CHAPTER 1
INTRODUCTION

Wetlands, the hotspots of biodiversity are the world’s most productive ecosystem having rich and diverse natural wealth and cultural heritage. They not only provide water and primary productivity to countless species of plants and animals but also to communities living in nearby areas that depend for their survival on these wetlands. Wetlands also influence lifestyles and livelihood of these local communities. Wetlands are found in every continent, except Antarctica, and in every climate, from the tropics to the tundra. It is estimated that approximately 86,00,000 sq. km (around 6.4% of the earth’s surface), an area somewhat larger than Europe, is covered by wetlands. Most of these wetlands have essentially been natural ecosystems stabilized over the years, and have retained their natural characteristics. In an ideal situation, it would be most appropriate to maintain their natural process, as far as possible, or at least restore/improve them if they are found degraded due to various reasons. Unfortunately recently wetlands have been subjected to degradation and loss by human interventions and activities. These interventions pertain to changing water quality, quantity, and flow rates, increasing pollutant inputs and by changing species composition as a result of disturbances and the introduction of non-native species. This degradation of wetlands has been accelerated by the needs of developed economies and economic compulsion of developing countries. It is therefore important to restore them.

Ecological restoration is defined as the intentional alteration of a site to establish the approximate biological, geological and physical conditions that existed before the disturbance of the indigenous ecosystem or habitat. Restoration projects attempt the re-establishment of all the earlier characteristics of a site, including plant and animal species, and a variety of community attributes such as structure, function and habitat values. Restoration is an essential tool to protect, improve and increase wetlands. Wetlands that have been filled and drained retain their soil characteristics and hydrology, allowing their natural functions to be restored. Restoration is a complex process that requires planning, implementation, monitoring, and management. It involves renewing natural and historical wetlands that have been lost or degraded, reclaiming their functions and values as vital
ecosystems. Restoring our lost and degraded wetlands to their natural state is essential to ensure environmental health.

Over utilization of natural resources by rapidly growing population, government ignorance together with apathy towards environmental regeneration and conservation has made the situation more gruesome. This also meant human exploits natural resources at a greater rate than it can be regenerated, and without putting them back into the natural ecosystem. This is responsible for a number of environmental maladies (Parikh and Datye 2003). Thus it becomes imperative for mankind to adopt a reformed approach to resource consumption and various conservation methods. This can be done by adopting an environmental management plan which is an interdisciplinary approach to resource conservation and recycling, and it acts as a regulatory force on human wantonness in resource exploitation and resource wasting. Environment management is required for proper resource use and resource management.

It is calculated that since 1990, with the alleged intention of recovering these lands for other uses, nearly half of the world’s wetlands have been destroyed, adding yet another threat to the many posed by human activity to the earth’s ecosystems (Online web: http://www.choike.org).

In Canada for eg., wetlands currently cover about 14% of its landmass, which accounts for over 24 % of wetlands worldwide. Drainage for agricultural use is the biggest cause of wetland loss. Canada has lost 85% of its wetlands to agricultural conversion since the first European settlers arrived in the early 19th Century.

In countries like India, such data is often not available to a satisfactory level. This is because ecological studies on wetland ecosystems of India have been of a preliminary and fragmentary nature (Mahajan 1986). There are varying estimates of the total extent of wetland resources in the country. A recent estimate is 58.4 million ha (Anon 1993). The predominant wetland types of the Indian subcontinent include flood plains of major rivers, estuaries, saline expanses, freshwater lakes, backwaters, mangroves, tanks, marshes, jheels, terai, swamps and man-made water bodies like paddy fields and reservoirs or dams.
1.1 Environmental Conservation: Differing views

Environment protection has been viewed differently by many scholars however, there views can be broadly summed under two basic ideologies namely, radical and reformist. The reformist (technocentric) holds that environmental protection can be effectively incorporated within modern industrial society, without fundamentally threatening economic growth and material prosperity. According to them development must be sustainable in nature. It is an optimistic approach, which puts faith in the ability of science and technology to solve environmental problems without fundamentally challenging our institution and value systems.

Radical holds that we need to limit our production and consumption level in order to control any environmental catastrophe. Radicals are sceptical of science and technology’s ability to perform the role of environment protection. However, radicals do recognise the fact that science has played an important role in the identification of environmental problems, which has in turn; put pressure on governments to act. It also views that faith in science and technology can lead to a reliance on technical fixes i.e., this will encourage the idea that we can continue to deplete non-renewable resources and to pollute because, in the end, science will come up with solutions. For radicals this is a complacent approach, and only a fundamental shift in values and more appropriate social and political institutions, will provide genuine answers to the environmental crisis. The radical’s further views that a reliance on technical fixes would mean to leave the resolution of environmental problems to experts, which, in turn, have the effect of depoliticising environmental issues thereby preventing the emergence of normative dimensions. The difference in approaches of the two political theories is as follows:

<table>
<thead>
<tr>
<th>Technocentrism</th>
<th>Ecocentrism</th>
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<tr>
<td>1. Modified sustainable economic growth</td>
<td>1. Limits to and undesirability of economic growth.</td>
</tr>
<tr>
<td>2. Large role of technological development as a provider of solutions for</td>
<td>2. A distrust of science and technological</td>
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environmental problems.

3. Environmental solution can co-exist with existing social and political structures.

4. Anthropocentrism and a commitment to intra-generational and intergenerational equity.

fixes.

3. Radical social and political change necessary. A preference for decentralised social and political organization.

4. Intrinsic value of nature, or at least a weaker version of anthropocentrism; a commitment to social justice within human society and between humans and non-human nature.


1.2 The Role of State in Environmental Conservation

Environmental conservation requires a strategy, plan of action and machinery for implementation. The environmental conservation in present scenario has become a priority issue for various agencies and countries of the world in the wake of environmental degradation and its consequent crisis. The efforts therefore been made for the aforesaid worldwide by various governments and agencies. The role of various governments thus becomes important since it’s the government on whom the responsibility lies for the deployment of their environmental resources and its optimal realization, adding thus, to the enhancement of the quality of life. Government even carries out the function of environment management when it manages agricultural land for sustained yield. It also manages the security and sovereignty of land, water holdings and air spaces. Government is thus the supreme manager of the environment. In this direction the Government of India has also set up a Ministry of Environment and Forest at the centre with the overall responsibilities of ensuring environment protection and conservation. Similarly at global level United Nations has set up United Nations Environment Programme (UNEP) to check environmental crisis. The Sri Lankan government has also set up concerned department for wetland conservation.
1.3 Global Effort in Wetland Conservation

At the global level, the need for wetland protection picked up momentum in the early 1960s. A series of conferences and technical meetings were held mainly under the auspices of the International Waterfowl Research Bureau. This culminated in the Convention on Wetlands of International Importance, especially the convention for waterfowl habitat, known more simply as the Ramsar Convention, after the Iranian town on 2nd February 1971. The Convention came into force on 21st December 1975, after seven states ratified it. This was the first modern global nature conservation treaty and still remained the one which is dedicated to the conservation of selected ecosystem and of the species dependent on them. The broad objectives of the convention are to stem the loss of wetlands and to ensure their conservation. To meet these objectives the Convention provided some general obligation relating to the conservation of wetlands throughout the territories of the contracting parties and for special obligations pertaining to those wetlands which have been designated as “wetlands of special importance”. The Ramsar Convention is thus an international treaty designed to address global concern regarding wetland loss and degradation. The primary purpose of the treaty is to list wetlands of international importance and to promote their wise use, with the ultimate goal of preserving the world's wetlands. Methods include restricting access to the majority portion of wetland areas, as well as educating the public to combat the misconception that wetlands are wastelands. A large number of government agencies and local and international NGOs are working in the form of research and surveys on the conditions of wetlands and implementation of various laws and policies. The ongoing regional initiatives addressing wetland issues are as follows:
Table 1.2: Regional Wetland Initiative in South Asia

<table>
<thead>
<tr>
<th>Institutions</th>
<th>Initiative</th>
<th>Activities/ Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetlands International</td>
<td>Asian water bird census and water bird conservation strategy facilitating the implementation of the Asian wetland Inventory</td>
<td>A project titled “Towards a strategy for wetland and water bird conservation in the Central Asian Indian Flyway”.</td>
</tr>
<tr>
<td>ICIMOD, WWF and Ramsar Bureau</td>
<td>Framework for an Action plan on wetland Conservation and wise use in the Himalayan High Mountains</td>
<td>Establishment of a regional Wetland Centre in great Asian mountains to set up a proper institutional base to assist regional</td>
</tr>
<tr>
<td>IUCN-Asia</td>
<td></td>
<td>Develop mountain programme for conservation and sustainable use of biodiversity in the Hindukush-Karakoram Himalayas.</td>
</tr>
<tr>
<td>IWMI</td>
<td>Wetlands and biodiversity programme. A memorandum of Cooperation (MoC) was signed between IWMI and Ramsar in 2004.</td>
<td>Research on the relationship between irrigation water management and the environment in an integrated manner, focusing</td>
</tr>
<tr>
<td>GEF</td>
<td>Sustainable Environmental management of the Bay of</td>
<td>Preparation of a transboundary diagnostic</td>
</tr>
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</table>
1.4 Wetlands: Definition, Ecosystem and Types

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. Wetland are distinguished by three major characteristics namely, the presence of water, by unique soils that differ from adjacent upper lands and by supporting vegetation adapted to the wet conditions. Various scientists have formulated a variety of definitions for wetlands. A complete definition of wetland involves a multidisciplinary approach.

However, the internationally accepted definition of wetlands given by Ramsar Convention describes them as, “Areas of marsh, fen, peat land or water whether natural or artificial permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which does not exceed 6 meters”. Article 2.1 of the convention states that "(Wetlands) may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands". Wetlands perform some useful functions in the maintenance of overall balance of nature. Some of the important functions are: flood control, water storage and purification, protection of shoreline and hinterlands, floral and
faunal, gene pools, recreation, besides providing outputs of commercial value and economic sustenance to the people (Online web: www.ramsar.org).

**Diagram 1.1: Conceptual Model of a Wetland Ecosystem**

In the above diagram, wetlands are shown to be a three-component ecosystem. The hydrology of the landscape influences and changes the physiochemical environment, which in turn, along with hydrology, determines the biotic communities that are found in the wetland. Overall, the forcing functions of the wetlands, or any landscape ecosystem for that matter, include climate, which includes solar energy, temperature patterns, and precipitation. Climate couples with the geomorphology of the landscape to influence where and when water is present long enough to cause wetlands to exist. Several wetland
Classification systems are used by scientists around the world to categorize wetland ecosystem (Mitsch et al. 2007).

Classification of wetlands has been complex. A number of national wetland classifications exist. In 1970s, the Ramsar Convention on wetlands of international importance made the first attempt to establish an internationally acceptable wetland classification scheme. The Ramsar classification of wetland types is intended as a means for fast identification of the main types of wetlands for the purposes of the Convention (Online Web: www.en.wikipedia.org.). The wetlands are classified into three major classes. These are: (1) Marine/coastal wetlands, (2) Inland wetlands, (3) Human- made wetlands. These are further subdivided by the type of water such as fresh or saline or brackish or alkaline; and may be further classified by the substrate type of other characteristics. In this research work coastal wetlands have been taken as case studies with respect to their environmental problems and management and therefore major emphasis has been given on the study of coastal wetlands.

Table 1.3: Classification of Wetlands

<table>
<thead>
<tr>
<th>Inland Wetlands</th>
<th>Riverine</th>
<th>Deltas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palustrine</td>
<td>Permanent freshwater marshes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seasonal marshes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Permanent freshwater lakes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floodplain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seasonal rivers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Permanent rivers</td>
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</tbody>
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The thesis focuses upon lagoon wetlands as part of case study thus coastal wetland ecosystem along with lagoon wetland is being dealt in detail.

1.5 Coastal Wetlands

Coastal Wetlands around the world are divided into three types, salt marshes, tidal freshwater wetlands and mangrove swamps. Wetlands in the coastal areas are influenced by alternate floods and ebbs of oceanic tides therefore near coastlines; the salinity of the water approaches that of the ocean, whereas further inland, the tidal effect can remain significant even when the salinity approaches that of freshwater. It is estimated that there are 0.36 million km² of coastal wetlands in the world. The salt marsh, a type of coastal wetlands are found distributed worldwide along coastline in middle and high latitudes,
flourishes wherever the accumulation of sediments are equal to or greater than the rate of land subsidence and where there is adequate protection from destructive waves and storms. The important physical and chemical variables that determine structure and function of the salt marsh include tidal flooding frequency and duration, soil salinity, soil permeability and nutrient limitation, particularly by nitrogen. Freshwater coastal wetlands include both marshes and swamps. Freshwater tidal marshes combine many factors of inland marshes and salt marshes. Biota and plant diversity increases here due to reduced salt content. Mangrove swamps replaces salt marshes in subtropical and tropical regions as dominant ecosystem. Salt marshes are found throughout the world along protected coastlines in the middle and high latitudes. Salt marshes are primarily detrital-based, with abundant fauna dependent directly (e.g., crabs) or indirectly (e.g., birds, estuarine fish) on this detrital production (Mitsch et al. 2007). A modest amount of the marsh grass productivity is consumed by grazing plants and animals in these systems have adapted to the stresses of salinity, periodic inundation, and extremes in temperature.

Lagoon¹ wetlands, a saltwater lacustrine wetlands are surrounded by a number of problems. These include pollution (including run-off from agricultural areas and industrial effluents), over fishing, over grazing, erosion and climatic change. These may affect water supply. Wetlands at the end of rivers are particularly vulnerable to the impacts of freshwater influx, affecting its salinity level and thus its productivity. The siltation caused due to mud brought by these streams leads to the danger of reduction of its area and eutrophication. Lagoon systems are a common and effective method to purify communal sewage in rural areas. Low costs and high purification rates are some of their advantages. But mostly algae blooms in the lagoon cause a secondary pollution of the following stream. In order to tackle this problem, several tests have been carried out combining both lagoon and filtering system (Steinmann et al. 2002).

A tidal salt marsh energy flow diagram makes us understand the working up of coastal wetland ecosystem. The energy flow diagram of tidal salt marsh is as follows:

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¹ A body of water cut off from a larger body by a reef of sand or coral
Diagram 1.2: Tidal Salt Marsh: Energy Flow Diagram

Source: Adapted from Mitsch & Gosselink
1.6 Threats to wetlands in India

Wetlands are one of the most threatened habitats of the world. Wetlands in India, as elsewhere are increasingly facing several anthropogenic pressures. Thus, the rapidly expanding human population, large scale changes in land use/landcover, burgeoning development projects and improper use of watersheds have all caused a substantial decline of wetland resources of the country. Significant losses have resulted from its conversion threats from industrial, agricultural and various urban developments. These have led to hydrological perturbations, pollution and their effects. Unsustainable levels of grazing and fishing activities have also resulted in degradation of wetlands. The current loss rates in India can lead to serious consequences, where 74% of the human population is rural (Anon 1994) and many of these people are resource dependent. Healthy wetlands are essential in India for sustainable food production and potable water availability for humans and livestock. They are also necessary for the continued existence of India’s diverse populations of wildlife and plant species; a large number of endemic species are wetland dependent. Most problems pertaining to India’s wetlands are related to human population. India contains 16% of the world’s population, and yet constitutes only 2.42% of the earth’s surface. Indian landscape has contained fewer and fewer natural wetlands over time. Restoration of these converted wetlands is quite difficult once these sites are occupied for non-wetland uses.

Hence, the demand for wetland products (e.g., water, fish, wood, fiber, medicinal plants etc.) will increase with increase in population. Wetland loss refers to physical loss in the spatial extent or loss in the wetland function. The loss of one km² of wetlands in India will have much greater impacts than the loss of one km² of wetlands in low population areas of abundant wetlands (Foote Lee et al. 1996). The wetland loss in India can be divided into two broad groups namely acute and chronic losses. The filling up of wet areas with soil constitutes acute loss whereas the gradual elimination of forest cover with subsequent erosion and sedimentation of the wetlands over many decades is termed as chronic loss. Acute wetland losses are due to various factors such as: (1) Agricultural conversion In the Indian subcontinent due to rice culture, there has been a loss in the spatial extent of wetlands. Rice farming is a wetland dependent activity and is developed
in riparian zones, river deltas and savannah areas. Due to captured precipitation for fishpond aquaculture in the catchment areas and rice-farms occupying areas that are not wetlands, water is deprived to the downstream natural wetlands. Around 1.6 million hectares of freshwater are covered by freshwater fishponds in India. Rice-fields and fishponds come under wetlands, but they rarely function like natural wetlands. Of the estimated 58.2 million hectares of wetlands in India, 40.9 million hectares are under rice cultivation (Anon 1993). (2) Direct deforestation in wetlands Mangrove vegetation are flood and salt tolerant and grow along the coasts and are valued for fish and shellfish, livestock fodder, fuel wood, building materials, local medicine, honey, bees wax and for extracting chemicals for tanning leather (Ahmad 1980).

Alternative farming methods and fisheries production has replaced many mangrove areas and continues to pose threats. Eighty percent of India’s 4240 km² of mangrove forests occur in the Sunderbans and the Andaman and Nicobar Islands (Anon 1991). But most of the coastal mangroves are under severe pressure due to the economic demand on shrimps. Important ecosystem functions such as buffer zones against storm surges, nursery grounds and escape cover for commercially important fishery are lost. The shrimp farms also caused excessive withdrawal of freshwater and increased pollution load on water like increased lime, organic wastes, pesticides, chemicals and disease causing organisms. The greatest impacts were on the people directly dependent on the mangroves for natural materials, fish proteins and revenue. The ability of wetlands to trap sediments and slow water is reduced.

Further wetland loss is due to (3) Hydrologic alteration Alteration in the hydrology can change the character, functions, values and the appearance of wetlands. The changes in hydrology include either the removal of water from wetlands or raising the land-surface elevation, such that it no longer floods. Canal dredging operations have been conducted in India from 1800s due to which 3044 km² of irrigated land has increased to 4550 km² in 1990 (Anon 1994). Initial increase in the crop productivity has given way for reduced fertility and salt accumulations in soil due to irrigated farming of arid soils. India has 32,000 ha of peat-land remaining and drainage of these lands will lead to rapid subsidence of soil surface. (4) Inundation by dammed reservoirs Presently, there are
more than 1550 large reservoirs covering more than 1.45 million ha and more than 100000 small and medium reservoirs covering 1.1 million ha in India (Gopal 1994). By impounding the water, the hydrology of an area is significantly altered and allows for harnessing moving water as a source of energy. While the benefits of energy are well recognized, it also alters the ecosystem.

Chronic wetland losses are due to factors like (1) Alteration of upper watersheds Watershed conditions influence the wetlands. The condition of the land where precipitation falls, collects and runs-off into the soil will influence the character and hydrologic regime of the downstream wetlands. When agriculture, deforestation or overgrazing removes the water-holding capacity of the soil then soil erosion becomes more pronounced. Large areas of India’s watershed area are being physically stripped of their vegetation for human use. (2) Degradation of water quality Water quality is directly proportional to human population and its various activities. More than 50,000 small and large lakes are polluted to the point of being considered ‘dead’ (Chopra 1985). The major polluting factors are sewage, industrial pollution and agricultural runoff, which may contain pesticides, fertilisers and herbicides. (3) Ground water depletion Draining of wetlands has depleted the ground water recharge. Recent estimate indicates that in rural India, about 6000 villages are without a source for drinking water due to the rapid depletion of ground water. (4) Introduced species and extinction of native biota Wetlands in India support around 2400 species and subspecies of birds. But losses in habitat have threatened the diversity of these ecosystems (Mitchell & Gopal 1990). Introduction of exotic species like water hyacinth (Eichornia crassipes) and salvinia (Salvinia molesta) have threatened the wetlands and clogged the waterways competing with the native vegetation.

1.7 Threats to wetlands in Sri Lanka

A large number of wetlands in Sri Lanka are facing a number of threats due to harmful human activities. One of the commonly reported problem is of siltation. This is generally not caused by natural factors operating in the wetlands, rather by actions on lands in the adjacent or away from the coast. Aquaculture has been posing a serious threat to wetlands
here as conversion on greater rate has been reported due to high shrimp demand. There are four major types of threats being faced by wetlands in Sri Lanka, these threats are: habitat deterioration, direct exploitation of species, spread of invasive alien species and natural phenomena.

Habitat deterioration has been due to factors like reclamation, clearing of vegetation, water pollution, garbage disposal, regulation of water flow, unplanned irrigation structures and mining. All these have resulted into loss of wetlands and their biodiversity including habitats and species, harmful effects on humans, eutrophication, spread of harmful diseases, gradual disappearance of lowland wetlands, changes in water quality, loss of habitats and species. The habitat deterioration problem has been reported from urban marshes to rivers and tanks to coastal lagoon as well as mangroves.

Direct exploitation of species in Sri Lankan wetlands has resulted in several species facing the risk of extinction. The factors causing extinction are poaching, water pollution, ornamental fish trade, ornamental plant trade, etc. This has resulted into reduction in the number of aquatic plant, aquatic animals and other targeted birds and mammals.

Spread of invasive alien species has also been one of the problems and it has been reported that almost 10 species of invasive alien fauna and 12 species of invasive alien flora has spread into different wetland ecosystem throughout Sri Lanka. These invasive alien species have resulted in direct exploitation or destruction of native species, superior competitors for resources, deterioration of the quality of wetlands and agriculture. Another problem being faced by wetlands in Sri Lanka are by natural phenomena. Prolonged drought, rise in seawater temperature due to climate change, and Tsunami are some of them. For instance prolonged drought in Hambantota district resulted in the drying off of several tanks, salt marshes and lagoons causing death to several wetland animal species (Kotagama et al. 2003).

It is in this backdrop of various threats, wetland conservation in Sri Lanka started as early as 1897 when an enactment was promulgated. It is not only the developed world where sound management and conservation are important, rather also in developing world. However, the compulsion differs for instance in the developed world concern for
environmental quality are rising and also very small portion of the original stretch remains. In developing world the survival of people as well as environmental and genetic resources is linked inextricably with wetland functioning.

There are major structural differences in the management requirements for wetlands worldwide. It would be naive however, to separate between the issue of wetland protection and management and the developed and developing nations. International development and technology aid and role of remote funding agencies in the wealthy nations are important factors influencing the survival of third world wetlands.

**Figure 1.1: Location of Chilika and Bundala Lagoon**
1.8 Chilika Wetland

In India, Chilika Lake is the biggest lagoon lake – designated by Ramsar Convention as wetland of international importance. It is of relatively recent origin, being formed several thousand years ago. Freshwater runoff from the drainage basin, combined with saline water inflows from the ocean, result in a wide range of fresh, brackish and saline water environments within the lagoon, supporting an exceptionally productive ecosystem. The lagoon is a well-known wintering site for migrating birds. It is also only one of the two lagoons in the world that is home to the Irrawadi dolphin. The lagoon is also extremely important for the local population, not only as a source of livelihood – mainly fisheries – but also as a focus of cultural, religious and spiritual activities. Unfortunately, Chilika was facing a series of problems by the 1990s that impaired many of its uses. Major problems were related to a decreased salinity in the lagoon, caused by the narrowing of the lagoon mouth. It was because of the choking of its outlet to the sea and sediment accumulation from the drainage basin that led to deterioration in the water condition as well as reduction in the water level. Recently, decline in the number of migratory birds has also been noticed, threatening the very existence of its habitat. There has also been a general increase in pollution from agricultural, aquaculture and domestic resources in the drainage basin. Traditional fisher folk were particularly hard hit by these problems. The decline in fish catches led them to use a smaller mesh size, thereby putting even greater pressure on the fishery and further complicating the problems. Pressure of the livelihood also led to poaching of birds and logging of in the watershed. In addition to these problems there came another in the form of changes in the lease of the fishing grounds, resulting in the loss of access by traditional fisher folk to many fishing grounds and rise of commercial prawn culture. Conflicts over these issues led to violence and death (CDA, 2008).

The Chilika Development Authority (CDA) was created in 1991 as a coordinating body between the wide range of institution and the people with a stake in the lagoon and the basin. The CDA has worked close with departments of the State Government of Orissa to improve the condition in the lagoon. The most noticeable decision till date under the guidance of CDA was making another opening, in 2000, into the Bay of Bengal, and
dredging the channel between the outer channel and rest of lagoon. This resulted in the restoration of the flow regime, leading to a dramatic improvement in the lagoon’s salinity and amelioration of many problems. As example, fish and crab catches have markedly increased, macrophyte coverage has declined and some rare and endangered species have returned. A monitoring program was instituted, a management plan was drawn up and environmental flow release is being negotiated from the upstream irrigation impoundments. Challenges undoubtedly remain. However, conflicts over fishing have abated mainly due to enhancement of the fishery resource. Furthermore, it is an achievement for the Chilika that after being placed in Montreaux Record (Ramsar’s list of sites undergoing ecological degradation) in 1993 it was awarded the prestigious Ramsar Wetland Award in 2002 (Ghosh 2006). It was removed from the Montreaux Record due to successful restoration efforts by the CDA.

1.9 Bundala Wetland

The Bundala National Park lagoons are located in the Hambantota district within the South-eastern arid zone of Sri Lanka. The park consists mainly of dry thorny scrubland and lagoons namely, Koholankala, Malala, Embilankala and Bundala. These shallow lagoons form a complex wetland system that harbours a rich life, including several species of migratory waterfowl. Bundala is Sri Lanka’s first Ramsar wetland – a wetland of international importance especially for migratory waterfowl. This was designated in 1991. The nine different habitat types harbour 97 species of birds, 48 reptiles, 32 fish, 52 butterflies, and 32 mammals, many of them endemic or threatened. However, it is facing a number of problems, because of nearby human settlements, cultural and tourist centres. These threats include habitat deterioration and degradation, direct exploitation of species, spread of alien invasive species, prolonged drought and inadequately planned land-use practices. The lagoon gets influx of freshwater from the upstream channel reducing its saline character especially in Malala and connected lagoon. Coupled with this they also get chemical fertilisers washed away from upstream agricultural land through streams. All this has led to change in the lagoons physicochemical characteristics though more pronounced in Malala and interconnected Embilankala lagoon.
The wetlands Conservation Project of the Central Environment Authority took initiative in 1993 to prepare a wetland site report and conservation management plan for Bundala. Subsequently a detailed management plan for Bundala was prepared by the Department of Wildlife Conservation in 1997 under the Global Environment Facility funded project. The recommendation of the latter plan is being gradually implemented by the Department of Wildlife Conservation. In this perspective, for the Conservation of marine turtles hatchery management guidelines have been developed and for rehabilitating degraded marine turtle habitats community based programme removes debris that impedes turtle nesting. Eco-tourism programme are being developed with the funding from the government and Global Environment Facility fund. There is another move by the Government in terms of re-demarcation of the park boundary line so that agricultural activities can be checked in the northern area.

1.10 Wetlands literature

Studies on wetlands in India are relatively recent and little is known about their distribution, structure, function, ecological status and management needs. Before 1973 there was no systematic survey. In 1973, an aquatic weed survey was conducted by the Department of Science and Technology (New Delhi) which estimated wetland areas. Another wetland survey was attempted in 1984 by the then Department of Environment of the Government of India but it did not succeed. Further effort made by IUCN (International Union for Conservation of Nature), with the help of (Integrated water Research Bureau) IWRB, by eliciting information from field workers. This resulted in an inventory of 93 wetlands and wetland complexes (Wolstencroft et al. 1989). The Ministry of Environment and Forests of the Government of India published a list of wetlands which comprises mostly the temple tanks fishery reservoirs and some multipurpose reservoirs. Recently, WWF-India revised and updated the Indian section of the Asian Wetland Directory, with information on 77 additional wetlands (WWF-India and AWB, 1993). Besides these efforts, information on the extent and distribution of different kinds of wetlands and there conservation status is available in few publication of which the most important are, Trisal and Zutshi (1985), and Gopal (1982). Trisal (1993) has
grouped wetlands in India according to their geographical distribution into Himalayan, coastal and Indo-Gangetic Wetlands.

Syama Prasad Rout (2005) analyses the role of management institutions on common property resources as development drivers and safety net providers. Particularly, the role of Supra-National, National and Sub-National institutions in fisheries management around Chilika Lake has been studied closely. Chilika Lake presents a complex ecosystem with multiple stake holders. The lake presents a classic case of conflict between the traditional fishing rights vis-à-vis commercial fishing by outsiders. Shrimp mafias have captured almost the entire lake for commercial exploitation of tiger prawn, shrimp species very popular in East Asian countries. Unauthorized encroachments for shrimp culture are rampant. Mostly the mafias running the trade involve local people to gain legitimacy. The local fisher folk which have been depending on the lake’s resources for generations are easily deprived of its basic livelihood.

In order to bring a controlled management for fishing the local Government has brought a number of legislations. A number of fisheries co-operatives are working. A high power autonomous body (Chilika Development Authority) is looking after the issues involving development, conflict resolution, peaceful settlement, eco-management etc. Legitimate stakeholders, particularly local communities and indigenous people are being strongly encouraged to take an active role in planning in these management institutions. Supra-national institutions, National institutions, Provincial Government institutions, Non-Government Organisations, Research institutions and Local Community institutions play active role in management of the common property resources of Chilika lake. With the intervention of these management institutions there is a visible change in production of fish and shrimp, conservation of ecosystem, livelihood protection of the depending fish folk population, conflict resolution etc. This sort of co-management between the Government and other supportive agencies has not only created a space for development but also has given a platform for the affected population. However, the insights gained into the ongoing struggles, conflicts, negotiation, mediation and adaptations of stakeholders, major learning points are identified to be replicated to the extent to which institutions can be better designed for governing the local commons.
O. P. Dwivedi (1997) discusses all-encompassing, wide-ranging environmental issues faced by India. The text analyses the political, institutional, legal, cultural and international dimensions of India’s environmental challenges. His book is divided into four parts. Part I deals with different aspect of environmental management such as the various influences on environmental quality, framework for environmental management, history of policy development and administrative changes in India and further assessment of major environmental laws and regulations. Part II deals with international environmental concerns and how India fits in with these concerns. He also proposes that developing countries faces developmental problem and pressures from developed countries and suggests need for a global environmental policy with special emphasis on pollution and poverty. Part III of the book examines the relationship of humans with nature from the spiritual perspective, and finally Part IV discusses how to improve the organisational effectiveness of environmental conservation and management and further it suggests ways of preventing further stress on India’s fragile environment.

Stephen Ison et al. (2002) looks into human perspectives on environmental issues and policy prescriptions, while at the same time seeks to give due attention to the more conventional issues and policies involving natural resources. From policy perspective it mainly discusses issues of advanced countries though, on issues of global scale role of supranational bodies have also been discussed. The environmental policy making machinery of EU is being discussed in detail though several cases to show its strength and weakness has also been discussed.

K. J. S. Chatrath (1992) explains the strategies being followed by the Government of India for conservation and management of wetlands in India. In one of the case studies on Loktak Lake of Manipur, Rasmi De Roy describes the economic value of this lake, being only refuge of the endangered sangai. She talks of the problem faced by it in terms of natural eutrophication, reclamation for agriculture and settlement purposes, depletion of vegetation cover and consequently heavy siltation, weed infestation, encroachment, pollution due to sewage and chemicals, depletory fishing practices and increased eutrophication due to Loktak hydroelectric project. She reviews the conservation
measures carried by Loktak Development Authority (LDA), which does not include environment impact assessment and submergence issue.

The writer makes recommendation of some measures like research and monitoring, siltation control, water hyacinth control, encroachment impact assessment, sangai protection and fertilizer usage control. C.C. Trisal in a case study on Dal Lake of Jammu and Kashmir gives an account of problem faced by it in terms of pollution. The author has recommended a regional ecological development plan taking into account the use of land for agriculture, orchards, the other crops based on studies of geomorphology, soil characteristics and other parameters. Another recommendation is for peripheral area development, control of encroachments and regular monitoring of the lake environment. In Harike Lake case study, Neelima Jerath analyses various areas of concern and explains various actions that is already on to conserve this wetland. Harike Lake, one of the largest wetland in northern India is facing the problem of excessive weed growth, deforestation, encroachment, unchecked grazing and soil erosion. A comprehensive management plan is under preparation. Other works like notification of this wetland as a sanctuary, manual weed control, afforestation, fencing, monitoring of pollution, regulation of fishing, etc. are under way.

In the case study of Sukhna Lake of Chandigarh, Ashok Pradhan tells us of the bold and fascinating experiment of enlisting public participation in saving Sukhna Lake. This has its importance in terms of recreation and one of the destinations of the migratory birds from Siberia every winter. It faced the problem of siltation due to free grazing in its catchments. Under the Sukhmanmi project villagers were persuaded to do away with their goats and instead keep the milch cattle. Again de-siltation were carried through shramdan. The movement proved to be a pace setter in checking environmental degradation.

K. J. S. Chatrath himself studied Chilika Lake, which is the largest salt-water lake in Asia. He accounts for its problem and various actions taken. This Lake is situated in one of the backward region of India and a large population is dependent on it for their livelihood. It is facing the problem of over-fishing, shrinkage in area, siltation,
eutrophication, etc. and thus the arrivals of migratory birds are on decline. This study talks of the steps taken to check its degradation. A state Environment Protection Council has been set up. Again remote sensing imagery is being used and management information system is being prepared. Concluding this article, Trishal talks about the need for a systematic approach in solving its problem. Indeed, this work has been successful in bringing together the available data on Indian lakes. Such studies would lead to sound management of ecology and development of lakes.

Donald M. Kent (2001) provides the fundamentals for delineating, identifying and regulating wetlands. It covers functions and values, ecological assessments, and how to minimize negative impacts on Wetlands. The book also presents essential information on Wetlands creation, enhancement, restoration and monitoring. Designing and managing coastal marshes and Wetlands education are some selected management topics. This indispensable guide furnishes extensive information of how wetlands function and how they can be protected and managed. Recognizing that each and every situation is unique and requires specific solution, this book focuses on providing guidelines for effective decision making.

As conserving biodiversity and using biological resources sustainably would benefit all of society, it is very necessary to get support of various sectors of society in the implementation of the Convention on Biological Diversity. Timothy Swanson (2005) describes the fundamental nature of the global problem now before the international community and the basic nature of the international agreement that is required to achieve its solution. He describes the decline of global diversity, cultural as well as biological, as a result of the uniform nature of the global development process and the by-product of the progress of this homogenising process across the face of the globe. Many movements for its concern, and nature of required solution has also been dealt with. Finally, Swanson describes the Biodiversity Convention as unprecedented opportunity for the institutions concerned with the opportunity for fostering alternative pathways to development.

Recently the importance of wetland conservation has been given due importance as it has been understood that wetland in natural state are more useful than their altered state. The
book written by Patrick Dugan & Patrick Dungan (1990) addresses the problem by reviewing the importance of wetlands, and reasons for wetland loss and identifying ways and means to improve management. It identifies contribution of wetlands in sustainable development, and critical issues to be addressed if these contributions are to be realised. Various types of wetland ecosystems and their values have also been dealt with. Together with these loss of wetland due to human factor and different strategy to improve wetland ecology drawn from experience of different case studies have been provided.

Jyoti Parikh and Hemant Datye (2003) has carried a comprehensive and multidisciplinary study of Wetlands. Their book unites the natural science perspective with approaches of strong social and economic approaches in order to design a practical national wetlands conservation strategy and action plan. It gives an overview of Indian wetlands and the problem faced by it. The policy for wetland conservation suffers from lack of integration and coordination. It advocates remote sensing information which can show the changes that have taken place in a particular time frame. It can help us to inventory different wetland attributes like fisheries, coastal zone stabilization and biodiversity, which can be used to address site-specific local needs. It says that eco development planning and the integration of wetland and river system are essential. For this purpose a river system can be divided into three regions, starting from the source. These are, conservation zone, transportation zone, and command area zone. In the conservation zone retention of forest cover has been suggested over hilltop along with river bank. Again, agro-forestry replacing shifting cultivation has been suggested. In the transportation zone it talks of the need of preventing encroachments from farming, grazing, settlement and other human activities in the basin and keeping a buffer of appropriate riverine vegetation on both sides of the bank. Command area eco-development involves prevention of encroachment and varied contamination, care of natural habitats, maintenance of buffer zones and eco-development of shallow reservoirs. The author has described here their experiment of the Panshet watershed in the western ghat that is highly successful. In designing this strategy, it is acknowledged that Wetlands are seen as a common property resource, while no one is really prepared to take responsibility for their preservation and sustainable use.
Therefore, the contributors argue that local users must be involved and traditional knowledge be incorporated in any long-term strategy plan. The contributors make a strong case for coordinated management of wetlands and outlined various social, economic and ecological indications, which can be used to assess the diverse management needs of different wetlands. They argue that any chosen management strategy must be dynamic and sustainable. According to them, it should be flexible enough to accommodate rapid corrective action to meet the long-term conservation and restoration goals. The unique feature of this book is that it focuses on the economic valuation of wetlands. The contributors argue that the conservation status of wetlands is undermined because there is no recognition of its economic benefits. This assessment will enable policy makers to weigh the pros and cons rationally and to arrive at a comprehensive strategy for sustainable development.

K. J. Walker (1989) views that focus on 'modern' industrialized societies obscures both the great antiquity of the state and the powerful selective pressures that have led to the dominance of interstate competition, especially warfare. In pursuit of power, elites encouraged population growth and intensified the exploitation of the natural resource base, with progressively more severe ecological impacts. Modern technology has vastly amplified the problem. Though, it provides for possible sophisticated environmental management that has been neglected for the demands of the military—industrial system. These ill-effects are reinforced by ignorance of ecology and inadequacy of traditional political thought. A major adaptive challenge faces modern states: to use their knowledge and resources for more humane, environmentally sensitive management and perhaps achieve a novel kind of steady state, or to renew emphasis on short-term competitive considerations.

D. A. Scott and T. A. Jones (1995) views that Classification of wetlands is extremely problematical, definition of the term wetland being a difficult and controversial starting point. Although considerable effort has gone into the development of national and regional wetland classifications, the only attempt at establishing a global system has been under the auspices of the Ramsar Convention on Wetlands of International Importance. In view of the fact that the Ramsar Convention has 70 Contracting Parties world-wide, it
is suggested that the Convention's definition and classification system should be adopted generally for international purposes. Much of the world has been covered by preliminary wetland inventories, but there is an urgent need to extend coverage to those areas not yet included. It is essential that all inventory projects give adequate attention to meeting the real information needs of agencies and individuals which have an impact on the conservation and wise use of wetlands. Attention should also be given to provide for wide dissemination and regular updating of information and establishment of procedures for monitoring ecological change at the sites identified.

William J. Mitsch and James G. Gosselink et al. (2009) discusses wetland ecosystems and systems approaches in studying wetlands. With its comprehensive coverage of wetland science, management, and restoration, Mitsch and Gosselink's Wetlands has been the premier reference on wetlands for more than two decades. Now, the coverage of specific wetland ecosystem types from earlier editions of this acclaimed work has been updated, revised, and supplemented with additional content in order to create this new text focusing exclusively on wetland ecosystems. This book now complements Wetlands, fourth Edition. Following an introduction to ecosystems in general and wetland ecosystems in particular, Wetland Ecosystems examines the major types of wetlands found throughout the world: coastal wetlands, freshwater marshes and forested swamps, and peatlands. It provides updated descriptions of the hydrology, biogeochemistry, and biology of the main types of wetlands found in the world, a broad international scope, new perspectives and additional insights into the latest ecosystem and modeling techniques. The final chapter reviews three fundamental systems approaches in studying wetlands: mesocosoms, full-scale experimental ecosystems, and mathematical modeling.

Resource management in the United States is undergoing a fundamental change. Traditional sustained-yield approaches that focus on commodity production and human resource use are steadily giving way to ecological approaches, often referred to as ecosystem management, that have long-term ecological sustainability as their primary goal. To achieve that goal, ecosystem management emphasizes socially defined goals and objectives, integrated and holistic science, collaborative decision making, and adaptable institutions. Political considerations are an essential component of ecosystem
management, yet its socio-political context has been largely ignored by those studying and writing on the subject.

Hanna Cortner and Margaret A. Moote (1999) discuss the political challenges facing ecosystem management as it moves from theory to practice. They have described the history of natural resource management in the United States. They also discusses theory behind ecosystem management, potential inconsistencies and contradictions in the themes of ecosystem management, political philosophies that undergird traditional resource management, alternative political principles inherent in ecosystem management opportunities, and barriers for achieving collaborative ecosystem management. The Politics of Ecosystem Management considers the sweeping and profound changes that will be required of the American governance system -- its political philosophy, institutions, notions of citizenship, and politics, as well its resource management practices -- if the shift to ecosystem management is to be realized. It is a lucid and accessible volume that represents a vital contribution to the literature for students, researchers, and professionals involved with any aspect of developing and implementing ecosystem-based approaches to resource management.

The survey about Sri Lanka’s wetland also started quite late. In this respect IUCN-The World Conservation Union undertook a biodiversity assessment during the first half of 2001. Directory of Asian wetlands also provides information about Sri Lanka’s wetlands (Scott1989). The rich birdlife have been studied by CEA/Euroconsult in 1993. The IUCN Sri Lanka has also listed the threatened fauna and flora of Sri Lanka in 1993. Coastal Zone Management Plan has also been prepared by coastal conservation department (Annon 1990). UNESCO-MAB Biosphere reserve Directory provides information regarding Bundala biosphere reserve. Besides these several scholarly books and articles have also been written on wetlands.

S.C. Piyankarge et al. (2004) in his article says that one of the key lagoons of the Bundala wetlands remains largely intact and relatively pristine, but the two interconnected lagoons, namely, Emblikala and Malala, are impacted by drainage from upstream agricultural lands. All the three lagoons reported pH levels conducive to most aquatic
species. This study provides an overview of the present status of the lagoons of the wetland.

Similar studies conducted by Amersinghe et al. (2001) and IIMI (1995) points to chemical and biological changes in the lagoon wetland due to drainage of irrigation water.

1.11 Rationale and Scope of the Study

It takes into consideration the wetlands of India and Sri Lanka. This has been experienced that in both countries wetland management emerged as a crucial indicator of the ecological management strategies of the government, particularly with the recent achievements in the conservation in Chilika Lake. Both the countries belong to same biogeographic region in the Bay of Bengal area, having similar climatic condition and in the same stage of development. Thus a comparative study of the wetlands of the two countries becomes crucial. This study tries to address the lacuna in the earlier researches in wetland and tries to connect the findings with the level of ecological management achieved by the two countries.

The conservation need of the Chilika lake ecology is important from the point of view of economy. It is the biggest lagoon and is important for both the local community and a large number of waterfowl in India. The study looks into the level of ecological health of the Chilika Lake in India and Lake Bundala in Sri Lanka. It tries to find out the stage of its ecologically deterioration and measures for its conservation and sustainable management. It also tries to look into some of the experiences that can be learnt from one another for the conservation of wetlands.

The study has been carried taking into account the following hypotheses related to management of the wetlands:

1. Management rather than protection is more effective for the survival of lagoon wetlands.
2. Human exploitative pressure has been the single most important factor in bringing about the degradation of wetland ecosystem and need measures beyond the traditional management practices.
3. The politics of environmental management is an important hindering factor in wetland management.

In Methodology, extensive use of secondary source materials have been used which includes literature on the subject, articles in journals and periodicals. Apart from these, primary sources like annual action plan, management plans, reports of International Convention, proceeding of workshops, broachers, guidelines, interviews conducted, and general observation have been used. Apart from these, documents of Non Governmental Organization working in this area, Environment Impact Assessment plan, Biodiversity report, Coastal Zone Management plan manuals, etc. have been extensively utilized. The content analysis of these primary sources will be done to bring out various measures, strategies of management and/or models used for management techniques of the wetlands. A preliminary attempt has been to examine the various management issues of wetlands from these sources and also to highlight the paucity of ecological studies on wetland ecosystem and bring out research needs.

The purpose is to analyse the functions of case study wetlands from hydrological, ecological and anthropological perspectives. This includes functions necessary for biodiversity support as well as livelihood support. The judicious utilisation of wetlands requires a large data base on the following parameters: Quality and extent of water, Periodicity and extent of soil erosion, Rainfall and occurrence of floods, Distribution of wildlife, Assessment of biological diversity, and Productive potential.

For the purpose of obtaining the above information a comparative study of management plan and sustainable use of effort has been studied and political ecological aspect of conflicts in the basin has been analysed.

1.12 Chapters

The first chapter Introduction discusses aspects of wetlands such as need for such study, present situation of wetlands particularly in India and Sri Lanka, reviews of literature on wetlands, discusses the methods of study, rational and scope of the study, and the chapters.
The second Chapter *Environmental Management of Wetlands* deals with issues such as, definition, and functions of wetlands, economic valuation of wetlands, necessity of environment management, aspects and approaches of environment management especially ecosystem approaches to environmental management that guards ecodiversity aspect, ecological bases of environmental management, global environmental agencies, and environmental concerns in Developing countries as wetlands are important part of sustenance for livelihood in this area. It also deals with environmental resources, wetland resources and Ramsar Convention. The chapter discusses South Asian Wetlands, wetland in Sri Lanka, and wetland in India as the case study wetlands are from these two countries.

The third chapter *The Chilika: Ecosystem, Problems and Management* deals with topics like the geographical attributes, the ecological setting, environmental significance, and economic importance of the Chilika. It also analyses history of land use, problems of the Chilika, and wetland management in India. The 18th and 19th century colonial management of the Chilika has been looked in detail. The Chilika wetland management policy whether it confirms to standard principle of wetland management has been tried to find out. Further the present management status of the Chilika as a result of intervention by Chilka Development Authority (CDA) has been analysed. Political ecology aspect of conflict in the Chilika basin is looked here as the political dimension of reason of conflict and finally some measures have been suggested.

The fourth chapter *The Bundala: Ecosystem, Problems and Management* discusses various aspects of Bundala such as geographical attributes, like geology, soil, climate, flora and fauna. Its importance from ecological, economic and aesthetic point of view has been discussed. Further discussion has been on current threats faced by the wetlands, and the efforts in management. Management approach right from historical times to present situation has been looked into. The CEA management plan, the GEF management plan, and the ADB assisted Protected Area Management and Wetland conservation plan, their various provisions, etc. has been looked into. Finally, the review of current plan has been discussed. It has been tried to ascertain whether management plan confirms to standard
principal of ecosystem management in the wetlands. A political ecology aspect of conflict in the basin of wetland has been discussed.

The fifth chapter *Comparative Analysis of the Bundala and the Chilika Wetlands: Approaches, Policy and legal framework* discusses aspects like legal protection of wetland in Sri Lanka, legal protection of wetlands in India, and the management issues in terms of comparative analysis of the Chilika and the Bundala in terms of inventory and monitoring, policy and legislation, consensus building and awareness and role of people in wetland management. Further various aspect of Wetland Management Plan such as identifying the wetland and determining its boundaries, assembling baseline information, preparing a computerised database, classification and identification of key characteristics, identifying function and values, identifying major impact and problems, determining management objective and problems, preparing management plan and preparing monitoring plan. Finally the research needs for each case study are being identified.

The last chapter i.e. sixth chapter is *Conclusion*. It discusses issues such as current situation of wetland management in India, and current situation of wetland management in Sri Lanka. It also discusses Bundala lagoon management, failure and its successes, Chilika lake management failure and successes, critically. I am giving here some suggestions which could be incorporated in future management plan of Bundala and Chilika in particular and wetlands in general.

Wetlands have been one of the most threatened ecosystems. The importance of wetlands for developing countries is immense since the livelihoods of a large number of communities are dependent on it. It is in this respect that Chilika and Bundala wetlands have been studied in detail. The chapters in this thesis thus cover various aspects of Chilika and Bundala, ranging from biodiversity, to threat assessment to management efforts in respective countries and political ecological synthesis of conflicts, and management have been analysed in the basin.