GENERAL CONSIDERATIONS

Wetlands are one of the crucial natural resources. Wetlands are areas of land that are either temporarily or permanently covered by water. This means that a wetland is neither truly aquatic nor terrestrial. The wetlands exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, plants and soil or sediment characteristics. Because of their transitional nature, the boundaries of wetlands are often difficult to define. Wetlands do, however, share a few attributes common to all forms. Of these, hydrological structure (the dynamics of water supply, storage and loss) is most fundamental to the nature of a wetland system.

The three study areas selected in the present study are man-made irrigation reservoirs with difference in hydroperiod, geography and anthropogenic pressures. Of the three selected reservoirs two are regularly inundated with Narmada water (WIR and TIR). The third one, JIR without Narmada inundation does get Narmada water through seepage from canal that is passing nearby. Further it also has river tributaries in its catchment area which might be responsible for the input of water in the wetland. The human disturbances as well as the land matrix around the three reservoirs are also different influencing the flora and fauna present differently. These reservoirs support good density and diversity of waterfowls since there is increase in hydroperiod after the Narmada inundation. The results of studies by Deshkar, (2008) led to the identification of WIR as a potential IBA and one more candidate of Ramsar sites in Gujarat. As the density and diversity of birds depend on food availability, shelter, physico-chemical properties of water and soil, a smaller portion of wader diversity with its associated characteristics of soil, water,
benthos and vegetation is considered in the present study. Deshkar, (2008) has stressed the need for evaluation of its potential to supports other organisms.

The present study is thus important in understanding occurrence of huge diversity and density of wader population in the reservoirs of Central Gujarat. This study is expected to make us understand the importance and dependence of macrobenthos that link the producers and consumers in an aquatic ecosystem like wetlands and its surrounding areas. With Ramsar convention, together with the Convention on Biodiversity, other species have also started receiving importance. The objectives of the present study were to determine the influence of water chemistry, sediment characteristics and availability of different prey categories on the wading bird use of the irrigation reservoirs and to evaluate the impacts of Narmada inundation on the same.

Birds are the prominent species inhabiting wetlands and form an important link in the food chain. Due to their ability to occur in varied conditions, they are considered as important indicators of health of an ecosystem. Study on wading bird populations was carried out at three irrigation reservoirs in a time span of two years from 2009 to 2011 (Chapter I). As these birds are dependent on other organisms especially benthic macroinvertebrates like insects and mollusc, the density and species richness of benthic fauna were studied (Chapter II and III). The primary productivity of a wetland depends on the water and soil chemistry which includes the physical, chemical parameters and inorganic non-metallic constituents. Hence, the fluctuations in water and soil chemistry are also considered (Chapter IV). Also, any fauna is ultimately dependent on the primary producers in an ecosystem. Thus a study on the vegetational composition at the three study sites has also been carried out in the present study (Chapter V).
The role of food abundance on water bird densities has been well established hence in a study of waders it becomes necessary to evaluate the factors affecting the abundance of macroinvertebrates.

The early migrants and resident species led to a moderate to higher density of waders at the reservoirs with less seasonal fluctuations (WIR and TIR). While during the non migratory seasons the density of birds was influenced by the microhabitats available at the wetlands. Extended hydroperiod and the availability of suitable habitat during different seasons were the two important factors affecting the species richness.

When the relation between waders and the physico-chemical properties of water is considered, variable significant as well as non-significant correlations were noted between wader density and physico-chemical properties of soil and water at the three reservoirs. This indicated the influence of Narmada inundation which keeps on changing chemistry of water and soil. Hence no single factor could be correlated with wader density.

Benthic macroinvertebrates have been intriguing targets of biological monitoring efforts because they are a diverse group of long-lived, sedentary species that react strongly and often, predictably to human influence on aquatic ecosystems. This group plays an important role as indicators of aquatic pollution. Benthos being rich in proteins, form an important component that influence habitat selection by waterbirds especially waders. Significant seasonal changes found in species richness and density of many species of the macrozoobenthic at the three irrigation reservoirs indicate their dependency on environmental factors. These changes are highly pronounced at the reservoirs under prominent Narmada inundation compared to non-inundated reservoir, JIR supporting the
influence of Narmada water on fauna. Another factor influencing the species richness is anthropogenic pressures. WIR is mainly undisturbed large habitat hence the number of species present therein may be positively influenced whereas TIR facing moderate human disturbances and urban expansion is expected to support urban adaptors too influencing species richness. At JIR, the reservoir with moderate size and low human impact such conditions do not prevail and hence supports moderate species richness. Further, a decline in the density of benthic fauna from post-monsoon to winter and there after increase till February, stresses the influence of climatic conditions on the benthic invertebrates. The heterogeneity in habitat is provided by emergent vegetation at JIR.

In general, percent occurrence was high for coleopterans and hemipterans while in addition at WIR, trombidiforms also occurred with high occurrence. Many ground dwelling coleopterans prefer moist/wet soils while aquatic and semi-aquatic hemipterans prefer burrowing as well as swimming in water. All other orders had moderate to low occurrence at the three reservoirs depending on the preference of varied microhabitats.

When correlations are considered between benthos and the water quality, a significant but negative correlation was noted with salinity and sulphate at WIR, a positive one with nitrite and water temperature at TIR while no correlations were obtained for JIR. On the other hand, the correlations with soil noted a positive and significant correlation with coarse sand at WIR while with very fine sand at TIR.

The high productivity of the silty-sand and loose sandy sediment make the benthic invertebrates easily accessible for waders which was also noted in the present study as percent silt+clay correlated positively at all the three irrigation reservoirs. On the basis of the correlation of the benthic fauna with the abiotic factors also it can be said that the
wetland ecosystems are maintained by the interdependency of various factors changing due to Narmada inundation.

The other component of benthic fauna, the molluscs had high density at WIR and TIR while at JIR it was low. This supports the idea that the characteristics of a wetland with Narmada inundation and without it are different. *Bellamya bengalensis*, was the most widely distributed and hence abundant at WIR. As WIR changed from seasonal to almost perennial, this species was abundant but it was frequent at TIR and JIR. *Indoplanorbis exustus* was frequent at WIR and TIR while abundant at JIR. The high organic input because of use of reservoir by locals may have led to its abundance as this species is tolerant to polluted water. *Thiara granifera* was a rare occurrence at all the three reservoirs while *Lymnaea auricularia* was noted only at WIR. The bivalve, *Lamallae consobrinus* was occasional at TIR, rare at WIR and altogether absent at JIR. Also, their breeding activities and the high levels of water in the reservoirs made their sampling difficult.

The correlation between physico-chemical properties of water and molluscs, indicated influence of fluctuating levels of water due to Narmada inundation leading to frequent change in its chemistry. However, molluscs being shelled animals can entrap their body mass in shell and protect it and emerge when the conditions are favorable in the seasonal change in their density and no single common best predictor could be defined which can be the sole factor responsible for the density of the molluscs. Further, the assumption that the presence of emergent vegetation (JIR) influences the diversity of dependent fauna stands true as at JIR status of various species of mollusc was quite different with differences in seasonal cycle.
GENERAL CONSIDERATIONS

All organisms and the communities are directly or indirectly affected by the physical characteristics of their environment. Thus, the study of interactions between biotic and abiotic factors becomes essential to understand the community structure of an ecosystem. The interrelated correlation of different parameters of water and soil chemistry suggests the physicochemical characteristic of the wetland. Hence, the quality of water and soil is also considered in the present study. The differences in these abiotic variables are mainly expected because of the climatic changes, the geographic locations (the distance from the city area), the anthropogenic pressures and the hydrology of a wetland. The seasonal differences in soil and water chemistry with differences among the three reservoirs supports the assumption that due to fluctuations resulted in water levels in response to Narmada inundations common correlations between various physico-chemical parameters could not be found.

On the basis of the present study it can be concluded that because of large size as well as Narmada inundation, WIR ahs good diversity of submergent and emergent vegetation. This provides shelter to migratory as well as resident species of waders but huge density and diversity of their prey base. Though fluctuations in parameter of water chemistry do not support a single species, the diverse species available with their own life cycle do provide prey base in different seasons.

Similarly, TIR also supports good diversity and density of waders which get almost similar conditions available at WIR. As it is a smaller reservoir density and diversity supported by it is comparatively lower.
GENERAL CONSIDERATIONS

Lastly, the vegetation studied at three reservoirs also showed differences in relation to Narmada inundation. In India, almost all the water resources are occupied with various types of macrophytes viz. rooted at shoreline, free-floating, submerged, etc, forming an integral part of the ecosystem and acting as bio-filters.

The similarity in the species composition at TIR and WIR further supports the assumption of effect of Narmada inundation. These two reservoirs are nearer to each other and receive Narmada water under the same schedule. At JIR, the earthen dam was mainly occupied by *Ipomoea aquatica* and some Poaceae family members. Hence least annual species richness was noted. The differences in vegetation may be related to the closer vicinity of TIR to urban conditions. At TIR, *Typha sp.* and *Ipomoea aquatica* contributed to the richness. Monsoon serves as a medium through which nutrients and other solutes move in the plants. Also, the water levels have increased in the reservoirs. These two factors lead to an increase in the species richness. In addition as higher water level also submerges some terrestrial vegetation grown on the earthen dam. The annual percentage occurrence was highest for emergent vegetation of *Ipomoea aquatica* at all the three reservoirs. The species provides shelter as well as nesting site for many species of birds. However, *Nymphaea nouchali* found at the edge of TIR and *Netumbo nucifera* in the middle of JIR also provide encourage to prey base of birds. This species was present all round the but was observed at JIR only.

The differences in the occurrence of plants (aquatic or terrestrial) are dependent on many factors such as biogeography, dispersal, climatic factors, hydrology, etc. The distance between the three reservoirs surveyed is about 25-50 kms. and hence the similarity
between the three reservoirs would be evident. Here, the movements of seeds due to natural conditions or human involvement cannot be ruled out.

The present study proves to be a useful source of information regarding the wetlands of the semi arid zone of Central Gujarat, India, and help in preparing the conservation and management strategies.