Chapter II

Review of Literature

Once, wetlands were thought to be waste lands and unnoticed by ecologists and exploited by the society. Only in the twentieth century was wetland significance felt, which resulted in the formation of the RAMSAR convention in 1971. The convention's mission is "the conservation and the wise use of all wetlands through local and international action and international co-operation, as a contribution towards achieving sustainable development throughout the world" (Ramsar, 1993).

Definition

The term *wetland* is self explanatory, meaning water-logged landscapes. But from the ecological point of view, their needs to be a specific definition which would encompass a wide range of ecosystems from semi-terrestrial fence, bogs and swamps to semi-aquatic marshes and shallow open waters.

Definition of US Fish and Wildlife Service (USFWS)

"Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water" (Cowardin *et al.,* 1979).

Definition of National Research Council (NRC)

Wetlands are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical and biological features reflective of recurrent, sustained inundation of saturation.

Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation (NRC 1995).

Definition of wetlands by RAMSAR Convention.

Areas of marsh, fen, peat lands 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 at low tides does not exceed 6 meters (Finlayson and Moser 1991).

Wetland Classification

Wetlands are diverse in nature. Classification aims at grouping similar wetlands under a common category. Classification is essential for understanding wetlands and for drafting conservation methods. Various classifications are adopted besides the classification of RAMSAR Convention.

Cowardine Classification

This classification is developed by National Wetland Inventory (NWI) of U.S. It classifies both wetland and deep water habitats under five different categories, namely marine, estuarine, riverine, lacustrine and palustrine. These units are defined by hydrology, substrate and non-specific structure of dominant vegetation (aquatic bed, emergent herbaceous, moss-lichen, scrub-shrub or forested) (Cowardin *et al.*, 1979)

Hydro-Geomorphic Classification (HGM 1993)

This classification is developed as an alternative to the vegetation-based classifications. It classifies vegetated wetlands according to their hydrology and geo-morphology, and does not include deep water or marine habitats. Sub-divisions of this classification are riverine, depressional, mineral soil flats, organic soil flats, slope, lacustrine fringe and estuarine fringe (Adamus, 2001)

National Vegetation Classification (NVCS 1998)

It is developed to facilitate vegetation mapping and habitat conservation. It includes both wetland and deep water habitats (Faber – Langendoen *et al.,* 2009)

Ramsar Classification System of different types of Wetland

Marine/Coastal Wetlands

A **Permanent shallow marine waters :-** in most cases less than six metres deep at low tide; includes sea bays and straits.

B **Marine subtidal aquatic beds :-** includes kelp beds, sea-grass beds and tropical marine meadows.

C **Coral reefs**.

D **Rocky marine shores :-** include rocky offshore islands and sea cliffs.

E **Sand, shingle or pebble shores :-** includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks.

F **Estuarine waters:-** permanent water of estuaries and estuarine systems of deltas.

G **Intertidal mud, sand or salt flats**.

H **Intertidal marshes:-** includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes.

I **Intertidal forested wetlands**; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.

J **Coastal brackish/saline lagoons**; brackish to saline lagoons with at least one relatively narrow connection to the sea.

K **Coastal freshwater lagoons**; includes freshwater delta lagoons.

Zk(a) **Karst and other subterranean hydrological systems**, marine/coastal

Inland Wetlands

L **Permanent inland deltas**.

M **Permanent rivers/streams/creeks**; includes waterfalls.

N **Seasonal/intermittent/irregular rivers/streams/creeks**.

O **Permanent freshwater lakes** (over 8 ha); includes large oxbow lakes.

P **Seasonal/intermittent freshwater lakes** (over 8 ha) include floodplain lakes.

Q **Permanent saline/brackish/alkaline lakes**.

R **Seasonal/ intermittent saline/ brackish/ alkaline lakes and flats**.

Sp **Permanent saline/ brackish/ alkaline marshes/pools**.

Ss **Seasonal/ intermittent saline/ brackish/ alkaline marshes/ pools**.

Tp **Permanent freshwater marshes/pools**; ponds (below 8 ha), marshes and swamps on inorganic soils, with emergent vegetation water-logged for at least most of the growing season.

Ts **Seasonal/intermittent freshwater marshes/pools** on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes.

U **Non-forested peatlands**; includes shrub or open bogs, swamps, fens.

Va **Alpine wetlands**; includes alpine meadows, temporary waters from snowmelt.

Vt **Tundra wetlands**; includes tundra pools, temporary waters from snowmelt.

W **Shrub-dominated wetlands**; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils.

Xf **Freshwater, tree-dominated wetlands**; includes freshwater swamp forests, seasonally flooded forests and wooded swamps on inorganic soils.

Xp **Forested peatlands**; peat swamp forests.

Y **Freshwater springs; oases**.

Zg **Geothermal wetlands**

Zk(b) **Karst and other subterranean hydrological systems**, inland

Note : "*floodplain*" is a broad term used to refer to one or more wetland types, which may include examples from the R, Ss, Ts, W, Xf, Xp, or other wetland types. Some examples of floodplain wetlands are seasonally inundated grassland (including natural wet meadows), shrublands, woodlands and forests. Floodplain wetlands are not listed as a specific wetland type herein.

Human-made wetlands

1 **Aquaculture** (e.g., fish/shrimp) **ponds**

2 **Ponds**; includes farm ponds, stock ponds, small tanks; (generally below 8 ha).

3 **Irrigated land**; includes irrigation channels and rice fields:

4 **Seasonally flooded agricultural land** (including intensively managed or grazed wet meadow or pasture).

5 **Salt exploitation sites**; salt pans, salines, etc.

6 **Water storage areas**; reservoirs/barrages/dams/impoundments (generally over 8 ha).

7 **Excavations**; gravel/brick/clay pits; borrow pits, mining pools.

8 **Wastewater treatment areas**; sewage farms, settling ponds, oxidation basins, etc.

9 **Canals and drainage channels, ditches**.

Zk(c) – **Karst and other subterranean hydrological systems**, human-made

An international committee under international agency (eg. IWRB, RAMSAR Bureau, IUCN) needs to be established to develop an international classification system and guidelines for carrying out a complete inventory of world wetlands (Finlayson and van deer Valk 1995).

Distribution of wetlands

Wetlands of the world - The aerial extent of wetland ecosystems in the world is estimated to be 917 million hectares (Lehner and Doll

2004), but Finlayson and Spiers 1999, estimated it to be 1275 million hectares. Listed below are some of the important wetlands in the world. The Pantanal wetland, which is spread over Brazil, Bolivia and Paraguay covering an area of 150,000 sq.km, is one of the largest wetlands in South America, besides the Amazon basin. The Camargue in Europe provides habitat for many birds. Wasur National Park is a massive wetland region in Indonesia which plays host to a large number of rare animals and birds. Kakadu Park in Australia, which attracts millions of migratory birds each year, is a home for fresh water and salt-water crocodiles.

Wetland distribution in India.

India has diverse and unique wetland habitats because of its varying topography and climatic regimes (Prasad *et al.,* 2002). These wetlands are distributed in different geographic regions ranging from Himalayas to the Deccan Plateau. Space Application Center (SAC) 2011 estimated the aerial extent of wetlands in India varies widely from a lowest of 1% to highest of 5% of geographical area but supporting a fifth of the known biodiversity. In addition to the various types of natural wetlands, a large number of man-made wetlands are present. These man-made wetlands are created for the needs of irrigation, water supply, electricity, fisheries and flood control. These man-made wetlands support wetland biodiversity and add to the country's wetland wealth (Deepa and Ramachandra 1999).

The first scientific national inventory of wetlands was carried out at 1:250,000 scale by Space Application Center (ISRO, Ahmedabad) at the behest of the Ministry of Environment and Forest (MoEF), Government of India using IRS satellite data (1992-93 time frame). According to the findings, the total wetland extent is about 8.26 million hectares. The major wetland types found in India include river/streams, inter-tidal mud flat, reservoir, tank and lakes/ponds. India has also some of the unique wetlands like mangroves and coral reefs. This inventory revealed numerous small wetlands, which are of great significance for local management of hydrology.

Wetland Inventory

Wetland inventories are a necessary pre-requisite for the conservation and management at a holistic level (Finlayson and Vandeer Valk 1995). Remote sensing technology in recent years has proved to be a very good tool in inventory studies (Ramachandran 1993, Ramachandran *et al.,* 1997, 1998). In most of the countries, GIS and Remote Sensing is used to map wetlands. Image segmentation and object-oriented analysis were applied to LandSat 7 imagery to map isolated wetlands in the St. John's river water management district of Alachua county, Florida (Robert *et al.,* 2009).

According to Zesmi and Bauer, 2002, all types of wetlands have been studied with satellite remote sensing. Land Sat MSS, Land Sat TM and SPOT are the major satellite systems that have been used to study

wetlands. In India, National Wetland Inventory and Assessment was carried out by Space Application Center, Ahmedabad in 2011, which is the latest inventory on Indian wetlands. In the entire country, a total of 201,503 wetlands were identified. In addition, 555,557 wetlands with area smaller than 2.25 ha, which is smaller than a minimum measureable unit were identified. India has 757.06 thousand wetlands (Bassi *et al.,* 2014).

Assessment and monitoring of mangroves of Bhitarkanika wild life sanctuary, Orissa, India using remote sensing and GIS was carried out by Reddy *et al.,* (2007). The impact of restoration of the degraded areas of Pichavaram mangrove wetland was analyzed using remote sensing (Selvam *et al.,* 2003).

Remote sensing data is a way for monitoring and managing water bodies effectively due to spatial, spectral and temporal resolution. Indian IRS – 1A and 1B satellites has been used for wetland inventory (Prasad *et al.,* 2002)

Significance of wetlands

Wetlands perform many functions in the environment. The following are the important functions :

- **Wetlands and their role in water cycle**

  Wetlands play a critical role in regulating the movement of water within watersheds as well as in the global water cycle (Mitsch and Gosselink 1993; Richardson 1994).

Wetlands store precipitation and surface water and slowly release the water into associated surface water resources, ground water and the atmosphere. Wetland types differ in this capacity based on a number of physical and biological characteristics including landscape position, soil saturation, the fibre content, the degree of decomposition of the organic soil, vegetation density and the type of vegetation (Taylor *et al.,* 1990).

Wetlands help to maintain the level of water table (O'Brien 1988, Winter 1988).

The extent of groundwater recharge occurs through mineral soils found primarily in the edges of wetlands (Verry and Timmons 1982).

Climate control is another hydrologic function of wetlands. Many wetlands return over two thirds of their annual water inputs to the atmosphere through evapotranspiration (Richardson and McCarthy 1994).

- **Wetlands are "Kidneys of Landscape"**

Wetlands are often described as 'kidneys of landscape' (Mitch and Gosselink, 1986). Wetlands help to improve the quality of surface and ground water by trapping sediments and contaminants in vegetation and soil before the filtered water finds its way back into the surface or groundwater systems.

- **Soil Erosion Control**

  Erosion control - The wetland plants can reduce soil erosion or the wearing away of the soil. The roots of the plants help to hold the soil in place.

- **Flood buffer**

  Wetlands contain soil that is like a sponge. This soil can soak up a lot of water and release it slowly, thus controlling flood-like situations (Maisarah and Kamaruzaman, 2007).

- **Wetlands are 'biological supermarkets'**

  Wetlands provide a habitat for many different plants, fish, animal species or parts of their life cycles. Some live in the wetland all through the year, while other migratory birds may visit only at certain times of the year. Many species living in wetlands are endangered (MEA, 2005). Without wetlands, these species will go extinct. Estuarine and marine fish, shell fish and some mammals must have wetlands to survive as they are breeding grounds and provide a rich source of food via decomposing plant matter.

- **Role in Carbon Cycle**

  Wetlands sediments are a rich storage of long-term carbon store, while the existing biomass is a short-term carbon reserve (Wylynko, 1999). Although wetlands contribute about 40 % of

the global methane production, they act as a carbon sink (Bassi *et al.,* 2014).

- **Wetlands as Habitat**

Wetlands are nurseries to many kinds of fish, birds and shell fish.

Wetlands are the home of hundreds of different kinds of animals. Most of the commercially important species of fish are wetland-dependant. About 80% of America's bird population relies on wetlands, according to the US fish and wildlife service. Some species of frogs, toads and salamanders depend exclusively on seasonal wetland areas as their only habitat. The temporary and seasonal wetlands allow the amphibians to thrive.

- **Irrigation**

Wetlands such as ponds, lakes, tanks and reservoirs provide water for irrigation. The southern states of India namely Andhra Pradesh, Karnataka and Tamil Nadu have the largest number of irrigation tanks numbering 0.12 million (Palanisamy *et al.,* 2010).

- **Food**

A large number of fishes live in inland and coastal wetlands. In India, 6 million people are dependent on inland fisheries for their

livelihood (Bassi *et al.,* 2014). Even in village tanks, people get additional protein and minerals from the available fishes.

- **Recreation**

  Wetlands provide places to hunt, fish and for watching birds and animals. Wetlands can also play a role in economy by creating jobs.

The wetland loss in India can be divided into two broad groups, namely acute and chronic losses.

Acute wetland losses

Filling up of wetland areas with soil constitutes acute loss. In the Indian subcontinent due to rice culture, there has been a loss in the spatial extent of wetlands. Of the estimated 58.2 million hectares of wetlands in India, 40.9 million hectares are under rice cultivation (Anon 1993). Although rice fields come under wetlands they rarely function like natural wetlands.

Alternative farming methods and fisheries production has replaced many mangrove areas and continue to pose threats (Prasad *et al.,* 2002). Most of the coastal mangroves are under severe pressure due to the economic demand of shrimps. The shrimp farms cause excessive withdrawal of fresh water and increase pollution load on water such as increasing lime, organic wastes, pesticides, chemicals and disease-causing organisms.

Alteration in the hydrology can change the character, functions, values and the appearance of wetlands. The changes in hydrology include the removal of water from wetlands, raising land surface elevation, canal drenching operations and impounding water (Prasad *et al.,* 2002).

Chronic wetland losses

Alterations of upper water sheds of wetlands significantly impact the wetlands when agriculture, deforestation or overgrazing removes the water-holding capacity of the soil. Then, soil erosion becomes more pronounced (Prasad *et al.,* 2002).

Water quality directly affects the wetlands. More than 50,000 small and large lakes are polluted to the point of being considered dead (Chopra 1985)

Draining of wetlands has depleted the ground water recharge. The recent estimates indicate that in rural India about 6,000 villages are without a source of drinking water due to the rapid depletion of ground water (Prasad *et al.,* 2002).

Introduction of exotic species like water hyacinth (*Eichhonia* species) and *Salvinia* species have threatened the wetlands and clogged the water ways competing with the native vegetation (Prasad *et al.,* 2002).

The most seriously threatened wetlands of India

Table 2.1

The Most Seriously Threatened Wetlands in India

Sl. No.	Wetlands
1.	Dal Lake
2.	Wular Lake
3.	Harike Land
4.	Jheels in the vicinity of Haidergarh
5.	Dehar and Sauj Jheels
6.	Southern Gulf of Kutch
7.	Gulf of Khambhat
8.	Khabartai
9.	Dipor Beel
10.	Loktak Lake
11.	Salt lakes swamp
12.	The sunderbans
13.	Chilka Lake
14.	Kolleru Lake

Sl. No.	Wetlands
15.	Estuaries of the Karnataka Coast
16.	Kaliveli Tank Yedayanthittu Estuary
17.	The Cochin Backwaters
18.	Wetlands in the Andaman and Nicobar Islands

(Kurian and Nagendran, 2004)

Wetland Conservation

Wetlands in India are increasingly facing several anthropogenic pressures (Prasad *et al.,* 2002). Significant losses have resulted from various threats such as industrial, agricultural, various urban developments and sustainable levels of grazing. The current loss rate in India can lead to serious consequences where 74% of the human population is rural (Anon 1994). Healthy wetlands are essential in India for sustainable food production and potable water availability for humans and live stock (Prasad *et al.,* 2002). Restoration of these wetlands is quite difficult once these sites are occupied for non-wetland uses.

Wetland management

The primary responsibility for the management of wetlands is in the hands of Ministry of Environment and Forest. But effective coordination between the different ministries (energy, industry, fisheries, agriculture, transport and water resources) is essential for the protection of these wetlands.

National wetland strategy

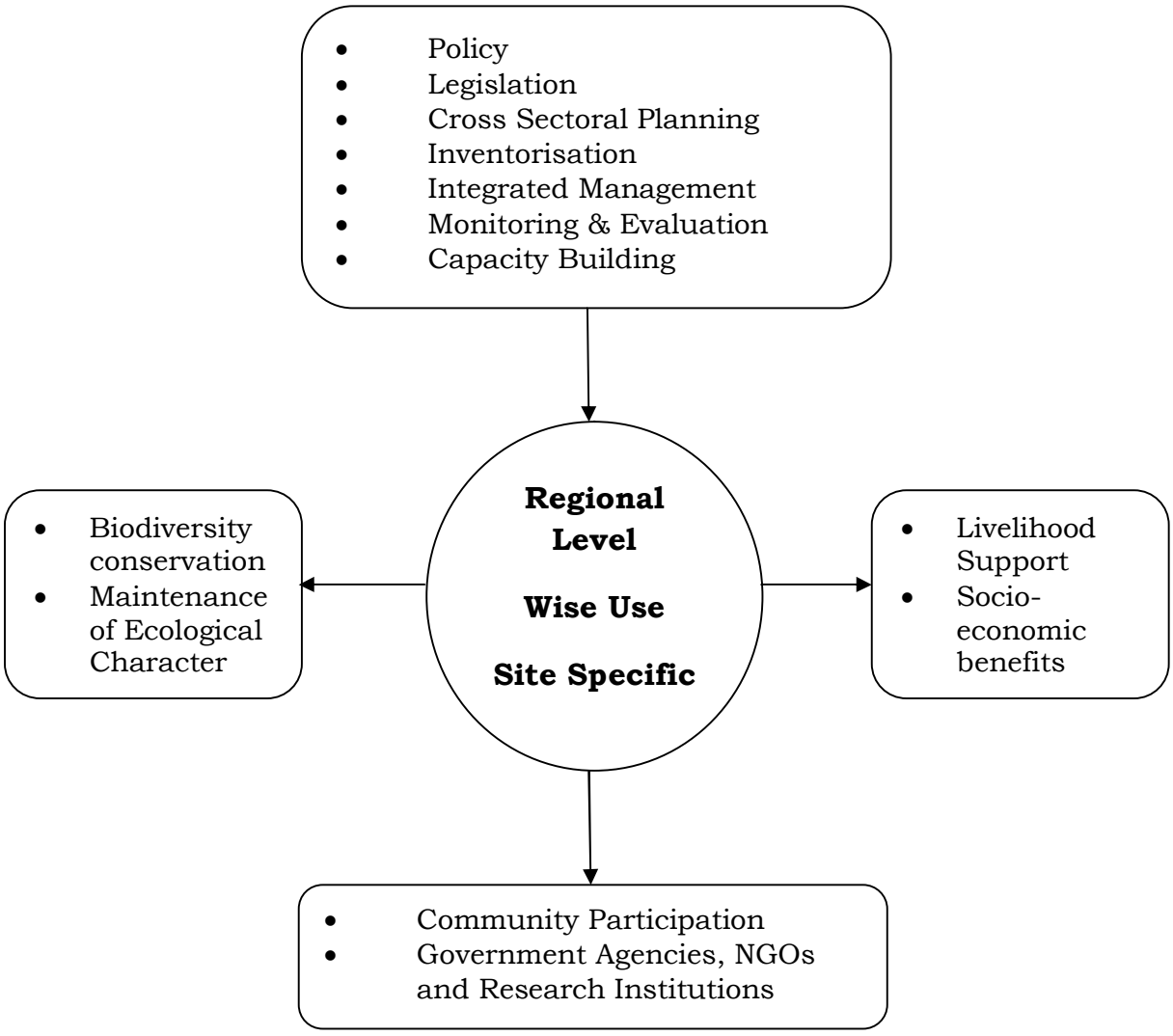
Protection - The primary necessity today is to protect the existing wetlands. Of the many wetlands in India, only around 68 wetlands are protected But there are thousands of other wetlands that are biologically and economically important but have no legal status (Prasad *et al.,* 2002).

Planning, managing and monitoring

Wetlands that come under the protective area network have management plans but others do not. It is important for an effective management plan for all wetlands especially small wetlands of the villages. For this to happen, the local community and the corporate sector should come together with efficient management plans for these wetlands.

National Wetland Policy

With rapid realization of wetland values, a national policy enshrining a commitment by the government to sustain and restore wetlands has been developed.



(Kurian and Nagendran, 2004)

Legislation

Although several laws protect wetlands, there is no special legislation pertaining specially to these ecosystems.

Key legislative measures for the conservation of wetlands in India.

- The Indian Fisheries Act 1857
- The Indian Forest Act 1927
- Wildlife (Protection) Act 1972
- Water (Prevention and Control of Pollution) Act 1974 and 1977
- Territorial water, Continental shelf, Exclusive economic zone and the marine zones act 1976
- Forest (conservation) act 1980
- Environmental (protection) act 1986
- Wildlife (protection amendment) act 1991
- National conservation strategy and policy statement on environment and development 1992
- National policy and macro level action strategy on biodiversity 1999
- India is also a signatory to the RAMSAR convention.

Scientific knowledge will help the planners in understanding the economic values and benefits, which in turn will help in setting priorities and focusing the planning process.

Since wetlands are common properties with multi-purpose utilities, awareness among the general public, education and corporate institutions must be created to achieve any sustainable success in the protection of these wetlands (Kar, 2014).

Use of remote sensing and GIS in wetland management

Remote-sensing data in combination with geographic information system (GIS) are effective tools for wetland conservation and management. This application helps in water resource assessment, hydrologic modelling, flood management, reservoir capacities survey, assessment and monitoring of the environmental impacts of water resources project and water quality mapping and monitoring (Jonah 1999).

Flood-zone mapping

Satellite data are used for interpretation and delineation of flood – inundated regions and flood-risk zones. Temporal data helps us to obtain correct ground information about the status of on-going conservation projects. IRS 1C/D WIFS data having 180km spatial resolution and high temporal repetitiveness has helped in delineating

the zonation of flood areas of large river bodies, thus helping in the preparation of state-wise and basin-wise flood inventories.

Remote-sensing data paves the way for economic methodology for inventorying, monitoring and management of water bodies. Satellite data in association with the geographical information systems provides a cost and time-effective tools for identification, mapping, inventorying etc. Indian IRS-1A and 1B satellites data has been used for such purposes. These data are used as inputs for formulation of conservation and management plans for the development of land and water resources (Prasad *et al.*, 2002).

Conclusion

In India, wetlands provide multiple services, besides irrigation. They play a vital role in ground water recharge. Although in India 26 wetlands are designated as Ramsar sites of International importance there are many more small and medium sized wetlands. Owing to the dynamic nature wetlands need constant monitoring. Literature survey conducted for the present study shows there are numerous lacunae existing in this area, especially on basic information like inventory. The present study may contribute to the baseline data of wetland inventory of Tiruchirappalli District.