INTRODUCTION

Urbanization could be defined as concentrated human presence in residential and industrial settings with their associated effects (Cringan and Horak, 1989; Marzluff, 1997). The process of urbanization means that changing the natural habitat by paving, building over or drowning them for human needs like residency and commercial use (Strohm, 1974). The urban extent of most metropolitan areas is expanding to adjacent rural landscapes (Alig and Healy, 1987; World Resources Institute, 1994; UN, 1997). With the global increase of urbanization, land cover conversions for urban use has been expected to increase fast altering ecosystem patterns and processes (Grimm *et* al., 2000). Strohm, way back in 1974 suggested the rate of urbanization at 4,00,000 hectares a year when the urban areas were increasing rapidly, particularly in the developing world (World Resources Institute, 1996). This continued to dominate the ecosystems around the world (Vitousek *et al.*, 1997). It resulted in the growth of the metropolitan cities that housed a large proportion of the world's human population (Brown *et* al., 1998). This growth called as urbanization, altered the native habitat and reduced the green patches. With the increase in human population there was an increase in the urban areas that increasingly influenced the biodiversity (Marzluff *et al.,* 2001). As man inhabited the natural habitat, destruction of biodiversity of that particular habitat was initiated. For the purpose of ecological studies urban centers have been quantified as containing more than 2500 people (Dumouchel, 1975). Marzluff *et al.,* (2001) described urbanization as a long process as follows: "*In developing world, increasing populations moved away from traditional city centres and caused the city*

to grow resulting in strong gradient of human density of suburbs. These gradients of suburb turned increasingly complex and took urban characteristics. These processes could be collectively called as urbanization."

In general, most urban planning and management remained focused on the impact of urbanization on human society rather than on the issues of biodiversity (Marzluff *et al.*, 2001). Urban ecosystems as a whole could be viewed as highly fragmented, heterogeneous landscapes dominated by buildings, roads and pavement and often lacking in substantial vegetation cover and characterized by high levels of human-associated disturbances, such as traffic, construction of concrete structures for human needs and recreation (Jokimaki, 1999).

During the process of urbanization, land was divided into several complex areas. These were classified by Marzluff *et al.* (2001) as follows:

Urban lands- those areas where the majority of the land was covered by buildings. Building density was high and many buildings were for commerce, employment or industry. Single family homes were rare besides land was densely packed with small gardens or lawn spaces. Multi-family housing *eg.* Apartments and multi-storied buildings characterized urban areas.

Suburban lands- the areas characterized by moderate to high density, single-family housing with plot size of 0.1 to 1.0 ha. with lawns and gardens around them.

Exurban lands- the areas of lands sparsely settled by individual homes with recreational development and small towns and villages surrounded by natural matrix.

Rural lands- the areas distinguished from exurban lands by the agricultural matrix surrounding settlement.

Urbanization was considered as a major driving force for biodiversity loss and biological homogenization not only in developed countries, but also in less developing countries (Savard *et al.*, 2000; Gupta, 2002; Mckinney, 2002). It produced different effects on the biota (Limbin *et. al.*, 2001). Urbanization and agriculture certainly were considered as a global phenomenon that widely influenced biodiversity with different magnitudes and differed among regions, across continents or the globe. Hotspots of high species richness and endemism occurred where ecosystem disruption was especially threatening the global biodiversity (Reid, 1998). Urbanization developed into a new ecosystem called urban ecosystem (Cleargeau, 1998). As the consumption levels of human population continued to increase, there was a need to develop a quick but precise method of identifying areas where high levels of human threats and biodiversity coincided (Ricketts and Imhoff, 2003).

Further, urbanization not only affected the terrestrial habitat but also altered the small water bodies with shallow wetlands in the area. According to Boyer and Polasky (2004) urbanization had become a major cause for the loss of wetland with its hydrology, runoff of nutrients and pollution. Urbanized lakes often undergo similar patterns of habitat alteration as was noted for terrestrial habitats (Traut, 2003).

As far as biodiversity is concerned, birds form an important community in urban ecosystem. In urban areas, development and the alteration of both aquatic and terrestrial habitat structure might be the most important factors in determining the composition and distribution of bird communities (Traut, 2003). United States is he country that has focused on the effects of recreation on avian abundance,

distribution and breeding success of urban aquatic environments (Hockin *et al.*, 1992).

With increasing urbanization tremendous pressures were applied on various habitats in the metropolitan cities resulting in habitat fragmentation due to increasing development. This could change the structure of native ecosystem, particularly vegetation, which generally influenced avian community composition (Strife, 2004). Ultimately, this change in vegetative cover contributed to a decrease in species richness and diversity but increase in biomass and density (Strife, 2004). In developing countries, growth was concentrated around urban cores and replaced adjacent lands into agricultural land. Increasing development decreased avian species richness, decreased avian evenness but increased bird density (Traut, 2003). Avian species diversity has been negatively correlated with elements of the built up environment, such as housing density (Lancaster and Rees 1979). Clergeau *et al.*, (1998) have also reported a negative relationship between species diversity and urbanization but have also added that urban communities were dominated by the few species (omnivores) that were able to adapt to the resources available in urban conditions. Although loss of habitat was the main cause of species decline, the mechanisms causing fragmentation and the spatial distribution of resources at different scales were also important factors (Flather and Sauer 1996, Rodewald and Yahner 2001; Franklin *et al*, 2002). The aves form one of the major fauna in urban area. Because of their high mobility they react very rapidly to the changes in their habitats (Morrison, 1986; Fuller *et al.*, 1995). Several reports indicated that urbanization favoured a few species but selected against most in such a way that the avian community composition of urban environment differs dramatically from local

natural environments (Beissinger and Osborne, 1982; Mills *et al.*, 1989; O'Connell *et al.*, 2000).

India is considered as developing country that has developed extensively into varied fields is like technology, medicine, education and entertainment. Because of these developments the green patches were replaced by commercial and multistoreyed residential buildings, entertainment joints, business centers, roads, malls, industries, *etc.* The number of studies that described avian responses to urbanization were immense and increasing (Marzluff *et al.*, 2001) however the number of such studies in Asia and in particular in India were meager. Hence the present study was planned to identify the hotspots that supports avian densities and/or diversity in urban ecosystem that has various microhabitats.

Blair (1996) divided the urban bird communities into three groups with respect to their relation to the urban ecosystem. They were:

Urban exploiters – The native species that adapt to and exploit the urban environment, often reaching their greatest densities in highly urbanized areas (Kark *et al.*, 2007).

Urban adapters - The native species that could exploit some of the urban resources such as ornamental vegetation typical of intermediate levels of urbanization (Kark et *al.*, 2007).

Alien species The species that were deliberately or accidentally set free in locations where they were not native (Richardson *et al.*, 2000).

The present work was aimed to study the avifaunal diversity in the urban areas which were confronting various human pressures. Urbanization not only changed habitat but also affected the guilds of birds as they are most sensitive organisms on

the earth. About 8,600 species of birds are recorded in the world of which more than 1200 species occurre in Indian subcontinent. Of which about 526 species were reported from Gujarat (Parasharya *et al.*, 2004) and 244 in Vadodara district (Padate *et al.,* 2001). However, of these 131 have been listed in and around Harni pond (Padate and Sapna, 1996) and about 80 in various terrestrial habitats of Vadodara (Padate *et al.,* 1998). The present study aims to find out the status of birds in Vadodara after a decade and also to find out their densities and distribution in the city.

The study was divided into two parts:-

Part I Avifauna in various parts of Vadodara city

Vadodara is one of the metro city of Gujarat State. In present study Avifauna of 12 areas of Vadodara city were surveyed from October 2005 to September 2007. The areas were categorized according to the human disturbances in to four groups, ***I Disturbed Areas (DA)*** that includes R. C. Dutt Road (RCDR), City Area (CA) and Industrial Area (IA). ***II Moderately Disturbed Areas (MD)***: University Campus (UC), Sayaji Garden (SG), Akota Garden (AG) and Residential Area (RA). ***III Undisturbed areas (UD)***: Model Farm (MD) and Postal Training Center Campus (PTCC). ***IV Ponds (PS)***: Lal baug Pond (LP), Gotri Pond (GP) and Harni Pond (HP). For the convenience of discussion, first three groups that included terrestrial habitats are considered in Chapter I whereas three aquatic habitats of the city are considered in Chapter II. The density, species richness, diversity indices like Shannon-wiener and evenness, abundance and similarity index between all the areas are considered in this part of study.

These varied areas provided food and shelter to the birds that were either urban exploiters or urban adaptors. Hence, chapter III, discusses their feeding guilds as well as roosting population of some species which roost in large flocks.

PART II Comparisons of Two water bodies

As human population grew it increased urbanization which not only affected the terrestrial habitat but also influenced the aquatic habitat. All organisms as well as human being require good quality of water and the quality of water resources in urban areas depend on the management of anthropogenic discharges (Efe *et al.*, 2005). Over consumption, misuse, pollution, etc. were actual anthropogenic causes of degradation of water bodies when high amounts of nutrients were unloaded into them mainly from human settlements via sewage (Khan and Ansari, 2005). Degradation of water could cause the eutrophication of the water body. Eutrophication has become a major cause of concern in the developing world (Khan and Ansari, 2005). Degraded quality of water, directly or indirectly affected the flora as well as fauna. Hence, knowing the calibre of the water in a water body became not only essential for the human being but also for the survival of flora and fauna supported by it (Aydemir *et al.*, 2005). The ponds exhibited a wide range of ecological, social and aesthetic values in urban areas (Gledhill *et al.*, 2004). Hence to find out influence of urbanization with its various anthropogenic pressure the second part of the study was planned to find out direct influence of urban pressures on avifaunal diversity at two water bodies located in same region and under the influence of same climatic conditions but different anthropogenic pressures.

The major aquatic fauna other than fishes that depended on water and were easy to monitor were planktons. The quality of water also depended on plankton the

primary producer and zooplankton. The primary consumer as well as prey base for several species. The plankton are the indicators of the pollution of the aquatic habitat too. Type of plankton and their abundance depend on the quality of water as well as seasons and they react rapidly to the changes in quality of water (Willen, 2001). Among zooplankton, the rotifers play significant role in the food chain and biological production of water by acting as aqua pollution indicators and / or water quality monitors (Sladecek, 1983). Hence, second part of study also deals with diversity of plankton and physico-chemical properties of water under urban influence. Thus, the second part of study was carried out to measure the impacts of urban development directly on avifauna, plankton density as well as physico-chemical parameters of two water bodies.

The two water bodies selected are: **1**. Savli Pond located at Savli (22° 33' 50" N and 73° 13' 23" E) a developing town in Vadodara district of Central Gujarat. It is a perennial pond which is under the pressures of urbanization. **2**. Jawala Irrigation Reservoir, located (22° 34', 20" N and 73° 19' 24" E), about a kilometer away from Savli Pond and surrounded by agricultural land. It is totally a monsoon dependent reservoir.

The density, species richness, diversity indices like Shannon–Wiener and Evenness and abundance of avifauna and plankton are evaluated at the two water bodies from July 2005 to June 2007. The Physico-chemical parameters analysis helped to know the difference in the quality of water at the two water bodies. Physico-chemical parameters studied are divided as physical and other aggregate properties and inorganic non-metallic constituents. The physical and other aggregate properties included Temperature, Total Solids (TS), Total Dissolved Solids (TDS), Total

Suspended Solids (TSS), pH, Acidity, Bicarbonate Alkalinity (HCO_3^-), Hydroxyl Alkalinity (OH^-), Salinity, Total Hardness, Calcium Hardness and Magnesium Hardness while Inorganic non-metallic constituents are Dissolved Oxygen (DO), Carbon dioxide (CO_2), Chloride (Cl^-), Nitrate (NO_3^-), Nitrite (NO_2^-) and Phosphate (PO_4^{-3}). Densities as well as species richness of birds and plankton are also correlated with the quality of water. Jaccard's similarity index of birds is also calculated to know the diversity of birds and direct and indirect effects of urbanization on the avifauna.