Chapter 1

INTRODUCTION

INTRODUCTION

Wetlands are the unique creation of nature on this blue planet and are to be treated as living bowls of soup because without water or moisture life is not possible. Wetland means the areas with adequate dampness, where terrestrial territory meets with aquatic territory. All kinds of small and big water bodies are generally considered as wetlands and even oceanic areas with less than 6 meter deep water are also included. Wetland soil is generally very rich in micro- and macro-nutrients, which are accountable for the survival of their rich and diverse floral, faunal and microbial inhabitants. According to Tiner (1999), it is a generic term used to define universe of wet habitats including marshes, swamps, bogs, fens and similar areas. Wetlands are also considered as *ecotonal* habitat as it lies on transition zone of tension between two or more communities with rich biota (Mitsch & Gosselink, 1986 & 1993; Clark, 1954; Odum, 1959). But, traditionally wetlands have been contemplated as useless wastelands and used mainly for muck-filled for urban sewage, damping ground for house hold garbage, and extending concrete structures after artificial increase of elevation. In folktales, the swamps are expressed as dirty, murky places full of hidden dangers. Wetlands are the most beautiful water bodies and full of unique biodiversity including plants, animals and microbes (Chowdhury, 2009). Condering from the biodiversity point, wetlands are the 2nd richest ecosystem after the tropical rain forests of the world. After the Ramsar Convention of IUCN in Iran in 1971, wetlands are now considered as hot-cakes and attention-grabbing topic to the scientists or biologists who are working in world's environment and ecological research. The Indian wetlands are quite diverse ecosystem located in various climatic zone and support around 20 % of country's total biodiversity (Deepa *et al*, 1999); (Chowdhury, 2009). Gopal (1995) prepared a list of over 1200 plant species and a partial list of animals those are found in Indian wetland systems.

Terai and Duars of Sub-Himalayan West Bengal are falling under 'Himalaya' Biodiversity Hotspot (Conservational International, 2005). The study area is harbouring a large number of floral species (Choudhuri, 1969); (Das, 1995, 2004; (Das & Chanda, 1987); (Rai, 2001) in its wide range of habitat providing ample opportunity for ecological diversity (Champion & Seth, 1968; (Kadir, 2001); (Ghosh, 2007); (Sarkar, 2011). High degree of endemism is the characteristic of its vegetation (Bhujel & Das, 2002). But, continuous physical threats in very drastic manner, forced the indigenous floras to their extinction is imminent for the region (Das, 1995, 2004; Bhujel & Das, 2002;). Sub-Himalayan wetlands are extending from Darjeeling to East bank of the River Ganga. The Terai and Duars region of West Bengal, Koch Behar district and low floodplains, lakes, streams, beels, seasonal waterlogged areas etc. (IWMED 1997) biodiversity rich areas. Highly favourable tropical to temperate climatic conditions, coupled with heavy rainfall, made these areas to support a large number of seasonal wetlands, covering wide areas, which are inhabited by diverse wet-loving aquatic or semi-aquatic plants. Innumerable anthropological activities like rapid expansion of civilization, construction of road, rail, increase of automobiles, implementation of mega-projects, population explosion, tourism related exploitation, rapid extension of crop field etc. are very rapidly converting these areas into fragmented wetlands and finally leading to the extinction of numerous wetlands. Random collection of wide array of useful plants, excessive agricultural activities, urbanization, pollution, filling for settlement areas and excessive tourism are causing the destruction of fertile and virgin wetlands. The rate and amount of exploitation of wetland areas are much above the sustainability limit (Sarkar, 2014). Floristic survey of plant community provides information for analysing the diversity dynamics and structures of the vegetation. Wetland plants quickly respond to changes in water quality and have been used as bio-indicator for pollution (Tripathi & Shukla, 1991).

A wetland is an area of ground that is inundated with water either enduringly or seasonally. This means that a wetland is neither truly aquatic nor terrestrial; it is possible that wetlands can be both at the same time depending on seasonal variability. They have been described as the *kidneys* of the landscape as they filter the sediments and nutrients from the surface water. Wetlands are often referred to as biologically fragile important ecosystem as they support all life forms through extensive food webs and biodiversity (Mitsch & Gosselink, 1993). These help to regulate water levels within watersheds, improve water quality, reduce flood and storm damages, provide habitat for important fish and wildlife, support hunting, fishing, other recreational and life-sustaining activities and perform some useful functions in the maintenance of ecological balance. Rapid urbanization, burgeoning human population and their various activities have contributed to the decline of quality and quantity of wetlands. So, it is imperative to focus on the preservation of these endangered habitats to achieve back the ecological sustainability on earth.

Hence, the present study has been taken up with a view to study the floristic diversity, recognition of RET plants and recording of ethnobotanical knowledge of the ethnic inhabitant in study areas. Phenology and pollination of wetland plants are also important and interesting aspects of study. The recognition of disturbance factors for different wetlands of the area, if recognized, may act as basics in framing required conservation strategies and developing sustainable utilization strategies.

1.1. DEFINITIONS OF WETLAND

The 'Wetland' has been defined differently by various authors and agencies for different purposes depending on the specific objective and needs. It is a fact that not only in our country but all over the world, there exists a lot of controversy and confusion regarding the definition of a wetland. Several such definitions of wetlands are at hand, among those one of the popular earlier definition and widely accepted scientific Ramsar definitions are given below:

A. One of the early definitions of wetland but still habitually used by Ecologist, and Researcher was given by S.P. Shaw & C.G. Fredine (1956) who suggested:

"*The term Wetlands refer to lowlands covered with shallow and sometimes temporary or intermittent waters. They are referred to by such names as marshes, swamps, bogs, wet meadows, potholes, sloughs, and river-overflow lands. Shallow lakes and ponds, usually with emergent vegetation as a conspicuous feature, are included in the definition, but the permanent waters of the streams, reservoirs and deep lakes are not included. Neither are water areas that are so temporary as to have little or no effect on the development of moist soil vegetation*".

B. Ramsar definition

The Ramsar Convention takes a broad approach in determining the wetlands which come under its regulations. Under the text of the Convention (Article 1.1), wetlands are defined as:

"*areas of marsh, fen, peatland, 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 tide does not exceed 6 meter*".

1.2. RAMSAR CONVENTION & ITS IMPORTANCE

The Ramsar Convention is an International convention on Wetlands of International Importance. It is an intergovernmental treaty, adopted in Ramsar, a city of Iran, on 2nd February, 1971, that provides the skeleton for national action and international co-operation for the conservation and sustainable utilization of wetlands and their resources. Now, 2nd February of every year is celebrating as *World Wetland Day*.

The importance of the Ramsar Convention is, as adopted by the Parties in 1999 and refined in 2002, is "*the conservation and sensible use of all wetlands through local, regional and national*

activities and international assistance, as a contribution towards achieving sustainable development throughout the world".

1.3. CLASSIFICATION OF WETLANDS

The Ramsar Convention developed a new and more widespread wetland classification system (adopted in 1990 and modified in 1996). This is given below:

Marine/Coastal

A. Permanent shallow marine waters less than six metres deep at low tide; includes sea bays and straits.

B. Marine subtidal aquatic beds; includes kelp beds, sea-grass beds, tropical marine meadows.

C. Coral reefs.

D. Rocky marine shores; includes rocky offshore islands, sea cliffs.

E. Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune systems.

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.

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); includes 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 soil; 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 marsh, shrub carr, alder thicket; on inorganic soils.*

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

Xp. Forested peatlands; peatswamp forest.*

Y. Freshwater springs; oases.

Zg. Geothermal wetlands.

Zk. Subterranean karst and cave hydrological systems.

** As appropriate, includes: floodplain wetlands such as seasonally inundated grassland (including natural wet meadows), shrublands, woodlands or forest.*

"Man-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.
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.

1.4. WETLAND DISTRIBUTION

Wetlands are distributed throughout the world from tropics to temperate and from plains to glacial mountains (Chowdhury, 2009). Two-third areas of this blue planet are covered by water (UNEP, 1994). Wetlands occur in every country, from the tropics to the tundra. The World Conservation Monitoring Centre has suggested and estimated of about 5.7 million square kilometres i.e., roughly 6 % of the earth's land surface [WCMC, *Global Biodiversity*, 1992] is wetland. Out of this 6 % of total wetlands, only 2.53 % area covers with fresh water wetlands and the rest vast areas are seawater. Of the global fresh water 69.6 % is locked away in the continental ice, 30.1 % is in underground aquifers and 0.26 % is composed of rivers and lakes. However, 0.0075 % fresh water areas are covered by particular lakes (UNEP, 1994). Out of total global wetlands, 30 % are bogs, 26 % fens, 20 % swamps, about 15 % flood plains, etc. (IUCN, 1999).

1.4.1. Continental distribution of Ramsar sites:

It has been recorded by Ramsar convention that highest percent i.e., around 53 % of global Ramsar sites are located in different countries of Europe followed by Asia (13 %) and Africa (13 %) whereas, lowest percentage is recorded from ice covered Oceania (5 %). [Figs. 1.1 & 1.2].

1.4.2. Wetlands in India

In India, a variety of wetlands covering inland and coastal areas even small ponds and ephemeral water bodies are located in different altitudinal rages. It is recorded that around 18.4% of total geographical

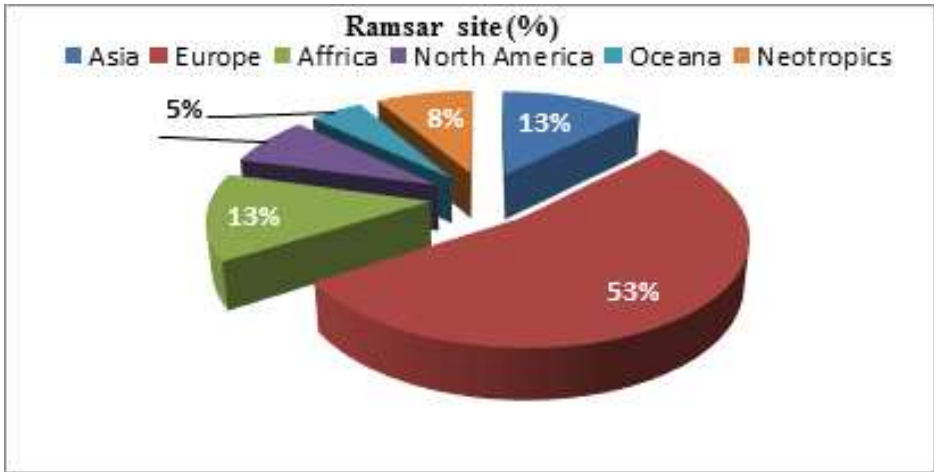

Fig. 1.1. Global distribution of declared Ramsar sites [*Source*: www. Ramsar.org]

Fig. 1.2. State wise distribution of Ramsar sites in India [*Source*: www. Ramsar.org]

area of the country occupied by wetland areas except rivers and 70 % of these wetlands are as paddy field (Deepa *et al.*, 1999).

In India, assessing their wetland wealth in different times, primary inventory by the Department of Science and Technology, Govt. of India recorded a total of 1,193 wetlands, covering an area of about 3,904,543 ha, of which 572 were natural (Scott & Poole, 1989); (Anonymous, 1993a & 1993b).The latest inventory records a total 67,429 number of wetlands in the Indian territory, which covers about 4.1 million hectares of total land, out of which 2,175 wetlands are natural and 65,254 are manmade i.e. artificial and are occupying the 1.5 and 2.6 million hectares of area, respectively (MoEF, 1990). Highest percentage of declared Ramsar Sites are established in the state of Kerala (31 %) followed by Orissa (27 %) and in West Bengal (2 %) only one Ramsar site is present covering 12,500 ha and lowest in Tripura covering only 240 ha. (Anonymous, 1993c).

1.4.3. Type-wise wetland distribution in India:

The major wetland types in inland category are rivers/streams, reservoirs/barrages, tanks/ponds and lakes/ponds. In coastal wetland category, major types are inter-tidal mudflats, mangroves, aquaculture ponds and lagoons. Type-wise area estimates are shown in Table 1.1.

Table 1.1. Type-wise wetland areas in India

Wetland category	No of wetlands	Total wetland area (ha)
Inland wetlands (Natural)		
Lakes/Ponds	11740	729532
Ox-bow lakes/Cut- off meanders	4673	104124
High altitude wetlands	2,707	124253
Riverine wetlands	2834	91682
Waterlogged areas	11957	315091
Rivers/Streams	11747	5258385
Inland artificial wetlands		
Reservoirs/Barrages	14894	2481987
Tanks/Ponds	122370	1310443
Waterlogged areas	5488	135704
Salt pan	60	13698
Total inland	**188470**	**10564899**
Costal-natural wetlands		
Lagoons	178	246044
Creeks	586	206698
Sand/Beach	1353	63033
Intertidal mud flats	2931	2413642
Salt marshes	744	161144
Mangroves	3806	471407
Coral Reefs	606	142003

Coastal artificial wetlands		
Salt pans	609	148913
Aquaculture ponds	2220	287232
Sub-total	**201503**	**14705015**
Wetlands (<2.25ha)	**555557**	**555557**
TOTAL	**757060**	**15260572**

Area	Post monsoon	Pre monsoon
Area under aquatic vegetation	1322837	2065096
Area under turbidity levels		
Low	3206003	1888493
Moderate	4168401	2967523
High	1226394	945204

1.4.4. Wetlands of West Bengal:

The wetlands comprise 11,07,907 ha of area accounting for about 12.5 % of total geographical area of the state of West Bengal (Chowdhury, 2009).The total number of wetlands mapped in the state is 1,47,826 including 1,38,707 wetlands are smaller than 2.25 ha (Chowdhury, 2009).The number of inland wetlands are recorded as 8670 including both natural (3675) and man-made (4995), distributed in an area of 7,47,383 ha. The total number of coastal wetlands are 449 comprising of 421 natural and 28 man-made distributed in an area of 2,21,817 ha. The major wetland types are rivers/streams (5,59,192 ha) followed by mangroves (2,09,330 ha), lakes/ponds (58,654 ha), waterlogged areas (56,603 ha) and reservoirs (22,672 ha). In addition, 1,38,707 smaller wetlands (< 2.25 ha) were also identified (Battacharyya *et al*., 2ooo). (Fig. 1.3).

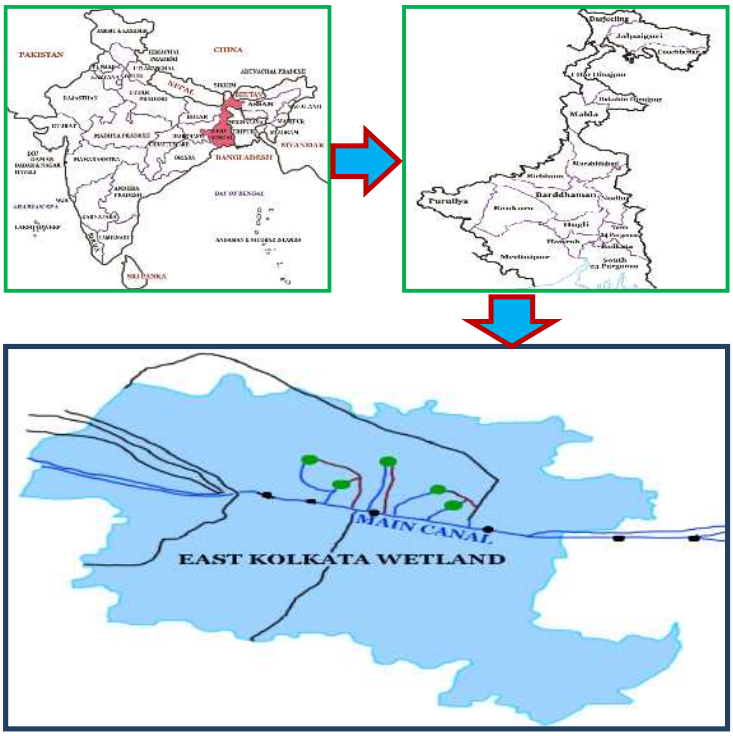

Fig. 1.3. Ramsar site of West Bengal [www.ramsar.org]

1.4.5. Wetlands of Terai and Duars:

The physiography of the study area is most suitable for the formation of ox-bow lakes as sediments brought down from the hills are deposited in this undulating plain located at around 150 m a.m.s.l. forming the land that is too much porous and loose with almost no sticking capacity. Due to abrupt changes of gradient in river systems in the region, repeated shifting occurred in the past lead to the formation of numerous riverine wetlands or dead rivers or ox-bow lakes. These riverine wetlands are the small or long dead or cut-off parts from the main river system and are water-fed or remain quite moist during summer, the most dry season in the area. These riverines are mostly linked to the major perennial river systems like the *Tista, Mahananda, Balason, Mechi, Torsa, Jaldhaka* and *Sankosh* those have originated mostly from the Himalayas. The important wetlands in the study area are *Ghoshpukuri Wetland, Teesta Char, Jalpaiguri Rajar Dighi, Saadbeki Beel* and *Ghoksadanga Beel* etc. along with three major reservoirs namely *Mahananda, Teesta* and *Aambari barrages*.
Three major wetland types are generally recognized from the study area and are:

- **Lacustrine** – small or big lakes or ponds
- **Riverine** - wetlands along rivers and streams
- **Palustrine** - meaning "marshy" - marshes, swamps and bogs

Numerical distributions of wetlands in the study area are summarized in Table 1.2.

Table 1.2. Type wise wetland numerical data of study area

Nature of wetland		Classes of wetland	Number	Area (Sq Km)
INLAND	Natural	Rivers/Streams	65	463.2
		Reverine wetlands	25	1.3
		Lakes	30	3.15
		Ox bow Lakes	33	3.61
		Marshes/ Swamps	18	1.71
		Waterlogged seasonal	21	3.64
		High altitude wetlands	05	1.05
	Manmade	Reservoirs	13	1.27
		Barrages	04	2.53
		Tanks	03	1.19
		Ponds	45	1.62
		TOTAL	**262**	**484.27**

1.5. IMPACT OF WETLANDS

– Goods and services of wetland ecosystems

Wetlands are the most dynamic ecosystems in the world. It plays an imperative role to provide healthy environment and services to millions of people directly or indirectly. They sustain important processes like the movement of water into streams and rivers; moulder of organic matters; release of nitrogen, sulphur, and carbon into the atmosphere; elimination of nutrients, sediment and organic matter from water moving into the wetland; and the growth and development of all organisms dependent on them.

It has significant role in socio-economic development too! Due to its diverse habitat it produces so many multidimensional products such as fish, housing materials, medicinal plants, fodder plants, leafy vegetables, humus rich sediment, fertile land for low-land agriculture, water supply for domestic,

agricultural and industrial purposes and hydro-power generation, transport, recreation, sustainable tourism opportunities, research-education, genetic reservoir for various wild relatives of cultivated species, support to different life forms, habitat to aquatic flora and fauna, as well as numerous species of local and migratory terrestrial and avi-fauna, flood mitigation, sinks and climate stabilizers etc.

In addition, wetlands have special attributes as part of the cultural heritage of humanity: they are related to religious and cosmological beliefs, constitute a source of aesthetic inspiration, cultural aptitudes, provide wildlife sanctuaries, and form the basis of important Ethnic traditions.

It has some indirect reimbursement such as improved water quality (including drinking water) removing or retaining its nutrients, processing organic wastes, reducing sediment before it reaches open and deep water areas.

1.5.1. Functions of wetlands:

Wetlands are referred to as the most productive ecosystems on earth. They directly or indirectly support millions of people and provide goods and services to them. Table 1.3 recorded various goods and services provided by wetlands are as suggested by Gopal *et al.* (2010)

Table 1. 3. Wetland ecosystem services [*Source*: Gopal *et al*., 2010]

Ecological services	**Example**
Provisioning	
Food	Production of fish, wild game, fruits, and grains
Fresh water	Storage and retention of water for domestic, industrial, and agricultural uses
Fibre and fuel	Production of logs, fuel wood, peat, fodder
Biochemical	Extraction of medicines and other materials from biota
Genetic materials	Genes for resistance to plant pathogens, ornamental species, and so on
Regulating	
Climate regulation	Source of and sink for greenhouse gases; influence local and regional temperature, precipitation, and other climatic processes
Water regulation	Groundwater recharge/discharge
Water purification and waste treatment	Retention, recovery, and removal of excess nutrients and other pollutants.
Erosion regulation	Retention of soils and sediments
Natural hazard regulation	Flood control, storm protection

Ecological services	Example
Pollination	Habitat for pollinators
Cultural	
Spiritual and inspirational	Source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems
Recreational	Opportunities for recreational activities
Aesthetic	Many people find beauty or aesthetic value in aspects of wetland ecosystems
Educational	Opportunities for formal and informal education and training
Supporting	
Soil formation	Sediment retention and accumulation of organic matter
Nutrient cycling	Storage, recycling, processing, and acquisition of nutrients

1.6. IMPORTANCE OF MACROPHYTES ON WETLAND HABITAT

Wetland provides shelter to the various types of plant groups like algae, fungi, bryophytes, pteridophytes and most importantly angiosperms. Plants growing in the wetlands are called aquatic and/or wetland plants; those can also be termed as hydrophytes (Raunkaier, 1934).

The vegetation of wetland makes it so beautiful and rich in biodiversity as well as healthy and fresh ecosystem. As in other ecosystems, the floral elements are act as primary producers or energy assimilator those synthesise food by photosynthesis in wetland ecosystem. The output of photosynthesis actually increases the nutrient status of wetland soil and water. Based on these outputs, food chains, food webs and energy flow sequences of such ecosystem are regulated (Chowdhury, 2009)

Some phytoplankton's and submerged aquatic macrophytes are the good food for fishes and other aquatic animals. Fishes eat seeds, leaves, and rootstock of different aquatic plants. Fishes choose roots of floating plant for breeding or releasing eggs. Seeds, leaves, rootstock are also taken as food by different migratory wetland birds.

The seasonal rainfall and regular flooding increase the soil erosion causing filling of wetlands, thereby loosing the depth of water. The shoreline erosion is controlled by the adventitious and densely anastomose root system of grasses and sedges.

Few species of wild submerged and marshland plants are also use as ornamentals for household aquariums along with different colourful fishes.

1.7. Threat to Wetlands

When, in future years, man will realise, what are the importance of wetland for their survival and sustenance, by then more than 60 % of wetlands will disappear. Most of the people always think that 'wetlands are just wastelands' and always misused these in various ways and such over exploitation causing a great

change in wetland structure and function negatively. Many research works to find out several causes behind the wetland loss and the causes are categorised into two major groups:

1.7.1. Anthropogenic threats:

The rapid increases of population are creating a heavy load on wetlands because it has been seen that most of the wetland areas are filling-off in favour of the extension of human settlements (Chowdhury, 2009). Due to over establishment of the industry and related pollution are dramatically increases that create pressure on wetlands and its ecosystem. That particular negligence is the main cause of such drastic loss. Wetlands of every country of the world always are used in bad manners from the very beginning. It is always used as sink for sewage discharge from urban and rural areas, chemicals from factory, various poisonous metals from different atomic power station etc. This process is steel being continued in various countries of the world.

1.7.2. Natural threats:

On the other hand, wetlands are also degraded by natural activities like siltation, eutrophication, reduction of depth due to the accumulation of excessive amount decayed macrophytes etc. The excessive nutrient from agricultural runoff and existing flora for decades the water is polluted. These situation induced growth of huge algal bloom creating eutrophication, which destroy the healthy wetland ecosystem.

All these factors are responsible for converting the wetlands into non-wetland or terrestrial areas rapidly.

1.8. SUSTAINABLE UTILIZATION

Wetlands of Terai and Duars are generally marsh or floodplains with littoral fresh water systems. The wetlands play important role in the life of people who reside surrounding such areas. Local people use the wetlands in their daily life for livelihood and many other means like, agriculture, irrigation, fisheries, ground water recharge and flood control, rural economy, jute retting, green manure etc.

1.9. FRAMING CONSERVATION STRATEGIES

Data recorded through the present survey and understanding the status of wetlands can help to framing the conservation strategies, which can be as follows: increasing the depth of wetlands, periodical weed removal, public awareness, creation of bird sanctuary, control over fishing, control of excessive agricultural activity, control of monoculture, control bird poaching, stop releasing urban and industrial influx or sewages, research and monitoring etc.