

Status of Wetlands in Bihar: Degradation and Their Sustainable Management

Paper Submission: 12/08/2020, Date of Acceptance: 24/08/2020, Date of Publication: 25/08/2020



Gautam Pandey

PGT,(Geography)

Senior Secondary School Rampur
dih, Bhagalpur, Bihar, India

Abstract

Wetlands are sensitive ecosystems located between terrestrial and aquatic ecosystems. It is distributed in all the climatic regions of the Earth, but is spread over the largest area between 50° N to 70° N latitude. In India, wetlands have spread about 4.5 percent of its total area. Study area Bihar is a landlock state in the eastern part of India. It is completely located in the drainage area of the Ganges and its tributaries. The wetlands of Bihar are under the category of inland wetlands mostly in floodplains, lakes, oxbow lakes and manmade water bodies. Its spread over an area of 4032 km² which is 4.40 percent of the total geographical area of Bihar. These wetlands are the base of water for domestic uses, irrigation for agriculture, fisheries and other important works. With the increasing economic development, the degradation of wetlands is taking place due to changing land use pattern, infrastructure development, excessive use of chemical fertilizers and pesticides in agriculture. Proper management is necessary to protect the existence of wetlands. We need to develop such models of development which are not subject to the loss of wetlands. This seems possible by providing immediate protection to wetlands, proper monitoring and making people aware to the protection of wetlands.

Keywords: Ecosystem, permafrost, Inland Wetlands, Degradation, Sustainable Management,

Introduction

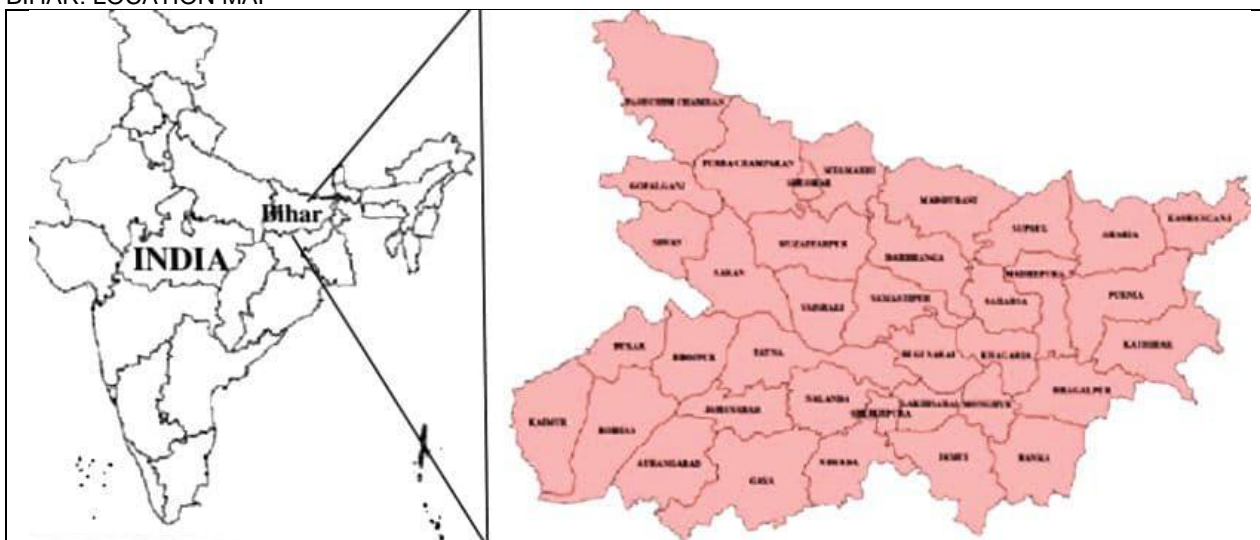
Wetlands are transitional ecosystems between terrestrial and aquatic ecosystem. It is saturated with water for extended periods of time, either seasonally or permanently. The saturated state of water in the land gives unique recognition to the wetland and living organism, which makes it distinct from the surrounding ecosystem. Wetland is common in all types of climate like Equatorial rain forest, Savanna grassland, Monsoon region, Hot deserts, Taiga and Tundra. In all climatic regions their position is usually in the coastal region, along with rivers, lakes, periglacial and marshy areas. Globally the distribution, nature and type of wetlands are determined by some geographical factors. Climate is the most important geographical factor. In addition, the nature and amount of precipitation, evaporation, degree of slope, type of rock and soil affects the nature and distribution of wetland. In order to understand the effect of climate on wetland it can be seen that Inland wetland found in Amazon basin of Brazil is developed by abundance of water is result of heavy precipitation while wetlands of Scandinavia and Siberia are the result of freeze and thaw process of permafrost. Regions where nature of precipitation is seasonal, slope of land is gentle becomes ideal sites for development of wetlands. Wetlands of floodplains have developed in this way. Regions where amount of precipitation is relatively small but its distribution is uniform in all months, there is a good support for the development of wetlands. In western European type of climate, wetlands have been developed in this condition. Considering these geographical factors if the distribution of wetlands is observed globally, it is clear that wetlands are prominently in the arctic and boreal region. "Nearby half of the world's wetlands may occur between 50°- 70° north latitude. More than one third of Earth's wetlands exist between 20° N to 30° S latitude. The remaining one fifth may be found in temperate regions."¹ Globally wetlands cover an area between 915 million hectare to 1275 million hectare with an estimated economicvalue of about us\$ 15 trillion in a year."²

Wetlands have been defined from time to time by subject experts, research institutions, government agencies and international institutions. Cawardin define wetlands as, "Wetlands are the transitional zone between land and water, where saturation with water is the dominate factor determining the nature of soil development and the type of plant and animal communities living in on it."³ The US department of Interior Fish and Wildlife service Authority adopted the definition of Cawardin. According the Paijman, "Wetlands are permanently or temporarily underwater or waterlogged"⁴. According to Semeniuk CA. and SemeniukV., "areas of seasonally,intermittently or permanently waterlogged soils or inundated land, whether natural or artificial, fresh or saline."⁵ Indian Space Research Organization defines wetlands,"all submerged or water saturated lands, natural or manmade, inland or coastal, permanent or temporary, static or dynamic, vegetated or non vegetated, which necessarily have a land water interface."⁶ Government of Indian Ministry of Environment and Forest defines as," wetland is an area of marsh, fen, peat land or water, 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 and includes all inland waters such as lakes, reservoir, tanks, backwaters, lagoon, creeks estuaries and manmade wetland."⁷The first International summit on wetland took place in Ramsar city, Iran in 1971. This summit detailed discussion on various aspects of wetland such as definition,distribution,degradation and conservation. For the first time in this summit, wetland is defined on the broad scale which is mentioned below in its article 1.1 and 2.1. Under the text of convention(Article 1.1), wetlands are defined as," area of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary with water thatthat is static or flowing, fresh brackish or salty, BIHAR: LOCATION MAP

including areas of marine water, the of which at low tide does not exceed six meter"⁸. In addition, for the purpose of protect the coherent sites, the article 2.1included in the Ramsar list to internationally important wetlands, "may incorporate riverine and coastal or bodies of marine water deeper than six meter at low tide lying within the wetlands."⁹

Study Area

Bihar is located in the eastern part of country with an area of 94163 km² which is 2.86 percent of total area of country and ranks 13th in terms of area. It is lies between 24^o 20' 10" N to 27^o 31' 15" N latitude and 83^o 19' 50" E longitude to 88^o 17' 40" E longitude. It is a landlocked state bounded by Nepal in the north and by Jharkhand in south. It lies between the humid West Bengal in east and the sub humid Uttarpradesh in west. This location of state provides a transitional character in respect to climate, culture, economy and agriculture. River Ganga flows from west to east and divides the state in two unequal halves i.e. North Bihar plain and South Bihar plain. The North Bihar plain has been formed by the deposits of the Ganges tributaries originated from the Himalayas. This plain is dominated by fertile new alluvial soil, which is the result of recurring floods. The plain is rich in water resources and wetlands meet over a wide area. While the plain of south Bihar is formed by the rivers originated from the peninsular plateau.It has the primacy of old alluvial soil. Somewhere small hills are seen in this plain,among themKaimur hills, Rajgir hills and Kharagpur hills are prominent. This plain is not as rich in water resources and wetlands as the North Bihar plain. According to the census 2011, Bihar has a total population of 10.40 crore, resides in 38 districts and constitutes 8.6 percent of the total population of the country. About 88 percent of the total population of the state is rural. People depends on wetlands for domestic uses, irrigation, fisheries, food, fodder and many other useful and essential needs.



PURPOSE OF THE STUDY:The purpose of the present study is related to the status, importance, degradation and management of wetlands in the state of Bihar. This can be seen in the following points:

- Demonstrate the distribution of wetlands in Bihar at the district level.
- Clarify disparity in distribution of wetlands in the state.

- Underline the economic, cultural and environmental importance of wetlands in the context of the large population of the Bihar.
- To draw attention to the damage of wetlands due to increasing human activities and changing environmental conditions.
- To give some suggestions for making the necessary strategy to sustainable management of wetlands in Bihar.

DATABASE AND METHODOLOGY: The present research paper is mainly based on secondary sources of data, which has been received from the Ministry of Environment and Forest Government of India and Department of Environment, Forest and Climate Government of Bihar. First these data of Wetlands in Bihar have been tabulated, then suitable map has been drawn based on these tables. After this it has been analyzed. Based on the obtained results, problems of the wetlands in Bihar have been analyzed and necessary suggestions have been made for their sustainable management.

Importance of wetlands: Wetlands provide many resources and service to us. It supplies water for agriculture and domestic uses. It recharges the ground water. In flood prone areas wetlands also play an important role to control the flood hazard. It helps to reduce the impact of flooding by absorbing water and slowing flood water flows. Along with this, wetlands have a significant contribution in the fisheries industry. About 60 percent of total fish production in India comes from inland water bodies such as river, pond, lake and canal. It has not only economic but environmental and cultural importance. Then other terrestrial ecosystem carbon density is relatively high in wetlands. Having enough carbon absorption capacity helps to maintain the oxygen-carbon dioxide ratio in atmosphere. Wetlands are the

hotspot of biodiversity. A large number of aquatic species, amphibians, reptiles, birds reside here. Wetlands are the center of special attraction to tourism. Sea beaches, lagoons, lakes are hot spot of tourism.

Distribution of wetlands: India with its large area, unique climate and geographical position supports a large area of wetlands, distributed in different regions of country like humid north east to hot arid Thar and cold arid Laddakh plateau to wet Malabar and Deccan plateau. Wetlands are also common in islands like Andaman and Lakshdweep. Along with this it has a nice extension in riverine plains. "The available estimate about the areal extension of wetland in India vary widely from a lowest of 1 percent to highest 5 percent of geographical area, but do support nearly fifth of the known biodiversity."¹⁰ According to the National Wetland Atlas 2011, "India has about 55.06 thousand wetlands with an area of 15.30 million hectare nearly 4.7 percent of total area of the country. Out of this, inland wetland shares 69 percent, coastal wetlands 27 percent and other wetlands 4 percent."¹¹ Bihar accounts for 8.58 percent population of the country in 2.42 percent of the land. It is a landlocked state lies in the Gangetic drainage system. Bihar is blessed with water resource in the form of numerous rivers and streams like Ganga, Ghaghra, Gandak, Kamla, Kosi, Mahananda, Son, Falgu, Harohar, Kiul and Chandan flow from here. In north Bihar most of them have changed their course very frequently, which causes the problem of recurring floods. The wetlands of Bihar are mainly floodplains, lakes, marshes and manmade water bodies. According to the data of Department of Environment, Forest and Climate Government of Bihar 2017, the total area of wetlands in Bihar is 4031.82 km², it is 4.40 percent of the total area of Bihar.

Table no. 1.1
Bihar: Category wise status of Wetlands - 2017

Wetland Category	No. of Wetlands	Total area of Wetlands (in hectare)	Percentage of total Wetlands area
1. Natural Wetlands	3214	371857	92.23
(i) River/Stream	438	300526	74.54
(ii) Waterlogged	1300	34878	8.65
(iii) Lake/Pond	514	20281	5.03
(iv) Ox-bow lake	989	16172	4.01
2. Manmade Wetlands	1175	13770	3.41
(i) Reservoir/ Barrage	90	8612	2.14
(ii) Tank/ Pond	1067	4822	1.20
(iii) Water logged	18	336	0.08
3. Wetlands (<2.25 hectare)	17582	17555	4.36
Total	21998	403182	100.00

Source: National Wetlands Atlas Bihar - 2015

Table no. 1.1 shows the category wise status of Wetlands in Bihar. All Wetlands of Bihar are inland Wetland type, they can be placed in three category, natural Wetlands, manmade Wetlands and Wetlands smaller than 2.25 hectare. The total number of Wetlands in Bihar is 21998, out of which natural wetlands are 3214, manmade wetlands are 1175 and Wetlands smaller than 2.25 hectare are 17582. Out of the total 3214 natural Wetlands, the number of riverine Wetlands is 438, water logged Wetlands

1300, lake or pond wetlands 514 and ox-bow lake or cut-off meander Wetlands are 989. Natural Wetlands cover an area of 371857 hectare, it is 92.23 percent of the total Wetlands area of Bihar. It includes river or stream Wetlands 300526 hectare, water logged Wetlands 34878 hectare, lake or pond Wetlands 20281 hectare and ox-bow lake or cut-off meander Wetlands 16171 hectare, which is 74.54 percent, 8.65 percent, 5.03 percent and 4.01 percent of total natural Wetlands respectively. It is clear from table no.

1.1 the total number of manmade Wetlands in Bihar is 1175, out of which reservoir or barrage is 90, tank or pond 1067 and water logged Wetlands are 18. Manmade Wetlands are spread over 13770 hectare, it is 3.41 percent of the total Wetlands area of Bihar, it includes reservoir or barrage Wetlands 8612 hectare, tank or pond Wetlands 4822 hectare and water

logged Wetlands 336 hectare, which is 2.14 percent, 1.20 percent and 0.08 percent of total man made Wetlands respectively. The number of Wetlands smaller than 2.25 hectare in Bihar is 17582 and it spreads at 17555 hectare which is 4.36 percent of the total Wetlands area of Bihar.

Table No. 1.2
Bihar: Distribution of wetlands at district level in Bihar- 2017

Districts	Total Geographic Area (in km ²)	Total wetlands (in km ²)	Percentage of total wetlands
Katihar	3010	310.11	7.69
Bhagalpur	2502	241.71	5.99
West Champaran	4250	216.97	5.38
Saran	2624	211.70	5.25
Patna	3130	206.78	5.13
Begusarai	1889	203.65	5.05
Supaul	2989	192.85	4.78
Rohtas	3838	186.14	4.62
Vaishali	1995	171.48	4.25
Samastipur	2579	150.22	3.73
East Champaran	4155	124.77	3.09
Purnea	2303	124.01	3.08
Saharsa	1196	120.86	3.00
Munger	1419	119.79	2.97
Khagaria	1486	116.45	2.89
Gaya	4941	114.22	2.83
Bhojpur	2337	111.54	2.77
Kishanganj	1939	109.54	2.72
Muzaffarpur	3123	104.90	2.60
Banka	3020	98.95	2.45
Madhubani	3478	89.58	2.22
Darbhanga	2502	87.09	2.16
Aurangabad	3389	81.16	2.01
Jamui	2997	73.51	1.82
Gopalganj	2003	71.22	1.77
Siwan	2213	71.05	1.76
Nawada	2498	54.64	1.36
Jehanabad	1569	43.45	1.08
Lakhisarai	1229	41.77	1.04
Araria	2797	41.57	1.03
Buxar	1634	37.17	0.92
Madhepura	1797	35.39	0.88
Sitamarhi	2628	26.01	0.65
Nalanda	2362	15.89	0.39
Sheohar	443	14.76	0.37
Kaimur	1840	7.96	0.20
Sheikhpura	689	2.96	0.07
Arwal	-	-	-
Total	91689	4031.82	100.00

Source: Department of Environment, Forest and Climate, Government of Bihar, 2017

It is clear from table no. 1.2 that there is no uniformity in distribution of wetlands at the district level in Bihar. In areal coverage Katihar ranks first with 310.11 km² or 7.69 percent of total wetland area of Bihar followed by Bhagalpur 241.71 km² or 5.99 percent, West Champaran 216.97 km² or 5.38 percent, Saran 211.70 km² or 5.25 percent, Patna 206.78 km² or 5.13 percent, Begusarai 203.65 km² or 5.05 percent, Supaul 192.85 km² or 4.78 percent, Rohtas 186.14 km² or 4.62 percent, Vaishali 171.48 km² or 4.25 percent, Samastipur 150.22 km² or 3.73

percent, East Champaran 124.77 km² or 3.09 percent, Purnea 124.01 km² or 3.08 percent, Saharsa 120.86 km² or 3.00 percent, Munger 119.79 km² or 2.97 percent, Khagaria 116.45 km² or 2.89 percent, Gaya 114.22 km² or 2.83 percent, Bhojpur 111.54 km² or 2.77 percent, Kishanganj 109.54 km² or 2.72 percent, Muzaffarpur 104.90 km² or 2.60 percent, Banka 98.95 km² or 2.45 percent, Madhubani 89.54 km² or 2.22 percent, Darbhanga 87.09 km² or 2.16 percent, Aurangabad 81.16 km² or 2.01 percent, Jamui 73.51 km² or 1.82 percent, Gopalganj 71.22 km² or 1.77

percent, Siwan 71.05 km² or 1.76 percent, Nawada 54.64 km² 1.36 percent, Jehanabad 43.45 km² or 1.08 percent, Lakhisarai 41.77 km² or 1.04 percent, Araria 41.57 km² or 1.03 percent, Buxar 37.17 km² or 0.92 percent, Madhepura 35.39 km² or 0.88 percent,

Sitamarhi 26.01 km² or 0.65 percent, Nalanda 15.89 km² or 0.39 percent, Sheohar 14.76 km² 0.37 percent, Kaimur 7.96 km² or 0.20 percent and Shaikhpura 2.96 km² or 0.07 percent.

Table No. 1.3

Bihar: District wise share of wetlands to total Geographic area in Bihar- 2017

Districts	Total Geographic Area	Total wetlands	Percentage of total Geographic area
Begusarai	1889	203.65	10.78
Katihar	3010	310.11	10.30
Saharsa	1196	120.86	10.11
Bhagalpur	2502	241.71	9.66
Vaishali	1995	171.48	8.60
Munger	1419	119.79	8.44
Saran	2624	211.70	8.07
Khagaria	1486	116.45	7.84
Patna	3130	206.78	6.61
Supaul	2989	192.85	6.46
Samastipur	2579	150.22	5.82
Kishanganj	1939	109.54	5.65
West Champaran	4250	216.97	5.11
Rohtas	3838	186.14	4.86
Bhojpur	2337	111.54	4.77
Purnea	3203	124.01	3.87
Gopalganj	2003	71.22	3.56
Darbhanga	2502	87.09	3.48
Lakhisarai	1229	41.77	3.40
Muzaffarpur	3123	104.90	3.36
Sheohar	443	14.76	3.33
Banka	3020	98.95	3.28
Siwan	2213	71.05	3.21
East Champaran	4155	124.77	3.00
Jehanabad	1569	43.45	2.77
Madhubani	3478	89.85	2.58
Jamui	2997	73.51	2.45
Aurangabad	3389	81.16	2.39
Gaya	4941	114.22	2.31
Buxar	1634	37.17	2.27
Nawada	2498	54.64	2.19
Madhepura	1797	35.39	1.97
Araria	2797	41.57	1.49
Sitamarhi	2628	26.01	0.99
Nalanda	2362	15.89	0.67
Kaimur	1840	7.96	0.43
Sheikhpura	689	2.96	0.43
Arwal	-	-	-
Total	91689	4031.82	100.00

Source: Department of Environment, Forest and Climate, Government of Bihar, 2017

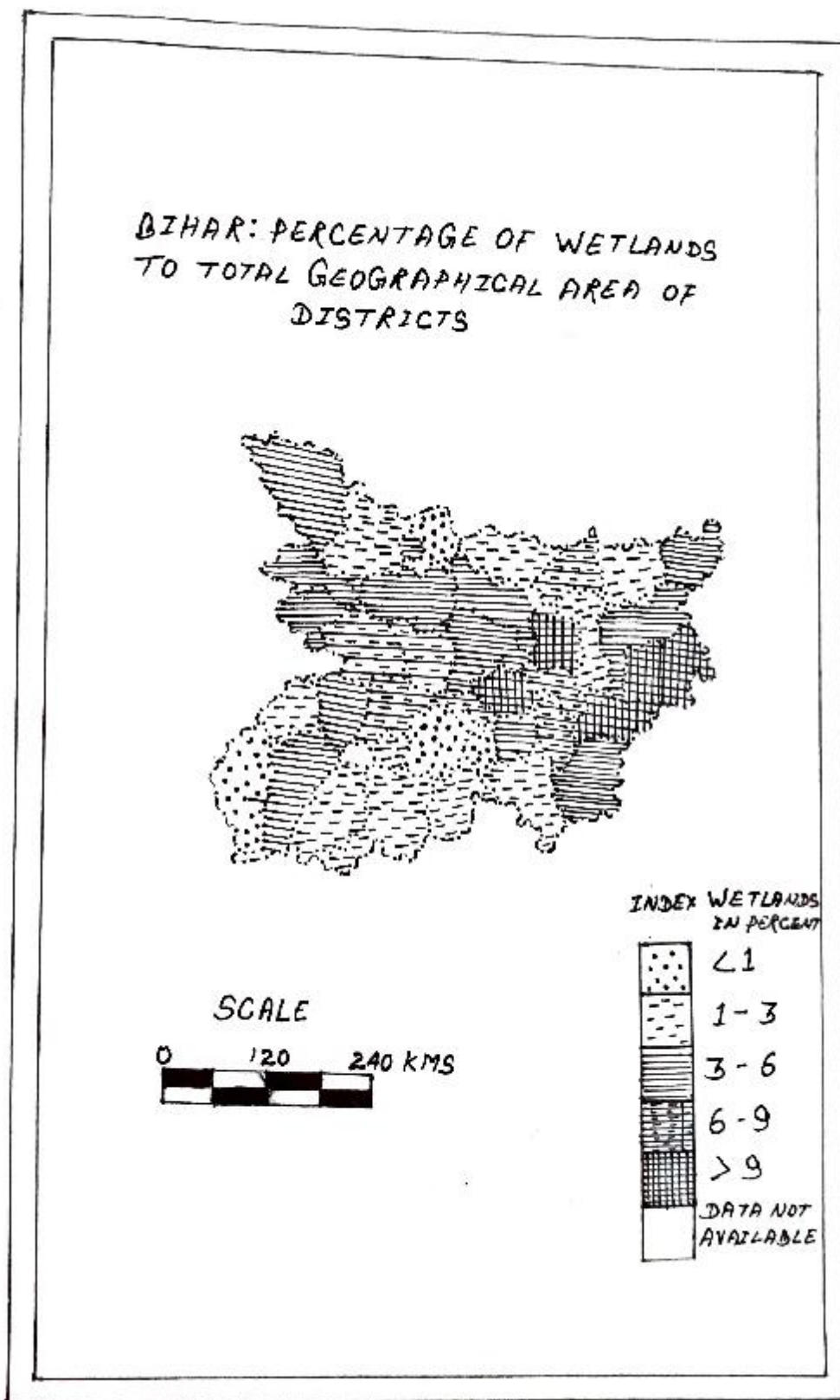


Table 1.3 shows the percentage share of wetlands in total Geographical area of districts of Bihar. Out of total Geographical area of Bihar 91689

km² wetlands are 4031.82 km² or 4.40 percent. On the basis of percentage share of wetlands in the total Geographical area Begusarai ranks first with 203.65

km² or 10.78 percent followed by Katihar 310.11 km² or 10.30 percent, Saharsa 120.86 km² or 10.11 percent, Bhagalpur 241.71 km² or 9.66 percent, Vaishali 171.48 km² or 8.60 percent, Munger 119.79 km² or 8.44 percent, Saran 211.70 km² or 8.07 percent, Khagaria 116.45 km² or 7.84 percent, Patna 206.78 km² or 6.61 percent, Supaul 192.85 km² or 6.46 percent, Samastipur 150.22 km² or 5.82 percent, Kishanganj 109.54 km² or 5.65 hectare, W. champaran 216.97 km² or 5.11 percent, Rohtas 186.14 km² or 4.86 percent, Bhojpur 111.54 km² or 4.77 percent, Purnea 124.01 km² or 3.87 percent, Gopalganj 71.22 km² or 3.56 percent, Darbhanga 87.09 km² or 3.48 percent, Lakhisarai 41.77 km² or

3.40 percent, Muzaffarpur 104.90 km² or 10.49 percent, Sheohar 14.76 km² or 3.33 percent, Banka 98.95 km² or 3.28 percent, Siwan 71.05 km² or 3.21 percent, E. champaran 124.77 hectare or 3.00 percent, Jehanabad 43.45 km² or 2.77 percent, Madhubani 89.58 km² or 2.58 percent, Aurangabad 81.16 km² or 2.39 percent, Gaya 114.22 km² or 2.31 percent, Buxar 37.17 km² or 2.27 percent, Nawada 54.64 km² 2.19 percent, Araria 41.57 km² or 1.49 percent, Sitamarhi 26.01 km² or 0.99 percent, Nalanda 15.89 km² or 0.67 percent, Kaimur 7.96 km² or 0.43 percent and Sheikhpura 2.96 km² or 0.43 percent.

Table No. 1.4
Bihar: Class categories of wetlands - 2017

Percentage of wetlands in total geographical area	Class categories	No. of districts	Name of the district
< 1	Very Low	04	Sheikhpura(0.43), Kaimur(0.43), Nalanda (0.67), Sitamarhi (0.99)
1 – 3	Low	10	Araria (1.49), Madhepura (1.97), Nawada (2.19), Buxar (2.27), Gaya (2.31), Aurangabad (2.39), Jamui (2.45), Madhubani (2.58), Jehanabad (2.77), E. champaran(3.00)
3 – 6	Moderate	13	Siwan (3.21), Banka (3.28), sheohar (3.33), Muzaffarpur (3.36), Lakhisarai (3.40), Darbhanga (3.48), Gopalganj (3.56), Purnea (3.87), Bhojpur (4.77), Rohtas (4.86), W. champaran (5.11), Kishanganj (5.65), Samastipur (5.82)
6 – 9	High	06	Supaul (6.46), Patna (6.61), Khagaria (7.87), Saran (8.07), Munger (8.44), Vaishali (8.60)
> 9	Very high	04	Bhagalpur (9.66), Saharsa (10.11), Katihar (10.30), Begusarai (10.78)

Source: Self calculated on the table no. 1.3.

Table no. 1.4 shows district wise class categories of the wetlands in Bihar. Four districts namely Sheikhpura, Kaimur, Nalanda and Sitamarhi are included in the very low class category. The districts included in this category have wetlands spread over less than one percent of the total geographical area. Ten districts are included in the low class category. The coverage of wetlands in these districts one to three percent of the total geographical area. These districts are Araria, Madhepura, Nawada, Buxar, Gaya, Aurangabad, Jamui, Madhubani, Jehanabad and E. champaran. Thirteen districts are member of moderate class category. The share of wetlands in these districts is between six to nine percent of the total geographical area. These districts are Siwan, Banka, sheohar, Muzaffarpur, Lakhisarai, Darbhanga, Gopalganj, Purnea, Bhojpur, Rohtas, W. champaran, Kishanganj and Samastipur. Six districts are included in the high class category. The share of wetlands in these districts is between six to nine percent. These districts are Supaul, Patna, Khagaria, Saran, Munger and Vaishali. Four districts namely Bhagalpur, Saharsa, Katihar and Begusarai are included in the very high class category. In these districts the share of wetlands above nine percent to the total geographical area.

Degradation of wetland

Globally, Wetlands have been the subject of discussion for their economic, cultural and environmental values. But in recent decades, its rapid degradation has emerged as the subject of

discussion. Increasing human intervention in all climatic regions, from equatorial rainforest to sub polar Taiga and Tundra, is primarily responsible for this. The existence of living organism in wetlands has been in crisis. "Including 21 percent of bird species, 37 percent of mammals species and 20 percent of fresh water fish species are either extinct or globally threatened."¹²The Bihar which is an agrarian state is also facing this problem. Changing land use pattern, urbanization, pollution and global warming are the major factors to wetland degradation.

Changing Land Use Pattern

Rapid growth of population is putting pressure on all resources. Between 1951 to 2011 population of India increased by 40 million to 1210 million. This growth trend of population is filling dolorous pressure on agricultural land for food. "In this period of time cultivable land in India increased from 130 to 155 million hectare."¹³This increase in the agricultural land is on the cost of forest, grassland, flood plains, course of rivers and others to meet the demand of growing population. Not only this infrastructure development like transport network, irrigation projects are being made at its cost. "In Asia alone about 5000 km² of wetlands area are lost annually to agriculture, dam construction and other uses."¹⁴

Urbanization

Urbanization has emerged as a major problem for wetlands globally. With the spread of cities, traditional water bodies are destroyed.

Buildings are built on a large scale by filling the ponds, lakes and marshy areas. This not only ceases the existence of wetland forever, but due to lake of ground water recharge water level also falls, causing severe water scarcity. "Between 1973 to 2007, Greater Bengaluru Region lost 66 wetlands with a water spread area of around 1100 hectare due to urban sprawl."¹⁵

Pollution

Pollution is the big threat to the degradation of wetlands. With the adoption of green revolution Indian agriculture advanced with the use of chemical fertilizers and pesticides. These chemical products affect extensively to living organism of wetlands. Not only this, a large amount of toxic substances from the chemical industry, leather industry, paper industry harm water bodies and the living organism.

Global warming

At present global warming is a major environmental challenge. Due to this the rising temperature of the earth is melting the glaciers, the water cycle is getting disrupted and the possibility of rising sea level is increasing. In these changing conditions, the existence of wetland is in danger. The area of inland wetlands is shrinking day by day. A study shows the famous oxbow lake wetland of Bihar Kanwar has dried up a large part in last thirty years. 'The lake covered an area of 6786 hectare in 1984, which reduced to 6043 hectare in 2004. By 2012, the lake was a mere 2032 hectare in area.'¹⁶

The National Wetland Atlas 2010 has identified over 4416 wetlands in Bihar with an area of 4031.82 km² or 4.40 percent of total geographical area of the state. The state government of Bihar has declared nine wetlands covers an area of 125 km² as a protected area. Out of nine protected area seven are bird sanctuaries. The state of Bihar does not have any special rule for the protection of wetlands in the state. But many such laws have been enacted which are related to conservation of forest and wildlife. Some laws have been made to control pollution. All these laws are also indirectly related to the protection of wetlands. Some of these important are as follows:

Air (prevention and control of pollution) Rules, 1983
Water (prevention and control of pollution) Rules, 1986
State level crisis Group under Environment (protection), Rules, 1986
Chemical Accident (emergency planning, preparedness and response) Rules, 1996
Noise pollution (regulation and control) Rules, 2000
Guidebook on application, approval and occupancy procedure (Bihar building bye laws), 2014
In all these rules made by the government of Bihar, only Bihar building bye laws, 2014 talks about protection from encroachment of rivers. According to this, 'no construction or re construction shall be allowed within a strip of land of 200 meter from the outer boundary of river Ganga and 100 meter in the case of other rivers.'¹⁷

Sustainable Wetlands Management

Human beings depend on the environment for food, water and shelter. Along with this, the cultural importance is also there. Man exploits the environment with their knowledge and known technology to fulfill their needs. But the desire to live a

high life and the pressure of growing population can make it greedy. Under these circumstances, humans make unwise use of natural resources. This trend is being observed globally due to the changing lifestyle and increasing population. Under these conditions, the risk of degradation of wetlands, which is a sensitive ecosystem, is increasing. Therefore, there is a need to sustainable management to wetlands. Sustainable management is a process of management that ensure the natural resources are used to meet human needs in such a way to fulfill the present needs of man as well as be useful for the future generation. The sustainable management of wetlands is related to its rational use. Wetlands are the one of the most contiguous ecosystem on Earth. If it used indiscriminately and selfish, then there is a possibility of its degradation. We should use it to meet our needs in such a way that it does not harm its existence. The wetlands in Bihar are the base of agriculture and fisheries, on which the economic future of millions of families rests. In view of this, we need to formulate a strategy in which the use of wetlands is wisely. Management of wetland is a multidimensional continuous process. This includes protection, planning, monitoring, research and awareness. Along with this, people's participation at the local level is important in accomplishing. The following procedures may be adopted for the sustainable management of wetlands.

Protection

The existence of wetlands is under threat due to increasing human activities around the world. Agriculture, industry and construction work are prominent in these. For its proper management, first it needs immediate protection. Bihar is an afflicted state, chemical fertilizer and pesticides are used extensively in agriculture. After use in agriculture, it is transported in large quantities in water bodies and damages the living organism. We have to make such a strategy that it should not be mixed in the water sources without treating. It is important to increase the use of organic fertilizer and pesticides instead of chemical fertilizer. The changing land use pattern is encroaching wetlands for constructions. We need such a model to ensure that the development of infrastructure should not be based on the cost of wetland losses. In Bihar most of cities including Patna, Bhagalpur, Gaya and others are located on the banks of rivers, everyday a lot of sewage water of the city is mixed into these rivers. There should we an alternative arrangement instead of putting it in rivers. If there is a compulsion to put it in rivers, then it should not be put without treatment. Most of the rivers and water bodies in Bihar is facing the problem of siltation, there should be proper arrangement to remove it time to time from their channels. The wetlands of Bihar are today plagued by illegal exploitation. For example, migratory birds arriving in northern Bihar in the winter are largely hunted by the local people, this need to be stopped immediately.

Monitoring

Bihar is a landlocked state, its all wetlands under the category of inland wetlands. Most of the wetlands are located near agricultural land in the river

basins. For the maintenance and protection of wetlands, a system needs to be developed in the state which is committed for its monitoring, planning and protection. For continuous flow of information and efficient execution of problems, it should be connected at district, block and panchayat level.

Research

There is a lack of accurate and adequate information regarding wetlands in Bihar. Comprehensive research is needed to understand the characteristics and problem of wetlands, its importance for environment and agriculture, its role in tourism and employment opportunities and cultural value. Necessary resources and funds should be made available to researchers, institutions and universities. International level research institutions also be involved in this work. For better management of wetlands, the personnel working for it need special training, able to use modern technologies like remote sensing and GIS.

Awareness

People living around wetlands are its biggest exploiters and protectors. The people must have actual information and importance of wetlands. For this, they need to be educated and made aware. They should also be aware of the damage caused by the degradation of wetlands. The importance and conservation of should be included in school and college curriculum. This need to multidisciplinary trained professionals.

Conclusion

Wetlands are useful for man in many forms. It has a unique identity in all aquatic and terrestrial ecosystems. Bihar which is completely situated in the Gangetic plain, its all wetlands fall in the inland Wetland category. But there is a disparity in distribution of Wetlands in the state, the expansion of Wetlands in North Bihar is on more area than South Bihar. The Wetlands of Bihar is degrading by the agricultural chemicals like fertilizers and pesticides, untreated sewage water as well as constructional works. Laws have been made by government of Bihar time to time for controlling pollution, but there is a lack of clear law for the conservation of Wetlands. In this situation sustainable management is needed to the existence of Wetlands. For this, along with the effort of government and non government organizations, it is necessary to make people aware at the local level.

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