

## **ABSTRACT**

### **Assessment of Wetland Resources in Malda District and Its Conservation for Sustainable Management**

Wetlands are formed at the interface of the terrestrial and aquatic ecosystem and comprise the characteristics of both. Wetlands are considered one of the most productive habitats on the Earth, to support diverse kinds of life processes. The present study has been conducted in Malda district (24°40'20" N to 25°32'08" N latitudes and 87°45'50" E to 88°28'10" E longitudes), which facilitates the formation of different categories of wetlands (natural and man-made) with having unique fluvio-geomorphic set-up. The present work is an attempt to assess the wetland resources in Malda district and its conservation through wise use in order to achieve the sustainable management. Therefore, the following objectives are set:

1. Mapping of wetlands of Malda district and to monitor their behavior for the development of innovative estimation measures.
2. Classification of wetlands and estimating the geographical extent of the different types and identifying the representative wetlands for detail analysis.
3. Survey and estimate the utilization of wetlands for agriculture, aquaculture, coir rotting, gathering fruits and fiber etc. and ascertaining their socio-economic impact.
4. Preparing an inventory of flora and fauna as well as estimate the potential for wildlife vis-à-vis aesthetic and recreational uses i.e., eco-tourism activities.
5. To study the potentialities of these wetlands to provide alternative economic support to rural people through generation of gainful self-employment.
6. Impact assessment of various anthropogenic activities in wetlands to understand the various degradation processes in Malda district.
7. Planning for the conservation and appropriate management technologies of the wetland on sustainable basis.

In the present study, in order to fulfil the mentioned objectives, the methodology and database have been obtained by the researcher, which comprise geomorphological, hydrological, meteorological, biological and anthropogenic inputs. The entire study is based on both the primary data and secondary sources and information.

As per the Institute of Wetland Management and Ecological Design (IWMED, 2000) and Space Application Centre (ISRO, 2010) Malda district is occupied by a total of 562 and 502 no. of wetlands (each with  $\geq 2.25$  ha) respectively, in which, natural classes are mostly dominant. Wetlands of Malda district are considered the most important resources as well as play a key role in hydrological, biological and ecological functioning of the region. Here, the wetlands cover different proportion of area in three distinct physiographic divisions; namely *Tal*, (north and north-west), *Diara* (south and south-west) and *Barind* (east) depending on the existing geological and hydrological characteristics. Most of the wetlands are directly or indirectly linked with the major river systems of Malda district; namely Mahananda, Kalindri, Fulahar and Tangan. However, out of the total no. of wetlands, 4 have been selected as case studies on the basis of three selection criteria (different categories of wetlands, degree of human interference and resultant encroachment of wetland area and agro-economic and biologic potentials of wetlands) namely; Siali wetland, Chakla wetland, Naghoria wetland and Chatra wetland for further detail analysis. The area coverage of case studies vary from 18 ha to 850 ha and the water depth vary from 1.5 m during pre-monsoon to more than 3.0 m in several pockets of wetlands during monsoon and post-monsoon period.

In order to prepare the inventory of biotic components (macrophytes, ichthyofauna, aquatic fauna and avifauna) within wetlands, of Malda district, field study has been conducted during March 2016 to February 2017. Diverse assemblage of aquatic macrophytes, with a total of 21 species, belonging to 21 genera and 17 families namely; *Centella asiatica*, *Enydra fluctuans*, *Eclipta alba hassk*, *Polycarpon prostratum*, *Heliotropium indicum* under emergent (growth form) water edge (habitat); *Hygrophilia auriculata*, *Ipomoea aquatic*, *Marsilea Quadrifolia* under semi-emergent water edge; *Aeschynomene aspera*, *Hydrilla verticillata*, *Potamogeton perfoliatus* etc. under open water submerged rooted; *Nelumbo nucifera*, *Nymphaea nouchali*, *Euryale ferox* etc. under open water rooted floating leaved; *Pistia stratiotes*, *Eichhornia crassipes* under free floating open water macrophytes etc. have been collected, photographed and identified with the help of “Plant systematics” of Simpson (2010) and “Plant systematics: An Integrated Approach” of Singh (2016). The dominant growth form is found emergent (28.57%), followed by free floating and rooted floating leaved (19.05%), semi-emergent and submerged rooted (14.29%). In the present study, the wetlands indicate rich ichthyofaunal diversity with a total of 24 species, belonging to 21 genera and 14 families. The ichthyofaunal species namely; *Arius arius*, *Mystus tengara*, *Clarias batrachus*, *Labeo bata*, *Labeo catla*, *Labeo calbasu*, *Labeo rohita*, *Cirrhinus*

*cirrrosis*, *Heteropneustes fossils*, *Trichogaster chuna*, *Wallago attu* etc. have been identified by the standard key of “The freshwater fishes of India...A Handbook” by K.C. Jayaram (1981). Cyprinidae is found as the most dominant and diversified family containing 11 species (45.8%). Apart from the fish fauna, aquatic fauna namely; *Teuthowenia pellucida*, *Lumbricus terrestris* etc. have also been found during field study. Moreover, the wetlands, under study are proved to be an important feeding and breeding ground for a total of 32 no. of avifaunal species, belonging to 27 genera and 17 families. The bird species namely; *Halcyon pileata*, *Alcedo atthis*, *Anas paltyrhynchos*, *Bubulcus ibis*, *Ardea alba*, *Egretta garzetta*, *Ardeola grayii*, *Ciconia ciconia*, *Melopsittacus undulates*, *Pycnonotus cafer*, *Spilopelia chinensis*, *Phalacrocorax fuscicollis* as the resident and *Anser anser*, *Anas acuta*, *Netta rufina*, *Anas poecilorhyncha*, *Porphyrio poliocephalus*, *Leptoptilos crumenifer* etc. as migrant species have been sighted as well as identified with the help of using “Pocket Guide to the Birds of the Indian Subcontinent” (Grimmett & Inskipp, 2001); “The book of Indian Birds” (Ali, 1990) and online data base (Avibase, 2015). As per the IUCN red list, most of the bird species are under least concern (LC) category. Being a historical heritage, the wetlands with rich biotic diversity (aquatic flora and fauna) in association with historical structures in Malda district are potential in order to promote eco-tourism activity as well as enhance the aesthetic importance and foster a greater appreciation of the wetland habitat.

In order to assess, the ever increasing anthropogenic disturbances at wetland catchment, and resultant water quality deterioration, field survey has been carried out for a period of consecutive three years from March 2015 to February 2018, covering three seasons (pre-monsoon, monsoon and post-monsoon). At the respective sampling sites a total of 15 water quality parameters under physical (2), chemical (11) and bacteriological (2) parameters have been quantified in the laboratory, by following the BIS May, 2012; APHA, AWWA and WEF, 2017. Based on the findings, most of the water quality parameters are recorded between permissible limit especially for biological species within the wetlands. The chemical parameters of total hardness, and conductivity; and physical parameter of turbidity, are found beyond permissible limit as per BIS (2012) and APHA (2017). In order to assess variation of different physical, chemical and bacteriological parameters as well as to identify different pollution sources, one way Anova has been conducted between wetlands and between seasons. The statistical analysis records, both significant ( $p$  value  $< \alpha$  value) and non-significant ( $p$  value  $> \alpha$  value) variation at 0.05 levels in two-tailed test at 95% confidence level in different water quality parameters between the case studies (wetlands); and between

seasons (pre-monsoon, monsoon and post-monsoon). The observation on the water quality parameters of case studies are further analysed with the Pearson's product moment correlation coefficient. The statistical analysis shows highly significant ( $p < 0.01$ ) positive and negative correlation between water quality parameters. Whereas, significant ( $p < 0.05$ ) positive and negative correlation have also been recorded between parameters. The statistical analysis and findings, reveal that, the wetlands of Malda district are encountered with immense challenges from diverse anthropogenic activities either in the form of land run-off from adjacent agricultural field, or are highly contaminated by municipal and domestic effluents along with solid waste dumping as well as eventually results into water quality deterioration.

In order to analyse the utilization of wetlands, by surrounding inhabitants, the habitats are categorised into two types; 1. *Bed village* (at immediate vicinity of wetland) and 2. *Belt village* (a bit far-off). The households, residing in bed villages are comparatively found more dependable as well as utilizing wetland water for irrigation and cultivation of diverse crops (paddy, jute, pulses, maize, makhana etc.). Moreover, the households utilize the wetlands for fish cultivation and fish catch (Bata, Kalbaush, Catla, Koi, Mangur, Prawn, Rohu, Tangra etc.), duck rearing and wetland products (macrophytes- thankuni, kalmi, hingcha; aquatic fauna- googly, mollusks etc.) gathering. The belt villagers are chiefly dependent on wetlands for the commercial purpose, especially for makhana cultivation, which is considered a flourishing aquatic commercial crop to sustain the socio-economy of the poor mass in Malda district. Moreover, the economic valuation and the net estimated benefit of wetlands (case studies) in the form of makhana cultivation, fishing and product gathering is recorded to range from Rs. 8,75,000 to Rs. 57,36,500 per annum. Apart from the mentioned utilization, the wetlands in Malda district are found highly potential in order to promote makhana, sola and paniphal cultivation on wetland bed on a large scale. Furthermore, the wetlands are potential in supporting duck rearing activities in ecologically sustainable manner in order to provide alternative economic support to the rural people through generation of gainful self-employment.

However, in spite of being occupied by fairly good number of wetlands, this natural ecosystem encounters several vulnerabilities and resultant environmental changeability in Malda district, which has been documented by analysing the satellite imagery (Landsat 5 TM & Landsat 8 OLI data), reveals conspicuous land use land cover change (in the form of mango orchard, agricultural field, brick kiln industry and built-up area), adjacent to the

wetlands and resultant water area shrinkage. Therefore, along with already implemented protection laws and legislative tools at international, national and state levels, the present study recommends the conservation strategies in order to restrict the remarkable changes, which has already happened to the overall land use conversion and other associated degradation of wetlands:

1. Strict measures and continuous monitoring should be taken by appropriate authority in order to restrict further wetland alteration to non-wetland purpose (urban encroachment, agricultural land encroachment).
2. Integrated planning is to be taken in order to maintain adequate surface flow within wetlands and recharge the ground water throughout the year.
3. Wetland conservation and management strategies must be comprehensive in addressing the degrading water quality which persists from point (sewage inflow) and non-point (agricultural run-off) sources of pollution.
4. Formulating stringent legal actions are required to be taken against the overexploitation of wetland resources as well as promoting judicious utilization of wetland resources in order to enable the socio-economic development of rural mass in Malda district.

The present work concludes with the necessity to coordinate between different govt. departments and the stakeholders in order to document, measure and value the linkages between wetland ecosystem and human population in the entire district of Malda.