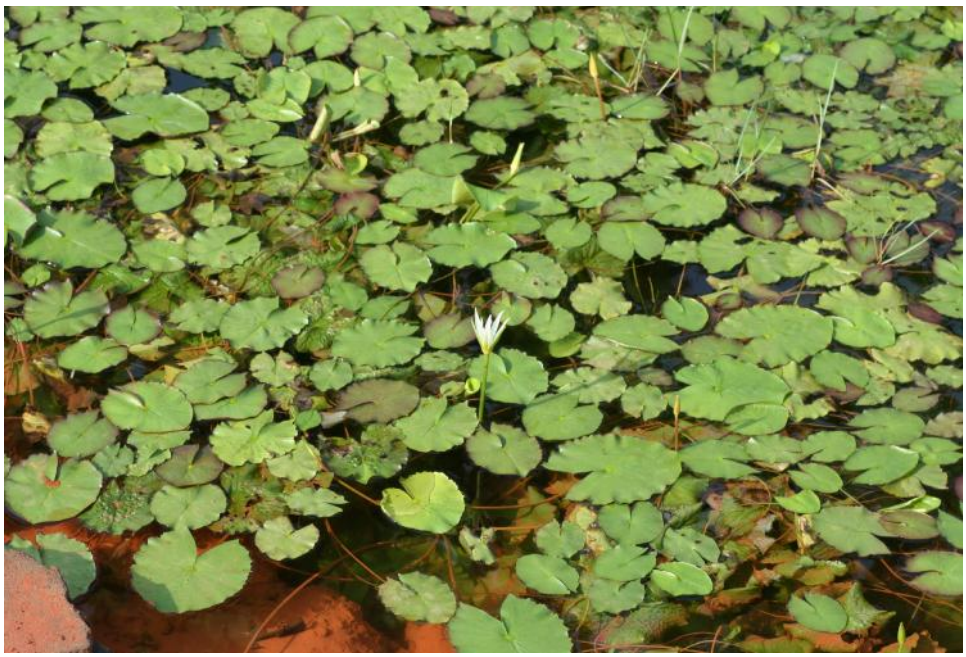
CONSERVATION OF KOTTULI WETLANDS, CALICUT, KERALA



Report Submitted to

TOURIST RESORTS (KERALA) LIMITED

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1.0 INTRODUCTION

Wetlands, one of the most productive ecosystems of the world, are rich in floral and faunal biodiversity and harbour great number of species including several endangered and threatened ones. Wetlands form breeding and feeding ground for numerous resident and local and migratory water birds and several other lesser known species. As a greatly productive life supporting system wetlands have immense socio-economical, ecological, and aesthetical importance. The natural beauty and diversity of animals (Tam and Wong, 2000), and plants makes wetland aesthetically captivating. Wetlands are one of the most threatened ecosystems of the world (Turner, 1991), for various reasons of which a major one is it's tagging along with wastelands that have to be put into use by alteration. The widespread gross nescience about the priceless ecosystem services the wetlands offer, ensue in large scale anthropogenic pressure proceeding to their decimation. In view of their environmental, ecological and conservation values some of the wetlands in the world are protected as national parks and world heritage sites and are able to generate directly considerable returns as income from tourism. Recreational activities such as fishing, hunting, boating and as retreats with relieving and stimulating aesthetically pleasing ambience uphold wetlands as a source income.

In India wetlands are distributed in almost all bioclimatic regions and biogeographic zones. The total wetland area of the country is about 4.1 million hectares. Nevertheless, for a range of anthropogenic pressures the wetland areas in the country are undergoing frightful depletion in the past couple of decades. Wetland diversion reclaiming the water logged ecosystem to other uses especially for building construction is widespread in the country. Cities actually grow in area at the expense of the wetlands. Kerala stands up among all the states of India in having a large proportion of land under wetlands (Nayar and Nayar, 1997). Its peculiar topography of undulating terrain with mountain ranges in the east and the Arabian Sea in the west provides the state to hold numerous wetland sites. Kerala is one among the high populous states in the country where human

habitations is a continuum from the northern most district of the state Kasaragod to the southern most district Trivandrum. The annual foreign remittances of the state is more than Rs 24000/- crores per annum Consequently, construction of buildings is the most growing activity in the state and real estate business a flourishing occupation (Raj and Azeez 2009) and emerging avocation for many. Naturally, the wetlands in the state confront severe anthropogenic threats than in other states of the country. Studies reveal that the state has almost completely lost its mangrove wetlands; the estimated area of mangroves in the state has reduced from an estimated area of 700 km^2 (Ramachandran et al. 1985) to about 17 km^2 (Basha 1991 and 1992). The status of other coastal as well as inland wetlands of the state could not be greatly different.

Urbanization is regarded as a ubiquitous and most drastic landscape modification, which affects the local biodiversity in terms of area loss, habitat fragmentation, and habitat alteration (Antrop, 1999). Urbanisation is a vital process of social development and proceeds in a fast track in developing countries, especially in this era of globalisation and liberalisation. The negative impacts of urbanisation and development that is practically irreversible is visible on its environment, microclimate and biodiversity. To moderate such damaging consequences, it is more redeeming to build and conserve green areas inside urban centres. These green patches add the ecological value of the city, by conserving water, reducing air as well as noise pollution. The green spaces act as control for the local climate (Jansson et al. 2007). Such green spaces including parks and gardens provide habitats for several taxa such as birds, butterflies and mammals. It provides space for leisure, recreational, social, aesthetic as well as research-oriented activities which may bring in long-term returns to human and other living kind. Though there are challenges to find realistic and effective ways for conserving pre-urban natural remnants to urban green spaces, it ensures better quality of life for both human as well as other species, and an alternate way to raise the local economy via eco-tourism.

Tourism is considered the third largest industry in the world after transport, equipment and petroleum products and it is growing with a high pace. It accounts 8% of the total world exports and more than 30% of international trade in services (Jacob 2003). It is obvious that the sector provides large number of employment for local community, indigenous people and others. It has a vast array of beneficiaries; those involved in maintenance, accommodation, transportation, conducting tours, recreation and catering. Ecotourism in India currently is widely promoted in locations of exquisite natural settings or of floral of faunal specialities. According to International Ecotourism Society (TIES), Ecotourism is the "responsible travel to natural areas, which conserves the environment and sustains the well-being of local people". Apparently ecotourism is a sustainable tourism that touches upon the tourists' mind that desires for comforting and refreshing nature away from the travails of the day to day chores, and longs to experience the rugged wilder environment. Ecotourism meets the requirements of the tourists, in the meantime helping conserve to a great extend the nature for posterity.

Ecotourism as an industry has several negative social, economic and ecological impacts. Nevertheless, it offers a substantial opportunity to realise benefits from conserving biodiversity and natural environmental milieu. The positive benefits are particularly broader where local communities are involved. When the local communities' starts deriving benefits, their valuation of the resources around them will rise. This will lead to a strong desire to protect and conserve such resources since they are indeed the source of their income (Pemberton and Charles, 2004). The significance of ecotourism projects is high in the case of developing countries like India, where the government and authorities are short of funds to manage and protect natural resources. Being one among the most threatened ecosystems, wetlands of the country needs highly proactive and participatory conservation strategy customised to the local situation and with ample returns discernible to the locals

Recently in Kerala the state government has rechristened the tourism potentials and locations of the state mostly as ecotourism, marketing its natural splendour under the slogan 'God's own country'. The very significance of the strategy is that projects focusing ecotourism have high capacity to generate employment, which is vital for a state like Kerala where most of the agriculture labours are loosing their livelihoods due to the rapid shift from agro based economy to more service-oriented one. Such ecotourism projects are also vital to the state, because that can help conserve natural settings and ecosystems. As noted earlier wetlands in the state are vanishing day after day to real estate developers who fill up the area disregarding the unvalued ecological services that the society derives from those ecosystems. In this regard Ecotourism projects on wetlands may help conserving them. However, such projects need to be extremely sensitive to the sensitivities and carrying capacity of the systems so that the ecotourism activities themselves do not pose threat. The presently proposed *Sarovaram* project needs to be examined in this back ground.

2.0 THE SAROVARAM PROJECT

2.1 Background

M/s Tourism (Resorts) Kerala Limited (TRKL), a Government of Kerala enterprise, has identified 262.14 acres of land in Kottuli Panchayath located north of the National Highway (NH 17) bye pass road lying along the eastern boundary of the Kozhikode (Calicut) City (Figure 1). The wetland at Kottuli is one among the 94 wetlands of national importance identified by the Government of India for conservation action under National Wetland Conservation Programme (MoEF, 2006-2007). The 'Connolly' canal, built in 1848 by the then district collector and later known after him, flows adjacent to the wetland forming its South-western boundary. The wetland is perennial, and is linked to the Connolly canal. *Nedungottur*, *Chevayur* and *Nellikkode* panchayaths forms northwest, northeast, and southeast boundaries respectively of the project location (Figure 2). The channel, built to facilitate inland water transport, connects the northern *Korapuzha* River with the southern *Kallayipuzha* River, for centuries the lifeline of the renowned timber business centre (Figure 1). However, in recent years, the canal has degenerated to an urban sewer, stagnant with municipal and other filth.

The *Sarovaram* Project area comprises of wetlands (260 acres) and vegetated / forested dry land (13 acres). Since the water bodies in the project area are connected with Connolly canal, the water is highly brackish, and supports a few species of mangroves. Except for some uninhabited houses, the project area is generally devoid of any human settlement. The people living in the surrounding area belong to middle class and none of them are totally dependent on the wetland for a livelihood or as a source of indispensable or essential supplementary income.

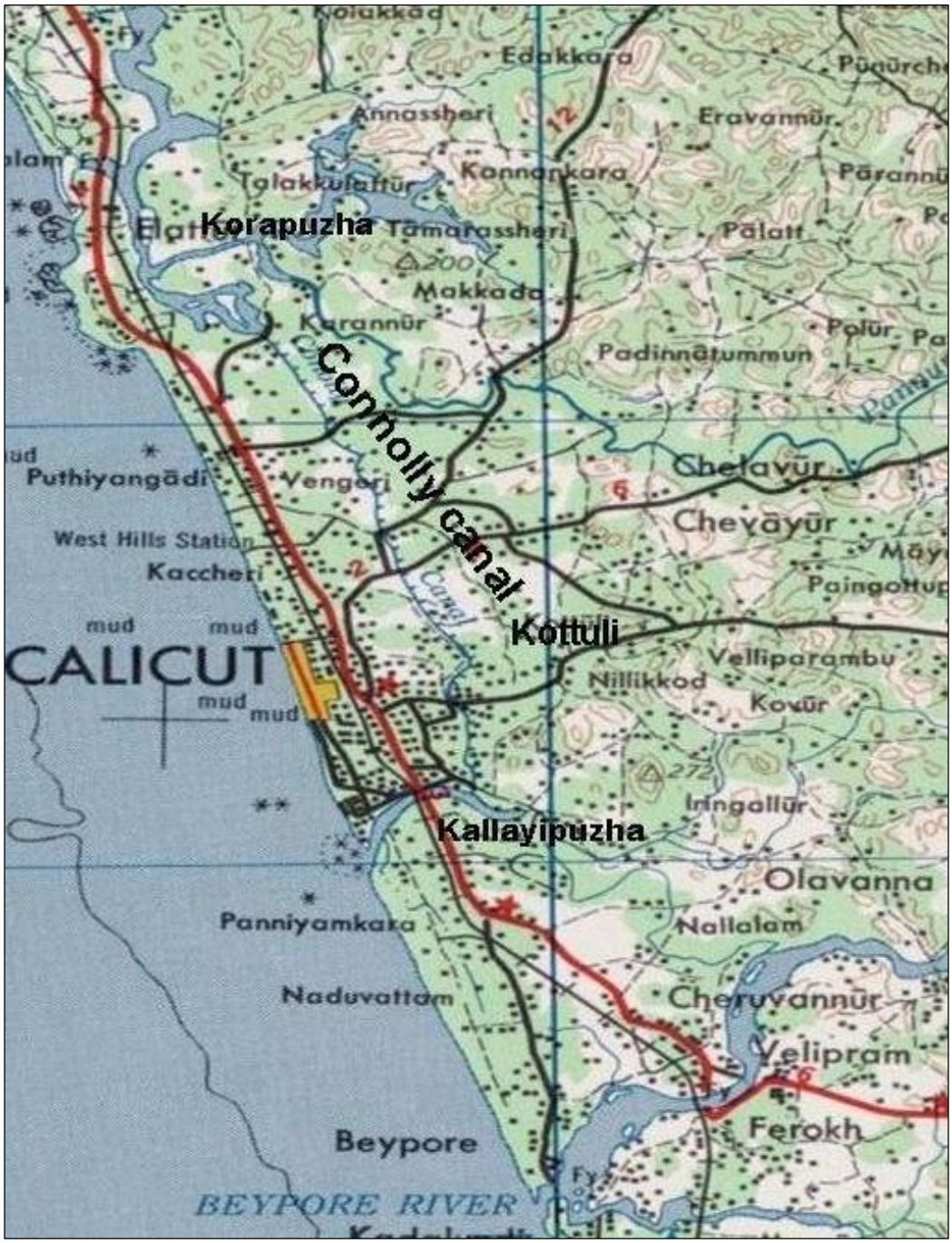

Figure 1. Location of the Connolly Canal, and the Kottuli wetland (courtesy: US Army Map Services)

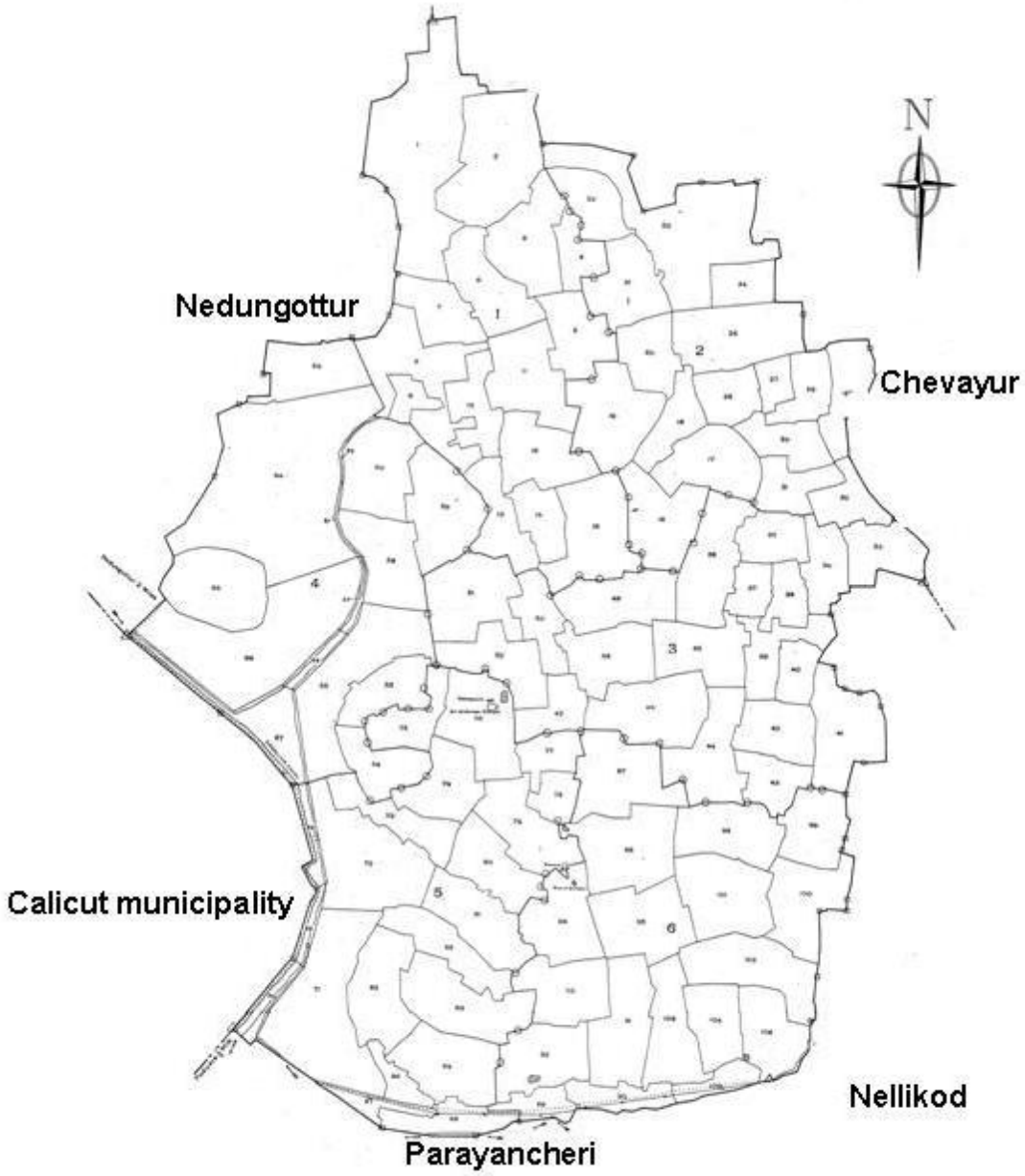

Figure 2 Kottuli Panchayath where the project is located (Source M/s TRKL)

2.2 The project

The prime objective of the *Sarovaram* project is to develop an ecotourism centre, in the Kottuli wetlands (Figure 3). Ecological value addition and conservation of the remnant urban wetland in Kozhikode, a major city in the north Kerala, are the ancillary objectives. It is intended that conserving the area, the mangroves and associated biodiversity, will help maintain the hydrodynamics of the place, and will directly enhance the ecological value of the city.

The project envisages building a tourism complex over the area. Facilities that are proposed includes vehicle parking area, shopping plaza, restaurant, courtyard, facilitation centre, interpretation centre, amphitheatre, bird sanctuary, butterfly park, observation towers, water park, otter park, children's play spots, toilets and musical dancing fountain. The area will be appropriately landscaped to accommodate these facilities. The TRKL aspires to complete building the project with low level of negative impact on the environment. The proposal also aims to promote participation of the locals.

2.2.1 Infrastructure

According to the basic plan conceived by M/s TRKL six different zones are distinguished in the entire project area (Figure 4, Appendix 1). The zone 1 (area) accommodates a green belt of trees developed with local participation. The zone 2 is a 2.5 km long stretch of trek path parallel to the Connolly canal. The history of the canal, of almost two centuries, will be demonstrated and rendered along the walkway.

The zone 3 (Area) accommodates the tourism complex with parking area, shopping plaza, restaurant, courtyard, facilitation centre, interpretation centre, amphitheatre, bird sanctuary, butterfly park, observation tower, water park, otter park, children's play area, musical dancing fountain and toilet facilities. General landscaping fitting the expected ambience is proposed in this zone.

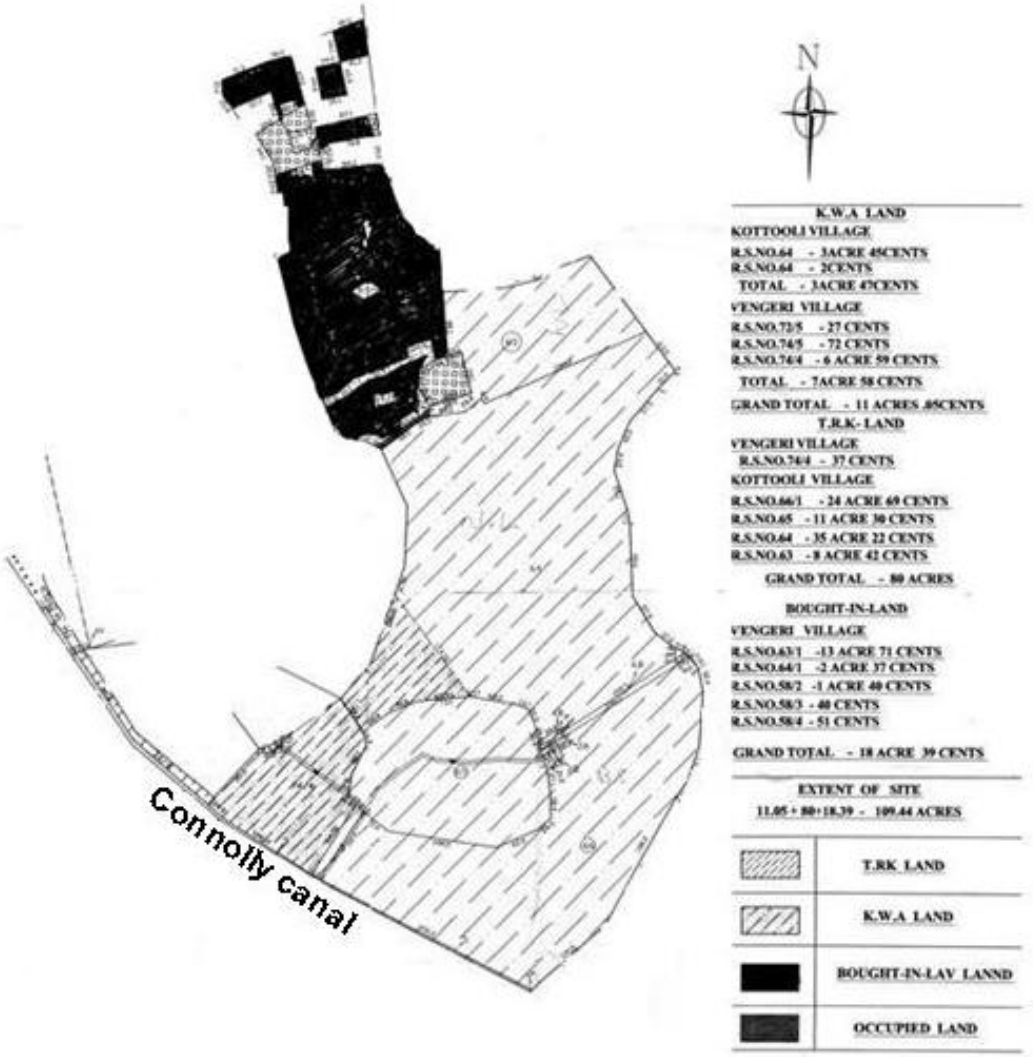

Figure 3 The site plan of the project located in Kottuli Panchayath (Source M/s TRKL)

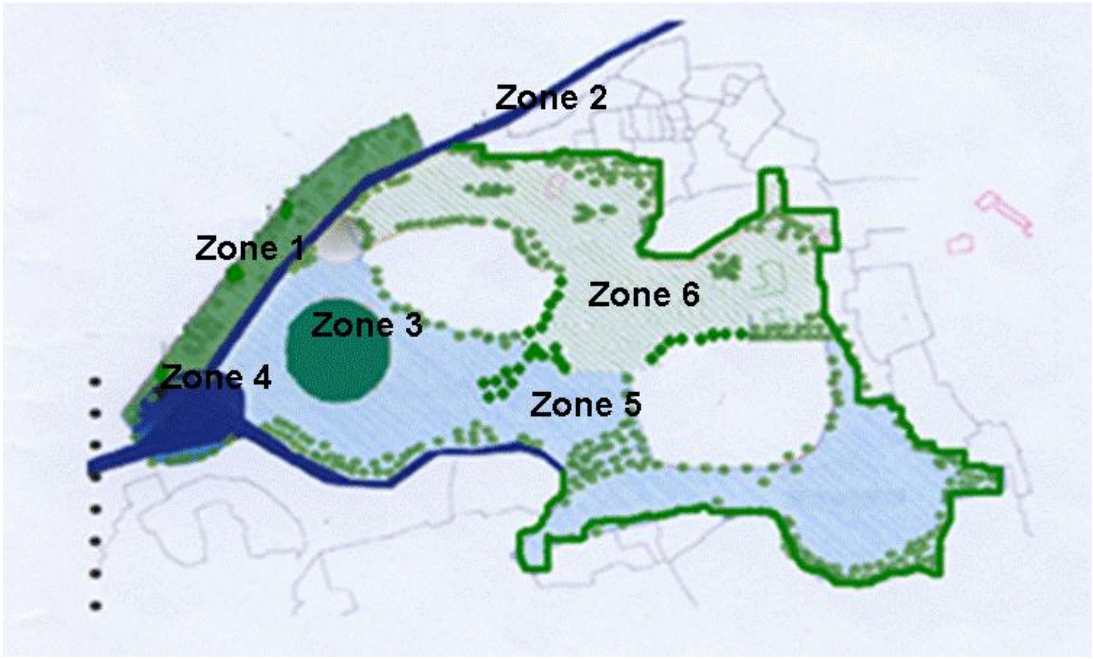

Figure 4. Zonation in the project area (Source M/s TRKL)

Plate 1 A view of the Kottuli wetland

The *Kalipoika*, the open water body in the wetland, is located in the Zone 4. Coracles and boats will be provided in the *Kalipoika*. In the zone 5 a bird park and bird interpretation centre is proposed. An observation tower to watch birds will be built in this zone. The Zone 6 will have a boardwalk through the mangrove patches and an interpretation centre.

2.2.2 Investment

As per the proposed schedule the entire works of the project will be completed in about five years, at a total investment of Rs 1750/- lakhs. The project aims to serve an average of 500-600 visitors per day. The total income from the ecotourism centre is projected to be about Rs 350/- lakhs per annum, of which about Rs 225/- lakhs will be the annual return on the investment.

2.3 The present study; Scope and objectives

M/s TRKL, the promoters of the Ecotourism project at Kottuli wetlands, wishes to undertake an ecological documentation of the proposed ecotourism project site at Kottuli and requested the expertise of Sàlim Ali Centre for Ornithology and Natural history (SACON), Coimbatore.

The broad scope of the study undertaken by SACON includes examination of the proposed *Sarovaram* Eco tourism project from the viewpoint of biological and ecological set-up. The major objectives of the study are,

- Assess the flora in the project area,
- Assess the fauna in the area emphasising on avian species,
- Identify probable impacts from the project to the biological and ecological environment, and
- Prepare an ecological management plan for the ecotourism project.

3.0 METHODOLOGY

Documentation of biodiversity in a project area and its immediate surroundings is advisable in the case of any developmental projects, to ensure that ecological setup of the area do not degrade and in effect is improved. In the case of projects that aim at ecological value addition of a location, conservation of an ecosystem such as wetlands, and promoting non-consumptive use of environmental resources it is imperative to record the ecological baseline information. For understanding the impact of a proposed project, it is better to prioritize the conservation issues, in terms of flora and fauna, in addition to other base line parameters.

To collect data and information on specific components of the ecological system and pertinent issues widely used standard scientific methods were adopted. Rapid field surveys were undertaken during February to June 2008 for collecting relevant data.

The avian fauna in and around the wetland was documented by surveying during early morning (06:00 to 10:00 hrs) and evening (17:00 to 19:00 hrs). Random walks as well as circular plots were used to document the species.

To document the vegetation of the area and conduct floral enumeration, quadrat method was followed. However, the mangrove patches being discontinuous no quadrats were laid in those patches. In other types of vegetations, quadrats of three sizes were laid. For recording the trees, the quadrats of 10 x 10 m were used. All individual plants having more than 10 cm GBH (Girth at Breast Height) were included in the tree category. Plots of 5 x 5 m and 1 x 1 m were laid within each tree quadrat at its each corner to record the shrubs and herbs respectively. A total of 12 quadrats for trees (1200 m^2), and 48 quadrats each for shrubs and herbs (1200 m^2 and 48 m^2 respectively) were laid. In each quadrat, species and their number were recorded. Specimens of the plants, which could not be identified or confirmed in the field, were collected, preserved using standard methods and

identified later. Certain species were confirmed at the Botanical Survey of India (Southern circle), Coimbatore. Plants were identified using the flora volumes such as Gamble (1916-1935, 1957), Matthew (1987, 1989), Manilal and Sivarajan (1982), Murthy and Venu (2005), Manilal and Raveendrakumar (1998), Ahmedullah and Nayar (1987), Sreekumar and Nair (1991), Ramachandran et al (1986), Manilal (1988), Ramachandran and Nair (1988), Vajravelu (1990), Mohanan and Henry (1994), and Sasidharan and Sivarajan (1996). Abundance, relative abundance, density and relative density of each species were calculated using the numerical data (Ludwig and Reynolds 1988, Lande 1996, Smith and Wilson 1996). The data were used for analysing secondary parameters such as density, frequency and abundance using standard phytosociological methods (Table 1). The Shannon-Wiener's index of diversity (H') was calculated using the software 'Species diversity and richness (version 2.65)'.

Table 1: Estimation of phytosociological parameters	
1	Frequency (%) = (Number of quadrats of occurrence of the species X 100) / Total number of quadrats sampled
2	Abundance = Total Number of individuals of the species / Number of quadrats of Occurrence
3	Density = Total Number of individuals of the species / Total number of quadrats sampled
4	Relative Frequency = (Frequency of the given species X 100) / Sum of all frequencies
5	Relative Density = (Density of the given species X 100) / Sum of all densities
6	Relative Abundance = (Abundance of species X 100) / Sum of all abundances
7	Basal Area = $(GBH)^2 / 4\Pi$
8	Dominance = Total Basal Area / Total area sampled
9	Relative Dominance = (Dominance of given species X 100) / Dominance of all species
10	Important Value Index (IVI.) = Relative Density + Relative Frequency + Relative Dominance

In order to find out the people's opinions on the project a brief socio-economic survey was also conducted. Randomly selected individuals from various locations of the city were presented about the project and their responses were elicited. To reduce / avoid bias in terms of professional or any other interests of the respondents we contacted almost equal samples from people engaged in different occupations.

4.0 OBSERVATIONS

During the field work observations were made on various aspects related with the project and its location such as the potentials of the area for tourism especially ecotourism, biodiversity in the area, over all environmental issues in the context of the project and the response of the local public on the implementation of the project and its implications. The salient observations are briefed below.

4.1 The location and its tourism potentials

Kerala is said to be one among the fifty '*must see destinations*' in the world (Jacob 2003). Its unique landscape, climate, culture, festivities, and tradition coupled with varied, fascinating and splendorous environmental backdrop make Kerala one of the popular tourist destinations. In addition to the picturesque landscape, greenery, and backwaters, traditional ayurvedic rejuvenation centres labelled under 'medical tourism' make tourism a promising industry in the state. In 2006 the state earned Rs.6880/- crores from tourism (Figure 5, www.keralaplanningboard.org).

The average annual growth rate of foreign tourist arrival from 1991 to 2006 in the state is 25 percent and that of domestic tourist 35 percent (www.keralaplanningboard.org). The exotic beaches, traditional art galleries and museums make the Calicut city as a tourist destination in the tourist circuit. The tourist statistics shows a percentage increment in the total foreign tourists reaching Kerala visiting Calicut (Figure 6). Although, during 2006 the domestic tourist arrival in Kozhikode is lesser than that of 2005, a noticeable increment in the foreign tourist arrival to the city was seen (Figure 7). In this context the proposed eco-tourism project will be offer Calicut higher recognition in the world tourism map.

The third most populated city in the state, Kozhikode (Calicut) is well known as a prominent trading centre catering the needs of almost half of the state. As per the 2001

census, the city of 84.29 Km^2 has 436556 people (Figure 8). In 1866 when the Kozhikode municipality was formed it spread 19.9 km^2 and had a population of 36,602 people under its jurisdiction. The city was famous for cotton, silk, spices and other goods, during the medieval period, having historical trade relation with China and Middle East. The city enjoys generally humid climate with warm summer extending from March to May. Both the monsoons are active here bringing in an average annual rainfall of 3266 mm.

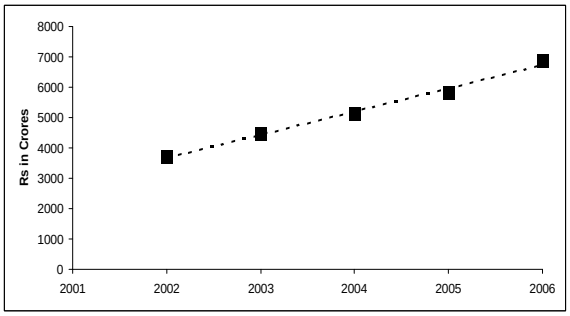

Figure 5 Earning from tourism Kerala state

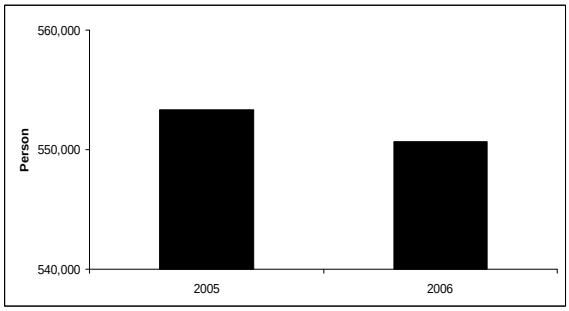

Figure 6 Domestic Tourist arrival in Calicut

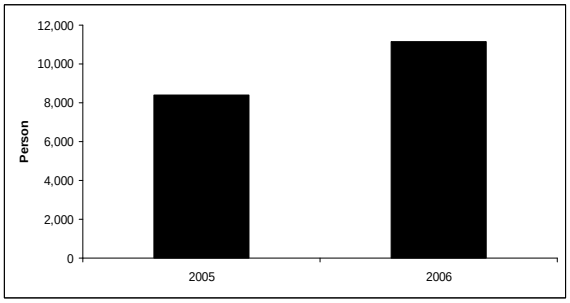

Figure 7 Foreign tourist arrival in Calicut

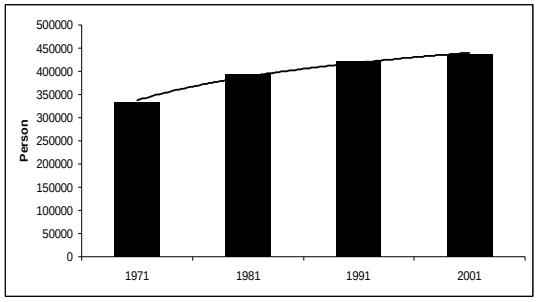

Figure 8 Decadal population growth, Calicut city

4.2 Vegetation in the project area

From the Kottuli wetlands, the total number of mangrove species recorded during the present study was 5 and mangrove associated species recorded was 29 (Appendix 2, Plate 2, Plate 3 and Plate 5). In total during the present study, we could record a total of 240 floral species, belonging to 85 families and 198 genera. Of the 240 species of plants, 8 species were climbers, 3 epiphytes, 8 ferns, 16 grass, 47 herbs, 11 sedges, 26 shrubs, 6 stragglers,

18 sub-shrubs, 85 trees, 2 twinners and 10 vines. The family with largest number of species was Fabaceae, having 20 members growing in the project area.

Plate 2. Pneumatophores growth in a mangrove patch

Plate 3 *Excoecaria agallocha* –milky mangrove

Among the aquatic vegetation in the project area the most striking ones attention were mangrove species such as *Acanthus ilicifolius, Aegiceras corniculatum, Avicennia* sp. and *Excoecaria agallocha*. However, as mentioned earlier the mangrove patches were discontinuous, although the most noticeable feature in the area. The common mangrove associates seen here were *Barringtonia acutangula, Brachiaria distachya, Cerbera odollam, Clerodendrum inerme, Crinum defixum, Derris scandens, Derris trifoliata, Dolichandrone spathacea, Fimbristylis cymosa, Fimbristylis ferruginea, Hibiscus tiliaceus, Ipomea pes-caprae, Melastoma malabathricum, Morinda citrifolia, Pandanus odoratissimus, Pongamia pinnata, Premna serratifolia, Sphaeranthus indicus, Terminalia catappa* and *Wedelia chinensis*. The mangrove ferns, *Acrostichum aureum* and *Stenochlaena palustris* were seen widely along the banks of the wetland.

Several hydrophytes were recorded from the wetland. The common marshy or hydrophyte species were *Centella asiatica, Eichhornia crassipes, Hygrophila sp., Ipomoea aquatica, Lemna perpusilla, Nymphaea nouchali, Nymphoides indica, Salvinia molesta, Spirodela polyrhiza* and *Typha angustata.* The water fern, *Ceratopteris thalictroides* (Plate 6) was also recorded from the wetland.

Several weedy colonising species such as *Ageratum conyzoides, Chromolaena odorata, Lantana camara* and *Mimosa pudica* were seen in the area. The garden plants, avenue trees and the cultivated species included *Acacia auriculiformis, Adenanthera pavoniana, Anacardium occidentale, Caryota urens, Cassia* sp., *Cocos nucifera, Erythrina* sp., *Ficus* sp., *Garcinia gummi-gutta, Ixora* sp., *Lagerstroemia reginae, Mangifera indica, Melaleuca* sp., *Plumeria rubra, Psidium guajava, Samanea saman, Tamarindus indica* and *Vernonia elaeagnifolia*,

Nearly 35% of the total number of species recorded from the area was tree species. The common tree species recorded were *Adenanthera pavoniana, Anacardium occidentale, Artocarpus* sp., *Bombax malabaricum, Bridelia* sp., *Canthium* sp., *Cassia* sp., *Cocos nucifera, Dolichandrone spathacea, Erythrina indica, Ficus* sp., *Garcinia gummi-guttata, Gliricidia sp., Leucaena leucocephala, Mallotus philippensis, Mangifera indica, Mimusops elengi, Peltophorum pterocarpum, Plumeria rubra, Pongamia pinnata, Samanea saman, Strychnos* sp., *Tectona grandis, Terminalia catappa* and *Ziziphus* sp. The highest IVI values for tree species (Table 2) recorded in the quadrats laid for enumeration of the floral species were for *Cocos nucifera* (89.6) followed by *Tectona grandis* (81.9). As indicated earlier as no phyto-sociological data were collected using quadrats in mangroves, since they were distributed in small patches or clusters those species could not be represented in terms of their IVIs. The Shannon-Wiener index (H') of species diversity for trees was 2.33.

Shrub species recorded common in the area were *Abutilon* sp., *Ageratum conyzoides, Antidesma* sp., *Aristolochia indica, Cerbera odollam, Chasalia ophioxyloides, Chromolaena odorata, Clerodendrum inerme, Colocasia esculenta, Derris trifoliata, Duranta repens, Grewia* sp., *Hibiscus* sp., *Ixora* sp., *Lantana camara, Morinda citrifolia, Naregamia alata, Pandanus odoratissimus, Stachytarpheta jamaicensis* and *Ziziphus oenoplia.* High IVI values for shrubs (Table 3) were found for *Grewia* sp. (51.5), *Chromolaena odorata* (35.5), *Ziziphus oenoplia* (23.4) and *Hibiscus* sp. (18.0). The Shannon-Wiener index (H') of species diversity for shrubs was 2.11.

The dominant herbs were *Alysicarpus* sp., *Brachiaria* sp., *Centella asiatica, Cleome* sp., *Crotalaria* sp., *Cyperus* sp., *Desmodium* sp., *Eichhornia crassipes, Fimbristylis* sp., *Mimosa pudica, Scoparia dulcis, Sida* sp., *Sphaeranthus indicus, Tridax procumbens, Vigna* sp. and *Wedelia chinensis*. High IVI values among herbs were found for *Mimosa pudica, Brachiaria distachya, Vigna* sp. and *Desmodium* sp (Table 4). The Shannon-Wiener index (H') of species diversity for herbs was 2.25.

Plate 4 A view of the wetland

Plate 5 *Dolichandrone spathacea* – a mangrove associate

Table 2. Quantitative analysis of the terrestrial tree species (GBH ≥ 10 cm) in the study area										
No	Species	F	A	D	RF	RA	RD	BA	Rdom	IVI
1	*Anacardium occidentale*	8.33	1.00	0.08	2.33	3.39	1.23	0.04	0.10	3.66
2	*Artocarpus* sp.	8.33	1.00	0.08	2.33	3.39	1.23	0.03	0.07	3.63
3	*Averrhoa carambola*	16.67	1.00	0.17	4.65	3.39	2.47	0.12	0.27	7.39
4	*Bombax malabaricum*	16.67	1.00	0.17	4.65	3.39	2.47	0.12	0.27	7.39
5	*Borassus flabellifer*	8.33	1.00	0.08	2.33	3.39	1.23	0.30	0.68	4.24
6	*Caryota urens*	8.33	1.00	0.08	2.33	3.39	1.23	0.01	0.02	3.58
7	*Cocos nucifera*	66.67	2.75	1.83	18.60	9.33	27.16	19.21	43.83	89.59
8	*Erythrina variegata*	16.67	1.00	0.17	4.65	3.39	2.47	0.44	0.99	8.11
9	*Ficus* sp.	25.00	1.33	0.33	6.98	4.52	4.94	0.47	1.06	12.98
10	*Macaranga peltata*	16.67	1.00	0.17	4.65	3.39	2.47	0.17	0.38	7.50
11	*Mallotus* sp.	8.33	1.00	0.08	2.33	3.39	1.23	0.01	0.02	3.58
12	*Mangifera indica*	16.67	2.00	0.33	4.65	6.78	4.94	2.40	5.47	15.06
13	*Peltophorum pterocarpum*	25.00	1.67	0.42	6.98	5.65	6.17	0.09	0.20	13.35
14	*Phyllanthus emblica*	8.33	1.00	0.08	2.33	3.39	1.23	0.02	0.05	3.61
15	*Plumeria rubra*	8.33	1.00	0.08	2.33	3.39	1.23	0.07	0.16	3.72
16	*Samanea saman*	25.00	1.33	0.33	6.98	4.52	4.94	0.87	1.99	13.90
17	*Sterculia guttata*	8.33	1.00	0.08	2.33	3.39	1.23	0.12	0.28	3.84
18	*Strychnos potatorum*	8.33	2.00	0.17	2.33	6.78	2.47	0.21	0.48	5.27
19	*Tectona grandis*	41.67	4.40	1.83	11.63	14.92	27.16	18.89	43.10	81.89
20	*Terminalia* sp.	8.33	1.00	0.08	2.33	3.39	1.23	0.26	0.59	4.15
21	*Trichilia* sp.	8.33	1.00	0.08	2.33	3.39	1.23	0.00	0.00	3.56
F=Frequency, A=Abundance, D=Density, RF=Relative Frequency, RA=Relative Abundance, RD=Relative Density, D=Dominance, RDom=Relative Dominance, IVI= Importance Value Index, Shannon-Wiener Index (H') = -Σpi Ln pi = 2.33										

Table 3. Quantitative analysis of the shrubs in the study area								
No	Species	F	A	D	RF	RA	RD	IVI
1	*Abutilon* sp.	4.17	1.50	0.06	1.20	1.25	0.24	1.45
2	*Antidesma menasu*	29.2	2.36	0.69	8.43	1.96	2.69	11.1
3	*Antidesma* sp.	6.25	3.33	0.21	1.81	2.77	0.82	2.62
4	*Arisaema* sp.	6.25	3.00	0.19	1.81	2.49	0.73	2.54
5	*Aristolochia indica*	8.33	33.8	2.81	2.41	28.1	11.0	13.4
6	*Barringtonia acutangula*	2.08	1.00	0.02	0.60	0.83	0.08	0.68
7	*Cassia* sp.	2.08	1.00	0.02	0.60	0.83	0.08	0.68
8	*Cerbera odollam*	2.08	2.00	0.04	0.60	1.66	0.16	0.77
9	*Chasalia* sp.	6.25	6.33	0.40	1.81	5.27	1.55	3.36

10	*Chromolaena odorata*	56.3	8.70	4.90	16.3	7.24	19.2	35.5
11	*Colocasia esculenta*	12.5	3.33	0.42	3.61	2.77	1.63	5.25
12	*Crotalaria* sp.	4.17	2.50	0.10	1.20	2.08	0.41	1.61
13	*Cyperus* sp.	2.08	1.00	0.02	0.60	0.83	0.08	0.68
14	*Dendrocalamus strictus*	2.08	1.00	0.02	0.60	0.83	0.08	0.68
15	*Derris trifoliata*	2.08	2.00	0.04	0.60	1.66	0.16	0.77
16	*Duranta repens*	12.5	1.67	0.21	3.61	1.39	0.82	4.43
17	*Grewia* sp.	72.9	10.6	7.75	21.1	8.84	30.4	51.5
18	*Hedychium* sp.	20.8	9.50	1.98	6.02	7.90	7.76	13.8
19	*Hibiscus* sp.	25.0	10.9	2.73	7.23	9.08	10.7	17.9
20	*Ixora* sp.	4.17	4.00	0.17	1.20	3.33	0.65	1.86
21	*Morinda citrifolia*	10.4	4.20	0.44	3.01	3.49	1.71	4.73
22	*Pandanus odoratissimus*	2.08	1.00	0.02	0.60	0.83	0.08	0.68
23	*Physalis minima*	2.08	1.00	0.02	0.60	0.83	0.08	0.68
24	*Ziziphus oenoplia*	50.0	4.54	2.27	14.46	3.78	8.90	23.4
F=Frequency, A=Abundance, D=Density, RF=Relative Frequency, RA=Relative Abundance, RD=Relative Density, IVI= Importance Value Index, Shannon-Wiener Index (H') = -Σpi Ln pi = 2.11								

Table 4. Quantitative analysis of the herbs in the study area

No	Species	F	A	D	RF	RA	RD	IVI
1	*Alysicarpus* sp.	4.17	36.0	1.50	1.74	13.0	3.76	5.50
2	*Brachiaria distachya*	43.8	17.8	7.79	18.3	6.45	19.6	37.8
3	*Brachiaria* sp.	6.25	23.3	1.46	2.61	8.45	3.66	6.27
4	*Cayratia pedata*	4.17	1.00	0.04	1.74	0.36	0.10	1.84
5	*Centella asiatica*	4.17	26.5	1.10	1.74	9.59	2.77	4.51
6	*Cicer arietinum*	2.08	1.00	0.02	0.87	0.36	0.05	0.92
7	*Cyperus* sp.	2.08	5.00	0.10	0.87	1.81	0.26	1.13
8	*Desmodium* sp.	16.7	14.5	2.42	6.96	5.25	6.06	13.0
9	*Desmodium triflorum*	12.5	13.83	1.73	5.22	5.01	4.34	9.56
10	*Fimbristylis* sp.	4.17	4.50	0.19	1.74	1.63	0.47	2.21
11	*Grewia* sp.	8.33	8.50	0.71	3.48	3.08	1.78	5.26
12	*Hibiscus* sp.	4.17	5.00	0.21	1.74	1.81	0.52	2.26
13	*Jasminum* sp.	18.8	4.44	0.83	7.83	1.61	2.09	9.92
14	*Justicia* sp.	2.08	2.00	0.04	0.87	0.72	0.10	0.97
15	*Lindernia* sp.	6.25	17.7	1.10	2.61	6.40	2.77	5.38
16	*Mimosa pudica*	45.8	20.3	9.29	19.1	7.34	23.3	42.4
17	*Phyllanthus fraternus*	2.08	2.00	0.04	0.87	0.72	0.10	0.97
18	*Ruellia* sp.	14.6	13.6	1.98	6.09	4.91	4.97	11.1

19	*Sida acuta*	2.08	1.00	0.02	0.87	0.36	0.05	0.92
20	*Sida rhombifolia*	2.08	6.00	0.13	0.87	2.17	0.31	1.18
21	*Tephrosia* sp.	4.17	1.50	0.06	1.74	0.54	0.16	1.90
22	*Vigna* sp.	20.83	38.80	8.08	8.70	14.05	20.28	28.98
23	*Wedelia chinensis*	8.33	12.00	1.00	3.48	4.34	2.51	5.99
F=Frequency, A=Abundance, D=Density, RF=Relative Frequency, RA=Relative Abundance, RD=Relative Density, IVI= Importance Value Index, Shannon-Wiener Index (H') = -Σpi Ln pi = 2.25								

4.3 Birds and other fauna

The wetlands of Calicut are reported to rich in aquatic organisms (Seedikkoya, 2003), that includes several insects, gastropods, amphibians and reptiles. Local fishermen reports about nine species of fishes from the Kottuli wetlands, which do not include several so called weed fishes and therefore the ichthyofauna is likely to have larger number of species. The area does not have any large wild mammals. During our brief surveys we could only see some species such as common mongoose (*Herpestes* sp.), toddy cats (*Paradoxerus* sp.), common squirrels (*Funambulus* sp) and jackals. Dogs and vermin such as rats are common.

Since the present study was emphasising on avifauna in the area no attempt was made to scientifically survey lower animal taxa. The wetland and the mangroves provide habitats for several species (Plate 7). During our survey, the total bird species recorded in and around the wetland were 69, which include 29 aquatic and 40 terrestrial species (Appendix 3). Of this, 9 species are migratory birds.

4.4 Public opinion on the project

The cumulative changes from the multifarious activities taking place in the project area are likely to have its impacts on the local people on their socio economic status. The present ecotourism project is likely to directly employ several skilled and semi-skilled labourers, largely during its execution and to a lesser number during its operation. The local public will be benefited directly and indirectly in quite a few associated activities. Many youngsters have chance of learning more about nature as tourist guide, and get the

opportunity to disseminate their knowledge and to take part directly in nature conservation related activities. The project is expected to support tourist-based sector including taxi / auto drivers, merchants, tourist home services, travel booking services and hotels directly. The indirect beneficiaries include those involved in real estate business, currency exchange services, property managers, shop keepers and skilled workers.

As noted earlier in our brief survey of people's opinion, we could obtain patient responses from 100 randomly selected people. 89% of the respondents supported the project assumptive that it will boost up the development of the state in general and the city in particular. Only 5% of the respondents were aware of the need for conserving their local biodiversity and the project's implication on the same. Those responding in unconcerned manner (6%) were either not aware of the project or do not have any special regards for any such projects (Figure 9) or were not touched upon by such issues.

Plate 6 Water fern – *Ceratopteris* sp.

Plate 7 Mangroves provide abode for birds and other species

Those respondents, who opposed the project (5%), were largely sceptical about such projects and expressed firm opinion on the malfunctioning, ill management, and corruption associated with such projects. They put forth the example of the present status of Mananchira Square in the city. People's annual income and their opinion were not found to be related. However, people involved in careers with occupations related more with tourism, travel or sales such as auto/ taxi drivers and textile shop owners had positive attitude towards the project.

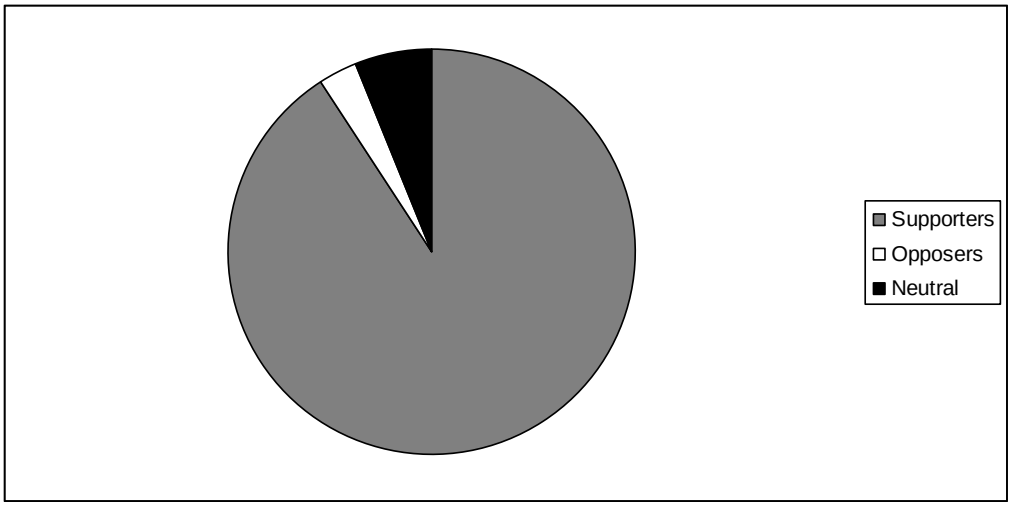

Figure 9. Peoples opinion on Sarovaram Eco- tourism project

Majority of the people expect varying increments in their annual income as the project comes to fruition. Only 4% of the people expected more than 50% increase in their annual income. 23% of the respondents did not expect any benefit from the project (Figure 10).

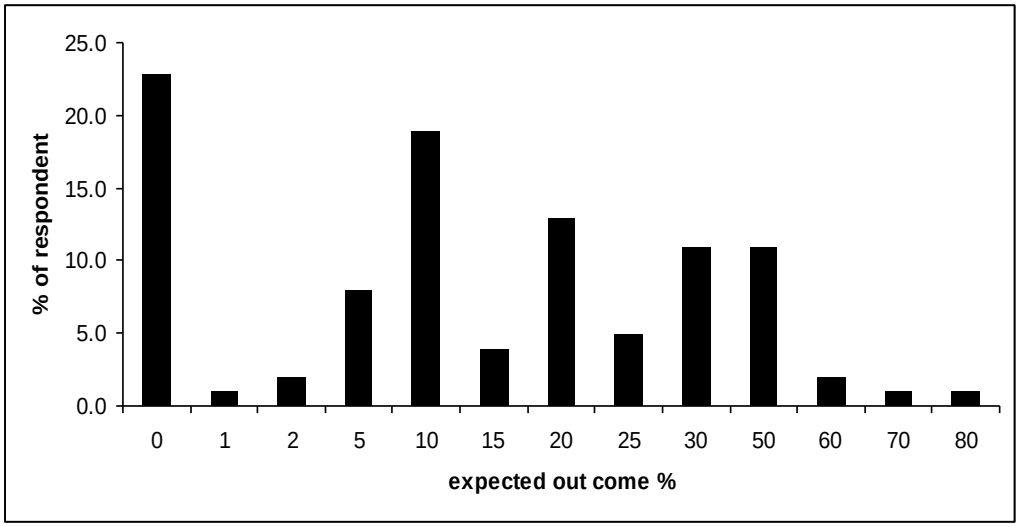

Figure 10.Expected out come from the project

5.0 ENVIRONMENTAL ISSUES

Wetlands are valuable habitats for numerous faunal and floral species of which several are rare and threatened. In the case of Kottuli wetland, mangroves are the ones, which are of highest explicit importance, and any form of disturbance to the habitat will be irreparable and loss to several aquatic lives. Mangroves are well known for their valuable ecological services, including being the breeding and spawning ground for several species. Wetlands absorb excess nutrients, sediments, and other pollutants, and act as sink in most of the cases. The Kottuli wetland being located in the heart of the historical and growing city, Calicut, is increasingly facing threats from ongoing developmental changes happening in the city, which in due course of time will decimate its biodiversity and ecological quality and values. It may be noted that the Kozhikode city has grown to its present glory over filled up wetlands. Several arterial roads, building complexes, hospitals and residences are raised on locations that were formerly wetlands or paddy fields that were abandoned for mounting real estate demands, a reflection of the situation in most of the whole state. The low lying wetlands, upon which the city has grown, were inundated throughout or at least for a notable period of the year. With bustling development activity, the city in the coming few years will lose all its low lying areas, wetlands and such natural habitats along with several of the bird and animals species, if appropriate conservation measures are not adopted. Along with the disappearing wetlands the city and its surroundings will also be deprived of the valuable ecological goods and services they offer.

The present *Sarovaram* project is a venture which has its declared aim of conserving the Kottuli wetlands as an 'integrated model to achieve sustained conservation'. The project proposal by the Kitco consultants lists out several aspects of the proposed project. It appears that if implemented and appropriately taken care of, the *Sarovarum* project is a step towards effectively buffering such changes in the city that will diminish the

wetlands. Nevertheless, execution of such a project involve several stages and activities (Table 5) that are likely to have notable environmental perturbations and lead to ecological changes both during its construction and operation phase, and are likely to pose consequential management issues.

	Table 5 Activities related with the project
1	Landscaping
2	Lighting
3	Construction of buildings
4	Construction of amenities, foot paths, entertainment facilities
5	Communication facilities
6	Transport, fuels, parking, foods and other requirements
7	Waste - biodegradable and non biodegradable
8	Safety of visitors, and ecological and environmental safety
9	Staff and support personals (80-100 persons are expected to be employed in the project during its operation)

5.1 Construction activities

The project is conceived for non consumptive use of the local ecological resources by ecological value addition and sustainable development of the ecological resources. It proposes improvement of the recreational and aesthetic values of the area and market it to the public. Interventions have to be made for the purpose and therefore, the project is likely to change the whole appearance of the area. The project envisages several facilities to be built at the location (Table 1 and Appendix 1). Extensive landscaping is proposed to make the location attractive to tourists and operationally convenient.

The establishment of facilities, building, pathways (Plate 8), observations towers and such like involve notable movement of materials and people to the area and intensive activities during the construction. Doubtlessly this is going to alter the local ecological makeup. However, it may be noted that the Kottuli wetlands, located almost in the centre of growing city is under serious physical and environmental threats. Already large scale real estate promoters have acquired lands adjacent to the wetland. It is only a matter of time that these developers fill the areas under their control and erects multi-storeyed

constructions. Unfortunate for the wetlands, any filling activities in the adjacent piece of land has serious repercussions; it totally distorts the functioning of the wetland. Hence, immediate steps have to be taken up to conserve the precious peace of wetland, preferably by ecological value addition and marketing as a recreational facility, since it preserves the ecosystem, provides a safe haven for several species, retains several of the unsung ecological services for posterity and is a source of revenue for the government.

Plate 8 Trek path, across the project site, in advance stage of construction

The ecological disturbance during construction may be minimised by proper scheduling and streamlining the works to bring back an ecological setup as close to the natural. Lessening the disturbances and alterations has to be particularly ensured in the wetland area. The pathway as seen above (Plate 8) is constructed in those areas that had already got altered. Table 6 given below provides a summary of the grading of the impact of the changes / perturbations on the natural system and its select components.

Table 6 Environmental impact evaluation matrix (Construction phase)							
Aspects		Impact on					
		Flora		Fauna			
		Trees	Others	Mammals	Birds	Herpetofauna	Others
Construction	Clearing the land	-	++	-	++	+++	++
	Machinery and materials mobilization	+	++	-	++	++	++
Workforce demands	Transportation	-	-	-	+	+	+
	Communication	-	-	-	+	-	
	Power / Fuel	-	-	-	-	-	
	Supportive infrastructure and other facilities	-	+	+	++	++	++
Note: Grades based on the severity (none to 5) of the impact; "-" denotes no impact and each "+" denotes to increased impact							

5.2 Entry and mixing of municipal sewage and other discharges

The Connolly canal is the only link of the Kottuli wetland to the other perennial water bodies and the Arabian Sea. This canal is essentially the only means of water movement / discharge of sewage and storm water to the sea through Kallayipuzha River. Almost for the last half a century the canal remains nearly not physically contiguous. It is currently a channel into which considerable quantity of municipal and fugitive effluents flow in (Plate 9 and Plate 10). It is no more used as a water way, and instead serves as the major drain for near by hospitals, and commercial / shopping complexes. Several housing / residential projects, commercial / business centres and hospitals are coming up in the nearby localities. This will add on to deteriorating quality of water incoming to the wetland.

The untreated effluent in the channel is likely to have damaging effects on the quality of wetland water and living forms. In a long term perspective this will be damaging the quality and ecological values of the system. The discharge of obnoxious chemicals let out

from various point / fugitive sources to the Connolly canal may lead to high nutrient load, making the wetland eutrophicated. The canal receiving untreated chemical and hospital waste is likely to be a source of pathogens, vectors and a haven for vermin, and a threat to the public health, apart from being prejudicial to the environmental health and aesthetic value of the city.

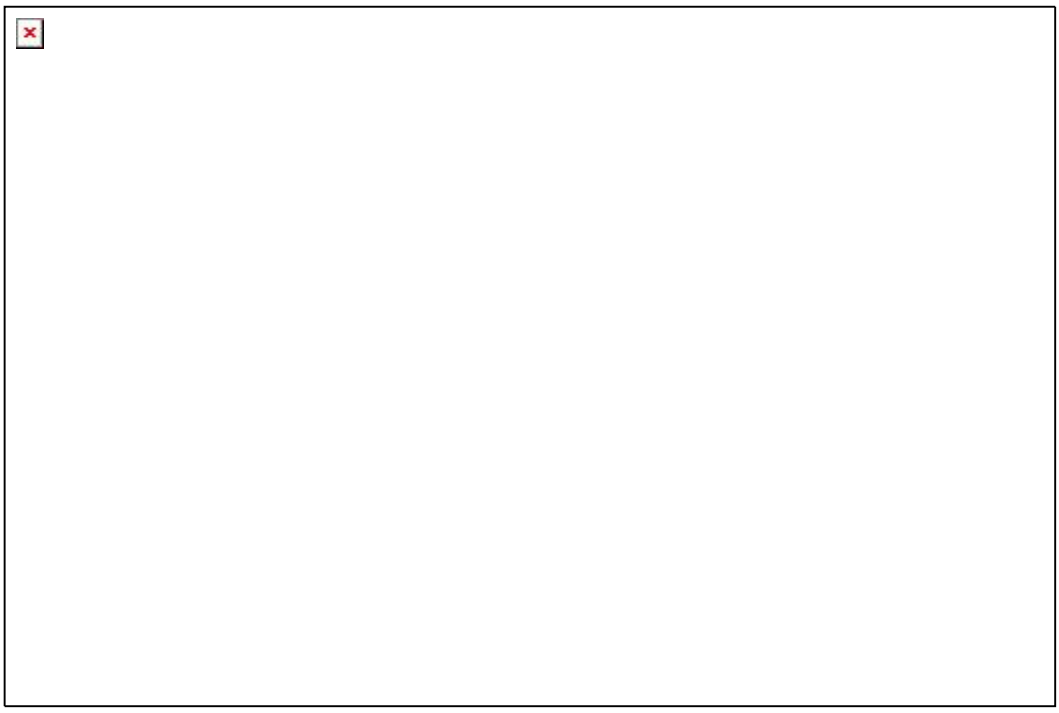

Plate 9 Connolly Canal; a bird's eye view

The local people also voice their annoyance as the polluted water in the Connolly canal is a major environmental problem in the area. 21% of the persons interviewed supported the *Sarovaram* project only because one of the major objectives of the project is renovating the Connolly canal. The *Sarovaram* project has an allocation of Rs. 300 lakhs for sewage treatment plant. Establishment of a sewage treatment plant will help considerably to improve the surface water quality of the canal and the wetland, since the flows entering them will be cleaner after treatment. In brief it is felt that changes expected after the project is operational will be positive to the local environment.

Plate 10 One of the Waste water inlets to the wetland

5.3 Municipal solid waste

Dumping solid waste close by wetlands or water bodies is a common practice in our country. This practice directly and indirectly affects the ecological quality, species richness or species distribution in the receiving ecosystem. The Kottuli wetland is not much an exception to this. Solid waste dumped in different part of the wetland is a major environmental and public health threat and management issue. Municipal waste deposited along the sides of the road leading from the National Highway bye-pass road to Kottuli requires compelling management attention.

Plate 11 Solid waste dumped near *Kalipoika*

5.4 Construction debris

Notable quantities of solid wastes are generated during the construction phase. The waste during specifically the construction phase are packaging materials, spoiled construction materials, wastes from other work related activities, waste produced by the labour force, wastes from vehicles, machineries and such like items left unattended or carelessly disposed off will spoil the wetland in several ways and therefore appropriate measures to handle such wastes need to be identified.

5.5 Weed Infestation

The canal is infested with several obnoxious species such as *Eichhornia crassipes* and *Salvinia molesta*, clogging certain locations in the canal hindering the flow path. Municipal waste discharges into water bodies promotes high growth of such exotic but widely distributed objectionable species. Such weed species act as silt and waste traps, curtail light penetration, add organic load and lead to oxygen deficiency in water. This in

turn affects other taxa of the system such as certain fishes and other submerged / rooted submerged species. It also selectively eliminates certain species that are less tolerant to falling dissolved oxygen, eutrophication and organic pollution stresses. Weed infested water bodies offer key breeding grounds for several vector species such as mosquitoes and pathogens.

Plate 12 *Salvinia* infestation in the surroundings of the project

The proposed project needs to find means to control weeds in and around its operational space and also in its feeder channels and adjacent wetlands. Both physical as well other means of controlling nutrient availability for the weeds need to be adopted to curtail their spread. Sewage treatment plant would help in improving the water quality and prevent colonisation of weeds. Control of weeds may be added benefit derived from the projects on the local environment.

5.6 Loss of biodiversity

Effluents, solid wastes and the like pressures are expected to cause biodiversity loss due to open and careless dumping practices. The mangrove ecosystem, and associated avifauna and the ichthyofauna are the ones which are likely to be affected relatively more by such pressures. The mangroves in the project area are seen in patches or fragments connected among only by trails or tracks. It seems that many species such as prawns that were earlier common here has almost become rare or disappeared, perhaps for the qualitative and quantitative reduction in the mangrove patches and quality changes in the Connolly water.

A recreational and developmental project such as *Sarovaram* project promotes the rise in the real estate (hedonic) values of the surroundings. Escalating demand for adjacent areas and ensuing price rise will adversely affect the wetlands. The wetlands will face serious threat in the form of filling and reclamation. Private entrepreneurs by one or other means will fill up the wetland areas around the project locations to build housing / commercial complexes. That wetland on the southern part of the Sarovaram project is already occupied by large scale real estate venture and is in serious threat of getting filled up. Filling adjacent wetlands will cause habitat loss for several aquatic fauna frequenting that area.

5.7 Automobile exhaust and pollution

The wetland is surrounded by a network of roads. The busy roads especially Eranchippalam bye pass, and the Kottuli road is passage for large number of vehicles. The *Sarovaram* project itself will increase the traffic on the roads. This will add on to rising vehicular pollution; gaseous, suspended particulates and particularly noise. This will have its own implications on both migratory as well as resident species.

5.8 Noise and other disturbances

During the construction phase, the activities involved are likely to make notable noise and dust. Piling for foundation, drilling, sawing and cutting cement tiles add noise pollution. Such intense sounds are deterrent to the birds. Many of the shy birds are known deserting nests and fledglings during such disturbances. During the operation phase the sounds due to the vehicles in the parking zone and the tourists themselves may cause noise and unwelcome sounds.

5.9 Human waste

The exposed mangrove patches of Kottuli wetland are currently locations for open defecation by labourers and local deprived families. This practice makes the area unhygienic. Appropriate steps for providing amenities for the resident deprived communities are needed. The needs of the local labourers involved in construction work should be also addressed properly.

5.10 Activities during operation phase

Attracting tourists is the major commercial aspects of the project. Thus, the project is expected to make financial returns for the investment (to the Government of Kerala through its special vehicle for ecotourism M/s TRKL). The number of visitors / tourists per day to the proposed park is expected to be around 500 to 600. Tourists are likely to carry food packets and other such items with them. The wrappers / waste packets invariably will be dropped in the vicinity of the park / wetland creating unhygienic situation with consequences. Treatment of human wastes also poses an issue to be managed in an ecologically benign manner.

Attracting tourists and serving them well involve a range of processes related to transport, parking vehicles, tourist movement in the Park, providing required amenities to the visitors, proper access to various entertainment facilities for the visitors, and management

of human, food and other solid wastes. The business of attracting tourists and catering to their recreational needs is likely to have its own environmental impacts (Table 7)

The visitors, even in low numbers, may throw solid wastes indiscriminately that can be later seen around sticking in the bushes, wetlands and channels. It is possible to handle biological wastes directly by ecologically benign means such as vermicomposting, provided adequate attention and facilities are given. Handling non-decomposable wastes such as those containing plastic and other such materials requires a different strategy to handle. On an average more than half a kilogram of solid waste including biodegradable as well as non-biodegradable components will be generated per person per day in a premium tourist location. Special strategy has to be adopted for managing these different types of wastes that would amount to ~ 300 Kg per day.

The operation of the park also includes maintenance of the whole setup, monitoring the quality of water, monitoring fauna especially birds, and monitoring the visitors to prevent untoward ecologically damaging actions from them. Tourists, of all ages especially younger ones, normally will be a serious source of pressure to wild species living in the wetlands and Bird Park. Proper guidance and monitoring will help abate the state of affairs. Steering the visitors, either physically or with definite signboards also is necessary.

During the operation phase, vehicles of various types - two, three and four wheelers of different types and makes will be arriving at the centre. Vehicles will add to air pollution, noise, oil spills etc. A parking lot is already identified and appropriate facilities and strategy to manage wastes and other pollutants arising from the parking lot is to be conceived.

The boating facilities can also pose a source of threats to the wetland. This is especially true for mechanised boats; they are a source of gaseous and particulate hydrocarbon in

the water body and will be more noisy and faster to cause stress to the water birds and birds in the banks and nearby trees. Using manually driven boats and coracles will help avoid such issues.

The snack bars, eateries and toilets are another cause of concerns, in terms if discharge of their wastes, smokes and noise. Eateries require attention in terms of large quantities of biodegradable and non-biodegradable waste, and wash water having organic load. Toilets and other such public conveniences also can not handle their liquid and solid wastes carelessly. Appropriate ways to handle these wastes and discharges in an ecologically and environmentally benign manner need to be adopted.

Table 7 Environmental impact evaluation matrix (Operation phase)

Aspects	Impacts on					
	Flora		Fauna			
	Trees	Others	Mammals	Birds	Herpetofauna	Others
Cottages / buildings: Maintenance and operation	-	++	+	+	+	-
Foot paths and other amenities: Maintenance and operation	-	++	+	+	+	+
Waste management	-	+	+	++	+	+
Tourists	+	+	-	++	++	+
Lights	+	+	+	+++	++	+
Staff and personals	-	-	-	+	+	-
Transport	-	-	-	-	-	-

6.0 ENVIRONMENTAL MANAGEMENT

As discussed earlier, the project basically envisages sustainable non-consumptive use of the local ecological resources and the aesthetic value in the area, and ecological value addition of the area by way of its conservation. It is appreciable that the project, as per the project proposal (TRKL 2007), proposes to conserve a wetland in the growing city of Calicut, where all the low lying areas are in a rapid pace of getting filled and converted into built up areas; decimating the natural vegetation and fauna. It is obvious that the ecotourism project at Kottuli wetlands is expected to change the overall appearance of the project location. In consequence, the project is likely to have impact, of both short and long term manifestations, and of reversible and irreversible in nature, on the environment as hinted earlier. Here, an attempt is made to discuss some of the issues that are likely and require timely and appropriate management attention. It is required that the management attention and interventions spreads to the project locations, its overall environs and its surroundings.

6.1 Construction activities

As noted above the project envisages several facilities to be built and extensive landscaping, which involve notable movement of materials and people, and intensive activities during the construction. Undeniably this is going to alter the local ecological makeup.

- Possibly scheduling of construction activities to be completed in a faster pace much before the pre-monsoon showers may reduce the impacts on the resident birds.
- Not touching the existing mangrove species in the wetland may be held as a thump rule during construction. However, plantation of more such species has to be undertaken as mentioned below.

- Dumping of any construction materials in the water logged area need to be avoided. Care may be taken to avoid cement, sand, rubble, bricks, wooden logs, steel and such construction materials spilling over to the water logged areas or its littoral flanks.
- Discarded items and solid wastes such as packing materials may be taken away from the project area and appropriately disposed off at designated locations.
- It is necessary that some areas may be desilted and mangroves species planted.

6.2 Municipal sewage and chemical discharge

The Connolly canal is a source of sewage and other contaminants to the Kottuli wetland. The project proposes renovation of the canal and that will take a long way towards improving the quality of the wetland. During the renovations attention needs to be given to issues mentioned below.

- Clearing the canal all along its course of all the silt and solid wastes accumulated in it.
- Reinforcing its sides and closing all unauthorised discharges to it.
- Establishing desilting basins / silt traps along the channels that drains storm water to the canal.
- Planting trees on the flanks of the canal out side the park is also advisable and this may be executed in collaboration with the forest department, local NGO's, nature clubs, schools, hospitals, business centres and shops.
- Preventing any sewers joining the canal and enforcing appropriate treatment of discharges to the canal.
- Regular monitoring water quality of canal.
- Erecting grids at the entry point of the canal to wetlands to prevent any floating solids' entry. Regular cleaning of these grids is also necessary.
- Enforce treatment requirements on all the commercial complexes, apartments and hospitals. Hospitals need to be specially monitored since their discharges are

hazardous contaminated with discarded drugs, chemicals, tissues, body fluids and pathogens.

- Erecting signposts and guideposts that instruct the pedestrians and other travellers not to throw unwanted items to the channel.
- Control discharge of obnoxious chemicals let out from various unauthorised point / fugitive sources and washouts from fuel outlets.

6.3 Solid waste

Solid wastes in and out of the tourism area need serious management attention. Proper strategy has to be executed to contain scattering solid wastes. Solid wastes enter the wetland through Connolly canal floating in water. During low tides or draw down these materials get stuck in the roots and pneumatophores of mangroves.

- User friendly bins have to be installed in side and out side of the Park. Also it is advisable to disallow carrying plastic bags and disposable packages inside the park.
- Dumping solids wastes packed in polythene carry bags callously nearby water bodies is a common practice in Kerala. This can be prevented by educating locals about the repercussions of the practice, manning the surroundings and warnings and punishments / penalties.
- Municipal waste deposited along the sides of the road from National Highway bye pass road to Kottuli requires immediate stoppage and proper management.
- Proper waste management and treatment programs should be implemented in the Park. Segregated biological wastes may be handled by vermi-composting. Non-decomposable wastes such as plastic and other materials may be sent for recycling or re-processing and appropriate disposal in designated areas away from the wetlands. Burying wastes nearby wetlands may contaminate the water percolating from terrestrial area to wetlands. The contaminants may include even recalcitrant chemicals or heavy metals.

6.4 Weed Infestation

Weed infestation is a serious threat to suburban wetlands, damaging mainly its ecological quality, species composition, and environmental goods and services offered by the wetlands. Weed infestation has to be prevented to improve the wetland.

- The Connolly canal was and can be a source of weeds to the wetlands. Grids of appropriate sizes installed at the entry of the canal to the wetland can control weed infestation to a certain extend.
- Initially physical removal of weeds may be necessary in the wetlands, its surroundings and the channel.
- The noteworthy growth of the water hyacinth *Eichhornia* and *Salvinia* in the Connolly canal and some perennial pools needs to be taken care of. Regular removal of these weeds will help sustain the canal, its habitat quality and species diversity, vegetation structure, water quality, salinity and the like. Other weed species growing along with aquatic vegetation also need to be controlled. Other aquatic species and mangrove associates should be nurtured for the system to thrive well.
- To prevent the seeds and remnants of weeds germinating and colonising again water rich with dissolved nutrients should not flow in. Suitable treatment of municipal sewage and other drainage entering the wetlands to eliminate nutrient enrichment can contain growth of weeds in the wetlands. It is appreciable that budget allocation is made in the *Sarovaram* project to establish sewage treatment facilities. The project authorities should ensure its maintenance and routine operations.
- Regular monitoring of aquatic species in the vicinity of the project area and routine clean up strategy should be strictly followed, to have a check on weed colonisation.

6.5 Loss of biodiversity

- The mangroves in the area are seen in patches and needs to be replenished. Re-vegetation with those species recorded there may be taken up.
- As mentioned earlier the wetland has mangroves in scattered patches of small sizes. Some such patches may be re-united and that may be favourable for several aquatic species. It is also proposed to re-establish links among the separated portion of wetlands, facilitating hydrologic and biological intermixing.
- It is also suggested that certain areas in the park may be desilted and mangroves can be planted.
- Regular regeneration studies of mangrove species in the area may be undertaken to update / watch their growth and regeneration or to make midway corrections in the strategy of plantation.
- Naturally occurring species should be selected for plantation along the canal and other areas. Species which grow in association with mangroves such as *Thespesia populnea, Pongamia pinnata* etc. also may be planted closer to more hydric locations (Table 8). Tree species which are likely to attract birds for nesting and also the herbs which attract butterflies and birds may also be planted. Species other than these to be planted may be those which are likely to absorb more dust and sound. Green belt / more plants including thick and luxuriant bushes along the roads, the surroundings and the parking area would help reducing vehicular pollution. Including large number of plants that largely attract birds will enrich the terrestrial bird fauna.

Table 8 Some plants that may be considered for planting

Along the road / green belt	**In the park**
Adenanthera pavoniana	*Acanthus ilicifolius*
Bauhinia variegate	*Acrostichum aureum*
Bombax malabaricum	*Aegiceras corniculatum*
Canthium dicoccum	*Avicennia marina*
Cassia fistula	*Avicinnea officinalis*
Cassia siamea	*Barringtonia racemosa*

Cipadessa baccifera	*Cerbera odollam*
Ficus drupacae	*Clerodendrum inerme*
Ficus racemosa	*Dendrophthoe falcate*
Ficus religiosa	*Dolichandrone spathacea*
Ficus tinctoria parasitica	*Excoecaria agallocha*
Flacourtia sp.	*Hibiscus tiliaceus*
Grewia sp.	*Pandanus odoratissimus*
Lagerstroemia reginae	*Pongamia pinnata*
Mangifera indica	*Thespesia populnea*
Tamarindus indica	
Mimusops elengi	
Peltophorum pterocarpum	
Plumeria rubra	
Samanea saman	
Ziziphus mauritiana	
Ziziphus oenoplia	

- Cleaning up the Connolly canal, preventing inflow of contaminated water and wastes and relieving of such pressures will promote re-colonisation of the wetland with common natural species. Fishes, molluscs and crustaceans such as prawns will return back.
- Control of disturbance and providing suitable habitats and nesting and feeding sites will promote more birds to visit and reside in the area.
- Establishing nest boxes in different locations can attract birds. The nest boxes may be fixed on trees at various heights or on pillars at secluded places, not to be disturbed by humans or predators. Nest boxes established at suitable locations during late winter may attract birds during the forthcoming breeding season (March-June). Bird baths and feeding places may also attract certain bird species.
- Subsequent to establishing the Park and completing construction of other facilities, protection and proactive management for certain years followed by lessened interventions, with active protection, will also help revive the biodiversity. The increasingly naturalised habitats will enter appropriate path of succession to more wilderness.

- It is observed that birds like purple swamp hen (*Porphyrio porphyrio*) and painted storks (*Mycteria leucocephala*) were not found any where in side the project wetland but are plenty in associated private wetlands, indicative of the fall in quality of the public owned lands. Those neighbouring wetland areas are ecologically richer. Perhaps, the authorities can explore means to incorporate and also physically link such associated wetlands, in the conservation action plan following the execution of the *Sarovaram* project.
- Attempts to fill the neighbouring wetlands and divert to real estate and construction projects, in any case, be prevented.

6.6 Automobiles exhaust and pollution

- As noted earlier, the wetland is situated in a high traffic density area, adjacent an arterial road that links two important highways, one towards Wynad and farther towns like Mysore and Bangalore and the other towards Medical College and farther. This road is also a part of the National Highway connecting to further north Kerala and Karnataka. Popular hospitals and residential colonies are also located nearby. High traffic density releases high exhausts containing gaseous pollutants such as SOx, NOx, suspended particulates containing compounds such as poly aromatic hydrocarbons (PAH) and other unburnt hydrocarbons. High density traffic also may generate considerable noise. Locally it is not much feasible to control pollutions or noise from vehicles.
- The *Sarovaram* project will considerably add on to the local traffic, especially during the evening hours and on holidays. The hike in traffic density due to the park will have higher pollution potentials since the vehicles will be idling or slow moving at the place to aid disembarking passengers.
    - However, certain measures such as facilitating a smooth flow of traffic by avoiding junctions / signals and steep speed-breakers may help reduce the pollutant levels. To control speed finer rumble strips and speed monitoring radars may be put to work.

- An area need to be earmarked and suitably aligned for conveniently parking tourist vehicles. It will be appropriate that a green belt is developed around the parking spot as well as on the sides of the adjacent roads. The green belt may have different levels of plants including thick bushes / shrubs such as *Clerodendrum paniculatum, Euphorbia leucocephala, Gardenia jasminoides, Murraya paniculata, Tabernaemontana coronaria* and trees with thick canopy of small leaflets.
- Vehicles should not be allowed idling in the parking space to reduce possible air pollution load. Cleaning vehicles also should not be allowed in the parking lot.

6.7 Noise and other disturbances

Construction activities that are likely to produce loud, stark and intense noises are deterrent to the birds.

- Using low noise and well maintained muffled machinery and limiting and completing noisy activities within the shortest minimum period, preferably by day time can reduce the negative impacts. Overall construction may be limited to non-migratory and non – breeding season.
- The workers engaged in noisy activities may also be made aware of the need for reducing noise for both their own health as well as for the health of the environment.

6.8 Human excrement

The exposed mangrove patches of Kottuli wetland currently being used for open defecation for labourers and local deprived families need to be controlled for environmental, public health and aesthetic reasons.

- Suitable public facilities for the purpose may be established in the area so that the public space is not used for such basic needs.

6.9 Activities during operation phase

Several issues of environmental consequences are to be addressed during the operation phase of the project, some of which are mentioned below.

- Appropriate means for management of biodegradable waste, probably by vermi-composting and utilisations of the compost thus produced in the garden in the park have to be implemented.
- In the case of non-biodegradable solid wastes means for their proper disposal may be identified, either for their recycling, reprocessing or other appropriate environmentally benign disposal.
- Appropriate parking space has to be provided buffered around by a green belt of thick bushes and trees with thick and low canopy.
- Toilet and other such public conveniences also need to be provided with treatment facilities so that human excrements do not get into the environment.
- The operation of the park also includes monitoring the quality of water, monitoring fauna especially birds, and monitoring the visitors to prevent untoward ecologically damaging actions.
- A meteorological station can be established in the park to document the local climatic details.
- The wetland should be protected from further disturbance. This can be achieved by making permanent boundary all around the wetland. The wall can also check the dumping of solid waste and other discharges, encroachment by local people, the practice of open defecation etc.
- Awareness campaign among local people, students, labours and teachers may be taken up to enlist their participation in conservation of wetlands.
- Filling and reclamation of the adjacent low lying wetlands to make huge commercial or residential constructions may be controlled, since these wetlands forms complementary habitats for several birds and other species and also provide valuable ecological services for the city. Further, it may be noted that filling

adjacent portions diminish the ecological characteristics and quality of a wetland. The ecological functions of unfilled portions are drastically curtailed.

- As reported above the wetland has scattered patches, which may be joined into a larger water course. Such links will enrich species composition of the area.
- Development of project involves various activities and there is scope for becoming more eco-friendly in these.
    - Eco-friendly items may be used for certain amenities for visitors. Benches, chairs are suggested to be made of local rocks, bamboo or such items.
    - Native species of plants may be used for planting.
    - Striking colours may be avoided for the buildings and other structures.
    - Striking, bright and attractive lights may deter birds.
    - The lights in the park may be fixed at low heights focussing towards the paths. Bright lights directed upwards may be avoided.
    - Compact fluorescent lamps may be used to meet light requirements, to save energy.
    - In eateries and interpretation centres sky windows and strategically placed windows may reduce lighting requirements
- As proposed by the project authorities it is welcome to build watch towers in the park. However, the towers may be sufficiently camouflaged so that visitors would not affect the nesting birds.
- As often seen in many parks and wildlife sanctuaries a nature interpretation centre is envisaged here.
    - An interpretation centre is one important component for outreach / nature education. The centre can emphasize the importance and conservation issues of wetland and the ecosystem services derived by mankind from such ecosystems. Audiovisual centre and museum are also important components of the centre.
    - Such a centre needs to be designed, with facilities such as gallery, diorama, museum, halls, and projection and field equipments. This can be

open to children, students and public. The centre can also organize and conduct camps, workshops and seminars targeting different segments of the society. This centre will also provide information to tourists. Signage / display boards, field guides, nature trails, boats and coracles shall be made to facilitate field visits. The staff designated for outreach should include a nature education officer, volunteers and assistants

- Facilities such as computers, projectors, phone and internet may be made available in the centre.

- A Local Ecological Monitoring Group (LEMG) should be organized which can monitor the ecosystem and the progress of the project from an ecological perspective. The group may also help conducting environmental awareness program to the workers, supervisory staff and contract labourers during the construction phase.
- Conservation of this wetland would attain better success with active public participation. Local people, students and others including marginalised and deprived may be taught about the importance of the biodiversity and its conservation strategies. The general public visiting the site for picnic and recreation should be made aware of nature conservation and importance of its conservation.
- Local people should be the beneficiaries of the project. A portion of earnings from the eco tourism project can be earmarked for improvement of the local livelihood, environment and biodiversity. May be, there are special stalls for selling / promoting local eco friendly products produced by self-help groups and such others.
- Nature education camps can be arranged for students/ teachers, in collaboration with education institutes, research institutes and schools.
- Research and monitoring is an essential part of a comprehensive eco-restoration / ecological development programme. It helps to document the status, identify the

threats, and suggest mitigatory measures. A structured eco-monitoring programme will be appropriate for the ecotourism centre.

- A research and monitoring committee may be set up, which advices upon the research and monitoring activities.
- Monitoring biodiversity (floral and faunal components) and basic physio-chemical parameters should be conducted seasonally over years preferably by independent research organizations. The changes in biotic and abiotic characteristics can indicate success of the project, and suggest future improvements.
- Assessing and monitoring the status of upstream and downstream areas, and suggestion for corrective measures may be entrusted to outside agencies in collaboration.
- Monitoring of pollutants (air, water, soil) and other threats may be done periodically by independent research organizations. A survey may be conducted to locate point and non-point sources of pollution.
- Monitoring the success of conservation measures is required by an independent agency, so that necessary midway alterations may be suggested for implementation, if required.

7.0 SUMMARY AND CONCLUSION

- The Government of India identified the Kottuli wetland at Kozhikode as one of the wetlands of National Importance. The wetland is included in the list of National Wetland Conservation Programme.
- As a means of conservation and development of the area M/s Tourist Resorts Kerala Limited (TRKL) proposes to develop an ecotourism centre in the area. M/s TRKL requested Sàlim Ali Centre for Ornithology & Natural History (SACON) to investigate and explore the area for possible threats.
- The rapid survey recorded 69 species of birds. In all 240 floral species were recorded. Of this 5 are mangrove species and 29 mangrove associates.
- Kottuli wetland being one of the scarce areas with mangroves in the state of Kerala, calls for care during both construction and operation phase of the project. Proper and planned management with active public participation in conserving the nature is needed for maintaining its biodiversity and for ecological value addition.
- Large scale construction work is likely to impose pressures on the existing system. However, proper planning during construction may help reduce the impacts.
- Attempts also may be made to protect neighbouring wetlands and prevent their filling, as they offer supplementary habitats for many wetland species.

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Appendix 1. Measurement of buildings and construction	
Sl. No	Items
1	Fabricated steel bridge
2	Gate and Tourism Plaza
3	Entrance plaza and control point
4	Office store and administration – 102 Sq. M
5	Pay and use toilet – 74 Sq. M
6	Sales and Mementos – 267 Sq. M
7	Cafeteria and Kitchen
8	Interpretation centre and cnferernce hall – 377.33 Sq. M
9	Landscape, Enclosure and passage – 550 Sq. M
10	Observation Tower – Height about 10m (Flat from 4m x 4m)
11	Butterfly park and Museum – 226 Sq. M
12	Aquarium – 371.71 Sq. M
13	Otter Park
14	Board Walk
15	Mangrove Nursery
16	Jeneeva Jet & Foundation and Irrigation system
17	Alternate energy model (Solar and Wind)
18	Water supply and sanitary work
19	Waste Management treatment plant
20	Boat club floating jetty
21	Coracle Jetty and Vessel
22	Water front treatment deck and plat form
23	Rain shelter
24	Open air stage – 1089 Sq. M

Appendix 2. Plant species recorded in and around the project environs			
Sl. No	**Species**	**Family**	**Habit**
1	*Abrus precatorius* L.	Fabaceae	Straggler
2	*Abutilon indicum* (Linn.) Sweet	Malvaceae	Shrub
3	*Acacia auriculiformis* A. Cunn. ex Benth.	Mimosaceae	Tree
4	**Acanthus ilicifolius* L.	Acanthaceae	Subshrub
5	*Achyranthes aspera* L.	Amaranthaceae	Subshrub
6	*Acrostichum aureum* L.	Pteridaceae	Fern
7	*Adenanthera pavonina* L.	Mimosaceae	Tree
8	*Adiantum* sp.	Adiantaceae	Fern
9	**Aegiceras corniculatum* (L.) Blanco	Myrsinaceae	Shrub
10	*Aerides ringens* (Lindley) C. Fischer	Orchidaceae	Epiphyte
11	*Aerva lanata* (L.) Juss.	Amaranthaceae	Herb
12	*Aeschynomene aspera* L.	Fabaceae	Subshrub
13	*Ageratum conyzoides* L.	Compositae	Herb
14	*Albizia chinensis* (Osbeck.) Merr.	Mimosaceae	Tree
15	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	Tree
16	*Alternanthera sessilis* (L.) R. Br. ex DC.	Amaranthaceae	Herb
17	*Alysicarpus* sp.	Fabaceae	Herb
18	*Anacardium occidentale* L.	Anacardiaceae	Tree
19	*Antidesma ghaesembilla* Gaertner	Euphorbiaceae	Tree
20	*Antidesma menasu* Miq. ex Tul.	Euphorbiaceae	Tree
21	*Antigonon leptopus* Hook. & Arn.	Polygonaceae	Climber
22	*Ardisia solanacea* Roxb.	Myrsinaceae	Shrub
23	*#Areca catechu* L.	Palmae	Tree
24	*Arisaema leschenaultii* Blume	Araceae	Herb
25	*Aristida arundinacea* L.	Gramineae	Grass
26	*Aristolochia indica* L.	Aristolochiaceae	Twinner
27	*Artocarpus heterophyllus* Lam.	Moraceae	Tree
28	*Artocarpus hirsutus* Lam.	Moraceae	Tree
29	*Asparagus racemosus* Willd.	Liliaceae	Vine
30	*Averrhoa carambola* L.	Averrhoaceae	Tree
31	**Avicennia marina* (Forsskal) Vierh.	Avicenniaceae	Tree
32	**Avicinnea officinalis* L.	Avicenniaceae	Tree
33	*#Azadirachta indica* A. Juss.	Meliaceae	Tree
34	*Barringtonia acutangula* (L.) Gaertner	Lecythidaceae	Tree
35	*Bauhinia purpurea* L.	Caesalpiniaceae	Tree
36	*Bombax malabaricum* DC.	Bombacaceae	Tree
37	*Borassus flabellifer* L.	Palmae	Tree
38	*#Bougainvilliea spectabilis* Willd.	Nyctaginaceae	Straggler
39	*Brachiaria distachya* (L.) Stapf	Gramineae	Grass

40	*Brachiaria ramosa* (L.) Stapf	Gramineae	Grass
41	*Bridelia retusa* (L.) Spreng.	Euphorbiaceae	Tree
42	*Bridielia scandens* (Roxb.) Willd.	Euphorbiaceae	Shrub
43	#*Callistemon citrinus* (Curt.) Stapf	Myrtaceae	Tree
44	*Calophyllum inophyllum* L.	Guttiferae	Tree
45	*Canna indica* L.	Cannaceae	Herb
46	*Canthium angustifolium* Roxb.	Rubiaceae	Shrub
47	*Canthium dicoccum* (Gaertner) Teijsm. & Binnend.	Rubiaceae	Tree
48	*Cardiospermum halicacabum* L.	Sapindaceae	Vine
49	#*Carica papaya* L.	Caricaceae	Tree
50	*Caryota urens* L.	Palmae	Tree
51	*Cassia fistula* L.	Caesalpiniaceae	Tree
52	*Cassia siamea* Lam.	Caesalpiniaceae	Tree
53	*Cassia tora* L.	Caesalpiniaceae	Subshrub
54	*Casuarina equisetifolia* Forster & Forster f.	Casuarinaceae	Tree
55	*Cayratia tenuifolia* (Wight & Arn.) Gagnep.	Vitaceae	Climber
56	*Cenchrus ciliaris* L.	Gramineae	Grass
57	*Centella asiatica* (L.) Urban	Umbelliferae	Herb
58	*Ceratopteris thalictroides* (L.) Brongn.	Parkeriaceae	Fern
59	*Cerbera odollam* Gaertn.	Apocynaceae	Tree
60	*Chasalia ophioxyloides* (Wall.)	Rubiaceae	Shrub
61	*Chenopodium album L.*	Chenopodiaceae	Subshrub
62	*Chloris barbata* Sw.	Gramineae	Grass
63	*Chromolaena odorata* (L.) R. King & H. Robinson	Compositae	Subshrub
64	*Cicer arietinum* L.	Fabaceae	Herb
65	*Cipadessa baccifera* (Roth) Miq.	Meliaceae	Shrub
66	*Cleome chelidonii* L.f.	Capparaceae	Herb
67	*Cleome gynandra* L.	Capparaceae	Herb
68	*Clerodendrum inerme* (L.) Gaertner	Verbenaceae	Shrub
69	*Clitoria ternatea* L.	Fabaceae	Vine
70	*Coccinia grandis* (L.) J. Voigt.	Cucurbitaceae	Vine
71	*Cocos nucifera* L.	Palmae	Tree
72	*Colocasia esculenta* (L.) Schott	Araceae	Herb
73	#*Corchorus* sp.	Tiliaceae	Herb
74	*Crinum defixum* Ker Gawler	Amaryllidaceae	Herb
75	*Crotalaria pallida* Aiton	Fabaceae	Subshrub
76	*Crotalaria retusa* L.	Fabaceae	Subshrub
77	#*Croton* sp.	Euphorbiaceae	Shrub
78	*Curcuma neilgherrensis* Wight	Zingiberaceae	Herb
79	*Cuscuta reflexa* Roxb.	Convolvulaceae	Vine
80	*Cyclea peltata* (Lam.) Hook.f. & Thomson	Menispermaceae	Twinner
81	*Cynodon dactylon* (L.) Pers.	Gramineae	Grass

82	*Cyperus corymbosus* Rottb.	Cyperaceae	Sedge
83	*Cyperus exaltatus* Retz.	Cyperaceae	Sedge
84	*Cyperus halpan* L.	Cyperaceae	Sedge
85	*Cyperus iria* L.	Cyperaceae	Sedge
86	*Cyperus triceps* Vahl	Cyperaceae	Sedge
87	*Dactyloctenium aegyptium* (L.) P. Beauv.	Gramineae	Grass
88	#*Delonix regia* (Boj. ex Hook.) Rafin.	Caesalpiniaceae	Tree
89	*Dendrobium macrostachyum* Lindl.	Orchidaceae	Epiphyte
90	*Dendrocalamus strictus* (Roxb.) Nees	Gramineae	Grass
91	*Dendrophthoe falcata* (L.f) Ettingsh.	Loranthaceae	Subshrub
92	*Derris scandens* (Roxb.) Benth.	Fabaceae	Straggler
93	*Derris trifoliata* Lour.	Fabaceae	Straggler
94	*Desmodium laxiflorum* DC.	Fabaceae	Shrub
95	*Desmodium triflorum* (L.) DC.	Fabaceae	Herb
96	*Dichanthium annulatum* (Forsskal) Stapf	Gramineae	Grass
97	*Digitaria bicornis* (Lam.) Roemer & Schultes	Gramineae	Grass
98	*Digitaria ciliaris* (Retz.) Koeler	Gramineae	Grass
99	*Dolichandrone spathacea* (L.) K. Schum.	Bignoniaceae	Tree
100	*Drynaria quercifolia* (L.) J. Sm. Hook.	Drynariaceae	Fern
101	*Duranta repens* L.	Verbenaceae	Shrub
102	*Eichhornia crassipes* (C. Martius) Solms-Laub.	Pontederiaceae	Herb
103	*Eleocharis acutangula* (Roxb.) Schultes	Cyperaceae	Sedge
104	*Eleusine indica* (L.) Gaertner	Gramineae	Grass
105	*Eragrostis tenella* (L.) P. Beauv. ex Roemer & Schultes	Gramineae	Grass
106	*Eragrostis viscosa* (Retz.) Trin.	Gramineae	Grass
107	*Ervatamia heyneana (*Wall.)	Apocynaceae	Tree
108	*Erythrina variegata* L.	Fabaceae	Tree
109	*Euphorbia hirta* L.	Euphorbiaceae	Herb
110	*Evolvulus nummularius* L.	Convolvulaceae	Herb
111	**Excoecaria agallocha* L.	Euphorbiaceae	Tree
112	*Ficus callosa* Willd.	Moraceae	Tree
113	*Ficus drupacea* Thunb. var. *pubescens* (Roth) Corner	Moraceae	Tree
114	*Ficus elastica* Roxb.	Moraceae	Tree
115	*Ficus exasperata* Vahl.	Moraceae	Tree
116	*Ficus hispida* L.f.	Moraceae	Tree
117	*Ficus racemosa* L.	Moraceae	Tree
118	*Ficus religiosa* L.	Moraceae	Tree
119	*Ficus tinctoria* Forster f. spp. *parasitica* (Willd.) Corner	Moraceae	Tree
120	*Fimbristylis cymosa* R. Br.	Cyperaceae	Sedge
121	*Fimbristylis ferruginea* (L.) Vahl	Cyperaceae	Sedge
122	*Fimbristylis miliacea* (L.) Vahl	Cyperaceae	Sedge
123	*Fimbristylis ovata (*Burm. f.) Kern	Cyperaceae	Sedge

124	*Flacourtia indica* (Burm. f.) Merr.	Flacourtiaceae	Tree
125	*Flemingia macrophylla* (Willd.) Prain ex Merr.	Fabaceae	Shrub
126	*Garcinia gummi-gutta* (L.) N. Robson var. *conicarpa* (Wight)	Guttiferae	Tree
127	*Glinus oppositifolius* (L.) DC.	Aizoaceae	Herb
128	*Gliricidia sepium* (Jacq.) Kunth ex Walp.	Fabaceae	Shrub
129	*Glycosmis pentaphylla* (Retz.) DC.	Rutaceae	Tree
130	*Gomphrena globosa* L.	Amaranthaceae	Herb
131	*Grewia lawsoniana* Drummond ex Gamb.	Tiliaceae	Shrub
132	*Grewia tiliifolia* Vahl	Tiliaceae	Tree
133	*Guazuma ulmifolia* Lam.	Sterculiaceae	Tree
134	*Hedychium coronarium* J. Koenig	Zingiberaceae	Herb
135	*Heliotropium indicum* L.	Boraginaceae	Subshrub
136	*Hibiscus hispidissimus* Griff.	Malvaceae	Shrub
137	*Hibiscus tiliaceus* L.	Malvaceae	Tree
138	*Hibiscus vitifolius* L.	Malvaceae	Subshrub
139	*Holigarna arnottiana* Hook. f.	Anacardiaceae	Tree
140	*Hybanthus enneaspermus* (L.) F. Muell. Fragm.	Violaceae	Herb
141	*Hygrophila* sp.	Acanthaceae	Subshrub
142	*Ipomea pes-caprae* (L.) R. Br.	Convolvulaceae	Herb
143	*Ipomoea aquatica* Forsskal	Convolvulaceae	Straggler
144	*Ipomoea carnea* Jacq.	Convolvulaceae	Shrub
145	*Ischaemum indicum* (Houtt.) Merr.	Gramineae	Grass
146	*Ixora pavetta* Andrews	Rubiaceae	Shrub
147	*Jasminum sambac* (L.) Aiton.	Oleaceae	Shrub
148	*Justicia betonica* L.	Acanthaceae	Shrub
149	*Kalanchoe pinnata* (Lamk.) Pers.	Crassulaceae	Herb
150	*Lagerstroemia reginae* Roxb.	Lythraceae	Tree
151	*Lantana camara* L.	Verbenaceae	Shrub
152	*Leea indica* (Burm. f.) Merr.	Leeaceae	Subshrub
153	*Lemna perpusilla* J. Torrey	Lemnaceae	Herb
154	*Lepisorus nudus* (Hook.) Ching	Polypodiaceae	Fern
155	*Leucaena leucocephala* (Lam.) de Wit	Mimosaceae	Tree
156	*Leucas aspera* (Willd.) Link	Labiatae	Herb
157	*Lindernia anagallis* (Burm. f.) Pennell	Scrophulariaceae	Herb
158	*Litsea deccanensis* Gamble	Lauraceae	Tree
159	*Luffa cylindrica* (L.)	Cucurbitaceae	Climber
160	*Macaranga peltata* (Roxb.) Muell. Arg.	Euphorbiaceae	Tree
161	*Mallotus philippensis* (Lam.) Muell. Arg.	Euphorbiaceae	Tree
162	*Mangifera indica* L.	Anacardiaceae	Tree
163	*Melaleuca* sp.	Myrtaceae	Tree
164	*Melastoma malabathricum* L.	Melastomataceae	Shrub
165	*Memecylon malabaricum* (Clarke) Cogn.	Melastomataceae	Tree

166	#*Michelia champaca* L.	Magnoliaceae	Tree
167	*Mimosa pudica* L.	Mimosaceae	Herb
168	*Mimusops elengi* L.	Sapotaceae	Tree
169	*Morinda citrifolia* L.	Rubiaceae	Tree
170	*Mukia maderaspatana* (L.) M. Roemer	Cucurbitaceae	Vine
171	#*Musa paradisiaca* L.	Musaceae	Tree
172	*Mussaenda hirsutissima (Hook. f.) Hutch. ex Gamble*	Rubiaceae	Shrub
173	*Naregamia alata* Wight & Arn.	Meliaceae	Herb
174	*Naringi crenulata* (Roxb.) Nicolson	Rutaceae	Tree
175	#*Nerium indicum* Mill.	Apocynaceae	Tree
176	*Nymphaea nouchali* Burm.f.	Nymphaeaceae	Herb
177	*Nymphoides indica* (L.) Kuntze	Menyanthaceae	Herb
178	*Ochna obtusata* DC.	Ochnaceae	Shrub
179	*Oldenlandia herbacea* (L.) Roxb.	Rubiaceae	Herb
180	*Pandanus odoratissimus* L.f.	Pandanaceae	Shrub
181	*Paspalum distichum* auct.	Gramineae	Grass
182	*Passiflora foetida* L.	Passifloraceae	Vine
183	*Peltophorum pterocarpum* (DC.) Backer ex K. Heyne	Caesalpiniaceae	Tree
184	*Phyllanthus amarus* Schum. & Thonn.	Euphorbiaceae	Herb
185	*Phyllanthus emblica* L.	Euphorbiaceae	Tree
186	*Physalis minima* L.	Solanaceae	Herb
187	*Plumeria rubra* L.	Apocynaceae	Tree
188	*Pongamia pinnata* (L.) Pierre	Fabaceae	Tree
189	*Portulaca oleracea* L.	Portulacaceae	Herb
190	*Pothos scandens* L.	Piperaceae	Climber
191	*Premna serratifolia* L.	Verbenaceae	Tree
192	*Psidium guajava* L.	Myrtaceae	Tree
193	#*Rhaphidophora aurea*	Araceae	Fern
194	#*Rhoeo discolor*	Commelinaceae	Herb
195	*Rhychosia rufescens* (Willd.) DC.	Fabaceae	Vine
196	*Ruellia tuberosa* L.	Acanthaceae	Herb
197	*Salvinia molesta*	Salviniaceae	Fern
198	*Samanea saman* (Jacq.) Merr.	Mimosaceae	Tree
199	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	Tree
200	*Schoenoplectus litoralis (*Schrader) Palla	Cyperaceae	Sedge
201	*Scolopia crenata* (Wight & Arn.) D. Clos	Flacourtiaceae	Tree
202	*Scoparia dulcis* L.	Scrophulariaceae	Herb
203	*Sebastiania chamaelea* (L.) Muell. Arg.	Euphorbiaceae	Herb
204	*Sida acuta* Burm.f.	Malvaceae	Subshrub
205	*Sida cordata* (Burm. f.) Borssum Waalkes	Malvaceae	Subshrub
206	*Sida rhombifolia* L.	Malvaceae	Subshrub
207	*Smilax zeylanica* L.	Liliaceae	Vine

208	*Smithia sensitiva* Ait.	Fabaceae	Herb
209	*Solanum surattense* Burm.f.	Solanaceae	Subshrub
210	*Spermacoce hispida* L.	Rubiaceae	Herb
211	*Sphaeranthus indicus* L.	Compositae	Herb
212	*Spirodela polyrhiza* (L.) Schleiden	Lemnaceae	Herb
213	*Stachytarpheta jamaicensis* (L.) Vahl	Verbenaceae	Shrub
214	*Stenochlaena palustris* (Burm.) Bedd.	Stenochlaenaceae	Fern
215	*Sterculia guttata* Roxb. ex DC.	Sterculiaceae	Tree
216	*Stictocardia tiliifolia* (Desr.) Hall. f.	Convolvulaceae	Climber
217	*Strychnos potatorum* L.f.	Loganiaceae	Tree
218	*Syzygium caryophyllatum* (L.)	Myrtaceae	Tree
219	#*Syzygium cumini* (L.) Skeels	Myrtaceae	Tree
220	*Syzygium jambos* (L.) Alston	Myrtaceae	Tree
221	*Tamarindus indica* L.	Caesalpiniaceae	Tree
222	#*Tecoma stans* (L.) H.B. & K.	Bignoniaceae	Tree
223	*Tectona grandis* L.f.	Verbenaceae	Tree
224	*Tephrosia purpurea* (L.) Pers.	Fabaceae	Subshrub
225	*Terminalia catappa* L.	Combretaceae	Tree
226	*Thespesia populnea* (L.) Sol. ex Corr. Serr.	Malvaceae	Tree
227	*Tinospora cordifolia* (Willd.) Hook.f. & Thomson	Menispermaceae	Climber
228	*Trema orientalis* (L.) Blume	Ulmaceae	Tree
229	*Trichilia connaroides* (Wight & Arn.) Bentv.	Meliaceae	Tree
230	*Tridax procumbens* L.	Compositae	Herb
231	*Typha angustata* Bory & Chaub.	Typhaceae	Herb
232	*Vanda testacea* (Lindl.) Reichb. f.	Orchidaceae	Epiphyte
233	*Vernonia cinerea* (L.) Less.	Compositae	Herb
234	*Vernonia elaeagnifolia* DC.	Compositae	Climber
235	*Vigna trilobata* (L.) Verdc.	Fabaceae	Climber
236	*Vigna unguiculata* (L.) Walp.	Fabaceae	Vine
237	*Wedelia chinensis* (Osbeck) Merr.	Compositae	Herb
238	*Ziziphus mauritiana* Lam.	Rhamnaceae	Tree
239	*Ziziphus oenoplia* (L.) Miller	Rhamnaceae	Shrub
240	*Ziziphus rugosa* Lam.	Rhamnaceae	Straggler
*: Mangrove species, #: Species recorded outside the study environ			

Appendix 3 Birds recorded in the study area		
No	**English Name**	**Scientific Name**
1	Ashy drongo	*Dicrurus leucophaeus*
2	Ashy prinia	*Prinia socialis*
3	Asian koel	*Eudynamys scolopacea*
4	Asian openbill++	*Anastomus oscitans*
5	Asian palm swift*	*Cypsiurus balasiensis*
6	Asian paradise-flycatcher	*Terpsiphone paradise*
7	Black bittern	*Dupetor flavicollis*
8	Black drongo	*Dicrurus macrocercus*
9	Black naped oriole	*Oriolus chinensis*
10	Black rumped flame back woodpecker	*Dinopium benghalense*
11	Black-crowned night heron	*Nycticorax nycticorax*
12	Black-headed ibis++	*Threskiornis melanocephalus*
13	Blue-tailed bee-eater*	*Merops philippinus*
14	Brahmini kite	*Haliastur Indus*
15	Brownze-winged jacana	*Metopedius indicus*
16	Cattle egret	*Bubulcus ibis*
17	Common kingfisher	*Alcedo atthis*
18	Common moorhen	*Gallinula chloropus*
19	Common myna	*Acridotheres tristis*
20	Common sandpiper	*Actitis hypoleucos*
21	Crimson-fronted barbet	*Megalaima rubricapilla*
22	Darter	*Anhinga melanogastur*
23	Emerald dove	*Chalcophaps indica*
24	Eurasian golden oriole	*Oriolus oriolus*
25	Great egret	*Casmerodius albus*
26	Greater coucal	*Centropus sinensis*
27	Greater racket-tailed drongo	*Dicrurus paradiseus*
28	Green bee-eater	*Merops orientalis*
29	Grey heron	*Ardea cinerea*
30	House crow	*Corvus splendens*
31	Indian pond heron	*Ardea grayii*
32	Indian roller	*Coracias benghalensis*

33	Intermediate egret	*Mesophoyx intermedia*
34	Jungle babbler	*Turdoides striatus*
35	Jungle myna	*Acridotheres fuscus*
36	Kentish plover	*Charadrius alexandrinus*
37	Large billed crow	*Corvus macrorhynchos*
38	Little cormorant	*Phalacrocorax niger*
39	Little egret	*Egrata garzetta*
40	Little grebe	*Tachybaptus ruficollis*
41	Little ring plover	*Charadrius dubius*
42	Little stint	*Calidris minuta*
43	Malabar grey hornbill	*Ocyceros grises*
44	Oriental magpie robin	*Copsychus saularis*
45	Painted stork	*Mycteria leucocephala*
46	Pariah kite	*Milvus migrans*
47	Pheasant-tailed jacana	*Hydrophasianus chirurgus*
48	Pied king fisher	*Ceryle rudis*
49	Purple heron	*Ardea purpurea*
50	Purple rumped sunbird	*Nectarinia zeylonica*
51	Purple swamp hen	*Porphyrio porphyrio*
52	Red-vented bulbul	*Pycnonotus cafer*
53	Red-wattled lapwing	*Vanellus indicus*
54	Yellow- wattled lapwing	*Vanellus malarbaricus*
55	Red-whiskered bulbul	*Pycnonotus jocosus*
56	River tern	*Sterna aurantia*
57	Rock pigeon	*Columba livia*
58	Rose-ringed parakeet	*Psittacula krameri*
59	Rufous tree pie	*Dendrocitta vagabunda*
60	Scarlet minivet	*Pericrocotus flammeus*
61	Shikra	*Accipitar badius*
62	Spotted dove	*Streptopelia chinensis*
63	Thick-billed flowerpecker	*Dicaeum agile*
64	White-breasted water hen	*Amaurornis phoenicurus*
65	White-browed wagtail	*Motacilla maderaspatensis*
66	White-cheeked barbet	*Megalaima lineate*
67	White-throated kingfisher	*Halcyon smyrnensis*

68	Yellow wagtail*	*Motacilla flava*
69	Yellow-billed babbler	*Turdoides affinis*
* Reported by Seethikoya K (2003), ++ Personal communication (Mr Boby Jose, Calicut)		

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