Ganga Cultural Documentation
2021

MUZAFFARNAGAR DISTRICT
Natural Heritage

NAMAMI GANGE

National Mission for Clean Ganga

INTACH

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Front Cover:	**Haiderpur Wetland At Ganga River, Muzaffarnagar**
Background:	**Ganga Upstream Of Bijnor Ganga Barrage**
Back cover:	**Muddy Marsh Skimmer Dragonfly At Haiderpur Wetland**
Formatting and Design by:	**Mohd. Sajid Idrisi**

GANGA CULTURAL DOCUMENTATION

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August, 2021

Sponsored by :

National Mission for Clean Ganga

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1.0 Introduction

1.1 Distt. Muzaffarnagar, situated on the right bank of Ganga River [Approx. 24 km reach in the Distt.], occupies the southern part of the Saharanpur division and in northeast, borders with the State of Uttarakhand. The district is the part of National Capital Region [NCR] and is located midway on Delhi – Haridwar/Dehradun National Highway [NH-58] The town was founded in 1633 A.D. near the site of an ancient town, Sarwat, by the son of a Mughal Commander Sayyid Muzaffar Khan during the reign of Emperor Shah Jahan. In 1901 A.D., during the British Raj, it was a district in the Meerut Division in United Provinces of Agra and Oudh[1].

1.2 The geographical area of the Distt. is 2991 Sq. km which is about 1.2 percent of the total Uttar Pradesh area. It shares boundary with Bijnor in East, Saharanpur and Haridwar Distt.s on the North, Shamli in West [carved out from Muzaffarnagar in 2011] and Meerut in South. The Distt. is divided into 9 development blocks and 4 tehsils – Sadar, Jansath, Budhana and Khatauli.

1.3 The Muzaffarnagar Distt. is a part of the Doab region of Indo-Gangetic plains sloping towards south. The Upper Ganga Canal runs through its eastern part entering district near Purquazi taking southwest course and leaving district near Khatauli. Two smaller rivers flow on its western and eastern boundary. At west, Kali Nadi – a tributary of Hindon River and towards east, Solani River – a smaller river with its source in Mohand Forest Range of Haridwar, Uttarakhand. Another smaller river i.e. Banganga River joins it around 1.5 km upstream of Shukratal. It is an old and active channel of Ganga River, splitting off from the main river around 14 km downstream of Haridwar city.

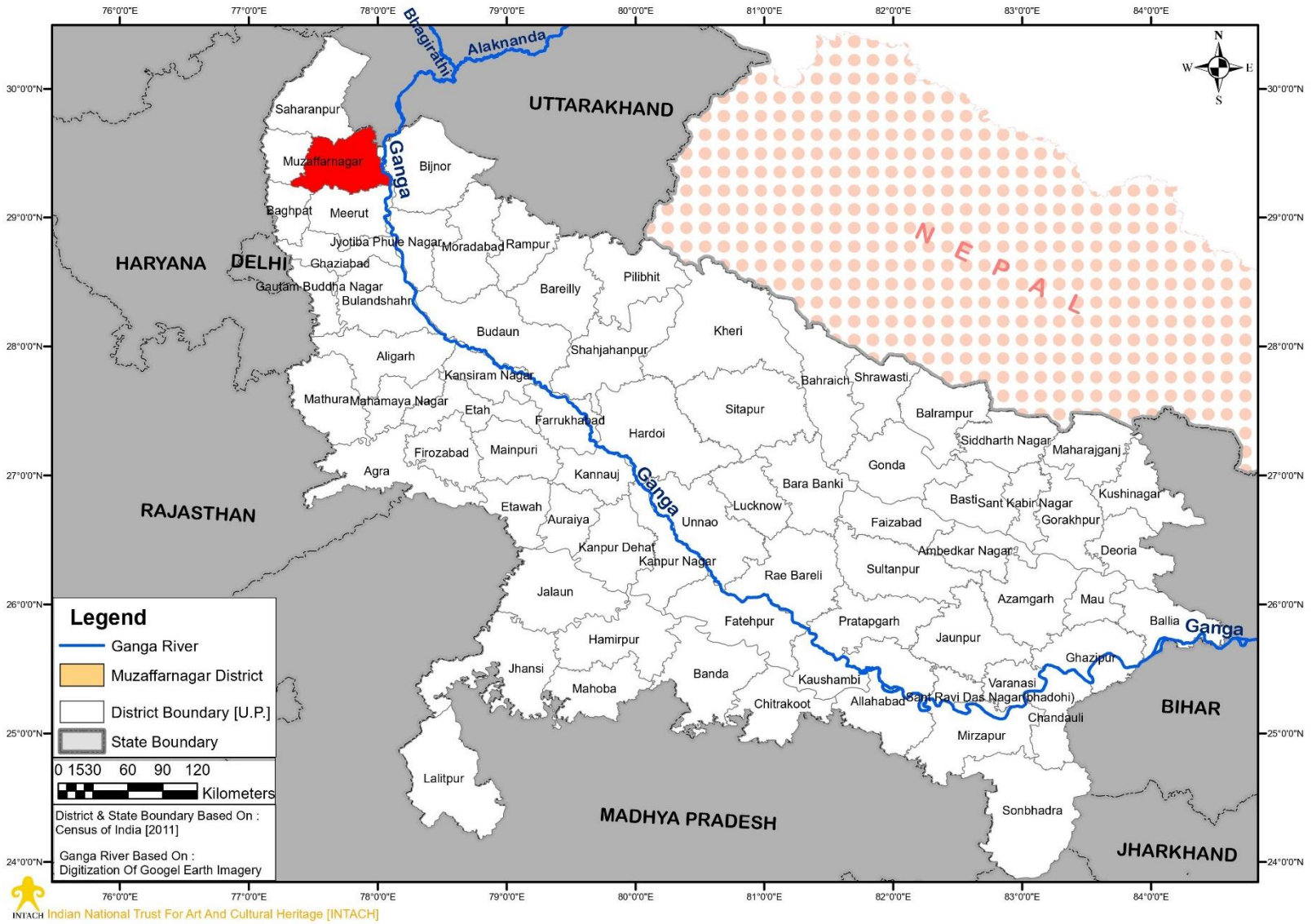
1.4 Geomorphologically[2], the entire Distt. is a flat terrain falling in middle Ganga plain. The highest point is 222.00 mamsl in the north and lowest is 201.00 mamsl in the South with an average slope of 0.40 m/km north to south. The district can be subdivided into five major units: sandbars, floodplain, ravines, younger alluvial plains, older alluvial plains and landforms such as water-logged area, swampy land, palaeochannels and levee deposit. Major soil type is sandy loam.

1.5 The primary occupation in the Distt. is agriculture owing to the fertile loamy soils. Sugarcane farming dominates the agriculture fields. Main rabi crops are wheat and oil seeds while kharif crops are paddy and pulses. Other agrarian activities include dairy

[1] Muzaffarnagar.nic.in/aboutdistrict
[2] Groundwater Brochure of Muzaffarnagar District, U.P. , CGWB

and milk production, fish farms, poultry farms, mango orchards, eucalyptus and poplar trees cultivation. Sugar and jaggery production are major economic activities in the district with 8 sugar mills as major industrial units. Other industrial units are steel and paper. The district is a part of Delhi-Mumbai Industrial Corridor [DMIC] and Amritsar-Delhi-Kolkata Industrial Corridor [ADKIC] and now claims to be the principal commercial, industrial and educational hub of Western Uttar Pradesh. There are few places of religious and cultural importance such as Shukratal Ghat with Hanuman dham and Ganesh dham, Akshay Vat, Bhairon Ka Mandir, Vahelna (Jain Temple) and Bahu Ki Mazaar.

Image 1 : Ganga River Between Muzaffarnagar And Bijnor District
[Upstream Area of Bijnor Barrage]



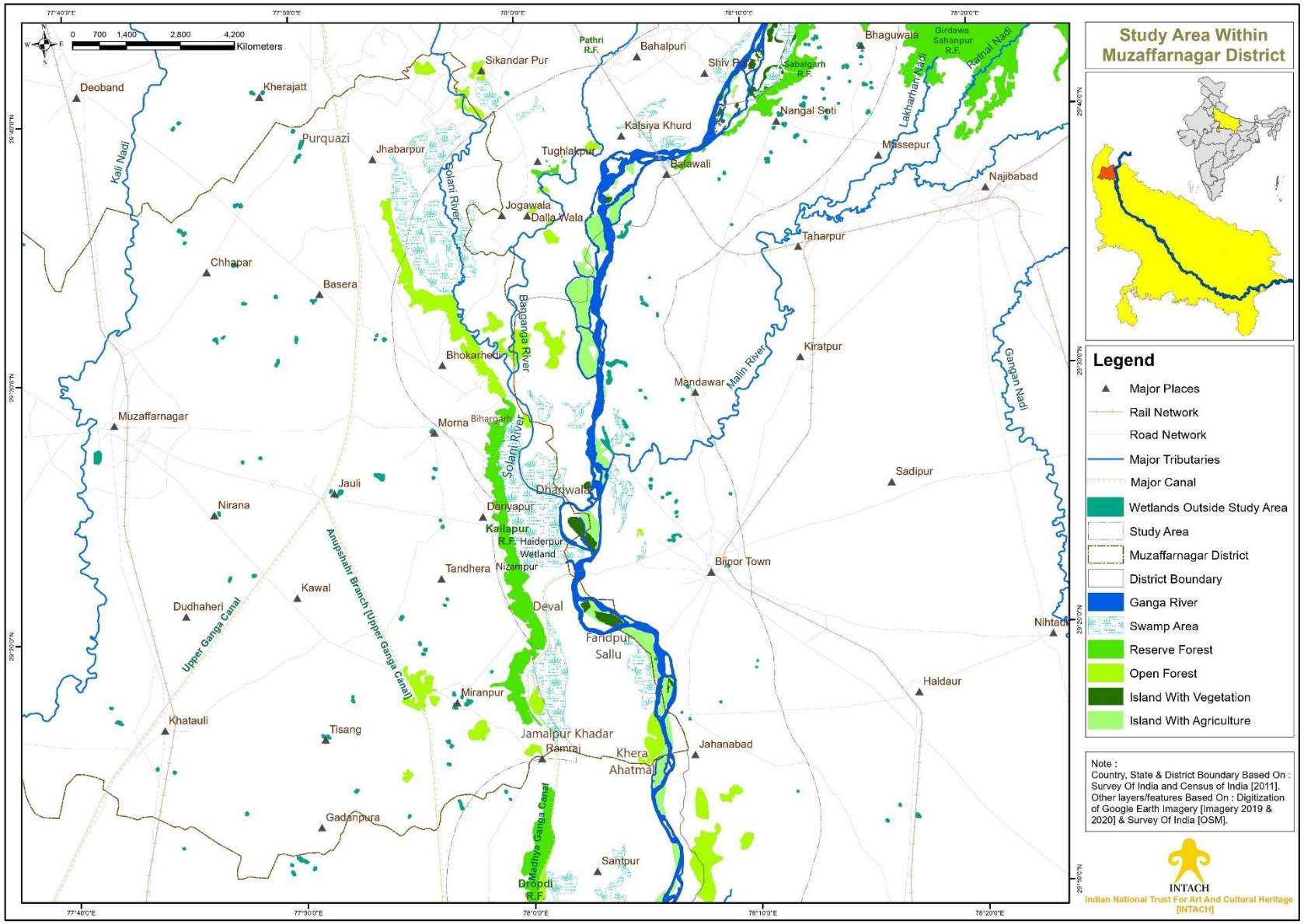
Map 1 : Location Of Muzaffarnagar Distt. on Right Bank of Ganga River

2.0 Ganga River in Muzaffarnagar Distt.

2.1 Ganga River enters Muzaffarnagar Distt. near Dhariwala, after crossing Bijnor district [See Map No.2]. The river channel is around 3 km in width here. The length of Ganga River in Muzaffarnagar Distt. is around 24 km, coursing along Distt. boundary on its right bank. Most of the distt. boundary area along Ganga River is swampy, bounded by Reserve Forest uplands, acting as buffer between the river and agriculture fields. These are actually levee deposits [older high tracts] of Ganga River ranging from 3 m to 18 m in height. Southern part of the swampy area has been designated as Haiderpur Wetland by the U.P. State Forest Dept. after observing frequent use of habitat by aquatic birds. It has watchtowers, cycle facility and information boards and now gaining popularity among bird watchers and nature enthusiasts.

2.2 The point where Ganga enters the district, its tributary, Solani River joins on its right. In between both of them, there are agriculture fields with intermittent smaller palaeochannels showing frequent meandering of the river around the landscape over the years. Here the river flows through narrow channels in non-monsoon season and there are very large islands and sand bars covering maximum area. Around 10 km kilometre upstream, an older channel Ganga River – known as Banganga, joins Solani River. Further downstream the river cross through Madhya Ganga Barrage or Chaudhary Charan Singh Ganga Barrage, commonly known as Bijnor Barrage. The barrage diverts water to Madhya Ganga Canal but only during monsoon months.

2.3 Around 4 km downstream till village Faridpur Sallu, Ganga again takes an easterly direction with channel width of around 2.5 km. From this point Ganga flows south till Nandnaur-Hastinapur Bridge, connecting Chandpur in Bijnor with Hastinapur in Meerut. The channel is comparatively narrow, bifurcating with large islands at some places. The Ganga exits Muzaffarnagar Distt. near Khera Ahatmal, in Jansath Tehsil.



Map 2 : Study Area In Muzaffarnagar Distt

3.0 Methodology

3.1 For carrying out surveys, a 7 km buffer zone of Ganga River in the Distt. was considered. Before carrying out surveys, various access points and routes to the river were located with the help of Google Earth. Special emphasis was given to the sites and features of interest such as river channel, biodiversity, floodplain conditions, farming and fishing activities, sites of natural heritage interest. Some known local residents living in villages near Ganga were contacted for field assistance.

3.2 The survey was undertaken from 20th-26th July, 2021 with the help of taxi, boat, bicycle and on foot. Sites were visited from downstream floodplain areas in Distt. to upstream areas. Sony Digital Camera Cyber-shot DSC-HX300 with 50X optical zoom and OnePlus 9 Pro mobile phone were used for photography. Garmin handheld GPS eTrex30 was used for marking locations and understanding elevation difference. Pre-marked Google Earth's Kml files and Google Maps were used for navigation. Field guides were used for flora and fauna identification. Information was obtained through informal interviews and discussion with farmers, fishermen, boatmen and local people.

Image 2 : Bicycle Used For Survey At Haiderpur Wetland

4.0 Tributaries of Ganga River

4.1 There are no major tributaries of Ganga River in Muzaffarnagar district except Solani River and Banganga River. Banganga is itself an older channel of the Ganga River. However, there are few smaller seasonal streams which join Solani River in the northeast section of the district. [See Map – 3]. The description of tributaries is given below:

1) **Solani River :** Solani River is a smaller river of length around 150 km which flows through Haridwar and Muzaffarnagar districts before meeting Ganga River at Haiderpur Wetland near Dhariwala. It has its source in hilly Mohand Forest Range of Haridwar, Uttarakhand and passes through agriculture fields throughout its length. The Gazetteer of Muzaffarnagar 1980[3], describes it as:

"This stream which formerly joined the Ganga in district Saharanpur, changed its course about 1852 and flowed into the old bed of the Ganga, linking the line of lakes therein. This was the same bed which had been left by the Ganga when it had changed its course during the reign of Shahjahan and where from it had continually shifted eastward. The Saloni enters the district in the extreme north of Pargana Pur Chhapar and flows south-eastward traversing parganas Pur Chhapar, Gordhanpur and Bhukarheri, meeting Ganga about 4 km northeast of the Bhukarheri (Bhokarhedi). The river flows in an uncertain course keeping almost as a rule, closer to the old high bank of Ganga than to the Ganga itself".

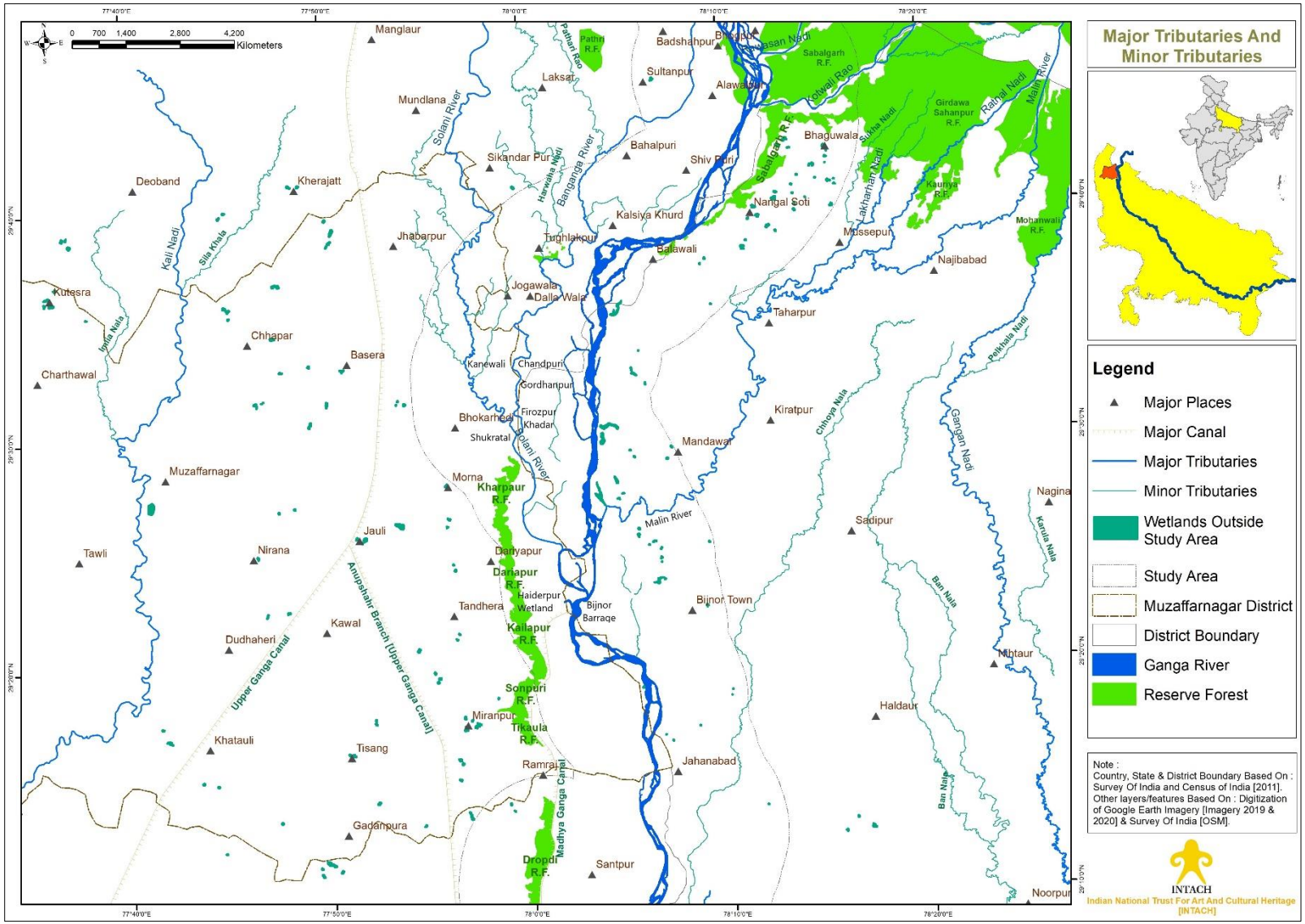
2) **Banganga River :** Banganga is an old channel of the Ganga River which is around 58 km long. It flows around 4-5 km west of main Ganga River and come closer as it meanders downstream. Its splits from the main river near Shahpur Shitala Khera village, 14 km downstream of Haridwar city and joins Ganga River around 1.5 km upstream of Shukratal in Firozpur Khadar. The Gazetteer of Muzaffarnagar (1980) describes it as :

"This stream is in reality a backwater of the Ganga and represents an old Channel of that river. It leaves the main stream around 6 km below Kankhal in district Saharanpur and enters the district near the village of Kanewali in pargana Gordhanpur. Flowing through the pargana in southerly direction it joins the Ganga near Chandpuri. Formerly this river entered this district near Gordhanpur about 6 km west of Kanewali. It has a well-defined bed and causes little damage to the land near its bank"

[3] Uttar Pradesh District Gazetteers, Muzaffarnagar, 1980, Published by The Govt. of Uttar Pradesh, Dept. of Distt. Gazetteers, U.P. Lucknow

Image 3 : Solani River at Shukratal [Towards Upstream]

Image 4 : Shukratal Ghat On Solani River *
[*At Shukratal, it is known as Banganga River]



Map 3 : Major and Minor Tributaries In Study Area

5.0 Land Use Land Cover [LULC]

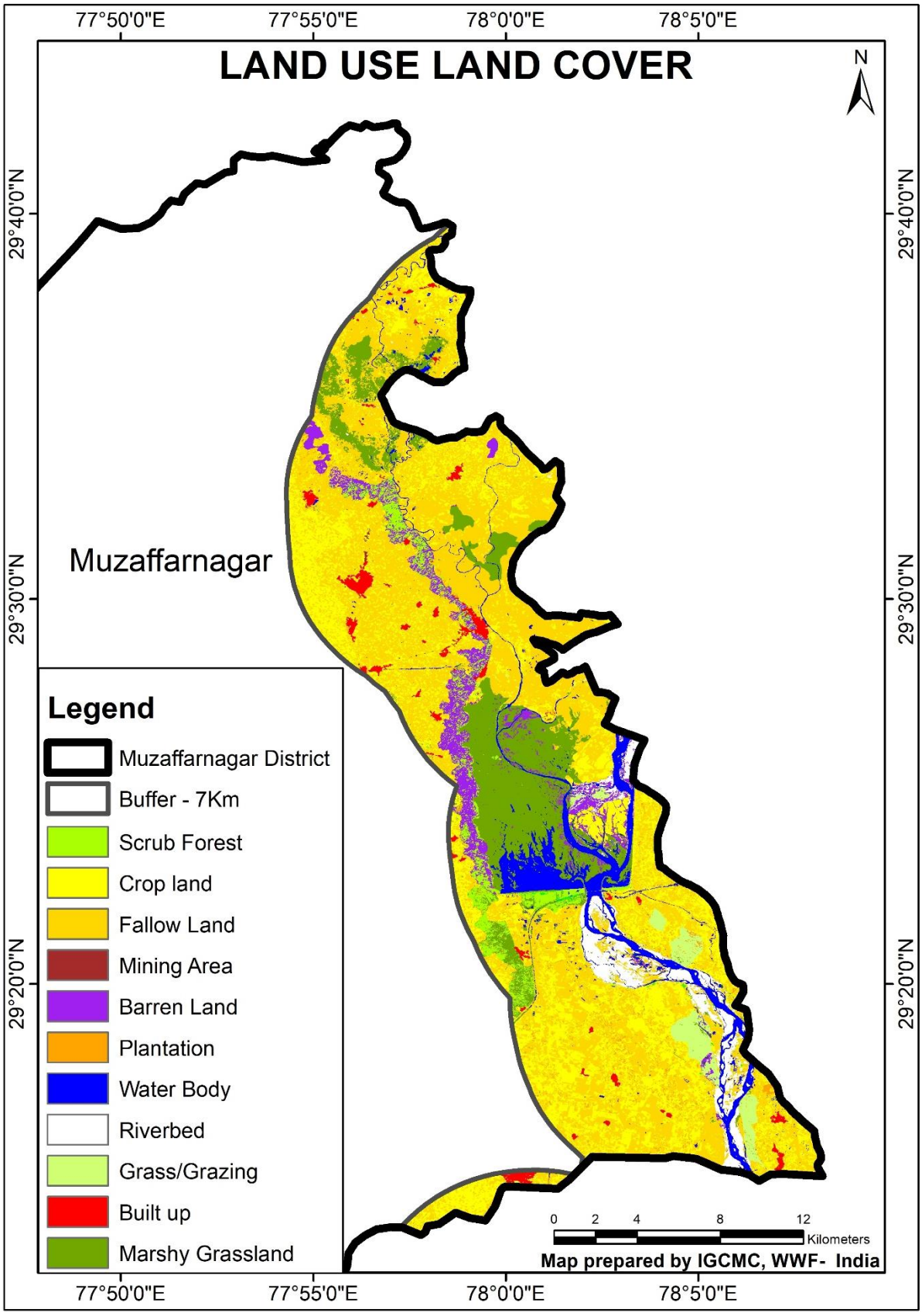
5.1 Land Use Land Cover [LULC] map of the study area has been prepared from Landsat imagery for the year 2020. [Table No.1] Using supervised classification system, 10 different classes were generated – scrub forest, cropland, fallow land, barren land, plantation, waterbody, open land, grass/grazing land, built-up, and marshy grassland [Map 3]. Since agriculture is the primary occupation in the Distt., cropland and fallow land area dominate other classes.

5.2 Major insights are the following :

i. Fallow land is the dominant land use with 41.18 % of the total area [160.32 Sq.Km]
ii. Crop land comes second with 25.5 % area under cultivation [99.63 Sq.Km]
iii. Together, the total area under agriculture is around 67 % [260 Sq.km]
iv. Forest is in poor state. Dense and open forest are completely absent in the study area. There is scrub forest with only 3.15% cover [12.27 Sq.km]
v. Marshy grassland is third largest with 12.12% [47.19 km]
vi. Barren land area covers 4.25% of the study area [16.55 Sq.km] while open land constitutes 3.58% [13.94 Sq.km]
vii. Built-up area is only 1.63% [6.33 Sq.km]
viii. Plantation – which includes mainly mango orchards, eucalyptus, poplars cover around 1.19% [i.e. 4.65 Sq.km]
ix. Waterbody which also includes river area is around 5.33 % [i.e. 20.73 Sq.km]

Table 1 : Land Use Land Cover of Study Area in Muzaffarnagar Distt. [2020]

Classes	Area (Ha)	Area (Sq.Km)	Area (%)
Scrub Forest	1227.56	12.27	3.15
Crop Land	9963.78	99.63	25.59
Fallow Land	16032.50	160.32	41.18
Barren Land	1655.90	16.55	4.25
Plantation	465.21	4.65	1.19
Water Body	2073.70	20.73	5.33
Open Land	1394.03	13.94	3.58
Grass/Grazing Land	760.87	7.60	1.95
Built-up	633.30	6.33	1.63
Marshy Grassland	4719.33	47.19	12.12
Total	**38935.31**	**389.35**	**100**

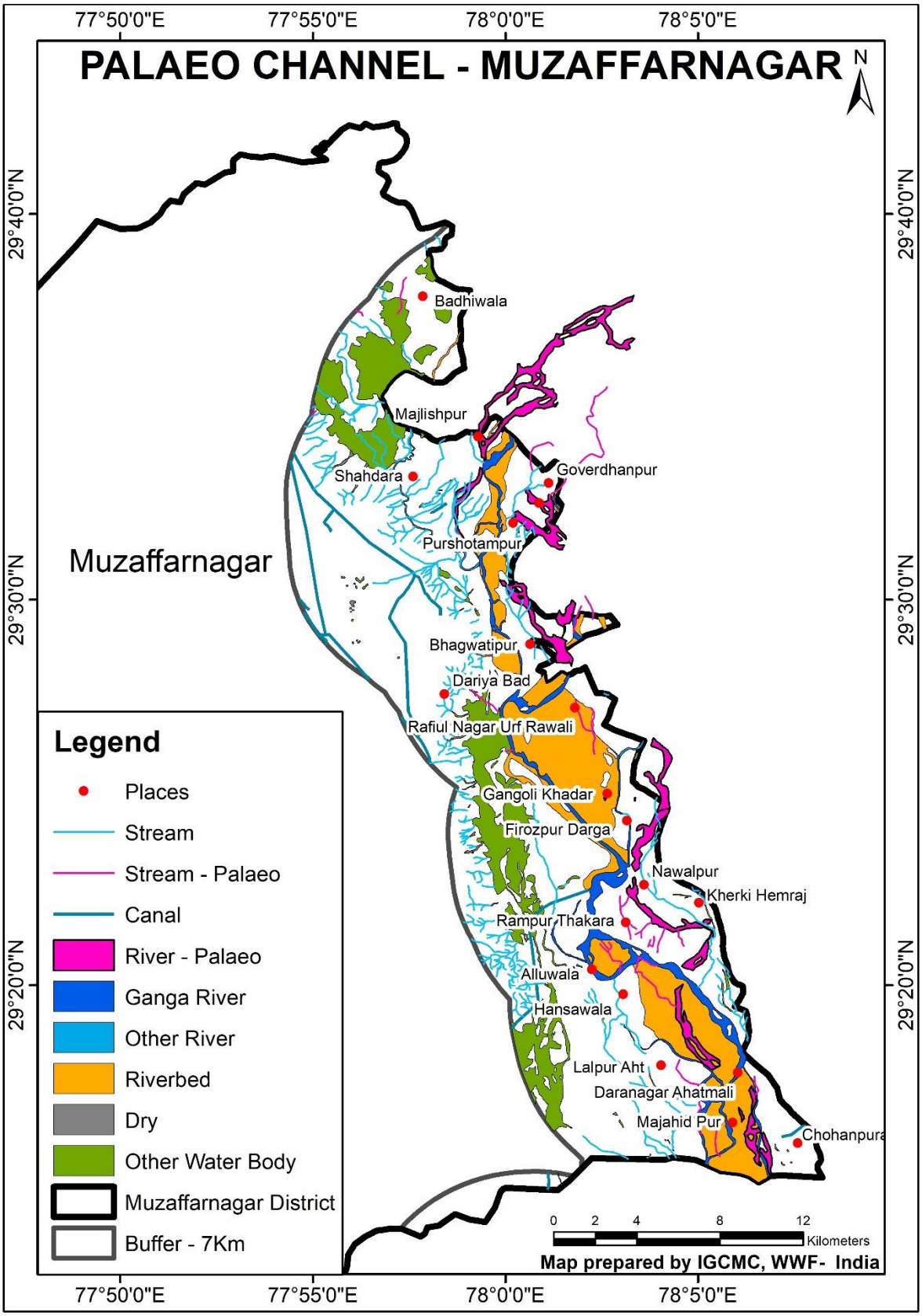


Map 4 : Land Use Land Cover In Study Area Of Muzaffarnagar Distt.

6.0 Palaeochannels Of Ganga River In Muzaffarnagar Distt.

6.1 Palaeochannels are the remnants or old channels of once active rivers or streams, some of which are lie buried under the cover of younger sediments. They are formed when the rivers or streams migrate their courses and form new ones. Paleochannels are important to understand area geology, old river routes, sediment deposition and are considered suitable areas for ground water recharge. Factors such as change in land use pattern, sand mining, agricultural practices, and industrial activities lead to disappearance of such channels along rivers. Generally, such old channels do not carry water during most of the year but may flow during flood events. Such abandoned and silted palaeochannels can be mapped using old maps and remote sensing techniques. Based on the available satellite data and remote sensing technique, Map No.5 was prepared, which depicts the various palaeochannels in the study area of Muzaffarnagar Distt.

Image 5 : Smaller Palaeochannels Upstream Of Bijnor Barrage in Muzaffarnagar District



Map 5 : Palaeochannels In The Study Region

7.0 Floodplain Of Ganga River In Muzaffarnagar Distt.

7.1 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 Distt.s, where it passes through, for agricultural purposes.

7.2 Ganga River floodplains in Muzaffarnagar Distt. are cultivated for major crops such as wheat, rice, maize, sugarcane and seasonal vegetables. The agriculture fields could be observed extended up to the edge of the active channel of the river and between the palaeochannels. Agriculture is one of the major sources of income in the Distt. and farmers of floodplain areas are benefitted by the fertile alluvium brought in by the river. Sugarcane is grown in abundance with around more than 2.0 Lakh Ha. area under cultivation[4]. Cucurbit and vegetable cultivation is mostly done in dry river bed areas and on river islands. According to riparian communities, the river reclaims its original channel every monsoon season, washing away these agriculture fields and changing their structure as it meanders downstream. Irrigation of crops is comparatively easy due to water availability from Ganga River, Solani River, Banganga River, various palaeochannels, and Madhya Ganga Canal in downstream areas of Madhya Ganga Barrage (Bijnor Barrage).

7.3 Rest of the floodplain areas are covered with swamps and marshes, some of which are used for water chestnut cultivation and fishing.

[4] Krishi Vigyan Kendra, Muzaffarnagar

Image 6 : Floodplain Area Near Nizampur

Image 7 : Sugarcane Dominates Agriculture Fields In Muzaffarnagar Distt.

8.0 Wetlands In Muzaffarnagar Distt.

8.1 Wetlands are highly productive ecosystems and help in maintaining ecological balance by providing food and habitat to large number of living organisms. They also help in controlling floods, recharging groundwater, nutrient recycling, climate stabilization and carbon sequestration. A report 'Wetland Report for Ganga River Basin Management Plan' published in 2012 by consortium of IITs mentions that 57% of the wetlands in Uttar Pradesh are related to river/streams with 181935 ha area while the National Wetland Atlas [Uttar Pradesh] published by SAC, ISRO in 2010 as a part of project 'National Wetland Inventory and Assessment' of MoEF, estimates it to be 48.88%. It clearly indicates the majority of riverine wetlands and floodplain lakes in the state.

8.2 As per National Wetland Atlas (2010) the total no. of wetlands in Muzaffarnagar Distt. are 1047 with 751 wetlands (<2.25 ha) with total area of 12589 ha. Riverine wetlands accounts for 23.92% [16 Wetlands] with wetland area of 3011 Ha while River/Stream category [39 Wetlands] constitutes around 39.82 % [5013 ha] of the total wetland area in the Distt.. In total, river related wetlands are 55 with 8024 Ha area.

8.3 Area estimates of wetlands in Muzaffarnagar Distt. mentioned in the above atlas is given below in Table No.2

Table 2 : Area Estimates Of Wetlands In Distt. Muzaffarnagar

S. No.	Wet.Code	Wetland Category	No. of Wetlands	Total Wetland Area [Ha]	% of Wetland Area
	1100	**Inland Wetlands - Natural**			
1.	1101	Lakes/Ponds	-	-	-
2.	1102	Oxbow lakes/Cut-off meanders	6	186	1.48
3.	1103	High altitude wetlands	-	-	-
4.	1104	Riverine wetlands	16	3011	23.92
5.	1105	Waterlogged	6	227	1.80
6.	1106	River/Stream	39	5013	39.82
	1200				
7.	1201	Reservoirs/Barrages	3	2252	17.89

8.	1202	Tanks/Ponds	219	920	7.31
9.	1203	Waterlogged	7	229	1.82
10.	1204	Salt Pans	-	-	-
		Sub-Total	296	11838	94.03
		Wetlands (<2.25 ha), mainly tanks	751	751	**5.97**
		Total	**1047**	**12589**	**100.00**

Source: National wetland Atlas, for NWIA, MoEF and ISRO (2010)

8.4 In the current exercise, a total of 15 wetlands have been mapped in the study area with the help of Google Earth satellite imagery and available maps. The list of mapped wetlands is given in Table No. 3 and their spatial distribution is shown in Map No. 6.

Table 3 : List Of Wetlands In The Study Area

Sr. No.	Wetland	Coordinates		Area [in Hectares]
		Latitude	Longitude	
01	01	29°32'32.21"N	77°55'5.48"E	3.24
02	02	77°56'4.12"E	77°56'4.12"E	1.36
03	03	29°29'47.49"N	77°56'4.28"E	0.70
04	04	77°56'21.02"E	77°56'21.02"E	0.40
05	05	77°55'41.42"E	77°55'41.42"E	0.32
06	06	77°57'27.27"E	77°57'27.27"E	0.47
07	07	29°25'42.58"N	77°59'16.73"E	1.20
08	08	77°58'49.45"E	77°58'49.45"E	0.70
09	09	78° 0'16.95"E	78° 0'16.95"E	67.10
10	Haiderpur Wetland	78° 0'52.61"E	78° 0'52.61"E	198.0
11	11	29°22'5.55"N	78° 0'45.71"E	70.90
12	12	78° 1'20.86"E	78° 1'20.86"E	5.82
13	13	77°59'44.54"E	77°59'44.54"E	36.5
14	14	78° 1'43.76"E	78° 1'43.76"E	0.35
15	15	78° 1'19.94"E	78° 1'19.94"E	3.79

8.5 **Haiderpur Wetland :** It is a marshy area formed after the construction of Madhya Ganga Barrage [Bijnor Barrage] in 1984 over Ganga River [Wetland No. 10]. Here Solani River joins Ganga River and forms intermittent swamps, channels, sandbars and islands. It is approachable through Bijnor-Meerut Road at Bijnor Barrage. The actual area is not known but is larger than what has been traced through Google Earth imagery i.e. 198 Ha. The wetland has been identified under *Namami Gange* programme of National Mission For Clean Ganga [NMCG] initiated in 2014. It is now serving as an important habitat of various resident and migratory birds. Around 295 bird species have been identified till 2020. Various other species such as Swamp Deer, Otter, Python snake, Crocodile, Gharial, Jackal, Nilgai have been spotted in and around the wetland. The wetland is an important repository of aquatic and riparian vegetation providing habitat to many invertebrates as well. The wetland is being managed by Forest Department of Uttar Pradesh (Muzaffarnagar Distt) with assistance from Muzaffarnagar Development Authority, NMCG, WWF-India, Gram Panchayat and Zilla Panchayat.

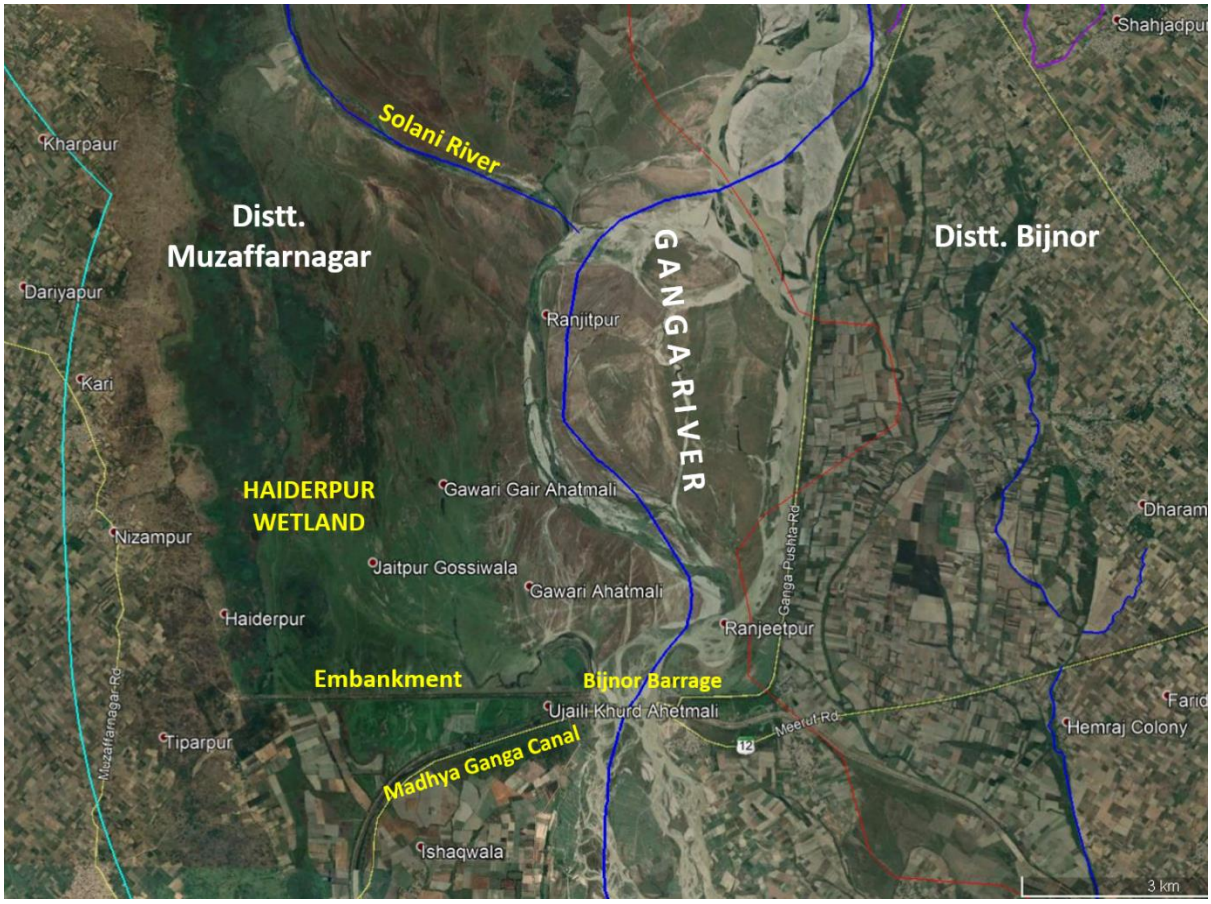


Image 8 : Location Of Haiderpur Wetland [29°22'41.39"N, 78° 0'36.14"E]

Image 9 : Haiderpur Wetland View From Bird Watching Tower [Looking North]

8.6 **Pond At Nizampur Village :** This pond is located on Muzaffarnagar road, at northwest corner of Nizampur village. The area of pond is around 0.70 Ha. [Wetland No. 8]. The pond is encircled by the village except at its western boundary with agriculture fields. It has one natural outlet channel which takes surplus water to the swampy areas of Ganga River in east. The pond was observed filled with runoff sediment and aquatic weeds especially duckweeds and water lettuce. It receives sewage discharge from the village which eventually reaches Ganga River swamps. Its riparian edge is natural and dotted with shrubs and trees such as Sheesam [*Delonix regia*], Jamun [*Syzygium cumini*], Neem [*Azadirachta indica*], Pongamia [*Millettia pinnata*], Bamboo [*Bambusa vulgaris*], Leucaena [*Leucaena leucocephala*], Colocasia [*Colocasia esculenta*], and Tall Reed [*Phragmites Karka*] and Castor Oil Plant [*Ricinus communis*]. Nesting sites of Cattle Egret [*Bubulcus ibis*] and Pond Heron [*Ardeola grayii*] were sighted on the Sheesam and and Pongamia trees. Some of these birds were sighted feeding their young ones. [Image-12]

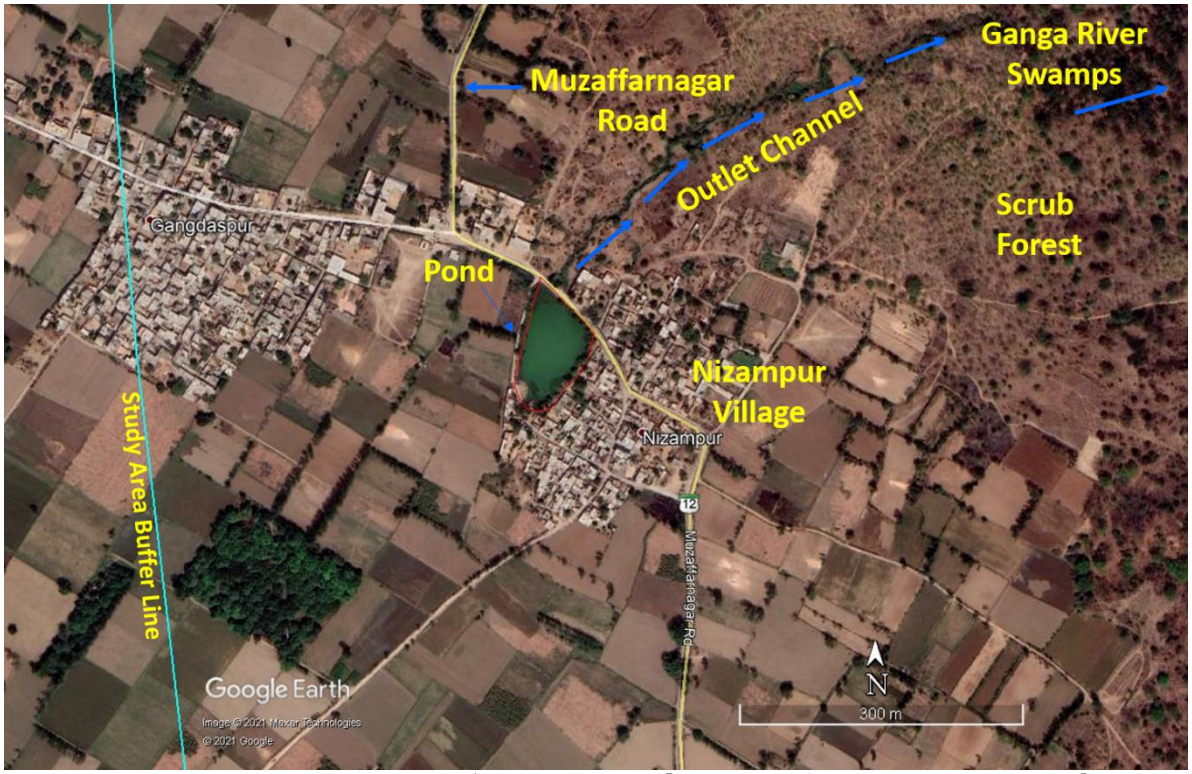


Image 10 : Location Of Pond At Nizampur [29°23'17.93"N, 77°58'50.15"E]

Image 11 : Condition Of Pond At Nizampur

Image 12 : Pond Heron With Her Offspring On Pongamia [*Millettia pinnata*] Tree

8.7 **Pond at Bhokarhedi Road:** This pond is located on Morna-Bhokarhedi road, around half a km before Bhokarhedi. [Wetland No. 2]. The area of the pond is around 1.36 Ha. There are 3-4 brick kilns in its vicinity and it has apparently formed due to excavated earth for brick making. The pond was observed infested with Water Hyacinth [*Eichhornia Crassipes*], Alligator Weed [*Alternanthera philoxeroides*] and several other aquatic weeds. The pond is used for fish culture by local villagers but fish species could not be ascertained. It's northern and southern edge is dotted with trees – Eucalyptus [*Eucalyptus spp.*], Mango [*Mangifera indica*], Poplar [*Populus spp.*], Neem [*Azadirachta indica*], Sheesham [*Dalbergia sisso*]. Its western edge with the road was observed being used for waste disposal. Large no. of Egrets were observed taking refuge in the pond towards its western side. Several other resident birds such as Black-winged Stilt [*Himantopus Himantopus*], Common Moorehen (*Gallinula chloropus*), White-breasted Waterhen (*Amaurornis phoenicurus*) were also sighted during the field visit.

Image 13 : Location Of Pond [29°29'54.99"N, 77°56'7.81"E]


Image 14 : Condition Of Pond At Bhokarhedi

8.8 **Pond At Seekri or Sikari Village :** This pond is located on around 4 km northwest of Bhokarhedi outside Seekri or Shikari village [Wetland No. 1]. The area of the pond is around 3.24 Ha. The western and northern side has been encroached with the expansion of the village over time. On other sides, there are agriculture fields. It is a torch-shaped pond with its tail touching the road. This part is used for waste disposal by the villagers. Upon interaction it was known that, waste disposal near ponds is an old practice in villages. But, the nature of waste was different earlier, generally composed of cattle dung, agriculture and household waste. It was used as a manure in agriculture fields. Now, the 'Waste in Polythene' practice adopted by villagers has changed this resulting in piling up waste over time. Some of this gets inside the water almost every day. The pond also receives village's sewage discharge via two drains joining pond at the same point. Despite being polluted, the pond is used for bathing cattle and fisheries. Few villagers have taken it on lease through govt.'s 'patta system' for breeding fish. They fill the pond with fresh water extracted through borewells in order to dilute its poor water quality. Few old men from the village informed that the pond area used to be larger and large no. of migratory birds would visit every winter season. Now, only few are sighted due to its poor water quality and decreased area.

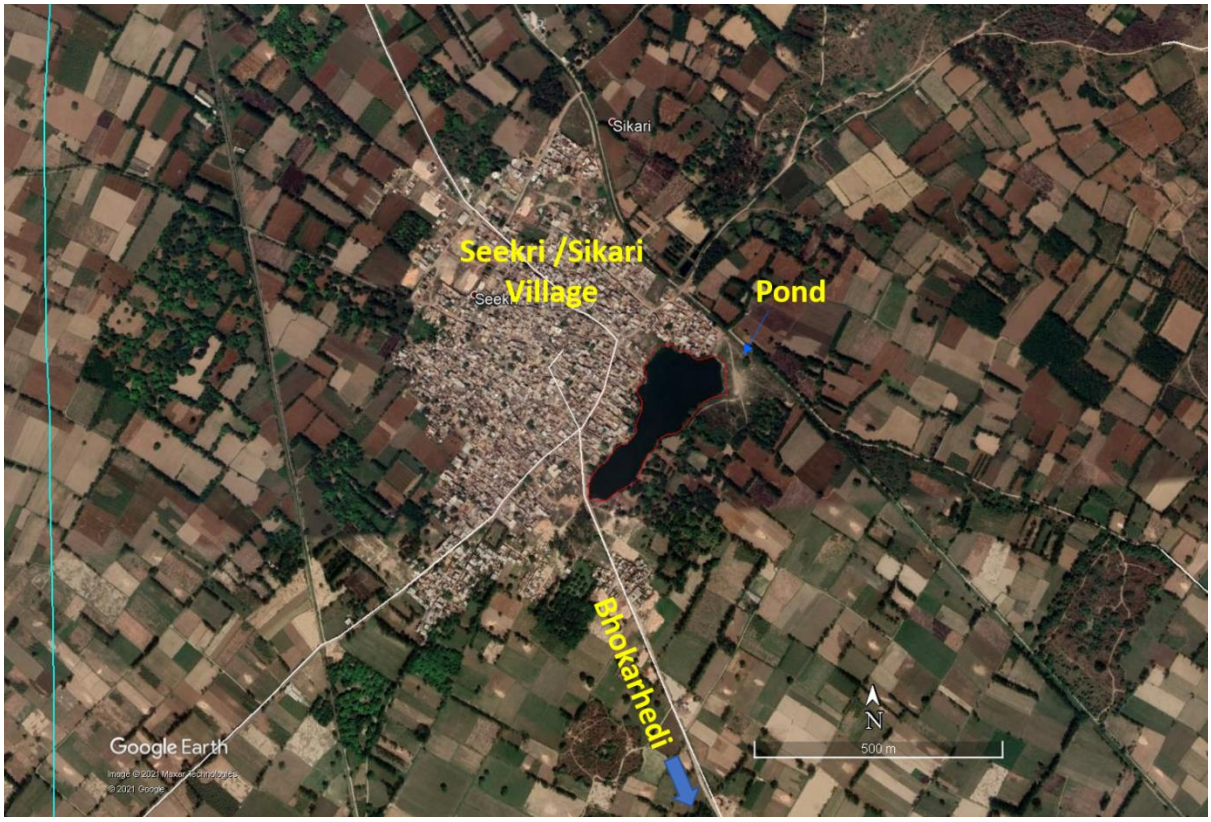
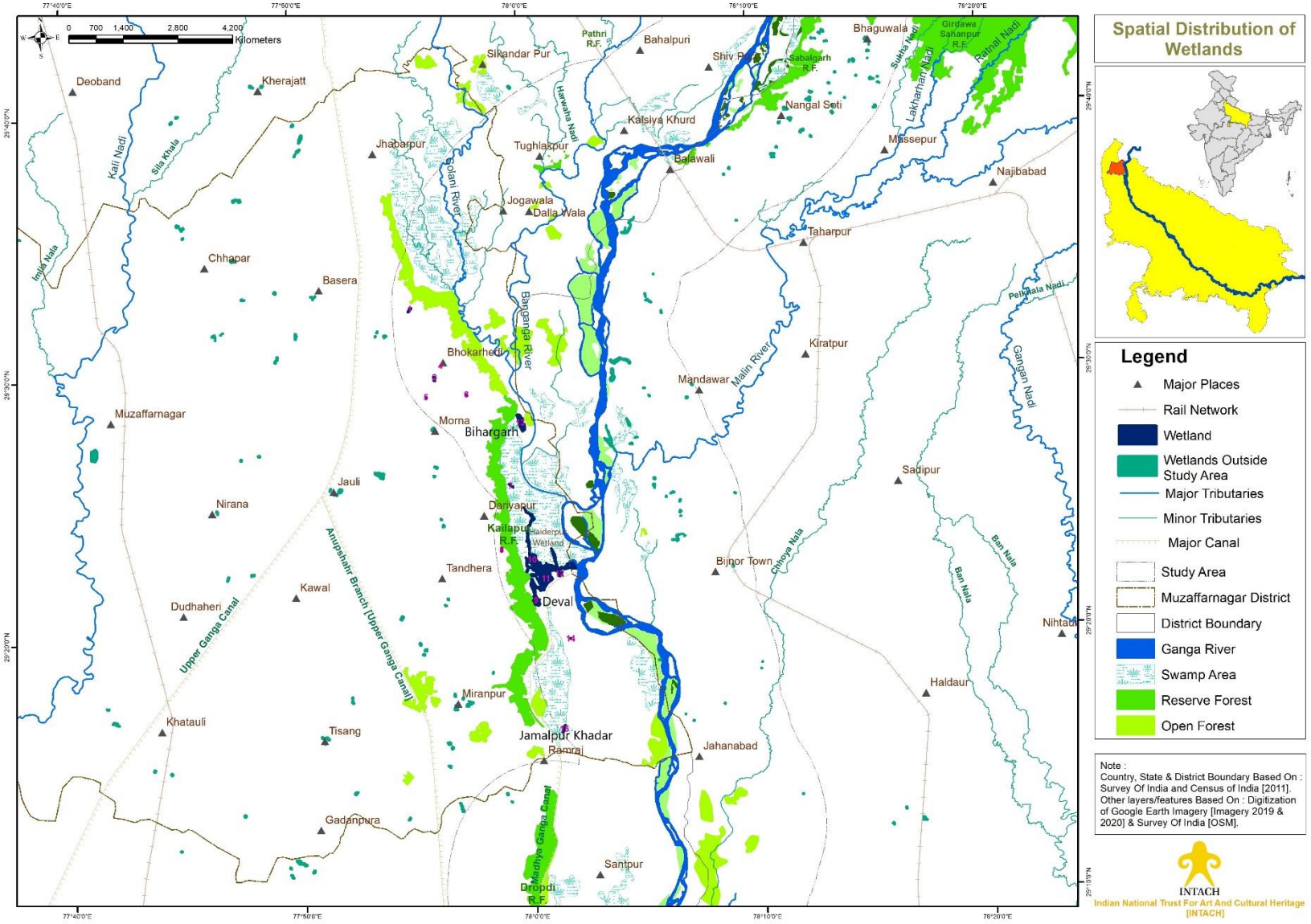


Image 15 : Location Of Pond At Seekri/Sikari Village [29°32'25.85"N, 77°54'58.41"E]

Image 16 : Pond At Seekri/Sikari Village
[Note the waste disposal site]

Image 17 : A Villager Cleansing Buffaloes In The Polluted Seekri Pond



Map 6 : Spatial Distribution Of Wetlands In The Study Area

9.0 Riparian Flora Along Ganga River In Muzaffarnagar Distt.

9.1 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 harbour 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, harbouring faunal diversity and providing livelihood resources [Groffmanet al., 1990; Castelle al., 1994].

9.2 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], Groffmanet al. [1990], Krishanmurti [1991], Castelle 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.

9.3 Muzaffarnagar Gazetteer of 1980[5] mentions some common shrubs that grew in the khadar tracts : Arusa (*Adhatoda vasica*), Ber (*Zizyphus mauritiana*), Bhang (*Cannabis sativa*), Jhar beri (*Zizyphus fruticose*), Kareel (*Capparis decidua*), Karonda (*Carissa spinarum*), Makoh (*Zizyphus oenoplia*), and Sitahani (*Artmesia scoparia*). Some of the climbers mentioned are Dudhi-bel (*Vallaris solanocea*), Hins (*Capparis zeylanica*), and Makoh (*Zizyphus oenoplia*). The grasses growing in the district chiefly in khadar tracts are Dab (*Desmostachya bipinnata*), Dub (*Cynodon dactylon*), Kans (*Saccharum spontaneum*), Moonj (*Erianthus munja*), and Patera (*Typha elephantiana*)

9.4 A study published in Scholars Academic Journal of Biosciences (SAJB) in 2015 with title 'Herbaceous Flora of Muzaffarnagar Distt[6].' (U.P.) lists a total of herbaceous species from Muzaffarnagar district. Close analysis reveals there are 83 species of 'Grasses' belonging

[5] Uttar Pradesh District Gazetteers, Muzaffarnagar, 1980, Published by The Govt. of Uttar Pradesh, Dept. of Distt. Gazetteers, U.P. Lucknow

[6] Malik, Vijai (2015), Herbaceous Flora of Muzaffarnagar District [U.P.], Sch. Acad. J. Biosci., 2015; 3(2B):182-196

to family 'Poaceae' and 36 species of 'Sedges' belonging to family 'Cyperaceae'. However, habitat-wise distribution has not been mentioned.

9.5 The pattern of riparian flora in Muzaffarnagar district is different to that of Bijnor Distt. located across the river. Although most of the floodplain area/island area is under agriculture, there are considerable patches of riparian vegetation and aquatic weeds in the swampy areas along the river [area extending from Bihargarh village in north to Haiderpur wetland in south and further downstream Deval to Jamalpur Khadar (check in Map.6 above)]. Patches of *Saccharum munja* [Munj], *Saccharum spontaneum* [Kaans], *Typha latifolia* [Common Cattail], *Phragmites karka* [Narkul], *Cynodon dactylon* [Doob] were observed thriving in the swamp. The upland scrub forest belt on the right bank and embankment at Haiderpur wetland have mix cover of various shrub and tree species. Main species are Arjun [*Terminalia arjuna*], Neem [*Azadirachta indica*], Sheesham [*Dalbergia sisso*], Jamun [*Syzygium cumini*], Siris [*Albizia lebbeck*], Leucaena [*Leucaena leucocephala*], Gular [*Ficus racemose*], Peepal [*Ficus religiosa*] Pilkhan [*Ficus virens*], Mango [*Mangifera indica*], Bamboo [*Bambusa vulgaris*], Ber [*Ziziphus mauritiana*], and Eucalyptus spp.

9.6 Some herb/shrub species observed are Common Tephrosia [*Tephrosia purpurea*], Congress Grass [*Parthenium hysterophorus*], Coffee Senna [*Cassia occidentalis*], Sickle Pod [*Cassia tora*], Country Mallow [*Abutilon indicum*], Goat Weed [*Ageratum conyzoides*], Calotropis [*Calotropis procera*], Lantana [*Lantana camara*] along with riparian grasses such as Phragmites [*Phragmites karka*] and Kaans [*Saccharum spontaneum*]

9.7 Some riparian grasses are economically valuable in the district. Kaans [*Saccharum spontaneum*] and Patera [*Typha elephantina*] are harvested from Ganga Khadar by local people. They are used for making hedges and thatch roof. During field visit it was known that Patera [*Typha elephantina*] is used for making mats [with 5.5 feet width and 11-12 feet length] which are sold in Muzaffarnagar city or Agra and adjacent districts. They are used to thatch roof of huts; used in houses for personal use and mosques for prayers; in trucks or transport vehicles as inner layer to protect goods from damage. [See Image-20 & 21]

Table 4 : Main Tree Species Recorded In The Study Area

S. No.	Botanical Name	Common Name	Family
1.	*Terminalia arjuna*	Arjun	Combretaceae
2.	*Albizia lebbeck*	Siris	Fabaceae
3.	*Azadirachta indica* A. Juss.	Neem	Meliaceae
4.	*Acacia nilotica* L.	Babool/Kikar	Fabaceae
5.	*Dalbergia sissoo DC.*	Sheesham	Fabaceae
6.	*Ficus religiosa* L.	Peepal	Moraceae
7.	*Ficus benghalensis* L.	Banyan	Moraceae
8.	*Ficus virens*	Pilkhan	Moraceae
9.	*Ficus racemosa*	Gular	Moraceae
10.	*Bombax ceiba L.*	Semal	Bombacaceae
11.	*Mangifera indica*	Aam	Anacardiaceae
12.	*Populus spp.*	Poplar	Salicaceae
13.	*Eucalyptus spp.*	Liptis	Myrtaceae
14.	*Phoenix dactylifera L.*	Khajur	Arecaceae
15.	*Tectona grandis* L.f.	Teak/Saagwan	Lamiaceae
16.	*Ziziphus mauritiana*	Indian Jujube	Rhamnaceae
17.	*Delonix regia*	Gulmohar	Fabaceae
18.	*Melia azedarach*	Bakain	Meliaceae
19.	*Leucaena leucocephala*	Subabool	Fabaceae
20.	*Syzygium cumini*	Jamun	Myrtaceae
21.	*Aegle marmelos*	Bel	Rutaceae
22.	*Butea monosperma*	Dhak	Fabaceae
23.	*Morus alba*	Shahtoot	Moraceae
24.	*Saraca ashoka*	Ashok	Fabaceae
25.	*Bambusa vulgaris*	Bamboo	Poaceae

Image 18 : Forest Upland Area Visible From Haiderpur

Image 19 : Tephrosia [*Tephrosia purpurea*]

Image 20 : A Woman Weaving Mat From Dried Typha At Chaurawala Village

Image 21 : Mats Ready For Transport [At Chauarwala Village, Muzaffarnagar]

10.0 Faunal Diversity Along Ganga River In Muzaffarnagar Distt.

10.1 Due to very few and scattered forest in the study area, the mammal diversity is poor and includes common terrestrial mammals which are sighted occasionally on floodplain areas along the Ganga. Although the part of Hastinapur Wildlife Sanctuary covers Ganga floodplains in the Distt., but most of it is agriculture landscape with little forest cover. Common mammals presently found in the district include Indian Jackal [*Canis aureus indicus*], Indian Fox [*Vulpes bengalensis*], Monkey [*Rhesus macaque*], Langur [*Semnopithecus spp.*], Indian Hare [*Lepus nigricollis*], Swamp Deer [*Rucervus duvaucelii*]. Indian Leopard [*Panthera pardus fusca*] occasionally strays from their habitat in the hilly forests of Uttarakhand. Nilgai (*Boselaphus tragocamelus*) and Wild Boar (*Sus scrofa*) are also found in small numbers and known to destroy crops. Insects and Arthropods are poorly recorded groups, especially along rivers. During field visit many insects were sighted in riparian vegetation along Ganga River, near palaeochannels, near waterbodies. Most common were Dragonflies and Damselflies (Order: Odonata), Grasshoppers and Crickets (Order: Orthoptera), Stick insects and Leaf insects (Order: Phasmatodea), Butterflies and Moths (Order: Lepidoptera). Among Dragonflies and Damselflies, Ruddy Marsh Skimmer [*Crocothemis servilla*] and Coromandel Marsh Dart [*Ceriagrion coromandelianum*] were frequently sighted.

10.2 Muzaffarnagar Gazetteer of 1920[7] mentions about large herds of wild pig and considerable numbers of hog-deer in the swampy portions of Ganga khadirs which destroyed scanty crops of the districts as well as of neighbouring uplands. The thick vegetation along canal too provided habitat for them and occasionally to leopards. Presence of the tiger has also been mentioned. Muzaffarnagar Gazetteer of 1980 states that Tiger (*Panthera tigris*) and Leopard *(Panthera pardus*) which were common in the beginning of the century, later practically disappeared. Nilgai (*Bosephalus tragocamelus*) and Wild Pigs (*Sus porcinus*) were found in the khadar area and damaged the crops. The Hyena (*Hyaena hyaena*) and the Jackal (*Canis aureus*) were found in small numbers. The Indian Black Buck (*Antilope cervicapra*), the Hogdeer (*Hyelaphus porcinus*) and Spotted Deer (*Axis axis*) were found in small herds. Further, it has been mentioned that their numbers had considerably decreased due to constant hunting in the past. Among reptile, majority of the snake species were non-poisonous except the Cobra (*Naja naja or Naja tripudians*), the Common Krait (*Bungarus*

[7] Muzaffarnagar: A Gazetteer, being Vol.III of the District Gazetteers of the United Provinces of Agra and Oudh. Compiled and Edited by H.R. Nevill, Reprint 1920, Allahabad. Printed by the Superintendent, Govt. Press, United Provinces. 1920

caeruleus) and the Russell's Viper (*Vipera russelli*). The crocodile (mugger), and the turtle were found in both Ganga and Yamuna. Among amphibians, *Rana tigrina* and *Bufo melanostictus* were found in abundance.

10.3 Some major aquatic fauna found in this stretch of Ganga River stretch have been described briefly below:

10.4 **Gangetic Dolphin** : The Gangetic River Dolphin (*Platanista gangetica gangetica*) is exclusively aquatic and piscivorous, occasionally found in small groups. It is one of the three freshwater dolphin species in the world and is distributed in the Ganga–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. A joint census[8] carried out in October, 2019 by Uttar Pradesh Forest Department's divisions of 5 Distt.s namely Bijnor, Meerut, Hapur, Amroha and Bulandshahr and WWF-India recorded 36 dolphins which also included 3 calves. Most of them (31) were recorded in Hastinapur Wildlife Sanctuary which stretches from Bijnor Ganga Barrage to Garhmukteshwar. Based on the interactions with local people, it was known that dolphins are sighted both upstream and downstream of Bijnor Ganga barrage (the river area shared by both Muzaffarnagar and Bijnor Distt.s). They are mostly sighted during monsoon season when the water level is high.

10.5 **Gharial** : Indian Gharial (scientifically known as *Gavialis gangeticus*) is the only surviving member of an ancient family of crocodiles found to reside mainly in Indian sub-continent. It derives its popular name – gharial or gavial from the bulbous knob like protuberance on a breeding male's snout which resembles a 'Ghara' meaning an earthen pitcher (Saikia, 2012). This species is endemic to the Indian sub-continent and is considered to be 'Critically Endangered' in the IUCN Red List. Once distributed across several major river systems in India and neighbouring countries, this species has seen an estimated 96-98% decline in its population owing and is now restricted to only few scattered locations in India and Nepal (Sinha, 2018).

10.6 Earlier records of Gharial in Muzaffarnagar and Bijnor Distts. come from the time when 225 captive reared Gharial released by the Uttar Forest Department in the Ganga River upstream of Bijnor in the Hastinapur Wildlife Sanctuary in the year 1991-92[9]. Later on, another batch of 678 Gharials was released in 2015 near Makhdoompur

[8] With three calves, Ganges dolphin population up to 36 in UP, Times of India, Oct.16, 2019
[9] Status of Higher vertebrates in the Ganga River : Ganga River Basin Environment Management Plan by IITs, June 2012

village in Hastinapur Wildlife Sanctuary – out of which only 16 Gharials survived[10]. During field visit, no gharial or crocodile was sighted.

10.7 **Turtles :** India is one of the world's hotspots for turtle diversity representing 29 species of tortoises and freshwater turtles among which 13 different species find their abode in the Ganga river system. These turtles play a significant role in the river by scavenging dead organic material and diseases fish, controlling fish population as predators and controlling aquatic plants and weeds (WII, 2017). Variety of habitats such as muddy and sand banks, islands, varying depth of water in Ganga, and floodplain lakes supports chelonian diversity but major threats such as floodplain agriculture, increasing pollution, irregular flow of water and sandmining activities are altering their habitats and thus their population is continuing to decline.

10.8 A report published by WWF-India[11] in 2011 mentioned the presence of 12 species of turtles between Bijnor and Kanpur stretch of Ganga River [Table-5]. Based on collections of shell and live specimens, eight species belonging to four genera and one family of hard-shell turtles, and four species belonging to three genera and one family of soft-shell turtles were identified by them. During the current field visit, no turtle was sighted as the water level was high in the Ganga River with rarely visible islands. However, there presence was confirmed from the local community and fishermen.

Table 5 : Freshwater Turtles In Ganga River* Between Bijnor and Kanpur

S.No.	Family	Genus	Species	Common Name
1.	Emydidae	*Hardella*	*thurjii*	Crown River Turtle
2.		*Geoclemys*	*hamiltonii*	Spotted Pond Turtle
3.		*Melanochelys*	*trijuga*	Indian Black Turtle
4.		*Batagur*	*kachuga*	Red-crowned Turtle
5.		*Pangshura*	*smithii*	Brown-roofed Turtle
6.		*Pangshura*	*tecta*	Indian-roofed Turtle
7.		*Pangshura*	*tentoria*	Indian Tent Turtle
8.		*Batagur*	*dhongoka*	Striped Roof Turtle
9.	Trionychidae	*Lissemys*	*punctata*	Indian Flapshell Turtle
10.		*Chitra*	*indica*	Narrow-headed soft-shell Turtle
11.		*Nilssonia*	*gangeticus*	Indian soft-shell Turtle
12.		*Nilssonia*	*hurum*	Indian Peacock Soft-shelled Turtle

[*Ganga River area shared by both Muzaffarnagar and Bijnor Distts.] Source : WWF-India, 2011

[10] WWF rescues Gharial trapped in Ganga canal after gates shut monsoon. Oct.28, 2017
[11] Behera, S., G. Areendran, P. Gautam and V. Sagar (2011), For A Living Ganga–Working with People and Aquatic Species, New Delhi: WWF-India, 84 pp.

10.9 **Avian Diversity :** During field survey, the diversity of avian species was recorded using binoculars and identified using field guides (Grimmett et al., 2016 and others). During the field visit, a total of 48 bird species were sighted. Out of which 17 are aquatic species and remaining 31 are terrestrial birds [Table-6].

10.10 Important observations are:

- On the basis of field experience, it can be said, the Distt. harbours rich bird diversity due various kind of habitats – rivers, swamps, depressions, lakes, riparian buffer of channels, open lands, and agriculture fields.
- Aquatic vegetation and riparian grasses of palaeochannels, waterbodies and depressions are serving as important habitats for birds in the river basin.
- Common birds sighted more often in and around the river are White-throated Kingfisher, Yellow-wattled Lapwing, River Tern, Grey Heron, Indian Pond Heron, Cattle Egret, Cormorants, and River Lapwing.
- Birds sighted more frequently in and around waterbodies are Indian Pond Heron, Asian Open Bill, White Breasted Waterhen, Cattle Egret, Little Egret, White-throated Kingfisher, Bronze-winged Jacana.
- River Lapwing fall under IUCN's 'Near Threatened' category and River Tern fall under 'Vulnerable Category'.

Table 6 : List Of Birds Sighted During Field Visit

S. No.	Common Name	Scientific Name	Conservation Status
1.	Asian Openbill	*Anastomus oscitans*	Least Concern
2.	Little Cormorant	*Microcarbo niger*	Least Concern
3.	Indian Cormorant	*Phalacrocorax fuscicollis*	Least Concern
4.	White breasted -Waterhen	*Amaurornis phoenicurus*	Least Concern
5.	Indian Pond Heron	*Ardeola grayii*	Least Concern
6.	Cattle Egret	*Bubulcus ibis*	Least Concern
7.	Little Egret	*Egretta garzetta*	Least Concern
8.	Great Egret	*Ardea alba*	Least Concern
9.	White throated Kingfisher	*Halcyon smyrnensis*	Least Concern
10.	**River Lapwing**	***Vanellus duvaucelii***	**Near Threatened**
11.	**River Tern**	***Sterna acuticauda***	**Vulnerable**
12.	Yellow-wattled Lapwing	*Vanellus malabaricus*	Least Concern
13.	Grey Heron	*Ardea cinerea*	Least Concern

14.	Purple Swamphen	*Porphyrio porphyrio*	Least Concern
15.	Common Moorehen	*Gallinula chloropus*	Least Concern
16.	Common Coot	*Fulica atra*	Least Concern
17.	Bronze-winged Jacana	*Metopidius indicus*	Least Concern
18.	Black Drongo	*Dicrurus macrocercus*	Least Concern
19.	Bank Myna	*Acridotheres ginginianus*	Least Concern
20.	Common Myna	*Acridotheres tristis*	Least Concern
21.	Oriental Dove	*Streptopelia orientalis*	Least Concern
22.	Spotted Dove	*Spilopelia chinesis*	Least Concern
23.	Black-winged Kite	Elanus caeruleus	Least Concern
24.	Shikra	*Accipiter badius*	Least Concern
25.	Asian Koel	*Eudynamys scolopaceus*	Least Concern
26.	Greater Coucal	*Centropus sinensis*	Least Concern
27.	Red-vented Bulbul	*Pycnonotus cafer*	Least Concern
28.	Red-whiskered Bulbul	*Pycnonotus jocosus*	Least Concern
29.	Indian Robin	*Saxicoloides fulicatus*	Least Concern
30.	Common Pigeon	*Columba livia*	Least Concern
31.	Common Koel	*Eudynamys scolopaceus*	Least Concern
32.	House Sparrow	*Passer domesticus*	Least Concern
33.	Indian Jungle Crow	*Corvus culminatus*	Least Concern
34.	House Crow	*Corvus splendens*	Least Concern
35.	Rose-ringed Parakeet	*Psittacula krameri*	Least Concern
36.	Common Tailorbird	*Orthotomus sutorius*	Least Concern
37.	Indian Silverbill	*Euodice malabarica*	Least Concern
38.	Yellow Wagtail	*Motacilla flava*	Least Concern
39.	White Wagtail	*Motacilla alba*	Least Concern
40.	Indian Bushlark	*Mirafra erythroptera*	Least Concern
41.	Common Babbler	*Turdoides caudatus*	Least Concern
42.	Jungle Babbler	*Turdoides striata*	Least Concern
43.	Asian Pied Starling	*Gracupica contra*	Least Concern
44.	Black Drongo	*Dicrurus macrocercus*	Least Concern
45.	Rufous Treepie	*Dendrocitta vagabunda*	Least Concern
46.	Ashy prinia	*Prinia socialis*	Least Concern
47.	Green bee-eater	*Merops-orientalis*	Least Concern
48.	Baya Weaver	*Ploceus philippinus*	Least Concern

Image 22 : Little Egret [*Egretta garzetta*]

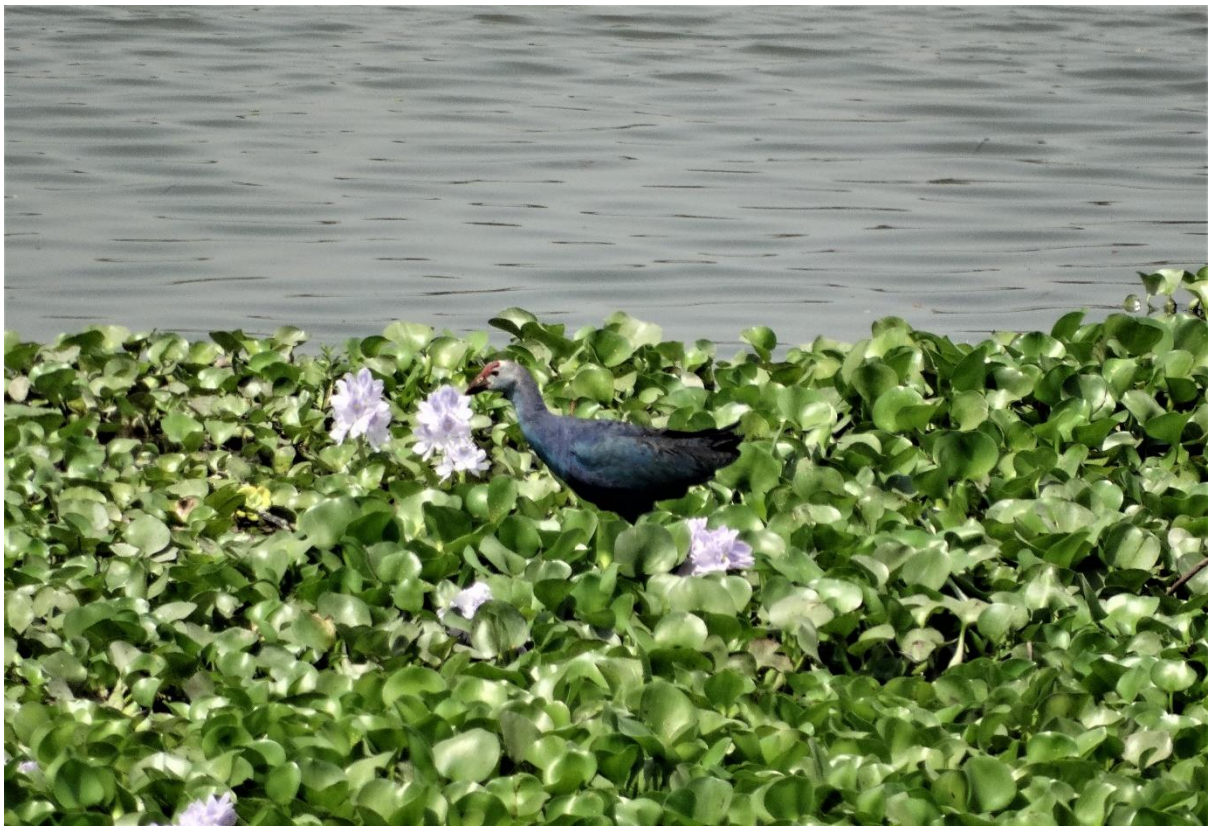


Image 23 : Purple Swamphen [*Porphyrio porphyrio*]

Image 24 : Indian Gray Heron [*Ardea cinerea*]

Image 25 : Common Moorehen [*Gallinula chloropus*]

Image 26 : Ruddy Marsh Skimmer [*Crocothemis servilia*]

Image 27 : Transparent or Indian Pierrot [*Tarucus indica*]

11.0 Ganga Riverine Islands In Muzaffarnagar Distt.

11.1 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]. Islands are generally formed by sand or sediments mass by currents during higher level of river flow and are exposed during dry season. River islands provide habitat to a large variety of living organisms such as birds, butterflies, insects and smaller mammals.

11.2 During the field visit it was observed that in Muzaffarnagar stretch of Ganga River, there are few exposed and partially exposed river islands of varying shape and size. Since Ganga River forms the district boundary between Muzaffarnagar and Bijnor, the nature of river islands and their information in both the district is same. As per the fluvial island classification proposed by Wyrick & Klingeman (2011), the islands here would be fall under 'Braided' category – which means many channels divided by islands and bars, which may be washed out in high flows. These islands and sandbars get immersed with the increased water flow in river – especially during monsoon season along with the river channels in between them. Such sand bars make it difficult for motor boats to navigate through as their outboard motor with propellor fan gets stuck in the sand. Local boatmen and fishermen identify these channels with the help of long bamboo or wooden poles which they use to propel their boats.

11.3 Apart from naturally formed islands in the river, a significant amount of island area is building up due to increasing sedimentation load upstream of Bijnor barrage – shrinking the water channel towards left bank [here the river bank is protected by embankment in order to avoid spillage and loss during high flow]. The similar sedimentation build up is visible downstream of barrage but here due to concave bank formed due to easterly course of the river. The island thus formed is cultivated for cucurbit crops every year. [Image-29]

11.4 These river islands are used for agriculture by local farmers except smaller or less stable ones. Cucurbits such as cucumber, melons, bitter and bottle gourds, tomatoes, pumpkins are grown and known as '*Palez*'. Smaller wooden boats are used for to and fro movement from the main land. As mentioned in faunal diversity section, all the main river islands are under cultivation, the smaller islands and exposed sand beds are

proving as last refuge for aquatic biodiversity especially migratory birds, turtles, gharials and crocodiles. The width of the islands varies between 500 m- 1 km and length 1 km to 4 km as observed via Google Earth's satellite imagery. [Image-28]

11.5 During monsoon season, as observed during field visit, these islands either get submerged under water or get covered with luxuriant growth of riparian grasses and aquatic vegetation. Bush Morning Glory [*Ipomoea carnea*], Tall Reed [*Phragmites Karka*], Kaans [*Saccharum spontaneum*] along with patches of Water Hyacinth [*Eicchornia crassipes*] were sighted on the islands. [See Image-29]

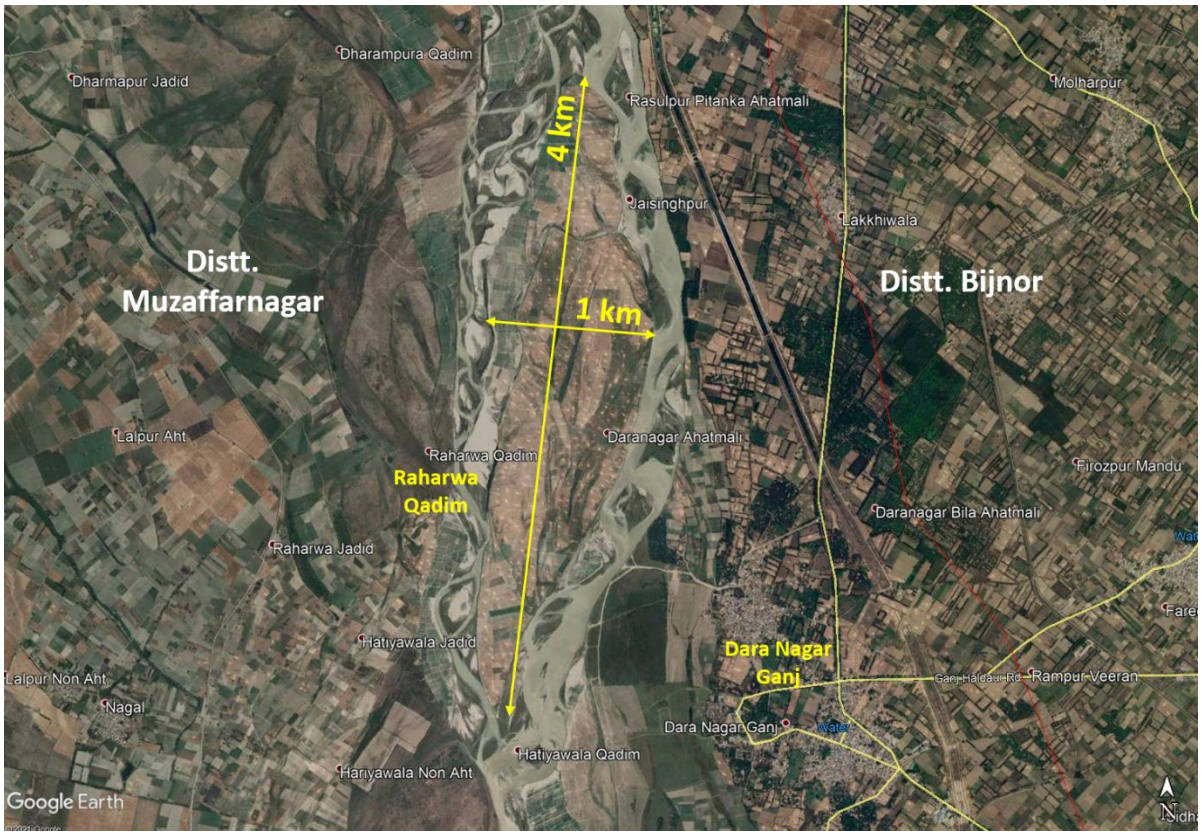


Image 28 : River Island At Raharwa Qadim As Seen Through Google Earth Imagery

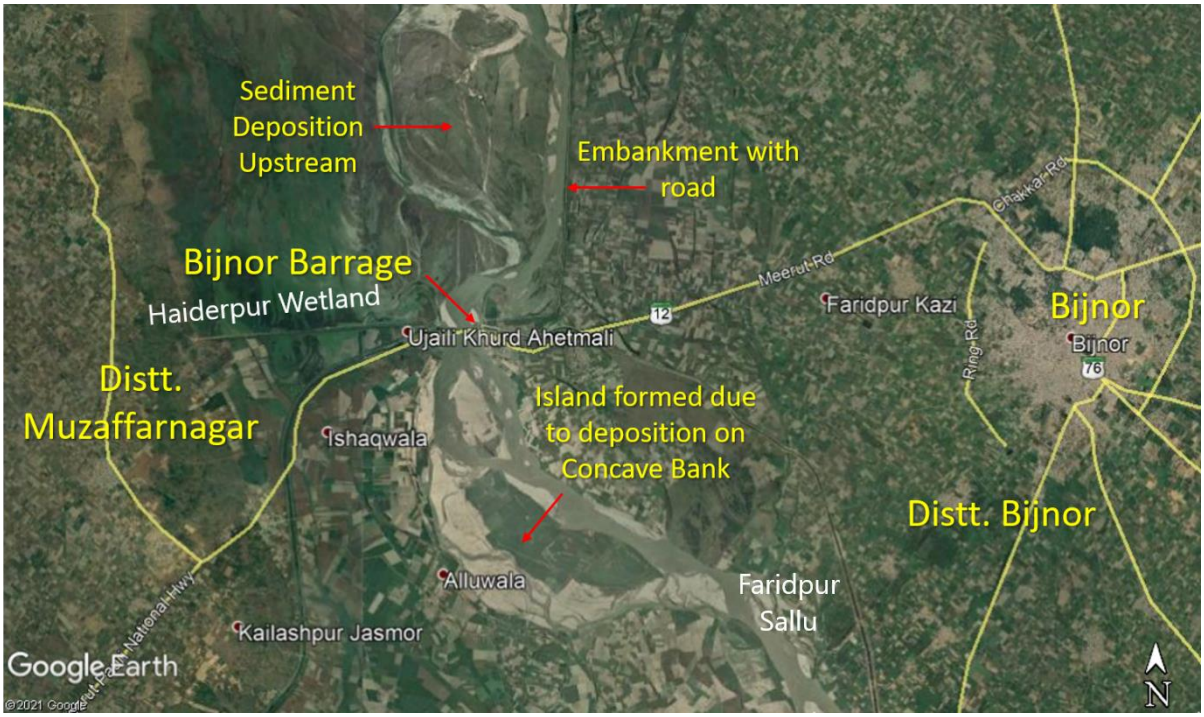


Image 29 : Sediment Deposition Upstream and Downstream Of Bijnor Barrage

Image 30 : Island Vegetation As Seen From Upstream Area Of Bijnor Ganga Barrage

Image 31 : Smaller Island With *Ipomea Carnea* Vegetation
[Mix Riparian Vegetation In Foreground; Location : Upstream Area Of Bijnor Ganga Barrage]

12.0 Fishing In Muzaffarnagar Distt.

12.1 Fish resources of Ganga River have been an important source of livelihood and food security for millions of people residing along its banks. Ganga river supports a diverse fish fauna with about 260 species reported for Indian waters (Sinha and Khan, 2001) among which about 35 species have been identified as having highest commercial value including carps (Cyprinidae), snakeheads (Channidae) and catfish (Siluriformes) (Islam et al., 2006). However, today these rich fish resources are threatened by various anthropogenic activities and resulting water pollution, accumulation of heavy metals, eutrophication, damming, alteration of hydrology and introduction of exotic species (Tripathi et al., 2017).

12.2 Fishing is an important source of income for fishermen and daily wagers in Muzaffarnagar Distt. Fishing is carried out by various means – nylon & rope nets, rods and nylon fishing lines (threads). Fish captured by fishermen are sold in the local markets and occasionally out of the district.

12.3 District Gazetteer of Muzaffarnagar of 1980, mentions about the presence of 30 fish species in the district. Fish species commonly cultured were Catla (*Catla catla*), Rohu (*Labeo rohita*), Kursa (*Labeo gonius*), Bata (*Labeo bata*), Pungussia (*Labeo pungussia*),

Karaunch (*Labeo Calbasu*), Nain (Cirrhina mrigala), Raiya (Cirrhina reba). There were 14 species of 'Catfish'. They fed upon the above fish species, hence were not cultured. Some of the important cat fish species were Parhin (*Wallago attu*), Pabda (*Ompak pabda*), Singhara (*Mystus aor, Mystus vitatus*), Katera (*Mystus vitatus*), Tengra (*Mystus cavessius*) and Singhi (*Heteropneustes fossilis*). About 11 species of minnos or weed fish were also found in the district, the chief being Kharda (*Colisa fasciatus*), Chilwa (*Chela bacaila*) and the Maluwa (*Amblipharyngodon mola*).

12.4 As per District Census Handbook of Muzaffarnagar (2011), the rivers, canals, and lakes are abundant in fish. About 30 species of fish are found in the district with Ganga, Yamuna and Hindon being the chief repositories. The most common varieties are Rohu, Naini, Bhakur, Karaunch, Mahaseer, Chilwa, Goonch, Saul, Mola, Anwari, Bata, Tengra and those belonging to the carp family. It further states that govt. had taken up few schemes for the development of fisheries in the district. One was Pradeshik Matsya Palan Vikas Abhikaran scheme in which the ponds of Gram Samaj were given on lease (patta) to local people through revenue department along with fingerlings for rearing.

12.5 Upon interaction with local fishermen, it was found that most of the fish species are found in this stretch of Ganga River. The fish species diversity increases during monsoon season and decreases as water level goes down post monsoon every year. There are no specific techniques to identify the spots for fishing in river. It entirely depends on accessibility and area divided between fishermen.

12.6 The most common fish species are Rohu (*Labeo rohita*), Catla (*Labeo catla*), Carp (*Cyprinus carpio*), Singhara (*S. seenghala*), Gonch (*Bagarius bagarius*), or Sawli (*Channa striatus*) and (*Channa punctata*) Singhi (*Heteroneustes fossilis*), *Naini* (*Cirrhinus mrigala*) [Table No.7].

Table 7 : Riverine Fish Common in Muzaffarnagar Distt.

S. No.	Common Name	Scientific Name
1.	Rohu	*Labeo rohita*
2.	Catla	*Labeo catla*
3.	Common Carp	*Cyprinus carpio*
4.	Grass Carp	*Ctenopharyngodon idella*
5.	Silver Carp	*Hypophthalmichthys molitrix*
6.	Sauli or Sawli	*Channa punctata*
7.	Sauli or Sawli	*Channa striatus*
8.	Naini	*Cirrhinus mrigala*
9.	Gonch	*Bagarius bagarius*

10.	Singhi	*Heteroneustes fossilis*
11.	Singhara	*Sperata seenghala*
12.	Chilwa	*Oxygaster bacaila*
13.	Chaal	*Chela bacaila*
14.	Puthi	*Puntius sarana (Ham.)*
15.	Bata	*Labeo bata*
16.	Kalmouch	*Labeo calbasu*
17.	Laanchi	*Wallagu attu*
18.	Teenghara	*Mystus vittatus*
19.	Manghur	*Clarias batrachus*
20.	Manghur	*Clarias gariepinus*
21.	Chapra	*Gudusia chapra*
22.	Cheetal or Mau	*Chitala chitala*

Image 32 : Sauli [*Channa punctata*] Caught by Fishermen From Ganga River

13.0 Groundwater Condition In Muzaffarnagar Distt.

13.1 As per Distt. Groundwater Brochure, CGWB [2008], the major part of the Distt. is underlain by alluvial sediments of quaternary period deposited by drainage system of Ganga and Yamuna Rivers. Lithologically, the alluvial sediments comprise of sand, silt, clay and kankars in varying proportions. The perusal of all available lithological logs of the tube wells in the area reveal the complex configuration of alluvial sediments showing quick alteration from finer to coarser lithology.

13.2 Four distinct groups of permeable layers occur in the area down to 450.00 mbgl. The top sandy clay bed is 3 m – 75 m in thickness covers the entire district. The aquifer groups are described as follows:

i. After the top clayey layer, the first aquifer starts, which has varying thickness at different places and continues down to 185 mbgl. Comprises of mostly medium to coarse sand. Gravels and kankars are also encountered sometimes. This aquifer at places, can be sub divided into two sub groups due to the presence of either clay lenses or sub regional clay layers.

ii. The second aquifer occurring at varying depths between 115 mbgl and 235 mbgl is separated by 10 m – 15 m thick clay layer from the first upper aquifer. The second group of aquifer consists of less coarse sediments than that of first one and at places kankar and clay lenses also occur.

iii. The third aquifer is separated by second aquifer by thick clay layer. The fine textural third aquifer ranges in thickness between the depths 255 to 329 mbgl. The third aquifer is followed by a clay layer.

iv. The thickness of the fourth aquifer varies between the depths 355 mbgl – 488 mbgl.

13.3 The aquifer material become coarser from west to east. The top clay layer is thickest at Lakkheri, Rajpur and Budhana in the south western part of the district but is almost absent at the Shukratal in the eastern most part of the district. As per observation noted in the brochure, Ganga River has deposited coarser material as compared to those deposited by Yamuna River.

13.4 The groundwater in the Distt. occurs in pore spaces and interstices of unconsolidated alluvial sediments under phreatic to semi confined conditions. The near surface aquifer

is under confined water table condition. The shallow phreatic aquifer is tapped by dugwells. The depth to water ranges from 3.43 mbgl to 23.27 mbgl in pre-monsoon period [May, 2015] whereas it ranges from 2.60 mbgl to 22.35 mbgl in post-monsoon period [Sept., 2015]. [Groundwater Year Book of Uttar Pradesh, CGWB, 2015-2016]

13.5 As per the 'National Compilation of Dynamic Groundwater Resource Assessment' of India (2017), the 'Total Annual Groundwater Recharge' of Muzaffarnagar district is 113168 Ham [Hectare metre] against 'Total Annual Groundwater Extraction' of 76895.51 Ham. The 'Stage of Groundwater Development' is 71.52%.

13.6 Major sources of irrigation are Upper Ganga Canal, govt. and private tube wells, permanent wells and ponds. Out of 9 blocks, 3 blocks viz. Baghara, Budhana, Chathawal fall under 'Over-Exploited', 1 block i.e. Shahpur under 'Critical' and rest 5 under 'Safe' category of CGWB's ground water assessment[12].

13.7 Groundwater levels noted in few villages in the study area during the survey are given below:

Table 8 : Groundwater Levels Of Some Villages Along Ganga In Muzaffarnagar Distt.

S. No.	Village	Coordinates		Depth to Water Table in Feet
		Lat.	Long.	
1.	Haiderpur	29°22'44.98"N	77°59'28.80"E	40
2.	Deval	29°20'45.65"N	78° 0'22.59"E	70
3.	Nizampur	29°23'14.87"N	77°58'51.59"E	50-80
4.	Morna	29°28'3.99"N	77°56'12.26"E	100
5.	Shukratal	29°29'12.44"N	77°58'57.46"E	50-70
6.	Bhokarhedi	29°30'23.86"N	77°56'11.82"E	100-150
7.	Seekri	29°32'25.15"N	77°54'54.47"E	> 100

[12] Report on Aquifer Mapping And Ground Water Management Plan, Muzaffarnagar District, Uttar Pradesh, by CGWB, August, 2017

Image 33 : Govt. Tubewell Near Nizampur Village

Image 34 : Private Tube Wells Are Major Source of Irrigation In The Distt.

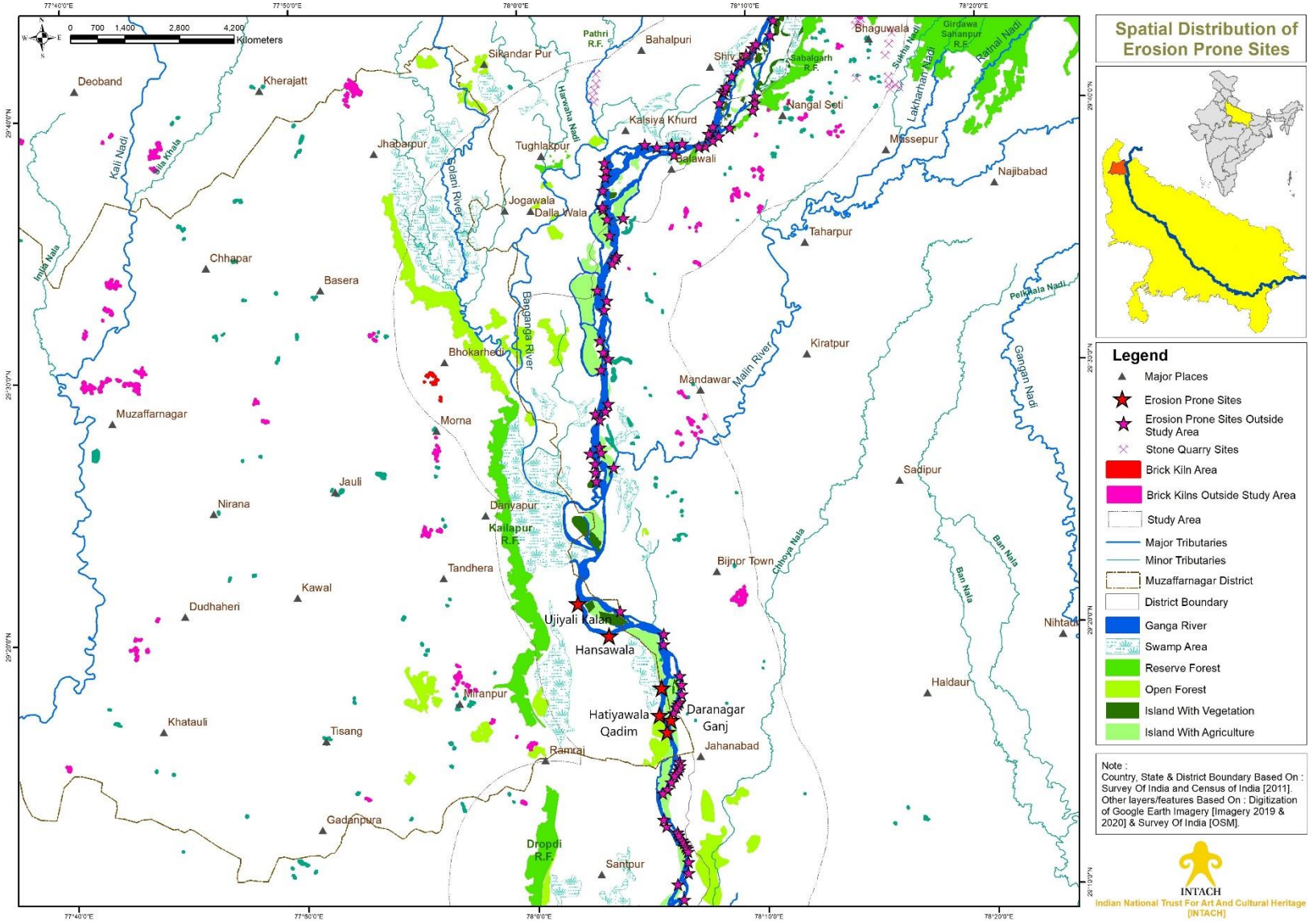
14.0 Ganga Bank Erosion In Muzaffarnagar Distt.

14.1 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).

14.2 In a recent attempt to make river banks greener, the Uttar Pradesh State govt. claims to have planted more than 2.2 Crore trees along river banks as a part of annual plantation drive. The Ganga River has got the maximum – around 67 lakh trees and the plantation has been done in all the 27 Distt.s along Ganga in the State as noted by Times of India [August 20, 2020][13]. ***However, this exercise cannot prevent bank erosion which is preventable only through the binding of an extensive root system as available in native riparian grasses.***

14.3 As assessed from the Google Earth imagery [2020], there are few major erosion prone sites on Ganga River in Muzaffarnagar Distt.. One such location is downstream of Bijnor Barrage between Ujiyali Kalan and Hansawala, where Ganga, while flowing southwest, takes a sharp left turn [See Map No.7]. Further downstream there are few erosion prone sites between Hadiyala Qadim in Muzaffarnagar and Daranagar Ganj in Bijnor due to southeast meandering of the river. The erosion prone sites could not be observed due to high flow in the river.

[13] River banks made greener in Uttar Pradesh. Aug.20, 2020. Times of India



Map 7 : Spatial Distribution Of Erosion Prone Sites In The Study Region

15.0 Mining And Brick Kilns In Muzaffarnagar Distt.

15.1 **Sand Mining** : Sand is one of the major minerals resource extracted from the Ganga River, especially in its mid and lower stretch. The demand is ever increasing due to rapid expansion of settlements and their upgradation across the country. Often carried out illegally and excessively to earn large profits, sand mining is altering rivers' overall health. Excessive sand mining results in the destruction of aquatic and riparian habitats and also poses threat to bridges, river banks and nearby structures[14].

15.2 In Muzaffarnagar Distt., illegal sand mining is carried out at Upper Ganga Canal. According to news sources, the local community members from villages located along the Upper Ganga Canal carry out sand mining during night. Upon local interaction, it was known most of the sand mining is carried out at Yamuna River which now borders Shamli district. Earlier, Shamli was a part of Muzaffarnagar district till 2011.

15.3 **Brick Kilns:** Brick making is one of the major economic activities in the Distt., providing employment to many daily wage workers. With rapid urbanisation, bricks have become important building material with ever increasing demand. However, the industry has current and future implications for the soil, agriculture land and air quality of the region. In Muzaffarnagar district, only few brick kilns are present within study area – located south of Bhokarhedi village [Map-7]. They are located around 10 km away from the main Ganga River in a cluster of 4 units. There are distance obligations for establishment of brick kilns from roads, railways, villages, mango orchards etc. set in 'The Uttar Pradesh Brick Kilns (Siting Criteria from Establishment) Rules 2011' but there is no mention of distance from river, floodplains or a waterbody in these rules.

[14] Impacts of Sand Mining. ENVIS Centre on Environmental Problems of Mining, IIT Dhanbad, Jharkhand

Image 35 : Brick-Kiln On Bhokarhedi Road

16.0 Boatmaking In Muzaffarnagar Distt.

16.1 Boatmaking is not a popular profession or income source in the Distt. Several fishermen or farmers whose livelihoods depend on the fishing or floodplain farming keep the smaller wooden boats. For both the districts – Muzaffarnagar and Bijnor, boats are procured from Shukratal area in Muzaffarnagar.

16.2 The price of small wooden boats ranges from between Rs.17,000/- to Rs.20,000/-. If carpenters are provided with the materials needed, the cost of the job comes down between Rs. 5000/- to Rs.7000/-. Comparatively, motorboats are expensive and are priced somewhere around Rs. 1.75 Lakhs per unit. Motorboats are made especially for local tourists who visit Shukratal Ghat and like to experience the boat ride. Boats are made by local carpenters (wooden boat) and blacksmith (iron motorboat – thick gauge GI sheet) who get such work occasionally.

Image 36 : Iron Boats Are Used For Tourists At Shukratal

Image 37 : Small Wooden Boats Used By Farmers

17.0 Inland Navigation In Muzaffarnagar Distt.

17.1 The Ganga River in both Muzaffarnagar and Bijnor Distt. is navigable except in spring and summer when it becomes shallow at some places with emergent sand bars making navigation difficult. River route is hardly used by people to travel downstream villages. Island farmers and fishermen use small wooden boats to move around the river landscape. The Muzaffarnagar Gazetteer of 1980 mentions about course of river : "*All along its course, the Ganga forms the eastern boundary of this district which separates it from district Bijnor. While in the district the channel of the river varies from time to time, the general tendency is to shift eastward. A great change in the course of the river is said to have taken place around 1400 A.D.*"

17.2 As observed on Google Earth satellite imagery and during field visit, the Ganga River in the district is easily navigable during monsoon season. During rest of the months, it changes into narrow channels intermitted by islands and sandbars which are crossed with the help of wooden boats by fishermen and riparian farmers. The Saloni and Banganga Rivers are easily approachable (due to their westward location and being close to the settlements) and navigable throughout the year.

Image 38 : A Farmer Pulling His Boat Downstream Of Ganga Barrage [April, 2021]

18.0 Key Observations and Recommendations

18.1 **Palaeochannels and Floodplain Lakes :** The Distt. authorities as well as farmers must acknowledge the role of palaeochannels, floodplain lakes and depressions along the Ganga River in the Distt. From acting as groundwater recharge zones to maintaining river biota especially aquatic plant species and fish diversity, their role along rivers have been undervalued. Their edges provide space for riparian grasses and trees and thus help in maintaining food chains by providing habitat to various birds, reptiles and insects. They provide invaluable service to farmers as water retention ponds for irrigation. They also add visual appeal to large and monotonous agricultural landscapes – especially in a state like Uttar Pradesh.

18.2 **Waterbodies Encroachment :** Waterbodies in the Distt. are highly threatened by encroachment, pollution and increasing eutrophication. During the field visit, it was observed that not even a single waterbody has been spared from solid waste dumping and illegal encroachment. There are settlements coming on their edges and thus decreasing their area and water spread. Healthy water bodies in villages and towns of the Distt. would ensure income generation options for the local people through fisheries and water chest nut production. They would also help in groundwater recharge as the current rate of withdrawal is high across villages due to installation of private submersible pumps.

18.3 **Riparian Flora :** The river banks along forest uplands are comparatively rich in riparian vegetation partly due to swampy area and presence of Solani and Banganga River channels. This has restricted agriculture and other anthropogenic activities to a certain level. This particular area till Bihargarh (10 km upstream from Haiderpur Wetland) should be marked and protected from future encroachments in line with the recent recognition of Haiderpur Wetland. In addition to providing habitat to many aquatic and terrestrial species, riparian vegetation would provide bank stability in long term. The area may also be considered as 'Riparian and Aquatic Vegetation Bank' for Ganga River river ecological studies.

18.4 **Aquatic Fauna:** The stretch of Ganga is an important habitat of major aquatic fauna such as Gangetic Dolphin, Gharial, Crocodile and at least 12 species of turtles – many of which are threatened by multiple factors. And there are many other associated species such as frogs, toads, butterflies, insects, aquatic invertebrates that are poorly documented but form important part of the food web. Forest dept. should carry out

annual faunal surveys in collaboration with expert institutions besides bird census. Such annual exercise would supplement the existing data on Ganga River biodiversity.

18.5 **Protection for River Islands :** River islands support better bird diversity in rivers and act as safe habitats for turtles, gharials, and crocodiles. Such islands and exposed sand-beds should be seen as refuges for biodiversity. River islands must be protected. Agriculture practices on such islands and sand-beds should be curbed and a central 'River Island Policy' must be drafted. Any conservation planning or initiative for rivers in the state should consider protection of islands an important priority.

18.6 **Sand and River Bed Mining** should be checked and curbed completely. Excessive mining alters the natural river bed forcing the river to change course and thus promotes banks erosion. It has also been noted that deep excavations due to mining transforms into deeper pools after the high flow in the river and thus endanger lives of people who come for bathing during religious ceremonies. To keep a regular track, distt. authorities may utilise Google Earth and drones to keep themselves updated. Excessive sand mined areas could be easily spotted from the Google Earth or other high resolution satellite imageries.

18.7 **Cremation :** Cremation of dead bodies and immersion of their remains is quite common along the Ganga River and its tributaries. The ongoing practice of cremation by local communities at their nearest river banks instead of designated crematorium sites pollutes the river. This, on a daily basis is contributing to the pollution levels in the river. Distt. authorities should encourage them to cremate at the designated crematorium facilities.

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