristolochiae</i>		UC
	Crimson Rose - <i>Pachliopta hector</i>		UC
	Lime Butterfly - <i>Papilio demoleus</i>		UC
	Tailed Jay - <i>Graphium agamemnon</i>		VC
Hesperiidae	Indian Skipper - <i>Pelopidas mathias</i>		C
	Large Branded Swift - <i>Pelopidas thrax</i>	T	R
	Dark Palm Dart - <i>Telicota ancilla</i>	T	R
	Chestnut Bob - <i>Suastus gremius</i>		UC

Appendix 10

List of Dragonflies recorded at Muthurajawela

Family	Species	Status	Abundance
Dragonflies			
Gomphidae	<i>Ictinogomphus rapax</i>		R
Libellulidae	<i>Orthetrum pruinosum</i>		UC
	<i>Orthetrum sabina</i>		C
	<i>Potamarcha congener</i>		C
	<i>Diplocodes trivialis</i>		C
	<i>Trithemis festiva</i>		UC
	<i>Trithemis pallidinervis</i>		UC
	<i>Pantala flavescens</i>		C
	<i>Neurothemis tullia</i>		VC
	<i>Neurothemis intermedia</i>	T	R
	<i>Tholymis tillarga</i>		UC
	<i>Crocothemis servillia</i>		R
	<i>Rhyothemis variegata</i>		VC
	<i>Brachythemis contaminata</i>		UC
	Damselflies		
Coenagrionidae	<i>Agriocnemis pygmaea</i>		VC
	<i>Ischnura aurora</i>		C
	<i>Ceriagrion coromandelianum</i>		UC
	<i>Ceriagrion cerinorubellum</i>		R
	<i>Pseudagrion microcephalum</i>		C
	<i>Pseudagrion rubriceps</i>		C
	<i>Pseudagrion malabaricum</i>		C
Protoneuridae	<i>Elattonaura</i> spp.	E;T	R

Appendix 11

Status of invasive alien plant species in different habitats of the Muthurajawela wetland sanctuary

Area	Sampling site	Habitat	Alien Invasive Species	Braun-Blanquet ¹ Cover Codes
1. Extreme North Dandugan-oya area	Wahatiyagama West	Reed Swamp	<i>Typha angustifolia</i>	B
			<i>Phragmites karka</i>	E
			<i>Annona glabra</i>	D-F
			<i>Wedelia sp.</i>	F
			<i>Salvinia molesta</i>	C
			<i>Pistia stratiotes</i>	F
	Nona-ela	Shrub	<i>Annona glabra</i>	B
			<i>Mikania cordata</i>	C
		Reed Swamp	<i>Annona glabra</i>	D
			<i>Phragmites karka</i>	E
			<i>Pistia stratiotes</i>	F
	Matiwala-bokka	Reed Swamp	<i>Phragmites karka</i>	A
			<i>Mikania cordata</i>	D
			<i>Annona glabra</i>	E
	Weinela	Mangrove	<i>Annona glabra</i>	E-F
2. North of Ja-ela – Tudella/South Mahawatte	Lenus Bund	Lentic flora	<i>Salvinia molesta</i>	D-E
			<i>Typha angustifolia</i>	D
			<i>Mikania cordata</i>	E
	Shrub	<i>Annona glabra</i>	A-B	
		<i>Mikania cordata</i>	D	
		<i>Wedelia spp.</i>	E	
		Reed Swamp	<i>Phragmites karka</i>	A
	<i>Wedelia spp.</i>		F	
	<i>Annona glabra</i>		E	
	Kadola	Shrub	<i>Annona glabra</i>	A
<i>Typha angustifolia</i>			C	
<i>Salvinia molesta</i>			C-E	

Area	Sampling site	Habitat	Alien Invasive Species	Braun-Blanquet ¹ Cover Codes
		Reed swamp	<i>Mikania cordata</i>	C
			<i>Phragmites karka</i>	A
			<i>Annona glabra</i>	E
		Marsh	<i>Mikania cordata</i>	C
			<i>Salvinia molesta</i>	E
			<i>Salvinia molesta</i>	C
			<i>Typha angustifolia</i>	D
			<i>Annona glabra</i>	E
			<i>Eichhornia crassipes</i>	E
3. North of Ambahiti -ela – Ja-ela canal	Minuwanbemmma	Marsh	-	-
	Short grassland	-	-	
		Scrub	<i>Annona glabra</i>	A-B
	Bopitiya (1)	Shrub	<i>Annona glabra</i>	A
			<i>Salvinia molesta</i>	D
			<i>Mikania cordata</i>	C-E
		Reed Swamp	<i>Typha angustifolia</i>	A
			<i>Annona glabra</i>	D
		Lentic flora	<i>Salvinia molesta</i>	C
	Bopitiya (2)	Lentic flora	<i>Salvinia molesta</i>	C
			<i>Annona glabra</i>	E
		Short grassland	<i>Annona glabra</i>	E
2. North of J'suriya Rd – Ambahiti-ela	Nugape	Shrub	<i>Annona glabra</i>	B
			<i>Mikania cordata</i>	C-E
			<i>Typha angustifolia</i>	C
			<i>Salvinia molesta</i>	F
			<i>Lantana camara</i>	E
		Lentic flora	<i>Eichhornia crassipes</i>	C
			<i>Typha angustifolia</i>	C
			<i>Annona glabra</i>	E

Area	Sampling site	Habitat	Alien Invasive Species	Braun-Blanquet ¹ Cover Codes
Extreme South 1. Mudiyanse-la – Jayasuriya Rd	Ambahiti-ela	Reed swamp	<i>Salvinia molesta</i>	E
			<i>Typha angustifolia</i>	A-B
			<i>Annona glabra</i>	D-E
			<i>Eichhornia crassipes</i>	E
			<i>Salvinia molesta</i>	E
		Lentic flora	<i>Typha angustifolia</i>	B
			<i>Pistia stratiotes</i>	A
			<i>Typha angustifolia</i>	C-E
			<i>Salvinia molesta</i>	E
			<i>Annona glabra</i>	F
	Marsh	<i>Mikania cordata</i>	F	
		<i>Ischaemum rugosum</i>	B	
		<i>Annona glabra</i>	A	
	Mudiyanse-ela	Shrub	<i>Mikania cordata</i>	F
			<i>Annona glabra</i>	B-C
		Reed swamp	<i>Phragmites karka</i>	E
			<i>Mikania cordata</i>	E
			<i>Salvinia molesta</i>	F
			<i>Phragmites karka</i>	A
			<i>Annona glabra</i>	D-E
<i>Salvinia molesta</i>			E	
<i>Mikania cordata</i>			F	
Farmwatte			Shrub	<i>Annona glabra</i>
	<i>Salvinia molesta</i>	E		
	Reed swamp	<i>Annona glabra</i>	A	
		<i>Salvinia molesta</i>	E	
		<i>Mikania cordata</i>	E	
				F

¹Braun-Blanquet scale for visual estimation of plants: 76%-100% cover (A); 51%-75% cover (B); 26%-50% cover (C); 6%-25% cover (D); 1%-5% cover (E); <1% cover (F)

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