1.0 Introduction

1.1 Patna Distt. is situated in the heart of South Bihar alluvial plainbetween 25.4840° N, 85.0233° E covering an area of approximately 3,202 sq.km. It is bounded by the Ganga River in the north, beyond which lie the Distt.s of Saran, Vaishali and Samastipur; Lakhisarai and Begusarai Distt.s in the east Arwal, Jahanabad and Nalanda Distt.s in the south [Refer Map 01]. The Distt. is administratively divided into six divisions viz., Paliganj, Masaurhi, Patna Sadar, Patna City, Danapur, and Barh. They are further sub-divided into twenty-three community development blocks [2011, Bihar Census Book].

1.2 The entire Distt. forms a part of the Gangetic plain characterized with alluvial formations. Traditionally soils in the area are divided into three groups on basis of deposition: Recent alluvium, Tal and Older Alluvium. The soils of the Distt. are predominantly sandy loam with clay loam.The alluvial tract of land yields rice, sugar-cane and other food grains.The ground level of Patna forms a gradient away from the Ganga River and the topography of the city resembles 'a saucer' [Patna Gazetteer, 1907].

1.3 The Distt. observes a subtropical and humid climate with the temperatures varying from 43° C – 30°C during summers and 21.4°C – 5°C during winters. The maximum temperature ever recorded was 46.6 °C in the year 1966, and the lowest temperature registered in Patna was 1.1 °C in the year 2013 [(2013, TOI) (2012, Imd.gov.in)]. According to weather statistics reports, the total yearly precipitation received by the distt. is around 1390 mm. [https://patna.nic.in]

1.4 The Distt. headquarters is Patna city which has also served as the capital of Bihar state since 1911. It is an ancient city with its history thriving across the ancient, medieval and colonial period.Ancient literature refers Patna by various names like Patalipatlam (700BCE – 600BCE),Palibothra (350 BCE-290 BCE), Pataliputra (4thcentury AD) and Azimabad (18th century AD). According to the Gazetteer of Patna Distt. (1907), Pataliputra is one of the ancient cities of the world, founded by Ajatashatru in the 6th century BC. The Distt. is named after its principal city, Patna. The city has a very long river line surrounded on three sides by rivers – Ganga, Son and Punpun. The river Gandak flows into the river Ganga making it a unique place having four rivers in its vicinity to the north of Patna. The bridge over the river Ganges named Mahatma Gandhi Setu [Image 1] is 5575m long connecting Patna in the south to Hajipur in the north of Biharand is the longest river bridge in India [CEPT, 2014].

Image 1 : Gandhi Setu - India's Longest River Bridge In Patna City

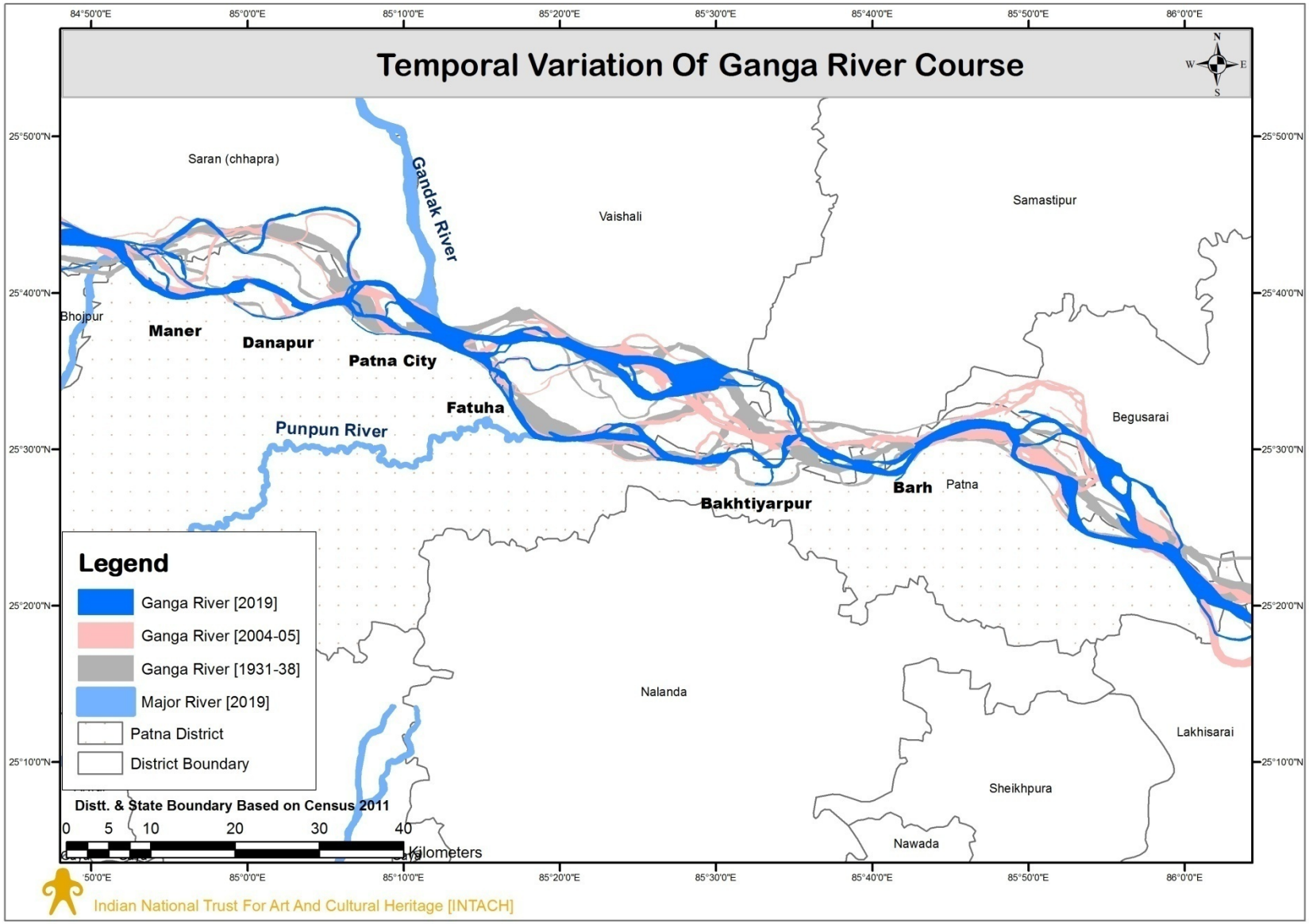
Image 2 : Ganga Expressway Under-Construction In River Along Ghats In Patna City

Map 01: Map Showing Patna Distt. And Ganga River

2.0 Ganga River in Patna Distt.

2.1 Ganga River forms the northern boundary of Patna Distt. from the confluence of its waters with Son River in the west upto Rampur Dumra village in the east covering a total distance of approximately 148 kms. The channel of this river shifts continuously as it meanders over the alluvial floodplain with many small and big islands forming one year and disappearing the next year. Just after its confluence with Son, Ganga River gets bifurcated into two streams parts due to the presence of a wide stretch of Diara (Riverine Island, about 20 kms long and 6-10 kms wide) separated from the main bank off Danapur in Patna Distt. These two separate channels meet near Digha and enter Patna city as a single channel of Ganga River. At a short distance downstream, a channel of Gandak River meets Ganga River near Sabalpur in Saran district. The Ganga river used to flow along Patna city till about 3 decades ago but the main channel has now shifted about 5-6 km away from the city [Refer Map 02]. This can be attributed to various geogenic factors along with increased sand mining and brick kilns in the region (Joshi, 2019). Further, around 3 km. downstream of Patna Sahib, the river again subdivides into two channels with the presence of Raghopur Diara, a riverine island about 30 kms long and 8-10 kms wide. Here, the southern channel of Ganga River flows along Jethuli, Fatwah, Kurtha, Baikathpur and Hatia in Patna Distt. confluencing with the small Punpun river at Fatwah, before reuniting near Bakhtiyarpur, where from it flows as a single channel towards Mekra Diara via. Barh.

Image 3 : Ganga River As Seen Near Bakhtiyarpur In Patna Distt.



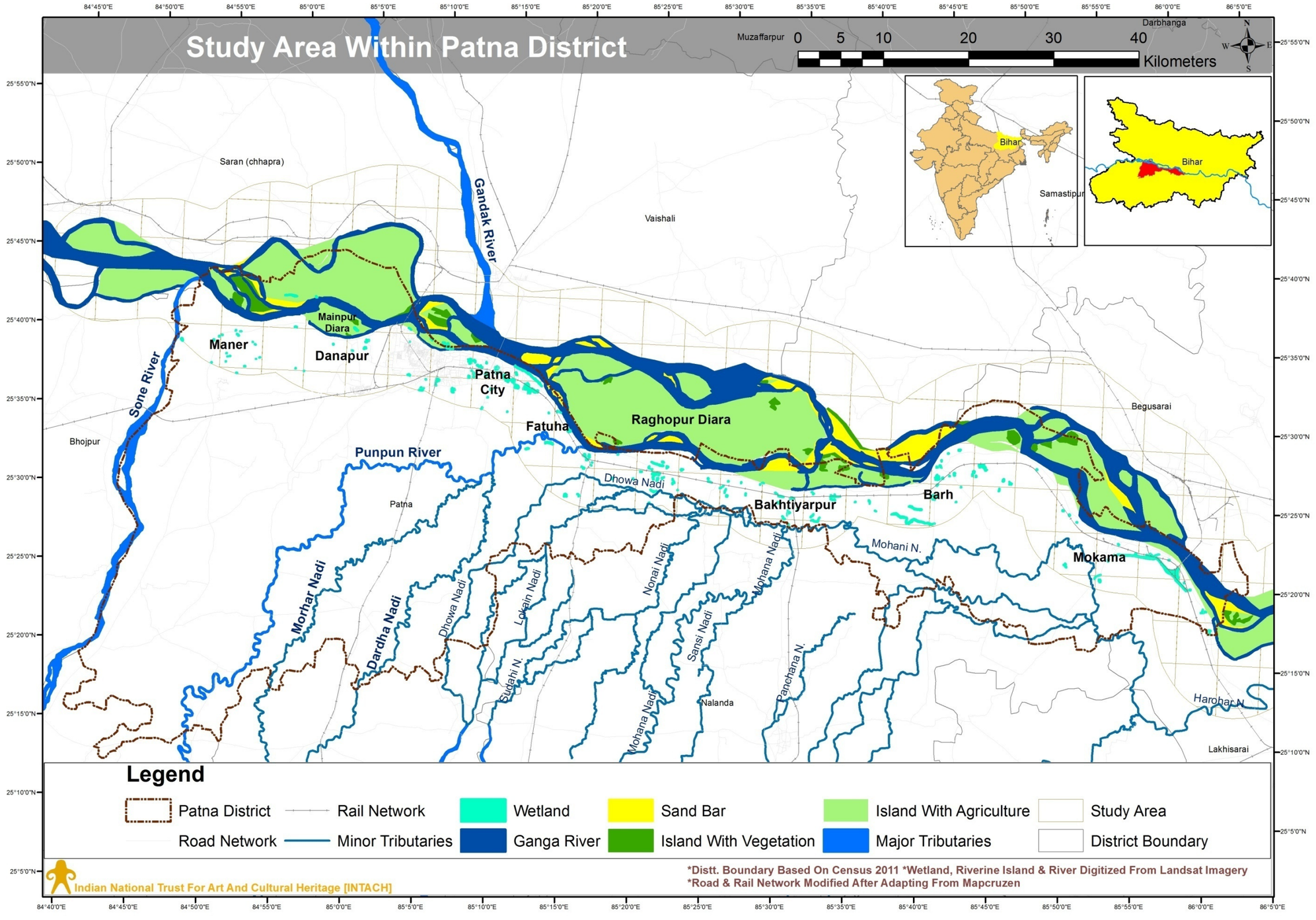
Map 02: Temporal Variation of Ganga River Course In Patna Distt.

3.0 Methodology

3.1 Patna Distt. lies on the right bank of the river Ganga. Hence, for carrying out the ground survey a 7 km of buffer zone on the right bank of Ganga River was selected encompassing a total area of 1212.15 sq.km. The study area was divided into grids of 5 × 5 km for field survey [Refer Map 3].

3.2 Based on the secondary information analyzed and the features noted on Google Earth imagery, plan for the fieldwork was constituted to cover different elements of natural heritage in these grids. Special focus was laid on denoting the sites important for riparian biodiversity, riverine fishing, boat making communities, river and stream confluences, important water bodies and oxbow lakes. Furthermore, contacts were developed with various stakeholders including riparian & *Diara* communities in the Distt. for carrying out relevant interactions.

3.3 The field survey in Patna Distt. was carried out in the month of March, 2020. Various sites were visited within the study area wherein field data was collected along with interactions with stakeholders. The co-ordinates of all localities were noted by hand-held GPS devices and the representative images of various parameters were taken with the help of DSLR cameras. The information on cultural, social, religious and natural linkages of people with Ganga River and other elements in the study region was noted.



Map 03: Study Area

4.0 Tributaries Of Ganga River

4.1 The rivers of Patna Distt. belong to the main system of river Ganga and comprise several sub-systems of which the most important are Son or Sone and Punpun rivers. Apart from these, there are several other tributaries belonging to Phalgu andHarohar sub-systems that drain through the study area. The tributaries are :

4.2 Sone River

4.2.1 Son River is the principal peninsular tributary of the river Ganga which originates in the Amarkantak hills of Maikal range [Madhya Pradesh] at an elevation of 1030 mamsl in central India (Maharana et al., 2015). After flowing a distance of 820.74 km (http://bcb.nic.in/about_us.html), it enters Patna Distt. near Mahabalipur village (25°18'42.03"N, 84°42'27.56"E) and drains into River Ganga near Haldi Chhapra Village.

Image 4 : Son River Near Son-Ganga Confluence

4.2.3 Around 8.6 Km. of the river stretch falls within the study area and it is a major sand mining site in the entire region. The active flood plain area of the river provides alluvial and fertile soil for growing crops especially the 'Zaid crops'. The local communities in the region claimed that "the river once had aplentiful flow but is now starving for water". They attributed this to the construction of Bansagar Dam

in Madhya Pradesh and Indrapuri Barrage in Rohtas district of Bihar. People also claimed that "the river usually dried up for 8-9 months of the year and gets the water only when it is released from the dams and barrages constructed in the upstream". This has posed a serious threat on biota and morphology of the river especially since the exposed riverbed has become a paradise for illegal sand mining in the entire stretch. Upon further interactions, the Mallah community of nearby villages claimed that, "owing to the construction of huge dams and barrages, they are hardly able to get fish catch in the river and the river is also not navigable most of the time".

Image 5 : Satellite Image Showing Sand Mining In Son River Near Koilwar Rail Bridge
Source : Google Earth Pro [Image Dated : April 2019]

4.3 Punpun River

4.3.1 Punpun river originates from Chota Nagpur Plateau in Palamu district of Jharkhand and joins river Ganga near Phatuha Bazar [Fatuha] of Patna Distt. at 25°30'56.60"N, 85°18'3.61"E. The river enters Patna Distt. near Helha village (25°13'43.05"N, 84°49'45.53"E) and flows in a north-easterly direction upto Jitu Chak (25°30'8.36"N, 85°1'20.14"E). After that, it makes a sharp turn to the east and is joined by two tributaries namely Morhar near Mundi Chak [25°28'50.13"N, 85°10'48.57"E] and Dardha near Jamalpur [25°29'19.72"N, 85°11'42.70"E].

4.3.2 After Jamalpur, the river makes another turn to the north and enters the Study Area [7 km Buffer] near Daulatpur. Here, the river is joined by a Nala named Barmutta

Nala from left bank of the river. Around 13.69 Km. of the river stretch falls within the study area. This stretch was once a major fishing site but is now carrying immense load of sewage from nearby settlements especially Fatuha town. The Barmutta Nala also carries sewage from Patna city area and drains into this river.

Image 6 : Punpun River As Viewed From Bridge, NH-31 [25°31'13.2"N, 85°16'19.2"E]

Image 7 : Punpun-Ganga Confluence

4.4. Apart from the major tributaries, there are other tributaries identified within the study area which finally drain into Kiul River. Their details are provided in the table below :

Table 1 : Tributaries In The Study Area

Dhowa Nadi	The river emerges from Phalgu river near Mandai Village at 25°13'31.82"N, 85° 9'25.75"E and joins Mohana river near Kharuara Village of Patna Distt. at 25°25'4.47"N, 85°31'46.91"E. After Joining River Mohana it drains towards north where it is named as Mohani.
Lokain/ Mahatwain River	Lokain river is the part of Phalgu river system. It also emerges from Phalgu near Mandai and drains Jahanabad, Nalanda and Patna distt.s and finally empties into Dhowa River at 25°28'4.40"N, 85°21'29.39"E.
Kathautia Nadi	It is a small channel emerges from Lokain river near Danara Village of Patna Distt. at 25°26'51.84"N, 85°18'13.93"E and joins Nonai river near Kazi Chak. A channel of the river also joins Dhowa river at 25°26'30.91"N, 85°25'53.20"E.
Nonai Nadi	The river originates near Benipur village of Nalanda Distt. and joins a channel of Dhowa river at 25°26'25.37"N, 85°26'20.55"E. The river is joined by a tributary named Donr Nadi near Kewai village. The extensive agricultural practices along the banks and loss of vegetation in the catchment area are main threats to the river.
Mohana Nadi	Mohana river emerges from Phalgu river Near Jaru Village at Jahanabad-Gaya border area [25° 0'28.11"N, 85° 5'52.59"E] and Joins Dhowa river in Patna Distt. A river named Chiraiya emerged from Mohana in Nalanda district and joins Dhowa river near Barun Tar at 25°26'14.46"N, 85°28'9.74"E.

5.0 Floodplain Of River Ganga In Patna

5.1 The active flood plain of a river is defined as an area on either side of the river channel with regular flooding on a periodic basis. Maintaining active flood plain of a river is critical for assuring equilibrium in ecosystem. The floodplains harbour rich biodiversity including riparian vegetation as well as many other groups of organisms which help in maintaining fertility of this region. Along with this, the floodplains have been of great cultural and economic importance with many early civilizations having risen in these fertile lands. As the rivers naturally meander through the landscape over a period of time, they deposit sand, silt and other soil forming materials in the floodplain region which make them ideal for agricultural production. Throughout history, people have learned to cultivate in the fertile floodplains and use their rich resources for sustaining livelihoods. Even today, in most of the riverine regions especially in India, the floodplains have been occupied by local farmers for carrying out their agricultural activities especially in the non-monsoon season. Ganga River floodplain is one such important floodplain in India which has been extensively utilized in almost all the districts, where it passes through, for agricultural purposes.

5.2 Patna Distt. is abundant with highly fertile floodplain lands which are utilized for agriculture. The Distt. falls under 'South Bihar Alluvial Zone' as per the classification of National Agricultural Research Project (NARP) having clay to clay loam, sandy loam and medium to heavy soils (NICRA-ICAR, 2013). Most of the villages in Distt. largely depend upon agriculture with many fields lying in the active floodplain of Ganga River. Rice and Wheat are found to be the major crops grown throughout in this Distt. along with others such as Maize, Mustard, Pigeon pea and Chickpea. Vegetables such as Potato, Sweet Potato, Tomato and different types of Gourds along with fruits such as melon and watermelon are also grown at different places in the Distt. While the major part of the floodplain is fertile alluvial plains in the Distt., there are fertile highlands along Ganga River towards the either ends of this Distt. which are utilized for cultivation by the local communities residing in these regions. Some of the villages surveyed for the floodplain agriculture along with their produce are provided in Table 2 while a representative image of floodplain field is provided in Image 08.

Table 2 : Floodplain Agricultural Produce In Different Villages Of Patna Distt.

Sr. no.	Village	Floodplain produce
1	Haldi Chhapra	Wheat, Mustard, Watermelon, Chickpea
2	Hatia	Wheat, Mustard, Coriander, Parwal
3	Rawaich	Wheat, Parwal, Sweet Potato, Maize
4	Gyaspur	Wheat, Mustard, Potato, Gourd

Image 8 : Wheat Fields In Ganga River Floodplain Near Rawaich

5.3 **Floodplain Grasses:** While the Ganga River floodplain supports luxuriant growth of many plant species including grasses, there are two major species – *Saccharum spontaneum* L. (locally known as *Kaans*) and *Desmostachya bipinnata* (L.) Stapf (locally known as *Kusa/Kusha*) which are widely distributed in the Distt. Among these, a special mention is to be made of *Kusha* grass which is a perennial grass species holding great sacred value owing to its role in many rituals and ceremonies since Vedic times. According to the locals, once available in plenty, this grass species has a patchy distribution today owing to its high religious importance and medicinal values. The main purpose of this grass is its use as a ring that has to be worn in fingers before starting any kind of religious ritual. Along with this, *Kusa* grass has been known for various medicinal properties in the Indian traditional system of medicine which include the use of its roots for cure of dysentery, diarrhea, bladder & skin diseases (Subramaniam & Sivasubramanian, 2015).

Image 9 : *Desmostachya bipinnata* (*Kusha* Grass)

5.4 Another important floodplain grass – *Saccharum spontaneum* L. (commonly known as 'Kaans' in the district) is also prevalent in the study region. This species is a tall and perennial grass growing naturally in the alluvial plains, swamps and riparian areas of north India. Owing to the deep roots and rhizomes, this grass successfully colonizes the floodplains and grows rapidly spreading in huge areas with its height reaching 3-4 m in some places. This grass is found in huge patches along rivers and streams throughout in the Distt. The dried grasses are used by the locals for thatching hut roofs and for demarcating their fields in the riverine villages as well as by the residents of the *Diaras*.

Image 10 : *Saccharum spontaneum* (*Kaans* Grass)

6.0 Wetlands In Patna Distt.

6.1 Wetlands are one of the most productive and unique ecosystems. They help in maintaining the food web and provide habitat for the aquatic biodiversity. They also help in controlling floods, recharging groundwater, nutrient recycling, climate stabilization and carbon sequestration. In this study, total 196 wetlands are identified with the help of Google imagery (June, 2019) in the Distt. Out of which some significant ones have been surveyed and discussed in this section. The details of all wetlands identified are presented in Table 3 and their locations are depicted in Map 04. The identified water bodies are categorised into village pond, wetlands of brick kiln, urban wetland and oxbow lakes.

Table 3 : List Of Wetlands Recorded In The Study Area

Sr. No.	Wetland	Location		Area [Hectares]
		Longitude	Latitude	
01	1	25°38'30.41"N	84°50'10.24"E	3.67
02	2	25°37'0.24"N	84°52'11.25"E	0.75
03	Dargah Lake	25°38'25.14"N	84°52'24.63"E	2.0
04	4	25°37'2.03"N	84°53'11.77"E	0.32
05	5	25°38'38.47"N	84°52'48.11"E	1.13
06	6	25°37'21.98"N	84°53'29.79"E	0.57
07	7	25°37'20.70"N	84°53'19.14"E	0.17
08	8	25°37'20.70"N	84°53'19.14"E	0.36
09	9	25°38'41.07"N	84°54'9.10"E	1.73
10	10	25°38'54.93"N	84°54'18.64"E	0.70
11	11	25°36'17.52"N	84°53'55.96"E	0.53
12	12	25°36'41.60"N	84°54'30.60"E	0.82
13	13	25°38'3.33"N	84°55'17.65"E	0.35
14	14	25°38'12.55"N	84°55'7.67"E	0.28
15	15	25°37'7.93"N	84°55'18.92"E	0.17
16	16	25°37'13.55"N	84°55'35.03"E	0.37
17	17	25°39'5.89"N	84°58'10.57"E	1.80
18	18	25°36'27.93"N	84°58'4.11"E	0.51
19	19	25°37'54.99"N	85° 0'45.44"E	0.99
20	20	25°37'28.90"N	85° 2'5.05"E	0.70

21	21	25°38'50.27"N	85° 2'23.23"E	8.0
22	22	25°37'36.82"N	85° 2'57.75"E	3.90
23	23	25°38'0.01"N	85° 3'3.36"E	2.45
24	24	25°38'7.68"N	85° 3'14.85"E	1.23
25	25	25°35'48.99"N	85° 5'58.31"E	2.40
26	26	25°37'55.76"N	85° 6'6.78"E	0.46
27	27	25°38'43.47"N	85° 6'11.55"E	1.19
28	28	25°34'53.01"N	85° 6'49.91"E	7.95
29	29	25°34'58.94"N	85° 6'47.84"E	1.1
30	Kachchi Talab	25°35'30.14"N	85° 7'9.17"E	0.81
31	31	25°38'1.90"N	85° 7'42.95"E	4.0
32	32	25°37'29.45"N	85° 8'45.83"E	26.5
33	33	25°35'24.07"N	85° 7'55.85"E	12.2
34	34	25°34'41.59"N	85° 8'59.51"E	2.76
35	35	25°34'48.75"N	85° 9'1.71"E	4.34
36	36	25°35'35.40"N	85°10'10.14"E	4.11
37	Nalanda Lake	25°35'58.11"N	85°10'22.13"E	0.67
38	38	25°36'25.98"N	85°10'19.04"E	2.1
39	39	25°36'35.91"N	85°10'15.63"E	9.53
40	40	25°36'25.87"N	85°11'26.82"E	0.98
41	41	25°36'35.81"N	85°10'36.63"E	3.51
42	42	25°35'34.77"N	85°10'30.26"E	1.74
43	43	85°10'31.47"E	85°10'31.47"E	1.35
44	44	25°36'8.98"N	85°11'6.85"E	1.15
45	45	25°36'14.99"N	85°11'1.07"E	1.64
46	46	25°36'18.11"N	85°10'47.60"E	0.81
47	47	25°33'33.12"N	85°10'59.80"E	1.48
48	48	25°34'14.79"N	85°11'26.02"E	0.79
49	49	25°34'43.39"N	85°11'41.77"E	4.34
50	50	25°35'45.18"N	85°11'24.94"E	3.82
51	51	25°36'5.64"N	85°12'9.06"E	8.31
52	52	85°12'8.88"E	85°12'8.88"E	4.41

53	53	25°35'22.06"N	85°12'44.53"E	6.57
54	54	25°35'15.23"N	85°12'54.92"E	2.81
55	55	25°35'13.98"N	85°13'15.53"E	12.6
56	56	25°34'49.39"N	85°13'31.92"E	14.3
57	Mangal Talab	25°35'41.69"N	85°13'30.31"E	4.0
58	58	25°36'9.29"N	85°13'26.81"E	1.53
59	59	25°35'57.00"N	85°13'48.16"E	9.19
60	60	25°35'45.77"N	85°14'12.12"E	0.71
61	61	25°35'38.33"N	85°14'22.23"E	4.65
62	62	25°35'12.17"N	85°14'52.00"E	12.4
63	63	25°34'31.30"N	85°14'41.28"E	42.9
64	64	25°34'59.89"N	85°14'15.49"E	6.67
65	65	25°33'17.65"N	85°12'46.75"E	0.35
66	66	25°30'54.79"N	85°14'5.02"E	3.59
67	67	25°34'31.39"N	85°14'55.08"E	2.87
68	68	25°31'12.96"N	85°15'37.53"E	12.3
69	69	85°15'40.90"E	85°15'40.90"E	0.33
70	70	85°16'17.50"E	85°16'17.50"E	2.67
71	71	25°27'54.11"N	85°16'36.35"E	3.72
72	72	25°27'48.01"N	85°16'43.95"E	0.30
73	73	85°17'3.34"E	85°17'3.34"E	9.72
74	74	25°27'49.97"N	85°17'35.30"E	1.61
75	75	25°29'34.02"N	85°17'58.95"E	2.57
76	76	25°29'38.82"N	85°17'51.86"E	0.37
77	77	25°30'22.38"N	85°18'3.89"E	4.92
78	78	25°30'3.79"N	85°18'13.97"E	1.92
79	79	25°30'15.70"N	85°18'23.73"E	4.48
80	80	25°29'54.21"N	85°18'35.42"E	0.35
81	81	25°29'43.38"N	85°18'31.46"E	0.33
82	82	25°28'51.04"N	85°19'57.36"E	1.81
83	83	25°30'21.39"N	85°20'25.11"E	0.79
84	84	25°28'47.13"N	85°21'25.39"E	0.60

85	85	25°29'11.78"N	85°21'59.79"E	0.97
86	86	25°27'13.21"N	85°22'28.97"E	0.66
87	87	25°28'59.46"N	85°23'0.64"E	0.88
88	88	25°29'5.61"N	85°22'56.50"E	0.27
89	89	25°28'42.75"N	85°23'7.49"E	3.28
90	90	25°28'48.54"N	85°23'34.34"E	0.35
91	91	25°29'42.09"N	85°23'1.46"E	6.79
92	92	25°29'26.65"N	85°22'32.29"E	1.69
93	93	25°29'19.59"N	85°22'45.33"E	0.77
94	94	25°29'2.54"N	85°22'47.53"E	3.14
95	95	25°28'48.33"N	85°22'48.96"E	3.71
96	96	25°27'56.29"N	85°22'48.28"E	4.99
97	97	25°28'43.84"N	85°23'26.55"E	0.54
98	98	25°29'3.92"N	85°23'17.23"E	2.82
99	99	25°29'35.61"N	85°23'18.87"E	1.57
100	100	25°29'33.12"N	85°23'31.34"E	1.68
101	101	25°29'46.08"N	85°23'33.10"E	2.2
102	102	25°29'27.22"N	85°23'51.84"E	2.43
103	103	25°28'38.25"N	85°24'11.01"E	0.45
104	104	25°28'29.65"N	85°24'16.55"E	0.70
105	105	25°28'23.03"N	85°24'9.63"E	0.89
106	106	25°29'14.96"N	85°24'50.21"E	2.95
107	107	25°35'30.61"N	85°11'21.74"E	1.34
108	108	25°27'58.20"N	85°24'30.48"E	0.26
109	109	25°28'25.78"N	85°26'45.81"E	1.57
110	110	25°28'38.83"N	85°26'40.38"E	0.96
111	111	25°28'6.82"N	85°27'40.46"E	0.83
112	112	25°27'29.24"N	85°29'14.74"E	0.12
113	113	25°28'1.41"N	85°27'31.27"E	1.0
114	114	25°27'49.19"N	85°27'49.43"E	0.82
115	115	25°27'29.14"N	85°27'55.18"E	2.74
116	116	25°28'25.49"N	85°28'4.07"E	0.83

117	117	25°28'18.68"N	85°28'57.92"E	0.52
118	118	25°27'36.47"N	85°29'14.99"E	0.40
119	119	25°28'9.32"N	85°30'16.94"E	0.43
120	120	25°28'13.80"N	85°30'28.70"E	1.0
121	121	25°27'34.96"N	85°31'20.75"E	0.97
122	122	25°27'20.90"N	85°31'41.66"E	5.0
123	123	25°26'57.73"N	85°31'30.15"E	3.46
124	124	25°25'53.79"N	85°31'54.39"E	1.54
125	125	25°25'27.64"N	85°32'10.00"E	1.99
126	126	25°27'13.95"N	85°32'26.21"E	5.34
127	127	25°26'18.98"N	85°32'14.06"E	4.54
128	128	25°26'28.26"N	85°32'50.67"E	1.23
129	Oxbow Lake Near Chanda Village	25°25'40.07"N	85°34'5.03"E	7.19
130	130	25°26'1.98"N	85°33'49.89"E	2.38
131	131	25°27'27.41"N	85°33'59.05"E	0.74
132	132	25°27'33.04"N	85°33'53.04"E	0.3
133	133	25°27'1.00"N	85°35'18.38"E	2.95
134	134	25°27'12.00"N	85°35'27.14"E	4.35
135	135	25°27'15.10"N	85°35'27.04"E	2.33
136	136	25°27'17.91"N	85°35'12.15"E	0.47
137	137	25°26'49.99"N	85°36'52.69"E	0.67
138	138	25°26'13.33"N	85°38'16.39"E	0.58
139	139	25°26'50.03"N	85°37'52.60"E	1.55
140	140	25°25'24.58"N	85°40'38.83"E	60
141	141	25°26'14.65"N	85°41'2.99"E	16.6
142	142	25°26'49.82"N	85°42'23.79"E	1.40
143	143	25°26'56.53"N	85°42'9.80"E	1.42
144	144	25°26'58.47"N	85°42'35.06"E	2.0
145	145	25°27'4.12"N	85°42'22.64"E	1.79
146	146	25°27'43.63"N	85°42'39.57"E	1.60

147	147	25°28'6.90"N	85°42'33.86"E	2.68
148	148	25°28'21.35"N	85°42'39.71"E	1.29
149	149	25°28'12.28"N	85°42'45.50"E	2.0
150	150	25°28'4.74"N	85°42'42.66"E	1.56
151	151	25°28'52.68"N	85°42'39.19"E	1.0
152	152	25°28'56.21"N	85°42'53.16"E	0.75
153	153	25°29'15.33"N	85°43'0.86"E	0.84
154	154	25°28'50.86"N	85°42'56.23"E	0.65
155	155	25°28'6.22"N	85°42'48.58"E	0.44
156	156	25°28'8.43"N	85°43'3.45"E	2.0
157	157	25°29'41.95"N	85°43'30.22"E	0.77
158	158	25°28'16.57"N	85°43'31.56"E	0.64
159	159	25°28'22.15"N	85°43'51.91"E	4.36
160	160	25°29'52.45"N	85°44'17.04"E	3.13
161	161	25°28'25.02"N	85°45'12.26"E	5.48
162	162	25°27'52.48"N	85°47'16.66"E	4.38
163	163	25°27'15.13"N	85°46'57.42"E	1.40
164	164	25°25'48.87"N	85°51'22.23"E	197
165	165	25°22'18.04"N	85°51'23.63"E	3.23
166	166	25°25'29.81"N	85°51'47.64"E	1.38
167	167	25°25'2.69"N	85°52'17.78"E	0.66
168	168	25°22'33.56"N	85°54'23.76"E	1.39
169	169	25°23'31.28"N	85°55'9.63"E	1.16
170	170	25°22'52.12"N	85°54'48.12"E	0.75
171	171	25°22'54.17"N	85°56'19.87"E	2.36
172	172	25°22'47.12"N	85°56'21.03"E	27.5
173	173	25°21'35.48"N	85°58'55.76"E	155
174	174	25°20'56.72"N	85°59'37.50"E	0.61
175	175	25°20'29.20"N	86° 0'0.61"E	1.95
176	176	25°19'1.67"N	86° 0'56.47"E	2.59
177	177	25°19'0.31"N	86° 0'43.13"E	0.44
178	178	25°19'7.03"N	86° 0'50.64"E	1.63

179	179	25°17'49.29"N	86° 1'14.67"E	4.90
180	180	25°17'37.22"N	86° 1'16.48"E	0.27
181	181	25°36'16.78"N	84°58'39.21"E	0.20
182	182	25°22'25.66"N	85°58'37.28"E	0.90
183	183	25°22'46.78"N	85°57'21.52"E	6.44
184	184	25°21'14.32"N	85°53'42.68"E	2.40
185	185	25°21'32.03"N	85°53'27.70"E	3.33
186	186	25°28'28.57"N	85°49'38.59"E	1.17
187	187	25°27'38.44"N	85°47'46.88"E	4.75
188	188	25°28'39.67"N	85°46'0.64"E	9.50
189	189	25°28'40.61"N	85°45'59.44"E	9.54
190	190	25°28'11.22"N	85°45'22.40"E	1.49
191	191	25°27'32.38"N	85°44'18.05"E	0.51
192	192	25°26'36.90"N	85°43'54.95"E	0.48
193	193	25°38'43.54"N	84°53'0.41"E	0.49
194	194	25°38'58.72"N	84°53'58.49"E	0.69
195	195	25°41'5.49"N	84°58'1.45"E	14.2
196	196	25°40'56.20"N	84°59'41.10"E	1.96
Total				**1005.06**

6.2 **Oxbow Lake in Chanda :** An oxbow lake having total area of 7.19 ha is found to be present in the Chanda Village of Patna Distt. Often referred as 'Chanda Talab' by the local residents, this crescent shaped oxbow lake is an important source of fresh water for household activities including bathing and washing. According to some locals, fishing used to be an important activity in this lake till 10-15 years ago when plentiful fish were found and were caught by the residents using hook and line method. However, later on this water body was given out on lease for fishing to those who are willing to pay the tender price. But since last 5-7 years, no one has taken this lake on lease for fishing and hence, it has almost stopped now. The residents of this village grow wheat as the main crop in the fields surrounding this lake for which its water is utilized.

6.3 Wild growth of plants such as *Lippia alba*, *Parthenium hysterophorum* (Congress Grass), *Cyanthillium cinereum* and *Desmostachya bipinnata* (*Kusha* grass) along with planted trees such as *Mangifera indica* (Mango), *Bombax ceiba* (Semal), *Dalbergia*

sisoo (Shisham) and *Borassus flabellifer* (Tad) are found growing around the water body. Among these, the medicinal properties of *Parthenium* and *Lippia* are found to be utilized by the local residents. According to them, the roots of *Parthenium* are employed for treating scorpion bites while different parts of *Lippia* plant are grounded and applied for treatment of cuts and wounds. The local residents also reiterated the religious importance and utilization of *Kusha* grass found around the lake in different ceremonies and auspicious occasions.

Image 11 : Location Of Chanda Oxbow Lake

Image 12 : Oxbow Lake Near Chanda Village In Patna Distt.

6.4 **Mangal Talab :** This is an important water body in Patna city and has a rich history associated with it. This historical Mangal Talab is a reservoir of fresh water having an area of about 4 ha and is believed to have been constructed in the year 1876 by the local Zamindar. During its construction, wooden planks were found from the excavated area which was later identified to be linked with the fortification walls of Mauryan Empire. According to the historians, this water body had different names such as Mansarovar, Mansar and Mangles Tank. However, some people used to bathe in this talab with the belief that it cured them from different skin diseases and hence, started referring this water body as Mangal Talab (Kumar, 2018).

6.5 In the recent years, the surroundings of this lake have been developed by the Bihar State Tourism Development as a tourist spot. However, during the survey it was observed that more than tourists, nearby local residents visit this lake for washing their clothes and bathing thereby leading to increased contamination of its water. Some people were also found to be fishing in this lake using hook and line gear. The main fish caught by them from the talab are Rohu, Catla and Bhakur.

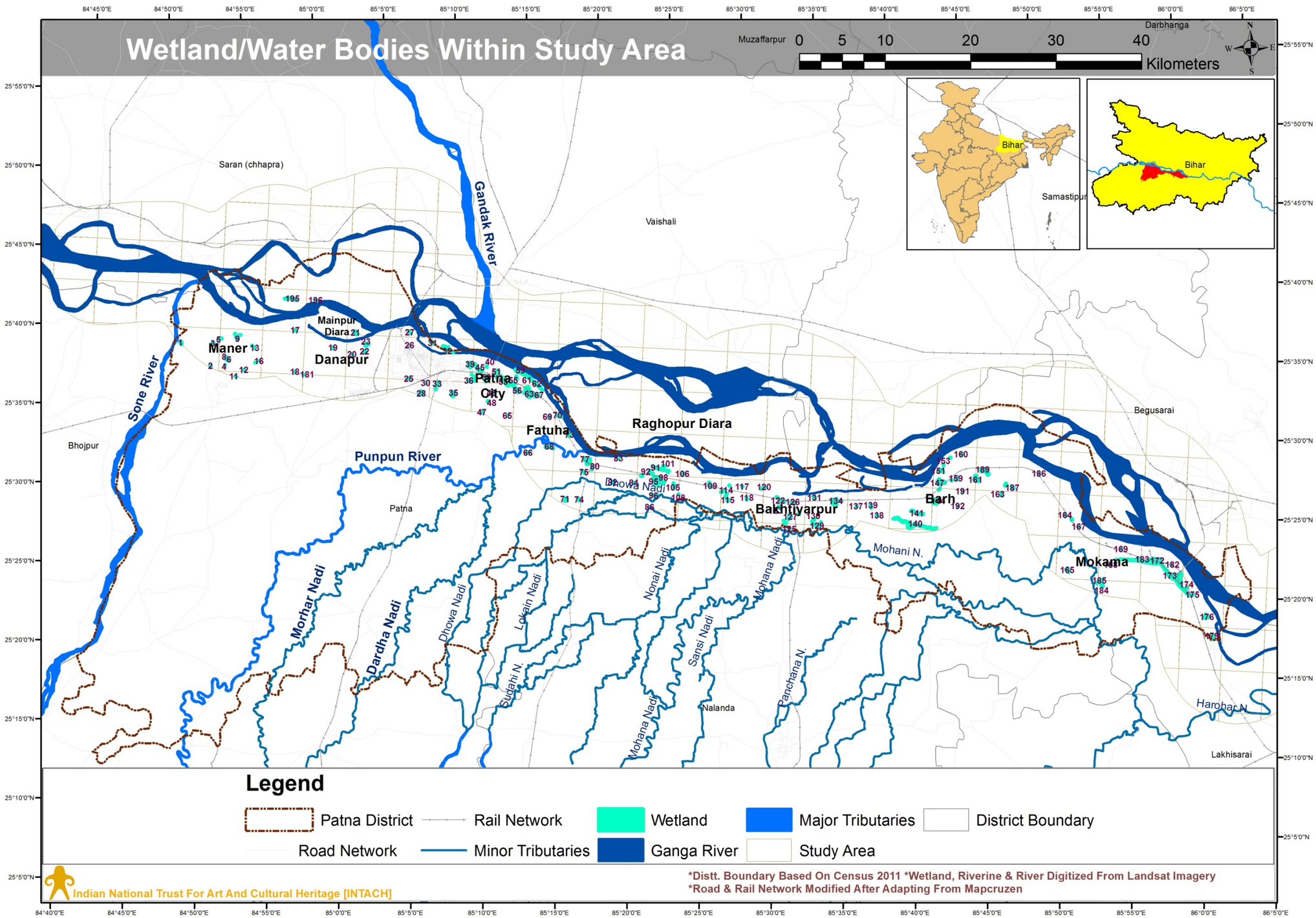
Image 13 : Location Of Mangal Talab

Image 14 : Mangal Talab

6.6 **Maner Dargah Pond :** Maner Sharif is a satellite town in Patna Distt. situated at a distance of about 25 km from Patna city. This town is well known for two very popular Muslim tombs – one tomb which is of Sufi saint Makhdoom Yahya Maneri (known as Bari Dargah) and another tomb which is of Makhdum Shah Daulat (popularly known as Chhoti Dargah). There is a small water body associated with the Chhoti Dargah which is referred by the local residents as 'jheel'. This pond is in a deteriorated state today with solid and liquid waste being dumped into it causing foul smell and increased water pollution. Despite this, some local residents were found to be using this water for washing their clothes and utensils along with small children who were taking bath in this polluted water. Some men were also found to be fishing in this pond using hook and line technique.

Image 15 : Location Of Chhoti Dargah Jheel


Image 16 : Chhoti Dargah Jheel In Maner



Map 04: Water Bodies In Patna Distt.

7.0 Riparian Flora Along Ganga River In Patna Distt.

7.1 The riparian areas, lying between the aquatic and the terrestrial habitats, serve as functional interfaces within the landscapes, mediating energy and matter between these two ecosystems. With dynamic environmental conditions and ecological processes, these areas tend to harbor rich biodiversity. A major component of this biodiversity is the plant communities growing along the river bank which are interacting with both terrestrial and aquatic ecosystems. The riparian vegetation is significant in the overall ecology and environmental aspects of the region owing to its important roles in soil conservation, harboring faunal diversity and providing livelihood resources [Groffman*et al.*, 1990; Castelle*et al.,* 1994].

7.2 Till some time ago, no proper systematic sampling had been undertaken or record had been maintained for the riparian plant diversity all along Ganga river. There are however, some scattered but significant works of Pallis [1934], Auden [1941], Sahai [1953], Gupta [1960], Bhattacharyya and Goel [1982], Groffman*et al.* [1990], Krishanmurti [1991], Castelle*et al.* [1994], Shyam [2008], Gangwar and Joshi [2006] and Gangwar and Gangwar [2011] which have explored the biodiversity of Ganga river basin. Also, a detailed study published in the form of a book titled – "The Ganga – A Scientific Study" edited by Krishnamurti [1991] documents 475 riparian plant species from Rishikesh to Chinasura. Patna Distt. forms a part of the Buxar – Barh stretch of Ganga River where earlier studies have reported the presence of 7 shrubs, 41 herbs, 6 grasses and 2 sedges in the riparian areas along with a number of tree species during 1987-88 [Kumar, 2001].

7.3 The construction of numerous Ghats along with unprecedented increase of brick kilns in the riparian zones can be considered a main reason for patchy distribution of riparian vegetation in the study region. While the tree cover was sparse to negligible in many riparian areas of the Distt., the shrubs and herbs were found to be growing more in number with the dominant species being – *Polygonum glabrum*, *Xanthium strumarium*, *Argemone mexicana* and *Rumex dentatus*. Some significant riparian vegetation patches in the Distt. are observed at HaldiChhapra, Near GyaspurGhat, Punpun-Ganga confluence and near Collectorate Ghat. A total of 28 different plant species are recorded from the riparian areas of Patna Distt., the details of which are presented in Table 4. Some of the important riparian plant species are depicted in Images 17-18.

Table 4 : Riparian Plant Species Recorded From Patna Distt.

Botanical Name	Family	Habit	Common Name
*Ailanthus excelsa*Roxb.	Simaroubaceae	Tree	
*Acacia nilotic*a (L.) Delile	Fabaceae	Tree	Babool
*Azadirachtaindica*A.Juss.	Meliaceae	Tree	Neem
Bombax ceiba L.	Bombacaceae	Tree	Semal
Dalbergia sissoo DC.	Fabaceae	Tree	Shisham
*Ficus benghalensis*L.	Moraceae	Tree	Banyan
Ficus religiosa L.	Moraceae	Tree	Peepal
Phoenix dactylifera L.	Arecaceae	Tree	
Borassusflabellifer L.	Arecaceae	Tree	Taad
Calotropis gigantea (L.) Dryand.	Apocynaceae	Shrub	Safed Aak
Calotropis procera (Aiton) Dryand.	Apocynaceae	Shrub	Aak
Lantana camara L.	Verbenaceae	Shrub	
Lippia alba (Mill.) N.E.Br. ex Britton &P.Wilson	Verbenaceae	Shrub	
*Polygonum glabrum*Willd.	Polygonaceae	Shrub	
Justicia adhatoda L.	Acanthaceae	Shrub	
Ricinus communis L.	Euphorbiaceae	Shrub	Wild Castor
Achyranthes aspera L.	Amaranthaceae	Herb	Chirchira
Amaranthus spinosus L.	Amaranthaceae	Herb	
*Croton bonplandianus*Baill.	Euphorbiaceae	Herb	Ban Tulsi
Ammaniabaccifera L.	Lythraceae	Herb	
Rumexdentatus L.	Polygonaceae	Herb	
Parthenium hysterophorus L.	Asteraceae	Herb	Congress Grass
Phyla nodiflora (L.) Greene	Verbenaceae	Herb	
Xanthium strumarium L.	Asteraceae	Herb	
Ocimum sp.	Lamiaceae	Herb	
Saccharum spontaneum L.	Poaceae	Grass	
Cyperus sp.	Cyperaceae	Grass	
Cynodondactylon (L.) Pers.	Poaceae	Grass	

Image 17 : *Lippia alba*

Image 18 : *Argemone mexicana*

8.0 Faunal Diversity In Patna Distt.

8.1 **Gangetic Dolphin :** The Gangetic River Dolphin is exclusively aquatic and piscivorus, occasionally found in small groups. The Ganges River Dolphin is one of the three freshwater dolphin species in the world and is distributed in the Ganges–Brahmaputra–Meghna and Sangu–Karnaphuli River systems in India, Nepal, and Bangladesh (Sinha & Kannan, 2014). It has been declared as the National Aquatic Animal by Govt. of India (Sinha & Kannan, 2014) and is classified as 'Endangered' in the IUCN Red List owing to the decrease in its population in the last 3-4 decades.While the presence of Gangetic Dolphin was reiterated by the local communities throughout the district, the visual sightings were recorded near Pontoon bridge at Kothiya (2-3 Nos.) and near Sati Sthan, Barh (1-2 Nos.). Upon interacting with the fishermen, it was found that the sightings of dolphin is usually more during monsoon season and drops drastically during remaining time of the year.

8.2 **Nilgai Conflict :** The Nilgai antelope – *Boselaphus tragocamelus* is widely distributed throughout the country. However, due to prolonged breeding activity and lack of potential predators, the numbers of Nilgai have increased considerably and become locally overabundant in states of Gujarat, Bihar, Uttar Pradesh, Haryana, Punjab, Rajasthan, Madhya Pradesh and Delhi (Meena, 2017). In the due course of time, this species has been successful in adjusting to the human-altered landscapes and in many places have become serious pests of agricultural crops. During the field survey, several farmers especially in Ganga floodplain agricultural fields reiterated this to be an important issue affecting their produce. Some of them indirectly admitted to even killing the Nilgai while majority chose to drive them away.

8.3 **Avian Diversity :** Birds are an important component of the ecosystem and they serve as useful biological indicators. India harbors a rich diversity of birds as it provides wide variety of wetland habitats that act as ideal wintering grounds especially for migratory birds. The Ganga River basin is important for the avifauna as its geo-morphological features provide wide variety of habitats in the form of mid channel Island, channel between Islands, sand bars, flood plains and a large number of floodplain wetlands which attract thousands of resident and migratory birds. However in the recent years, increased anthropogenic factors such as loss of natural vegetation, uncontrolled urbanization, extensive agriculture on the floodplains, increased use of chemical fertilizers and shrinking of wetlands have adversely affected the avian diversity in Ganga River basin especially in the stretch of Bihar. Despite this, in a recent avian diversity survey carried out by Kumari et al. (2014), 90 different bird species were recorded along Ganga River stretch in Bihar state which also included one endangered, seventeen rare, two vulnerable and seven near-threatened species. During the

surveyalong Ganga River stretch in Patna Distt., the diversity of avian species was recorded using binoculars and identified by using field guides (Salim Ali, 2012; Grimmett et al., 2016). A total of 28 different bird species are sighted in the survey which is presented in Table 5.

Table 5 : List Of Bird Species Recorded In Patna Distt.

Sr No.	Common Name	Scientific Name	IUCN Red List Status
01	Little Cormorant	*Phalacrocorax niger*	Least Concern
02	Indian Pond Heron	Ardeolagrayii	Least Concern
03	Little Egret	Egretta garzetta	Least Concern
04	Red - Wattled Lapwing	*Vanellus indicus*	Least Concern
05	White-Breasted Waterhen	*Amauronisphoenicurus*	Least Concern
06	Common Moorhen	*Gallinulachloropus*	Least Concern
07	Purple Mooorhen	*Porphyrio porphyrio*	Least Concern
08	Common Kingfisher	*Alcedoatthis*	Least Concern
09	Greater Coucal	*Centropusbengalensis*	Least Concern
10	Black Kite	*Milvus migrans*	Least Concern
11	Asian openbill stork	*Anastomusoscitans*	Least Concern
12	Black-Winged Stilt	*Himantopushimantopus*	Least Concern
13	Grey Francolin	*Francolinuspondicerianus*	Least Concern
14	Scaly-breasted Munia	*Lonchura punctulate*	Least Concern
15	Indian Roller	*Coracias benghalensis*	Least Concern
16	Green Bee-Eater	*Meropsorientalis*	Least Concern
17	Common Hoopoe	*Upupa epops*	Least Concern
18	Common Myna	*Acridotherestristis*	Least Concern
19	Bank Myna	*Acridotheresginginianus*	Least Concern

20	Asian Pied Starling	*Sturnus contra*	Least Concern
21	Rose Ringed Parakeet	*Psittaculakrameri*	Least Concern
22	Purple Sun-Bird	*cinnyrisasiaticus*	Least Concern
23	Rock Pigeon	*Columba livia*	Least Concern
24	Black Drongo	*Dicrurusmacrocercus*	Least Concern
25	Eurasian Collared Dove	*Streptopeliadecaocto*	Least Concern
26	Spotted Dove	*Spilopeliachinensis*	Least Concern
27	House Sparrow	*Passer domesticus*	Least Concern
28	House Crow	*Corvus splendens*	Least Concern

Image 19 : A Group Of Asian Openbill Stork Observed Near Bakhtiyarpur

9.0 Ganga Riverine Islands/Diaras In Patna Distt.

9.1 The riverine fluvial islands are present in many major rivers and are defined as 'land masses within a river channel that are separated from the floodplain by water on all sides and exhibiting some kind of stability' [Osterkamp, 1998]. Such islands may not be permanent on the geologic time scale owing to the river meandering, climate change, etc. but can remain in place over decadal or century time scales and hence exhibit stability [Wyrick & Klingeman, 2011]. Many such islands are existent in the Ganga River stretch of Patna Distt. which are locally referred to as *Diaras*. This term is derived from the word *Diya* (which means an earthen oil lamp) and has been coined for a land where a *Diya* is never lit [Udas *et al.*, 2018]. In local parlance in different parts of Bihar state, it symbolizes a village which is located outside the embankments of Ganga River floodplain. Some of the major *Diaras* surveyed in the study are described in this section.

9.2 The biggest *Diara* in Ganga River stretch of Patna Distt. is Raghopur Diara which forms a part of Vaishali Distt. as a community development block. Measuring about 30 kms long and 8-10 kms wide, this Diara is situated between the two bifurcated streams of Ganga River with Patna Distt. on the left bank (bordering lower Ganga stream) and Vaishali Distt. on the right bank bordering upper Ganga stream). This Diara mainly consists of alluvial soil and every year it gets submerged during the floods in Ganga River. According to Census of India (2011), this area is inhabited by 232,909 people spread across in villages such as Birpur, Paharpur, Fatehpur, Rampur, Jurawanpur and Shiv nagar to name a few. This Diara is connected with Patna Distt. through pontoon bridges [Images 20-21] which is used by the natives to access this island along with use of boats. Many residents of this Diara practice agriculture including crops such as Mustard, Rice, Chana and Wheat. Some residents are involved in sand mining from Ganga River while some residents are involved in fish catching mainly using drag net and hook & line method. The residents on this Diara also rear cattle – mainly cows and buffalos whose milk is collected for local consumption as well as for selling in Patna City.

Image 20 : Pontoon Bridge Connecting RaghopurDiara With Patna Distt.

Image 21 : Residential Settlements On Raghopur Diara

9.3 Another big and significant Diara in Ganga River exists off the Danapur Cantonment region close to Son-Ganga confluence. This Diara is about 20 kms long and 6-10 kms wide with two bifurcated streams of Ganga River surrounding it on upper side (bordering Saran Distt.) and lower side (bordering Patna Distt.). Some part of this Diara towards upper Ganga stream forms part of Saran Distt. while the remaining part of the Diara forms part of Patna Distt. The Diara is connected with Patna through a pontoon bridge in Danapur along with access provided by various boats plying from the banks to this Diara. The residential settlements can be observed only on one half part of this Diara (which is connected to Danapur) while the other half part (closer to the confluence) is covered with wild vegetation intermixed with agricultural fields. The residents of this Diara engage in growing wheat, mustard, potato, sweet potato and some pulses in their fields. Some people here are also involved in fishing activity while some rear cattle for procuring milk mainly for the local consumption.

9.4 A small Diara known as Mainpura Digha Diara is also present near the Collectorate Ghat in Patna city. Measuring about 7 kms long and 0.75-1.75 kms wide, this Diara is mainly utilized for agricultural purposes by the local residents. Crops such as wheat, rice and chana are mainly grown in this region. Along with this, sand mining was also found to be prevalent here which was mainly employed for the ongoing construction of elevated highway in this region.

Image 22 : Mining On Mainpur Digha Diara

9.5 A roughly conical shaped Diara can be observed from the GhaghaGhat in Patna city which is located behind the Mainpura Digha Diara and measures about 10 kms long and 1.5-2.5 kms wide. Parts of this Diara are inhabited with the residents mostly involved in agricultural activities. Boats are employed for ferrying passengers and transporting materials from Patna city to this Diara and back.

Image 23 : Diara Observed From Ghagha Ghat In Patna City

10.0 Fishing In Patna Distt.

10.1 Ganga River supports a rich diversity of fish fauna with about 260 fish species reported for Indian waters [Sinha & Khan, 2001]. About 35 species havebeen identified as having highest commercial value, including carps (Cyprinidae), snakeheads (Channidae),and catfishes (Siluriformes) [Islam et al. 2006]. However, most of these high value fish species have declined in numbers and many are also on the brunt of extinction today owing to a variety of environmental and anthropogenic factors. According to a recent study conducted by Das (2019), the Ganga River stretch at Patna exhibits maximum catch of *Cabdio morar*, *Crossocheilus latius*, *C. reba* in Pre-monsoon months whereas the monsoon months are chiefly dominated by Cyprinds (69 %) *Cabdio morar*, *Labeo calbasu*, *Systomus sarana* etc. However, the post monsoon season exhibits maximum contribution from catfishes (55%) such as *Clupisomagarua*, *Eutropiichthys vacha* and *Ailia coila*.

10.2 During the field survey, various fishermen were interacted with at different sites in Patna Distt which revealed that the main fishing gears employed by them are Drag Net, Cast Net, Dip Net and Hook & Line. For drag, dip and cast nets, fishermen made use of small boats mainly made out of Sekua (*Shorea robusta*) wood. They also reiterated the problem of fish catch decline in the last 2-3 decades and mainly attributed that to the changing environmental conditions and increased pollution. They claimed to have a higher fish catch during the monsoon season as compared with pre-monsoon and post-monsoon period. The main fishes caught during monsoon season are – Rohu (*Labeorohita*), Catla (*Labeocatla*), Bachwa (*Eutropiichthysvacha*), Buari (*Wallago attu*), Tengra (*Aorichthysaor*) and Ritha (*Rita rita*). Most of the fishermen reiterated a sharp decline in the percentage catch of Rohu in the last few years as compared to other fish. The fish caught in this region was often sold in the local markets of Patna city and other nearby towns for local consumption.

Image 24 : Fishermen Using Dip Net and Cast Net For Fishing Near Bakhtiyarpur

Image 25 : Different Types Of Fishing Nets And Boats Near Punpun-Ganga Confluence

11.0 Groundwater In Patna Distt.

11.1 Ground water characteristics of a particular area are subject to several natural factors like precipitation, drainage, topography, lithology and hydrogeological conditions of the region. It is also influenced by human induced factors like groundwater withdrawal and changes in land use pattern. The soil resource of the study area falls under soils of Gangetic plain and are recent alluvial deposits.

11.2 Geologically, the study area is underlain by Quaternary alluvial formation comprising of various grades of clay, silt, sand with occasional and gravel. Central Ground Water Board (CGWB) has categorized the study area into good to very good category. CGWB found that, the minimum and maximum water levels fluctuate within the range of 3.64 and 10.09 m bgl (meters below ground level) respectively in pre-monsoon season and between 1.40 to 7.12 m bgl in post-monsoon season.

11.3 During field survey, the team interacted with local communities throughout the study area and observed that the average groundwater level in the district is 10-12 m bgl. It has been also found that most of the households in study region have hand-pumps and the use of wells for drinking and bathing purposes is almost negligible. The water from the wells is utilized by the local communities during auspicious occasions such as Chhath Puja as they consider the well water to be pure and sacred.

11.4 Major interaction sites for groundwater observations are – Haldichhapra, Maner, Sherpur, Raipura, Bakhtiyarpur, Rashtampur and Barh. The groundwater observations were noted and are presented in Table 6.

Table 6 : Water Levels In Dug Wells (Based On Field Interactions)

Location	Coordinates	GW Level (in mbgl)	
		Post-Monsoon	Pre-Monsoon
Haldichhapra	25°40'43.01"N, 84°52'15.48"E	5-7	10-12
Maner	25°38'59.53"N, 84°52'49.46"E	8	10
Sherpur	25°39'4.74"N, 84°58'21.94"E	8-10	10-12
Raipura	25°30'25.94"N, 85°18'41.31"E	10-12	12-14

Bakhtiyarpur	25°28'00.5"N 85°30'56.2"E	10-15 *Handpump dig upto 33-35m	~~~~~
Rashtampur [riverine Island]	25°33'00.9"N, 85°17'05.7"E	6-8 *Handpump dig upto 18-20m	~~~~
Barh	25°29'10.70"N, 85°42'33.40"E	12-15	~~~~~
Temple Well, Bakhtiyarpur	25°29'14.9"N, 85°27'00.6"E	12	~~~~

Image 26 : An Old And Sacred Well In Bakhtiyarpur

12.0 Ganga River Bank In Patna Distt.

12.1 Left and right banks within the study area together constitute 1212.15 sq.km. Most of the study area is located at the right bank of river Ganga and is mostly covered by builtup area, agricultural fields and brick kiln area. The river bank is devoid of riparian vegetation. Thus, it is more prone to lateral erosion. Established brick kilns along Ganga river bank in Maner, Danapur, Patna Rural, Fatuha and Bakhtiyarpur blocks is a major threat for bank stability. It has been observed that brick kilns trigger the bank erosion, increases siltation rate and runoff. Sand bars, and riverine islands are used for rabi and zaid cropping and sand mining [some areas]. Ploughing at riverine islands increases the siltation rate and destroys the vulnerable riparian vegetation patches.

Image 27 : Brick Kilns Along Ganga River Bank In Fatuha [Right Bank]

12.2 Cremation Ground Along Ganga River Bank:

12.2.1 Ganga River Banks are used as cremation and burial ground for generations. In Patna Distt. River banks are mainly used for cremation by Hindus. In field surveys there are six major cremation sites are were reported. However, there are other several sites used for cremation in the district. It has been found that the basic infrastructure at most of the cremation grounds are lacking. Also designated sites for cremation are not

available. Thus, local communities utilize any place of the river bank for cremation. [Ref. Table 7 & Image 28].

Table 7 : Cremation Sites In The Study Area

Site	Location		Remarks
	Latitude	Longitude	
Son-Ganga Confluence Near Haldi Chhapra [Right Bank]	25°41'25.66"N	84°52'29.26"E	Used for cremation
Bas Ghat	25°37'23.03"N	85° 7'59.04"E	Used for cremation
Gulbi Ghat	25°37'12.90"N	85°10'49.64"E	Used for cremation
Mukti Asthal, Fatuha	25°31'9.34"N	85°17'54.67"E	Used for cremation
Chiraiya Ghat, Bakhtiyarpur	25°29'6.31"N	85°30'19.35"E	Used for cremation
Sati Asthal, Barh	25°29'45.00"N	85°42'54.70"E	Used for cremation

Image 28 : Sati Sthal In Barh

12.3 Bank Erosion:

12.3.1 Weathering of soils by natural forces is both constructive and destructive. Erosion is the chief agent responsible for the natural topographic cycles as it wears down higher elevations, banks (lateral erosion) and deposits sediments in the plains. However, erosion gets aggravated due to human interventions through change in land use, excessive grazing, extensive farming, cultivation without taking proper conservation measures, destruction of forest and riparian vegetation. It is well known that exposed soil may erode rapidly (Singh et al., 2004).

12.3.2 Depending on the intensity and severity of erosion, the study area [7 km Buffer] is grouped under non to very slight, slight and moderate erosion category (Singh et al., 2004). The study area in Maner, Khagaul [Danapur], Fatwah, Khusrupur, Bakhtiarpur, Atmalgola, Barh, Pandarak, Ghoswari and Mokameh block are slight to moderately eroded while erosion in Patna Rural and Sampat Chak block are almost negligible of slightly eroded.

12.3.3 Ongoing river mining activities, increasing number of brick kilns mainly at Ganga river bank, decrease in riparian vegetation area and change in land use are major anthropogenic reason behind the lateral erosion of Ganga River banks and its tributaries in Patna distt.. The action of forceful water flow on the left and right banks of the River Ganga could be easily observed throughout the study area. The lateral erosion of the banks occurs under intense rainfall accompanied by torrential flow in rivulets generating vast quantities of sediment transported downstream.

12.3.4 There are 49 lateral erosion sites marked within the study area and provided in Table 8. Major eroded sites are found near village – Haldichhapra [near Ganga- Son confluence], Dudhaila, Mahavirtola, Ratantola, Ganghara, Hetanpur, Purana Panapur, Phulwaria, Bidhipur, Lakhanpura, Bakhtiyarpur, Kala Diara, Sahabad, Sultanpur and Gangaprasad [Refer Map 05].

Table 8 : Erosion Prone Sites In Patna Distt.

Sr. No.	Latitude [N]	Longitude [E]	Nearest Settlement
1	25°41'42.17"N	84°52'15.62"E	Near Haldichhapra Village [Right Bank]
2	25°41'27.95"N	84°52'27.92"E	
3	25°40'32.80"N	84°53'14.43"E	Near Dudhaila Village [Right Bank]
4	25°40'26.56"N	84°53'20.90"E	
5	25°40'17.94"N	84°53'36.29"E	
6	25°40'5.47"N	84°54'7.15"E	Near Mahavirtola Village [Right Bank]
7	25°40'6.52"N	84°54'0.42"E	

8	25°39'42.54"N	84°54'49.93"E	Near Ratantola Village [Right Bank]
9	25°39'34.14"N	84°55'42.38"E	Between Maulanipur, Nilkanthtola,Vyaspur and Lodipur [Right Bank]
10	25°39'34.91"N	84°56'0.01"E	
11	25°39'37.53"N	84°56'22.10"E	
12	25°39'44.42"N	84°56'58.44"E	
13	25°39'49.13"N	84°57'22.81"E	
14	25°40'53.87"N	85° 0'10.00"E	Between Ganghara and Hetanpur [Left Bank]
15	25°40'52.55"N	85° 0'44.30"E	
16	25°40'42.81"N	85° 1'15.60"E	
17	25°41'47.75"N	84°55'56.52"E	~~~~~~~~~~~~~~~~
18	25°39'53.11"N	85° 2'48.80"E	Near Purana Panapur Village [Left Bank]
19	25°39'43.96"N	85° 2'57.13"E	
20	25°39'29.03"N	85° 3'18.28"E	
21	25°30'29.45"N	85°20'56.08"E	Near Phulwaria Village [Right Bank]
22	25°30'30.60"N	85°21'43.41"E	
23	25°29'13.03"N	85°27'16.30"E	Near Bidhipur Village [Right Bank]
24	25°29'6.73"N	85°27'48.11"E	
25	25°29'1.79"N	85°28'11.65"E	
26	25°30'4.43"N	85°26'26.99"E	Near Kala Diara [Left Bank]
27	25°29'45.92"N	85°26'50.40"E	
28	25°29'34.23"N	85°27'14.44"E	
29	25°28'55.86"N	85°29'3.98"E	Near Lakhanpura Village [Right Bank]
30	25°29'3.76"N	85°29'55.61"E	
31	25°29'50.41"N	85°30'45.76"E	Left Bank
32	25°30'0.62"N	85°31'17.26"E	
33	25°27'40.44"N	85°32'55.53"E	
34	25°28'49.83"N	85°33'59.27"E	Near Bakhtiyarpur [Right Bank]
35	25°29'7.57"N	85°34'17.52"E	
36	25°28'36.45"N	85°39'1.65"E	Between Ratanpur and Barh City [Right Bank]
37	25°28'29.14"N	85°39'31.73"E	
38	25°28'27.62"N	85°39'46.30"E	
39	25°28'17.29"N	85°41'7.41"E	
40	25°28'17.83"N	85°41'31.47"E	
41	25°30'45.63"N	25°30'45.63"N	Left Bank
42	25°31'40.98"N	85°45'15.51"E	
43	85°45'15.51"E	85°46'6.52"E	
44	25°31'54.43"N	85°46'37.75"E	
45	25°31'51.50"N	85°47'37.25"E	
46	25°29'6.95"N	85°49'32.28"E	Between Sahabad and Sultanpur Village [Right Bank]
47	25°28'57.93"N	85°49'46.24"E	
48	25°27'54.00"N	85°50'55.28"E	
49	25°28'29.88"N	85°51'57.94"E	Near Gangaprasad [Right Bank]

Image 29 : Eroded River Bank In Bakhtiyarpur [Right Bank]

Image 30 : Eroded River Bank NearHaldichhapra Village [Right Bank]

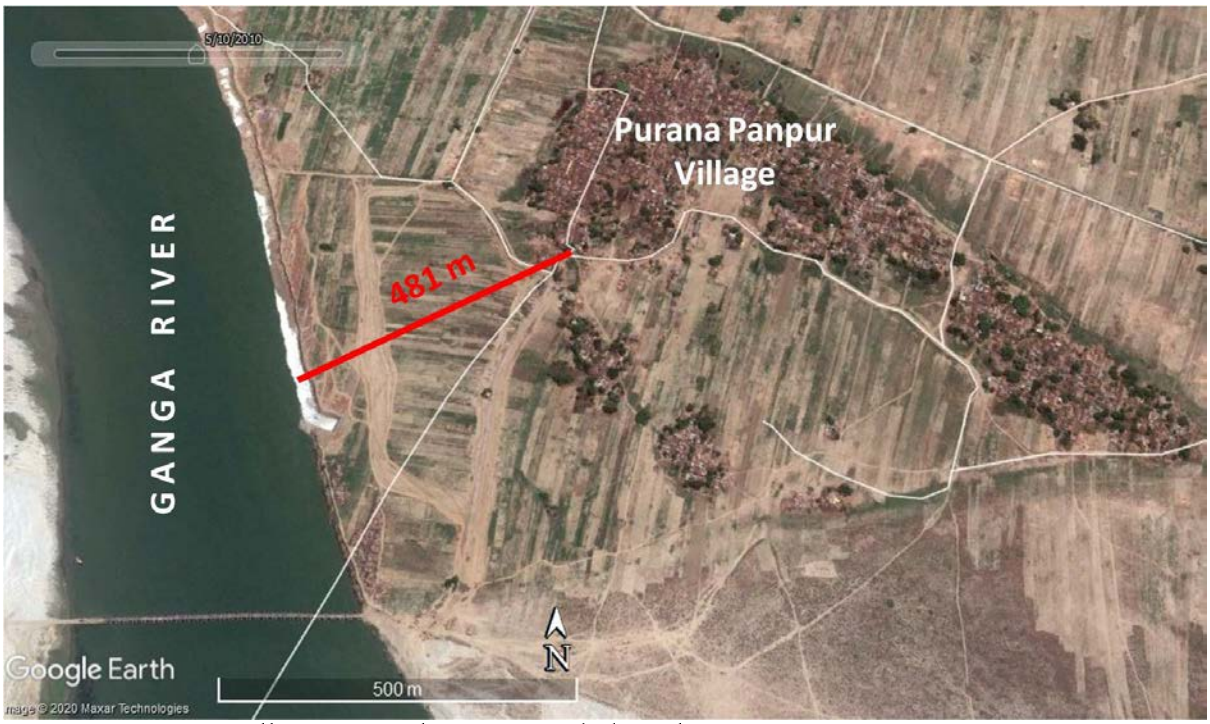
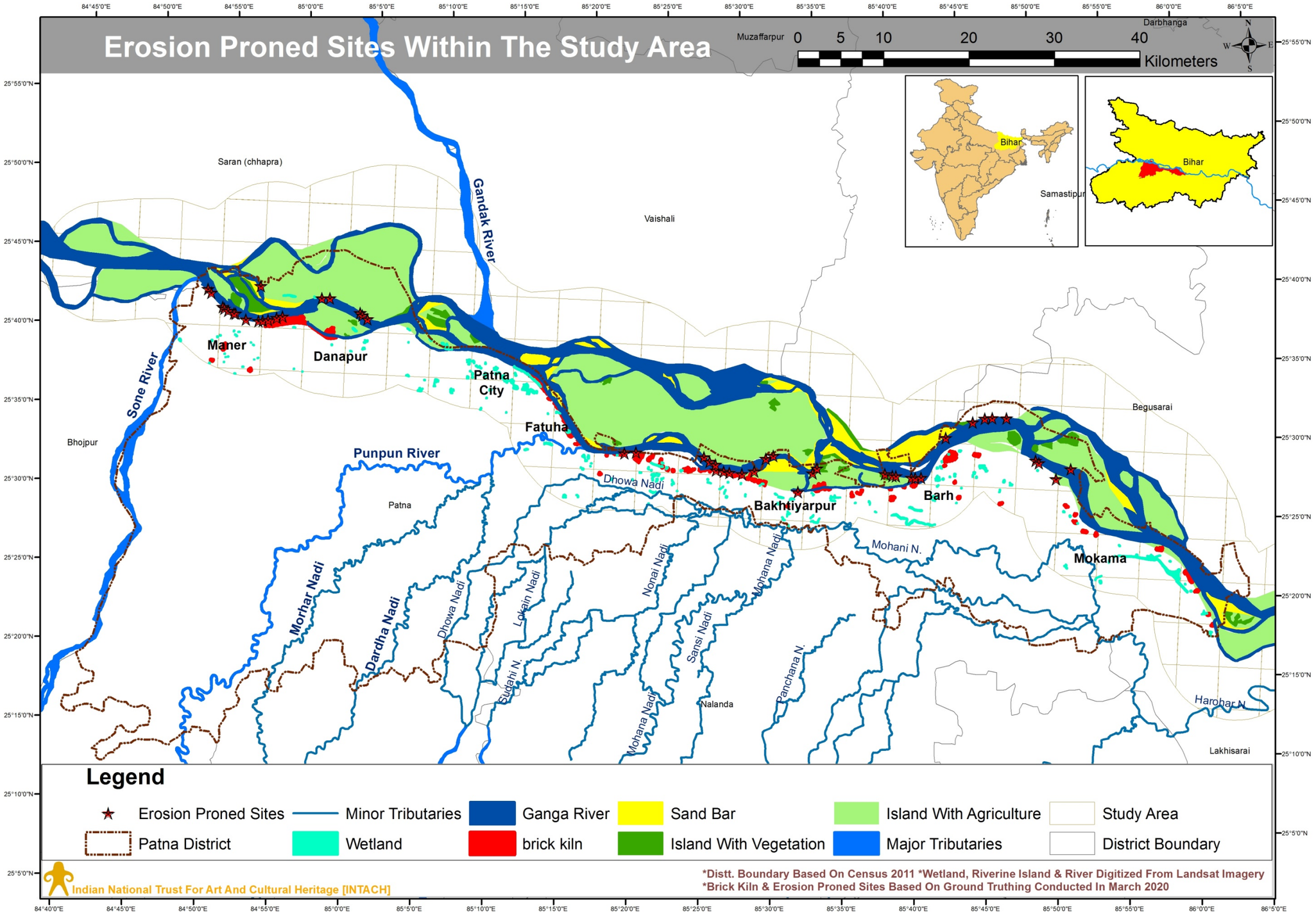


Image 31 : Satellite Image Showing Eroded Bank Near Purana Panpur In Year 2010
Source : Google Earth Pro [Image Dated : 10.05.2010]

Image 32 : Satellite Image Showing Eroded Bank Near Purana Panpur In Year 2019
Source : Google Earth Pro [Image Dated : 15.11.2019]



Map 05: Erosion Prone Sites Within The Study Area

13.0 Mining And Brick Kilns Within Study Area

13.1 **Sand mining in Ganga River :** Reckless sand mining causes degradation of river ecosystem. Instream mining lowers the stream bottom, which may cause lateral and enhanced river bed erosion. During the survey nine sand mining sites are reported to be present in Ganga River and Son River in Patna Distt.. These sites are located near Haldi Chhapra, Patna Rural block, Bakhtiyarpur and Deedarganj. In the study area Son river bed is one of the major sites for sand mining as its entire stretch is used for sand mining. Upon interactions, the local communities claimed that there are other places near Son-Ganga confluence where people are engaged in illegal sand mining. The **'Enforcement and Monitoring Guidelines for Sand Mining 2020' are not being enforced on the ground to the detriment of the River.**

Table 9 : Location Of Sand Mining Sites In Patna Distt.

Sr. No.	Latitude	Longitude	Nearest Settlement
1	25°42'19.43"N	84°51'45.44"E	Near Ganga-Son Confluence
2	25°40'1.84"N	84°56'2.50"E	Near Haldi Chhapra Village [Right Bank]
3	25°39'2.79"N	85° 6'15.48"E	Patna Rural [Right bank]
4	25°38'8.06"N	85° 8'38.02"E	Near Collectorate Ghat [Right bank]
5	25°37'31.36"N	85° 9'32.12"E	Near Kali Ghat [Right Bank]
6	25°35'6.20"N	85°15'23.36"E	Near Deedarganj [Right Bank]
7	25°28'6.12"N	85°31'7.17"E	Bakhtiyarpur [Right Bank]
8	25°29'3.79"N	85°30'24.82"E	Bakhtiyarpur [Right Bank]
9	25°38'42.46"N	84°50'2.92"E	Mining carried out throughout the stretch of river Son in the study area

Image 33 : Boats Preparing For Sand Mining In Son River [Near Son-Ganga Confluence]

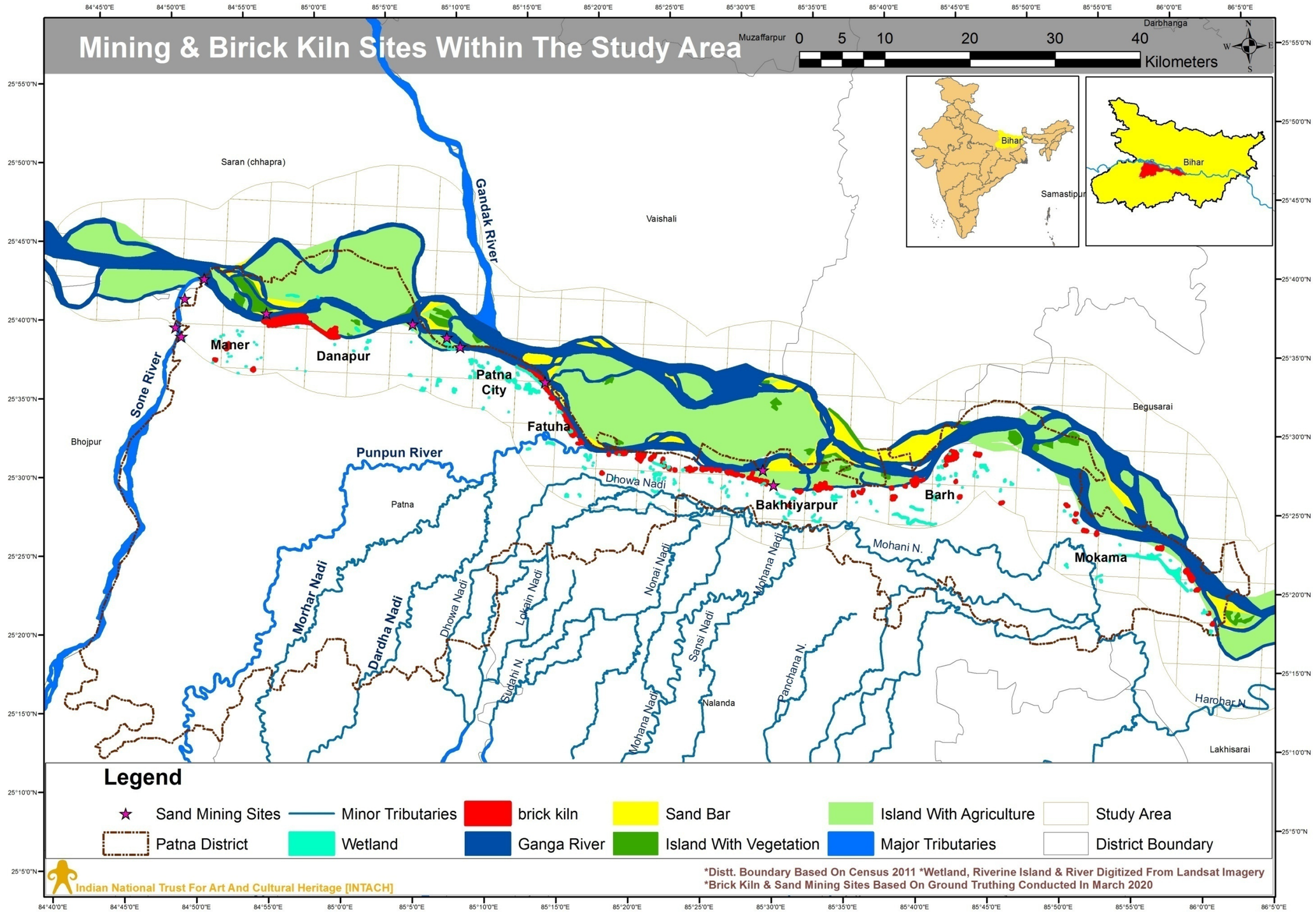
13.2 Brick Kilns : With rapid urbanization, bricks have become an important building material for construction activities. Brick kilns in the study area provide livelihood opportunity to the local community. However, this industry has posed current and potential future threats to the soil, air, biota and water system of the region. The clay digging process deteriorates the soil quality and productivity as the bricks are made from the top soil thereby leading to soil erosion during floods.

13.2.1 Location of brick kilns, clay and river sand mining sites have initially been identified from Google imagery (June, 2019) and thereafter verified during field survey conducted in March, 2020. The spatial distribution of brick kilns in the study area is delineated in Map 06. After identification of sites, it was found that:

- Brick Kilns constitutes 1212.15 hectares i.e. 1.0 % of the total study area. This area is more than the identified water bodies in the study area.
- Most of the brick kilns are situated along Ganga river bank as the good quality of bricks are made from the recent alluvial deposits. Local communities believe that "bricks made from alluvial deposits remain free from Noni [lichens]".
- Brick kilns working at the river banks are a major threat for bank stability and riparian vegetation as they may induce lateral bank erosion.

Image 34 : Brick Kilns Along Ganga River Bank, Patna Rural Block [Right Bank]


Image 35 : Brick Kiln Near Fatuha



Map 06: Mining And Brick Kiln Sites Within The Study Area

14.0 Inland Navigation

14.1 **National Waterway I :** The stretch of Ganga River in Patna Distt. is a part of 1620 km long National waterway (NW 1). The waterway covers approximately 140 km. length of river Ganga [From Munger border to Bhojpur Distt. Border] in the Distt. [Refer Map 07]. For making the waterway workable Inland Waterway Authority of India (IWAI) is planning to maintain atleast 3.0 meters of Least Available Depth (LAD) in the river by continuous dredging.

14.2 Ferry Services : Ferrying is a crucial livelihood activity of the Mallah community living in the villages on the banks of river Ganga. Local residents of this community in Patna Distt. have been ferrying passengers for generations. There are 20 sites reported in the study area where ferry services are available. However, there are several sites where ferry services were once operated but in recent years, ferrying is not workable due to lack of water or inadequate water in the channels. Based on the analysis of US Army Maps [compiled 1953], it was found that there were ten places in the Distt. where ferry services were operated. In recent years, most of the ferry services have closed due to shifting of river course, lack of water in channels or inadequate water, siltation and construction of pontoon bridges. Details of Ferrying sites are provided in the Table 10:

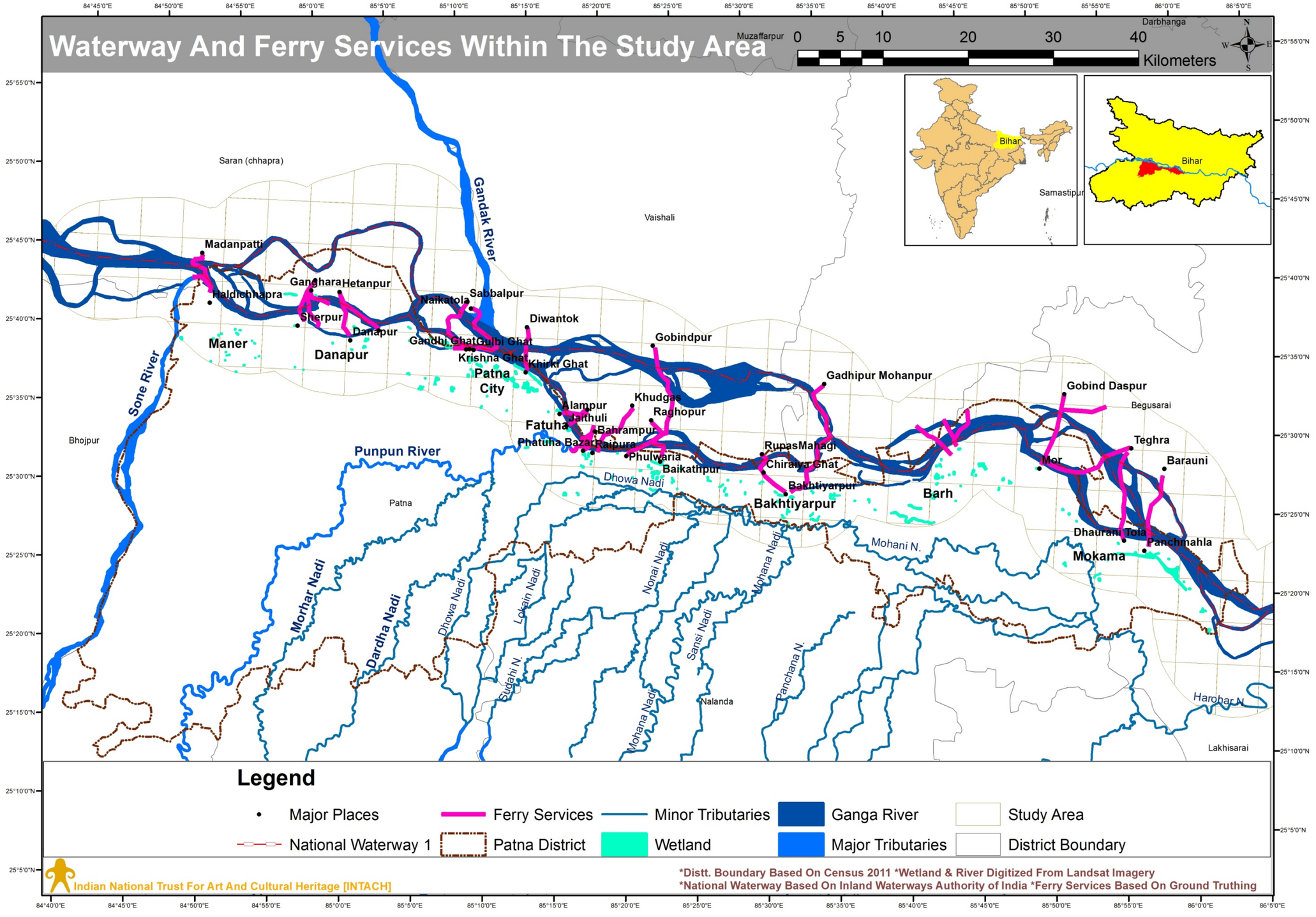
Table 10 : Details Of Ferry Services In The Study Area

Sr. No.	Latitude	Longitude	Nearest Settlements	No. of Boat & Ferry Season
01	25°40'43.01"N	84°52'15.48"E	Between Haldichhapara and Madanpatti ***Purpose : Sand mining and movement of goods**	Approximately 15-20 boats (September to Mid July)
02	25°40'43.01"N	84°52'15.48"E	Between Haldichhapra village &Gnaga-Son confluence ***Purpose : Sand mining**	More than 30 boats (September to Mid July)
03	25°39'6.19"N	84°58'21.95"E	Between Sherpur Village and Noniatola	Two Boats (September to Mid July)
04	25°39'51.30"N	84°59'13.30"E	Between Khaspur and Ganghara Village	Two Boats (September to Mid July)
05	25°40'55.89"N	85° 0'3.36"E	Between Ganghara and Riverine Island **Current Status : Ferry service is stopped due to drying up of Ganga Channel**	Two Boats (September to Mid July)
06	25°38'20.19"N	85° 1'58.59"E	Between Danapur and	~~~~~~~~~~~~~~

			Hetanpur	
07	25°38'50.49"N	85° 3'53.74"E	Between Sikandarpur and Hetanpur	Two Boats (September to Mid July)
08	25°37'15.86"N	85°10'5.21"E	Between Krishna Ghat and Sabbalpur	Two Boats (September to Mid July)
09	25°37'20.37"N	85° 9'12.75"E	Between Kali Ghat to Krishna Ghat and Riverine Island	4-6 Boats (September to Mid July)
10	25°37'18.30"N	85°10'20.84"E	Between Gandhi Ghat and Riverine Island	Two Boats (September to Mid July)
11	25°37'14.94"N	85°10'36.54"E	Between GulbiGhat and Naika Tola	2-3 Boats (September to Mid July)
12	25°35'50.77"N	85°14'17.20"E	Between KhirkiGhat and Diwantok	~~~~~~~~~~~~~~~
13	25°33'1.06"N	85°16'39.36"E	Between Alampur and Saidabad [Riverine island]	Two Boats (September to Mid July)
14	25°32'15.96"N	85°17'5.94"E	Between Jethuli and Saidabad Village	Two Boats (September to Mid July)
15	25°30'54.38"N	85°17'38.41"E	Between Punpun River and Behrampur Village ***Purpose : Fishing**	Approximately 10-12 boats (September to Mid July)
16	25°30'43.69"N	85°18'17.31"E	Between Phatuha Bazar to Behrampur Village	Two Boats (September to Mid July)
17	25°30'34.12"N	85°19'5.38"E	Between Raipura and Khudgas Village [Riverine Island]	~~~~~~~~~~~~~
18	25°30'28.48"N	85°21'16.45"E	Between Phulwaria Village and Raghopur Village	Four Boats (September to Mid July)
19	25°30'33.61"N	85°23'40.31"E	Between Baikathpur Village and Gobindpur Village	Two Boats (September to Mid July)
20	25°29'1.01"N	85°30'19.71"E	Between ChiraiyaGhat and Rupas	Two Boats (September to Mid July)

Image 36 : Ferrying In Ganga River Near HaldiChhapra Village

Image 37 : Ferrying In Ganga River At Chiraiya Ghat



Map 07: Waterway And Ferry Services Within The Study Area

15.0 Boatmaking in Patna Distt.

15.1 Some members of local communities are involved in boat making activity at HaldiChhapra area near Sone-Ganga confluence in Patna Distt. Upon interacting, they revealed that most of the boats constructed by them were large-sized and made from metal alloys (mainly comprising of iron). According to them, the main reason for this is the low cost involved as compared to the wooden boats and the weight of boats is suitable for carrying heavier loads (mainly sand/silt). The locals procure the raw material from factories nearby and involve welders from neighboring villages for construction of these boats. Along with these, some boats were also made of wood but have smaller sizes when compared to metal boats. The wood of Sekua tree (*Shorea robusta*) is the chief raw material involved in construction of wooden boats.

Image 38 : Boat Making Observed Near Haldi Chhapra In Patna Distt.

16.0 Sacred Trees In Patna Distt.

16.1 Forests and their constituent trees have been an integral part of human civilizations since time immemorial. Apart from deriving various tangible benefits from these trees, they formed an integral part of the socio-religious beliefs and practices especially in a diverse country like India. During the survey, some old and sacred trees were found to be associated with temples in different parts of Patna Distt. These temples are locally known as 'Thakur Bari' in the Distt. and usually have one or two trees associated with them. The local residents tie sacred threads and make some offerings to these trees especially during auspicious occasions. Some important sacred trees recorded in the survey are presented in Table 11 and are presented in Images 39-41.

Table 11 : Some Sacred Trees Recorded In Patna Distt.

S. No.	Description	Locality
1.	Old and Sacred Banyan Tree associated with Hanuman temple	Patna City
2.	Sacred Peepal Tree associated with Goddess Kali temple	Patna City
3.	Sacred Peepal Tree associated with Shiva Thakurbari	Near Punpun-Ganga Confluence
4.	Old and Sacred Ficus Tree with Ram-JankiThakurbari	Near GyaspurGhat
5.	Sacred Peepal tree with Ram JankiThakurbari	Rawaich Village

Image 39 : Sacred Peepal Tree Near Punpun-Ganga Confluence

Image 40 : Old And Sacred Peepal Tree Associated With Kali Temple In Patna City

Image 41 : Sacred Peepal Tree Associated With Ram-JankiThakurbari at Rawaich Village

17.0 Urban Green Spaces In Patna

17.1 Owing to the rapid urbanization, the stress on natural resources such as water bodies and biodiversity rich areas has increased manifolds. This has impacted urban dwellers in the form of poor air quality, decreased water availability and increased levels of noise pollution. In the wake of this, the importance of urban green spaces has been realized worldwide for their numerous tangible and intangible benefits to mankind. Among the major cities in India, Patna cityis one of the oldest continuously inhabited places in the world and has also witnessed massive urbanization in the last few decades owing to its historical importance. A study conducted by Ashraf and Sarkar (2015) highlighted that the urban green areas in Patna city have shrunk to one-third of what it was in 1993 while the built-up area has more than tripled in the last quarter century. Despite this, there are many important green spaces in the city which continue to shelter rich biodiversity and serve as an important retreat for the local residents. Most of these green spaces are in the form of parks and gardens containing plants of ornamental value. Some important tree species recorded from the urban green spaces of Patna is presented in Table 12.

17.2 The important green spaces in Patna City include – Sanjay Gandhi Biological Park, Eco Park, Buddha Smriti Park and Danapur Cantonment. Among these, Danapur Cantonment is the biggest space with an area of about 848.40 acres. It is one of the oldest European cantonments in the region established in the year 1765. This cantonment had played an important role in the freedom struggle of 1857 and currently serves as the regimental centre of Bihar Regiment of the Indian Army. Located close to Ganga River, this cantonment is enriched with many naturally growing and planted tree species thereby maintaining a green cover throughout the year. As this area is protected by the Army, the vegetation and its associated biodiversity remains unharmed and unchanged thereby making it an important green space in the region.

17.3 Another important green space of Patna is the Sanjay Gandhi Biological Park (popularly known as the Patna Zoo). Spread in an area of about 153 acres, this park was initially established as a botanical garden in 1970 by the forest department in an area of 34 acres which was bestowed by the then Governor of Bihar state. Later on the Forest Department acquired adjoining lands and together this area was officially declared as a Biological Park (https://www.zoopatna.com/history.aspx). Today, this park houses diverse species of animals along with a rich diversity of flora including many native and exotic species. It serves as an important tourist spot for the local residents of Patna as well as is thronged by a large number of tourists from nearby cities and towns. With numerous environmental benefits, this park serves as another important green space in the heart of Patna city.

17.4 Yet another important green space in the heart of Patna City is Rajdhani Vatika (popularly known by the locals as Ecological Park or Eco Park). Inaugurated in the year 2011, this park is spread across an area of about 23 acres and is very popular especially for morning walkers and joggers. Equipped with two small lakes, children area, jogging tracks and well developed aesthetic gardens, this area is popular for visitors from all age groups both from the city and outside the city. The rich plant diversity in this park comprising of more than 3000 different varieties is well looked after by the authorities to ensure an aesthetic green cover round the year.

17.5 Yet another important place in Patna city is Buddha Smriti Park (also known as Buddha Memorial Park) which was developed as an urban park by Bihar State Govt. to commemorate the 2554th birth anniversary of Lord Buddha. While inaugurating this park, Tibetan Spiritual Leader Dalai Lama in the year 2010 had planted two saplings of the sacred Bodhi tree – one brought from Bodh Gaya and the other from Anuradhapura in Sri Lanka. This roughly 22 acres park is also located in the heart of Patna City with the main attraction being 200 ft high Stupa housing a pot containing holy ashes of Lord Buddha.

Table 12 : Some Important Tree Species Recorded From Urban Green Spaces Of Patna

Sr. No.	Botanical Name	Common Name
1.	*Ailanthus excelsa*Roxb.	
2.	*Alstoniascholaris*R. Br.	Scholar tree
3.	*Azadirachtaindica*A. Juss.	Neem
4.	*Bauhinia purpurea*Linn.	
5.	*Bombax ceiba* L.	Semal
6.	*Borassusflabellifer* L.	
7.	*Callistemon lanceolatus* (Sm.) Sweet	Bottle Brush
8.	*Caryotaurens* L.	Shivajata
9.	*Dalbergiasisoo*Roxb.	Shisham
10.	*Delonix regia* (Hook.) Raf.	Gulmohar
11.	*Eucalyptus globulus*Labill.	Eucalyptus
12.	*Ficus benghalensis* L.	Bargad/Banyan tree
13.	*Ficus religiosa* L.	Peepal
14.	*Mangiferaindica*L.	Mango
15.	*Peltophorumpterocarpum* (DC.) K. Heyne	
16.	*Plumeria rubra* L.	Champa
17.	*Polyalthialongifolia*(Sonn.) Thwaites	False Ashok
18.	*Roystonea regia* (Kunth) O. F. Cook	
19.	*Thespesia populnea* (L.) Sol. ex Corrêa	
20.	*Wodyetiabifurcata*A.K. Irvine	

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