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Human Impact on Wetland Ecosystems: A Case Study – The Mundel Lake and Its Environs – Sri Lanka

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Abstract

The Mundal Lake and its environs can be considered as a disturbed wetland system due to excessive utilization of the resources beyond the sustainable limit. The area is located between Puttalam Lagoon (on the north) and the lower basin of the Deduru Oya (river) (on the south). The flat continental shelf on the western margin of the Lake consists of a straight coastline with wide beaches, berms and sand dunes. The old raised dune ridges bound the eastern margin.

The Mundal Lake and its surroundings are consisted of different types of landforms, and formation and evolution of these features have a close relationship with local climatic conditions, such as temperature, rainfall pattern, evapotraspiration, wind circulation and salinity levels. All these factors have contributed to the rich biodiversity in and around the lake.

Fishermen and farmers are hereditary people in the area. About twenty-thirty years ago, fertile patches of coconut lands were located along the sand barrier and old dune ridges, while mangrove associates and salt marshes associations covered the edges of lagoon and the creeks. But introduction new development activities such as aquaculture farms in recent years have disturbed the physical environment in and around the Mundal Lake. Use of tidal and mud flats and destruction of mangrove patches and salt marshes in large scale to construct prawn ponds are the main human impacts in the area. Damming and destruction of natural cannel network to intake water to ponds as well as to discharge of effluents from the prawn ponds, construction of dykes, canals, pipe lines and electric wire networks are the other destructive activities. Converting ridge and runnels and reclamation of mud flats to cultivate of coconut and other crops, and extraction of ground water thorough deep well to reduce the high salinity of the ponds are also have responsible for raise a number of issues of the area.

Keywords: wetlands, human impacts, pollution

Introduction

Wetland is a geographic area with characteristics of both dry land and bodies of water. Wetlands typically occur in low-lying areas that receive fresh water at the edges of lakes, ponds, streams, and rivers, or salt water from tides in coastal areas protected from waves. Accordingly, the wetland is an area covered permanently, occasionally, or periodically by fresh or salt water up to a depth of 6 m. About 6% of the total surface area of the world is covered by wetlands and they are unique transient ecosystems. They are falling between true aquatic systems on one-hand and terrestrial systems on the other. The water table in this environment is usually at or near surface, or the land is covered by shallow water (Shanbhag and Ajay Gramopadhye, 1994).

Wetlands support extensive freshwater and marine fisheries. As well, they are natural sewage treatment plants. An 8-ha marsh or a pond can clean 4.54 million litres of raw sewage every day. The Plants found in wetlands such as water hyacinth act as pollution filters for some heavy metals. They serve as the breeding and feeding sites for resident and migrating water birds. Wetlands act as an efficient buffer against natural calamities in flood or cyclone-prone areas. In estuaries, mangrove forests shield the coast against storms. Moreover wetlands help maintain the water table by recharging ground water. With almost twice the productivity of tropical rain forests, wetlands are among the earth's most productive ecosystems. Wetlands have immense value from ecological, economic, biological and aesthetic viewpoints. These characteristics are very common to the Mundal Lake and its environs. It can be considered as a disturbed wetland ecosystem.

Study Area

Mundal Lake and its surroundings consist of invaluable coastal wetlands with a diversity of physical and human environments. The area is located between Puttalam Lagoon (to the north) and the lower basin of the Deduru Oya (river) (to the south). The flat continental shelf on the west margin of the Mundal Lake consists of a straight coastline with wide beaches, berms and sand dunes, and the old raised dune ridges bound the eastern margin of the lake. Consequently, the study area lies roughly between 7°.45" & 7°..59" N latitudes and 79°.36" E & 79°.51" E longitudes. Closest towns are Puttalam, some 20 km towards the north, and Chilaw, at similar distance towards the south. Battulu Oya, Madurankuliya, Kiriyankalliya and Palavi are the small towns between Puttalam and Chilaw in the eastern margin. Udappuwa Township is located at the southwestern end of the lake showing about 100m wide sand barrier.

Purpose and Objectives

The quality of physical, social and economic environments of the Mundal Lake and its surroundings have declined due to degradation of the lake and the other wetlands of its surroundings. In the absence of proper management and legal framework, this declining has aggravated further.

The reduction of endemic floral and faunal resources of the area has dropped to a minimum level causing social and economic difficulties for the adjoining communities. The connection between the sea (Puttalam Lagoon) and the Lake as well as southern wetlands have been completely cut off due to encroachments and filling State Lands as well as private lands for aquaculture ponds and other purposes. The rapid rate of population growth by migration also has created and increased the constraints in the area due to insufficiency of land for residential purposes.

The overall objective of this research is to present a broad overview of the current human impacts in respect of the Mundal Lake and its surroundings. This paper highlights the main impacts associated issues on physical, faunal and floral characteristics of the area. It also reflects the views and opinions of the residents on these impacts and issues.

Methodology

The following methodologies adopt in the collection of information and data for the purpose of preparing the final report:

- Collection of data and information from secondary sources such as published and unpublished reports, maps and photographs including aerial photographs.
- Focused group discussions with key stakeholders such as local residents and community based organizations, government agencies and non-governmental organizations
- Questionnaire based surveys
- Direct observations and enumeration technique

The collected data were analyzed by using a number of accepted analytical methods**.**

Physical and Environmental Settings

Mudal Lake covers an area of 20 sq. km with an average depth of 0.75m. It length is approximately 12 km long and 1.3 km wide. The morphological sequence from west (sea) to east, across the lagoon, consists of various types of formations. Beach berms, low sand dunes, channel way, high dunes, ridge & runnels, mud flats with tidal creeks are located westward of the lake water. As well, mud flats, salt marshes, Dutch Canal, ridges of Red Beds, alluvial valleys with terrace gravel and basal ferruginized gravel beds extend eastwards from the lake water (Figure 1). But, from Puttalam Lagoon to Deduru Oya outfall, it appears as a narrow corridor. All these features have laid over the Miocene limestone and crystalline basement (Katupotha & Dias, 2002). The Mudal Lake has developed its diversity on micro-landforms, flora and fauna as well as on the other environmental phenomena since Last Glacial Maximum, which began around 18,000 yr B.P. in the Late Pleistocene Epoch.

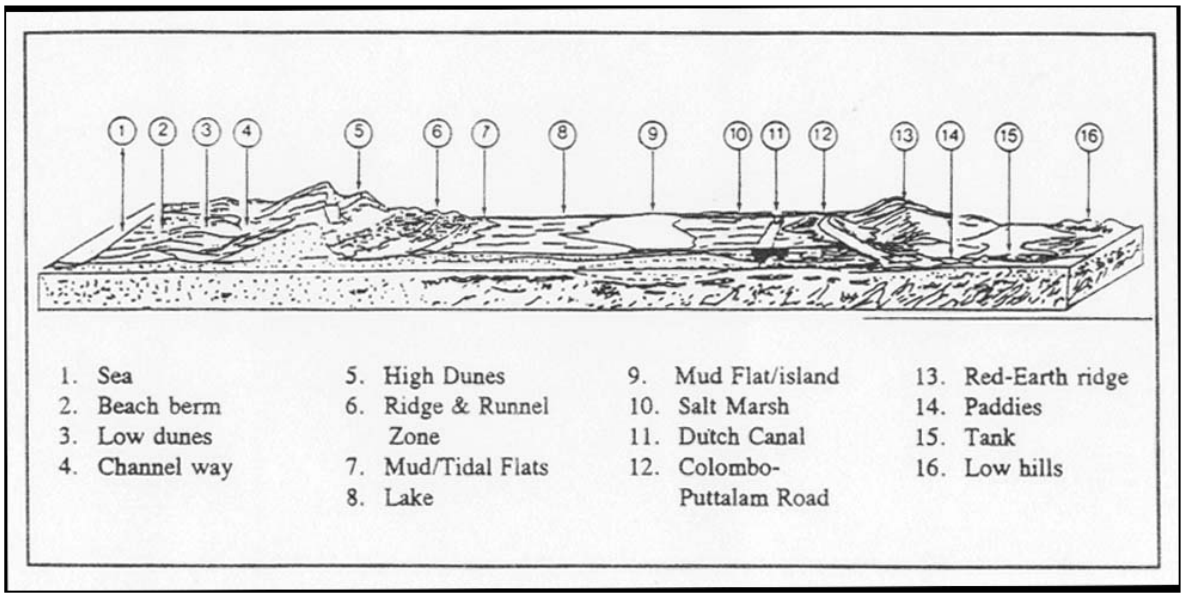

Figure 1. Micro landforms in the Mundal Lake and its surroundings (Source: CEA, 1994)

The rivers (from eastward) including three catchments namely, the Madurankuli Aru, the Kalagamu Oya and the Ratambala Oya supply a considerable amount of terrestrial waters during the rainy season. The tidal creeks stretch along the narrow corridor and both terrestrial and tidal waters deposit layers of fine silt and mud. Hence, the lake and its surrounding are forming up of mud and thin tidal flats. The Tide Tables for the past 30-year period indicate that the average tidal amplitude along the west coast is about 80 cm. The lake may finally be converted into a swampy or peaty bog in which dead and decaying vegetation would accumulate to form peat owing this process.

The soil pH value has been recorded from 4 locations (at Ambalaveli, Mundalama) at different levels (NARA, 1995). Accordingly, the pH value of H_2O varies between 5.40 and 6.85 and pH of KCl varies between 4.80 and 6.55. As well, the clay contents are high in the area and vary from 36.00% to 48.80% at six sample points. In the same points sand content vary from 38.70% to 60.95% and silt content vary from 3.03% to 22.85% respectively. The borehole data at the Muthupantiya lagoon further reveal that the content of clay, sand and silt are considerably high of the lagoon bed, which have laid down on the Tertiary Beds.

The area falls into the dry zone having two rainy periods and two dry periods (Figure 2). The first season begins around April and reaches its peak in May/June receiving more rainfall than the second season, which occurs between October and November. These seasonal variations are important as it affects the hydrological characteristics of the area in terms of quantity and quality of the water and transportation as well as deposition of sediment.

Terrestrial streams and tidal canals are responsible for the water temperature, salinity levels, pH value and dissolved oxygen in the study area. The intended water source is Mundal Lagoon and Dutch Canal that flow close to the site. The recorded water temperature, pH, dissolved oxygen and salinity in the lagoon ranged between 26^{o}-33^{o} C, 6.0-8.1, 4.5-9.0 ppm and 5-60 ppt respectively (IEE, 1995).

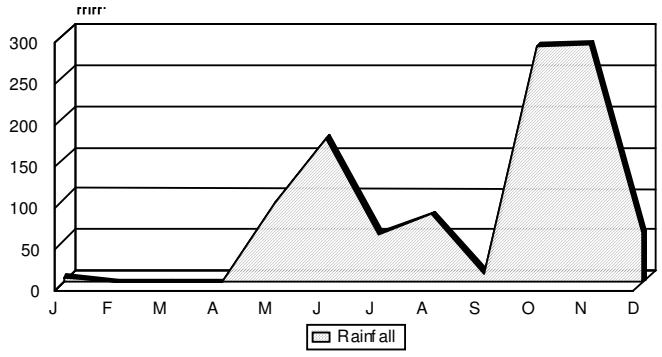

Figure 2: Monthly variations of rainfall of the Puttalam area - 1992

As shown in Figure 1, the physical and natural environments of the lake and its environs consisted of different types of micro-landforms. Formation and evolution of these landforms have a close relationship with local climatic conditions (such as temperature, rainfall pattern, evapotraspiration, wind circulation etc.), salinity levels and tidal flow patterns. Though, due to terrestrial floods during the rainy seasons, the salinity levels drastically changed throughout the area. Sometime it becomes 3 ppt or below. All these factors have affected to change physical, morphological and biological conditions in and around the Mundal Lake for a long period.

The distribution and extent of the land use of the study have a close relationship with geological structure, local relief, climate, soil and drainage. The sand dunes from Deduru river mouth to northwards are mainly barren lands inclusive of sand dunes and consist of medium sized dunes with an area of 10 - 15 m in height and they are active and migratory. Close to the coast these dunes are covered by creeping vegetation such as *Spinifix littorerus* and *Ipomoea pescaprae*. The barren sandy scrublands are covered by sparsely scattered bushes such as *Phoenix zeylanica* (Indi), *Cassia auriculata* (Ranawara), *Feronia limonia* (Divul), *Dichrostachys cinerea* (Andara), *Carissa spinarum* (Karamba), *Tephrosia purpurea* (Katupila and Pila), *Solanum xanthocarpum* (Elabatu), *Drega* spp.(Anguna) etc.

Salt marshes and tidal waterways of the area are subjected to daily tidal fluctuations. *Anthrocnemum indicum, Acanthus ilicifolius, Acrostichum aureum, Avicennia marina, Suaeda sp. and Lumnizera racemosa* are the dominant mangrove species of the area. Variety of herbaceous, salt-tolerant grasses, sedges and bullrushes and *Atthrocneum indicum* and *Salicornia brachiata* are covered by salt marshes (Field Survey, 2002). Besides, NARA (1987), CEA (1994) have listed a large number of aquatic vegetation (microphytes) and faunal species (zooplankton, benthic organisms and fish found in Mundal Lake), birds, mammals and reptiles recorded at Mundal Lake and surroundings.

About 20-30 years back, the residents of the area were farmers and fishermen. The farmers cultivated seasonal food crops (vegetable, yams, grain crops etc.) on sand ridges of ridge and runnel zone and ridges of Red Beds. The residents and some planters used fertile barrier beaches and ridges of Red Beds for coconut cultivation with coverage of about 40% in total agricultural lands. Tobacco and gherkins have newly introduced cash crops to the area with use of groundwater by tube wells. Chemical fertilizer and pesticides users also very high, but collecting of data is not easy. As well, suitable runnels of the sand ridges and wide valley bottoms converted in to paddy fields. This activity also depends on rainy season, and coverage is unable to calculate.

Mangrove associates and adjacent mudflats are highly rich in invertebrates, fishes and crustaceans, birds etc. providing major sources of foods and shelter for animals, and have commercial value to man. Furthermore, mangroves are extensively utilized for collection of firewood, medicinal herbs and other non-wood products.

Mangrove associates, salt marsh associations as well as pasture lands use for cattle and goats by residents. Field surveys in August and September (2002) revealed that animal

husbandry is practiced in homestead plots and in coconut plantations in and around Mundal Lake.

Local fishermen extensively carry out fishing as small-scale operations in the lagoon and the Dutch canal using traditional methods. Mundal, Kiriyankalliya, Udappuwa and Andimuni villages are the main landing sites at the lagoon. Gunaratne (1992) estimated the annual yield of Mundal Lake at approximately 109 kg/ha. In 1994, Mundal Lake provided employment and income to 400 - 600 persons who are engaged in fishing on a full-time or part-time basis (CEA, 1994). But, the annual productions of the fish yield, employment and income have decreased seriously due to aquaculture farms.

Results and Discussion

During the period between 1990 and 2000, about 90% of fringing vegetation of Mundal Lake and its environs have cleaned to construct aquaculture ponds and salterns by outsider. These activities have made significant impacts on physical and human environment in and around the Mundal Lake. The main activities can be listed as follows:

- Extracting tidal and mud flats in large scale to construct prawn ponds
- Destruction of mangrove patches and salt marshes at the time of construction of ponds.
- Damming and destruction of natural cannel network to intake water to ponds as well as to discharge of effluents from the prawn ponds
- Construction of dykes, canals, pipe lines and electric wire networks
- Use of generators to supply electricity at night and other purposes
- Converting ridge and runnels and sometimes reclamation of mud flats to cultivate of coconut and other crops.
- Extraction of ground water thorough deep-well to reduce the high salinity of the ponds.

The main issues due to the above activities can be identified as follows:

- Sedimentation the lake and creeks due to soil erosion during the heavy rains and floods as well as through effluents removed by prawn ponds
- Changing the salinity levels and water quality
- Lowering the ground-water table
- Reduction the endemic floral and faunal species
- Decreasing the traditional agriculture, animal husbandry and fishing activities
- Diminishing of wild-life and the decrease of animal husbandry due to destruction of pastures and scrubs

The introduction of prawn ponds in recent years has disturbed the mangroves and mud/tidal flats, salt and brackish marshes, tidal creeks and even ridge and runnel zones in and around the Mundal Lake. Reclamation of lake margins for construction of prawn ponds has caused detrimental effects to most of these areas. Moreover, to construct prawn ponds, associated dams and waterways, the aquaculture entrepreneurs have

destroyed the mangrove patches, salt marshes, tidal creeks and both sides of the Old Dutch canal (Plates 1 & 2). Nearly 90% of the area, from mouth of the Deduru Oya to Puttalam Lagoon, has been changed for this purpose. Such construction has further created conflicts with local people and outside aquaculture entrepreneurs due to deprivation the State and traditional lands for agriculture and fishing activities. Besides, these encroachments the obstructed the traditional access to the lagoon.

Constructors are used heavy machines to making ponds, canal and access roads within their premises. The surface earth of tidal and mud flats as well as sub soils have become unconsolidated during the dry period.

Therefore, serious soil erosion occurs by heavy rains and floods transporting sediments to the lagoon and tidal creeks. Besides, a considerable amount of effluents also removed intermittently by prawn farmers adding to the bed-load and transforms the deep water into shallow swamps. This sedimentation helps to transform wetlands into land, and forms healthy shallow wetlands from deeper water. According to the traditional fisherman, they emphasized that about 20 years ago the natural channel system and Dutch Canal were 3.0-6.0 metres deep than at present. But, even in rainy season this level has reached to 1.0 -3.0 metres constraining to transport of canoes (*oru*) and log-rafts (*teppam*). This has seriously responsible for the low income of the local fishermen.

PLATE 1. Tidal flat at Muthupanitiya lagoon (A), mismanaged pond areas (B), a dam for removing of excess water as well as some effluents from the ponds (C) and manmade canal (d) in the Mundal Lake area.

PLATE 2. Unplanned constructions (A), Planned ponds (B), Access road and electrical wire systems in pond area (C) and Polluted stagnant water patches (D) in the study area.

The aquaculture pond effluents have been categorized by CEA (1994) as residues of fertilizers and supplementary feed, acidic discharges from new ponds constructed on potential acid sulphate soils, and chemicals use for water treatment, insect control, predator fish control and shrimp health control. These effluents have polluted the ponds, wetlands and canal systems. Though wetlands are natural purifiers, they cannot withstand excessive pollution. Pollutants may also get into the food chain. Furthermore, these activities besides the Mundal Lake have changed the salinity levels and reduced water quality thus adversely affecting endemic floral and faunal species.

Construction of dams and canals for supply and drainage of pond water and pumping of brackish water to more inland prawn-farms and hatcheries often resulted in hydrological changes and salinization of groundwater. Besides, extraction of fresh or brackish waters from deep well to dilute the high salinity of ponds may also result in salinization of fresh/brackish aquifers through intrusion. As well, this is directly impact to the domestic and agricultural users in the area.

Conclusion

Mundal Lake and its surroundings are invaluable coastal wetlands with a diversity of physical and human environments of western coast of Sri Lanka. With introducing prawn farms to the Mundal Lake and its surrounding a number of constructional activities introduced by aquaculture entrepreneurs. As a result, tidal and mud flats were extracted in large scale to construct prawn ponds. As well, mangrove patches and salt marshes destructed for these purposes. Furthermore, damming and destruction of natural channel network continued to intake water to ponds as well as to discharge of effluents from the prawn ponds. To earn a large income within a short period of time, the entrepreneurs spent money to provide infrastructure and other facilities within in own premises creating number of issues to physical and natural environments, and to local people of the area. Therefore it is necessary a special management plan for proper aquaculture development, Dutch Canal rehabilitation, drinking and agricultural water supply programme, lagoon and canal boundary demarcation and flood water protection/relief programme. Besides, it is required that protect and maintain proposed sanctuary area (northeastern part of the Mundal Lake) and mangrove rehabilitation programme. All these help to sustain the biodiversity in the area. For this purpose it is highly required focused group discussions with key stakeholders such as local residents and community based organizations, government agencies and non-governmental organizations to get perfect results.

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