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Wetland Report For Ganga River Basin Environment Management Plan

GRBMP : Ganga River Basin Management Plan

by

Indian Institutes of Technology













IIT Roorkee

IIT Bombay

IIT Delhi

IIT Guwahati Ka

IIT Kanpur

Kharagpur

Preface

In exercise of the powers conferred by sub-sections (1) and (3) of Section 3 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government has constituted National Ganga River Basin Authority (NGRBA) as a planning, financing, monitoring and coordinating authority for strengthening the collective efforts of the Central and State Government for effective abatement of pollution and conservation of the river Ganga. One of the important functions of the NGRBA is to prepare and implement a Ganga River Basin Management Plan (GRBMP).

A Consortium of 7 Indian Institute of Technology (IIT) has been given the responsibility of preparing Ganga River Basin Management Plan (GRBMP) by the Ministry of Environment and Forests (MoEF), GOI, New Delhi. Memorandum of Agreement (MoA) has been signed between 7 IITs (Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and MoEF for this purpose on July 6, 2010.

This report is one of the many reports prepared by IITs to describe the strategy, information, methodology, analysis and suggestions and recommendations in developing Ganga River Basin Management Plan (GRBMP). The overall Frame Work for documentation of GRB EMP and Indexing of Reports is presented on the inside cover page.

There are two aspects to the development of GRB EMP. Dedicated people spent hours discussing concerns, issues and potential solutions to problems. This dedication leads to the preparation of reports that hope to articulate the outcome of the dialog in a way that is useful. Many people contributed to the preparation of this report directly or indirectly. This report is therefore truly a collective effort that reflects the cooperation of many, particularly those who are members of the IIT Team. Lists of persons who have contributed directly and those who have taken lead in preparing this report is given on the reverse side.

Dr Vinod Tare Professor and Coordinator Development of GRB EMP IIT Kanpur

The Team

- 1. A K Thakur, IIT Kanpur
- 2. M D Behera, IIT Kharagpur
- 3. Naveen Navania, IIT Roorkee
- 4. Partha Roy, IIT Roorkee
- 5. Pruthi Vikas, IIT Roorkee
- 6. R P Mathur, IIT Kanpur
- 7. R P Singh, IIT Roorkee
- 8. Ramasre Prasad, IIT Roorkee
- 9. Ranjana Pathania, IIT Roorkee
- 10. Sandeep Behera, WWF-India, New Delhi
- 11. Utpal Bora, IIT Guwahati
- 12. Vinod Tare, IIT Kanpur

akthakur@iitk.ac.in mdbehera@coral.iitkgp.ernet.in navnifbs@iitr.ernet.in paroyfbs@iitr.ernet.in vikasfbs@iitr.ernet.in rpm_2k1@yahoo.com rpsbsfbs@iitr.ernet.in rapdyfbs@iitr.ernet.in rpathfbs@iitr.ernet.in sbehera@wwfindia.net ubora@iitg.ernet.in vinod@iitk.ac.in

Lead Persons

- 1. Utpal Bora, IITGuwahati
- 2. Ranjan Tamuli, IIITGuwahati
- 3. Mrinal Kanti Dutta, IIITGuwahati
- 4. Shamim Rahman, IITGuwahati
- 5. Ajoy Kumar Das, IITGuwahati
- 6. Ranjan Baruah, IITGuwahati

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1. Introduction

Wetlands are defined as 'lands transitional between terrestrial and aquatic eco-systems where the water table is usually at or near the surface or the land is covered by shallow water (Mitsch and Gosselink 1986). Ramsar Convention on Wetlands defines wetlands as: "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"

1.1. Importance of wetlands

Wetlands are the repository of vital ecosystem information services. They perform many functions and provide many ecosystem services, such as maintenance of food web, providing habitat to aquatic flora and fauna, as well as numerous species of birds, including migratory species, filtering of sediments and nutrients from surface water maintaining of nutrients recycling, purification of water, controlling of flood, recharging of ground water, providing drinking water, fish, fodder, fuel and providing source of livelihood and recreation to local people.

The Millennium Assessment (MA) uses the following typology to categorise ecosystem services-

- **Provisioning services**: The resources or products provided by ecosystems, such as food, raw materials (wood), genetic resources, medicinal resources and ornamental resources (skin, shells, flowers).
- **Regulating services**: Ecosystems maintain the essential ecological processes and life support systems, like gas and climate regulation, water supply and regulation, waste treatment, pollination, etc.
- **Cultural and Amenity services**: Ecosystems are a source of inspiration to human culture and education throughout recreation, cultural, artistic, spiritual and historic information, Science and education.
- **Supporting services**: Ecosystems provide habitat for flora and fauna in order to maintain biological and genetic diversity.

1.2. Importance of wetlands in river basin management

Wetlands provide good support to invertebrates (e.g. insects) and lower vertebrates (e.g. herpetofauna). They are the indicators of healthy ecosystem. The wholesomeness of higher strata depends on them. Thus the whole food web is well maintained. Wetlands are the resting and breeding place for many species. Many fishes migrate and breed in wetlands. Wetlands reseed the river. 'Wetlands-river' maintains a 'leaf-trunk' relationship of a tree. Wetland filters sediments and nutrients from surface water, maintains nutrients recycling,

and purifies water and it acts as natural kidney. During flood the river interacts with the wetlands and the neighbouring system.

1.3. A global look for wetland management

The Ramsar Convention, an Inter-Governmental treaty to maintain the ecological character of wetlands of international importance bears the philosophy of 'wise use concept' which is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approach, within the context of sustainable development".

1.4. Data on wetlands of India

Prasad *et al* (2002) mentioned that wetlands in India occupy 58.2 million hectares, including areas under wet paddy cultivation. They quoted Deepa and Ramachandra (1999) as freshwater wetlands alone support 20 per cent of the known range of biodiversity in India.

During 1992-93, Space Application Centre (ISRO) mapped wetlands of India for the Ministry of Environment and Forest, Govt. of India using remote sensing data. In 2004, Salim Ali Centre for Ornithology and Natural History prepared atlas on wetland habitat and species conservation. National Wetland Inventory and Assessment project was initiated in 2007 by SAC, approved and funded by MoEF.

2. Wetlands of the Ganga Basin

The main stem of the river Ganga flows through the states of Uttarakhand, Uttar Pradesh, Bihar and West Bengal in India. Only the Sahebganj district of Jharkhand can be taken when main stem of Ganga River is considered. Ministry of Environment and Forest, Govt. of India sponsoring National Wetland Inventory and Assessment (NWIA) project reported 103882 ha area under wetlands in Uttarakhand, 1242530 ha in Uttar Pradesh, 403209 ha in Bihar and 1107907 ha in West Bengal.

2.1. Wetlands in Uttarakhand

Uttarakhand is the source region of two important rivers of India, *viz* Ganga and Yamuna. This is mainly a hilly state with high altitude wetlands. Wetlands of this state are both spring fed as well as river fed. As per the National Wetland Atlas, the three districts Uttarakashi, Tehri Garhwal and Haridwar include a total of 461 wetlands with a cumulative area of 25185 ha. The wetlands include high altitude wetlands (3 nos.) river and streams and wetlands (< 2.25 ha) area. The river and stream contribute 85.69% area (ha). The district wise distribution is represented in Figure 1 (a, b, c). Many wetlands in this state are considered as sacred. Important wetlands of this state are Arolital, Badhanital, Bhikaltal, Devtal, Hemkund, Roopkund, Sahstrabahu Lake, Ramganga reservoir, Nainital lake, Kedar tal, Nanak sagar, Tehri reservoir, Dhauliganga, and Tumaria reservoir. Biodiversity valuation of many wetlands is yet to be established. The details related to area assessment are given in Table 1

(a, b, c). Geographical location of some important wetlands is also shown in Google earth Figure 2.



Figure 1a: Wetlands in district Uttarkashi (Uttarakhand)



Figure 1b: Wetlands in district Tehri Garhwal (Uttarakhand)



Figure 1c: Wetlands in district Haridwar (Uttarakhand)

Table 1 a: Area estimates of wetlands in district Uttarkashi

| SNo | Wetland category | No. of wetlands | Total area wetland (ha) | % of wetland area |
|-----|-----------------------|-----------------|-------------------------|-------------------|
| 1 | High altitude wetland | 3 | 12 | 0.14 |
| 2 | River/stream | 12 | 8477 | 99.36 |
| 3 | Wetland (<2.25 ha) | 43 | 43 | 0.50 |
| 4 | Total | 58 | 8532 | 100.00 |

Table 1 b: Area estimates of wetlands in district Tehri Garhwal

| S No | Wetland category | No. of wetlands | Total area wetland (ha) | % of wetland area |
|------|--------------------|-----------------|-------------------------|-------------------|
| 1 | River/stream | 11 | 2909 | 69.71 |
| 2 | Reservoir/Barrages | 1 | 1247 | 29.88 |
| 3 | Wetland (<2.25 ha) | 17 | 17 | 0.41 |
| 4 | Total | 29 | 4173 | 100.00 |

Table 1 c: Area estimates of wetlands in district Haridwar

| SI. No. | Wetland category | No. of wetlands | Total area wetland (ha) | % of wetland area |
|---------|-------------------------------|-----------------|-------------------------|-------------------|
| 1 | Ox-bow lakes/cut off meanders | 4 | 18 | 0.14 |
| 2 | River/stream | 9 | 11859 | 95.02 |
| 3 | Tanks/Ponds | 18 | 90 | 0.72 |
| 4 | Waterlogged | 1 | 171 | 1.37 |
| 5 | Wetland (<2.25 ha) | 342 | 342 | 2.47 |
| 6 | Total | 374 | 12480 | 100.00 |

*District wise area information of wetlands in the Ganga River Basin (Source: National Wetland Inventory and Assessment. National Wetland Atlas. MoEF, Govt. of India. Space Applications Centre, Indian Space Research Organization





2.2. Wetlands in Uttar Pradesh

Uttar Pradesh is the most populated state of India. Rivers and tributaries flowing through the state are Ganga, Yamuna, Ghaghra, Rapti, Gandak, Ramganga, Gomti, Hindan, Chambal, Saryu, Sai, Kosi, Betwa, Belan, Dhasan, Tons, Son etc. Huge numbers of lakes, ponds, canals are present in the state. Majority of these wetlands are related to the rivers directly or indirectly. 17 districts of Uttar Pradesh fall in the Ganga River Basin directly. Those are Bijnor, Saharanpur, Jyotiba Phule Nagar, Bulandshahar, Raebareli, Farrukhabad, Kannauj, Kanpur Dehat, Kanpur Nagar, Fatehpur, Allahabad, Azamgarh, Ballia, Varanasi, Sant Ravidas Nagar, Mirzapur and Ghazipur.

The entiredistricts collectively have 25113 wetlands with cumulative area of 314775 ha. The river/ stream accounts for 181935 ha approximately 57.7% of the wetlands in Uttar Pradesh followed by 13.6% water logged areas and wetlands (< 2.25 ha). The Figure 3 (a-q) represent distribution of wetlands as lakes/ ponds, ox-bow lakes/ cut off meanders, river and stream, reservoir/ barrages, tanks/ ponds and wetlands (< 2.25 ha). The area estimate of the districts is given in Table 2 (a-q). A location map of Google earth for some important locations is shown in Figure 4.



Figure 3a Wetlands in district Bijnor (Uttar Pradesh)



Figure 3b Wetlands in district Saharanpur (Uttar Pradesh)











Wetlands in district Raebareli (Uttar Pradesh)



Figure 3f: Wetlands in district Farrukhabad (Uttar Pradesh)



Figure 3g: Wetlands in district Kannauj (Uttar Pradesh)



Figure 3h: Wetlands in district Kanpur Dehat (Uttar Pradesh)



Figure 3i: Wetlands in district Kanpur Nagar (Uttar Pradesh)



Figure 3j: Wetlands in district Fatehpur (Uttar Pradesh)



Figure 3k: Wetlands in district Allahabad (Uttar Pradesh)



Figure 3I: Wetlands in district Azamgarh (Uttar Pradesh)



Figure 3m: Wetlands in district Ballia (Uttar Pradesh)









Figure 3p: Wetlands in district Mirzapur (Uttar Pradesh)



Figure 3q: Wetlands in district Ghazipur (Uttar Pradesh)

| Table 2a: Area Estimates of Wetlands of Saharanpur | | | | |
|--|-------------------------------|-----------------|------------------------|-------------------|
| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
| 1 | Lakes/Ponds | 4 | 60 | 0.52 |
| 2 | Ox-bow lakes/cut off meanders | 2 | 10 | 0.09 |
| 4 | Waterlogged | 1 | 4 | 0.03 |
| 5 | River/stream | 64 | 10440 | 90.49 |
| 6 | Tanks/Ponds | 108 | 413 | 3.58 |
| 7 | Wetland (<2.25 ha) | 610 | 610 | 5.29 |
| | Total | 789 | 11537 | 100.00 |

| ZD. AICA LITIAICI VI WETIAIIUI II DISTICT DIJIV | e 2b: | Area Estimates of Wetlands in District Bijnor |
|---|-------|---|
|---|-------|---|

| Table 2b: Area Estimates of Wetlands in District Bijnor | | | | | |
|---|-------------------------------|-----------------|------------------------|-------------------|--|
| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area | |
| 1 | Lakes/Ponds | 21 | 118 | 0.66 | |
| 2 | Ox-bow lakes/cut off meanders | 16 | 243 | 1.36 | |
| 3 | Riverine wetlands | 16 | 962 | 5.38 | |
| 4 | Waterlogged | 40 | 654 | 3.66 | |
| 5 | River/stream | 64 | 12826 | 71.74 | |
| 6 | Reservoirs/Barrages | 6 | 931 | 5.21 | |
| 7 | Tanks/Ponds | 186 | 786 | 4.40 | |
| 8 | Wetland (<2.25 ha) | 1359 | 1359 | 7.60 | |
| | Total | 1708 | 17879 | 100.00 | |

| | Table 20. Alea Estimates of Wetlands in Jyotiba Filde Nagai | | | | | |
|---------|---|-----------------|------------------------|-------------------|--|--|
| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area | | |
| 1 | Lakes/Ponds | 8 | 52 | 0.47 | | |
| 2 | Ox-bow lakes/cut off meanders | 12 | 111 | 1.01 | | |
| 3 | Riverine wetlands | 5 | 140 | 1.27 | | |
| 4 | Waterlogged | 29 | 422 | 3.83 | | |
| 5 | River/stream | 33 | 9744 | 88.37 | | |
| 6 | Tanks/Ponds | 30 | 132 | 1.20 | | |
| 7 | Wetland (<2.25 ha) | 425 | 425 | 3.85 | | |
| | Total | 542 | 11026 | 100.00 | | |

Table 2c: Area Estimates of Wetlands in Jyotiba Phule Nagar

Table 2d:Area Estimates of Wetlands in District Bulandshahar

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 37 | 674 | 7.33 |
| 2 | Ox-bow lakes/cut off meanders | 3 | 49 | 0.53 |
| 3 | Riverine wetlands | 2 | 11 | 0.12 |
| 4 | Waterlogged | 134 | 2101 | 22.58 |
| 5 | River/stream | 10 | 5009 | 54.49 |
| 6 | Tanks/Ponds | 90 | 382 | 4.16 |
| 7 | Wetland (<2.25 ha) | 967 | 967 | 10.52 |
| | Total | 1243 | 9193 | 100.00 |

Table 2e: Area Estimates of Wetlands in District Raebareli

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 90 | 4428 | 11.49 |
| 2 | Ox-bow lakes/cut off meanders | 136 | 5457 | 14.17 |
| 3 | Riverine wetlands | 7 | 577 | 1.50 |
| 4 | Waterlogged | 602 | 13227 | 34.33 |
| 5 | River/stream | 35 | 11123 | 28.87 |
| 6 | Reservoirs/Barrages | 1 | 119 | 0.31 |
| 7 | Tanks/Ponds | 133 | 1556 | 4.40 |
| 8 | Wetland (<2.25 ha) | 2053 | 2053 | 5.28 |
| | Total | 3057 | 38540 | 100.00 |

| | Table 21. Area Estimates of Wetlands in District randkhabad | | | | | |
|---------|---|-----------------|------------------------|-------------------|--|--|
| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area | | |
| 1 | Lakes/Ponds | 23 | 658 | 2.95 | | |
| 2 | Ox-bow lakes/cut off meanders | 107 | 589 | 2.64 | | |
| 3 | Riverine wetlands | 170 | 7073 | 31.70 | | |
| 4 | Waterlogged | 98 | 1598 | 7.16 | | |
| 5 | River/stream | 81 | 12078 | 54.14 | | |
| 6 | Tanks/Ponds | 6 | 28 | 0.13 | | |
| 7 | Wetland (<2.25 ha) | 285 | 285 | 1.28 | | |
| | Total | 770 | 22309 | 100.00 | | |

Table 2f: Area Estimates of Wetlands in District Farrukhabad

Table 2g: Area Estimates of Wetlands in District Kannauj

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 32 | 1345 | 16.42 |
| 2 | Ox-bow lakes/cut off meanders | 10 | 193 | 2.36 |
| 3 | Riverine wetlands | 9 | 554 | 6.76 |
| 4 | Waterlogged | 97 | 2195 | 26.80 |
| 5 | River/stream | 65 | 3489 | 42.60 |
| 6 | Reservoirs/Barrages | 1 | 10 | 0.12 |
| 7 | Tanks/Ponds | 10 | 36 | 4.44 |
| 8 | Wetland (<2.25 ha) | 368 | 368 | 4.49 |
| | Total | 592 | 8190 | 100.00 |

Table 2h: Area Estimates of Wetlands in District Kanpur Dehat

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 36 | 883 | 7.61 |
| 2 | Ox-bow lakes/cut off meanders | 7 | 180 | 1.55 |
| 3 | Riverine wetlands | 9 | 19 | 0.16 |
| 4 | Waterlogged | 189 | 1502 | 21.57 |
| 5 | River/stream | 58 | 5380 | 46.37 |
| 6 | Reservoirs/Barrages | 2 | 6 | 0.05 |
| 7 | Tanks/Ponds | 160 | 781 | 6.73 |
| 8 | Wetland (<2.25 ha) | 1852 | 1852 | 15.96 |
| | Total | 2313 | 11603 | 100.00 |

| | Table 21. Area Estimates of Wetlands in District Kanpur Nagar | | | | |
|---------|---|-----------------|------------------------|-------------------|--|
| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area | |
| 1 | Lakes/Ponds | 17 | 124 | 0.84 | |
| 2 | Ox-bow lakes/cut off meanders | 5 | 94 | 0.64 | |
| 3 | Riverine wetlands | 11 | 120 | 0.81 | |
| 4 | Waterlogged | 89 | 1238 | 8.38 | |
| 5 | River/stream | 87 | 11152 | 75.50 | |
| 6 | Tanks/Ponds | 129 | 853 | 5.78 | |
| 7 | Wetland (<2.25 ha) | 1189 | 1189 | 8.05 | |
| | Total | 1527 | 14770 | 100.00 | |

Table 2i: Area Estimates of Wetlands in District Kanpur Nagar

Table 2 j: Area Estimates of Wetlands in District Fatehpur

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 59 | 1125 | 5.51 |
| 2 | Ox-bow lakes/cut off meanders | 5 | 192 | 0.94 |
| 3 | Riverine wetlands | 2 | 266 | 1.30 |
| 4 | Waterlogged | 274 | 3785 | 18.52 |
| 5 | River/stream | 39 | 12691 | 62.10 |
| 6 | Tanks/Ponds | 76 | 390 | 1.91 |
| 7 | Wetland (<2.25 ha) | 1986 | 1986 | 9.72 |
| | Total | 2441 | 20435 | 100.00 |

Table 2 k: Area Estimates of wetlands in District Allahabad

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 22 | 1879 | 6.84 |
| 2 | Ox-bow lakes/cut off meanders | 21 | 382 | 1.39 |
| 3 | Riverine wetlands | 6 | 313 | 1.14 |
| 4 | Waterlogged | 186 | 2814 | 10.24 |
| 5 | River/stream | 39 | 18143 | 66.01 |
| 6 | Reservoirs/Barrages | 19 | 1270 | 4.62 |
| 7 | Tanks/Ponds | 192 | 794 | 2.89 |
| 8 | Wetland (<2.25 ha) | 1892 | 1892 | 6.88 |
| | Total | 2377 | 27487 | 100.00 |

| (| | | | | |
|---------|-------------------------------|-----------------|------------------------|-------------------|--|
| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area | |
| 1 | Lakes/Ponds | 145 | 5800 | 22.77 | |
| 2 | Ox-bow lakes/cut off meanders | 34 | 1750 | 6.87 | |
| 3 | Riverine wetlands | 29 | 797 | 3.13 | |
| 4 | Waterlogged | 72 | 3716 | 14.59 | |
| 5 | River/stream | 69 | 9972 | 39.15 | |
| 6 | Tanks/Ponds | 5 | 31 | 0.12 | |
| 7 | Wetland (<2.25 ha) | 3406 | 3406 | 13.37 | |
| | Total | 3760 | 25472 | 100.00 | |

Table 2 I: Area Estimates of Wetlands in District Azamgarh

Table 2 m: Area Estimates of Wetlands in District Ballia

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 111 | 4747 | 14.81 |
| 2 | Ox-bow lakes/cut off meanders | 27 | 1328 | 4.14 |
| 3 | Riverine wetlands | 31 | 1636 | 5.11 |
| 4 | Waterlogged | 43 | 1481 | 4.63 |
| 5 | River/stream | 34 | 21405 | 66.79 |
| 6 | Tanks/Ponds | 3 | 8 | 0.02 |
| 7 | Wetland (<2.25 ha) | 1442 | 1442 | 4.50 |
| | Total | 1691 | 32047 | 100.00 |

Table 2 n: Area Estimates of Wetlands in District Varanasi

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 8 | 224 | 3.00 |
| 2 | Ox-bow lakes/cut off meanders | 1 | 135 | 1.81 |
| 3 | Riverine wetlands | 3 | 18 | 0.24 |
| 4 | Waterlogged | 20 | 689 | 9.22 |
| 5 | River/stream | 17 | 5323 | 71.26 |
| 6 | Wetland (<2.25 ha) | 1081 | 1081 | 14.47 |
| | Total | 1130 | 7470 | 100.00 |

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 8 | 347 | 16.02 |
| 2 | Ox-bow lakes/cut off meanders | 1 | - | - |
| 3 | Riverine wetlands | 1 | 10 | 0.17 |
| 4 | Waterlogged | 30 | 938 | 16.26 |
| 5 | River/stream | 75 | 3400 | 58.96 |
| 6 | Tanks/Ponds | 2 | 59 | 1.02 |
| 7 | Wetland (<2.25 ha) | 1013 | 1013 | 17.57 |
| | Total | 1130 | 5767 | 100.00 |

Table 2 o: Area Estimates of Wetlands in District Sant Ravidas Nagar

Table 2 p: Area Estimates of Wetlands in District Mirzapur

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 4 | 31 | 0.10 |
| 2 | Ox-bow lakes/cut off meanders | 5 | 234 | 0.77 |
| 3 | Waterlogged | 153 | 1692 | 5.59 |
| 4 | River/stream | 58 | 16193 | 53.46 |
| 5 | Reservoirs/Barrages | 254 | 9960 | 32.88 |
| 6 | Tanks/Ponds | 118 | 515 | 1.70 |
| 7 | Wetland (<2.25 ha) | 1666 | 1666 | 5.50 |
| | Total | 2258 | 27487 | 100.00 |

Table 2q: Area Estimates of Wetlands in District Ghazipur

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 75 | 1597 | 6.77 |
| 2 | Ox-bow lakes/cut off meanders | 27 | 1588 | 6.73 |
| 3 | Riverine wetlands | 13 | 478 | 2.03 |
| 4 | Waterlogged | 120 | 3987 | 16.90 |
| 5 | River/stream | 62 | 13567 | 57.53 |
| 6 | Reservoirs/Barrages | 1 | 5 | 0.02 |
| 7 | Tanks/Ponds | 3 | 15 | 0.06 |
| 8 | Wetland (<2.25 ha) | 2344 | 2344 | 9.94 |
| | Total | 2645 | 23581 | 100.00 |

*District wise area information of wetlands in the Ganga River Basin (Source: National Wetland Inventory and Assessment. National Wetland Atlas. MoEF, Govt. of India. Space Applications Centre, Indian Space Research Organization



Fig. 4 The wetlands of Uttar Pradesh

2.3. Wetlands in Bihar

The state of Bihar is divided into two unequal parts by the river Ganga which flows through the middle from west to east. Wetlands in Bihar are locally known as chaurs, mauns and pats. In Bihar, the main stem of Ganga passes through 12 districts viz. Begusarai, Bhagalpur, Buxar, Katihar, Khagaria, Lakhisarai, Munger, Patna, Purnia, Saran, Sheikhpura, and Vaishali. The total wetlands in all the district are 5183 which includes Lakes/ Ponds, Ox-bow lakes/cut off meanders, Riverine wetlands, Waterlogged areas, River/stream, Tanks/Ponds and Wetland (<2.25 ha). The total area of all types in all districts cumulative is around 168758 ha. The largest component is in river and streams (138218 ha) approximately 81.9% followed by small wetlands <2.25 ha, lakes and ponds. A graphical representation is shown in Figure 5 (a-I). The area estimates district wise is depicted in Table 3 (a-I). Geographical locations are shown in Google earth Figure 6.







Figure 5b: Wetlands in district Katihar (Bihar)



Figure 5c: Wetlands in District Saran (Bihar)



Figure 5d: Wetlands in district Vaishali (Bihar)



Figure 5e:

Wetlands in district Begusarai (Bihar)



Figure 5f: Wetlands in District Khagoria (Bihar)



Figure 5g: Wetlands in district Bhagalpur (Bihar)



Figure 5h: Wetlands in district Sheikhpura (Bihar)







Figure 5j: Wetlands in District Lakhisarai (Bihar)







Figure 5I: Wetlands in District Munger (Bihar)

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area | |
|---------|-------------------------------|-----------------|------------------------|-------------------|--|
| 1 | Lakes/Ponds | 47 | 831 | 6.70 | |
| 2 | Ox-bow lakes/cut off meanders | 176 | 1404 | 11.32 | |
| 3 | Riverine wetlands | 6 | 22 | 0.18 | |
| 4 | Waterlogged | 141 | 1902 | 15.34 | |
| 5 | River/stream | 26 | 7564 | 61.00 | |
| 6 | Reservoirs/Barrages | 2 | 102 | 0.82 | |
| 7 | Tanks/Ponds | 42 | 140 | 1.13 | |
| 8 | Wetland (<2.25 ha) | 436 | 436 | 3.52 | |
| | Total | 876 | 12401 | 100.00 | |

 Table 3 a:
 Area Estimates of Wetlands in District Purnia

| Table 3 b: | Area estimates of wetlands in district Katihar |
|------------|--|
| | |

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 128 | 3146 | 10.14 |
| 2 | Ox-bow lakes/cut off meanders | 237 | 2768 | 8.39 |
| 3 | Riverine wetlands | 35 | 451 | 1.45 |
| 4 | Waterlogged | 186 | 2486 | 8.02 |
| 5 | River/stream | 34 | 21255 | 68.54 |
| 6 | Tanks/Ponds | 80 | 303 | 0.98 |
| 7 | Wetland (<2.25 ha) | 602 | 602 | 1.94 |
| | Total | 1302 | 31011 | 100.00 |

Table 3 c: Area Estimates of Wetlands in District Saran

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 26 | 737 | 3.48 |
| 2 | Ox-bow lakes/cut off meanders | 10 | 121 | 0.57 |
| 3 | Riverine wetlands | 10 | 102 | 0.48 |
| 4 | Waterlogged | 30 | 2801 | 13.23 |
| 5 | River/stream | 27 | 16886 | 79.76 |
| 6 | Tanks/Ponds | 10 | 93 | 0.44 |
| 7 | Wetland (<2.25 ha) | 430 | 430 | 2.03 |
| | Total | 543 | 21170 | 100.00 |

Table 3 d: Area Estimates of Wetlands in Vaishali

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 31 | 3095 | 18.05 |
| 2 | Ox-bow lakes/cut off meanders | 6 | 184 | 1.05 |
| 3 | Riverine wetlands | 5 | 46 | 0.27 |
| 4 | Waterlogged | 62 | 2950 | 17.08 |
| 5 | River/stream | 16 | 10594 | 61.78 |
| 6 | Tanks/Ponds | 7 | 24 | 0.14 |
| 7 | Wetland (<2.25 ha) | 275 | 275 | 1.60 |
| | Total | 402 | 17168 | 100.00 |

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 23 | 3240 | 15.91 |
| 2 | Ox-bow lakes/cut off meanders | 54 | 1177 | 5.78 |
| 3 | Riverine wetlands | 16 | 242 | 1.19 |
| 4 | Waterlogged | 15 | 347 | 1.70 |
| 5 | River/stream | 21 | 15142 | 74.35 |
| 6 | Tanks/Ponds | 22 | 101 | 0.50 |
| 7 | Wetland (<2.25 ha) | 116 | 116 | 0.57 |
| | Total | 267 | 20365 | 100.00 |

Table 3 e: Area Estimates of Wetlands in Begusarai

Table 3 f: Area Estimates of Wetlands in Khagoria

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 24 | 416 | 3.57 |
| 2 | Ox-bow lakes/cut off meanders | 55 | 1264 | 10.85 |
| 3 | Riverine wetlands | 42 | 509 | 4.37 |
| 4 | Waterlogged | 31 | 1217 | 10.45 |
| 5 | River/stream | 44 | 8084 | 69.42 |
| 6 | Tanks/Ponds | 17 | 80 | 0.69 |
| 7 | Wetland (<2.25 ha) | 75 | 75 | 0.64 |
| | Total | 288 | 11645 | 100.00 |

Table 3g:

Area Estimates of Wetlands in Bhagalpur

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 16 | 558 | 2.31 |
| 2 | Ox-bow lakes/cut off meanders | 63 | 1034 | 4.28 |
| 3 | Riverine wetlands | 23 | 157 | 0.65 |
| 4 | Waterlogged | 21 | 445 | 1.84 |
| 5 | River/stream | 28 | 21446 | 88.73 |
| 6 | Reservoirs/Barrages | 1 | 5 | 0.02 |
| 7 | Tanks/Ponds | 26 | 99 | 0.41 |
| 8 | Wetland (<2.25 ha) | 427 | 427 | 1.77 |
| | Total | 605 | 24171 | 100.00 |

Table 3 h: Area Estimates of Wetlands in Sheikhpura

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|--------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 2 | 19 | 6.42 |
| 2 | River/stream | 2 | 2 | 0.68 |
| 3 | Tanks/Ponds | 50 | 203 | 68.58 |
| 4 | Wetland (<2.25 ha) | 72 | 72 | 24.32 |
| | Total | 126 | 296 | 100.00 |

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 1 | 5 | 0.02 |
| 2 | Ox-bow lakes/cut off meanders | 11 | 207 | 1.00 |
| 3 | Riverine wetlands | 2 | 35 | 0.17 |
| 4 | Waterlogged | 14 | 194 | 0.94 |
| 5 | River/stream | 22 | 19986 | 96.65 |
| 6 | Tanks/Ponds | 13 | 87 | 0.42 |
| 7 | Wetland (<2.25 ha) | 164 | 164 | 0.79 |
| | Total | 227 | 20678 | 100.00 |

Table 3 i: Area Estimates of Wetlands in Patna

Table 3 j: Area Estimates of Wetlands in Lakhisarai

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 1 | 8 | 0.19 |
| 2 | Ox-bow lakes/cut off meanders | 3 | 21 | 0.50 |
| 3 | Riverine wetlands | 4 | 32 | 0.77 |
| 4 | Waterlogged | 2 | 42 | 1.01 |
| 5 | River/stream | 11 | 3660 | 87.62 |
| 6 | Reservoirs/Barrages | 1 | 107 | 2.56 |
| 6 | Tanks/Ponds | 49 | 184 | 4.41 |
| 7 | Wetland (<2.25 ha) | 123 | 123 | 2.94 |
| | Total | 194 | 4177 | 100.00 |

Table 3 k: Area Estimates of Wetlands in Buxar

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 2 | 705 | 18.97 |
| 2 | Ox-bow lakes/cut off meanders | 5 | 396 | 10.65 |
| 3 | Waterlogged | 1 | 4 | 0.11 |
| 4 | River/stream | 6 | 2444 | 65.75 |
| 5 | Tanks/Ponds | 8 | 32 | 0.86 |
| 6 | Wetland (<2.25 ha) | 136 | 136 | 3.66 |
| | Total | 158 | 3717 | 100.00 |

| Table 3 I: Area E | stimates of Wetla | ands in Munger |
|-------------------|-------------------|----------------|
| | | |

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 3 | 22 | 0.18 |
| 2 | Ox-bow lakes/cut off meanders | 1 | 3 | 0.03 |
| 3 | Riverine wetlands | 19 | 194 | 1.62 |
| 4 | Waterlogged | 1 | 4 | 0.03 |
| 5 | River/stream | 13 | 11155 | 93.12 |
| 6 | Reservoirs/Barrages | 3 | 352 | 2.94 |
| 7 | Tanks/Ponds | 31 | 125 | 1.04 |
| 8 | Wetland (<2.25 ha) | 124 | 124 | 1.04 |
| | Total | 195 | 11979 | 100.00 |





2.4. Wetlands in Sahibganj

Only the Sahibganj district of Jharkhand falls directly into the Ganga river basin. The district has 555 wetlands having the area of 16118 ha. Like Uttar Pradesh and Bihar rivers and streams constitute nearly 65% of the wetland area followed by lakes and ponds17.75% and wetlands <2.25 ha and riverine wetlands. The numerical relation of wetlands is graphically represented in Figure 7. The area estimates are shown in Table 4. Geographical locations are shown in Google earth Figure 7.



Figure 7: Wetlands in district Sahibganj (Jharkhand)

| SI. No. | Wetland category | No. of wetlands | Total area wetland (ha) | % of wetland area |
|---------|-------------------------------|-----------------|-------------------------|-------------------|
| 1 | Lakes/Ponds | 10 | 2861 | 17.75 |
| 2 | Ox-bow lakes/cut off meanders | 15 | 73 | 0.45 |
| 3 | Riverine wetlands | 14 | 1204 | 7.74 |
| 4 | River/stream | 13 | 11378 | 70.59 |
| 5 | Reservoirs/Barrages | 3 | 16 | 0.10 |
| 6 | Tanks/Ponds | 18 | 104 | 0.65 |
| 7 | Wetland (<2.25 ha) | 482 | 482 | 2.99 |
| | Total | 555 | 16118 | 100.00 |

 Table 4:
 Area Estimates of Wetlands in Sahibganj

*District wise area information of wetlands in the Ganga River Basin (Source: National Wetland Inventory and Assessment. National Wetland Atlas. MoEF, Govt. of India. Space Applications Centre, Indian Space Research Organization



Figure8: The wetlands of Jharkhand represented in the Google earth map

2.5. Wetlands in West Bengal

The Ganga is the perennial river in the state of West Bengal. One branch of Ganga enters Bangladesh in the name of Padma and the other flows through the state in the names of Bhagirathi and Hooghly. In West Bengal, 7 district fall directly into the Ganga river basin. Wetlands up to Malda district (Farakka Barrage) are considered in this report. Malda district has 123 wetland aggregate area of 4608 ha. The river/ streams contribute the largest wetlands of 51.27% followed by lakes/ ponds 18.31% and wetlands <2.25 ha 17.63%. The wetlands types are given in Figure 9 and geographical locations are shown in Google earth Figure 10. The area estimates are shown in Table 5.





| i adie 5. Alea estimates di Wetianus in Maiua | Table | 5: Are | a Estimat | es of Wet | lands in | Malda |
|---|-------|--------|-----------|-----------|----------|-------|
|---|-------|--------|-----------|-----------|----------|-------|

| SI. No. | Wetland category | No. of wetlands | Total area wetland(ha) | % of wetland area |
|---------|-------------------------------|-----------------|------------------------|-------------------|
| 1 | Lakes/Ponds | 123 | 4608 | 18.31 |
| 2 | Ox-bow lakes/cut off meanders | 31 | 582 | 2.31 |
| 3 | Riverine wetlands | 148 | 1527 | 6.07 |
| 4 | Waterlogged | 63 | 544 | 2.16 |
| 5 | River/stream | 32 | 12906 | 51.29 |
| 6 | Tanks/Ponds | 105 | 558 | 2.22 |
| 7 | Wetland (<2.25 ha) | 4437 | 162 | 17.63 |
| | Total | 4939 | 20887 | 100.00 |

*District wise area information of wetlands in the Ganga River Basin (Source: National Wetland Inventory and Assessment. National Wetland Atlas. MoEF, Govt. of India. Space Applications Centre, Indian Space Research Organization



3. Biodiversity of some Wetlands in the Ganga River Basin

1. Banganga Wetland:Banganga wetland is situated in the state of Uttrakhand. It is a riverine wetland and originates near Bishenpur and flows through the Haridwar district of Uttrakhand. In this region many small islands are formed. These are the home to threatened species like Swamp deer (*Cervus duvauceli*). These provide habitat for Hog deer (*Axisprocinus*) and Otter (*Lutra lutra*). 70 species of birds and 40 species of fishes are reported from this region. Globally threatened avian species include *Sarus crane*, Darter and Black tailed godwit (*Limosa limosa*). Small population of marsh crocodile *Crocodylus palustris* are reported here. Indian flapshell turtle, Spotted pond turtle and Red crowned roofed turtle (*Batagur kachuga*) are reported here. *Phragmites karka, Ipomoea* sp., *Polygonum barbatum*, and *Polygonum glabrum* are mostly seen plant species in the islands. Reported free floating plants are *Azolla, Eichhornia*, and *Lemna*, semi submerged are *Ludwigia*, *Potamogeton*, *Nymphaea*, *Nymphoides*, *Marsilea* and *Trapa*, submerged *are Ceratophyllum*, *Hydrilla*, *Najas*, *Potamogeton* spp. and *Vallisneria*. Weed infestation occurs by *Eichhorniacrassipes*, *Enydra fluctuans*, and *Ipomoea* etc. Adhikari *et al.* (2008) reported 178 plant species from a part of the wetland (Table 6).

2. Jhilmil Jheel: This wetland is situated on the bank of river Ganga in the Haridwar district of Uttarakhand. Tall grassland and moist deciduous forest are seen in this region. 160 bird species are reported from this region. Critically endangered *Gyps bengalensis* are reported here. Other threatened avian species including Egyptian vulture, Lesser adjutant stork, Black bellied tern, Black necked stork are also reported. Other common and rare fauna include Spotted deer, Sambar, Barking deer, Swamp deer, Elephant, Nilgai, Leopard, Tiger, Golden jackal, Jungle cat, Civet, Common langur, *Rhesus macaque*, Python, Common krait, Monitor lizard etc.

3. Tehri dam: Tehri dam is situated on the Bhagirathi river with an area of 1245ha. In the riparian zone trees like Chir, Oaks, Conifers, Sal, Deodar, Haldu, Yew, Cypress, Rhododendron etc. are found. This region is well known for the medicinal plants like Brahmi and Ashwagandha. Fruits like Cornel, Figs, Kaiphal, Mulberry, Kingora, Raspberry, Blackberry, Currants, Medlars, Gooseberries, Hazelnuts, Apples, Pears, Apricots, Plums, Peaches, Oranges, Limes, Bananas, Pomegranates and Walnuts are found in the forest area. The riparian forest is full with animals like Monkey, Langur, Wild-Cat, Goat, Pig, Fox, Wild-Dog, Black Bear and Flying Squirrel. Musk deer found in the forest is a threatened species. Pheasants, Kalij, Koklas, Cheers, Monal, Wild Fowls, Harial, Parrots, Chatak, Papiha, Haldu, Neelkanth, Pigeons, Partridges, Kala Titar, Chakor and Neora are some reported avian fauna.

4. Lakh Bahosi Wildlife Sanctuary: It is situated in the Farrukhabad district of Uttar Pradesh. Two ox bow lakes, Lakh and Bahosi are situated here. Other small wetlands are also found in the vicinity. Globally threatened avian species, *Aquila clanga* (Greater spotted eagle), *Grus antigone (Sarus crane)* are reported from here. Black necked stork and Bar headed goose are also reported. Bluebull, Jungla Cat, Golden Jackal amd Blacknaped Hare are other the key species found here.

5. Samaspur Bird Sanctuary: It is situated in the Raebareily district of Uttar Pradesh. Earlier it was named as Salon wetland. Six small lakes are connected here. More than 110 bird species are reported from here. Among these, 14 species are reported as ducks, 13 species as waders, 4 species as stork and 10 species as raptors. Black necked stork and Pallas's fish eagle breed in this region. More than 10 fish species of economic importance are reported from this region.

6. Surha Taal Wildlife Sanctuary: It is situated in the Ballia district of Uttar Pradesh. This area is important because of the huge flock of birds during winter. Anatidae is numerous, followed by Phalacrocoracidae, Jacanidae and Ardeidae are reported avian families. *Sarus crane* breeds here.

7. Naroradam and adjoin areas: It is situated in the state of Uttar Pradesh. When the water level goes low, many small sand bars are formed near the barrage and the adjoining lakustrine region. These islands provide resting and breeding place for ducks, geese, cranes,

terns, lapwings and Indian skimmer. 133 bird species are reported from this region. Sarus, Diving Ducks, Common Pochard, Red Crested Pochard, Tufted Pochard, White Eyed Pochard, Pallas's Fish Eagle and Black Necked Stork are reported avian fauna in this place. Other key species include Gangetic Dolphin, Mugger, Gharial, Fishing Cat and Hog Deer. 11 species of freshwater turtle are reported from this region.

8. Gogabil Pakshi Vihar, Bhagar Beel and Baldia Chaur: This wetland is situated in the Kathihar district of Bihar. 71 bird species are reported from this ox-bow lake. Out of these 1 is Vulnerable, 3 Near Threatened and 4 biome restricted.

9. Kursela river course and Diyara flood plain: It is situated in the Kathihar district of Bihar. Threatened avian species like *Gyps bengalensis* (Oriental white backed vulture), *Leptoptilos javanicus* (Lesser adjutant stork), *Haliaeetus leucoryphus* (Pallas's fish eagle), *Leptoptilos dubius* (Greater adjutant stork) are reported avian fauna from this region. Endangered Gangetic Dolphin inhabits here.

10. Mokama Tal: It is situated in the Patna, Samastipur and Begusarai district of Bihar. About 149 bird species are reported from this region. *Pseudibis papillosa* (Black ibis), *Plegadis falcinellus* (Glossy ibis), *Platalea leucorodia* (Eurasian spoonbill), *Anser anser* (Greylag goose), *Anser indicus* (Bar headed goose), *Dendrocygna javanica* (Lesser whistling duck) and *Dendrocygna bicolour* (Large whistling duck) are reported avian species.

11. Vikramshila Gangetic Dolphin Sanctuary: This wetland is present in the Bhagalpur district of Bihar and famous for the endangered Gangetic Dolphin. *Leptoptilos dubius* (Greater adjutant stork), *Leptoptilos javanica* (Lesser adjutant stork), *Mycteria leucocephala* (Painted Stork), *Ciconia nigra, Ephippiorhynchus asiaticus, Anstomus oscitans* (Asian openbill), *Grus grus* (Common crane) and *Platalea leucordia* (Eurasian spoonbill) etc. are reported avian fauna.

12. Salah Chor: This wetland is situated in the Vaishali district of Bihar with an area of 638 ha. Major flora is not present. Stork and Cormorant are common avian fauna.

13. Morwe reservoir: This reservoir is situated in the Lakhisarai district of Bihar with an area of 107 ha. Stork and Cormorant are commonavian fauna. Rohu, Magur, Singhi are cultured fishes.

14. Khabar Tal:This natural lake is situated in the Begusarai district of Bihar with an area of 2680 ha. 55 species of macrophytes are found. They are submerged, floating or emergent type. As this lake support huge number of resident and migratory birds, it is declared as a bird sanctuary. Dabchick, herons, egrets, openbill stork, black ibis, whistling ducks, cotton teal, purple moorhen, little grebe, grey pelican, raylag goose, golden plover and common snipe are found here. Indian major and minor carps (*Labeo rohita, Catla catla, Cirrhinus mrigala, Cirrhinus reba*), snake headed fishes (*Channa punctatus, Channa striatus*) and air

breathing fishes (*Heteropneustes fossilis, Notopterus notopterus, Anabas testudineous*) are found here. *Pila globosa* is common in this area. This wetland is under threat due to poaching of birds, infestation of aquatic vegetations, agricultural encroachment and eutrophication by the use of fertilizers and pesticides.

15. Mora Mahananda Tal: This is natural riverine wetland. It is situated in the Katihar district of Bihar with an area of 68 ha. Macrophytes are found around the wetland. Filamentous algae are found in the wetland. It is the home to many resident birds. Migratory birds are also reported. Tortoises are observed frequently from this wetland. Indian carps and freshwater prawns are cultured in this wetland. Due to the poor communication facility of this area, the wetland is not under severe threat. However aquaculture and other agricultural activities have increased the eutrophication problem with a consequence of weed infestation.

16. Udhuwa Lake Bird Sanctuary: It is situated in the Sahebganj district of Jharkhand. Two water bodies, Pataura and Berhale are found here. The sanctuary is connected with the Ganga river at Farakka. 97 bird species are reported from this region. Near threatened *Ephippiorhynchus asiaticus* (Black necked stork) is reported from this place.

17. Naya Bandh wetland complex: This is situated in the Malda district of West Bengal. About 150 bird species are reported from this region, of these 6 are globally threatened, 5 near threatened, 11 biome species.

18. Farakka barrage and adjoining areas: It is situated in the Malda district of state of West Bengal. The small riverine islets formed during winter provide diurnal activity place for birds. About 70 bird species are reported from this region. *Dendrocygna bicolour* (Large whistling duck), *Aythya fuligula* (Tufted duck) etc. are some important avian species found here. This area provide habitat for endangered Gangetic Dolphin, Gharial, Marsh Crocodile and Otters. More than 50 economically important fishes are found in this region.

Table 6:Plant species in the Banganga wetland (Source: Adhikari, B.S., Babu, M.M.
Floral diversity of Baanganga Wetland, Uttarakhand, India.Check List 4(3):
279–290, 2008)

| SI. No. | Scientific name | Family |
|---------|------------------------------|----------------|
| 1. | Hygrophila polysperma | Acanthaceae |
| 2. | Rungia parviflora | Acanthaceae |
| 3. | Rungia pectinata | Acanthaceae |
| 4. | Sagitaria sagitifolia | Alismataceae |
| 5. | Achyranthes aspera | Amaranthaceae |
| 6. | Alternanthera paronychioides | Amaranthaceae |
| 7. | Alternanthera philoxeroides | Amaranthaceae |
| 8. | Alternanthera sessilis | Amaranthaceae |
| 9. | Amaranthus spinosus | Amaranthaceae |
| 10. | Centella asiatica | Apiaceae |
| 11. | Hydrocotyle sibthorpioides | Apiaceae |
| 12. | Psamogeton canescens | Apiaceae |
| 13. | Seseli diffusum | Apiaceae |
| 14. | Oxystelma secamone | Asclepiadaceae |
| 15. | Ageratum conyzoides | Asteraceae |
| 16. | Ageratum houstonianum | Asteraceae |
| 17. | Bidens bitternata | Asteraceae |
| 18. | Blumea laciniata | Asteraceae |
| 19. | Blumea membranacea | Asteraceae |
| 20. | Blumea mollis | Asteraceae |
| 21. | Centipeda minima | Asteraceae |
| 22. | Cirsium arvense | Asteraceae |
| 23. | Eclipta prostrata | Asteraceae |
| 24. | Elephantopus scaber | Asteraceae |
| 25. | Enydra fluctuans | Asteraceae |
| 26. | Erigeron bonariensis | Asteraceae |
| 27. | Gnaphalium pensylvanicum | Asteraceae |
| 28. | Gnaphalium polycaulon | Asteraceae |
| 29. | Grangea maderaspatana | Asteraceae |
| 30. | Ixeris polycephala | Asteraceae |
| 31. | Launaea procumbens | Asteraceae |
| 32. | Parthenium hysterophorus | Asteraceae |
| 33. | Pulicaria crispa | Asteraceae |
| 34. | Sonchus asper | Asteraceae |
| 35. | Sonchus oleracea | Asteraceae |
| 36. | Tridax procumbens | Asteraceae |

| 27 | Vernenie eineree | Actorogog |
|----------|------------------------------|------------------|
| <u> </u> | Ventium atrumatium | Asteraçõe |
| <u> </u> | | |
| 39. | Azolla pinnata | Azollaceae |
| 40. | Cordía dichotoma | Boraginaceae |
| 41. | Cynoglossum zeylanicum | Boraginaceae |
| 42. | Brassica junceae | Brassicaceae |
| 43. | Coronopus didymus | Brassicaceae |
| 44. | Rorippa nasturtium-aquaticum | Brassicaceae |
| 45. | Cassia tora | Caesalpiniaceae |
| 46. | Parkinsonia aculeate | Caesalpiniaceae |
| 47. | Tamarindus indica | Caesalpiniaceae |
| 48. | Campanula wallichii | Campanulaceae |
| 49. | Cannabis sativa | Cannabinaceae |
| 50. | Stellaria media | Caryophyllaceae |
| 51. | Ceratophyllum demersum | Ceratophyllaceae |
| 52. | Chenopodium album | Chenopodiaceae |
| 53. | Chenopodium ambrosioides | Chenopodiaceae |
| 54. | Suaeda fruticosa | Chenopodiaceae |
| 55. | Terminalia arjuna | Combretaceaes |
| 56. | Commelina benghalensis | Commelinaceae |
| 57. | Commelina hasskarlii | Commelinaceae |
| 58. | Ipomoea carnea | Convolvulaceae |
| 59. | Ipomoea aquatica | Convolvulaceae |
| 60. | Momordica dioica | Cucurbitaceae |
| 61. | Carex sp. | Cyperaceae |
| 62. | Cyperus bulbosus | Cyperaceae |
| 63. | Cyperus compressus | Cyperaceae |
| 64. | Cyperus cyperoides | Cyperaceae |
| 65. | Cyperus kyllingia | Cyperaceae |
| 66. | Cyperus pygmaeus | Cyperaceae |
| 67. | Cyperus rotundus | Cyperaceae |
| 68. | Cyperus triceps | Cyperaceae |
| 69. | Elaeocharis palustris | Cyperaceae |
| 70. | Fibristylis falcata | Cyperaceae |
| 71. | <i>Scirpus</i> sp. | Cyperaceae |
| 72. | Scirpus tuberosus | Cyperaceae |
| 73. | Dryopteris sp. | Dryopteridaceae |
| 74. | Equisetum ramosissimum | Equisetaceae |
| 75. | Euphorbia hirta | Euphorbiaceae |
| 76. | Euphorbia prostrata | Euphorbiaceae |

| 77. | Kirganelia reticulata | Euphorbiaceae |
|------|----------------------------|------------------|
| 78. | Trewia nudiflora | Euphorbiaceae |
| 79. | Acacia catechu | Fabaceae |
| 80. | Acacia farnesiana | Fabaceae |
| 81. | Acacia nilotica | Fabaceae |
| 82. | Dalbergia sissoo | Fabaceae |
| 83. | Desmodium triflorum | Fabaceae |
| 84. | Lathyrus aphaca | Fabaceae |
| 85. | Medicago lupulina | Fabaceae |
| 86. | Melilotus alba | Fabaceae |
| 87. | Melilotus indica | Fabaceae |
| 88. | Pongamia pinnata | Fabaceae |
| 89. | Trifolium tomentosum | Fabaceae |
| 90. | Trigonella foenum-graecum | Fabaceae |
| 91. | Trigonella hamosa | Fabaceae |
| 92. | Vicia hirsute | Fabaceae |
| 93. | Vicia sativa | Fabaceae |
| 94. | Vicia tetrasperma | Fabaceae |
| 95. | Exacum pedunculatum | Gentianaceae |
| 96. | Hydrilla verticillata | Hydrocharitaceae |
| 97. | Vallisneria natans | Hydrocharitaceae |
| 98. | Leucas cephalotes | Lamiaceae |
| 99. | Nepeta hindostana | Lamiaceae |
| 100. | Perilla frutescens | Lamiaceae |
| 101. | Salvia plebeia | Lamiaceae |
| 102. | Lemna perpusilla | Lemnaceae |
| 103. | Spirodela polyrhiza | Lemnaceae |
| 104. | Linum usitatissimum | Linaceae |
| 105. | Ammannia baccifera | Lythraceae |
| 106. | Rotala densiflora | Lythraceae |
| 107. | Malvastrum coromandelianum | Malvaceae |
| 108. | Sida rhombifolia | Malvaceae |
| 109. | Urena lobata | Malvaceae |
| 110. | Marslea quadriolia | Marseliaceae |
| 111. | Martynia annua | Martyniaceae |
| 112. | Albizia procera | Mimosaceae |
| 113. | Pithecellobium dulce | Mimosaceae |
| 114. | Ficus palmata | Moraceae |
| 115. | Ficus racemosa | Moraceae |
| 116. | Syzygium cumini | Myrtaceae |

| 117. | Najas graminea | Najadaceae |
|------|-------------------------|------------------|
| 118. | Najas minor | Najadaceae |
| 119. | Boerhavia diffusa | Nyctaginaceae |
| 120. | Nymphaea nouchali | Nymphaeceae |
| 121. | Nymphoides cristata | Nymphaeceae |
| 122. | Nymphoides indica | Nymphaeceae |
| 123. | Ludwigia adscendens | Onagraceae |
| 124. | Zeuxine strateumatica | Orchidaceae |
| 125. | Oxalis corniculata | Oxalidaceae |
| 126. | Argemone mexicana | Papaveraceae |
| 127. | Avena sativa | Poaceae |
| 128. | Brachiaria distachya | Poaceae |
| 129. | Brachiaria ramosa | Poaceae |
| 130. | Cynodon dactylon | Poaceae |
| 131. | Eleusine indica | Poaceae |
| 132. | Imperata cylindrical | Poaceae |
| 133. | Oplismenus burmanii | Poaceae |
| 134. | Phalaris minor | Poaceae |
| 135. | Phragmites karka | Poaceae |
| 136. | Polypogon fugax | Poaceae |
| 137. | Saccharum bengalensis | Poaceae |
| 138. | Saccharum spontaneum | Poaceae |
| 139. | Setaria verticillata | Poaceae |
| 140. | Triticum vulgare | Poaceae |
| 141. | Polygonum barbatum | Polygonaceae |
| 142. | Polygonum glabrum | Polygonaceae |
| 143. | Polygonum hydropiper | Polygonaceae |
| 144. | Polygonum lapathifolium | Polygonaceae |
| 145. | Polygonum plebeium | Polygonaceae |
| 146. | Rumex dentatus | Polygonaceae |
| 147. | Rumex nepalensis | Polygonaceae |
| 148. | Eichhornia crassipes | Pontederiaceae |
| 149. | Monochoria vaginalis | Pontederiaceae |
| 150. | Potamogeton crispus | Potamogetonaceae |
| 151. | Potamogeton nodosus | Potamogetonaceae |
| 152. | Potamogeton pectinatus | Potamogetonaceae |
| 153. | Anagallis arvensis | Primulaceae |
| 154. | Primula umbellata | Primulaceae |
| 155. | Ranunculus muricatus | Ranunculaceae |
| 156. | Ranunculus sceleratus | Ranunculaceae |

| 157. | Zizyphus mauritiana | Rhamnaceae |
|------|-----------------------------|------------------|
| 158. | Potentilla supina | Rosaceae |
| 159. | Hedyotis corymbosa | Rubiaceae |
| 160. | Wendlandia exserta | Rubiaceae |
| 161. | Bacopa monnieri | Scrophulariaceae |
| 162. | Bacopa procumbens | Scrophulariaceae |
| 163. | Lindernia ciliata | Scrophulariaceae |
| 164. | Mazus pumilus | Scrophulariaceae |
| 165. | Verbascum chinense | Scrophulariaceae |
| 166. | Veronica anagallis-aquatica | Scrophulariaceae |
| 167. | Nicotiana plumbaginifolia | Solanaceae |
| 168. | Physalis minima | Solanaceae |
| 169. | Solanum nigrum | Solanaceae |
| 170. | Solanum torvum | Solanaceae |
| 171. | Solanum viarum | Solanaceae |
| 172. | Tamarix dioica | Tamaricaceae |
| 173. | Trapa natans var bispinosa | Trapaceae |
| 174. | Typha elephantina | Typhaceae |
| 175. | Pouzolzia pentandra | Urticaceae |
| 176. | Pouzolzia zeylanica | Urticaceae |
| 177. | Utricularia sp. | Utriculariaceae |
| 178. | Phyla nodiflora | Verbenaceae |

4. Threats to Wetlands

The biodiversity of freshwater ecosystem is declining faster than other biomes. The rate of loss of freshwater biodiversity during 1970-2000 was almost double that of marine and terrestrial biomes. Wetlands perform many functions, provide ecological services and support thousands of lives. However, overexploitation of resources and other anthropogenic and natural processes put stress and continuous threats on the wetlands. With the increase of human population and land demand, wetland areas are encroached for agriculture. As a consequence erosion and nutrient runoff to the wetland increases leading to eutrophication. Accidental or illegal introduction of alien species push threat to indigenous biodiversity of wetlands altering the food chain and the nutrient cycle in lentic water ecosystem. Ahmed et al (2002) estimated an average of 100 waterbirds traded illegally per week at one area of Uttar Pradesh. Major illegally traded waterbird species are *Pelecanus onocrotalus, Mycteria leucocephala, Ephippiorhynchus asiaticus, Ciconia ciconia, Platalea leucorodia, Phoenicopterus ruber, Grus antigone, Anthropoides virgo, Anser indicus, Anser anser, Anus acuta, Ans clypeata, Anas crecca, Tadorna ferriginea, Anas Penelope, Nettapus coromandelianus, Rostratula benghalensis, Hydrophasianus chirurgus, Metopidius*

indicus, Dendrocygna javanics etc. Conservation issues of some wetlands of Ganga river basin are reported in Table 7.

Various threats on wetlands of this basin are:

- a) Removal of vegetation (deforestation) and its consequence as erosion.
- b) Shifting of wetlands to paddy fields.
- c) Pressure due developmental activities like industry or residential areas.
- d) Pollution due to industrial and domestic waste dumping.
- e) Overfishing and unregulated fishing.
- f) Poaching of birds and other animals.
- g) Introduction of exotic plant and animal species.
- h) Pollution due agricultural runoff.

Table 7: Conservation issues of some wetlands of Ganga River Basin

| Name of the wetland | State | Conservation issues |
|--|---------------|--------------------------------|
| Banganga wetland | Uttarakhand | Agricultural encroachment |
| | | Human settlement |
| | | Weed infestation |
| | | Silt deposition |
| | | Livestock grazing |
| Jhilmil Jheel | Uttarakhand | Livestock grazing |
| | | Poaching |
| | | Road kill |
| | | Invasive plant species |
| | | Encroachmen |
| Lakh Bahosi wildlife sanctuary | Uttar Pradesh | Grazing |
| | | Grass collection |
| | | Hunting and Bird trapping |
| Samaspur Bird Sanctuary | Uttar Pradesh | Fishing |
| | | Drainage |
| | | Livestock grazing |
| | | Siltation |
| | | Pesticides |
| Surha Taal Wildlife Sanctuary | Uttar Pradesh | Excessive fishing |
| | | Irrigation |
| | | Weed infestation |
| | | Over exploitation |
| Gogabil Pakshi Vihar, Bhagar Beel and Baldia | Bihar | Poaching |
| Chaur | | Bird trading |
| | | Land disputes |
| | | Fisheries |
| Kursela River Course and Diyara Flood plain | Bihar | Bird trapping |
| | | Poaching |
| | | Less scientific investigations |

| | | Poor administration |
|--|---------------|------------------------------------|
| | | Agricultural runoff |
| Mokama Tal | Bihar | Poaching |
| | | Construction of thermal power |
| | | plants |
| | | Agricultural runoff |
| Vikramshila Gangetic Dolphin Sanctuary | Bihar | Agricultural runoff |
| | | Fishing |
| | | Transportation |
| Khabar Tal | Bihar | Poaching of birds |
| | | Weed infestation |
| | | Agricultural encroachment |
| | | Eutrophication |
| | | Agricultural run off |
| | | Livestock grazing |
| Mora Mahananda Tal | Bihar | Threatened by eutrophication and |
| | | weed infestation |
| Udhuwa Lake Bird Sanctuary | Jharkhand | Illegal settlement |
| | | Agriculture |
| | | Poaching |
| | | Illegal fishing |
| | | Fertilizers and pesticides |
| Naya Bandh Wetland complex | West Bengal | Aquaculture activities |
| | | Bird trapping |
| | | Pesticides |
| | | Land reclamation |
| Naroradam and adjoin areas | Uttar Pradesh | Over fishing |
| | | Poaching |
| | | Agricultural activities |
| | | Pesticides |
| | | Industrial pollution |
| Farakka Barrage and Adjoining Areas | West Bengal | Agricultural infestation |
| | | Fisheries |
| | | Obstruction of T. ilisha migration |

5. Management and conservation of wetlands

(a) Developing conservation strategies

Due to the rapid increase of human population, the wetlands as well as the other aquatic systems are facing constant stress because of shifting of water bodies into agricultural land. The marginal areas of wetlands are used for agriculture and consequently the wetland area shrinks. This compels the dependent water birds to congregate in a smaller place that makes them susceptible to poaching. Shrinkage of wetland area reduces the food sources for birds. As a result birds move to agricultural lands that increases the conflict of farmers with the birds. The non cultivable marshy

patches of wetlands are to be protected and managed. The nesting grounds of the birds are to be protected. Community conservation programmes and indulge of traditional relation of human with animal would decrease the human animal conflicts. Some wetlands in the Ganga basin are directly used for aquatic plant cultivation that provides edibles. The extensive cultivation of aquatic plants in the wetlands decreases the access ground of birds and restrict their feeding habits. Thus the wide cultivation of aquatic plants in the wetlands is to be regulated.

(b) Wetland vegetation management

The vegetation around the wetlands is very important. These provide nesting and resting place for many water birds. These vegetation are generally removed. Tall trees are cut for timber. Plantation of tall trees should be encouraged around the wetlands; these are used for nesting by bird like storks. Engineered vegetated treatment systems especially effective at removing suspended solids and sediment from non point source (NPS) pollution before the runoff reaches natural wetlands

(c) Reforestation and flood and siltation control

Deforestation accelerates the erosion and consequently heavy siltation and sediment deposition in the wetlands. Siltation and flooding destroys the sandbank colonies of many birds. Fringe area forest protection and programmed reforestation should be taken into consideration for flood and siltation control.

(d) Regulation of developmental activities

Many anthropogenic activities are due the rapid urbanization and the developmental activities around the wetlands. Excavations for soil, stone quarry, brick industry around the wetlands are to be regulated to prevent the siltation problem.

(e) Pollution

Wetlands are highly polluted by the industrial, municipal and agricultural waste. Fertilizers and pesticides are immensely used in the agricultural lands. Toxic chemicals may induce bio-magnifications of toxicants. Waste disposal at the wetlands are to be strictly regulated and use of organic fertilizers should be encouraged in place of toxic fertilizers and chemicals.

(f) Regulation of overexploitation

Change of fringe human population should be recorded time to time by the concerned authority. This would reveal the dependency on the wetland and the stress on the wetland. Overexploitation of bio-resources should be checked. Mesh size of the fishing net should be regulated so that juvenile cannot be caught. Catch of brooder fish should be banned. Similarly fishing through poison and dynamite should be banned.

(g) Community conservation and mass involvement

Fringe people are directly dependent on wetland resources. Their active participation in the conservation programme is most important. Indulge of traditional knowledge and conservation strategy induces the management of wetlands. Cage culture and pen culture fish practices can be introduced depending upon conditions to have more fish yield from the wetlands. Public awareness would lead to the sustainable development.

(h) Identification of wetlands

Major criteria for prioritizing wetlands are birds by the international conventions. The points of considerations are total number of species, total number of birds (abundance), number of threatened species, number of threatened birds, number of rare or near threatened species and number of species of raptor as they are predatory and often on the top of the food chain. Wetlands can also be identified on the basis of their type, location and area. Other biological factors may be included for the identification of wetlands, such as-

-Presence of endemic fish.

-Number of water birds

-Important aquatic vegetation

-Life cycle of any important flora or fauna

-Flagship species

-Presence of threatened species

(i) Analysis of biotic elements

Information on biotic elements is essential. Species diversity, growth of vegetation, biomass estimates, etc. are items to be described in biologically relevant terms, to define the ecological value of the biotic elements as well as that of the whole ecohydrological study. The various biotic communities are

(j) Identification of species

Conservation programmes, the first question comes "what to conserve". Identification of threatened species is important, because they are the visible form of biodiversity loss. The more degraded ecosystems are to be conserved first and the most threatened species are to be protected first. Molecular tools and techniques can be used to reduce the ambiguity in the conventional taxonomic procedures.

(k) Biomonitoring

Invertebrates and lower vertebrates are important bioindicators of wetlands. Insect, fish and amphibians play significant role in healthy ecosystems. Insect is very crucially integrated in the lentic water food web and well linked to both fish and amphibians as food source. Fish is very vital bioindicator of confined water ecosystem.

(I) Energy transformation in wetland

Energy dynamics for

-Transformation and storage of solar energy into chemical energy by the producers. -Flow of energy through different trophic levels

(m)Mapping and Modelling for wetland management

Topographical maps and geospatial techniques like GPS and GIS can be used for the mapping of wetlands. Information regarding catchment area, connections with the river stem, water table change, ecohydrology can be achieved through the mapping. Mapping may lead to restoration of linkage and sediment removal. Ecohydrology models can be designed by coupling an ecological model with a conceptual hydrological model (Arnold *et al.* 2009). Such models are pattern oriented based on a good number of parameters as water balance, biotic species, etc. Some of the important models currently employed in the field of Ecohydrology are Soil and Water Assessment Tool (SWAT), Soil and Water Integrated Model (SWIM), Integrated Quantity Quality Model (IQQM), River and Stream Water Quality Model (QUAL2K), etc. In general modelling in wetlands involves linear models. Monitoring, modeling and management of wetland exist together. Vegetation change, hydrology, plankton variation, thermal conditions are the monitoring of wetlands, whereas outflow control, denitrofication and restoration are the management activities through the ecohydrological modelling, nutrient modelling or flow pattern modeling.

(n) Legal Framework:

Wetlands conservation in India is indirectly influenced by an array of policy and legislative measures (Parikh & Parikh 1999). Some of the key legislations are given below:

- The Indian Fisheries Act 1857
- The Indian Forest Act 1927
- Wildlife (Protection) Act 1972
- Water (Prevention and Control of Pollution) Act 1974
- Territorial Water, Continental Shelf, Exclusive Economic Zone and other Marine Zones Act 1976
- Water (Prevention and Control of Pollution) Act 1977
- Maritime Zone of India (Regulation and fishing by foreign vessels) Act 1980
- Forest (Conservation act) 1980
- Environmental (Protection) Act 1986
- Coastal Zone Regulation Notification 1991
- Wildlife (Protection) Amendment Act 1991
- National Conservation Strategy and Policy Statement on Environment and Development – 1992
- National Policy And Macro level Action Strategy on Biodiversity-1999
- Tribal Forest protection Act of 2004

In summary, mapping and modelling utilizing topographical maps and geospatial techniques like GIS and Remote Sensing can establish change in water table of wetlands, their connections with the nearby rivers and other water bodies and other ecohydrological parameters. Monitoring, modelling and management co exist and they are interdisciplinary. Monitoring may include analysis of thermal condition, vegetation pattern change, hydrology and plankton variation. Modelling may include eco hydrological model, nutrient retention model or flow pattern model. Monitoring and modelling would light the pave for the management of outflow control, denitrification, sediment removal or restoration of wetlands. Proper identification of wetland is very important from the management point of view. Identification on the basis of type and location would give the general information of the wetlands. As already mention identification on the basis of biotic community is necessary. Water bird and fish biodiversity analysis is to be done primarily for the wetland management. Status analysis and management of threatened, endemic and special key species is mandatory because these are the most visible symbol of biodiversity loss. Biological study of these biotic community as well as lower groups (Invertebrates: e.g. insects and lower vertebrates: e.g. herpetofauna) is to be done for biomonitoring of wetlands and invasive species management of the wetlands. Simultaneously, mass involvement and public awareness is necessary for sustainable development.



Figure 11: Line Diagram of the Management Plan

6. Conclusion

A prime need of hour to protect wetlands is to understand the human wetland interaction. Estimation of fringe human population, their historical change and their dependence on the wetlands for the resources can find out the stress on the wetland. Public awareness and mass involvement are necessary for the protection of the wetlands. Total ecological change

of wetlands due to cleaning, weed removal or embankment for tourism is not advisable. However, weed control and cleaning of wetland may be some management tool depending upon the necessity. Threatened wetlands are to be prioritized and managed first. Engineered vegetated treatment systems (VTS) are especially effective at removing suspended solids and sediment from non point source (NPS) pollution before the runoff reaches natural wetlands. Wetlands are the breeding ground for many fishes. Wetlands support many amphibians, invertebrates and plant species. Amphibians and lower organisms are the indicator of healthy wetlands. Their habitat protection is most important which would ensure the survival of higher fauna.

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