

## ***INTRODUCTION***

The Earth is the only planet that has biosphere and supports the life. The biosphere includes various ecosystems which in turn support diverse forms of living organism, the biodiversity. The diversity and density of organisms in a habitat depend on availability of water. The human being is no exception to this and to satisfy his needs for water, has developed ponds and reservoirs for the conservation of rain or river water useful in adverse conditions. This results in the propagation of other aquatic organisms. The interdependency of these organisms on the productivity of such water bodies led to the development of a dynamic aquatic ecosystem. One such ecosystem is the wetland; the transitional zone between land and water, saturated with water. These shallow areas being highly productive support varieties of submergent as well as emergent plants and animals. Due to the dynamism exhibited by the wetlands, it has become a challenge for ecologist to define this ecosystem. Among the earlier definitions, by Cowardian *et al.* (1979), "*Wetlands form the transitional zone between land and water, where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in and on it*". Among the various definitions, the most widely accepted so far is given by IUCN (International Union for Conservation of Nature and Natural resources 1971). According to this definition "*Wetlands are the 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 at low tide does not exceed six meters*". Wetlands, in simple words are wet-lands consisting of saturated soil with water for atleast some part of the year. However, this does not turn all the land holding water into wetlands. Wetlands are characterized by special soils, by specific plants and animals particularly adapted to water logging or submergence of the soils during growth period of the organisms (Gopal, 1995).

Several ecologists classified wetlands, prominent among them is the classification given by Corwardin *et al.* (1979). Corwardin and his team have classified the wetlands mainly into five systems, which are further divided into sub systems and then the classes. The five main systems are Marine, Estuarine, Riverine, Lacustrine and Palustrine. However, this classification being complex a new classification of wetlands developed (Davis, 1994) including thirty five types of different habitats.

The wetlands are categorized on the basis of various criteria:

1. Depending on whether marine: Coastal or freshwater: Inland wetlands.
2. Depending on origin: Natural or Artificial (man made).
3. Depending on the basis of the nutrient contents:
  - Oligotrophic: Those wetlands that have minimum amount of nutrients.
  - Mesotrophic: Those having moderate amount of nutrients.
  - Eutrophic: Those wetlands that have high nutrient content.

Though being such an important ecosystem, the due justification in the form of its recognition as an independent ecosystem is only about 5 decades old (Gopal, 1995).

Earlier, wetlands were often considered as a sub ecosystem of other aquatic ecosystems. Even though being recognized as an independent ecosystem, only the larger wetlands are given importance but the small wetlands, are ignored; underestimated and finally drained out (Krapu, 1974; Weller, 1988; Boyer and Polasky, 2004).

The main source of water in freshwater wetlands is rainwater especially if they are located in regions with monsoon type of climate. In the marine wetlands, intertidal zones, the tides become major source of water. In other landscape, the shallow depressed low lying area may get flooded and develop into temporary wetlands. Thus, the wetlands are often subjected to the fluctuations in the water levels or changes in the water cover or water cover. However, they are productive ecosystems, obtaining their productivity is often difficult (Kushlan, 1986a). They are rich source of nutrients, as the soil is rich in organic matter. Soil is saturated with water. Other source for nutrients in the wetland is from the drained water from the catchment area along with nutrients in it. Being rich in nutrients the wetlands support good plant diversity starting from the diverse phytoplankton to the higher angiosperms. As the plant diversity is high the faunal diversity is also high and ranges from the zooplankton to the mammals. Besides Avifauna the major visible component of the wetland ecosystem, the Fishes, Amphibians and

Mammals are also important biota. However, these higher fauna depends on lower fauna like the Arthropods and Molluscs. Hence these invertebrates also form important biota of a wetland ecosystem. The flora and fauna together forms a dynamic ecosystem at the wetlands and makes it the second most productive ecosystem (Ramchandra *et al.*, 2002). The hydrological changes in the wetlands alter the basic primary producers and hence bring about variations in the wetland ecosystem (Hutchinson, 1957).

It is only recently that the values of wetlands are recognized. Certain main functions attributed to wetlands are:

- Hydrological – Retention of water and flood control.
- Biological –Support to diverse organisms.
- Biogeochemical – Regulation and recycling of nutrients.

*Hydrological:* The wetlands have capacity to retain water which may allow sufficient time for movement of water by percolation to the aquifer. This function is considered to be the most important one as this property is responsible for the flood control (Leschine *et al.*, 1997; McKenna, 2003). This depends to a great extent on the geology of the soil in the wetland. In the Arid and the semi- arid zone the wetlands have an important function of being a major water source. The oasis are the best examples of this. They also serve for trapping the silt, that gets deposited and becomes economically valuable (Gopal, 1995).

*Biological:* The other important function of the wetland is their biological role in supporting many plants and animals (Weller, 1988, Gibbs, 1995). There are

certain organisms called obligatory that are totally dependent on wetlands throughout their life. But there are several others that are facultative as they are dependent on the wetlands for certain part of their life or the terrestrial species utilizing the wetlands for short period in their life. Thus, the dependency of various flora and fauna on wetland increases the total species richness of the wetland (Weller and Spatcher, 1965). There are certain species that are endemic to the wetlands while many endangered species are supported by the wetlands. It is estimated that in India about 26 species of birds categorized as threatened and 10 near threatened are dependent on wetlands (Prasad and Vijayan, 2005).

*Biogeochemical:* Apart from above mentioned functions the wetlands are also important in regulating and maintaining the nutrients in the water. They play important role in the regulation of the quality of wetland (Hemond and Benoit, 1988) by acting as filters for the nutrients (Lowrance *et al.*, 1984) and hence maintaining the environmental quality (Tiner, 1984).

The other important, immediate values of wetlands for mankind are:

- Socio-Economic Values
- Cultural and Aesthetic Values

Wetlands also provide various necessities of greater part for human population in the form of irrigation water, aquaculture ponds, water for domestic use, *etc.* Many of the inland waterbodies are now given on lease so as to develop them as aquaculture pond providing livelihood to the local communities. Further, the wetlands are also having certain aesthetic values and in recent days they serve as a place for

recreation, a place close to the nature and hence support socio-economic value by development of ecotourism.

Apart from being such an important ecosystem, the wetlands also have certain negative values. The most important negative value, which is of major concern to the human being, is that they serve as the habitat for the pathogens, as well as the vectors which could transmit these pathogens.

Wetlands are considered as one of the most sensitive ecosystems. The changes occurring in the wetland as well as in the catchment area can bring about the variations in the ecology and the habitat structure, especially of the inland wetlands (Firth and Fisher, 1992; McKnight *et al.*, 1996; Verschuren *et al.*, 2000). These changes are either by natural processes or by the actions of several human activities (Hemond and Benoit, 1988) that can bring about positive or negative effects in the wetland ecosystem. Some of the natural processes that bring about the changes in wetlands are: siltation, weed infestation, surface runoffs, droughts, floods, *etc*, while the man made changes are the construction of dams, hydroelectricity power plants, irrigation reservoirs; encroachment, pollution, (especially in urban wetlands), sewage disposal, tree felling, regulation of lake levels, ditching, road/ bridge construction, landfill, or waste water/ effluent discharge (Maynard and Wilcox, 1997; Wilcox *et al.*, 2002). Urbanization has become a major cause of the loss of wetland with its hydrology, runoff of nutrients and pollution (Boyer and Polasky, 2004).

Till the end of 20<sup>th</sup> Century the wetlands were under threat and the loss of wetland habitat was at a greater pace. Realizing the usefulness of the wetlands and the important functions that wetlands are serving, an immediate attention and a call for the conservation of wetlands was raised world wide. However, the initial criteria for the conservation of wetland was the attributes of avian species, the most conspicuous species that form one of the major component of the wetland ecosystem and use wetlands as one of their habitats. (Weller, 1981; Weller, 1988). Out of several organisms, birds having higher dispersal rate and also being sensitive to the habitat change, are considered to be one of the most important indicators of health of an ecosystem. This has made the birds important principle component. For the assessment of an ecosystem, the evaluation of birds species richness (Weller, 1978) and also their density are important attributes (Patterson, 1976; Nilsson and Nilsson, 1978).

Giving waterfowl the utmost priority, as they are one of the most remarkable components of global biodiversity, several laws for the conservation of wetlands came into implementation from the third decade of twentieth century. The realization for the need of conservation of waterfowl habitat had passively given importance to the wetlands resulting into their conservation. Several laws are now implemented for their conservation. Many wetlands are now considered for conservation as community reservoir, Nationally Important Wetland, Important Bird Area, Sanctuary, National Park or the wetland of International Importance- the Ramsar site.

Though these laws have various criteria, most of them give importance to the waterfowls, (the birds) that are dependent on water for their survival (Fog and Lampio, 1982). The Ramsar convention which is considered to be the master piece, as far as the conservation of wetlands is concerned, also gives due importance to waterfowls. The Ramsar convention was passed during an International conference which was held in Iran 1971. Among the various criteria on the basis of which a wetland can be declared as Internationally Important, two related to waterfowls are:

- The wetland should regularly support more than 20,000 waterfowls.
- The wetland should support 1 % population of some of the identified waterfowl species.

The realization that wetlands are the important habitats for bird increased the inquisitiveness of the scientists to find out various factors that affect the congregation of the waterfowls at the wetland. The realization of the fact that the community organization is not governed by a single process (Dunson and Travis, 1991), the holistic study of wetlands is now initiated which includes the study of biotic factors like the flora and fauna with the important abiotic factors like the Topology, Hydrology, Geology, Temperature, *etc.*, with water chemistry in detail. This can reveal the important factors that either directly or indirectly affect the congregation of the waterfowls. In the present study several biotic and abiotic components of the wetland ecosystem are studied in semiarid zone of Central Gujarat. As the waterfowls are considered to be one of the principle components



of a wetland and as they depend on various biotic factors that in turn depend on abiotic factors, the congregations of the waterfowls are studied in detail.

Availability of food is one of the major factor for the occurrence of the bird in a particular habitat. In the hierarchy of trophic cascade the birds are on the top of the wetland ecosystem. The food requirements of the birds change according to their life stages. They prefer food rich in carbohydrates and protein as well as calcium during the breeding period (Baldassarre and Bolen, 1994; Eeva and Lehikoinen, 1995; Brenninkmeijer *et al.*, 1997; Nisbet, 1997). One of the major biota that serves as an important source of calcium for the birds during breeding season is mollusc. Hence, in the present study along with waterfowl, molluscan diversity and density has been studied. The change in the density of the mollusc can result in change in the breeding performance of the birds. The protein requirement of several birds (like ducks and flamingo) is met by feeding on plankton. Thus the abundance of the plankton can either directly or indirectly affect the bird community. Hence, the present study includes diversity, density and seasonal changes in the plankton communities too.

It is an established fact that the biotic and abiotic components of wetland depend on each other and can not be considered independently (Terborgh, 1973; Al-Mufti *et al.*, 1977; Nakashima *et al.*, 1977; Nilsson and Nilsson, 1978). The studies on the effects of the abiotic factors on the animal population dynamics has started in the recent past (Kingsolver, 1989; Dunson and Travis, 1991). Hence, in the present

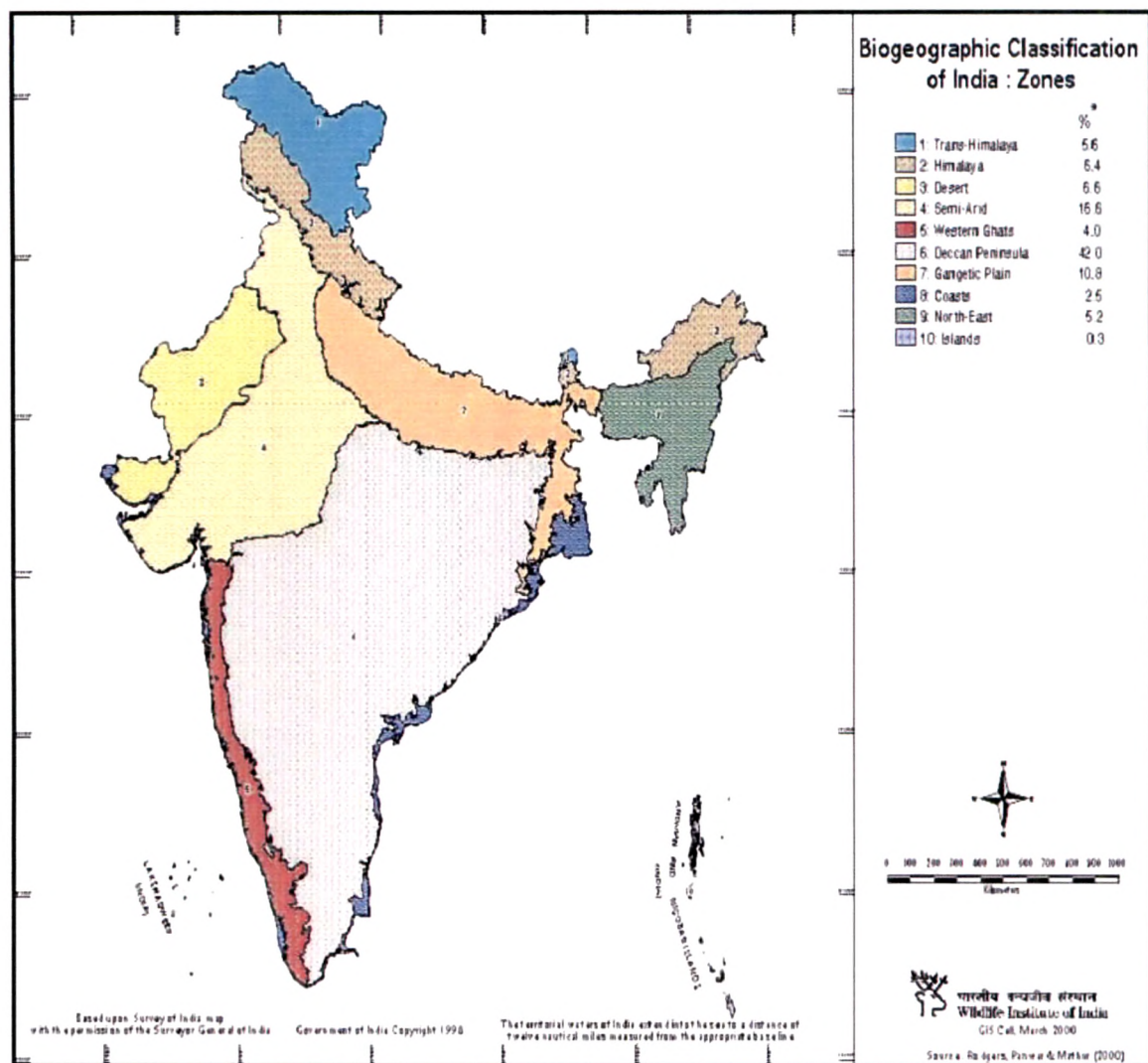
study the abiotic factors related to water chemistry are also taken into consideration.

India stands in sixth position out of the twelve mega diversity countries in the world. The various biogeographic zones of the region are mainly responsible for the biodiversity supported by that region. India with 10 different biogeographic zones (Fig.1) (Rodger and Panwar, 1990) provides various habitats for rich biodiversity. Wetland is one such habitat.

#### *Wetlands of India:*

India has 67,429 wetlands covering an area of about 4.1 million hectares (MoEF, 1990). Out of these, 2,175 are natural and 65,254 are man-made. Wetlands in India account for 18.4% of the country's geographic area, of which 70% is under paddy cultivation (Garg *et al.*, 1998). There are about 14,657 Natural Inland wetlands covering about 14,32,628 hectare area and 23,444 Man made; Inland wetlands covering about 35,58,916 hectare area. About 3,547 Natural Coastal wetlands cover 38,80,569 hectare and 4,009 Man made coastal wetlands cover 40,22,956 hectare (Garg *et al.*, 1998).

Figure 1. Biogeographic classifications of India:



Source: WII India.

### *Wetlands of Gujarat:*

According to Panwar's biogeographic zonation of India, parts of Gujarat fall in Arid, Semiarid, Western Ghats and Coastal regions (Fig. 1). Gujarat has special significance as it has the longest coast line among Indian state. Because of the 1650 kms. of coastline, the number of coastal wetlands in Gujarat is highest in the western region. The coastal wetlands cover an area of 25,08,262.3 hectare that comes to about 62.3 % of the total coastal wetland area of India.

The Inland wetlands covers 2,09,206 hectares and it accounts for 5.9 % of total wetland area of India. These inland wetlands mainly include the irrigation reservoirs, lakes, ponds, rivers and dams. Gujarat covers about 36% of the total wetland area of the country.

Of the inland wetlands of Gujarat, Natural lakes covers 154 km<sup>2</sup>, Water logged 289 km<sup>2</sup>, Reservoirs 1,394 km<sup>2</sup>, Tanks/ Ponds 198 km<sup>2</sup> and Marshlands 57 km<sup>2</sup>.

The coastal wetlands categorized as Mangroves cover 1,031 km<sup>2</sup>, Coral reefs 130 km<sup>2</sup>, Mudflats 21,954 km<sup>2</sup>, Saltpans 460 km<sup>2</sup> and others cover 1,508 km<sup>2</sup> area (Garg *et al.*,1998).

Main land of Gujarat being partly in the Arid and partly in the semi arid zone of India, number of reservoirs are developed in the region to overcome the problem of water shortage created because of the low rainfall. The phenomenon of change in the hydrology of the wetland can be more pronounced in the wetlands of semi arid zone of Gujarat.

Gujarat falls in the major migratory path of birds and hence, receives enormous congregations of migratory birds from Europe and Siberia. For conservation of these wetlands the adequate information regarding the wetland is necessary.

#### *Conservation:*

Man had considered the environment as the background of the studies rather than the main subject of the study. This had led to the decreased attention paid towards the environment and ultimately increased in the rate of the loss of species. The realization for conservation of habitat started with isolated initiative and culminated in to International dimensions and joint actions for nature protection with institutions such as International Council for Bird Preservation (ICBP), International Union for the Conservation of Nature and Natural Resources (IUCN), International Wildfowl Research Bureau (IWRB), World Wildlife Fund now known as World Wide Fund for Nature (WWF) and others. Wetlands, being the most vulnerable type of habitats, needs regular monitoring for the loss of species. The waterfowls species are estimated on several occasions, with the alarming figures illustrating the great need to take action (Finlayson and Moser 1991). The conservation of wetlands can not be differentiated from the conservation of waterfowl; this can be noted by the evolution of the name of IWRB over last few years. It started with the name International Committee of Bird Preservation (British Section)-Wildfowl Inquiry Sub-Committee (ICBP 1941), which changed to several other names specifying the birds (ICBP-International Wildfowl Inquiry, followed by International Wildfowl Research

Institute, International Wildfowl Research Bureau, International waterfowl and wetlands Research Bureau) and finally changed to Wetlands International (1995) (Boere, *et al.*, 2006).

Of the several steps taken by various organizations for conservation, the important event for the conservation of wetland was the Ramsar Convention passed on 2<sup>nd</sup> February, 1971 in the city of Ramsar, Iran. The Ramsar Convention is recognized as a most dynamic and functional treaty, which has opened the way for wetland conservation, especially in developing countries (Boere *et al.*, 2006) like India. India became party to Ramsar Convention in 1971 and the new phase of identification and study of wetlands was initiated soon. In mid 1980s, Bird Life International (UK) came up with Mid Winter Waterfowl Census which encouraged thousands of amateur bird watchers to visit various wetlands in their areas and count the birds. On the basis of this various wetlands were identified and categorized too.

Not only the International programmes like the Ramsar Convention, but certain other Programmes like the declaration of Important Bird Area (IBA) by Bird Life International, UK, are also some of the landmark steps on the path of conservation of birds. The Indian IBA programme was initially launched at the BNHS in March 1999. The IBA programme is expected to produce inventories of internationally recognized habitats important for the conservation of birds. These habitats are to be identified using a set of four standard global criteria. 1. The Globally Threatened species supported by the site. 2. Restricted-Range Species *i.e.*