Chapter 2

REVIEW

OF

LITERATURE
Wetlands are one of the most valuable and important natural environments. They provide suitable habitats to innumerable organisms.

2.1: WETLAND

An internationally agreed upon definition of wetlands is unavailable. However, the common and overriding theme of most definitions consists of some component related to hydrologic conditions (Zedler and Kercher 2005, Moore 2008). Despite this, the degree and extent of conditions constituting a wetland is not widely agreed upon (Zedler and Kercher 2005, Ramsar 2011). This is exemplified in a definition from Niering, in which he describes wetlands as areas in which water controls both the environment and associated biota of an area.

Niering's broad-reaching definition should be carefully considered. This idea is supported by Moore (2008), who suggests that it is in fact possible to define what a wetland is, but notes a single definition would not justify the diversity of wetland types that exist.

Perhaps one of the best current definitions of a wetland, at minimum for the context of this paper, was that set by the Ramsar Convention. The Ramsar Convention on Wetlands (1971) produced an international, intergovernmental treaty which defined wetlands somewhat broadly. Article 1 states that wetlands include 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 six meters” (Ramsar 2011).

Furthermore, the area of land covered by this treaty was later expanded in Article 2, providing that wetland areas “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” (Ramsar 2011).

The Ramsar Convention as earlier noted, the Ramsar Convention, officially named The Convention on Wetlands of International Importance especially as Waterfowl Habitat, plays a large international role for wetlands and their conservation. The first intention of the agreement sought to protect waterfowl habitat through the conservation and wise use of wetlands. This was soon realized to be somewhat narrow, and has been further broadened to include all aspects of wetland conservation, as well as recognizing the systems as crucial to biodiversity conservation and the well-being of human communities. The treaty, which now encapsulates 1,916 “wetlands of international importance”,

[23]
These areas currently span an approximate area of 187,044,576 hectares (462 Million Acres) over 160 nations which have agreed to the treaty and its terms, covering virtually all geographic regions of the planet. To put the size of this area into further context, the entire surface area of the "wetlands of international importance" covers a spanse larger than the surface area of France, Germany, Spain and Switzerland combined. The significance of this treaty is exemplified in that this is the only ratified global environmental treaty dealing with a particular ecosystem to date (Ramsar 2011). Moore further states on the importance of the Ramsar Convention, noting that it was created to conserve wetlands not only on a purely local level, but rather on a global scale (2008).

Wetlands are one of the most valuable and important natural environments. They provide suitable habitats to innumerable organisms including birds. Wetlands in India cover an area of 58.2 million hectares (Prasad et al., 2002). Of 1340 bird species found in India (Ali and Ripley, 1987), 310 species are known to be wetland birds (Kumar et al., 2005). Mitsch and Gosselink (2000) stated that wetlands help in maintaining biodiversity of flora and fauna and it was further emphasized in the study that countless species of birds, mammals, reptiles, amphibians, fish and invertebrate species depend on water and wetland vegetation for their survival. Similar observations on wetlands were also made by Buckton (2007).

2.2: AVIAN BIODIVERSITY

Water birds have long attracted the attention of public and scientists because of their beauty, abundance, visibility and social behavior, as well as for their recreational and economic importance. Importance of Wetlands as valuable habitats for waterfowl has been reported by Basavarajappa (2004) and he highlighted that the wetlands support fish, crustaceans, invertebrates, water plants and planktons that further sustain high diversity of wetland birds.

Wetland birds inhabit a range of different niches in wetland. Many international studies have been carried out on avian diversity of wetlands and reported wetlands as important habitats holding maximum species of birds (Sonobe and Usui, 1993; Baral, 1998; Stattersfield and Capper, 2000; Ali et al., 2011 and Bibi and Ali, 2013). Rai (2003) also recorded 60 wetland species from a single Ramsar Site, Beeshazari Tal in Nepal. Similarly, Ali (2005) had studied distribution of migratory bird species at Uchhali wetlands complex, Punjab, Pakistan. Some of the national studies also highlighted wetlands as prominent habitats for resident as well as migratory birds.
STUDY OF SELECTED WETLAND IN VADODARA DISTRICT TO ESTABLISH BASIS FOR CONSERVATION AND INTEGRATION OF WETLANDS FOR WATER RESOURCE MANAGEMENT

(Kotangole and Ghosh, 2002; Bassoualingam et al., 2012; Ramamurthy and Rajakumar, 2014 and Sharma and Saini, 2014). All studies in this direction concluded high dependency of birds on wetlands.

Diversity of waterfowl was found to be influenced by aquatic vegetation. Reinold et al. (1975) reported that primary productivity decreases due to overgrazing by waterfowl. Bassatt (1980) reported the high occurrence of waterbird diversity in areas devoid of excessive vegetation. Rai and Sharma (1991) studied the tropical wetlands of the Indo-Gangetic plain and reported the correlation of waterfowl diversity with aquatic vegetation. In a similar study, Urfi (1993) correlated the biomass of aquatic vegetation with increased number of herbivorous bird species such as moorhen and coot. Weller (1994) observed that seasonal and annual water variations determine the type of vegetation which in turn resulted in changes in bird assemblages. Ramachandran and Vijayan (1995) reported the high incidence of sighting Bronze tailed jacana and Pheasant tailed jacana from areas where Eichhornia sp. and Ipomea aquatica were abundant.

Rai (1980) studied wetlands of north Bihar (India) and reported that the percent frequency of bottom-rooted floating leafed species attains the highest value in monsoon and lowest in winter, whereas the submerged species have the highest frequency in winter and lowest in monsoon. Bernard (1998) reported that emergent populations have maximum biomass in rhizomes during winters and maximum shoot growth after the arrival of summers. Many studies have emphasized the need for the wetland macrophytes conservation for better management of bird habitat.

Morphometric (Habitat) Variations and Water Bird Diversity

Kershaw and Cranswick (2003) studied the behavior of water birds in response to factors such as cold weather, changes in water levels, availability of food resources and reported their effect on abundance of water birds. According to Karen and Johnson (1993) precipitation changes and temperature had a greater impact on water level and surface area under shallow water. They further correlated the changes in wetland hydrology with the quality of habitats for breeding birds particularly waterfowl.

Summer felt (1971) reported that water depth was primarily responsible for the species community structure and diversity in the wetland and it could significantly influence the preference of water birds to inhabit those wetlands. Lane and Munro (1983) reviewed the effect of rainfall on wetlands in the southwest of Western Australia and concluded that rainfall has profound effect on
wetland hydrology and therefore leading to attraction of waterfowl species towards a wetland. Kushlan (1989) said that water depth is the determining factor of species structure in wetlands.

Breininger and Smith (1990) observed an increase in wading bird densities with declining water levels in coastal impoundments. Ntiamoaa Baidu et al (1998) correlated changes in water depth with parameter likes salinity and temperature, which in turn affects the survival of prey organisms living in the area and determine the availability of food for ground feeding water birds. Various studies emphasized that morphometric variations influence community structure of wetlands and therefore, specific efforts need to be made for management of wetlands as valuable habitats. William and James (2000) described the morphometry, physical features and topography of lakes and related the changes with associated biodiversity. Tamisier and Grillas (1994) studied the changes in topography of the marshes due to duration of flooding and its impact on plant communities.

2.3: WATER QUALITY AND AVIAN DIVERSITY

Fluctuations in physico-chemical nature of water have strong influence on productivity and species composition of aquatic community (Eaton et al., 1998). If water resources are not better managed and protected, shortage and contamination of water can impose the major dangers to health and environment (IAEA, 1998).

Changes in physico-chemical parameters of water have been widely studied through biotic response (Sinha and Sinha, 1993). Boyd (1979) studied the water quality of natural waters and reported the average range of total alkalinity and conductivity for natural waters.

Effect of water quality and its relation with water bird diversity was reported by Logan (1975). Several workers have reported the relation in terms of distribution and abundance of planktons with water chemistry and considered temperature as an important factor in determining the periodicity of Chlorophycae which in turn influence the waterfowl diversity (Sinha and Sinha, 1993; Kumar et al., 1995 and Deshkar et al., 2010).

Species composition of planktons of a water body is readily affected by environmental changes because of their short life cycles hence, their composition and abundance can in turn determine presence and abundance of birds feeding on planktons. According to Eaton et al (1998) planktons also have strong influence on certain non-biological aspects of water quality like pH, colour and odour. Jindal and Kumar (1993) studied the physico-chemical characteristics of water quality and recorded a negative correlation between pH and free carbon dioxide.
Mckinney and Schoch (1998) in their study reported that increase in temperature directly lowers oxygen content of water and therefore affect biotic communities. Minor changes in dissolved oxygen levels are responded by the short life cycles of planktons. Plankton populations also affect fish populations and indirectly bird populations.

According to Eriksson (1985) selection of wetland by piscivores may be influenced by the water transparency. Parker et al. (1992) further observed that water birds that depend on fish were found abundant in wetlands with pH 5.5 whereas insectivores and omnivores showed no selection for wetlands with specific acidity.

Minns (1989) also considered pH as indicator of overall productivity that can influence habitat diversity and established a correlation of pH with species richness of phytoplankton invertebrates, fishes, amphibians and water birds which depend on planktons. pH value was further reported to influence the process of decomposition and nutrient regeneration. Hence, many studies have reported strong influence of physiochemical water quality in determining the biotic community structure at wetlands.

2.4: WETLANDS AND FISH DIVERSITY

Fishes are excellent indicators of ecological health of a water body (Johal, 2002). According to Kar et al., 2000, the Indian fish fauna is represented by two classes, viz., Chondrichthyes and Osteichthyes. The Chondrichthyes are represented by 131 species under 67 genera, 28 families and 10 orders in the Indian region whereas Osteichthyes are represented by 2,415 species belonging to 902 genera, 226 families and 30 orders are endemic to India (Paul and Ali, 2013). Comprehensive study of fish fauna of Punjab has been done by Tandon and Johal (1979, 80) and they reported 116 species belonging to 49 genera, 17 families and 8 orders from the Punjab state. Dua and Prakash (2005) assessed the importance of fisheries of Harike wetland- a Ramsar site in India.

Many workers established the effects of habitat structure (both physical and chemical) on fish assemblages in various zones in aquatic ecosystems. Gorman and Karr (1978) correlated fish species diversity with habitat complexity. Scott and Hall (1997) used fish assemblages as indicators of environmental degradation. Bath and Kaur (1998) assessed seasonal distribution and population dynamics of aquatic insects and rotifers in Harike Wetland. Smith (1990) reported reduced productivity in wetlands, and its effect on the aquatic food web by reducing the
phytoplankton and invertebrate population upon which the fish population depends. Loss of fish further reduces the survival and reproductive success of fish eating birds like herons.

2.5: CLASSIFICATION OF WETLANDS

Classification of wetland types can be a very in-depth and complicated process, because the more one considers the variations in wetland characteristics, the more categorizations can be created. However, such in-depth processes would be outside the scope of this paper. In lieu of this digression, one of the most basic classification schemes shall be considered compared to a more advanced system, which will illustrate the point of how complex these classifications can truly be. There are four main types of wetlands in a basic system of classification: swamp, marsh, bog, and fen (Keddy, 2000). The following descriptions are based upon a synopsis of literature by Keddy (2000) and Moore (2008):

1. Swamp (Carr)-
   
   A wetland community dominated by trees with a developed leaf canopy, which have invaded from nearby areas into herbaceous marshes and fens, rooted in hydric soils, but not peat; Examples include tropical mangrove swamps and bottom-land forests in floodplains.

2. Marsh-
   
   A wetland community dominated by herbaceous plants, usually emergent through water and rooted in hydric soils, but not peat; Examples include cattail marshes around the Great Lakes and reed beds around the Baltic Sea.

3. Bog (Schwingmoor)-
   
   A wetland community dominated by sphagnum moss, sedges, ericaceous shrubs or evergreen trees rooted in deep, sometimes uncompacted peat; Examples include blanket bogs which cover mountain sides in Europe and floating bogs which cover the shores of many lakes in temperate and boreal regions.

4. Fen-
   
   A wetland community usually dominated by sedges and grasses rooted in shallow peat, often with considerable water movement through the peat; Examples include the extensive peatlands in northern Canada and Russia, as well as smaller seepage areas throughout the temperate zone.”
Keeping these four basic types of wetlands in mind, more advanced classification systems such as those used by the Ramsar Convention and Cowardin, et al should be considered for comparison. In this system, there are five main wetland systems, each with their own specific subdivisions.

The five systems, based upon observations from both Ramsar and Cowardin, et al are:
1. **Marine-** coastal wetlands including coastal lagoons, rocky shores, and coral reefs;
2. **Estuarine-** including deltas, tidal marshes, and mangrove swamps;
3. **Lacustrine-** wetlands associated with lakes;
4. **Riverine-** wetlands along rivers and streams; and
5. **Palustrine-** meaning "marshy" - marshes, swamps and bogs.

One of the best known and widely used in the United States and adopted internationally by the Ramsar Convention (Cowardin et al., 1979) can be, and further explains why difficulty exists in precisely defining what a wetland is.

### 2.6: GLOBAL DISTRIBUTION OF WETLAND

Next, a discussion on the global distribution of wetlands past and present is crucial to understand the full context of the ecosystems. According to Keddy (2000), there are three reasons which make wetland mapping difficult on a global scale. First, wetlands cover a relatively small area of the landscape. Second, their distribution cannot be mapped at a suitable scale, as they are often distributed in small patches or strips throughout biomes. Finally, biomes can contain a wide array of wetland types, and that great variability exists across an entire biome (Keddy 2000). (A biome is a broad, regional type of ecosystem characterized by distinctive climate, soil, and biota)

Despite the challenges noted by Keddy (2000), some researchers have sought to quantify and map wetland distribution, but results are highly varied.

Vymazal (2011) evidences this in his comparison of three estimates from Matthews and Fung, Aselman and Crutzen, and Lehner and Döll; the paper by Matthews and Fung (1987) estimated that wetlands cover an area of 6.8 million km². Aselman and Crutzen (1990) posed a similar estimation of wetland area, proposing that they cover 6.9 million km². Lehner and Döll (2004) sought to make further estimations of wetland area using technological advances such as Geographical Information Systems (GIS) which were achieved after the two previous studies were
published. Lehner and Döll (2004) estimated wetlands to cover an area between 8.3 million km\(^2\) and 10.1 million km\(^2\) worldwide.

According to some sources, wetlands presently exist on only half of the land area where they historically occurred due to modification and reclamation (World Wildlife Fund 2004). Some argue that because few nations have historically accurate maps, these estimates may not necessarily be exact (Zedler and Kercher 2005).

2.7: WETLAND DISTRIBUTION IN INDIA

Total wetland area was estimated to be 15.260 m ha using 2006–07 LISS-III data, which is around 4.63% of the geographical area of the country. This includes 555,557 ha area under small wetlands. (Sushma et al. 2012). This inventory estimated the total wetland area as 15.26 m ha. River/stream is the largest type wetland accounting for 5.26 m ha.

DIVERSITY OF FLORA AND FAUNA IN GUJRAT

According to Gujrat biodiversity board diversity of flora and fauna is high in the wetlands of Gujarat. A total of 3,23 species of wetlands of India are endemic or globally threatened, and at least 30 of them are from Gujarat. Of 114 endemic wetland plants of India, 11 are found in the wetlands of Gujarat.

WATER-BIRDS

Regular water fowl counting reveals that each of the sites- Nalsarovar in Ahmedabad; Thol lake in Mehsana; Janan and Chhardhundh in Kachchh; Bardasagar, Dhonivira, Amipur in Porbandar; Aji dam, Sani dam, Sarmat Bhandhara dam and Khijadia lake in Jamnagar; Dhanasara dam and Korddda Moti Sander in Patan; Patangadi in Dahod, Nani-Kakrad in Navsari, Kanewal in Kheda supported more than 20,000 water birds.

Wetland dependent rare and threatened fauna in Gujarat (Gujrat Biodiversity board). A large number of birds, amphibians and other fauna are dependent on the health of wetlands. A good number of them are threatened due to the loss of habitat or their poaching, and some of them are on the verge of extinction. The threatened wetland fauna in Gujarat are as follow.
Table No. 2.1.: The threatened wetland fauna in Gujarat.

<table>
<thead>
<tr>
<th>Birds</th>
<th>Reptiles and amphibians</th>
<th>Marine life</th>
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<tbody>
<tr>
<td>• Indian sarus</td>
<td>• Green Sea Turtle</td>
<td>• Sea Horse and corals</td>
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<tr>
<td>• Pink-headed Duck</td>
<td>• Olive Ridley</td>
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<tr>
<td>• Morbled Teal</td>
<td>• Leather-backed Turtle</td>
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<tr>
<td>• Baikal Teal</td>
<td>• Marsh Crocodile</td>
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<td>• Spot-billed Pelican</td>
<td>• Indian Flap-shelled Turtle</td>
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<td>• Lesser Adjutant</td>
<td>• Indian Soft shelled Turtle</td>
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<td>• Black necked Stork</td>
<td>• Indian Python</td>
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<td>• Black Stork</td>
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<td>• Baer's Pochard</td>
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<td>• Over half dozen raptors</td>
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<td>• White-bellied Sea Eagle</td>
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<td>• Indian skimmer</td>
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THE VALUE OF WETLANDS

The loss of ecosystem services of wetlands can have both economic and environmental consequences. Multiple authors acknowledge a vast variety of literature has been published attempting to give wetlands an economic value (Mitsch and Gosselink 2000, BenDor et. al 2008). However, it is important to note that these studies attempt to assign monetary values to the services and functions that are provided by wetlands (Spash 2000, Brander et. al 2006, Woodard and Wui 2001, Carlsson et. al 2003).
Table No. 2.2: Listing of general wetland Important value (World Wildlife Federation 2004)

<table>
<thead>
<tr>
<th>Regulating function</th>
<th>Carrier function</th>
<th>Information function</th>
<th>Production function</th>
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<tr>
<td>• Storage and recycling of nutrients</td>
<td>• Agriculture, irrigation</td>
<td>• Research, education and monitoring</td>
<td>• Water,</td>
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<tr>
<td>• Storage and recycling of human waste</td>
<td>• Stock farming (grazing)</td>
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<td>• Food</td>
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<td>• Storage and recycling of organic waste</td>
<td>• Wildlife cropping/resources</td>
<td>• Uniqueness, rarity or naturalness</td>
<td>• Fuel wood</td>
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<tr>
<td>• Groundwater recharge</td>
<td>• Transport</td>
<td>and role in cultural heritage</td>
<td>• Medicinal resources</td>
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<tr>
<td>• Groundwater discharge</td>
<td>• Energy production tourism and recreation</td>
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<td>• Genetics resources</td>
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<tr>
<td>• Natural flood control and flow regulation</td>
<td>• Human habitation and settlement</td>
<td></td>
<td>• Raw materials</td>
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<tr>
<td>• Erosion control</td>
<td>• Habitat and nursery for plant and animal</td>
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<td>for building, construction and industrial use</td>
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<td>• Salinity control</td>
<td>species</td>
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<td>• Water treatment</td>
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<td>• Climatic stabilization</td>
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<td>• Maintenance of migration and nursery habitats</td>
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<td>• Maintenance of ecosystem stability</td>
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<td>• Maintenance of integrity of other ecosystem</td>
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<td>• Maintenance of biological and genetic diversity</td>
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<td>• Carbon sequestration</td>
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2.8: THREATS TO WETLAND ECOSYSTEMS

Wetlands are National assets but are facing tremendous anthropogenic pressures. Various workers have studied the condition of wetlands in India and discussed the effects of tremendous pressures on wetlands. They have also observed significant losses resulting from industrial, agricultural and various urban developments. These studies have also considered the degradation of wetlands as habitat loss and reported that such habitat degradations have great influence on the structure of bird communities (Prasad et al., 2002, Kler, 2002; Verma et al., 2004; Reginald et al., 2007 and Bibi and Ali, 2013).

Kingsford (2000) reviewed the effects of river diversion and construction of dam on estuarine and coastal ecology. Sonobe and Usui (1993) considered wetlands as one of the most threatened habitats in the world and discussed various threats arising from human activities and development.

Agricultural runoff in a water body or various herbicides can affect the growth rate of algae (Transpurger et al, 1996). Prasad et al (2002) conducted the study and reported that grazing and fishing activities beyond the sustainable levels are prominent factors resulting in degradation of wetlands. The fast pace of disappearance of wetlands and degradation of ecological health of the ecosystems providing vital habitats is of great concern.

Baral (1998) studied the Pokhara valley wetlands (with unprotected status) and reported fast rate of disappearance of wetland ecosystems in Nepal. Singh (2004) studied Jhilmila and Kalikich wetlands in Nepal and reported habitat alteration or degradation due to heavy human and livestock pressures. He reported hunting and poisoning as the main threats to these wetlands. Various studies have been conducted to identify prevailing threats to wetlands and are identified as: drainage, diversion, obstruction, siltation, encroachment, infrastructure development, land use changes and pollution (Karki et al., 1997; Karki and Thapa, 1999 and Subedi, 2003).

Phosphala et al (1974) studied duck population inhabiting wetlands and reported intensive agriculture as important factor affecting the dependent populations. Khan (1992) studied population trends of waterfowl species in wetland and reported the decline due to increase in human and livestock activities. Gautam and Kafle (2007) observed and emphasized the effects of pollution on fish community and further correlated it with the reduction in bird numbers and species diversity.
2.9: CONSERVATION AND MANAGEMENT OF WETLANDS

Though Wildlife Protection Act (1972 and amendment 2002) protects some of the notified ecologically sensitive regions, several small wetlands are being over exploited because of their unprotected status. Groombridge and Jenkins (1998) emphasized the assessment and documentation of natural resources as the first step in conservation of biodiversity. Various workers (Timothy, 1999; Gole, 1989 and Ahmed, 1995) evaluated wetlands and suggested their management especially with respect to bird habitats. Other important studies in this direction were conducted by Burger (1973), Bellrose and Low (1978), Larsson (1982), Cooke (1986) and Grigorieve (2000).

Prasad et al (2002) reviewed the use of Remote Sensing and Geographic Information System (GIS) tools in flood zonation mapping, in monitoring irrigation and cropping patterns, water quality analysis and modelling, change analyses and in mapping of surface water bodies and wetlands. Space Applications Centre (SAC), ISRO (2011) had taken an initiative for development of GIS based wetland information system and Lake Information system for conservation of Wetlands. Besides, the mapping of wetlands at 1:250000 scale. SAC mapped wetlands in the states of Sikkim, West Bengal, Goa, Punjab, Haryana, Himachal Pradesh, Chandigarh, Delhi, Andaman, Nicobar, Lakshwadeep, Dadra and Nagerhaveli at 1:50000 scale. However, in the rest of the country, only wetlands of 56.25 ha and above in size could be mapped. Das et al. (1994) reported that majority of wetlands requiring immediate restoration plan are below 50 ha in size. Therefore, there is a great need to map wetlands of size smaller than 50 ha. Past research on wetland conservation in the country had shown conclusively that small wetlands around a bigger wetland act as a constellation of habitat mosaic for resident and migratory waterfowl (Vijayan, 1991).

The importance of natural wetlands over constructed wetlands in improving water quality as well as in providing habitat for various life forms is well demonstrated by Younger et al. (1997); Jarvis and Younger (1999) and Younger et al. (2002). Unfortunately, biodiversity of small and unprotected natural wetlands of Vadodara District is poorly documented. Therefore, the present study is an attempt to document ecological status and bird diversity of Natural wetlands of Vadodara District, Gujarat, India.