

Wetlands

in Ganga River Basin

GRBMP : Ganga River Basin Management Plan

by

Indian Institutes of Technology



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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.

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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.

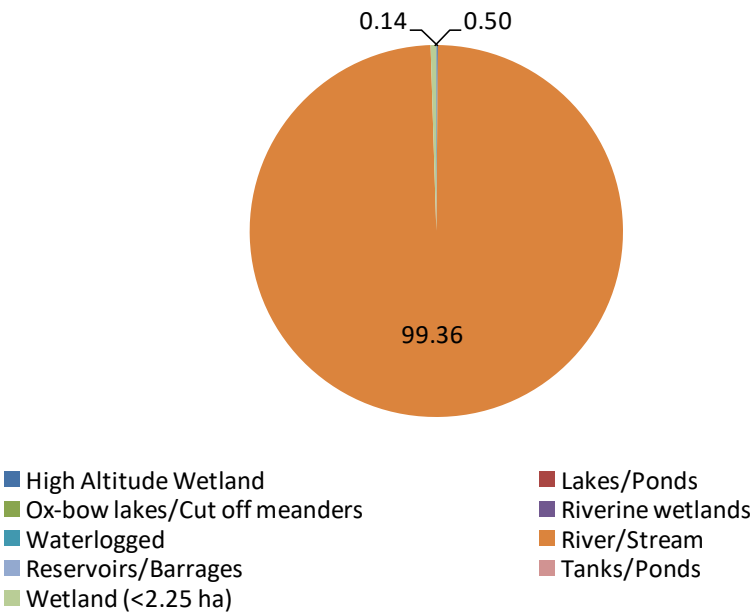


Figure 1a: Wetlands in district Uttarkashi (Uttarakhand)

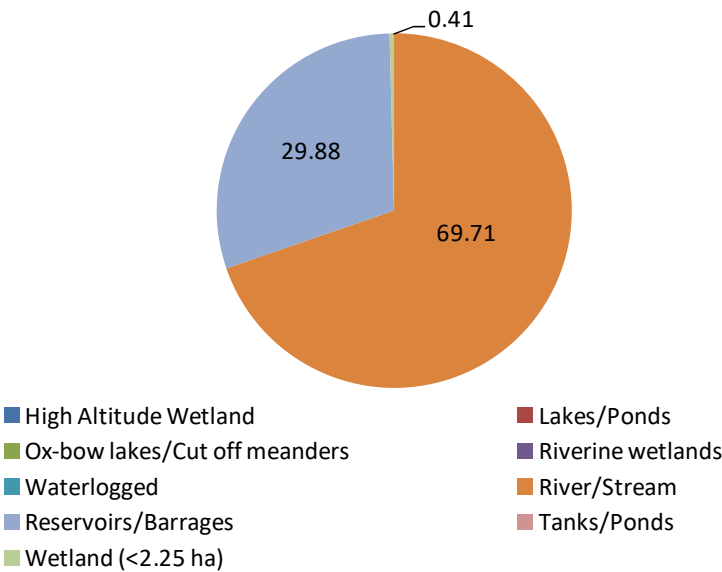


Figure 1b: Wetlands in district Tehri Garhwal (Uttarakhand)

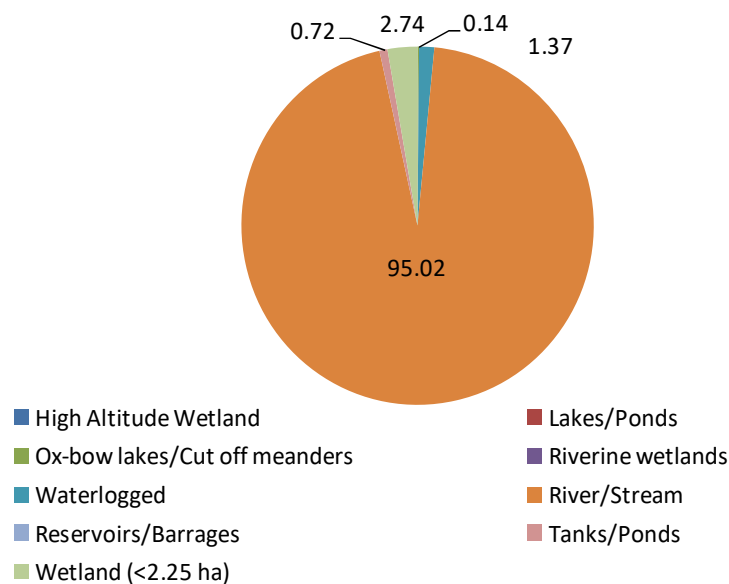


Figure 1c: Wetlands in district Haridwar (Uttarakhand)

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

Sl. 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
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**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*

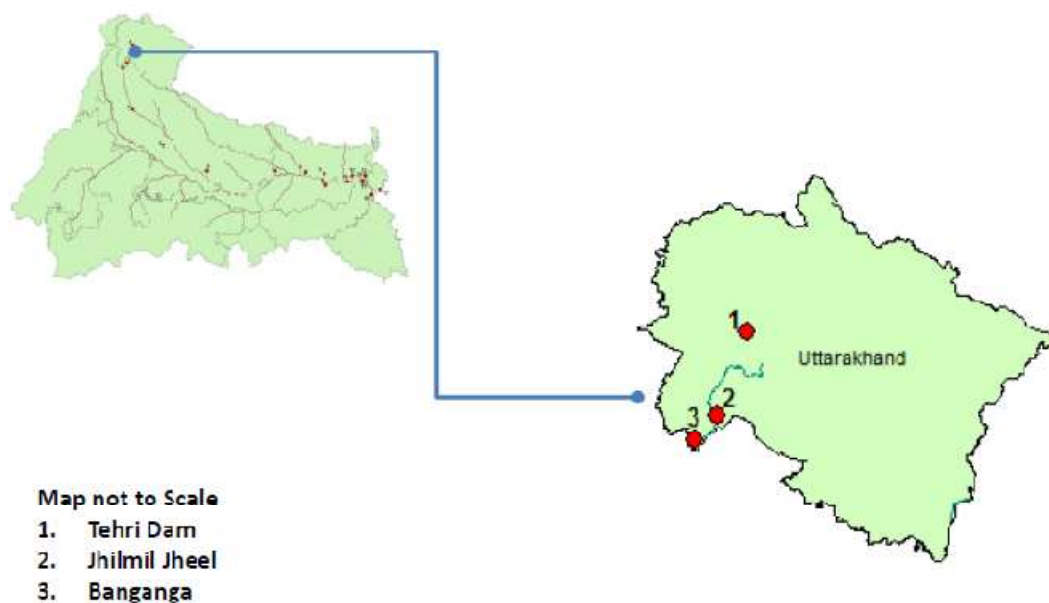


Fig. 2 The wetlands of Uttarakhand

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 entire districts 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.

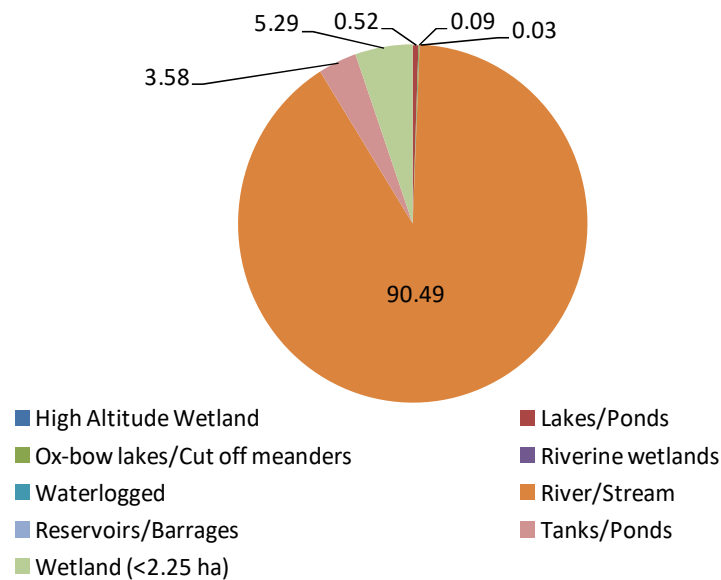


Fig. 3a Wetlands in district Bijnor (Uttar Pradesh)

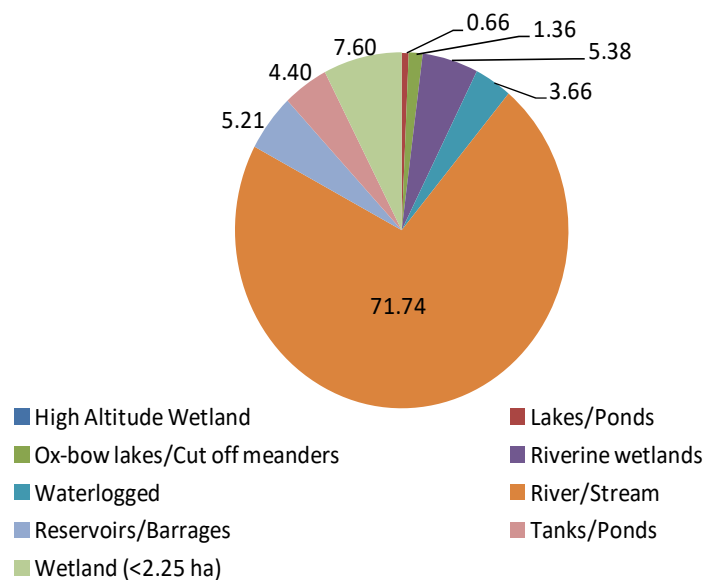


Fig. 3b Wetlands in district Saharanpur (Uttar Pradesh)

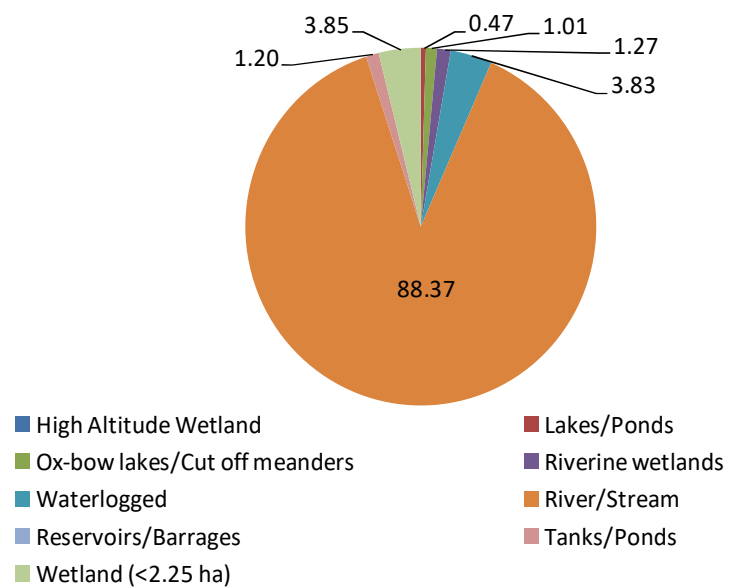


Fig. 3c Wetlands in district Jyotiba Phule Nagar (Uttar Pradesh)

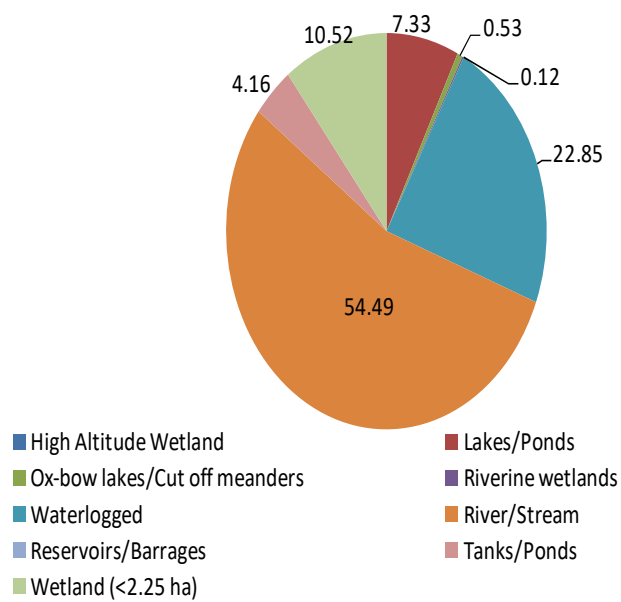


Fig. 3d Wetlands in district Bulandsahar (Uttar Pradesh)

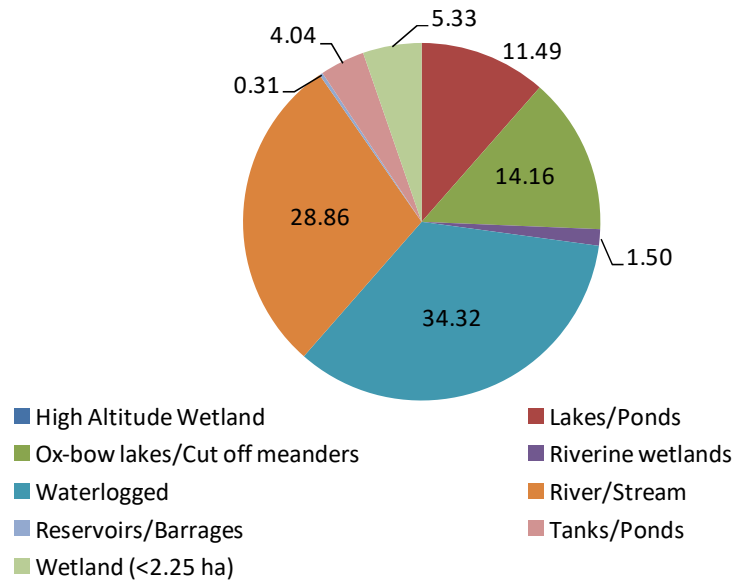


Fig. 3e Wetlands in district Raebareli (Uttar Pradesh)

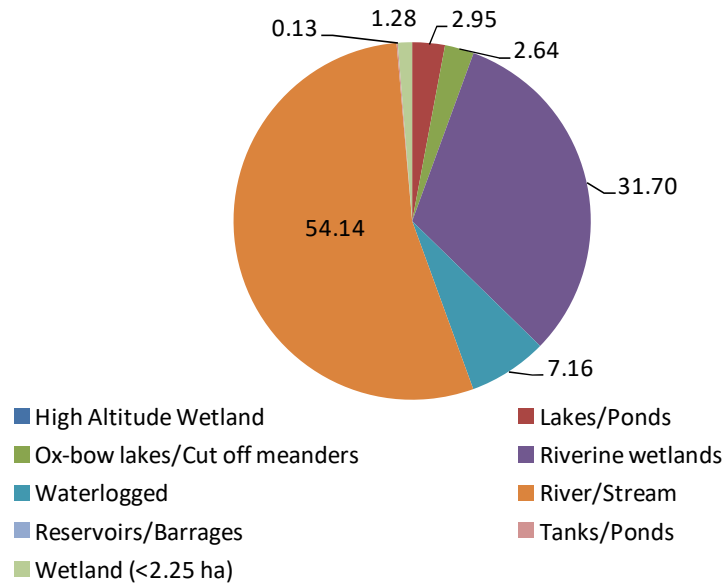


Fig. 3f Wetlands in district Farrukhabad (Uttar Pradesh)

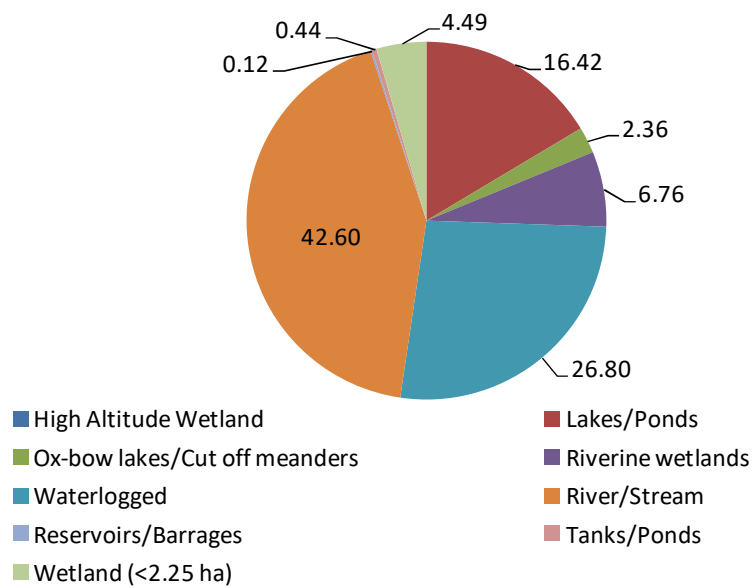


Fig. 3g Wetlands in district Kannauj (Uttar Pradesh)

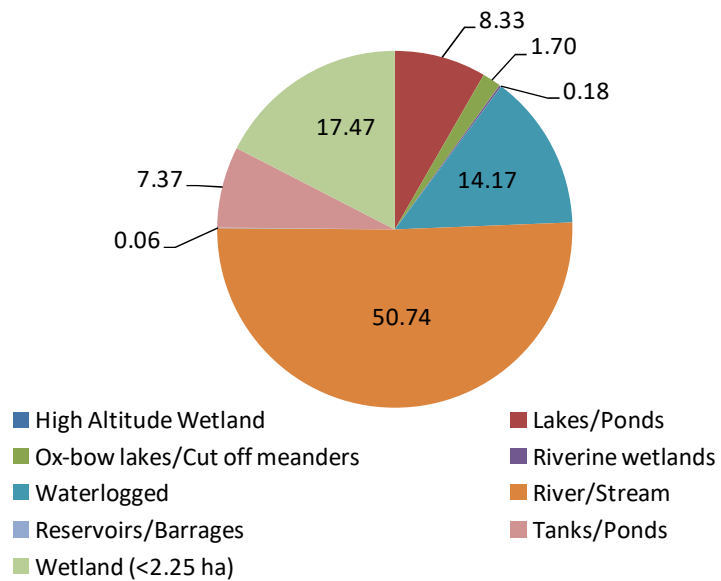


Fig. 3h Wetlands in district Kanpur Dehat (Uttar Pradesh)

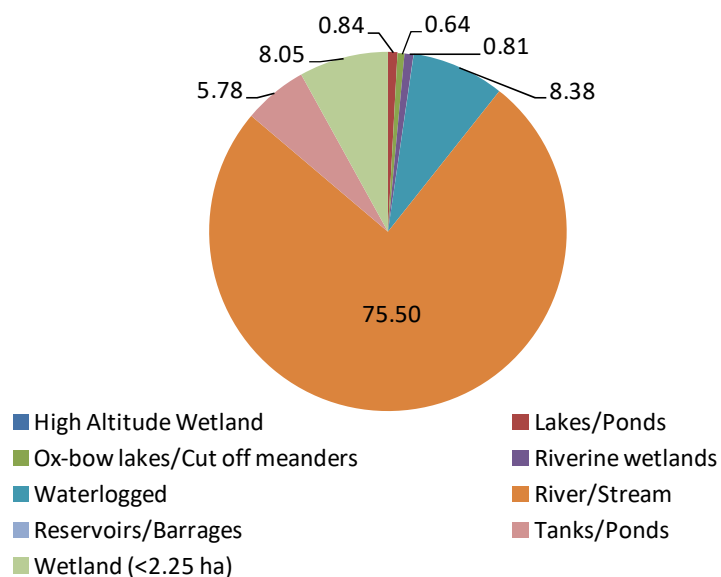


Fig. 3i Wetlands in district Kanpur Nagar (Uttar Pradesh)

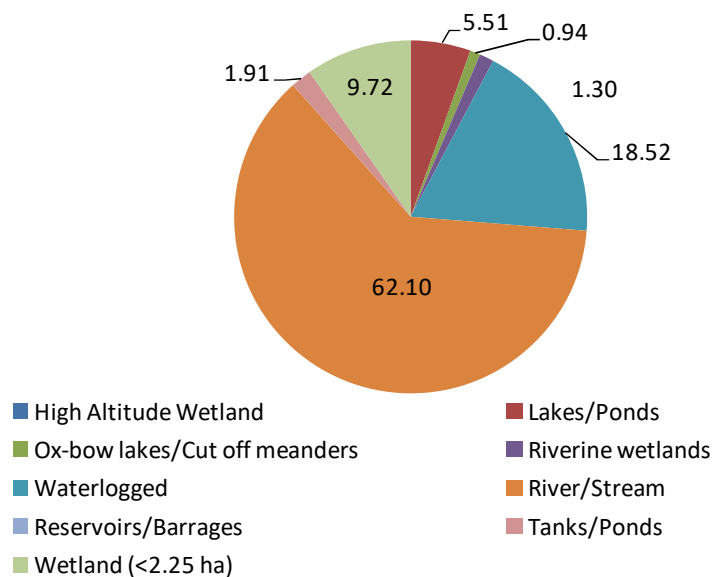


Fig. 3j Wetlands in district Fatehpur (Uttar Pradesh)

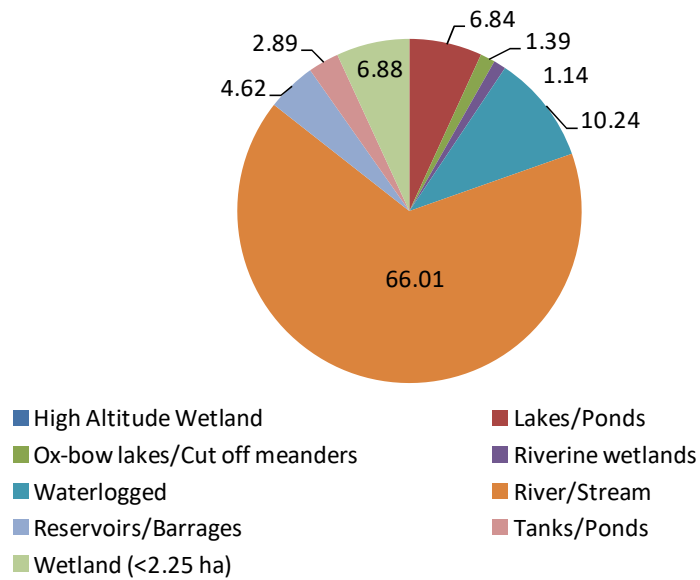


Fig. 3k Wetlands in district Allahabad (Uttar Pradesh)

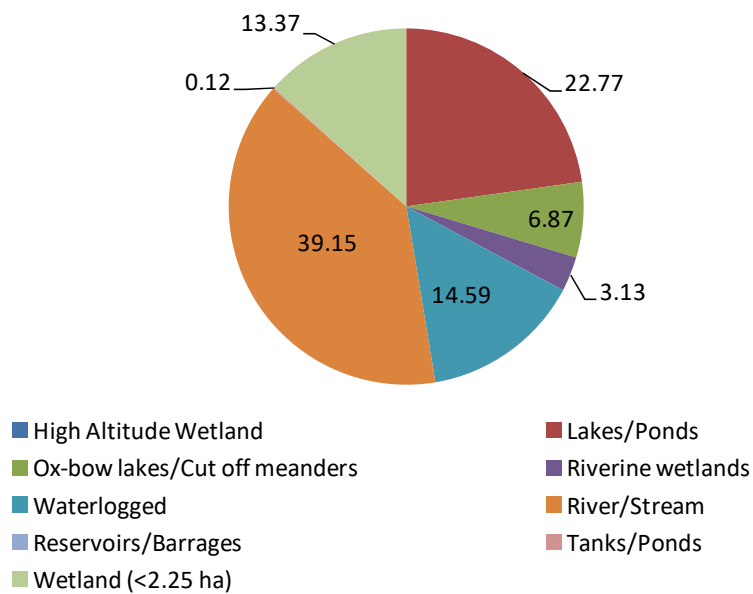


Fig. 3l Wetlands in district Azamgarh (Uttar Pradesh)

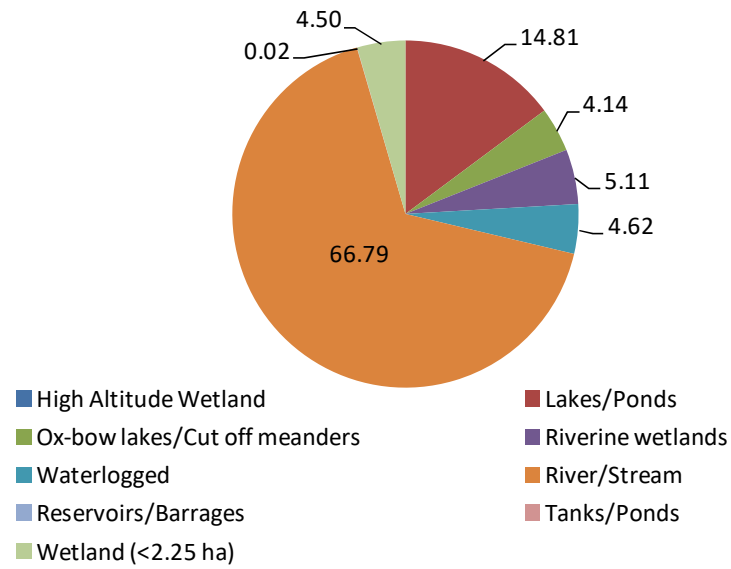


Fig. 3m Wetlands in district Ballia (Uttar Pradesh)

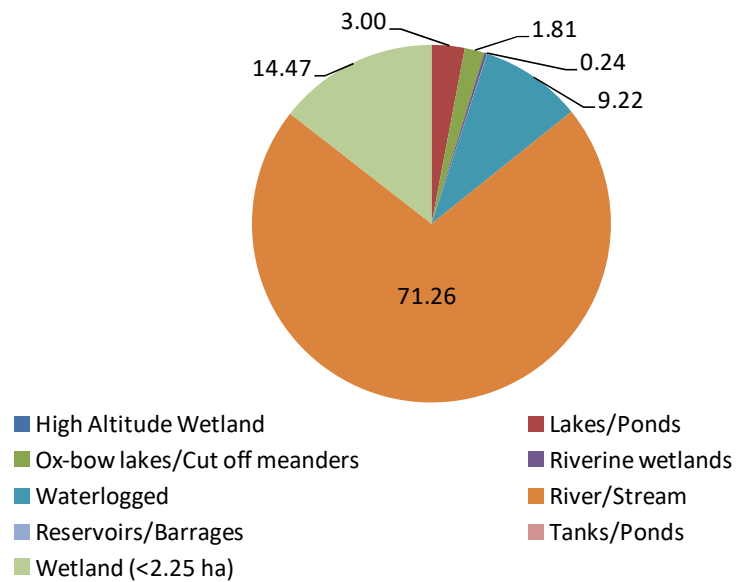


Fig. 3n Wetlands in district Varanasi (Uttar Pradesh)

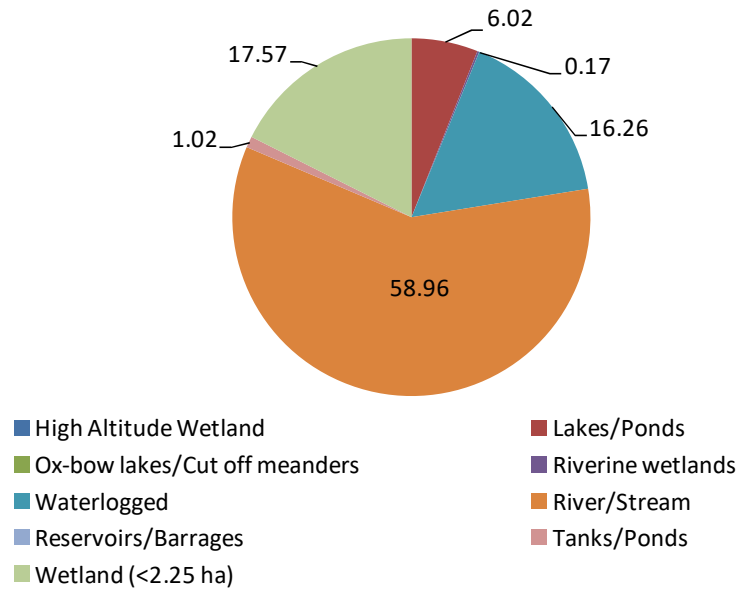


Fig. 3o Wetlands in district Sant Ravidas Nagar (Uttar Pradesh)

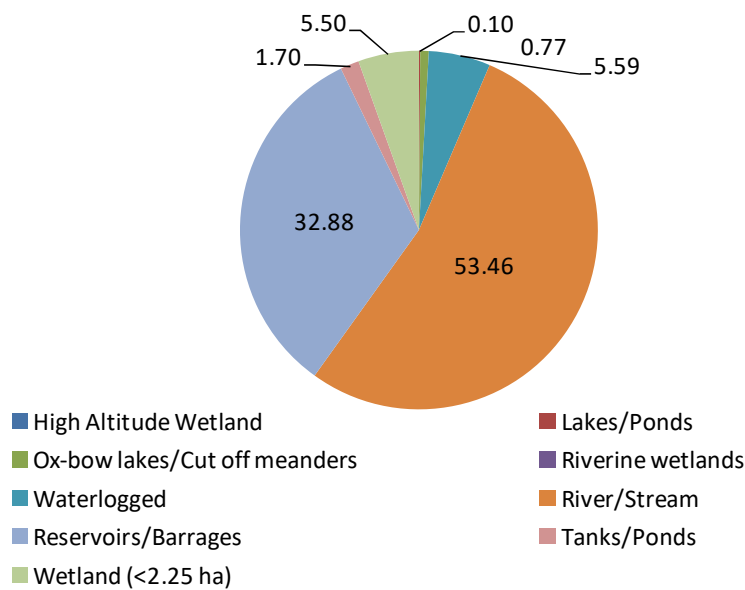


Fig. 3p Wetlands in district Mirzapur (Uttar Pradesh)

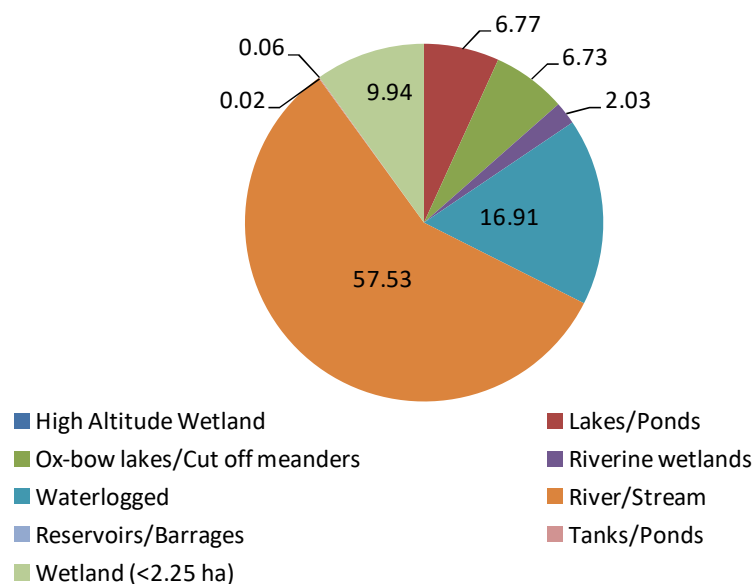


Fig. 3q Wetlands in district Ghazipur (Uttar Pradesh)

Table 2 a: Area estimates of wetlands of Saharanpur

Sl. 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
8	Total	789	11537	100.00

Table 2 b: Area estimates of wetlands in district Bijnor

Sl. 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
9	Total	1708	17879	100.00

Table 2 c: Area estimates of wetlands of Jyotiba Phule Nagar

Sl. 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
8	Total	542	11026	100.00

Table 2 d: Area estimates of wetlands in district Bulandshahar

Sl. 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
8	Total	1243	9193	100.00

Table 2 e: Area estimates of wetlands in district Raebareli

Sl. 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
9	Total	3057	38540	100.00

Table 2 f: Area estimates of wetlands in district Farrukhabad

Sl. 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
8	Total	770	22309	100.00

Table 2 g: Area estimates of wetlands in district Kannauj

Sl. 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
9	Total	592	8190	100.00

Table 2 h: Area estimates of wetlands in district Kanpur Dehat

Sl. 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
9	Total	2313	11603	100.00

Table 2 i: Area estimates of wetlands in district Kanpur Nagar

Sl. 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
8	Total	1527	14770	100.00

Table 2 j: Area estimates of wetlands in district Fatehpur

Sl. 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
8	Total	2441	20435	100.00

Table 2 k: Area estimates of wetlands in district Allahabad

Sl. 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
9	Total	2377	27487	100.00

Table 2 l: Area estimates of wetlands in district Azamgarh

Sl. 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
8	Total	3760	25472	100.00

Table 2 m: Area estimates of wetlands in district Ballia

Sl. 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
8	Total	1691	32047	100.00

Table 2 n: Area estimates of wetlands in district Varanasi

Sl. 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
7	Total	1130	7470	100.00

Table 2 o: Area estimates of wetlands in district Sant Ravidas Nagar

Sl. 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
8	Total	1130	5767	100.00

Table 2 p: Area estimates of wetlands in district Mirzapur

Sl. 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
8	Total	2258	27487	100.00

Table 2 q: Area estimates of wetlands in district Ghazipur

Sl. 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
9	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*

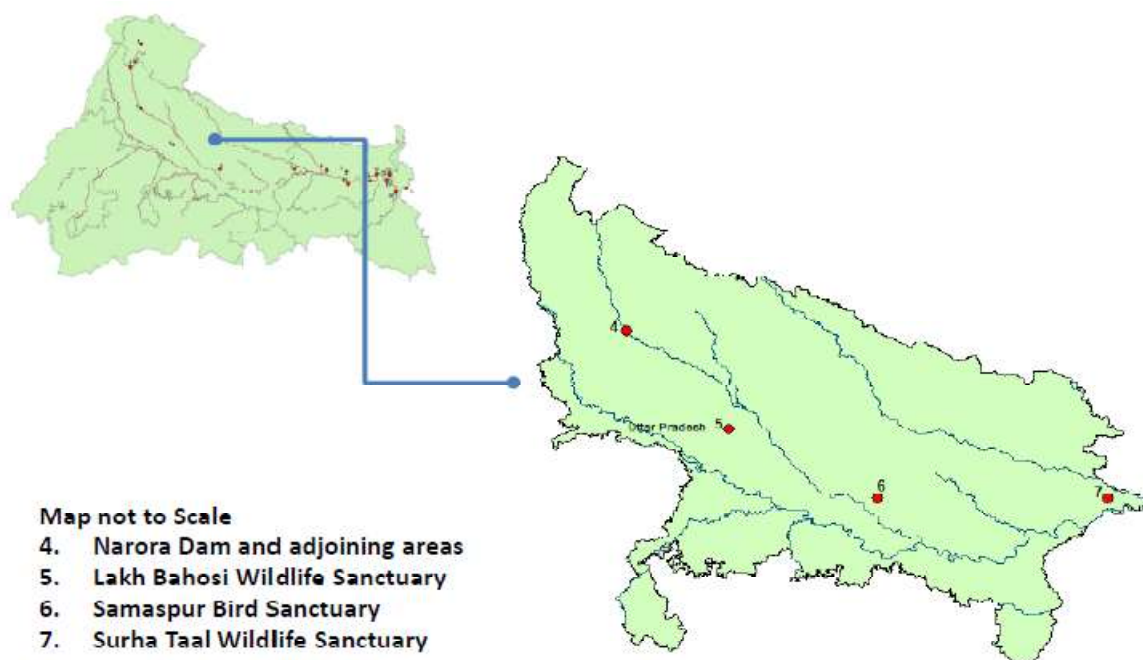


Fig. 4 The wetlands of Uttar Pradesh

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 chauras, 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-l). The area estimates district wise is depicted in Table 3 (a-l). Geographical locations are shown in Google earth Figure 6.

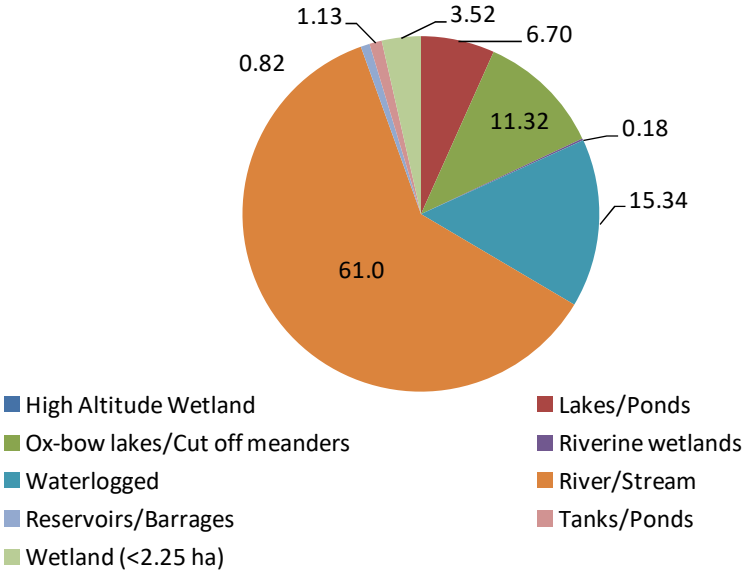


Fig. 5a Wetlands in district Purnia (Bihar)

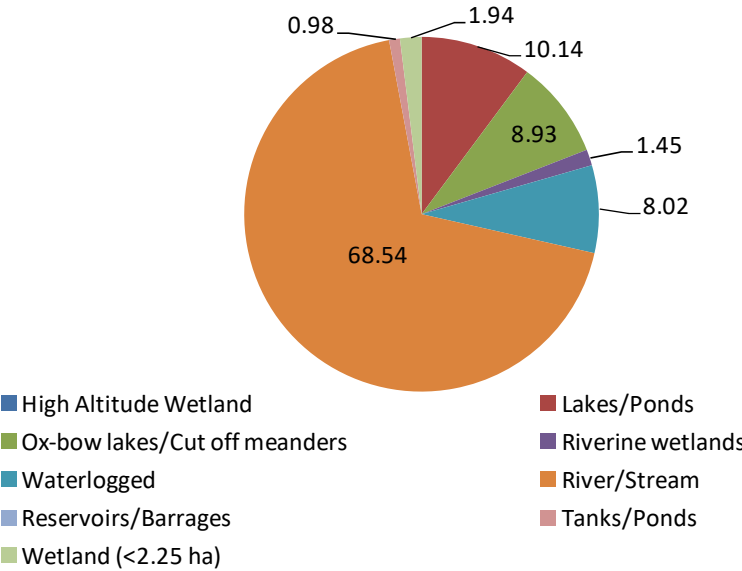


Fig. 5b Wetlands in district Katihar (Bihar)

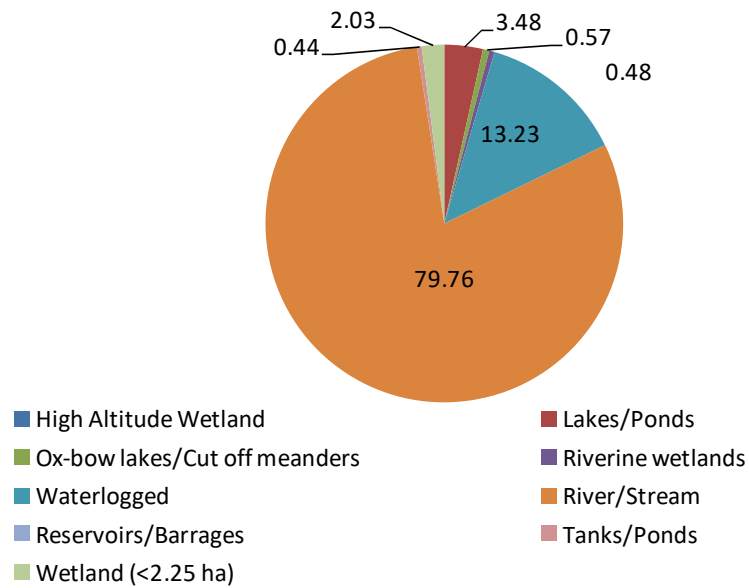


Fig. 5c Wetlands in district Saran (Bihar)

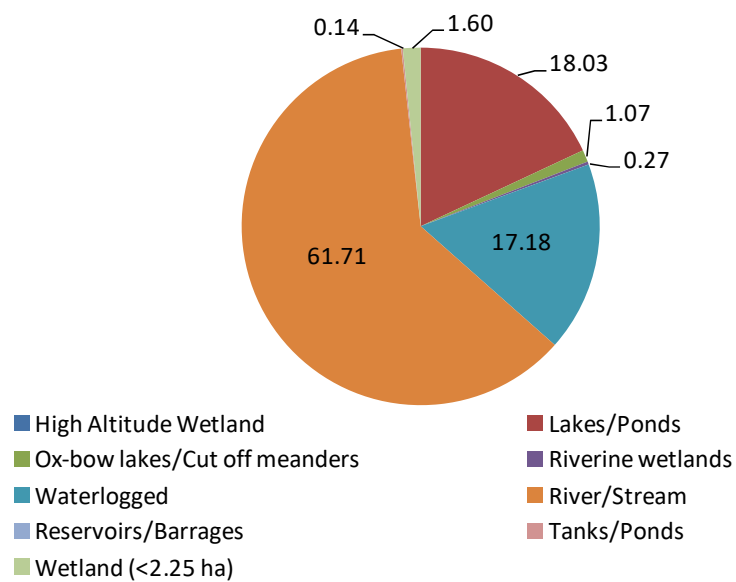


Fig. 5d Wetlands in district Vaishali (Bihar)

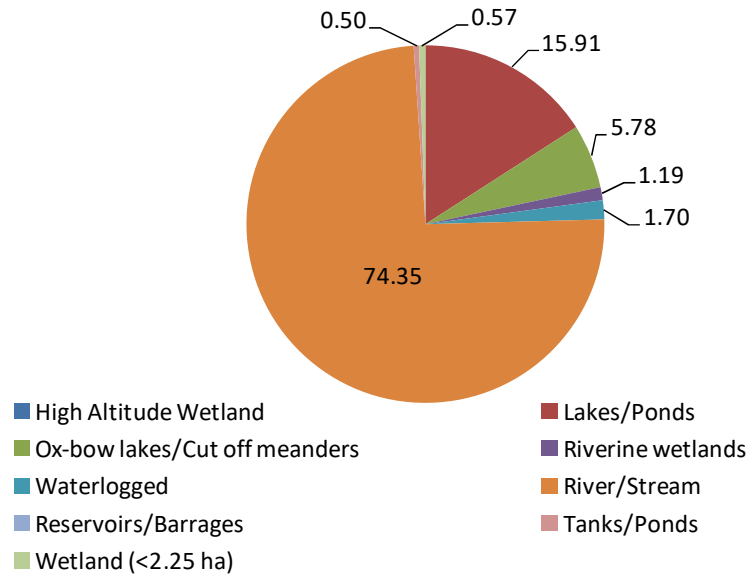


Fig. 5e Wetlands in district Begusarai (Bihar)

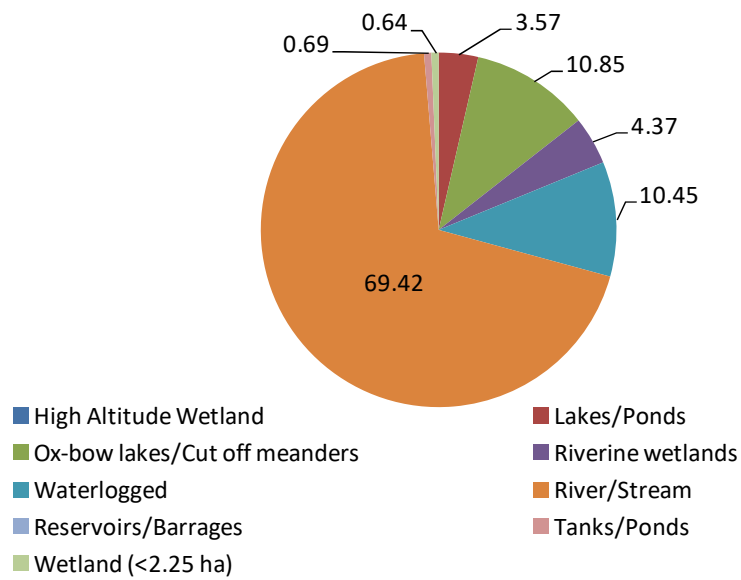


Fig. 5f Wetlands in district Khagoria (Bihar)

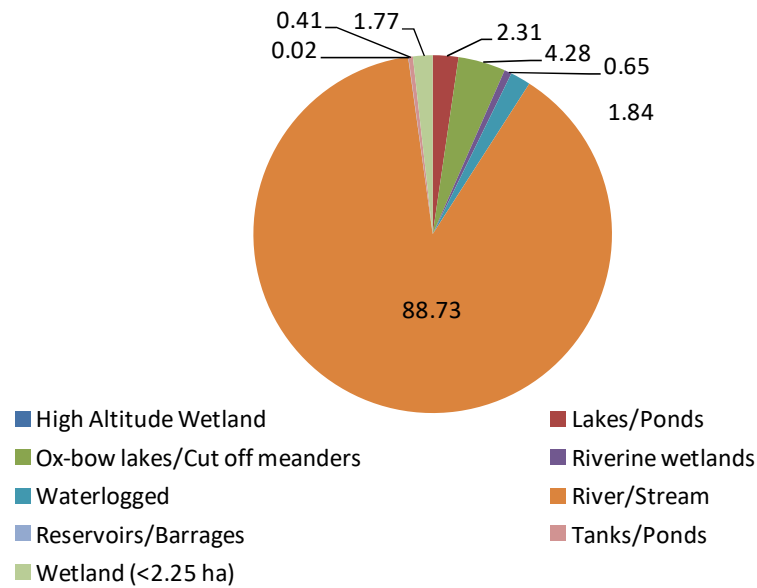


Fig. 5g Wetlands in district Bhagalpur (Bihar)

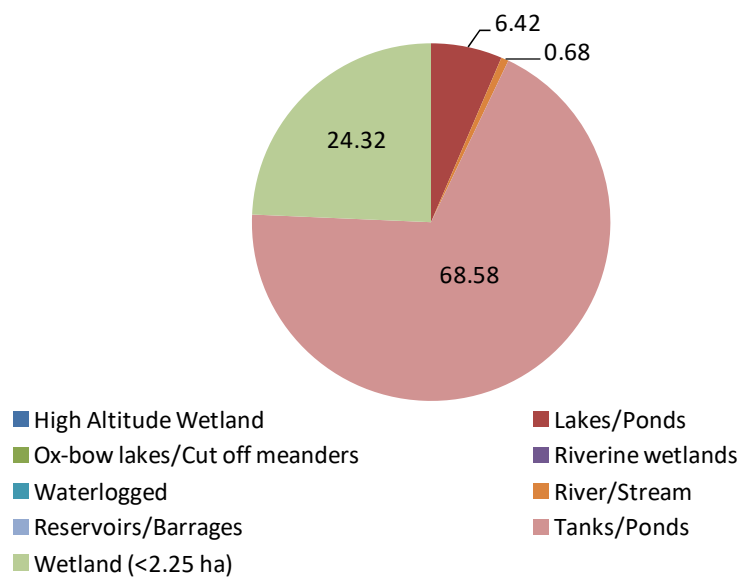


Fig. 5h Wetlands in district Sheikhpura (Bihar)

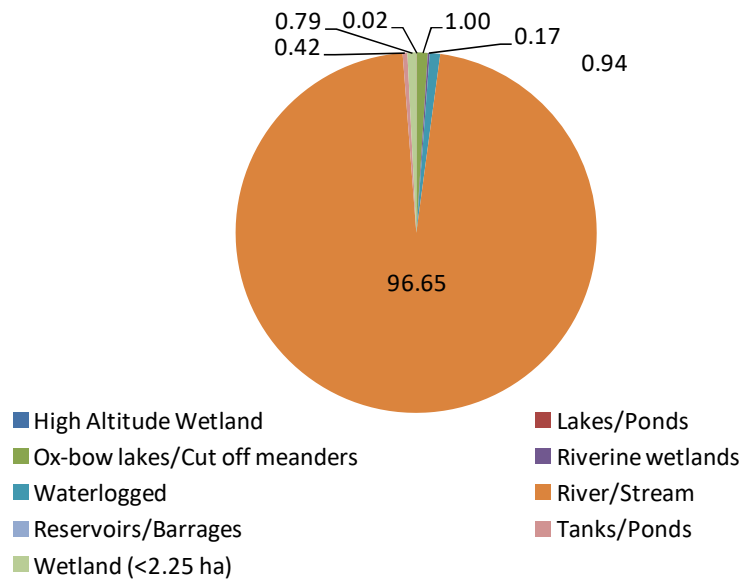


Fig. 5i Wetlands in district Patna (Bihar)

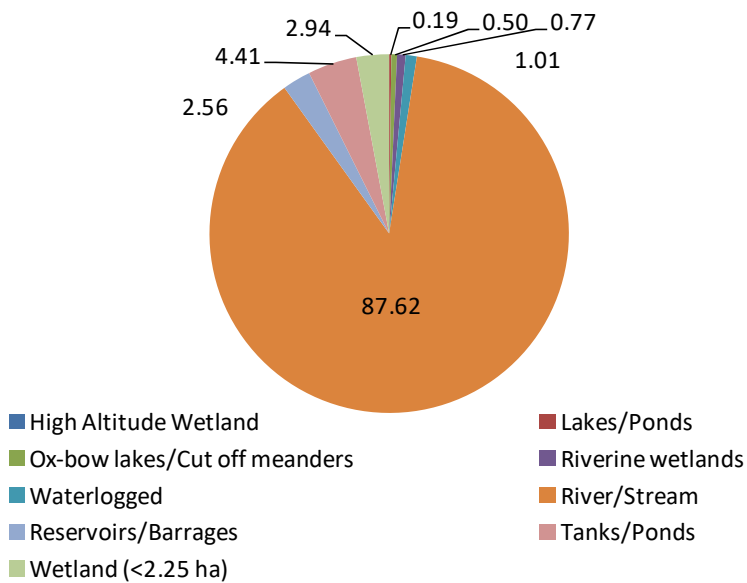


Fig. 5j Wetlands in district Lakhisarai (Bihar)

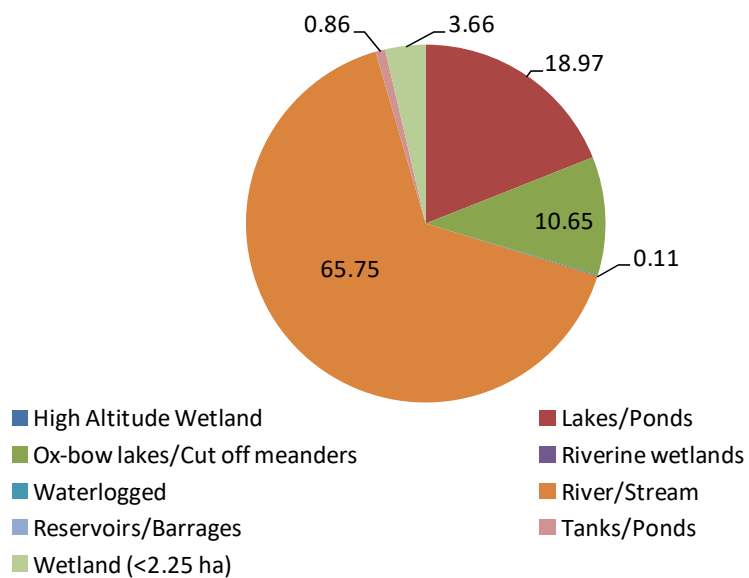


Fig. 5k Wetlands in district Buxar (Bihar)

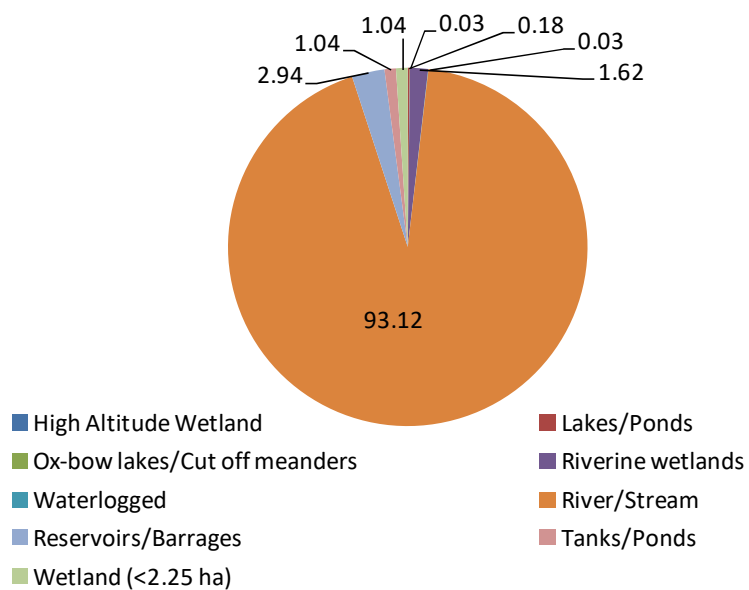


Fig. 5l Wetlands in district Munger (Bihar)

Table 3 a: Area estimates of wetlands in district Purnia

Sl. 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
9	Total	876	12401	100.00

Table 3 b: Area estimates of wetlands in district Katihar

Sl. 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
8	Total	1302	31011	100.00

Table 3 c: Area estimates of wetlands in district Saran

Sl. 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
8	Total	543	21170	100.00

Table 3 d: Area estimates of wetlands in Vaishali

Sl. 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
8	Total	402	17168	100.00

Table 3 e: Area estimates of wetlands in Begusarai

Sl. 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
8	Total	267	20365	100.00

Table 3 f: Area estimates of wetlands in Khagoria

Sl. 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
8	Total	288	11645	100.00

Table 3 g: Area estimates of wetlands in Bhagalpur

Sl. 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
9	Total	605	24171	100.00

Table 3 h: Area estimates of wetlands in Sheikhpura

Sl. 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
5	Total	126	296	100.00

Table 3 i: Area estimates of wetlands in Patna

Sl. 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
8	Total	227	20678	100.00

Table 3 j: Area estimates of wetlands in Lakhisarai

Sl. 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
8	Total	194	4177	100.00

able 3 k: Area estimates of wetlands in Buxar

Sl. 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
7	Total	158	3717	100.00

Table 3 l: Area estimates of wetlands in Munger

Sl. 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
9	Total	195	11979	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*

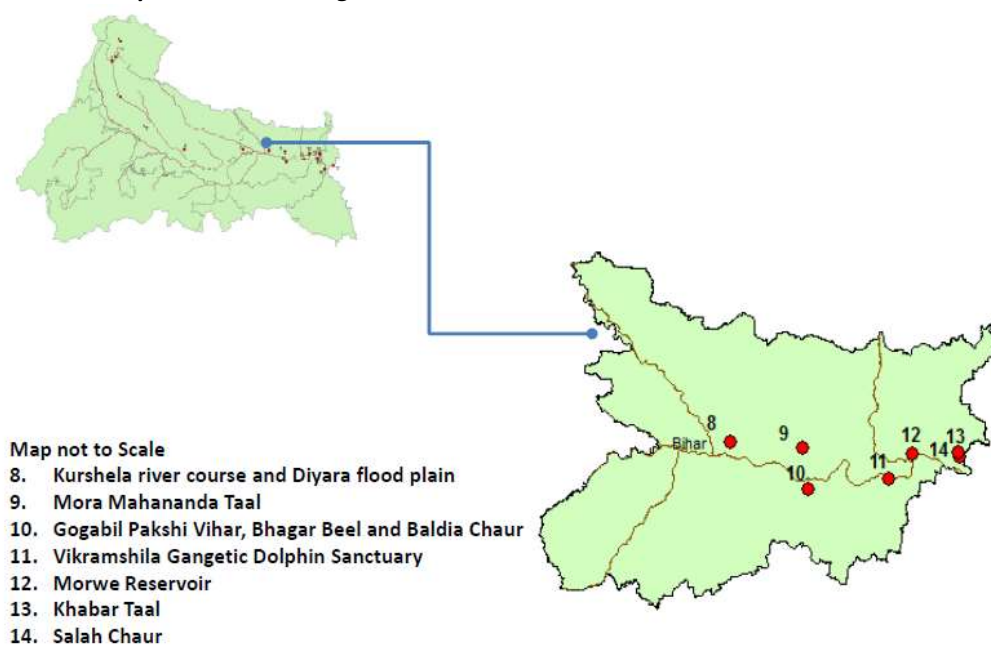


Fig. 6 The wetlands of Bihar

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 ponds 17.75% 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.

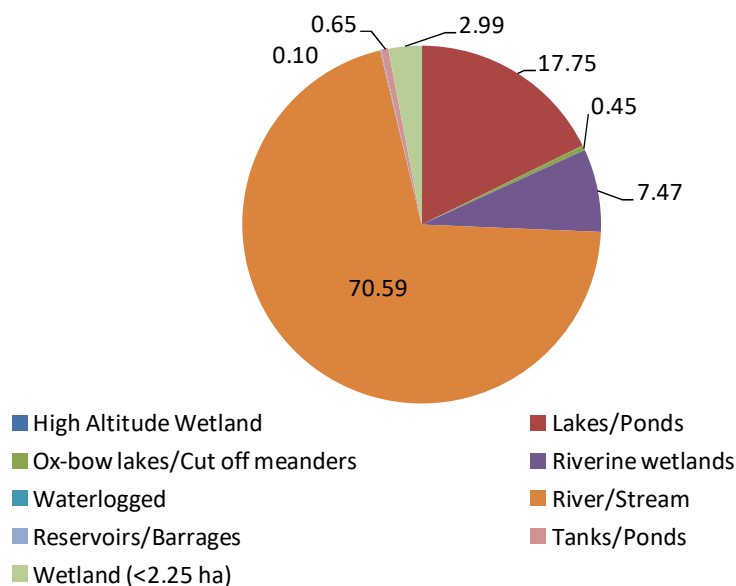


Fig. 7 Wetlands in district Sahibganj (Jharkhand)

Table 4: Area estimates of wetlands in Sahibganj

Sl. 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
8	Total	555	16118	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)*

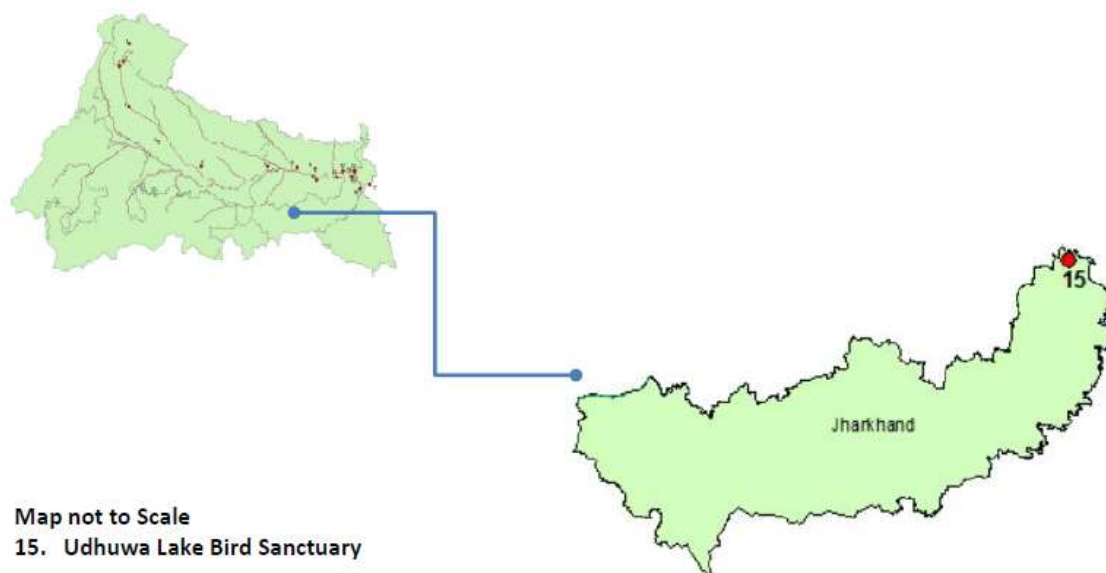


Fig. 8 The wetlands of Jharkhand represented in the Google earth map

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.

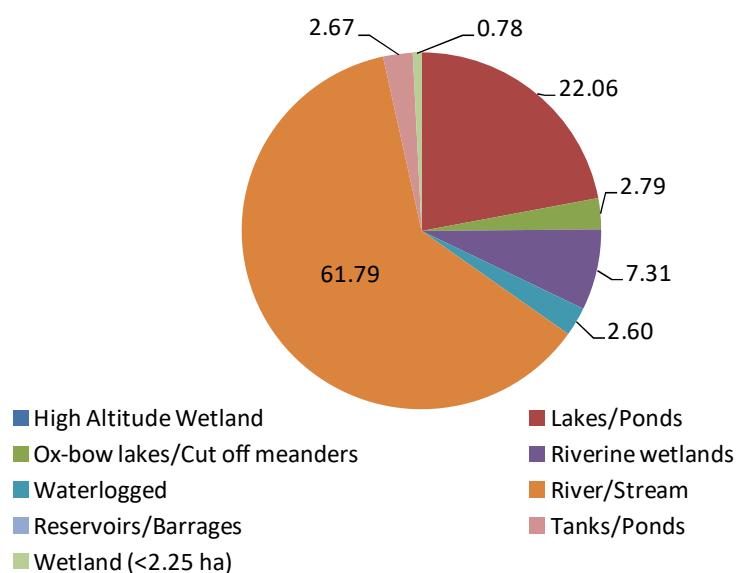


Fig. 9 Wetlands in district Malda (West Bengal)

Table 5: Area estimates of wetlands in Malda

Sl. 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
8	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*

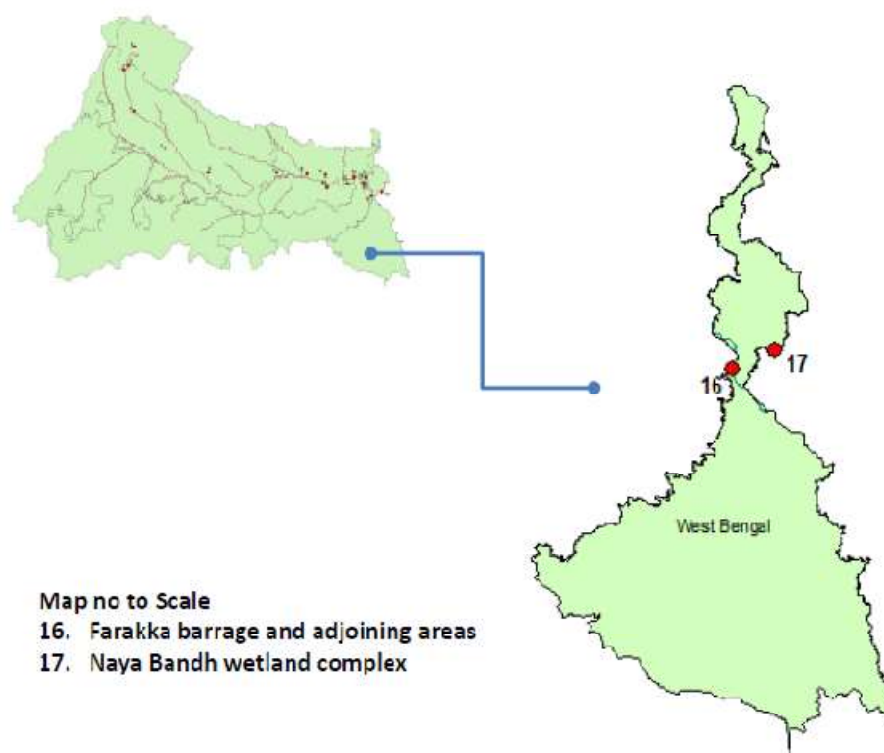


Fig. 10 The wetlands of Malda (West Bengal)

3. Biodiversity of some wetlands in the Ganga river basin

1. Banganga wetland: Banganga wetland is situated in the state of Uttarakhand. It is a riverine wetland and originates near Bishenpur and flows through the Haridwar district of Uttarakhand. 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 and Blacknaped Hare are other the key species found here.

5. Samaspur Bird Sanctuary: It is situated in the Raebareilly 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 Kathiwar 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 Kathiwar 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 bicolor* (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 common avian 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 testudineus*) 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. Udhwa 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 bicolor* (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)

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

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

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

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

157.	<i>Zizyphus mauritiana</i>	Rhamnaceae
158.	<i>Potentilla supina</i>	Rosaceae
159.	<i>Hedyotis corymbosa</i>	Rubiaceae
160.	<i>Wendlandia exserta</i>	Rubiaceae
161.	<i>Bacopa monnieri</i>	Scrophulariaceae
162.	<i>Bacopa procumbens</i>	Scrophulariaceae
163.	<i>Lindernia ciliata</i>	Scrophulariaceae
164.	<i>Mazus pumilus</i>	Scrophulariaceae
165.	<i>Verbascum chinense</i>	Scrophulariaceae
166.	<i>Veronica anagallis-aquatica</i>	Scrophulariaceae
167.	<i>Nicotiana plumbaginifolia</i>	Solanaceae
168.	<i>Physalis minima</i>	Solanaceae
169.	<i>Solanum nigrum</i>	Solanaceae
170.	<i>Solanum torvum</i>	Solanaceae
171.	<i>Solanum viarum</i>	Solanaceae
172.	<i>Tamarix dioica</i>	Tamaricaceae
173.	<i>Trapa natans var bispinosa</i>	Trapaceae
174.	<i>Typha elephantina</i>	Typhaceae
175.	<i>Pouzolzia pentandra</i>	Urticaceae
176.	<i>Pouzolzia zeylanica</i>	Urticaceae
177.	<i>Utricularia</i> sp.	Utriculariaceae
178.	<i>Phyla nodiflora</i>	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*, *Anas acuta*, *Anas clypeata*, *Anas crecca*, *Tadorna ferruginea*, *Anas Penelope*, *Nettapus coromandelianus*, *Rostratula benghalensis*, *Hydrophasianus chirurgus*, *Metopidius*

indicus, *Dendrocygna javanica* 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 Encroachment
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 Chaur	Bihar	Poaching 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 <i>T. ilisha</i> 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 indulgence 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.

(l) 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.

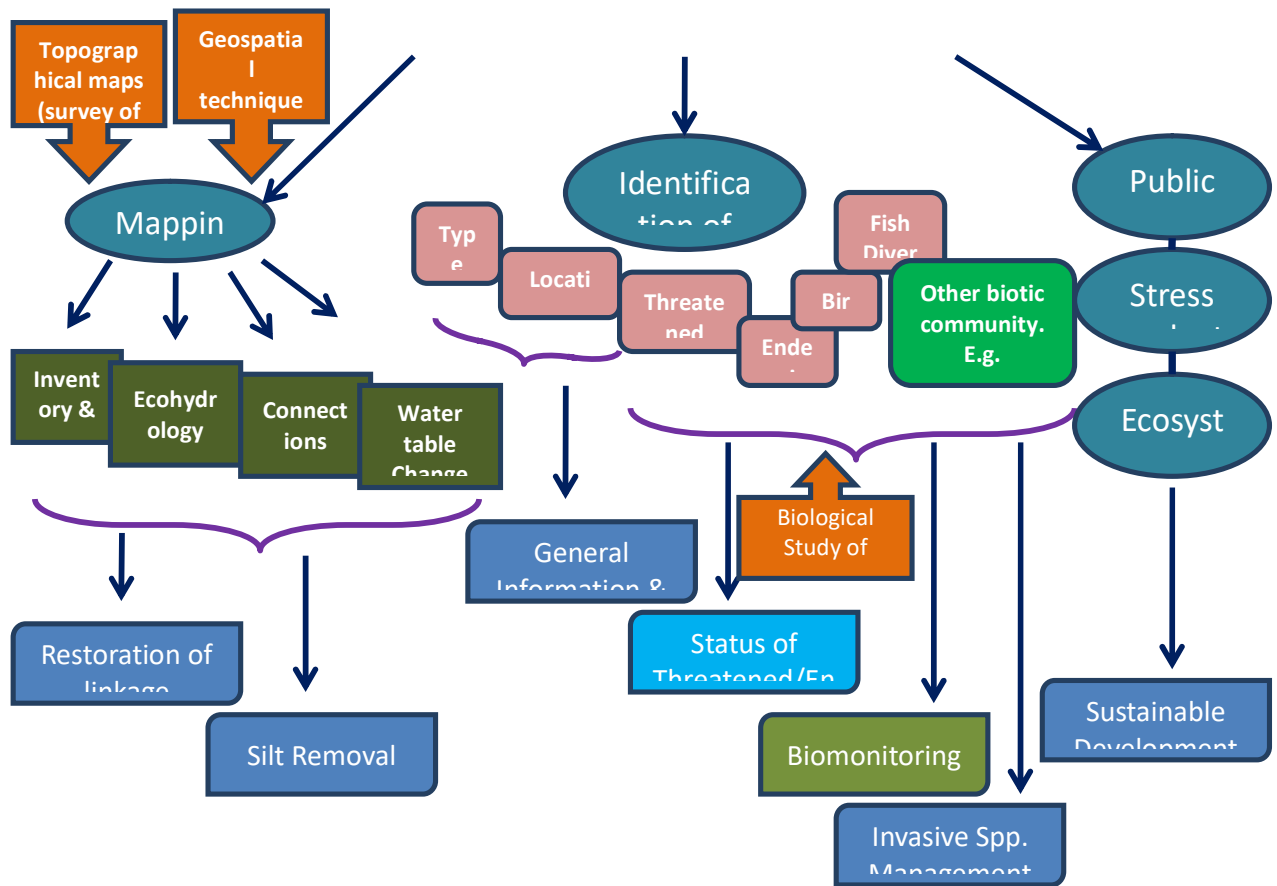


Fig. 11 Line Diagram of the Management Plan

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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