



WETLANDS OF MALDAH DISTRICT, WEST BENGAL (INDIA)

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Abstract: Fifty five wetlands comprising bils (32), dighis (7), jhils (2), pond/pukur (8) and rivers (6) distributed in 13 administrative blocks of Maldah district were surveyed and characteristic features were studied for occurrence of different types of aquatic plants, their categories and local environmental conditions. During the study, altogether 37 aquatic plant species were identified, belonging to Algae and Bryophytes (one species each), 3 species to Pteridophytes and 32 species to Angiosperms (7 species to Monocots and 25 species to Dicots). Depending upon occurrence of these plants in and along the wetlands, they have been categorized into 5 categories *namely* free-floating and bottom rooted floating (7 species each), submerged and emergent (6 species each) and littoral (constitutes 11 species). Occurrence of free floating *Azolla pinnata* R.Br. having symbiotic relationship with *Anabaena azollae* Strasb. in a few wetlands was remarkable. Besides, most of the observed wetlands have either been extinct and/or on the verge of extinction, needs for their restoration and protection to save the aquatic biodiversity (including micro flora and fauna).

Keywords: Anthropogenic impacts, Aquatic macrophytes, Restoration measures, Wetlands.

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INTRODUCTION

Wetland is one of the most productive and multifunctional ecosystems of the world, which may also be called 'Biological supermarkets' as it represents the important natural capital due to diverse food-chain, food-web and rich biodiversity (Costanza and Daly, 1992). The rich biodiversity is necessary for ecological balance, human survival and sustainable development (Ashok, 2018; Verma, 2019). It requires proper management of

natural resources to provide continued benefits to the future generation (Richardson, 1994; Finlason, 1999). Wetlands have also been described as 'Kidneys of Landscape' due to the activities of most of the aquatic microflora like algae, bacteria, fungi, etc. as they consume, disintegrate and convert wastes into simpler forms to a greater extent. The wastes were generated by natural means, aquatic living beings and anthropogenic as well as other activities.



Besides, it is also known as 'Carbon dioxide sinks' and 'Climate stabilizers' (Hussain, 1999), as it sustains most of the life forms and performs some useful functions in maintenance of overall balance of Mother Nature. Directly, it supports millions of people as it provides bio-fertilizer, protein rich food, medicines, goods, socio-economic development, etc. and invariably used for water supplies, irrigation, recreation, etc. and indirectly functions in control of flood, ground water recharge and protection from storm. But, due to drastic alterations and changes in climatic conditions and drainage pattern (resulted in varying topography of land and water bodies), indiscriminate anthropogenic activities such as destruction of vegetation due to use/reclamation to create additional agricultural fields, fish ponds, infrastructural developments and townships to supplement present day requirements, unplanned mining, disposal of untreated domestic as well as industrial/mining liquid and solid wastes and pesticides/insecticides/weedicides, etc. from agricultural runoff are badly affecting the wetlands, associated aquatic biodiversity and dependents (Maltby, 1986; Dixon, 1989; Nilsson *et al.*, 2000; Prakash and Verma, 2022). The electronic wastes are mainly anthropogenic in nature that causes severe bad effects on environment and public health (Verma and Prakash, 2020).

In India, there are approx. 2,175 natural wetlands (spread over in 1.5 million hectares) comprising swamps (bils), marshes, flood plains, lakes (jhils), coastal areas, banks of rivers and diaras, dighis (large ponds), etc. and 65,254 artificial (man made) wetlands (spread over in 2.6 million hectares) comprising ditches, fish ponds and agricultural water bodies, etc. (Kumar, 1999; Kumar, 2001; Mohapatra and Khalid, 2001). The National Committee on Wetland (NCW) was setup in 1990 by the Ministry of Environment and Forests (MOEF) now known as Ministry of Environment, Forest and Climate Change (MOEF&CC), recognized sixteen major fragile/endangered wetlands and by the end of 1992 altogether, 93 wetlands were recorded as endangered. This might be due to extensive survey work carried out at Regional/National

level by various Organizations/Institutions under the sponsorship of MOEF (WWF, 1992). Subsequently in 1993, National Lake Conservation Directorate (NLCD) was also formed and among all, wetlands and lakes were given priority (depending upon maximum output) and a plan was prepared to intensify more and more endangered lakes for its protection (MOEF, 1990, 1999). Rai and Sharma (1991) reviewed the phyto-ecological structure and classified the wetlands of north Bihar based on the aquatic macrophytic communities.

Over all, identification of the endangered wetlands and detailed studies of their components are still in a nascent stage. Keeping these things in view, the survey of wetlands in Maldah District was carried out to know the factual profile and type of vegetation to suggest preventive/control measures.

MATERIALS AND METHODS

The survey of wetlands was carried out in 13 administrative blocks of Maldah (a commercially important district since time immemorial, situated in central part of West Bengal and lies in between 24°41' and 25°32'3" N. latitude and 80°48' and 87°28'E. longitude extended over 3,733 sq. km) during winter and summer seasons. Even extreme remote areas of the district were also visited and covered about 1,680 km distance. Both the authors observed the wetlands from its close proximity and collected the information from local people, Govt. records and publications such as Statistical Accounts and Census of West Bengal (Hunter, 1876; Mitra, 1954; DCO, 1991) and topographical map sheets of Survey of India.

Some of the local environmental conditions were recorded as per standard method of APHA (2017). The free-floating plant species were collected by using plant sampler and bottom rooted floating, submerged, emergent, etc. were collected by uprooting the plants with the help of steel rod and brought to the laboratory for identification. Plants were identified by consulting monographs and standard publications (Arber, 1920; Cowan and Cowan, 1929; Desikachary, 1959; Joseph and Joseph, 1986; Sreekumar and Nair, 1990; Moulik, 1997a, 1997b; Kumar *et al.*, 2005).

RESULTS AND DISCUSSION

Fifty five wetlands (27 natural and 28 man-made) comprising bils (32), dighis (7), jhils (2), pond / pukur (8) and rivers (6) were studied for its past and present characteristic features, distribution and occurrence of aquatic flora. As per record of Land Reform Office of Maldah District, the area of wetlands surveyed ranged from 1.2 to 44.08 hectare in monsoon and 0.0 to 30.5 hectare in

summer season (Photo 1 to 5). The environmental conditions and plants occurring in wetlands are depicted in table 1 and the list of plant species and their categories are presented in table 2. During the study, it is also found that most of the natural and manmade wetlands are invariably under drying due to various reasons and the conditions of a few wetlands as well as some interesting plant species are depicted in photo 1 to 24.

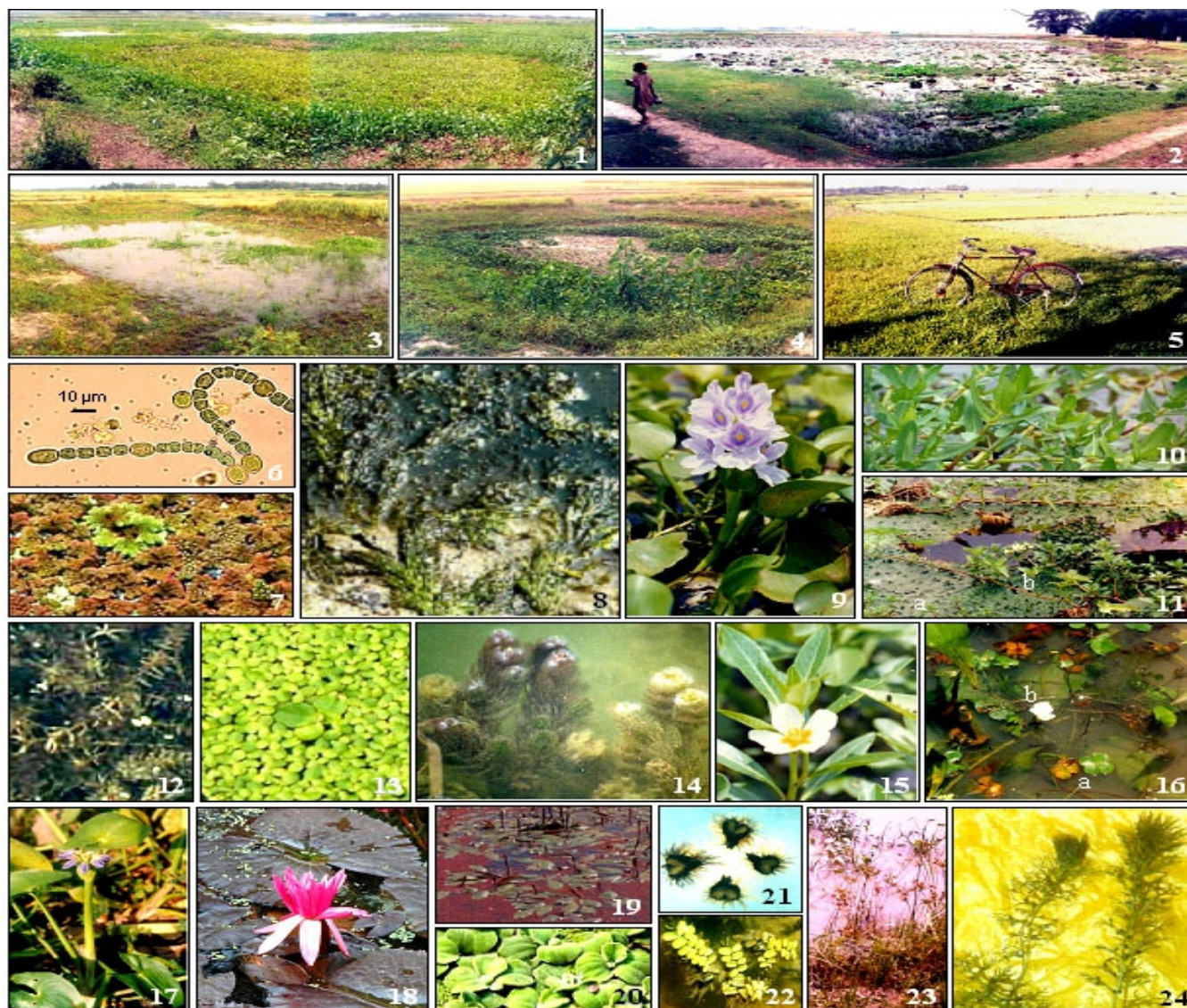


Photo: 1. Adhsoi bil a natural wetland with different plant species; 2. Damua pond a man-made wetland under cultivation of *Eurayle ferox* Salisbury with other macrophytes and siltation; 3. Sanak bil in which water is restricted to a limited area; 4. Singsar bil is almost dried with different macrophytes; 5. Bochahi jhil is under paddy cultivation in which bicycle of a farmer is parked; 6. *Anabaena azollae* Strasb.; 7. *Azolla pinnata* R.Br.; 8. *Ceratophyllum demersum* L.; 9. *Eichhornia crassipes* Solms.; 10. *Enhydra fluctuans* Lour. Fl. Cochinch.; 11a. *Euryale ferox* Salisbury & 11b. *Ipomoea aquatica* Forsk.; 12. *Hydrilla verticillata* Presl; 13. *Lemna minor* L.; 14. *Limnophila brownii* B.S. Wannan; 15. *Ludwigia adscendens* (L.) H. Hara; 16a. *Marselia minuta* L. & 16b. *Ottelia alismoides* Pers.; 17. *Monochoria hastata* Solms.; 18. *Nymphaea rubra* Roxb. ex. Salisb.; 19. *Potamogeton nodosus* Poir.; 20. *Pistia stratiotes* L.; 21. *Ricciocarpos natans* (L.) Corda; 22. *Salvinia oblongifolia* Martius; 23. *Schoneplectus* sp. and 24. *Utricularia stellaris* L. f.

Table 1: Environmental conditions and occurrence of plant species in Wetlands of Maldah District, West Bengal.

S. No.	Wetlands	Temperature (°C)				pH		Source-wise Name of Plants
		Atmos.		Water		Win.	Sum.	
		Win.	Sum.	Win.	Sum.			
1.	Ibils							
1.	Amkhaki (Kanchan Nagar, Ratua - I)	25.0	36.0	21.0	35.0	6.5	7.0	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Monochoria bastata</i> Solms.
2.	Liltua (Kanchan Nagar, Ratua - I)	25.0	34.0	22.0	33.0	5.5	6.5	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Monochoria bastata</i> Solms.
3.	Makaiya (Bhaluka, Ratua - I)	28.0	35.0	25.0	34.0	7.5	7.0	<i>Eichbornia crassipes</i> Solms, <i>Hydrilla verticillata</i> Presl, <i>Lemna minor</i> L., <i>Nymphaea nouchali</i> Burm. f., <i>Ottelia alismoides</i> Pers., <i>Vallisneria spiralis</i> L.
4.	Barabilla (Arai Danga, Ratua - II)	25.0	31.0	23.0	29.0	6.5	6.5	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Hydrilla verticillata</i> Presl, <i>Lemna minor</i> L., <i>Lippia alba</i> (Mill.) N.E.Br., <i>Ottelia alismoides</i> Pers., <i>Vallisneria spiralis</i> L.
5.	Garhal (Haripur, Chanchal - I)	28.0	-	24.0	-	6.5	-	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Ceratophyllum demersum</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Hydrilla verticillata</i> Presl, <i>Ipomoea aquatica</i> Forssk., <i>Ludwigia perennis</i> L., <i>Marsilea minuta</i> L., <i>Nymphaea nouchali</i> Burm. f., <i>Nymphoides hydrophylla</i> (Lour.) O. Ktze., <i>Oryza sativum</i> L., <i>Ricciocarpos natans</i> (L.) Corda in Opiz, <i>Vallisneria spiralis</i> L.
6.	Singera (Ganga Devi, Chanchal - II)	27.0	30.0	25.0	28.0	6.8	6.5	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Euryale ferox</i> Salisbury, <i>Hydrilla verticillata</i> Presl, <i>Lemna minor</i> L., <i>Oryza sativum</i> L.
7.	Ghogha (Ganga Devi, Chanchal - II)	28.0	30.0	25.0	29.0	6.5	7.0	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Hydrilla verticillata</i> Presl.
8.	Chakla (G.anga Devi, Chanchal - II)	28.0	31.0	25.5	30.0	6.5	6.8	<i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Hydrilla verticillata</i> Presl, <i>Hygrobila polysperma</i> T. Anders., <i>Ipomoea fistulosa</i> Mart. ex Choisy, <i>Lippia alba</i> (Mill.) N.E. Br., <i>Ludwigia adscendens</i> (L.) H. Hara, <i>Nymphaea nouchali</i> Burm. f.
9.	Bochamari (Bowalia, Chanchal - II)	29.0	33.0	24.0	32.0	6.5	7.0	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Euryale ferox</i> Salisbury.
10.	Hazartakia (Mobarakpur Gram, Harishchandrapur-I)	29.0	34.0	26.0	32.0	6.5	7.0	<i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Euryale ferox</i> Salisbury.
11.	Adhsoi (Pachla, Harishchandrapur-I)	25.0	36.0	23.0	34.0	6.5	6.0	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Euryale ferox</i> Salisbury, <i>Hydrilla verticillata</i> Presl, <i>Hygrobila polysperma</i> T. Anders., <i>Lemna minor</i> L., <i>Ludwigia adscendens</i> , <i>Marselia minuta</i> L., <i>Monochoria bastata</i> Solms., <i>Nymphaea nouchali</i> Burm. f., <i>Salvinia oblongifolia</i> Martius.
12.	Janipukur (Serpur, Harishchandrapur-I)	30.0	35.0	27.0	34.0	7.5	6.0	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Euryale ferox</i> Salisbury, <i>Ludwigia adscendens</i> (L.) H. Hara, <i>Monochoria bastata</i> Solms., <i>Pistia stratiotes</i> L., <i>Salvinia oblongifolia</i> Martius.
13.	Ashi Doab (Uttar Harishchandrapur, Harishchandrapur-I)	-	30.0	-	29.0	-	6.8	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Euryale ferox</i> Salisbury, <i>Hygrobila aristata</i> (Retz.) Nees, <i>Ipomoea aquatica</i> Forsk., <i>I. fistulosa</i> Mart. ex Choisy, <i>Lippia alba</i> (Mill.) N.E.Br., <i>Ludwigia adscendens</i> (L.) H. Hara, <i>Marselia minuta</i> L., <i>Monochoria bastata</i> Solms., <i>Nymphaea nouchali</i> Burm. f., <i>Pistia stratiotes</i> L., <i>Salvinia oblongifolia</i> Martius, <i>Scirpus grossus</i> L. f.

S. No.	Wetlands	Temperature (°C)				pH		Source-wise Name of Plants
		Atmos.		Water		Win.	Sum.	
		Win.	Sum.	Win.	Sum.			
14.	Manna (Bhaluka, Harishchandrapur-II)	27.0	33.0	26.0	32.0	7.0	7.5	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Euryale ferox</i> Salisbury, <i>Marselia minuta</i> L.
15.	Dhekul (Khidirpur,	28.0	36.0	26.0	34.0	6.5	7.5	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L.
16.	Meetna (Barnali, Harishchandrapur-II) Harishchandrapur-II)	24.0	33.0	23.0	32.0	6.5	7.0	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Euryale ferox</i> Salisbury, <i>Ludwigia perennis</i> L.
17.	Singsar (Chandipur, Harishchandrapur-II)	26.0	34.0	24.5	32.0	6.0	6.8	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Ipomoea fistulosa</i> Mart. ex Choisy
18.	Sanak (Chandipur, Harishchandrapur-II)	26.0	33.0	24.0	32.0	6.0	6.0	<i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Hydrilla verticillata</i> Presl, <i>Ludwigia adscendens</i> (L.) H. Hara, <i>N. rubra</i> Roxb. Ex. Salisb., <i>Polygonum glabrum</i> Willd.
19.	Pulintola (Chandipur, Manikchak)	27.0	-	23.0	-	7.2	-	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Hydrilla verticillata</i> Presl, <i>Ottelia alismoides</i> Pers.
20.	Kuchla (Eklakhi, Gajol)	26.0	31.0	24.0	29.0	6.5	7.0	<i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch, <i>Euryale ferox</i> Salisbury, <i>Hydrilla verticillata</i> Presl, <i>Ipomoea fistulosa</i> Mart. ex Choisy, <i>Marselia minuta</i> L., <i>Monochoria bastata</i> Solms., <i>Nymphaea nouchali</i> Burm. f., <i>Ottelia alismoides</i> Pers., <i>Vallisneria spiralis</i> L.
21.	Hatia (Bilhatia, Gajol)	26.0	34.0	23.0	32.0	7.2	7.0	<i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Euryale ferox</i> Salisbury, <i>Monochoria bastata</i> Solms.
22.	Singer (Saluka, Gajol)	30.0	34.0	23.0	33.0	7.0	6.5	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Euryale ferox</i> Salisbury, <i>Hydrilla verticillata</i> Presl, <i>Lemna minor</i> L., <i>Ludwigia adscendens</i> (L.) H. Hara.
23.	Kendha (Saluka, Gajol)	31.0	34.0	27.0	32.0	6.0	6.5	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Euryale ferox</i> Salisbury, <i>Lemna minor</i> L., <i>Ludwigia adscendens</i> (L.) H. Hara, <i>Monochoria bastata</i> Solms.
24.	Chand (Jagarnathpur Gram, Habibpur)	30.0	31.0	27.0	29.5	6.0	6.5	<i>Cynodon dactylon</i> Pers.
25.	Madhaipur (Madhaipur, Old Maldah)	27.0	-	25.0	-	5.0	-	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Oryza sativum</i> L.
26.	Nawabganj (Nawabgan, Old Maldah)	23.0	33.0	22.0	32.0	6.0	6.5	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Lemna minor</i> L.
27.	Tarkeshwar (Nawabgan, Old Maldah)	24.0	33.0	23.0	32.0	6.0	6.0	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Lemna minor</i> L.
28.	Balotuli (Jatra Danga, Old Maldah)	28.5	30.0	25.5	29.5	7.5	6.0	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch, <i>Ludwigia adscendens</i> (L.) H. Hara, <i>Ipomoea fistulosa</i> Mart. ex Choisy, <i>Monochoria bastata</i> Solms., <i>Oryza sativum</i> L., <i>Scirpus sp.</i>
29.	Jalsukha (Kajigram, English Bazar)	27.0	33.0	25.0	30.0	6.5	6.8	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch, <i>Hydrilla verticillata</i> Presl, <i>Lemna minor</i> L., <i>Marselia minuta</i> L., <i>Nymphaeoides hydrophylla</i> (Lour.) O. Ktze., <i>Scirpus grossus</i> L. f., <i>Utricularia stellaris</i> L. f., <i>Vallisneria spiralis</i> L.
30.	Beachcol (Kamlabari, English Bazar)	Dry	Dry	Dry	Dry	Dry	Dry	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Monochoria bastata</i> Solms., <i>Oryza sativum</i> L.
31.	Chattara (Uttar Ramchandrapur, English Bazar)	24.0	32.0	22.0	31.0	7.0	7.6	<i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Hydrilla verticillata</i> Presl, <i>Utricularia stellaris</i> L. f., <i>Vallisneria spiralis</i> L.
32.	Lakshmipur (Lakshmipur, English Bazar)	25.0	33.0	20.5	31.0	6.5	7.0	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch, <i>Ipomoea aquatica</i> Forsk., <i>Lemna minor</i> L., <i>Monochoria bastata</i> Solms., <i>Oryza sativum</i> L., <i>Pistia stratiotes</i> L., <i>Salvinia oblongifolia</i> Martius.

S. No.	Wetlands	Temperature (°C)				pH		Source-wise Name of Plants
		Atmos.		Water		Win.	Sum.	
		Win.	Sum.	Win.	Sum.			
II Dighis								
1.	Raikha (Eklakhi, Gajol)	27.0	34.0	25.0	33.0	6.0	6.5	<i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Hydrilla verticillata</i> Presl, <i>Ludwigia adscendens</i> (L.) H. Hara, <i>Vallisneria spiralis</i> L.
2.	Thinnagar (Daulatipur, Bamongola)	25.0	32.0	24.0	31.0	6.0	6.5	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Lippia alba</i> (Mill.) N.E.Br.
3.	Paradhala (Paradhala, Old Maldah)	26.0	35.0	24.0	34.0	6.5	7.5	<i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms
4.	Sukan (Sukan, Old Maldah)	30.0	36.0	26.0	33.0	6.5	7.5	<i>Cynodon dactylon</i> Pers., <i>Enhydra fluctuans</i> Lour. Fl. Cochinch
5.	Kalua (Narayanpur, Old Maldah)	25.0	35.0	23.0	34.0	7.0	6.5	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms.
6.	Bara Sagar (Kamlabari, English Bazar)	27.0	31.0	25.0	30.0	6.0	7.2	<i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Hydrilla verticillata</i> Presl, <i>Ipomoea fistulosa</i> Mart. ex Choisy, <i>Limnophila brownii</i> B.S. Wannan, <i>Ludwigia perennis</i> L., <i>Nymphaea nouchali</i> Burm. f., <i>Vallisneria spiralis</i> L.
7.	Chotta Sagar (Nadirkhani, English Bazar)	27.0	33.0	23.0	32.0	6.5	6.5	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Hydrilla verticillata</i> Presl, <i>Ipomoea aquatica</i> Forsk., <i>I. fistulosa</i> Mart. ex Choisy, <i>Lemna minor</i> L., <i>Vallisneria spiralis</i> L.
III Jhils								
1.	Bochahi (Kanchan Nagar, Ratua - I)	26.0	33.0	24.0	32.0	6.5	7.0	<i>Cyperus corymbosus</i> Rottb., <i>Eichbornia crassipes</i> Solms, <i>Lemna minor</i> L., <i>Ludwigia adscendens</i> (L.) H. Hara, <i>Marselia minuta</i> L., <i>Monochoria hastata</i> Solms., <i>Nymphaea nouchali</i> Burm. f., <i>Oryza sativum</i> L., <i>Ottelia alismoides</i> Pers.
2.	Mahadhap (Mahadhap, Ratua - II)	25.0	-	24.0	-	6.5	-	<i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Hydrilla verticillata</i> Presl, <i>Marselia minuta</i> L.
IV Ponds								
1.	Damua (Konar, Harishchandrapur-I)	28.0	29.0	26.0	28.0	6.5	6.5	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Euryale ferox</i> Salisbury, <i>Hydrilla verticillata</i> Presl, <i>Ipomoea aquatica</i> Forsk., <i>Lemna minor</i> L., <i>Ludwigia adscendens</i> (L.) H. Hara, <i>Nymphaea nouchali</i> Burm. f., <i>Vallisneria spiralis</i> L.
2.	Jorkuppa (Karmanigram, English Bazar)	24.0	30.0	21.0	32.0	6.5	7.0	<i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Nymphaea nouchali</i> Burm. f., <i>N. rubra</i> Roxb. Ex. Salisb., <i>Ottelia alismoides</i> Pers., <i>Polygonum glabrum</i> Willd., <i>Saccharum munja</i> Roxb.
3.	Kuppa (Karmanigram, English Bazar)	27.0	32.0	24.5	30.0	6.5	7.0	<i>Anabaena azollae</i> Strasb., <i>Azolla pinnata</i> R.Br., <i>Ceratophyllum demersum</i> L., <i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Hydrilla verticillata</i> Presl, <i>Ipomoea fistulosa</i> Mart. ex Choisy, <i>Ludwigia perennis</i> L., <i>Marselia minuta</i> L., <i>Potamogeton nodosus</i> Poir., <i>Vallisneria spiralis</i> L.
4.	Samda (Samda, English Bazar)	26.5	32.0	24.0	31.0	6.8	7.0	<i>Cynodon dactylon</i> Pers.
5.	Salami Darwaza (Maldah Fort, Kaliachak-I)	28.0	34.0	24.0	33.0	7.0	7.5	<i>Cynodon dactylon</i> Pers.
6.	Shivrampalli (Mangalbari, Old Maldah)	27.0	34.0	24.0	33.0	7.0	7.5	<i>Cynodon dactylon</i> Pers., <i>Eichbornia crassipes</i> Solms, <i>Ipomoea fistulosa</i> Mart. ex Choisy
7.	Rohini (Jatra Danga, Old Maldah)	28.0	35.0	26.0	34.0	7.0	7.5	<i>Cynodon dactylon</i> Pers.
8.	Meenatula (Mohamadpur, Old Maldah)	28.0	34.0	25.0	33.0	7.5	7.8	<i>Cynodon dactylon</i> Pers., <i>Ipomoea fistulosa</i> Mart. ex Choisy, <i>Lippia alba</i> (Mill.) N.E.Br., <i>Marselia minuta</i> L., <i>Saccharum munja</i> Roxb.

S. No.	Wetlands	Temperature (°C)				pH		Source-wise Name of Plants
		Atmos.		Water		Win.	Sum.	
		Win.	Sum.	Win.	Sum.			
V	Rivers							
1.	Ganga* (Mahadhap, Ratua - II)	26.0	-	25.0	-	7.0	-	<i>Eichbornia crassipes</i> Solms, <i>Lipia alba</i> (Mill). N. E Br., <i>L. lanceolata</i> Michx., <i>Saccharum munja</i> Roxb.
2.	Ganga** (Gopalpur, Manikchak)	21.0	32.0	20.0	31.0	6.5	7.0	<i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch, <i>Lipia alba</i> (Mill). N.E.Br., <i>L. lanceolata</i> Michx., <i>Saccharum munja</i> Roxb.
3.	Kalindari (Bhaluka, Harishchandrapur-II)	26.0	33.0	23.0	32.0	7.2	6.5	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Saccharum munja</i> Roxb.
4.	Phulhar (Sankatala Ghat, Manikchak)	26.5	31.5	23.0	30.0	6.8	6.5	<i>Cynodon dactylon</i> Pers., <i>Ceratophyllum demersum</i> L.
5.	Mahananda (Alal Bridge, Gajol)	27.0	28.0	23.0	26.0	7.2	6.5	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L., <i>Eichbornia crassipes</i> Solms, <i>Enhydra fluctuans</i> Lour. Fl. Cochinch., <i>Polygonum glabrum</i> Willd., <i>Scirpus grossus</i> L. f.
6.	Tangan (Madhaipur, Old Maldah)	Dry	Dry	Dry	Dry	Dry	Dry	<i>Cynodon dactylon</i> Pers., <i>Cyperus rotundus</i> L.

Atmos. = Atmospheric; Sum. = Summer; Win. = Winter; * = Rambari Jhil and ** = Gopalpur and Hilsamari Jhils have been engulfed by river Ganga.

The atmospheric and water temperature during the winter season ranged from 21 °C to 31 °C and 20 °C to 27 °C respectively and from 28 °C to 36 °C and 26 °C to 35 °C respectively in the summer season. pH of water in different wetlands ranged from 5.0 to 7.5 in winter and 6.0 to 7.8 in the summer season. The colour of water of different wetlands were observed as blue, green, black and muddy, possibly due to the presence of different filamentous and planktonic forms and/or algal blooms or due to intense anthropogenic activities and/or remain covered for longer period by varying range of aquatic macrophytes. The odor of water bodies was recorded as foul, rotten, fishy, grassy and odorless. The Beachcol bil and Tangan river were found dried due to which the temperature and pH were not recorded.

During the survey, a maximum number of wetlands were surveyed in Ratua, English Bazar, Old Maldah, Harishchandrapur and Chanchal Blocks. One each wetland was surveyed in Bamongola and Kaliachak Blocks. It was recorded that there are a lot of variations and changes in the morphometry of the wetlands in the last 30 to 35 years. Most of the wetlands like jhils of Rambari, Gopalpur and Hilsamari have been engulfed by the river Ganga due to changes in its course of discharge. Some of the wetlands have either been dried as recorded in case of Bochahi jhil and/or are on the verge of drying as the depth of water

ranged hardly from 1.0 to 2.5 feet. The whole area of Bochahi jhil has been fully converted into arable land (photo 5) and wherever the water is available in low lying areas of the actual jhil are nowadays given some other name like Amkhaki and Liltua and treated as bil. The farmers use the water from these wetlands mainly for irrigation purposes.

During cropping season, most of the wetlands were cleaned by the local farmers for cultivation and left unattended during off season due to which a varying range of aquatic macrophytes re-occur. Besides, the Madhaipur and Beachcol bils have also dried up and the villagers are using the land for cultivation. The river Tangan passing through the Madhaipur bil was also found dry and thus, there is almost total decline in the diversity of the aquatic vegetation in these areas. In other wetlands, where water was more or less at an appreciable level, the diversity of aquatic vegetation was greater. But, in most of the wetlands due to fishery practice, cultivation of *Euryale ferox* Salisbury (Makhana) and cropping of paddy after pumping out the water hinders the natural growth of aquatic plant species (Kumar and Gupta, 2022).

Out of collected specimens of aquatic macrophytes from 55 wetlands, altogether 37 plant species were identified. These identified

Table 2: List of plant species and their categories.

S. No.	Name of Plant	Family	Type of Plant
1.	<i>Anabaena azollae</i> Strasb. [*]	Nostocaceae	Algae
2.	<i>Azolla pinnata</i> R.Br. [*]	Azollaceae	Pteridophyte
3.	<i>Ceratophyllum demersum</i> L. ^{***}	Ceratophyllaceae	Angiosperm
4.	<i>Cynodon dactylon</i> Pers. ^{*****}	Poaceae	Angiosperm
5.	<i>Cyperus corymbosus</i> Rottb. ^{****}	Cyperaceae	Angiosperm
6.	<i>C. rotundus</i> L. ^{****}	Cyperaceae	Angiosperm
7.	<i>Eichhornia crassipes</i> Solms	Pontederiaceae	Angiosperm
8.	<i>Enhydra fluctuans</i> Lour. Fl. Cochinch. ^{****}	Asteraceae	Angiosperm
9.	<i>Euryale ferox</i> Salisbury ^{**}	Nymphaeaceae	Angiosperm
10.	<i>Hydrilla verticillata</i> Presl ^{***}	Hydrocharitaceae	Angiosperm
11.	<i>Hygrophila polysperma</i> T.Anders. ^{****}	Acanthaceae	Angiosperm
12.	<i>Hygroryza aristata</i> (Retz.) Nees ^{****}	Poaceae	Angiosperm
13.	<i>Ipomoea aquatica</i> Forsk. ^{**}	Convolvulaceae	Angiosperm
14.	<i>I. fistulosa</i> Mart. ex Choisy ^{****}	Convolvulaceae	Angiosperm
15.	<i>Lemna minor</i> L. [*]	Lemnaceae	Angiosperm
16.	<i>Limnophila brownii</i> B.S. Wannan ^{***}	Scrophulariaceae	Angiosperm
17.	<i>Lippia alba</i> (Mill.) N.E.Br. ^{*****}	Verbenaceae	Angiosperm
18.	<i>L. lanceolata</i> Michx. ^{*****}	Verbenaceae	Angiosperm
19.	<i>Ludwigia adscendens</i> (L.) H. Hara ^{****}	Onagraceae	Angiosperm
20.	<i>L. perennis</i> L. ^{****}	Onagraceae	Angiosperm
21.	<i>Marselia minuta</i> L. ^{****}	Marsileaceae	Pteridophyte
22.	<i>Monochoria hastata</i> Solms. ^{***}	Pontederiaceae	Angiosperm
23.	<i>Nymphaea nouchali</i> Burm. f. ^{**}	Nymphaeaceae	Angiosperm
24.	<i>N. rubra</i> Roxb. ex. Salisb. ^{**}	Nymphaeaceae	Angiosperm
25.	<i>Nymphoides hydrophylla</i> (Lour.)O.Ktze. ^{**}	Menyanthaceae	Angiosperm
26.	<i>Oryza sativum</i> L. ^{*****}	Poaceae	Angiosperm
27.	<i>Ottelia alismoides</i> Pers. ^{***}	Hydrocharitaceae	Angiosperm
28.	<i>Pistia stratiotes</i> L. [*]	Araceae	Angiosperm
29.	<i>Polygonum glabrum</i> Willd ^{*****}	Polygonaceae	Angiosperm
30.	<i>Potamogeton nodosus</i> Poir. ^{**}	Potamogetonaceae	Angiosperm
31.	<i>Ricciocarpos natans</i> (L.) Corda [*]	Ricciaceae	Bryophytes
32.	<i>Saccharum munja</i> Roxb. ^{*****}	Gramineae	Angiosperm
33.	<i>Salvinia oblongifolia</i> Martius [*]	Salviniaceae	Pteridophyte
34.	<i>Schoneplectus</i> sp. ^{*****}	Cyperaceae	Angiosperm
35.	<i>Scirpus grossus</i> L. f. ^{*****}	Cyperaceae	Angiosperm
36.	<i>Utricularia stellaris</i> L. f. [*]	Lentibulariaceae	Angiosperm
37.	<i>Vallisneria spiralis</i> L. ^{***}	Hydrocharitaceae	Angiosperm

* = Free-floating, ** = Bottom rooted floating, *** = Submerged, **** = Emergent and ***** = Littoral.

species include 1 each species of *Anabaena azollae* Strasb. (Photo 6) an Alga and a symbiont in *Azolla pinnata* R.Br. (Photo 7) a Pteridophyte, 1 Bryophyte *Ricciocarpos natans* (L.) Corda (Photo 21), 3 of Pteridophytes [(*Azolla pinnata* R.Br. (Photo 7), *Marselia minuta* L. (Photo 16a) and *Salvinia oblongifolia* Martius (Photo 22)] and 32 species of Angiosperms (7 species to Monocots and 25 species to Dicots), as depicted in Table 2.

The *Azolla pinnata* R.Br. was found in 12 wetlands belonging to bils (9), ponds (2) and dighi (1). Out of 9 bils, 3 bils namely Garhal, Lakshmipur and Singera are specifically being used by the farmers for cultivation of paddy after pumping off water. Rest 9 wetlands in which *Azolla pinnata* R.Br. was recorded harbouring maximum number of plant species such as in bils 19, 16, 14, 11, 10 and 7 in Ashi Doab, Adhsoi, Jalsukha, Barabilla, Janipukur and Pulintola respectively, in ponds 14 and 11 species in Damua and Kuppa respectively and 10 species in Chota Sagar dighi were recorded and indicating the water bodies where nitrogenous nutrient is continuously available to the plant species from the natural source the 'green manure' a symbiont *Anabaena azollae* Strasb. which lies within the leaf cavities of *Azolla pinnata* R.Br. and releases ammonia due to the presence of thick-walled heterocysts often appear more transparent with distinctive "polar nodules" at each end of the cell, bears cyanophycin granules (co-polymer of arginine and aspartic acid) and serves as a nitrogen storage product source.

As per maximum number of species is concerned, in bils Ashi Doab thrived 19 species followed by 16 species in Adhsoi, 14 species in Jalsukha, 13 species in Garhal and 12 each species in Kuchla and Lakshmipur. In Chand bil, there was no vegetation other than *Cynodon dactylon* Pers. depicted in table 1. The most fascinating thing during the survey was the collection of *Ricciocarpos natans* (L.) Corda. for the first time from this Gangetic Plain as it was floating on the surface of water of Garhal bil along with other macrophytes like *Azolla pinnata* R.Br. (with endophytic *Anabaena azollae* Strasb.), *Ceratophyllum demersum* L., *Eichhornia crassipes* Solms, *Enhydra fluctuans* Lour. Fl.

Cochinch., *Hydrilla verticillata* Presl, *Ipomoea aquatica* Forssk., *Ludwigia perennis* L., *Marsilea minuta* L., *Nymphaea nouchali* Burm. f., *Nymphoides hydrophylla* (Lour.) O.Ktze. and *Vallisneria spiralis* L. (Kumar *et al.*, 2005) while, the occurrence of an insectivores plant *i.e.* *Utricularia stellaris* L.f. in Jalsukha and Chattra bils is indicative of nitrogen deficient wetland.

In case of dighis, maximum (10 each) plant species was found in Barah Sagar dighi and Chhota Sagar dighi followed by 8 species in Raikhan. While, in Thinnagar, Kalua and Paradhala dighis, *Cynodon dactylon* Pers. along with *Eichhornia crassipes* Solms were common. Bochahi jhil was found to be highly enriched by *Monochoria hastata* Solms. along with other forms like *Cyperus corymbosus* Rottb., *Eichhornia crassipes* Solms, *Lemna minor* L., *Marselia minuta* L., *Nymphaea nouchali* Burm. f., *Ottelia alismoides* Pers. and in Mahadharp jhil *Ceratophyllum demersum* L., *Cynodon dactylon* Pers., *Cyperus rotundus* L., *Hydrilla verticillata* Presl and *Marselia minuta* L. were recorded.

Out of 8 ponds, maximum plant species were recorded in Damua followed by Kuppa and Jorkuppa 14, 11 and 8 respectively. In Samda and Salami Darwaza there was no vegetation other than *Cynodon dactylon* Pers. on and along the bank. Whereas, out of 6 rivers, maximum 6 plant species namely *Cynodon dactylon* Pers., *Cyperus rotundus* L., *Eichhornia crassipes* Solms, *Enhydra fluctuans* Lour. Fl. Cochinch., *Polygonum glabrum* Willd and *Scirpus grossus* L. f. were found in Mahananda followed by 4 each plant species in Ganga at Mahadharp and Gopalpur as well as Kalindri.

All identified 37 plant species depending upon their characteristic features and way of their occurrence have been categorized to 5 categories namely free-floating and bottom rooted floating (7 species each), submerged and emergent (6 species each) and littoral (11 species) depicted in table 2. Under free-floating community, *Eichhornia crassipes* Solms showed thick mat formation on surface of water of most of the wetlands followed by *Azolla pinnata* R.Br. in Lakshmipur bil was remarkable. Under bottom

rooted floating flora like *Euryale ferox* Salisbury and *Nymphaea nouchali* Burm. f. together with submerged *Hydrilla verticillata* Presl, *Ceratophyllum demersum* L., *Vallisneria spiralis* L. and *Ottelia alismoides* Pers. were dominant. Under the emergent category, *Ludwigia adscendens* (L.) H. Hara, *Marselia minuta* L. and *Cyperus corymbosus* Rottb. were dominant while under the littoral community, *Cynodon dactylon* Pers. and *Cyperus rotundus* L. were dominant. Besides these, *Lippia alba* (Mill.) N.E.Br. and *Saccharum munja* Roxb. were dominant in diara under the course of Ganga river basin, which are well known for as good as soil binders.

Based on the above facts, it is clearly indicative that these wetlands of the district studied need urgent attention for protection and restoration, so that, it may help in socio-economic development of the State. It will also be able to influence the growth of aquatic macrophytes and other flora and fauna to have rich aquatic biodiversity for future generations.

Restoration of Wetlands

Main purpose of restoration of such wetlands is to restore natural habitat, native vegetational diversity, capacity function and value to a close approximation of the pre-disturbance by restoring soil characteristic, hydrology (water depth, duration and reason of inundation and/or duration and soil saturation, drainage pattern, etc.). The authors suggest following points to follow for the restoration of wetlands:

1. Feasible flood control measures should be developed.
2. Restoration and management policy should be developed, strengthened and enforced for proper implementation.
3. Wetlands should not be drained or pumped off for agricultural and other purposes.
4. Water resource management process should be developed to maintain water level in water deficient wetlands.
5. Untreated waste water from domestic and industrial origin as well as solid wastes should not be disposed/dumped in wetlands and cleaning as well as de-silting should be done at regular intervals.

6. Fertilizers, pesticides, insecticides, etc. should be used judiciously.
7. Regular monitoring of the abiotic factors of wetlands is to be studied scientifically to supplement the deficient micro and macro nutrients.
8. Nitrogen deficient water bodies should be maintained by introduction of nitrogenous contents.
9. Pisci-culture practice should be restricted to control the loss of natural habitat and biodiversity.
10. Intensive training and awareness programme should be organized for sustainable use of the wetlands.

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