Table of Contents

INTACH

List of Images

List of Maps

List of Tables

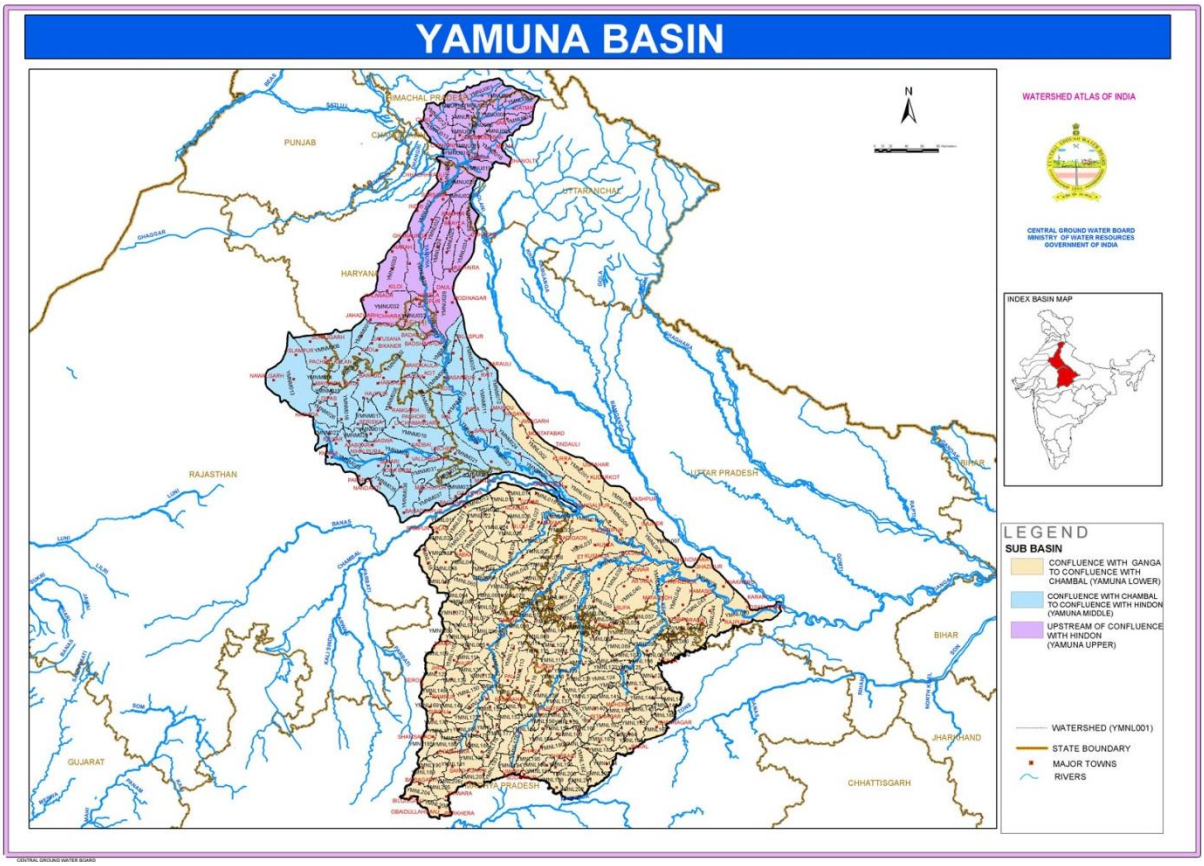
Chapter I – The Hindon Basin

1.1 Yamuna River, one of the largest tributaries of River Ganga, originates near Banderpoonch peaks in the Mussoori range of lower Himalayas at an elevation of about 6387 m above mean sea level in the district of Uttarkashi. As per CGWB's Watershed Atlas of India the larger basin is divided into three sub basin shown in the map below :

(i) Yamuna upper - upstream of confluence with Hindon

(ii) Yamuna middle - confluence with Hindon to confluence with Chambal

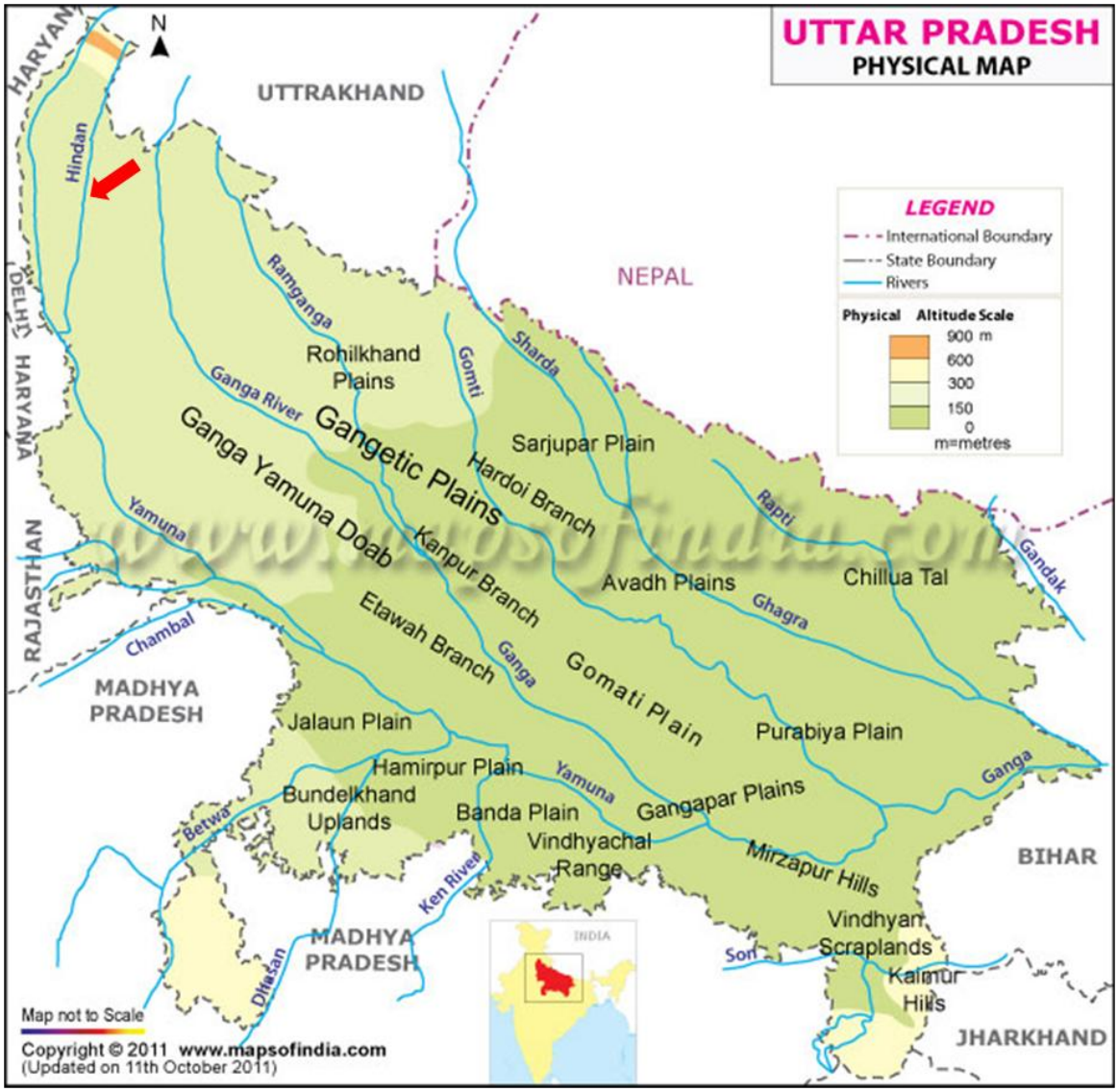
(iii) Yamuna lower - confluence with Ganga to confluence with Chambal



Map 1 : Yamuna Basin Map [Source: CGWB]

1.2 The basin consists of highly fertile alluvial plains supporting livelihoods of millions of people. The topography of basin varies from steep in the Himalayan segment to almost flat in the middle and lower segments. The major land uses include agriculture, forest, non-agriculture, barren land, permanent pasture, cultivable wasteland and fallow with more than 50 per cent area under

agriculture[1]. Hindon River lies in the northeastern part of the basin arising from lower Himalayan range and meets Yamuna River at Tilwada village in Gautam Buddha Nagar near Delhi.



Map 2 : Course of Hindon and Major Rivers in Uttar Pradesh [Source:mapsofindia.com]

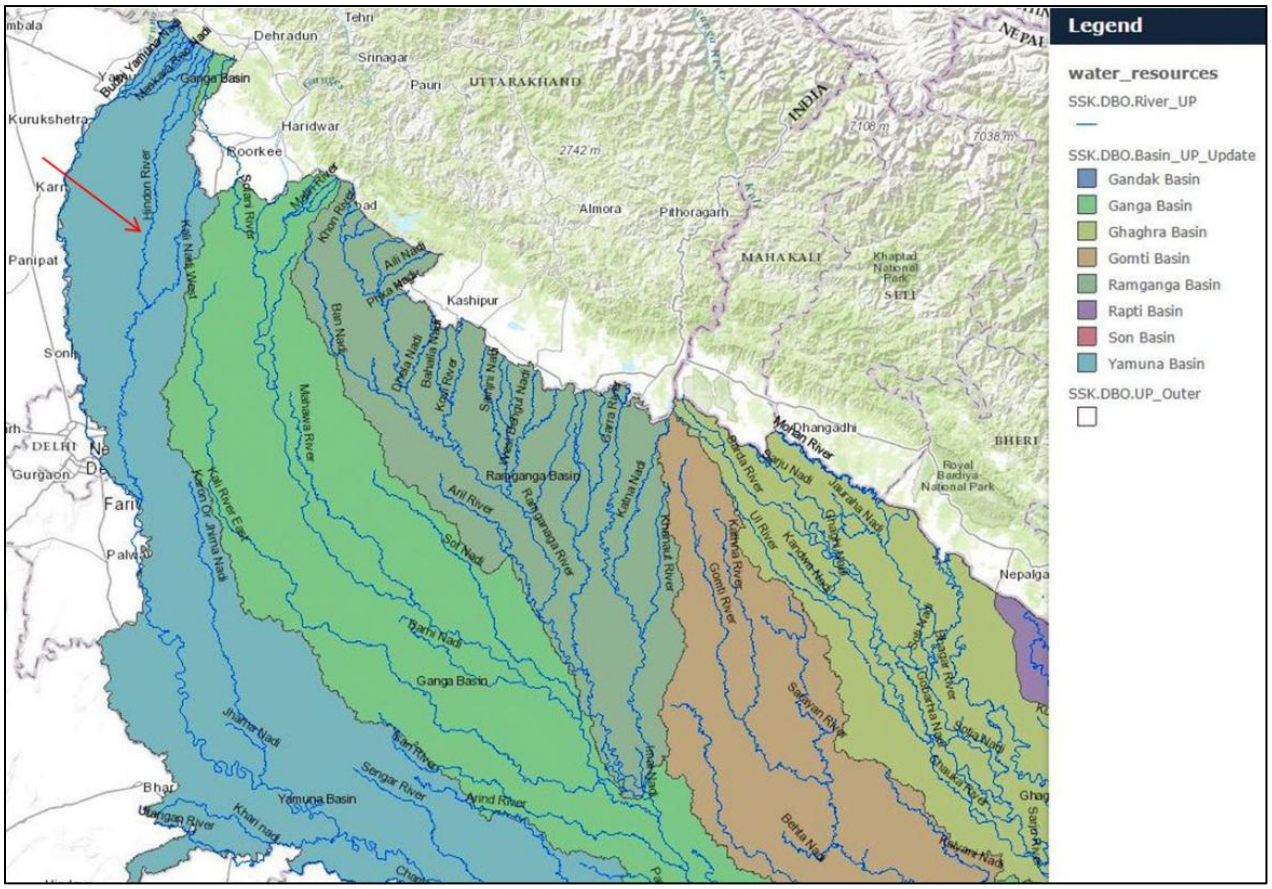
2.0 The Hindon River

2.1 The Hindon is an approximately 350 km long tributary of Yamuna with a catchment area of about 5975 sq. km. It is entirely an intra-state river with its course falling within UP [Table 4]. River Hindon passes through six districts Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad and Gautam Buddha Nagar in West Uttar Pradesh. Till recently it was believed to originate at Pur ka Tanka (or Pur ka Tanda) village at upper East Saharanpur and joins Yamuna River at Tilwara Village, West of Gautam Buddha Nagar**.**

[1] Report - IWRM and Water Quality Modelling of the Yamuna River Basin, YAP Phase-2, Oct, 2010

2.2 It is a purely rainfed river which originates from upper Shivalik in the lower Himalayan range. The river, which has been the main source of water for agrarian communities of six districts, is dying a slow death due to substantial water abstractions and severe pollution loads which it receives from various sources along its course.

2.3 It's two major tributaries Kali River (W) [originating near Dhanakpur village joining Hindon near Pithlokar village] and Krishni or Karsuni River [originating at Kairi village joining Hindon near Barnawa village] add further pollution load to the main stem [See Map No.5]

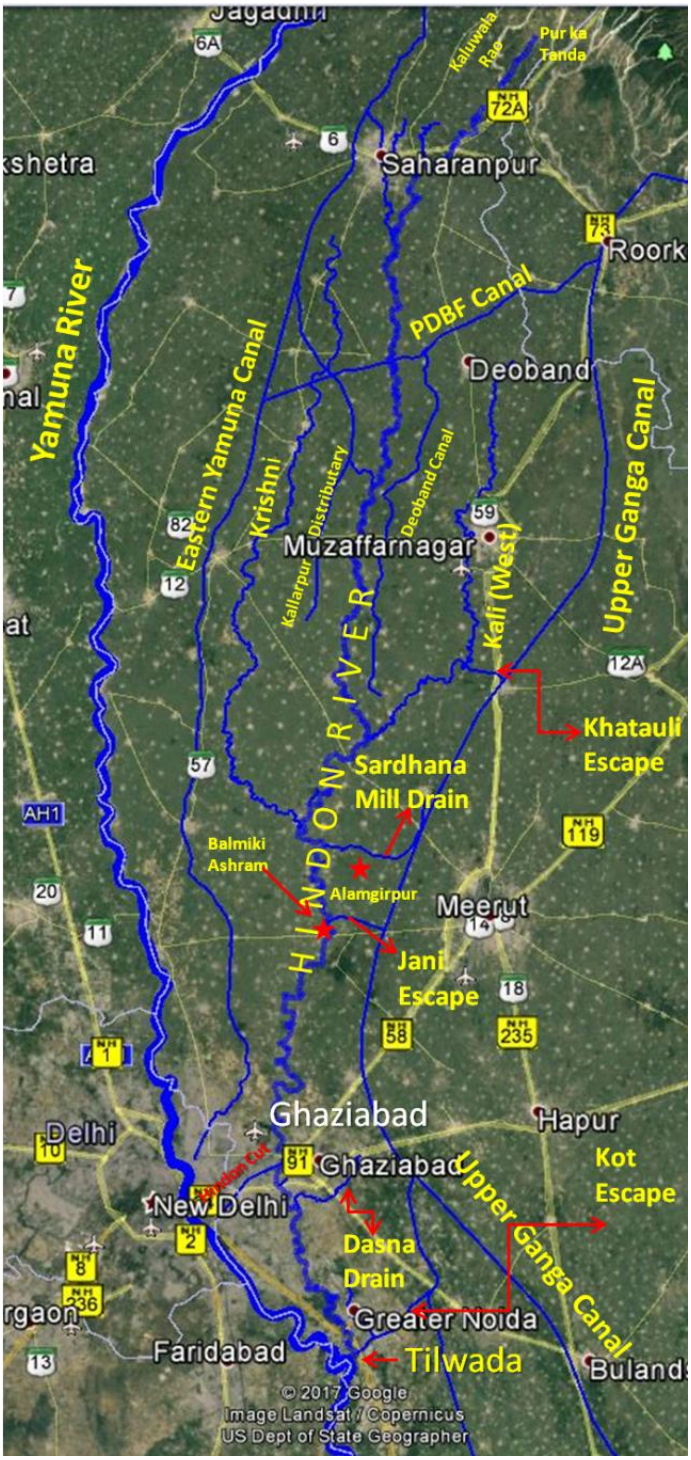


Map 3 : Hindon River Location In Yamuna Basin [Source: Basin Webmap, BAPS, Irrigation Dept, UP]

2.4 The basin is mainly agricultural with two major urban settlements, Saharanpur, near the origin of Hindon and Ghaziabad, which is near its confluence with Yamuna. Major industrial clusters operate at Saharanpur and Ghaziabad. These two urban areas are the source of much domestic and industrial effluents contaminating the river water. The surface water also gets polluted by the inflow of pesticides and fertilizers from the fields during rains and all these pollutants ultimately leach into the aquifer.

2.5 The basin falls between the courses of the Yamuna and Ganga and for this reason the unconfined alluvial aquifers offer copious yields. Water users in the basin, in the main, are dependent on groundwater extraction for meeting their needs.

2.6 The course of the river and its main tributaries is depicted in the following maps :



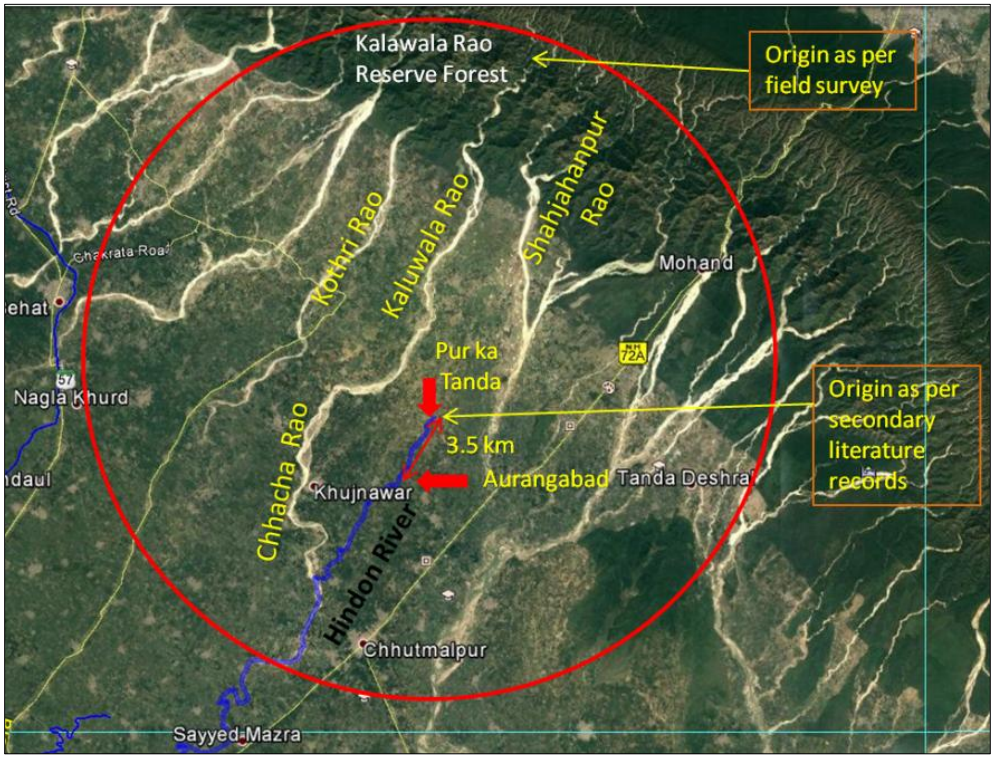
Map 4 : The Hindon Basin

Map 5: Hindon River, 1940

INTACH

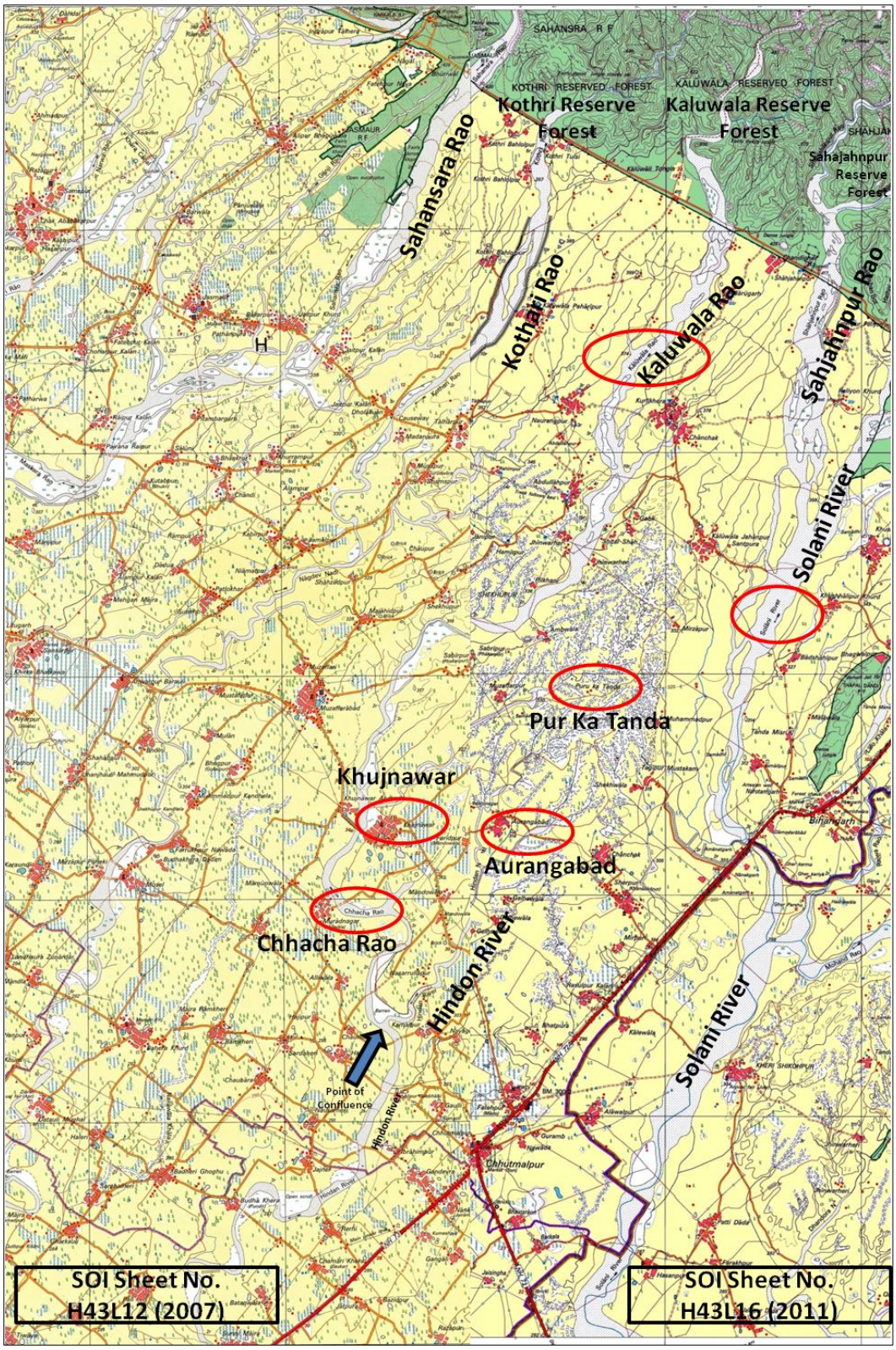
Hindon River Origin
Pur Ka Tanda OR Kaluwala Rao Reserve Forest

As per secondary literature (newspapers and earlier reports), origin of Hindon River has been mentioned as Pur Ka Tanda (or Tanda Puru village) situated in tehsil Behat in north-east of Saharanpur Distt. District Gazetteer[2] Saharanpur (1981) records "The name Hindan is first applied to a small stream which rises near Aurangabad but the bulk of water is derived from a torrent known in it upper course as Kaluwala Rao and afterwards as the Chahcha Rao which receives Khokra on its left bank at Khujnawar and joins the Hindan on the northern boundary of Pargana Haraura". Aurangabad is 3.5 km south of Pur ka Tanda village. Pur ka Tanda village has not been mentioned in any District Gazetteer and the river stream or trail is difficult to trace beyond Aurangabad. As per Survey of India open series maps H43L12 (2007) and H43 L16 (2011), the main channel first known as Chacha Rao and then Kaluwala Rao originates from Kaluwala Rao Reserve Forest in district Saharanpur. The channel remains dry during lean season - clearly visible on satellite imagery and is upto 500-600 m wide at some places (measured approximately on Google Earth). During field surveys, this channel which rises from Kaluwala Rao reserve forest seemed to be the origin of River Hindon [See Map No. 7 and 8 below]



Map 6 : Hindon Origin in Shivaliks of Northeastern Saharanpur [Basemap Source: Google Earth]

[2] Uttar Pradesh District Gazetteers [Saharanpur], 1981, Govt. of Uttar Pradesh



Map 7 : Hindon Origin and Associated Locations on SOI Toposheets

Image 1 : Shallow Dry Hindon River Channel at Aurangabad, Saharanpur Being Used As a Track

2.7 The fertile Khadar plains of the river have long been used for agriculture. Meerut Gazetteer[3] of 1922, states that the water of the river was used for irrigating *rabi* crops and melons on the fertile grounds inundated by the river. The harvests were of excellent quality.

2.8 Over years, intensive farming in the flood plains right up to the edge water channel has deprived the river banks of protective riparian vegetation that acted as a buffer. In most parts of upstream areas, the farmers have extended their fields into the floodplain area thus decreasing the width of the main channel to a few metres. For instance, engraved stone plate on an old bridge at Maheshpur, built on Hindon River in 1961, indicates that the clear waterway was 375' (114 m) whereas active channel today is reduced to around 20 metres (See map no. 9 below). District Gazetteer of Muzaffarnagar[4] (1980) states that Hindon's khadar areas were extensive at the southern boundary of the district where it meets Kali River and banks were, in some places, spread more than one and half kilometers apart

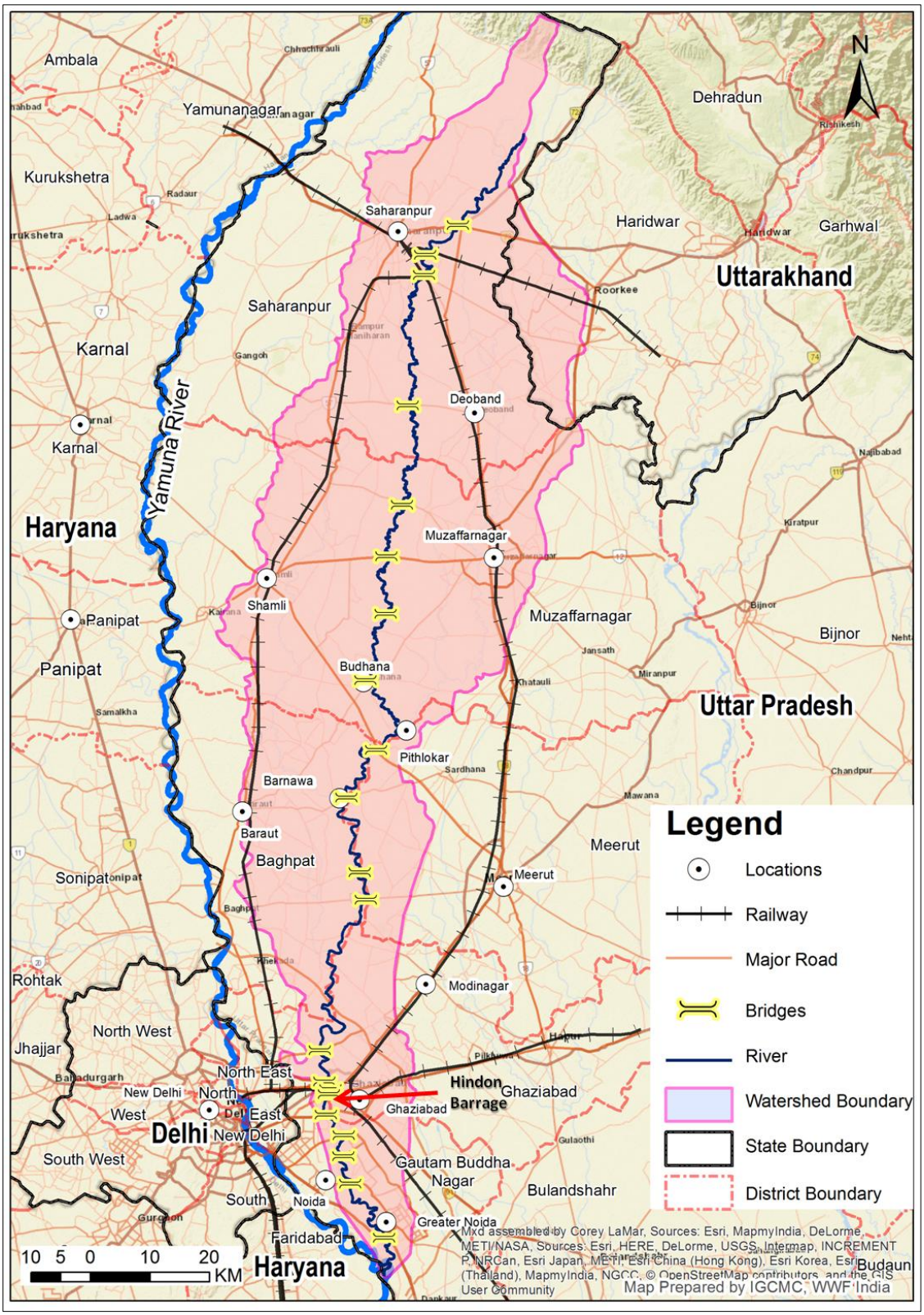
[3] Meerut: A Gazetteer being Volume IV of the District Gazetteers of the United Provinces of Agra and Oudh by H.R. Nevill, 1922

[4] Uttar Pradesh District Gazetteers, Muzaffarnagar (1980), by Dangli Prasad Varun

Map 8 : Width of River Water Channel [Maheshpur] Has Decreased Considerably Over Years

2.9 Hindon has been a victim of various engineering interventions which have interfered with its main course. Various bridges built over the river have restricted the width of the main channel while disturbing its natural flow. One example of this engineering juggernaut is Karera Bridge built over Hindon in Ghaziabad on Loni bypass-Rajnagar extension road. It has shifted the river channel by 350 metres away from the main course (refer Section : Threats & Issues).

2.10 As observed from satellite imagery there are 23 bridges (which also includes two railway bridges and also Hindon Barrage at Ghaziabad) over main stem of Hindon River from Saharanpur to Gautam Buddha Nagar. [See Map No. 9]



Map 9 : Bridges, Barrage, Railway Line, Major Roads in Hindon River Basin

3.0 Efforts Of Civil Society Organisations

3.1 Local NGOs and individual activism have been instrumental in keeping Hindon river issues in the lime light. NGO's like Samvardhan Trust, Harnandi Jal Samaj, Hindon Jal Biradri [NGO] based at Ghaziabad [one of the major industrial city on the course of Hindon], have been painstakingly working for the protection of Hindon River. They are involved in creating awareness, river walks, campaigns and fighting legal battle against illicit activities on the course of river. GPVS, an NGO in Doula Village [Baghpat], and NEER Foundation, Meerut, are also working actively in mobilising people and administration, raising concerns over current situation of Hindon. These local organisations and individual activists have been instrumental in bringing major issues to the court after which some significant decisions have been taken recently. On 25th Aug 2015, National Green Tribunal issued a directive in response to a petition filed by a local resident of Ghaziabad against dumping of construction waste in the Hindon canal and river as follows : *"Any person throwing municipal solid waste, construction debris or any other waste in and around the Hindon canal will be liable to pay Rs 20,000 as environmental compensation in accordance with Section 15 read with Section 17 of the NGT Act, 2010."*

3.2 Janhit Foundation, an NGO based at Meerut, carried out a comprehensive study[5] during 2005 - 2007 to evaluate the presence and extent of toxic pollutants within surface and groundwater resources of the Hindon River catchment. A wide range of highly toxic organochloride and organophosphorus pesticides and heavy metals were identified within stream and ground water throughout catchment. The report had a significant impact in mobilising state govt and judiciary and highlighted the need for industry and govt. regulatory bodies to take immediate action.

3.3 The 2030 Water Resources Group, a public-private-civil society collaborative organisation under International Finance Corporation, has been working actively to raise awareness on water resources management in India since 2012. The group in association with govt., local people and NGOs has been organising Hindon Yatra – an activity involving the public in order to raise awareness, showcase good initiatives and bring togther multiple stakeholders working for Hindon River.

4.0 Hindon Basin In The District Gazetteers

4.1 Khadirs and forest areas of Ganges, Jumna and Hindon used to be home to lot of wildlife species. District Gazetteers of Meerut (1922), Muzaffarnagar (1980) and Saharanpur (1981) note the presence of tiger, leopard, antelope, nil gai, fox, wild pig, wolf, jackal, porcupine, hare and monkey.

[5] Hindon River: Gasping for Breath (2009) by Heather Leawis, Janhit Foundation, Meerut

4.2 As per District Gazetteer of Saharanpur (1981)[6], the fauna of Saharanpur district was more diverse owing to habitat diversity with the presence of Shivalik Hills and forests and existence of large tracts of khadirs of two major rivers i.e. Ganges and Yamuna. Besides common faunal species found in other districts, there were species as such as Sloth Bear (*Selenarctos thibatanus*), various species of deer such as Harin (*Antelope cervica*), Sambur (*Cervus unicolor niger*), Spotted Deer or Chital (*Axis axis*), and the Barking Deer or Kakar (*Mantiacus muntajak*). Indian Black Buck was rarely seen while Nilgai (*Bosephalus tragocamelus*) was found in the river basins and small forests of the north. The Gural or Himalayan Chamois (*Nemorhaecatus*) was seen in the Shivalik ridges while Chausingha or Four-horned Antelope (*latin name*) and Barahsingha (*Cervus durana*) were rarely seen. The Khargos (*Lapusni gricoli*) was found throughout the district.

4.3 Gazetteer of Saharanpur, 1981[7] mentions that fish were plentiful in large rivers, canals and lakes. The common species were Mahaseer *(Barbas to*r), Rohu (*Labeo rohita*), Saul (*Opheocophalus sp.*), Anwari, Chilwa and the Gunch.

4.4 District Gazetteer of Meerut (1922) mentions that leopards were fairly common in the Khadir of Ganges and ravines of the uplands. Pigsticking was a popular sport in Meerut district where a well known annual Khadir-Cup meeting used to take place during March or April and attracted people from all over.

4.5 Resident as well as migratory game birds used to flock in large numbers. District Gazetteer of Meerut (1922) mentions the presence of a large number of Wild Duck and Teals in places along Burhganga, Hindon and Jumna and in many large size Jhils (seasonal waterbodies) in the interior. Grey Patridge, Quail, Blue Rock Pegions were abundant. Sandgrouse was plentiful in certain seasons and occurred chiefly in the khadirs of Mawana, Hapur and Ghaziabad. There were also occasional sightings of floricans.

4.6 With destruction of most of the floodplain forests and much of the natural khadir tracts converted to agricultural, only a few faunal species are seen. Jackal, fox, hare, wild pig, occasionally leopard and wolf and some species of snakes thrive along the floodplains and villages of Hindon River. District Gazetteer of Meerut (1922) narrates that snakes were a more common cause of mortality than other wild animals. Atkinson recorded a large number of species from a note supplied by Mr. H.M. Rogers I.C.S. It further describes that as per popular classification there were not less than 34 species of snakes that were found in the Meerut district, some of them being rare.

4.7 With deterioration in water quality of the Hindon the aquatic life including native fish species has disappeared. Local residents from villages situated on the banks of Hindon river recall the times when the river used to be a favourite stream for fishing. Fish such as Catla, Rohu, Chilwa, Singhi, Katera used to be the favorite catch. Although there is no clear mention of the fish

[6] Uttar Pradesh District Gazetteers, Saharanpur (1981), by Dangli Prasad Varun
[7] Uttar Pradesh District Gazetteers, Saharanpur (1981), by Dangli Prasad Varun

species found in Hindon River but as per Uttar Pradesh District Gazetteers a large range of fish species were found in the various rivers and canals. Ganges River and Ganges Canal contained almost the same species. Similar was the case of Jumna River and Eastern Jumna Canal.

4.8 Four common modes of fishing have been mentioned in Meerut Gazetteer [1922] : by net, using rod, employing the tapa or bottomless basket and by forming dams. Muzaffarnagar Gazetteer, 1980[8] mentions about 30 fish species. Major species were Catla (*Catla Catla*), Rohu (*Labeo rohita*), Kursa (*Labeo gonius*), Bata (*Labeo bata*), Pungussia (*Labeo pungussia*), Karaunch (*Labeo kalbasu*), Nain (*Cirrhina mrigala*) and Raiya (*Cirrhina reba*). There were about fourteen species of catfish which were not cultured as they eat other fish species. Some important cat fish species were Parhin (*Wallago attu*), Pabda (*Ompak pabda*), Singhara (*Mystus aor, Mystus vitatus*), Katera (*Mystus vitatus*), Tengra (*Mystus cavessius*) and Singhi (*Hertopneustes fossilis*). About eleven species of minnos or weed fish were also found in the district. The chief ones were Kharda (*Colisa fasciatus*), the Chilwa (*Chaila bacaila*), and the maluwa (*Amblipharyngodon mola*).

5.0 History, Mythology and Cultural Sites

5.1 Hindon like other major rivers in India has its particular cultural associations. At the confluence of the Hindon and Krishni Rivers at Varnavrat or the present day Barnawa near Sardhana lies the ancient Mahadev Temple believed to be from Mahabharata period. This is where the Pandavas prayed before leaving for Lakshagrah, the place made of lac by Duryadhana. The temple is visited by thousand of devotees during the month of Shravana when Kanwarias bring the holy water from the Ganga to worship Shiva. [Map 11]

5.2 Historically, Hindon river basin has witnessed warfare. Recent research has revealed that seven wars were fought around the river belt, especially in Ghaziabad region. In 14th century CE, the Kot war was fought at Loni while the one between Taimur and Indian warriors was fought at Surajpur. The banks of the river witnessed Maratha-Mughal war between the rulers of Bharatpur [Surajmal] and Najib [Rohilkhand]. During British rule, General Lake and the Maratha army fought here. During the struggle of 1857, Hindon river bank witnessed the first leg of Indian War of Independence where Indian troops revolted against the British raj including the battle of Badli ki Sarai[9]. An Indus valley civilization site – Alamgirpur [See Map No. 5] has been identified on the banks of Hindon River.

[8] Uttar Pradesh District Gazetteers, Muzaffarnagar (1980), by Dangli Prasad Varun
[9] River Sutra, Crossings Insight Vol I iSSUE II November 2012 Magazine by Crossings Republik

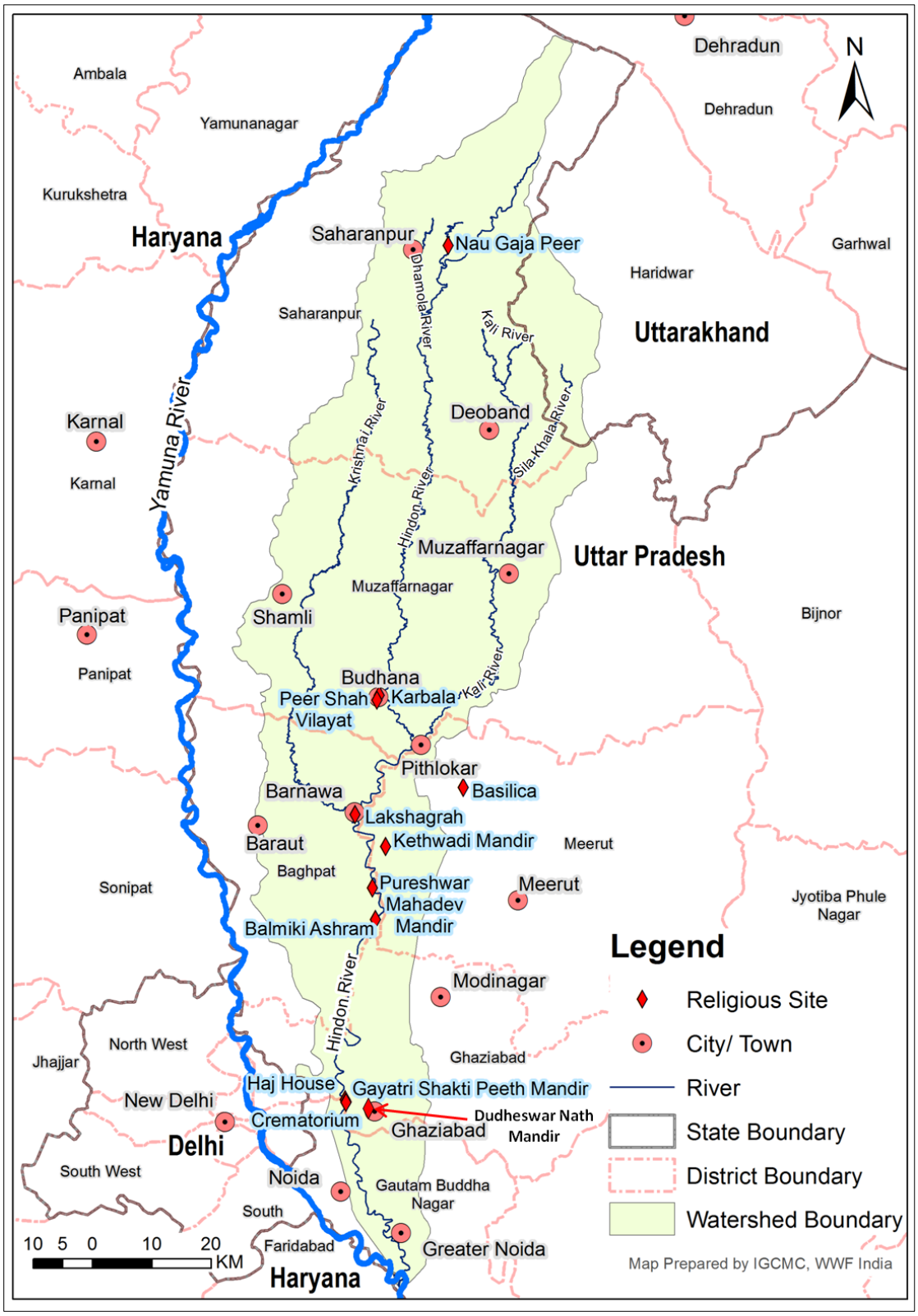
Image 2 : Lakshagrah At Barnawa Is An Important Historical Site Associated With Hindon River

Image 3 : Balmiki Ashram (Luv Kush Temple), Hindon River Bank, Near Baleni, Dist. Baghpat

5.3 Around 25 km from the city of Baghpat towards Meerut at village Baleni lies Balmiki Ashram (or Luv-Kush Temple) [See Map 5 & 11] which is situated on the bank of Hindon River. According to Ramayana, Lord Rama's sons Luv and Kush were born here. This is the place where Lord Rama's wife Sita found refuge after Rama and Ravana's war.

5.4 Another great religious attraction of historic importance by the Hindon River in Ghaziabad is Shri Dudheshwar Nath Mahadev Math Mandir, the 5,000 year old temple, which has a self effulgent Shivlinga.

Image 4 : Shri Dudheshwar Nath Math Mandir, Ghaziabad (Source: Dudheshwarnath.com)



Map 10 : Major Towns & Religious Sites in Hindon Catchment

6.0 Administrative Boundaries

6.1 The Hindon Basin, some 5975 sq.km. area, is spread across the districts of Haridwar [Uttarakhand] and Saharanpur, Muzaffarnagar [now bifurcated into Shamli in year 2011], Meerut, Baghpat, Ghaziabad and Gautambudh Nagar in Uttar Pradesh. The district-wise area is as follows:

Table 1 : District Area & Hindon Basin Area

S.No	District	Distt.Area (Sq. Km.)	Basin Area (Sq. Km.)
1	Haridwar	2360	290
2	Saharanpur	3689	1802
3	Muzzafarnagar	4008	2009
4	Meerut	2559	321
5	Baghpat	1321	828
6	Ghaziabad	1179	422
7	Gautam Budh Nagar	1282	303
	Total	16,398	5,975

Source: Data compiled from Adminitrative Atlas of Uttar Pradesh Vol 1, Census of India, 2011

6.2 Whilst administrative jurisdiction is exercised by the District Administration, river issues, inflows, diversions, hydraulic structures are the domain of the UP Irrigation Dept. with CWC exercising a remote control for major decisions.

Table 2 : District Subdivisions

District	No. of Tehsils	No. of Vikas Khands	No. of Towns	No. of Villages In Distt.	No. of Villages in Basin*
Haridwar	3	6	24	612	75
Saharanpur	5	11	16	1,572	768
Muzaffarnagar+Shamli	6	14	27	1019	511
Meerut	3	12	18	663	84
Baghpat	3	6	8	315	198
Ghaziabad	4	8	26	547	196
Gautam Buddha Ngr	3	4	13	320	76
Total	24	55	108	4436	1904

Source: Data compiled from Adminitrative Atlas of Uttar Pradesh Vol 1, Census of India, 2011

*Approximate as based on ratio of Basin Area to Distt Area x Total Vllages in Distt.

6.3 Major towns which fall in the basin area are Saharanpur, Muzzafarnagar, Shamli, Baraut and Ghaziabad.

7.0 Population Data

7.1 River Hindon Basin lies in districts of Haridwar, Saharanpur, Muzaffarnagar [incl. Shamli], Meerut, Baghpat, Ghaziabad and Gautam Buddha Nagar in West Uttar Pradesh. The population

of these districts grew considerably in the last more than two decades increasing population density and pressure on land and natural resources. Around 1,86,86,391 [as per Census 2011] people live in these districts which encompass more than the Hindon basin area lying in these districts.

7.2 **The data is at district level whereas the catchment boundary is not coterminous with the district boundaries**. Constant bifurcations of districts have made the task of deriving population trends tricky. For eg. Meerut Distt. has been split into Ghaziabad in 1976 and further into Baghpat Distt. in 1997. Ghaziabad Distt. has been parted with Gautam Budh Nagar in 1997. In 2011 Muzaffarnagar Distt. has been bifurcated as Muzzafarnagar and Shamli Distt.

Table 3 : District Population Levels

District	[1971]	[2001]	Decadal Growth Rate [1971 to 2001]	[2011]	Decadal Growth Rate [2001 to 2011]
Haridwar	-	14,47,187	-	18,90,422	23%
Saharanpur	20,54,834	28,96,863	29%	34,66,382	16%
Muzaffarnagar [incl.Shamli]	18,02,289	35,43,362	49%	41,43,512	14%
Meerut	33,66,953	29,73,877	-	34,43,689	13%
Baghpat	-	11,63,991	-	13,03,048	10%
Ghaziabad	-	33,14,070	-	46,81,645	29%
Gautam Buddha Ngr	-	11,05,292	-	16,48, 115	33%
Total/Average	73,51,776	1,50,36,931	-	1,86,86,391	19.71%

Source : Census of India, 1971 & Census District Handbook 1971 Meerut UP, Supplement of Paper 1 of Census 2001, Registrar General of India, Government of India, New Delhi, www.census2011.co.in [Accessed on 28/07/2016]

7.3 Data in Table 3 shows that highest growth rates are in Ghaziabad and Gautam Budh Nagar Districts adjacent NCT Delhi which is 66% higher than national decadal growth rate of 17.64 %. When considered with data from Table 6 it is obvious that the population distribution in the basin is highest adjacent NCT Delhi and at the tail end of the basin. It is also clear that population density of Ghaziabad Distt. is 2.66% higher than average density elsewhere in the basin.

Table 4 : Population, Area & Density of Catchment Districts [2011]

District	Population	Area (sq. km)	Pop. Density/sq.km.
Haridwar	18,90,422	2,360	801
Saharanpur	34,66,382	3,689	940
Muzaffarnagar[incl. Shamli]	41,43,512	4,008	1,034
Meerut	34,43,689	2,559	1,346
Baghpat	13,03,048	1,321	986
Ghaziabad	46,81,645	1,179	3,971

Gautam Buddh Ngr	16,48, 115	1,282	1,286
Total	1,86,86,391	16,398	1,480 (Avg.)

Source: www.census 2011.co.in [Accessed on 28/07/2016]

7.4 Table 5 shows that Ghaziabad Distt is most urbanized with 66% urban population. This is followed by Gautam Budh Nagar having 60% urban population and Meerut with 51% urban population. In other districts rural population still enjoys majority although, in line with national trends, the population distribution is increasingly urban. This has a bearing on total water use as well as sewage generation.

Table 5 : District-Wise Total Urban And Rural Population In 2001 And 2011

District	Population [2001]			Population [2011]			%age Change		
	Rural	Urban	Total	Rural	Urban	Total	R	U	T
Haridwar	--	--	14,47,187	11,97,328	6,93,094	18,90,422	--	--	30.6
Saharanpur	21,49,291	7,47,572	28,96,863	23,99,856	10,66,526	34,66,382	11.7	42.7	19.7
Muzaffrngr [inc. Shamli]	26,39,480	9,03,882	35,43,362	29,52,200	11,91,312	41,43,512	11.8	31.8	16.9
Meerut	15,21,894	14,51,983	29,73,877	16,84,507	17,59,182	34,43,689	10.7	21.2	15.8
Baghpat	9,34,559	2,29,432	11,63,991	10,28,023	2,75,025	13,03,048	10.0	19.9	11.9
Ghaziabad	14,97,655	18,16,415	33,14,070	15,19,098	31,62,547	46,81,645	1.4	74.1	41.3
GB Nagar	6,63,016	4,42,276	11,05,292	6,73,806	9,74,309	16,48, 115	1.6	120.3	49.1
Total/Avg	94,05,895	55,91,560	1,50,36,931	1,02,57,490	84,28,901	1,86,86,391	7.8	51.6	26.4

Source: District Census Handbooks, Directorate Of Census Operations, 2011

7.5 Table 6 shows the district-wise basin population figures which are heavily dominated by Saharanpur and Ghaziabad Districts. The figures confirm the status of these two districts as the dominant consumers of water [domestic] and thus the major generators of sewage. An attempt has been made in Table 6 to derive catchment population distributed in the catchment districts.

Table 6 : Population Of Hindon Basin* [2011]

District	Basin Area (Sq. Km.)	Distt.Pop. Density/sq.km.	Rural Pop.	Urban Pop.	*Basin Pop.	%age Pop. Of Basin
Haridwar	290	810	1,45,221	-	1,45,221	1.45%
Saharanpur	1802	940	11,72,147	10,66,526	22,38,673	22.40%
Muzaffarngr [incl. Shamli]	2009	1,034	14,79,782	11,91,312	26,71,094	26.73%
Meerut	321	1,346	2,11,303	-	2,11,,303	2.1%
Baghpat	828	986	6,44,362	-	6,44,362	6.45%
Ghaziabad	422	3,971	5,43,731	31,62,547	37,06,278	37.10%
G Budh Ngr	303	1,286	1,59,252	2,13,686	3,72,940	3.77
Total	**5,975**	**1,480 (Avg.)**	**43,55,798**	**56,34,073**	**99,89,871**	**100%**

* Basin Area x Distt. Population Density + Urban Populations of Saharanpur, Muzzafarnagar, Shamli, Baraut, Ghaziabad
Note : This provides an approximate but workable estimate of the population in the Hindon Basin

8.0 Climate

8.1 Yamuna basin is a heterogeneous basin and climate can be divided into three broad categories :

(a) humid at the upstream Himalayan catchment

(b) semi-arid in northwest to western catchments

(c) sub-humid in south-west catchments and catchments located on the left bank of the river

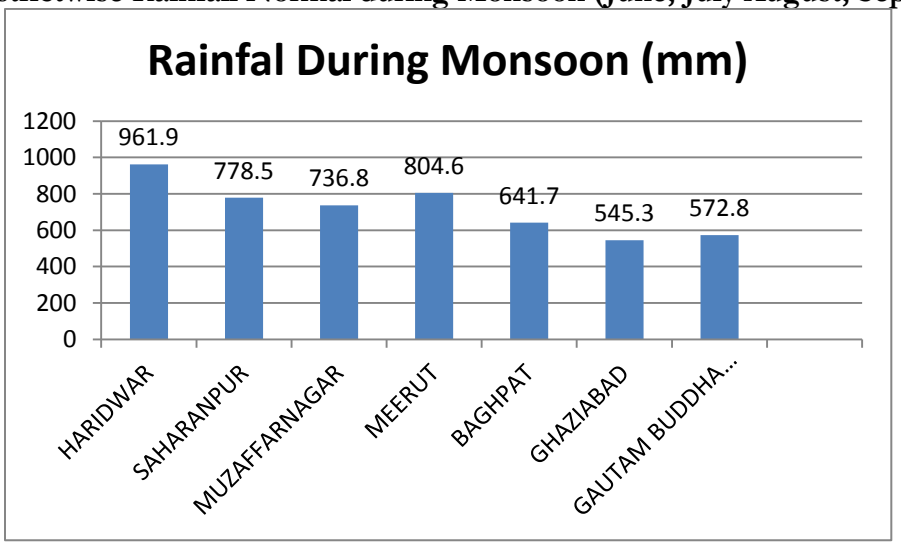
Hindon River located on the north-east part of the basin falls in semi-arid [Baghpat, Ghaziabad, Gautam Budh Nagar] and sub-humid [Meerut, Muzaffarnagar, Saharanpur, Hardwar] categories. **Over time climate change trends are emerging from the data substantiating the impressionistic experience of changes and the impact of changes on the water budget of the basin has to be considered for realistic future planning.**

Rainfall

8.2 Rainfall is the major input to the hydrological cycle in the Hindon River basin. The entire basin comes under the influence of the south-west monsoon and a major part of the rainfall is received between June and September. The rainfall in winter season is scanty.

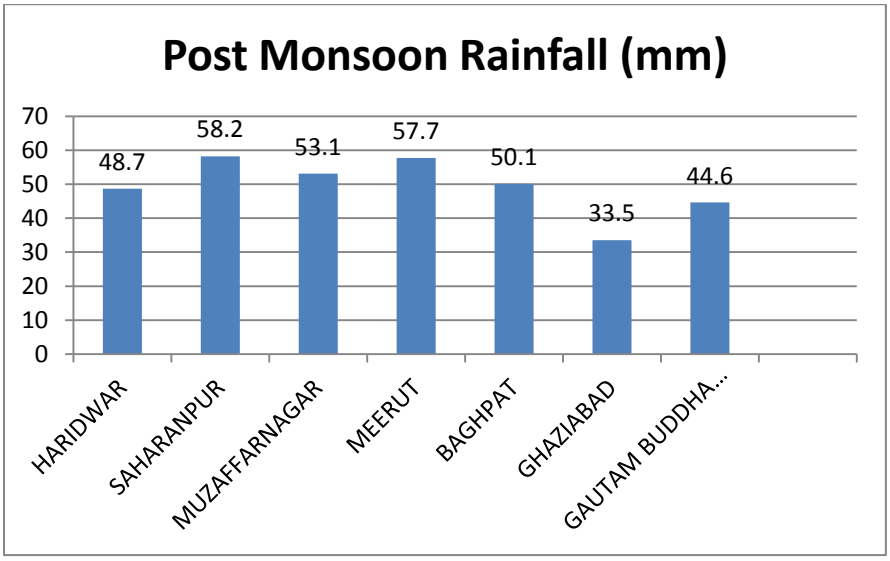
8.3 The average annual rainfall in Hindon sub-basin during 1951- 2000 was 887.7 mm. Monsoon rainfall [July – October] averaged 734.0 mm, post-monsoon rainfall 47.2 mm. and winter rainfall averaged 53.8 mm. However, against 887.7 mm annual average precipitation in 1951 – 2000, the 1991 – 2001 period annual average was 780.9 mm [Table 13] and during 2012 – 2016 was 648 mm only [Table 14] showing a significant declining trend in precipitation. Table 12 also shows the descending level of precipitation from north to south in this longitudinal basin.

Table 7 : Districtwise Rainfall Normal during Monsoon (June, July August, Sept) 1951-2000*



[Source: OGD Portal, India]

Table 8 : District-wise Rainfall Normal Post Monsoon (Oct, Nov, Dec) 1951-2000*



[Source: OGD Portal, India]

**The graphs above refers to details on climatological normals of districtwise rainfall (in mm) calculated with the data for the period 1951-2000. Main Data Contributed by: India Meteorological Department, Ministry of Earth Sciences. Source: Open Government Data (OGD) Platform, India . Accessed on 28th July 2016.*

Table 9: Monthly Precipitation Data In mm [Annual Mean: 1991 - 2001]

District	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Haridwar	18.1	22.4	15.2	12.6	24.6	100.9	201.7	241.7	107.7	10.8	8.2	3.1
Saharanpur	8.02	21.8	15.1	12.7	22.2	90.0	189.3	219.1	91.7	9.0	8.6	3.1
Muzaffarngr	18.01	18.7	12.4	10.9	21.2	82.5	178.5	229.0	94.4	9.4	9.2	4.1
Meerut	17.9	18.3	11.0	10.1	20.6	81.9	177.1	241.6	104.3	10.6	10.1	4.6
Baghpat	17.4	17.0	10.0	9.0	20.0	71.6	167.1	221.0	86.5	8.00	9.5	4.6
Ghaziabad	17.2	17.9	9.2	8.9	19.4	76.1	171.5	240.3	104.5	10.2	11.1	5.0
Gautam Buddh Ngr	14.6	14.8	7.2	8.5	17.5	73.7	173.5	244.1	109.1	11.2	9.8	5.0

Source: India Water Portal

Table 10: Average Annual Monsoon and Post Monsoon Rainfall [2012 - 2016] in Catchment Districts [mm]

District	Monsoon				Post Monsoon		
	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Haridwar	154.04	335.34	334.56	94.84	11.62	1.2	7.62
Saharanpur	86.72	236.94	249.12	83.98	23.2	1.86	11.1
Muzaffarnagar	89.38	182.54	185.1	63.64	16.16	3.24	8.56
Meerut	64	154.8	146.3	67.28	12.68	0.94	3.78
Baghpat	68.56	111.06	137.54	56.26	11.74	0.92	5.02
Ghaziabad	67.66	87.52	92.7	40.5	2.08	0.38	3.4
Gautam Budh Nagar	22.6	80.2	137	57.2	7.8	0	2.4

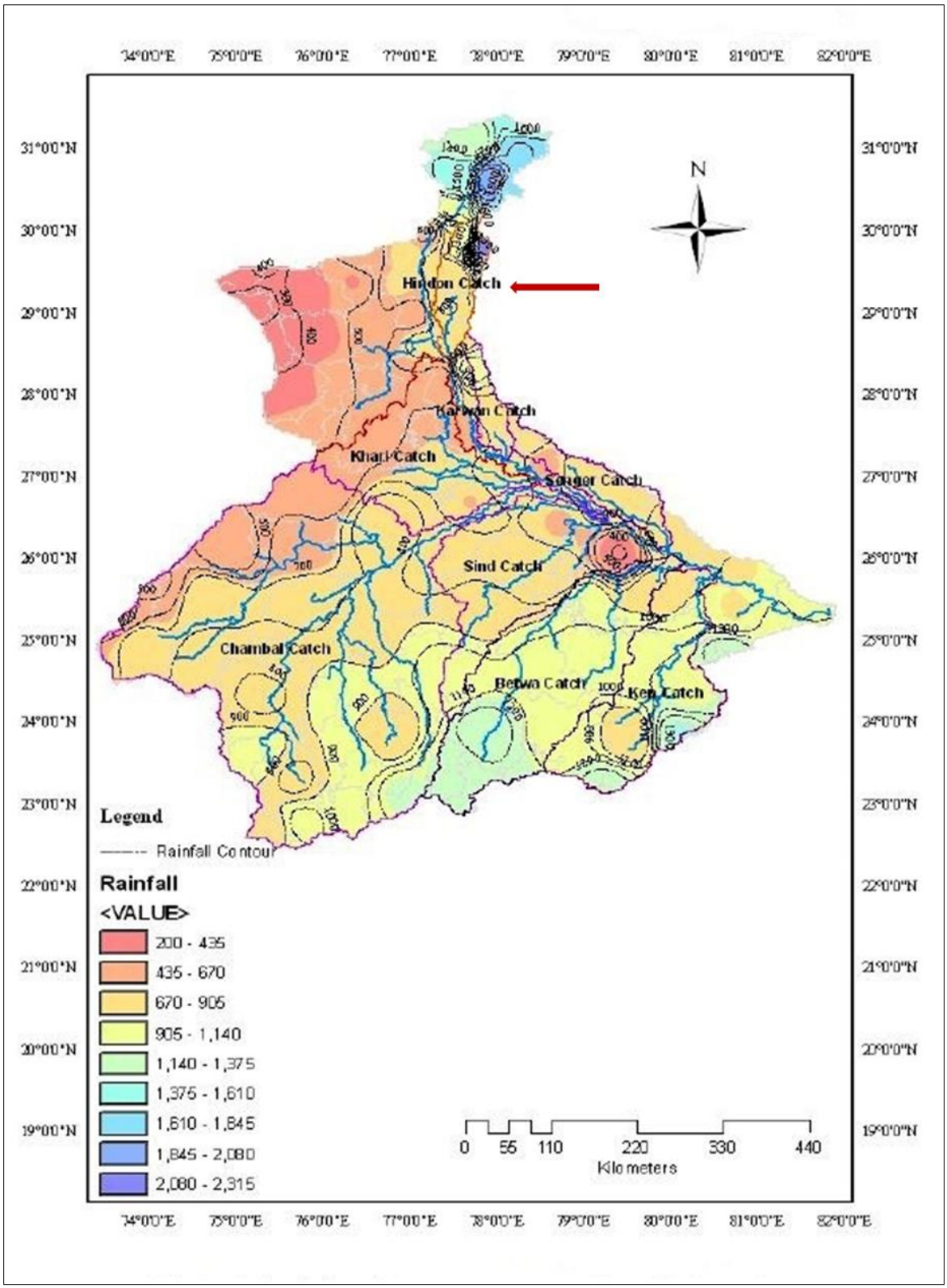
Average	78.9	169.7	183.1	66.2	12.1	1.2	5.9	

Source: CRIS, IMD

Table 11 : Mean Rainfall Distribution in Yamuna Basin

Mean Values	Period of Analysis	Betwa	Ken	Sind	Chambal	Hindon	Khari	Tons	Giri	Himalayan Upper	Yamuna Basin
Annual Rainfall	1951-2003	1064.9	1125.0	848.3	783.7	**887.7**	644.2	831.1	1045.1	1175.5	906.7
75% Probability of Exceedance	1951-2003	892.0	928.9	705.0	667.1	**752.1**	548.5	583.1	853.0	994.0	796.3
Annual Rainfall(mm)	1994-2003	1074.1	1116.3	828.7	749.3	**780.9**	589.3	1081.4	1010.0	1257.5	894.8
Monsoon Rainfall(mm)	1951-2003	972.1	1025.6	769.5	717.4	**734.0**	572.1	323.3	579.1	707.3	756.4
Monsoon Rainfall(mm)	1994-2003	981.9	1021.0	756.0	673.7	**639.2**	517.1	667.1	626.4	853.0	754.9
Winter Rainfall(mm)	1951-2003	26.0	29.9	19.4	10.9	**53.8**	19.5	188.4	175.5	165.8	47.6
Winter Rainfall(mm)	1994-2003	23.5	26.6	16.9	13.8	**62.5**	23.3	135.5	145.7	138.9	46.4
Post Monsoon Rainfall (mm)	1951-2003	50.8	51.2	44.3	41.5	**47.2**	29.6	88.9	88.3	89.4	50.4
Post Monsoon Rainfall (mm)	1994-2003	48.6	50.5	39.6	47.6	**33.8**	25.0	50.5	51.4	50.7	41.1

[Source: Report - IWRM and Water Quality Modelling of the Yamuna River Basin, YAP Phase-2, Oct, 2010]



Map 11 : Spatial Variation of Mean Annual Rainfall in Yamuna Basin

[Source: Report - IWRM and Water Quality Modelling of the Yamuna River Basin, YAP Phase-2, Oct, 2010]

"An analysis of droughts that hit the country between 1901 and 2010 by the Earth System Science Organization of the Ministry of Earth Sciences showed that the frequency of multi-year droughts [of 24 months] increased in recent decades. Twelve multi-year droughts were recorded during 1951 – 2010. There were only three such droughts between 1901 – 1950. The analysis also showed an ncrease in drought frequency between 1977 – 2010. This increase was more pronounced over central and peninsular India. The recent spell of droughts was reported from these areas. There was also an increase in areas hit by moderate droughts." -

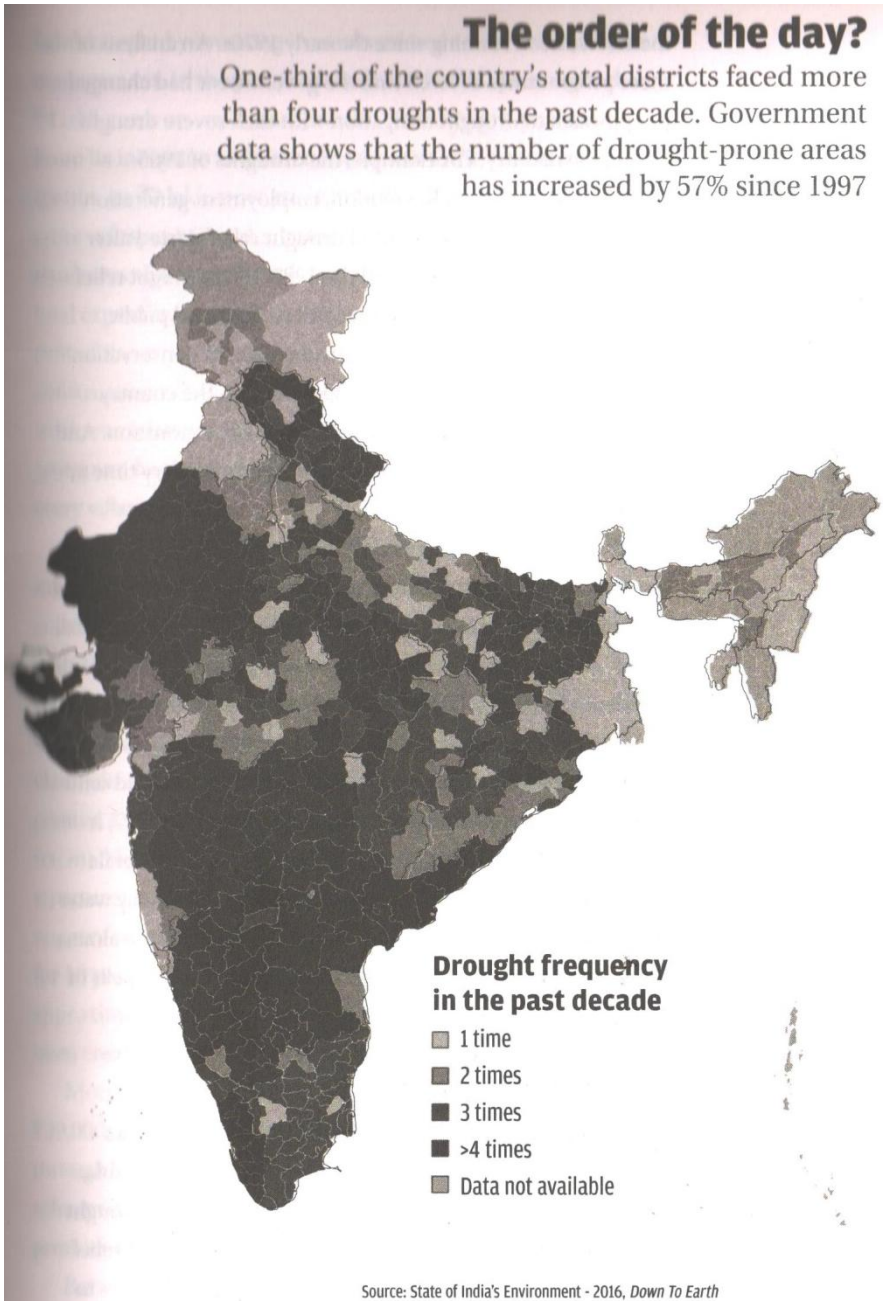


Table 12: No. of Rainy Days In Ghaziabad Distt [1901 – 1950]

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1.54	1.39	1.19	1.00	1.32	3.47	8.83	8.46	4.07	0.90	0.39	0.80

Source : India Water Portal

Table 13: No. of Rainy Days In Ghaziabad Distt [1980 – 2002]

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1.57	1.57	1.17	1.23	1.92	3.55	7.28	7.45	3.42	0.62	0.38	0.75

Source : India Water Portal

8.4 Comparison between Tables 12 & 13 shows the declining trend in the number of rainy days in Ghaziabad Distt. particularly in the monsoon months [July – October] which deliver 80% of the annual precipitation. If the data in Table 9 were to be averaged for a shorter period, say, 1990 – 2003 the declining trend would be more marked. Lack of ready availability of data for the period 2003 – 2016 precludes the statement that the declining trend has further accentuated but it would not be off the mark to expect it to be so.

Temperature

8.5 Temperature plays a fundamental role in governing the hydrological cycle. It directly affects the magnitude of snow melt runoff, evapotranspiration rate, water use and water quality in the river. Hindon basin experiences a wide range of thermal spatio-temporal variability. Mean maximum and mean minimum temperature in the basin ranged from 40.31°C and 6.5°C respectively. Annual Mean Min amd Max temperature values between year 1971-2001 for Saharanpur Distt. in the upper catchment and Ghaziabad Distt. in the lower catchment are given in Tables 17-20.

8.6. Data in Table 17 makes it evident that mean minimum temperatures are on the rise in the upper [north] Hindon basin. Similarly, data in Table 18 demonstrates the increasing trend in mean maximum temperatures in the upper Hindon basin.

Table 14 : Annual Mean Min. Temp. Of Saharanpur District [1971 - 2001]

Temp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1971-81	6.79	8.91	13.76	19.98	23.92	26.18	25.61	25.17	23.31	18.4	12.01	7.43
1981-91	6.82	9.13	13.99	19.49	23.7	26.67	26.03	25.35	23.72	18.07	11.88	7.93
1991-2001	6.4	9.59	14.06	19.96	24.59	26.3	26.02	25.27	23.8	18.38	12.49	8.15

Source: India Water Portal

Table 15 : Annual Mean Max. Temp. Of Saharanpur District [1971 - 2001]

Temp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1971-81	20.68	23.18	28.79	36.35	39.47	38.41	34.11	33.46	33.41	32.91	28.06	22.83
1981-91	20.8	23.41	28.69	35	38.37	38.52	34.57	33.29	33.77	32.25	27.84	22.57

1991-2001	20.5	23.85	29.02	35.51	39.6	38.34	34.55	33.3	33.71	32.58	28.42	23.17

Source: India Water Portal

8.7. Data in Table 16 makes it evident that mean minimum temperatures are on the rise in the lower [south] Hindon basin. Similarly, data in Table 17 demonstrates the increasing trend in mean maximum temperatures in the lower Hindon basin.

Table 16 : Annual Mean Min. Temperature Of Ghaziabad District [1971 - 2001]

Temp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1971-81	7.27	9.64	14.95	21.46	25.61	27.49	26.13	25.53	24.06	19.32	12.9	8.09
1981-91	7.48	9.88	15.15	20.96	25.26	27.87	26.74	25.76	24.44	19.11	12.91	8.66
1991-2001	6.98	10.08	15.07	21.2	25.85	27.31	26.66	25.6	24.22	18.99	12.87	8.31

Source: India Water Portal

Table 17 : Annual Mean Max. Temperature Of Ghaziabad District [1971 - 2001]

Temp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1971-81	21.28	24.03	30.02	37.25	40.27	39.06	34.43	33.25	33.87	33.62	28.69	23.27
1981-91	21.63	24.26	29.98	36	39.06	39.13	35.05	33.15	34.18	33.14	28.65	23.23
1991-2001	21.21	24.45	30.1	36.3	40	38.8	35.02	33.09	33.87	33.04	28.58	23.22

Source: India Water Portal

8.8 A clear rising trend in temperature in most months can be discerned from the tables above. In recent years the trend has only accentuated. This has implications for the faster loss in soil moisture post monsoons and for the increased evapotranspiration losses as also the greater requirement of irrigation water, all impinging on the water budget of the Hindon basin.

Humidity

8.9 Relative humidity in the basin is generally high during monsoon period (July to September) and low in summer season (March to June). August has the maximum humidity.

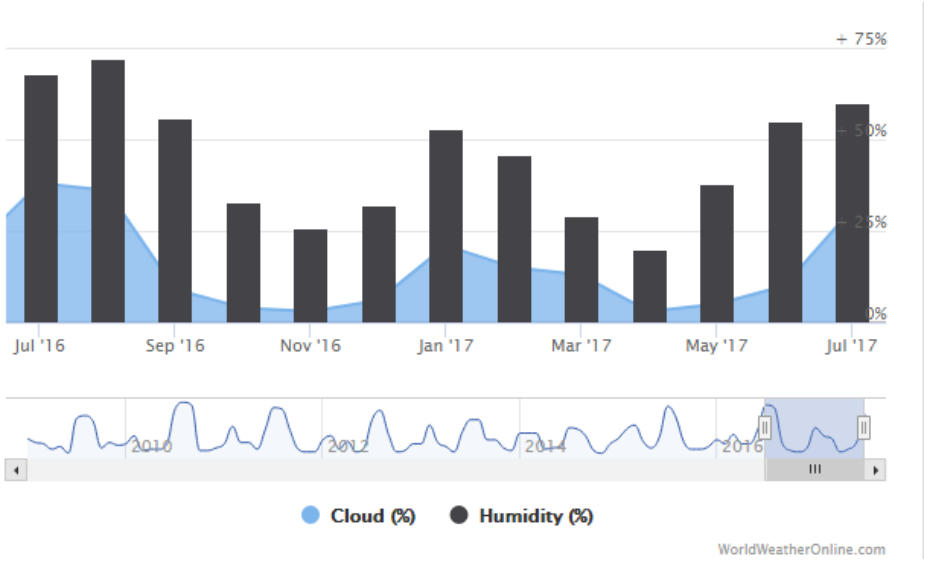


Image 5 : Mean Humidity Data For Saharanpur [Upper Hindon Basin]

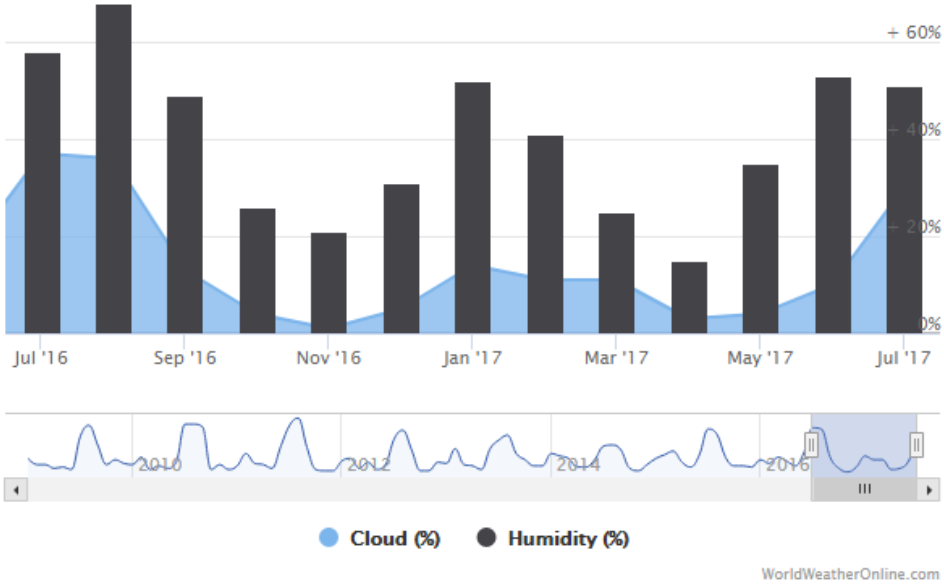


Image 6 : Mean Humidity Data For Ghaziabad [Lower Hindon Basin]

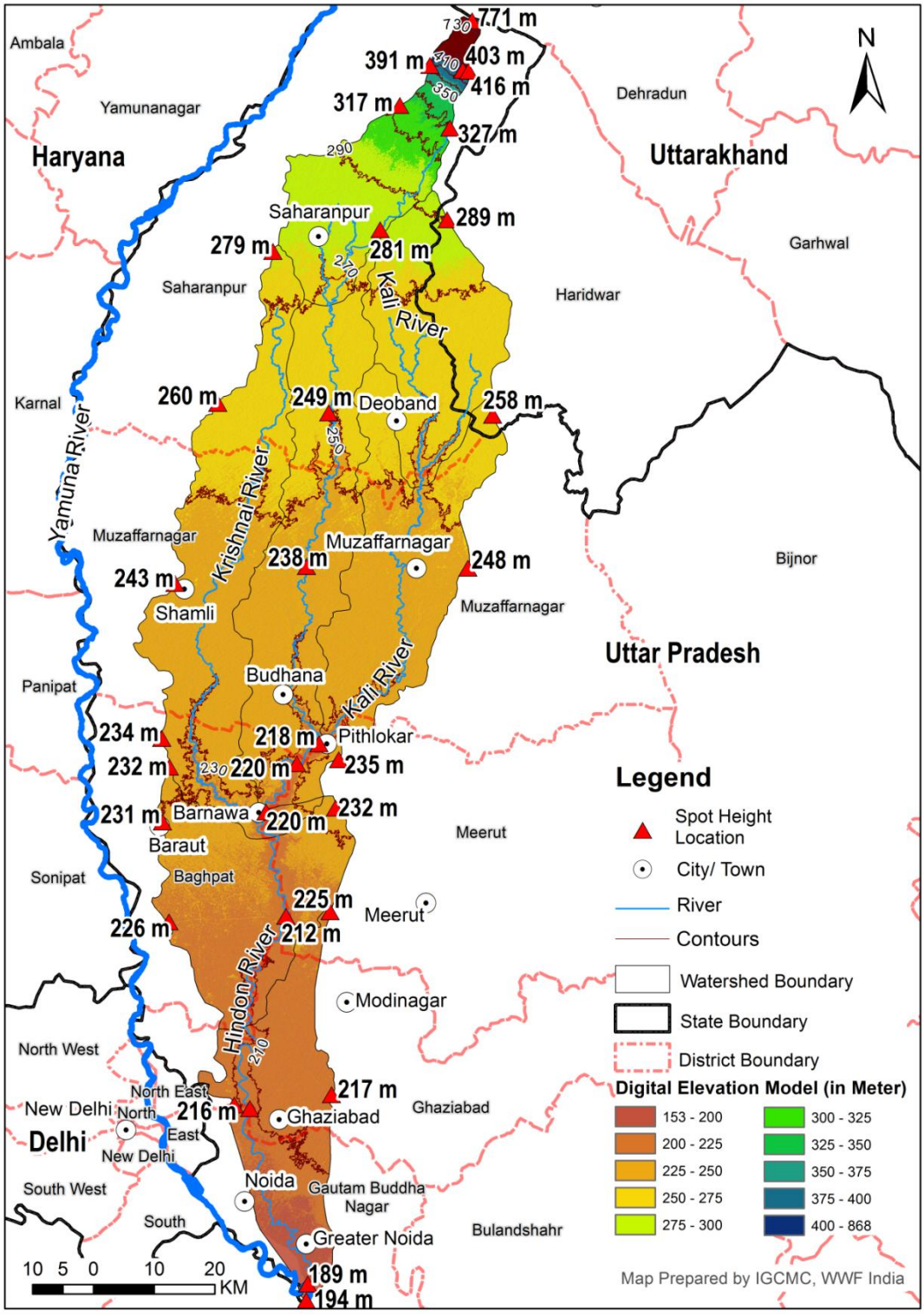
9.0 Topography of The Basin

9.1 The topography of Hindon basin varies from steep in the Himalayan segment to almost flat in the middle and lower segments. The elevation varies from 404 mamsl [metres above mean sea level) in the Shivaliks hills of Saharanpur to around 172 mamsl near confluence with Yamuna river at Tilwada in Gautam Buddh Nagar. The elevation near Saharanpur city is 267 mamsl which declines to 243 mamsl downstream at Maheshpur in the same district. Near Muzaffarnagar the elevation comes down to 226 mamsl. The elevation difference of around 8 -

10 m has been noted at major cities downstream - Pithlokar (208 mamsl), Barnawa (200 mamsl), Pura Mahadev (190 mamsl), Ghaziabad (182 mamsl) , Gautam Budh Nagar (172 mamsl).

9.2 The total elevation negotiated by the river is 232 m. The steepest gradient is in Saharanpur Distt. starting from Kaluwala Rao in the Shivaliks from 404 mamsl to 243 mamsl near Deoband or a fall of about 161 m in 85 km. or 1 : 530. Thereafter, upto the confluence with the Yamuna the river flows over a gentle gradient covering a distance of 265 km. whilst negotiating a fall of 71 m or 1 : 3700.

9.3 Lateral Section : From Map No. 12 it can be seen that the east west cross-section of the basin is fairly gentle. At its widest the basin [EW axis] nowhere exceeds 75 km. and the fall in elevation from the watershed line to the main river channel does not exceed 12m anywhere in the plains area or 1 in 6000.



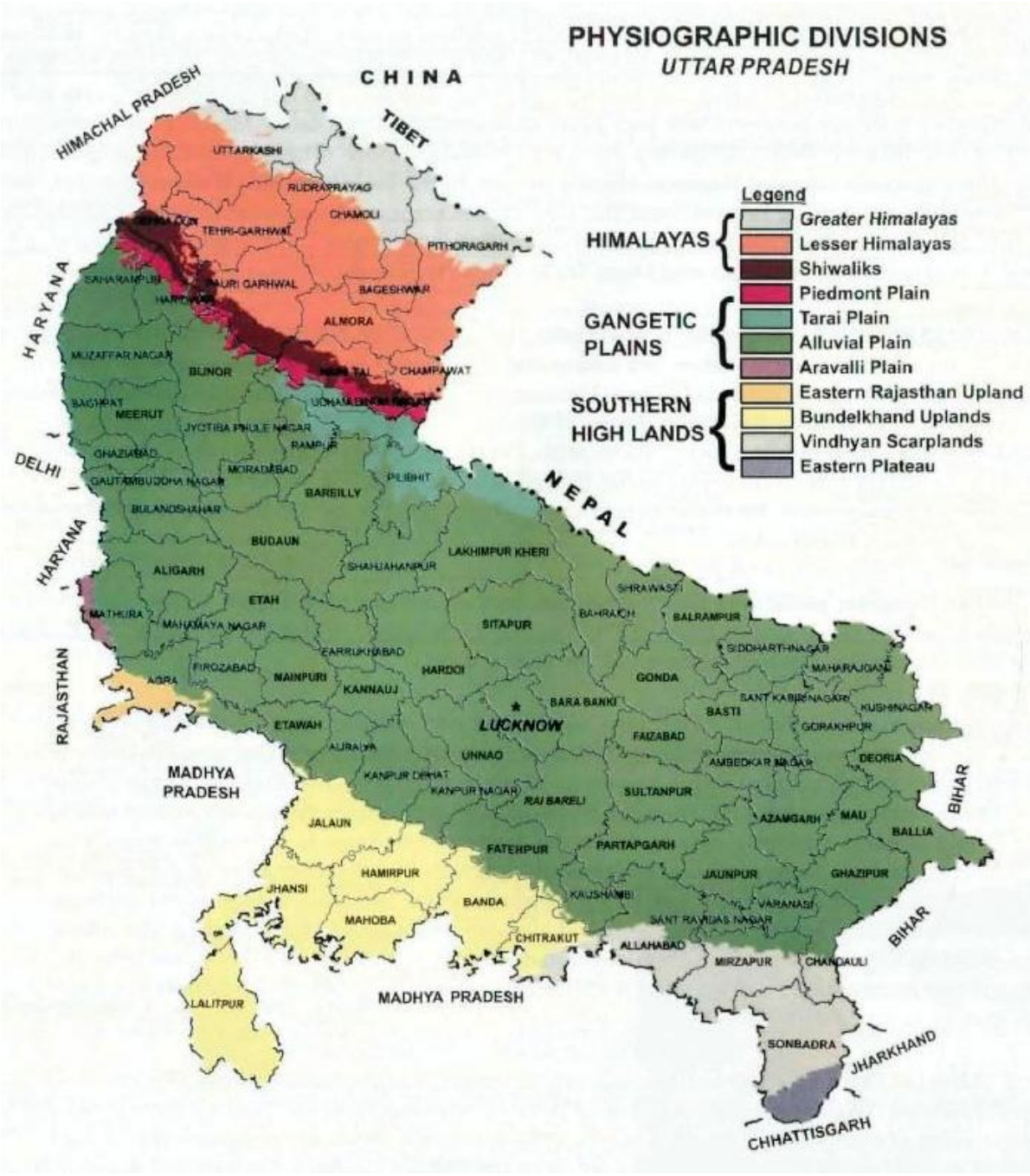
Map 12 : Topography and DEM Map of Hindon River Basin

10.0 Soils

10.1 The major soil type in Yamuna basin basin is alluvial. However, towards the extreme north of the basin mountain soil composed of weathered hard rock and Terai alluvium is to be found. For the rest of the basin the soil is riverine alluvial soil common to Gangetic Plains.

Map 13 : Geological Map of Uttar Pradesh

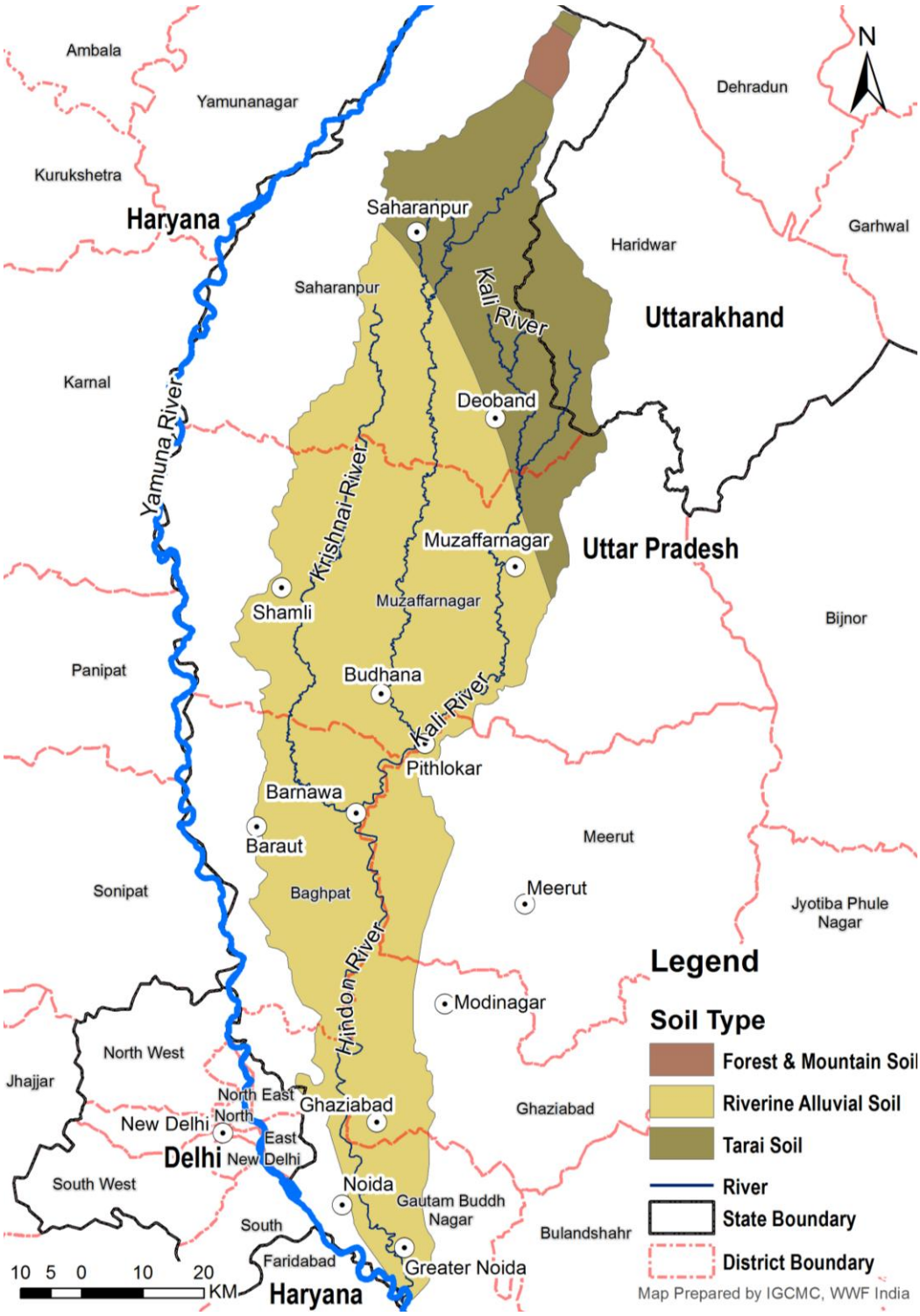
[Source: Directorate of Geology and Mining, Uttar Pradesh]



Map 14 : Map Showing Physiographic Division of Uttar Pradesh

[Source: Soils of Uttar Pradesh for Optimising Land Use by NBSSLUP, ICAR & Dept. of Agriculture, Govt. of Uttar Pradesh, 2003]

10.2 Out of two major geomorphic units i.e. Gangetic plains and Bundhelkhand plateau, the Hindon River falls in the former one which covers nearly 85% of the area and is underlain by a thick pile of unconsolidated alluvial sediments of Quarternary age overlying the Precambrian basement. These sediments are composed of sands of different grades with clay, silt and occasional gravel and kankar.



Map 15 : Map: Soil Type Map of Hindon Basin

11.0 Groundwater Conditions in The Hindon Basin

11.1 In Uttar Pradesh, about 78% percent of irrigation requirements are being met from ground water resources. It's indiscriminate exploitation is leading to lower ground water tables. Last year, on Dec 5, 2016, Times of India[10] reported that out of 75 districts in Uttar Pradesh, 34 are "over exploited for ground water."

11.2 Hindon River catchment area lies partly in Haridwar Distt. of Uttrarakhand but is mainly spread across 6 districts of Western Uttar Pradesh i.e. Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad, and Gautam Budh Nagar. The alluvium of the Gangetic plain forms a very rich reservoir of ground water.

11.4 According to available Central Groundwater Board (CGWB) district reports, 5 out of 6 blocks in Baghpat (2013-16[11]) were " over exploited" while the sixth was categorized as "semi critical"' the overall stage of groundwater development being at 116.61%.

11.5 In Saharanpur, as per CGWB report[12] (2011), total annual replenishable ground water resource was recorded was 146365 ha.m. (hectare metre) while stage of ground water development was at 133%.

11.6 In district Muzaffarnagar, (2008-09[13]), the trend was declining with 2 blocks " over exploited" while 5 blocks being in "semi critical" category with ground water development being at 82.0% which declined to 66% in 2011[14].

11.7 In Meerut district, total annual replenishable ground water resource recorded was 126513 ha.m. (hectare metre) and stage of ground water development was at 70%.

11.8 In district Ghaziabad, the district groundwater brochure (2008-09[15]) mentions of the declining trend due to over exploitation and deterioration in groundwater quality due to pollution and salinity in Loni block. The groundwater development had reached 105% in 2011(CGWB).

11.9 In district Gautam Buddha Nagar (2008-09[16]) the stage of ground water development was at 51.40 % with all the 4 blocks being in "safe" category [Ground water in deeper zones gets brackish to saline as it records more than 1000 μ/cm at 25 °C (in Sector-8 & 9). In 2011, the stage of groundwater development reached 93%.

---

[10] Out of 75 UP districts, 34 'over-exploited' for groundwater, Aditya Dev, Dec 5, 2015, Times of India
[11] District Groundwater Brochure of Baghpat (2013-16), CGWB
[12] Dynamic Groundwater Resources of India (As of March, 2011), CGWB
[13] District Groundwater Brochure of Muzaffarnagar (2008-09), CGWB
[14] Dynamic Groundwater Resources of India (As of March, 2011), CGWB
[15] District Groundwater Brochure of Ghaziabad (2008-09), (CGWB)
[16] District Groundwater Brochure of Gautam Buddha Nagar (2008-09), CGWB

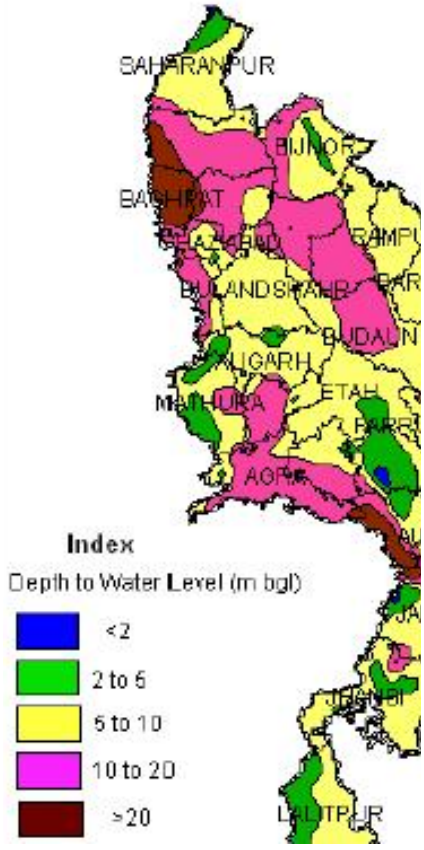
11.10 The rising levels of groundwater exploitation can only reduce discharge from the aquifers to the river system. This is especially critical for the lean season flow.

Table 18 : Depth To Water Level in Basin Districts [2013]

District	Depth to Water Level (mbgl)	
	Pre Monsoon	Post Monsoon
Haridwar (2009)	0.78 – 50.20	0.64 – 48.56
Saharanpur [2013]	2 - 10	–
Muzaffarnagar (2007)	3.20 – 9.95	2.50 – 7.95
Muzaffarnagar (2013)	5 - 20	
Meerut [2013]	>20	–
Baghpat (2012)	4.71 – 32.03	4.72 - 32.08
Ghaziabad (2006)	22.78	21.95
Gautam Budh Ngr (2007)	3.35 – 14.40	2.00 – 13.35
Gautam Budh Ngr (2013)	>20	

Source : District Ground Water Brochures & Groundwater Scenario Pre-Monsoon, 2013, (CGWB)

11.11 The rising levels of groundwater exploitation can only reduce discharge from the aquifers to the river system. This is especially critical for the lean season flow.



Map 16: Depth To Water Table Pre-Monsoon, 2013 [Source : CGWB]

Table 19 : Districtwise Grounwater Resources Availability, Utilization and Stage of Development (ha.m.)

District	Annual Replenishable Ground Water Resource					Natural Discharge During Non Monsoon Period	Net Groundwater Availability	Annual Ground Water Draft			Projected demand for Domestic and Industrial uses upto 2025	Net Ground Water Availability for Future Irrigation use	Stage of Ground Water Development (%)
	Monsoon Season		Non Monsoon Season		Total			Irrigation	Domestic & Industrial Water Supply	Total			
	Recharge From Rainfall	Recharge From Other Sources	Recharge From Rainfall	Recharge From Other Sources									
Haridwar	22058	15348	5932	30839	74177	3074	71103	38104	1411	39515	2294	30705	56
Saharanpur	71478	24900	12021	37966	146365	13284	133081	171402	5523	176925	8804	0	133
Muzaffarnagar	51273	17292	9560	30232	108357	10218	98139	60527	4718	65246	7644	36019	66
Shamli	20672	8905	4384	13102	47063	4706	42357	56694	2636	59331	3841	447	140
Meerut	47580	27422	5742	45769	126513	11353	115160	77433	3381	80814	4636	33560	70
Baghpat	29823	6355	0	12872	49050	3681	45369	42401	2199	44600	3598	934	98
Ghaziabad	13444	5484	1730	10938	31596	1580	30016	24457	7109	31567	12456	2452	105
Gautam Budh Nagar	19100	8500	2796	20515	50911	5091	45820	39872	2772	42644	3134	3944	93
Total (ha.m.)	**275428**	**114206**	**42165**	**202233**	**634032**	**52987**	**581045**	**510890**	**29749**	**540642**	**46407**	**108061**	**95.125 (Avg.)**

Source: Dynamic Ground Water Resources Of India (As on March, 2011), CGWB, Faridabad [Report Date: July 2014]

12.0 Hindon River Flow & Discharge

12.1 Reliable river discharge data is hard to come by especially for medium and minor rivers.

12.2 WAPCOS Report[17] (1994) mentions that Hindon River is ephemeral in its initial stages but becomes perennial due to domestic and industrial discharges at Saharanpur. Waste water from Ghaziabad and Noida [Gautam Buddha Nagar] also flows into the river.

12.3 The flow in upstream areas of the river (including its tributaries, the Har Krishan and Kali) at the confluence point is almost 368 MLD. The inflow through the Khatauli escape is of the order of 2880 MLD of which 2250 MLD is diverted at the Hindon Barrage into Hindon Cut Canal for conveying Ganga waters into Yamuna and thereon into the Agra Canal. The remaining flow downstream of the Barrage is used for irrigation.

12.4 From Meerut Gazetteer[18] [1922] we learn that :

- Jani Escape from the Ganga Canal was used to convey substantial volume of Ganga water into the Hindon
- It also states that tail-fall of the Deoband Canal also emptied it superfluous water into the Hindon near Budhana in Muzaffarnagar.
- Presently, Upper Ganga Canal waters are transferred to Hindon through :
  - Khatauli Escape [Muzaffarnagar Distt.] conveys water from Upper Ganga Canal through Kali West River to Hindon
  - through Jani Escape (Meerut)
  - Kot Escape (Gautam Budh Nagar)
- Hindon Barrage in Ghaziabad diverts Ganga water through Hindon Cut Canal to the Yamuna
- The water is diverted for irrigation purposes in the lower catchment of the river

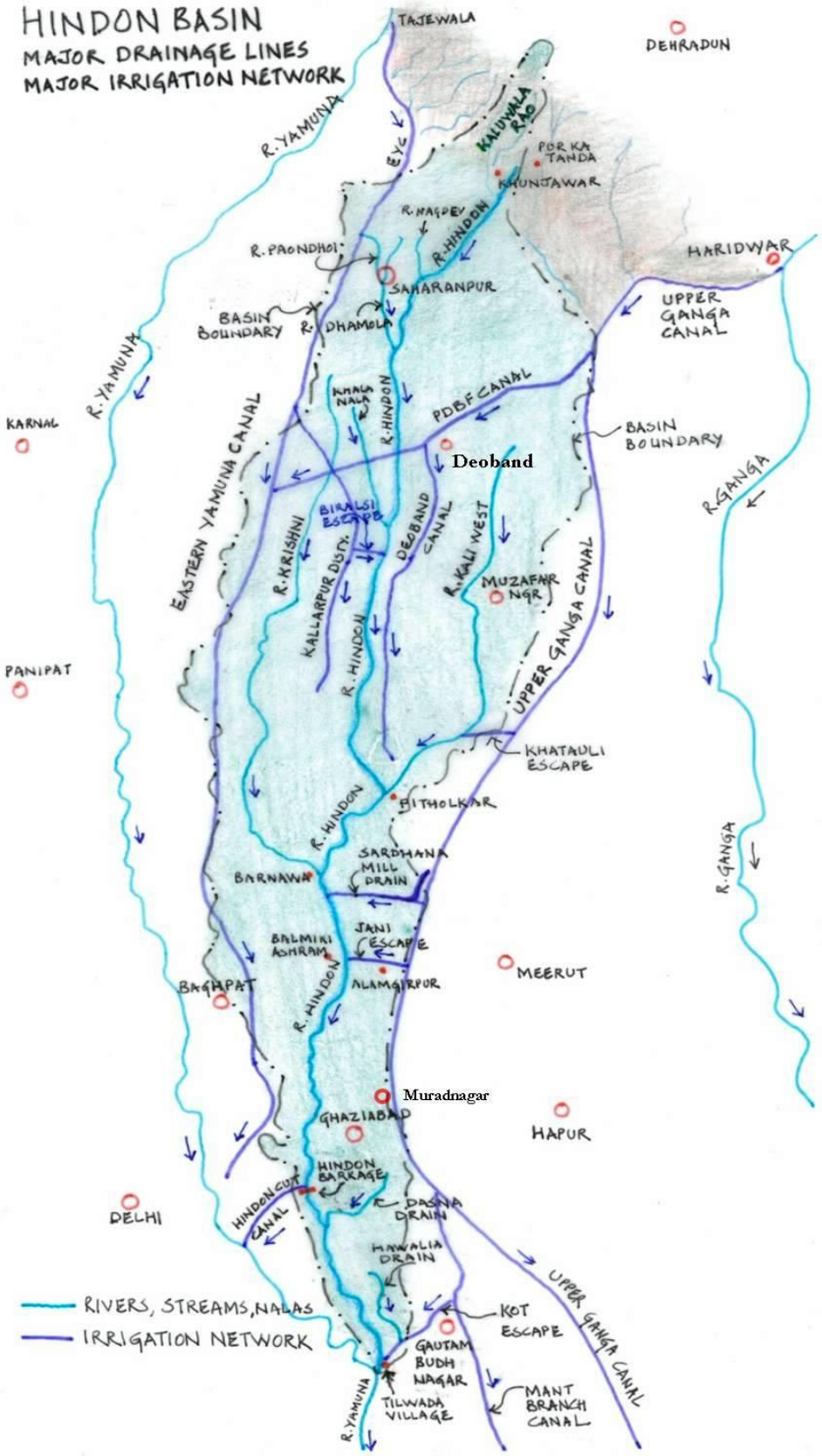
12.5 [19]Officials at Ganga Organisation, Irrigation and Water Resource Department, Meerut, say, that to revive Hindon, 1500-2000 cusec water is released from Ganga River through Jani and Khatauli Escapes while 300 cusec is released through Kot Escape in Gautam Budh Nagar just 3 km before Hindon meets Yamuna.

12.6 Thus, the flow in Hindon River is a mix of rainfall runoff, groundwater seepage, effluents/wastewater and majorly transferred water from the Ganga to the Yamuna using Hindon channel as a transfer conduit.

[17] Report-Study on Drainage System and Flood Control including Water Resources in National Capital Region, NCRPB, Govt. of India & WAPCOS, Oct 1994

[18] Meerut : A Gazetteer being Volume IV of the District Gazetteers of the United Provinces of Agra and Oudh by H.R. Nevill, 1922

[19] Water from Ganga used to Revive Hindon, experts say it's a Waste-Hindustan Times, 15th July, 2015



Map 17 : River System, Drainage & Major Irrigation Network

12.7 Data retrieved from U.P. Irrigation Dept. Agra Canal, Okhla, New Delhi shows that the average water released through Hindon Barrage at Ghaziabad during summer and monsoon

season (June-Oct, 2016) into Hindon Canal is 1071.33 cusec. The average water released into the river during the same period is 681.29 cusec. During the month of June no water was released into the river. The data for water released from Upper Ganga Canal into Jani escape could not be availed for any season.

Table 20 : Mean Stream Run-Off Of River Hindon (BCM)

River	Area of Catchment [Sq.Km.]	Total	Monsoon	Post Monsoon	Winter	Summer
Galata (Hindon)	7,083*	1.1	0.7	0.1	0.2	0.1

[Source: Report-Study on Drainage System and Flood Control including Water Resources in National Capital Region, NCRPB, Govt. of India & WAPCOS, Oct 1994]

- As per current satellite imagery assessment the catchment area is 5795 sq.km.

Table 21 : Flow With 90% Probability (MCM)

River	Monsoon (July-Aug)	Post Monsoon (Oct-Nov)	Winter (Dec-Feb)	Summer (Mar-May)
Galata (Hindon)	1.8	1.2	1.2	0.7

[Source: Report-Study on Drainage System and Flood Control including Water Resources in National Capital Region, NCRPB, Govt. of India & WAPCOS, Oct 1994]

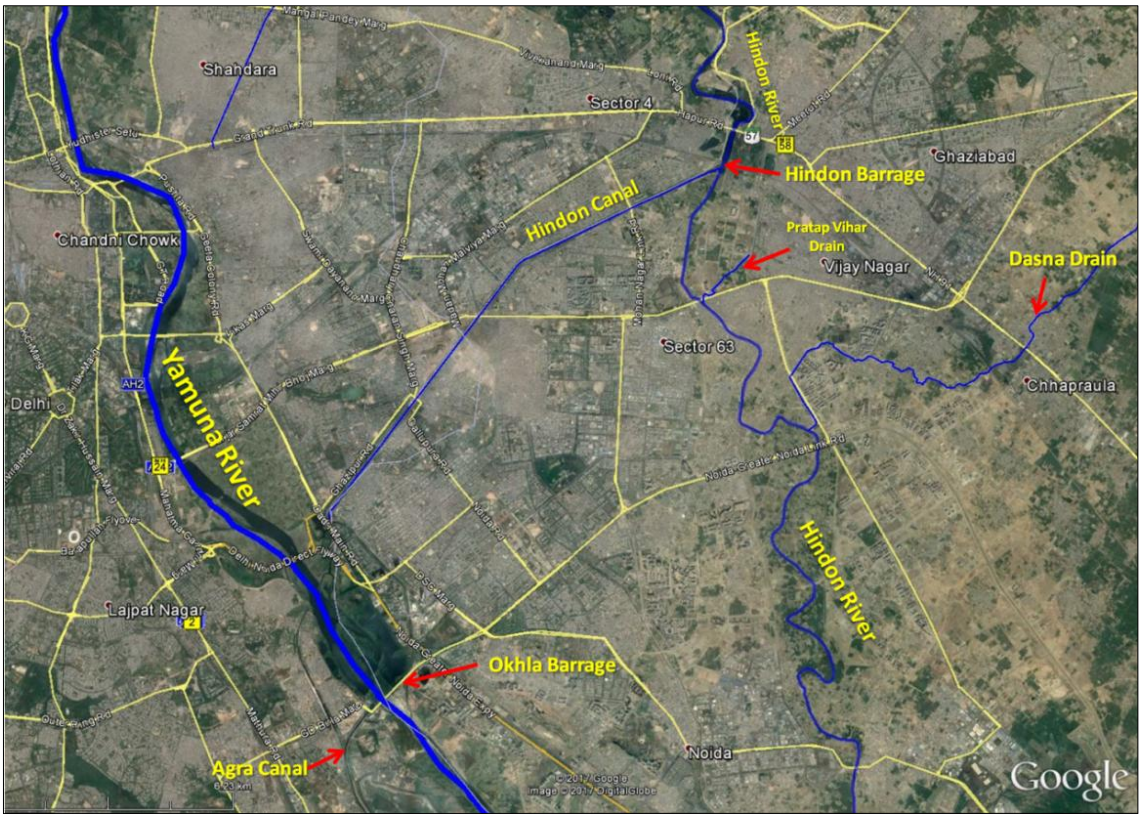
Table 22 : Water Discharge Data From Hindon Barrage [Ghaziabad] [Average Values In Cusecs Calculated From Daily Flow Data During June - Oct, 2016]

	Jun		July		August		Sept		Oct	
	Hindon River	Hindon Canal	Hindon River	Hindon Canal	Hindon River	Hindon Canal	Hindon River	Hindon Canal	Hindon River	Hindon Canal
Cusecs	0	1810.21	1009.46	1865.62	786	0	786	739.85	825	941
Cumecs	0	51	28.5	52	22	0	22	21	23	26.5

Source : U.P. Irrigation Department, Agra Canal, Okhla

Table 23 : Salient Features of Hindon Barrage

Name of the Structure	**Hindon Barrage**
Nearest City	Dadri
District	Gautam Buddha Nagar
State	Uttar Pradesh
Basin	Ganga
Year of Commencement	1977
Year of Completion	1979
Mean Annual Rainfall (mm)	No info
Total Annual Yield of Catchment (MCM)	No Info
Design Flood (cumec)	2833
Length of Barrage and Anicut (m)	162
No. of Bays (i.e. no. of openings)	6
Width of Bay (m)	6
Type of Spillway Gate	Other
Spillway Gates - Number	8
Pond Level (mamsl)	203.252
Under Sluice Bay - Number	2
Gates for under sluice - Number	8
Gates for under sluice - Size (m)	18*5.2
Means for dissipating energy (Hydraulic)	Baffle Block and Dentated Blocks
Status of BWA Construction	Completed
Source: India-WRIS wiki (Water Resource Information System of India)	



Map 18: Location of Hindon Barrage, Hindon Canal and Hindon River at Ghaziabad

Map 19: Old and New Barrage Structures

Image 7 : Hindon Barrage [1979] Diverts Ganga Water in Yamuna at Ghaziabad[19/08/2016]

Image 8: Old Regulator Now In Disuse

12.8 The WAPCOS data on seasonal river flow is of 1994 vintage. It is not certain whether scientific measures were employed to measure the river flow over the full year and if so for how many years. Moreover, all statistics point out to the declining trend in precipitation over the basin and therefore must result in a decline in surface runoff. Moreover, Table 19 also shows that the groundwater discharge is about 500 MCM – this too would be on the decline with the fall in the ground water level.

12.9 **Estimate Of The Total Yield Of Catchment From Surface Runoff** : A broad estimate of the total surface runoff which reaches the Hindon and its tributary streams has been attempted by using the following formula :

Annual Rainfall x Catchment Area x Runoff Coeff = Runoff Volume

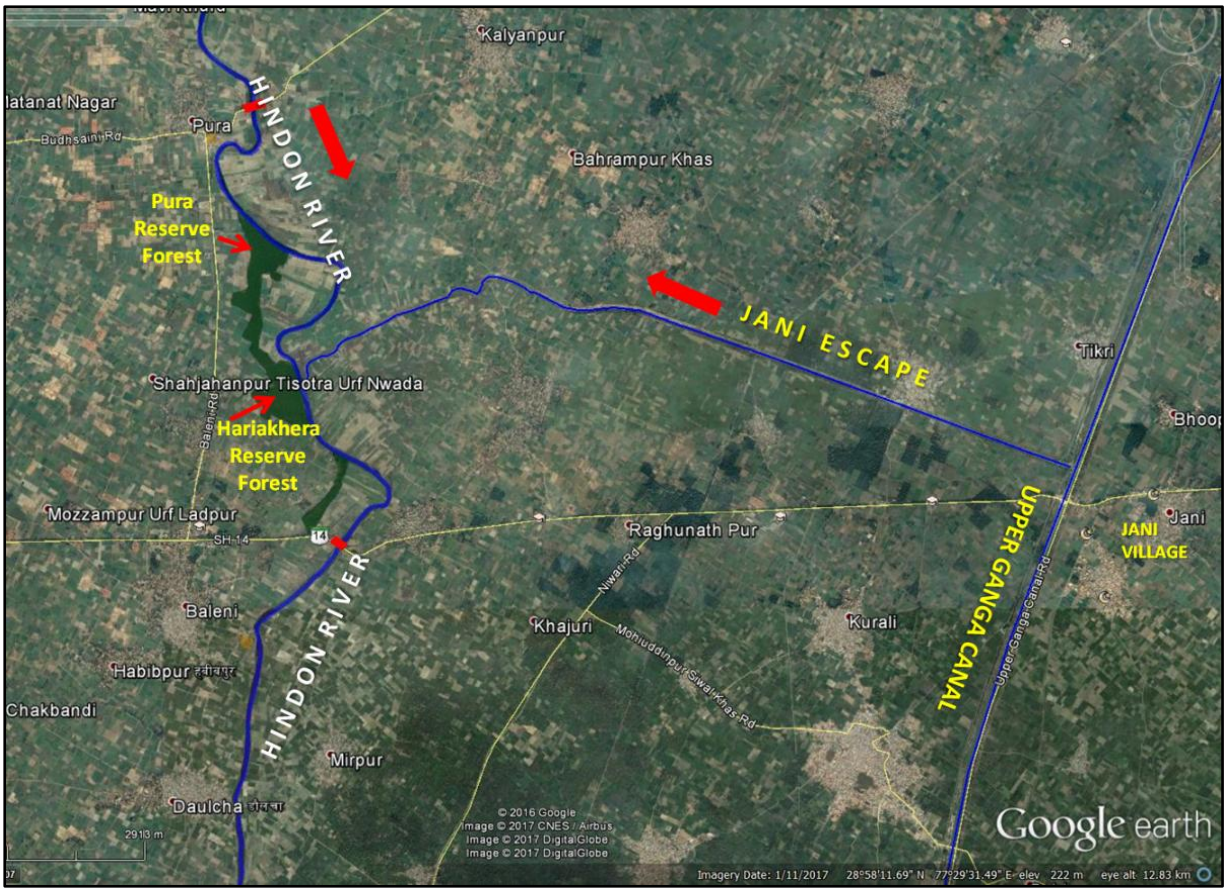
The runoff coefficient depends on the slope, soil character and landuse. On this basis the surface runoff generated by the basin rainfall is shown in Table 24 below :

Table 24 : Estimation of Surface Runoff In The Hindon Basin

Annual Rainfall [mm]	Catchment Area [Sq.Km.]	Runoff Coefficient*	Runoff Volume [MCM]
939.22	34	0.6	19
690.62	152	0.5	53
688.31	475	0.4	131
708.10	1630	0.36	416
641.70	2572	0.15	248
691.30	973	0.15	101
689.00	139	0.10	10
	5975	**Total**	**968 MCM**

*Areas within different gradients derived from Map No. 12
**Runoff Coefficient From 'Hydrology and Water Resources Engineering' by SK Garg, 1996

12.10 Thus, the natural water discharge in Hindon river by current computation amounts to 993 MCM + 500 MCM [GW seepage] = 1500 MCM [rounded off] over the entire year.



Map 20 : Map showing Upper Ganga Canal, Jani Escape and Hindon River

12.11 **Data from the Irrigation Dept. of UP regarding the transferred flows from Upper Ganga Canal, from East Yamuna Canal, PDBF Canal, overflows from irrigation channels in terms of frequency and associated discharge volumes into the main stem of Hindon River would be immensely helpful in assessing the virgin flow of the river at various locations at various times of the year. Presently, there is no way of knowing the virgin flow of the river which also makes it challenging to arrive at e-flows in different seasons and at different locations.**

13.0 Tributaries, Escapes & Major Drains [Sequence North to South]

13.1 The entire basin is riven and criss–crossed by several canals, distributaries, minors, escapes, drains. It is difficult to describe each one of them. The major ones have been described here in a north to south sequence whilst mentioning the bank on which they join Hindon. Survey of India maps and US Army maps [based on SoI] have been added in the Annexures where the entire system has been highlighted.

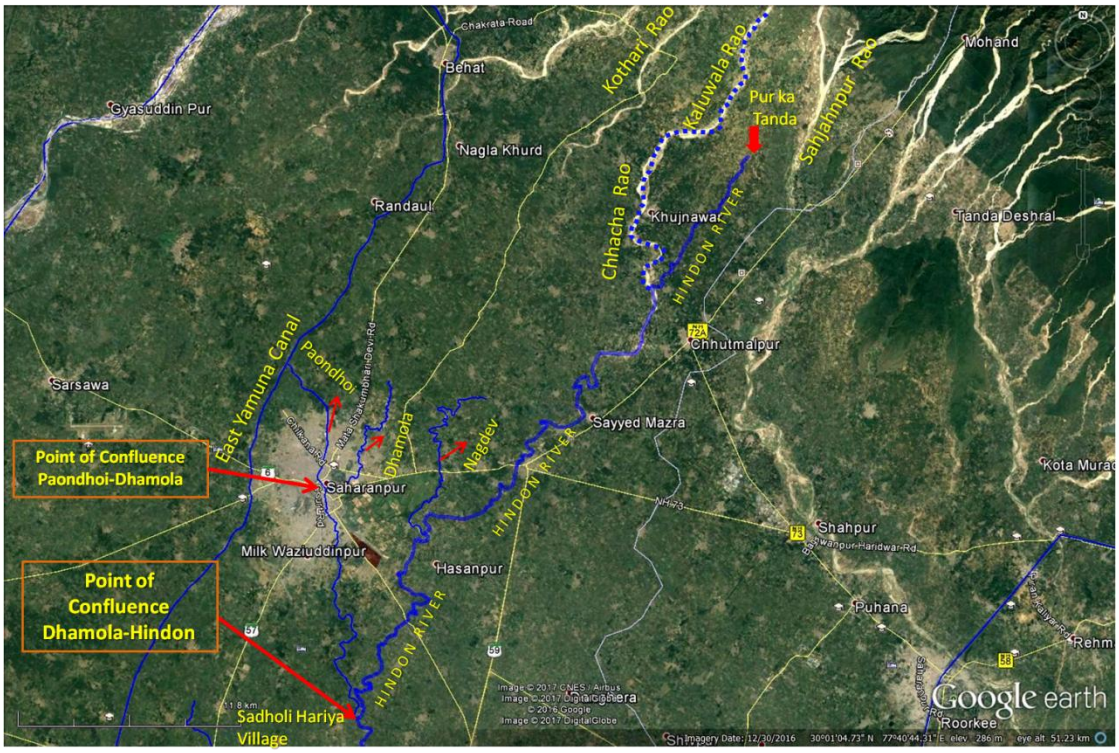
13.2 **Chaccha Rao [Kaluwala Rao] originating in Kaluwala Reserve Forest joined on its left bank by Khokra from Pur ka Tanda to become Hindon**. The latter is a seasonal rivulet getting activated in the monsoons. [Refer Map No. 21]

13.3 **Nagdev -** As per Saharanpur Gazetteer (1981), Nagdeo is the first important tributary of Hindon which originates in the Kotri Rau in the Shivaliks to the North of Pargana

Muzaffarabad and runs south-westwards in a narrow bed with an insignificant volume of water. After passing along the boundary between Saharanpur and Haraura it meets the Hindon (right bank) at Ghagreki, a few kilometers south-east of Saharanpur. [Refer Map No.21]

Image 9 : Nagdev on Dehradun Road [NH-73] [08/08/2016]

13.4 **Dhamola –** This rivulet rises in the outer edge of the submontane tract near Jasmaur in Pargana Muzaffarabad and runs in the south-westerly direction, traversing the town of Saharanpur where it picks up much of the domestic drainage and is joined by a minor rivulet known as Paondhoi. From Saharanpur, it flows southwards to join the Hindon (right bank) at Firozpur Nandi. [Refer Map No. -21]



Map 21 : Map Highlighting the Location of Paondhoi, Dhamola and Nagdev Tributaries

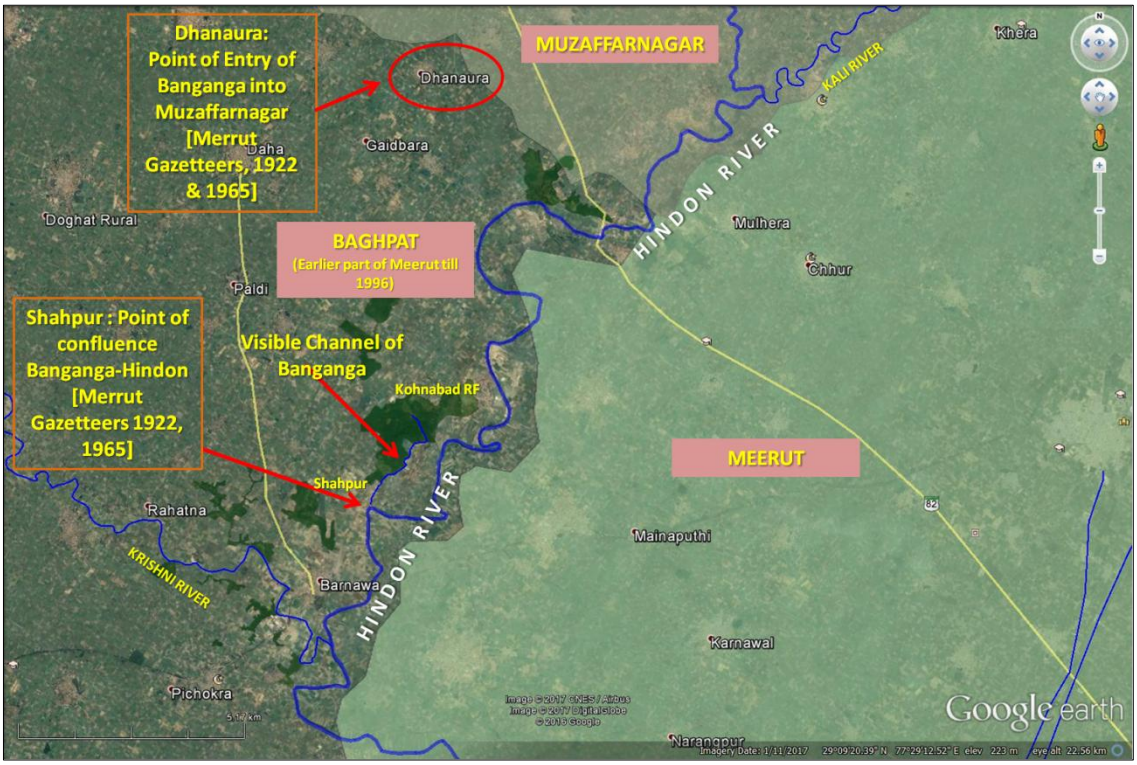
Image 10 : Dhamola Nala at Shaharanpur [08/08/2016]

13.5 **Paondhoi -** Paondhoi is originates near village Shankalapuri, 8 km north to the Saharanpur city in the form numerous small springs and meets Dhamola (right bank) in Saharanpur city. It's a 13 km long rivulet which was a clear water course earlier but got highly polluted and obstructed with time. As per folklore and historical evidence, the tributary was blessed by Hindu saint Sant Baba Lal Das and Muslim saint Sant Hazi Shah Kamal. The tributary has

been revived recently with the collective effort of local people and district administration. [Refer Map No. 21]

13.6 **Khala Nala or Chakwali Nala -** Khala Nala or Chakwali Nala is an irrigation canal which starts from Chakwali village in South of district Saharanpur and meets Hindon (right bank) near Dudhli village in Muzaffarnagar. It is 32 km long approximately. (Refer Map no.24)

13.7 **Banganga -** 'Banganga' has been described as an insignificant stream entering Meerut district from Muzaffarnagar at village Dhanaura, which after a course of about eight miles **joins the Hindon right bank** at Shahpur, two miles north of Barnawa. Like Krishni, its bank were also broken by numerous small ravines. It turns dry in summers. Its bed had an average width of some 15 m. The tributary is faintly visible on Google Earth imagery or relevant toposheet with some part of its channel left at Kohnabad Researve Forest near Barnawa. (Refer Map no. 22) No significant data for this river is available.



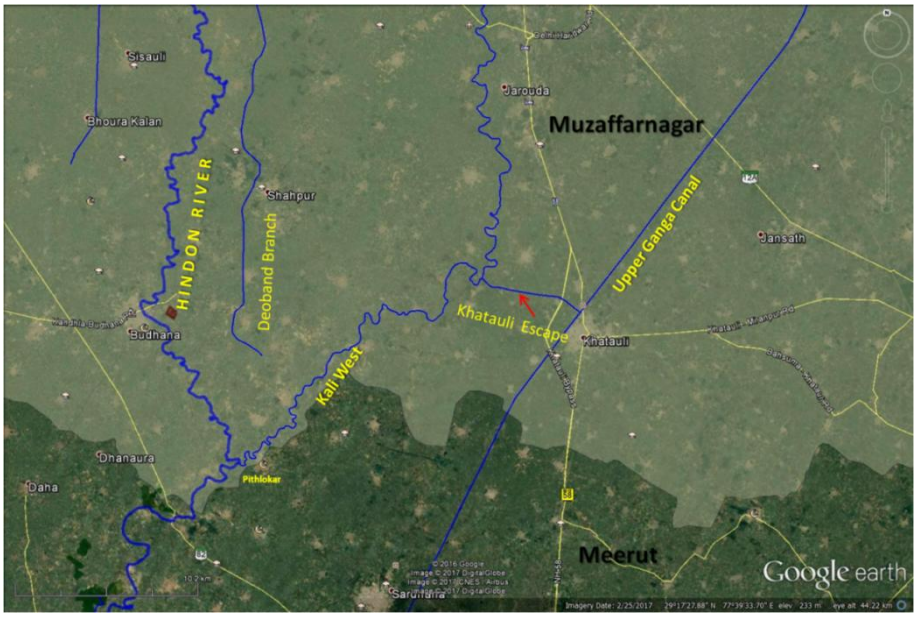
Map 22 : Location Of Banganga Tributary

13.8 **PDBF Canal –** This takes off from the Upper Ganga Canal at Roorkee and crosses the Hindon in a south westerly direction to link up with the East Yamuna Canal. An offshoot from the PDBF is the Deoband Branch which irrigates territory south of Deoband running parallel to Hindon on its left bank and emptying into Hindon at Village Budhana.

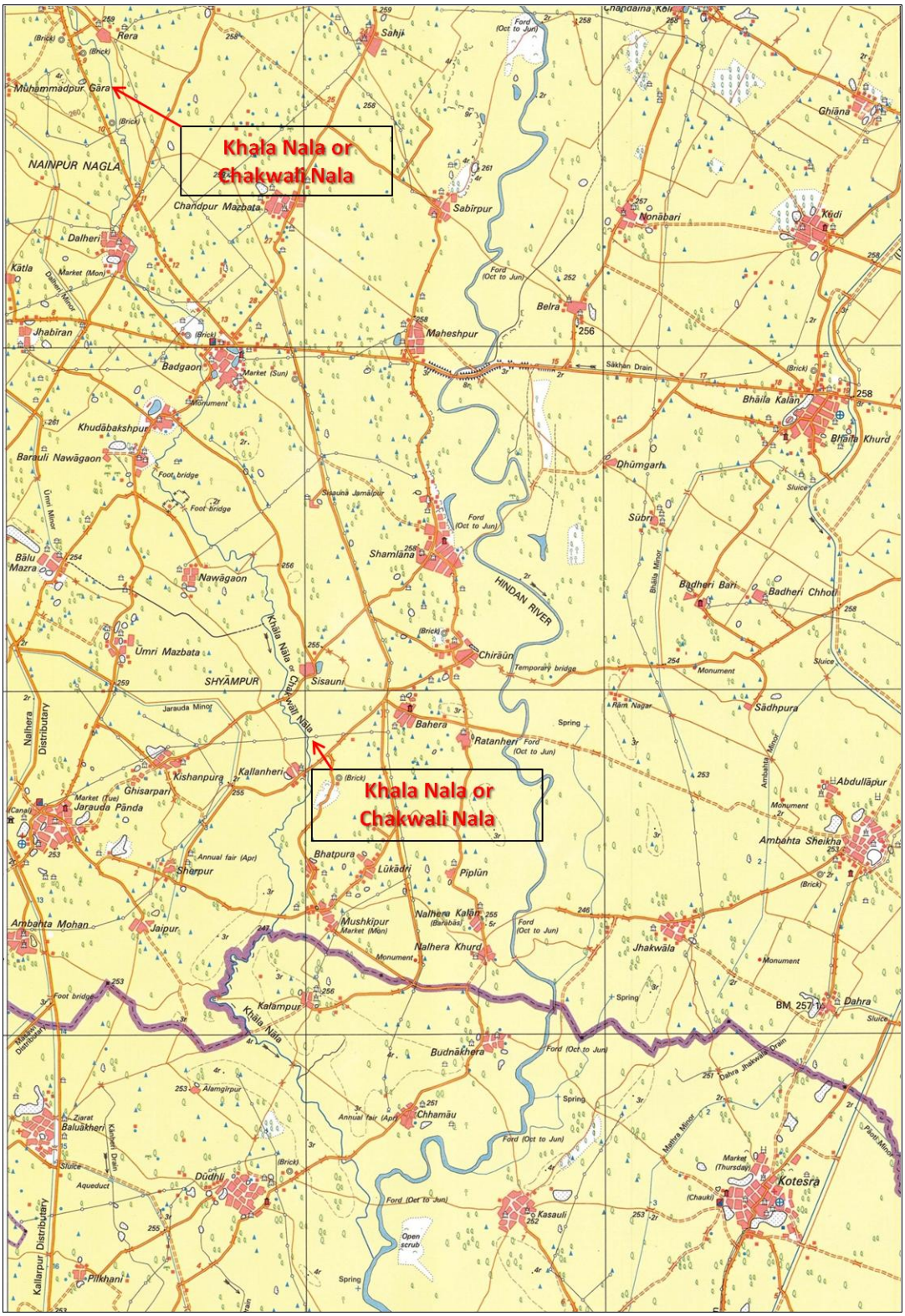
13.9 **Biralsi & Charthawal -** Biralsi Escape is located on the right bank of Hindon River near Biralsi village. It is around 7 km long approximately. It starts from Kallarpur distributary located west of Biralsi village and meets Hindon east of Pipalsan village. Charthawal Escape is 2.8 km long starting from Deoband branch of Upper Ganga Canal near village

Mahablipur and meets Hindon River around 2.5 upstream to Biralsi escape confluence with Hindon. (Refer Map no.25)

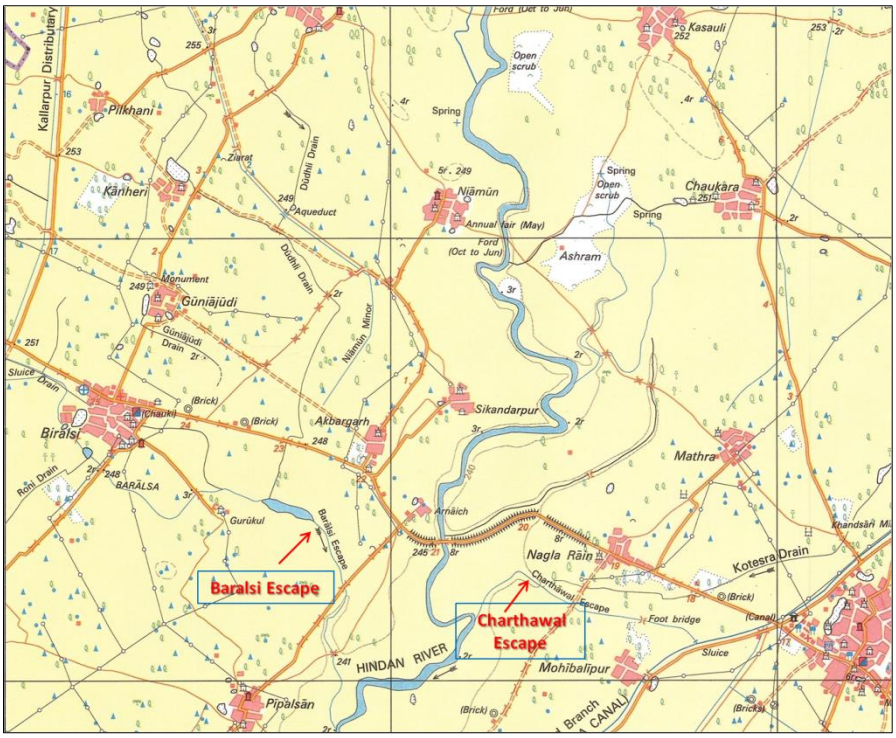
13.10 **Khatauli Escape :** The Escape carries water from Upper Ganga Canal to River Kali (West) which eventually **joins Hindon on the left bank** near Pithlokar. The length of Katauli Escape is approximately 6 km. [Refer Map No.23]



Map 23 : Location of Khatauli Escape



Map 24 : Location of Khala Nala in SOI Map [H43 R10]



Map 25 : Location of Biralsi Escape in Charthawali Escape in SOI Map [H43 R10]

13.11 **Kali Nadi (West) -** This river originates in two streams, both known by the same name, which rise in the northern part of Pargana Haraura and running southward, unite in Pargana Nagal close to the point where the Deoband canal is carried over the river. Of the two branches, the eastern is the larger and possesses a deeper channel, with fairly high banks crowned with narrow belt of light sandy soil. After their junction the river attains a considerable size and bed and increases in width and depth. In the north of Deoband it is reinforced by the **Khala, a small stream**, which rises near Jataul and drains the south-eastern part of Pargana Nagal. At Mahtauli, where the river passes into district Muzaffarnagar, it receives **another large watercourse known as Sila** on its left bank. Another **tributary of Kali known as Imlia** rises to the southeast of Deoband and carries the town's drainage by means of artificial channels. During rainy season its volume increases significantly causing damage to the neighbouring tract. The Imlia runs southwards, past Rankhandi, into district Muzaffarnagar, and joins the Kali on its right bank a few kilometres beyond the southern boundary of the district. The length of the river from origin to confluence with **Hindon on the left bank** is 145 km. [Refer Map No. 17]

Image 11 : Kali River [East] Near Pithlokar, Muzaffarnagar [07/08/2016]

13.12 **Krishni -** Meerut Gazetteers of 1922[20] and 1965[21] mention the presence of two small streams - Kirsani (or Krishni) and Banganga which drained the north central upland tract between the Jumna (Yamuna river) and Hindon River. Krishni originates from western region of Saharanpur district and **joins Hindon right bank** near Barnawa village of Baghpat district. The stream was considered unimportant with no towns on its banks and little used for irrigation purpose. At present, the Krishni has several small settlements on both banks all along the course as evident in the satellite imagery. It used to flow in a well marked bed with its banks broken by numerous small ravines. [refer map no.18] No significant data for this river is available. However, the length of the river from origin to confluence with Hindon is 153 km.

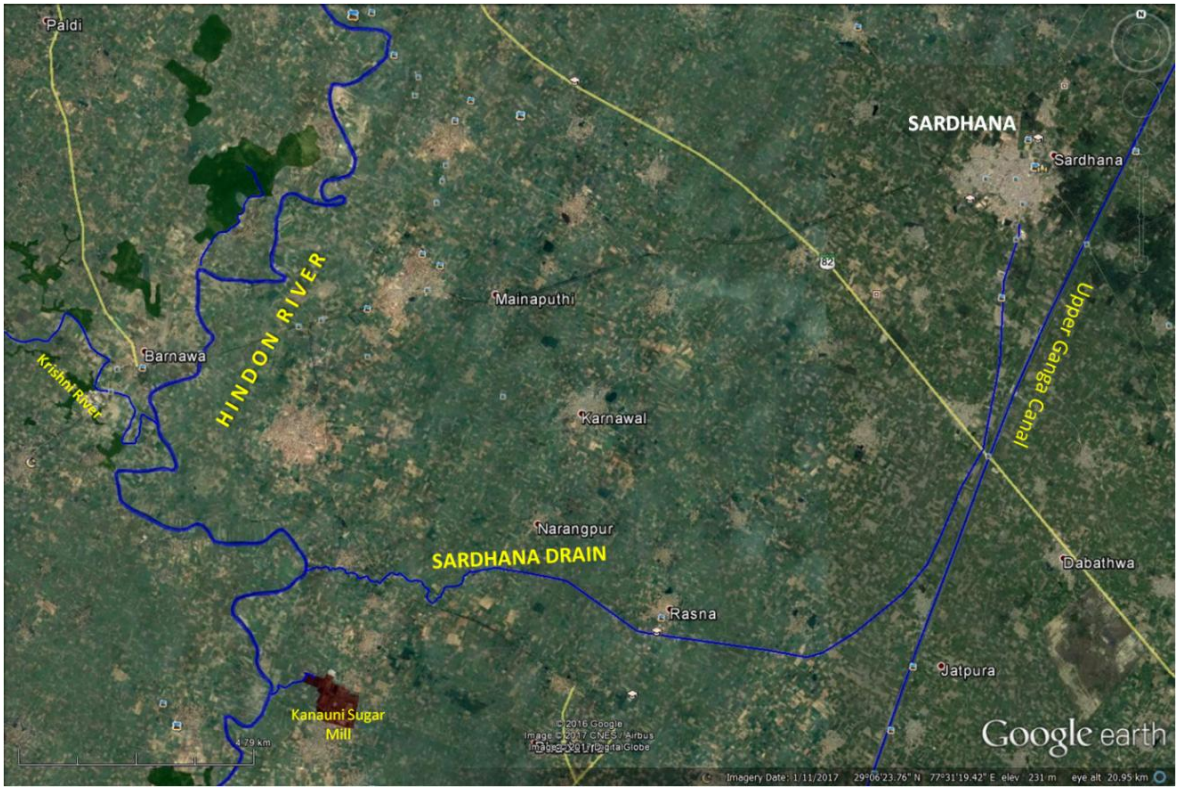
13.13 **Sardhana Drain -** Sardhana Drain is approximately 23 km in length and joins **Hindon on the left bank** at Kheri Nizd Kalina north of Kanauni Sugar Mill in Meerut. This drain carries storm waters of Sardhana and areas en route as well as is an outlet for sewage. [Refer Map No. 18 & 26]

13.14 **Kanauni Sugar Mill Drain -** It's a 1.5 km drain which carries effluent of Kanauni Sugar Mill located east of Hindon River [left bank] and north of Village Kanauni in Meerut district. This is a major source of pollution. [Refer Map No. 27]

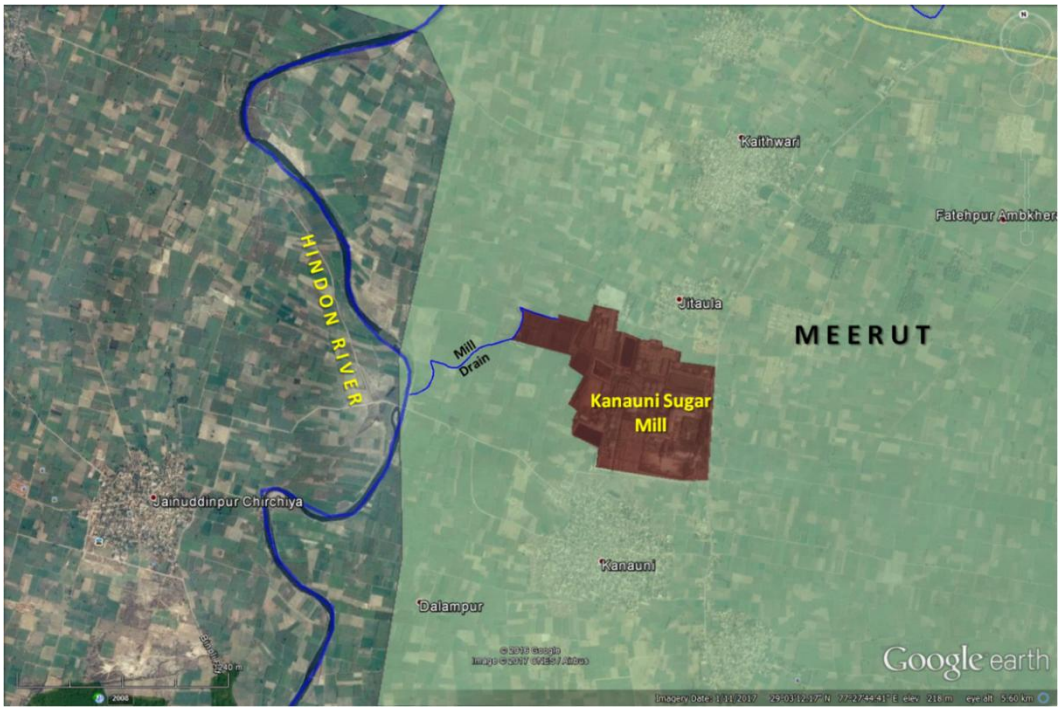
[20] Meerut: A Gazetteer, Volume IV of the District Gazetteer of the United Provinces of Agra and Oudh, 1922 by H.R. Nevill

[21] Uttar Pradesh District Gazetteer - Meerut, 1965 by Esha Basanti Joshi (Govt. of Uttar Pradesh)

Image 12 : Krishni River at Barnawa, Baghpat [26/05/2017]



Map 26 : Location of Sardhana Drain Which Joins Hindon at Kheri Nizd Kalina, Meerut



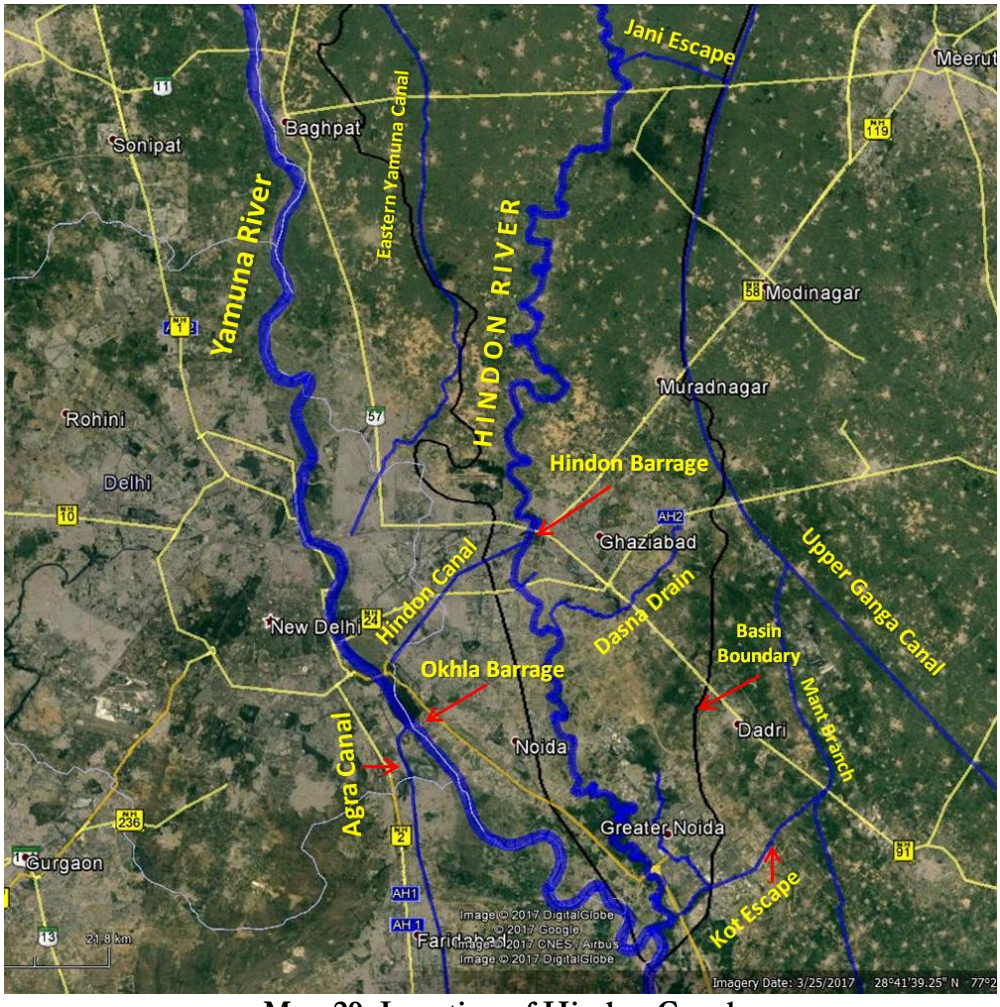
Map 27 : Location of Kanauni Sugar Mill Drain

3.15 **Jani Escape :** The Escape carries water from Upper Ganga Canal (near Jani village) to Hindon River. It **joins Hindon on the left bank** opposite Harikhera Reserve Forest, Baghpat. The length of Jani Escape is approximately 9.5 km and falls in Meerut district. Meerut Gazetteer[22] [1922] states that the portion between the Hindon and the Ganges Canal at Daulatpur was converted into an escape by Colonel Cautley but afterwwards it was abandoned and replaced by the newer Jani Escape.

13.16 **Hindon Canal :** It is around 13 km long canal which takes water from Hindon River to Yamuna in Delhi. It starts at Hindon barrage at Ghaziabad and meets Yamuna at its left bank near New Ashok Nagar. The water is further transferred to Agra Canal from Yamuna River.

[22] Meerut: A Gazetteer being Volume IV of the District Gazetteers of the United Provinces of Agra and Oudh by H.R. Nevill, 1922

Map 28 : Location of Jani Escape



Map 29: Location of Hindon Canal

13.17 **Pratap Vihar Drain -** The drain carries residential sewage of Pratap Vihar colony situated 2 km east of Hindon River [**left bank**] in Ghaziabad. The approximate length of drain is 2 km.

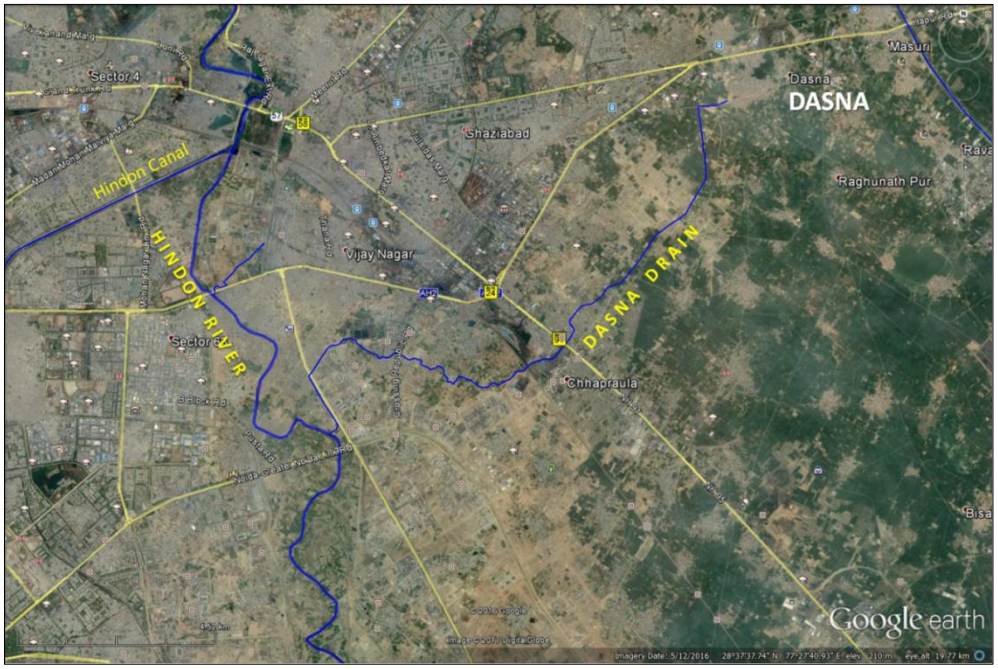
Map 30 : Location of Pratap Vihar Drain Which Joins Hindon Near NH-24, Ghaziabad

13.18 **Meerut Road Industrial Area Drain -** This drain carrries indutrial effluents of Meerut Road Industrial Area located on Meerut road in Ghaziabad. It joins Ghaziabad residential area drain at Meerut Road near sector-7. The length of drain is around 1.5 km.

13.19 **Ghaziabad Residential Drain -** The drain carries residential sewage of many colonies of Ghaziabad and industrial effluents of Meerut road industrial area and **joins Hindon left bank** near railway bridge.

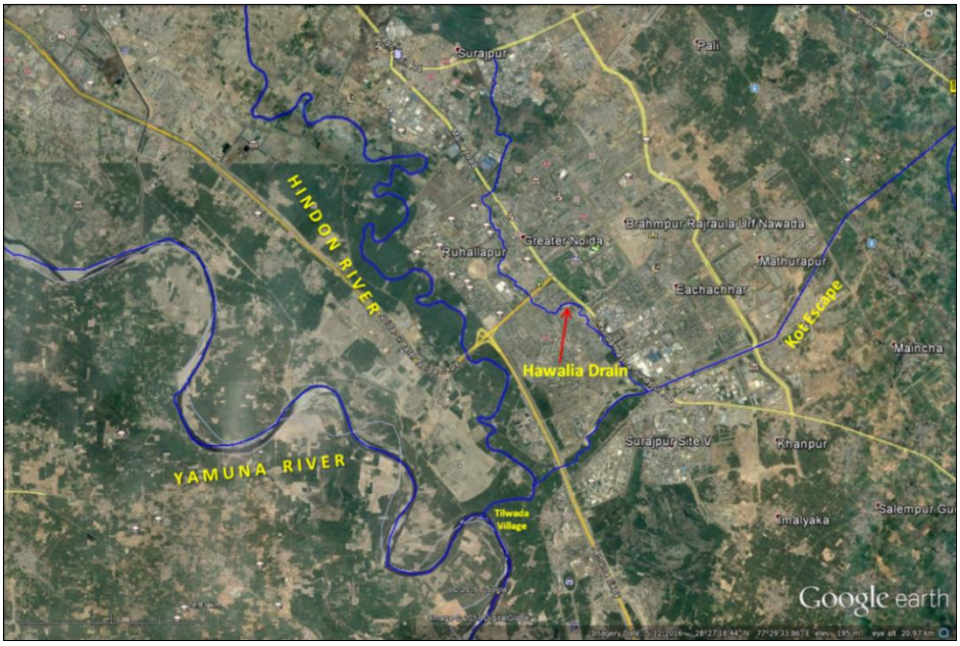
Map 31 : Location of Meerut Road Industrial Drain & Ghaziabad Residential Area Drain

13.20 **Dasna Drain -** Dasna drain is approximately 17 km long which carries residential and industrial effluents of Dasna town joining Hindon left bank near Gaur City, Sector-4, NOIDA.



Map 32 : Location of Dasna Drain

13.21 **Hawalia Drain -** Hawalia drain joins Kot escape near Kasna village which eventually joins Hindon River at Momnathal village, Gautam Buddha Nagar. The complete route of the drain could not be traced.



Map 33 : Location of Hawalia Drain in Gautam Buddha Nagar

13.22 **Kot Escape -** Kot Escape carries water from Upper Ganga Canal (near Kot village) to Hindon River. It **joins Hindon left bank** near Momnathal village 1.5 km before Hindon joins Yamuna River. The length of Kot Escape is approximately 15.5 km.

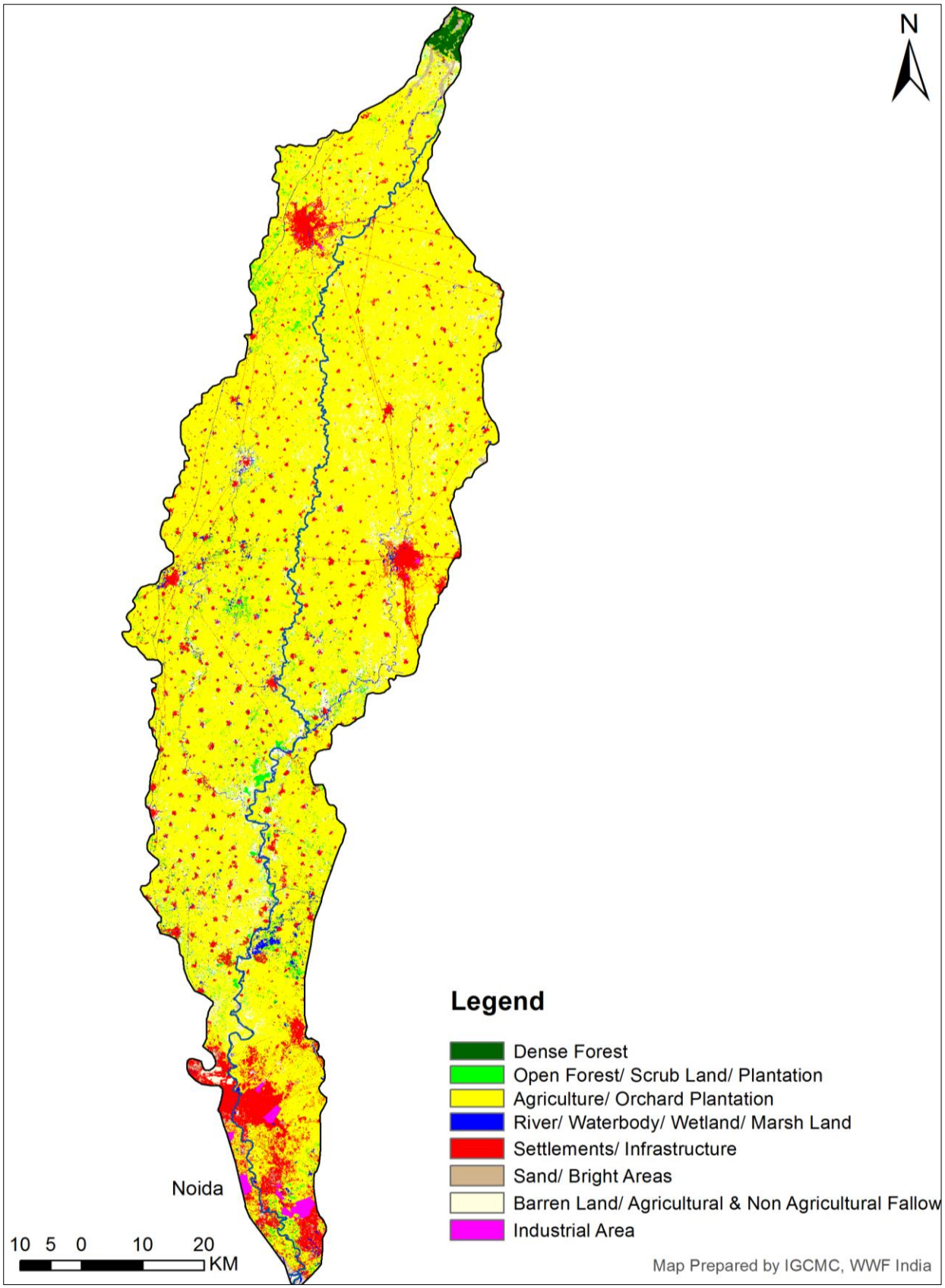
Map 34 : Location of Kot Escape in Gautam Buddha Nagar

14.0 Land Use, Land Cover Types & Change Detection

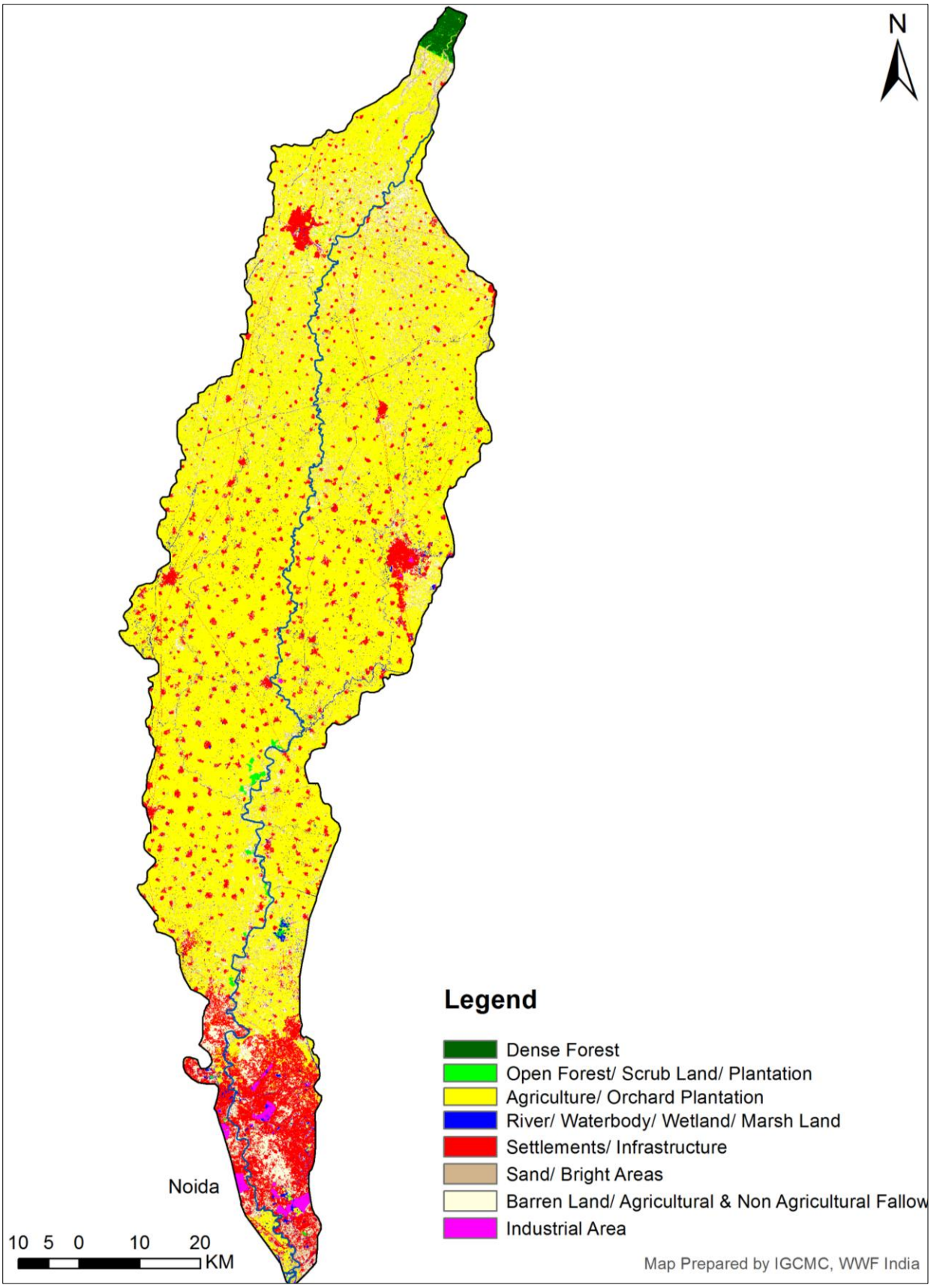
14.1 Major landuse in Hindon basin can be categorised into agriculture, forest, non agriculture, barren land, permanent pasture, cultivable wasteland and cultivable fellow land etc. Agriculture remains the main landuse in entire Yamuna basin. Land Use Land Cover analysis of the Hindon catchment area calculated with the help of Landsat satellite imagery of 2016 reveals that agriculture constitutes around 65% of the total land use. Further land Land use and Land cover (LULC) analysis of the Hindon basin is prepared using Landsat Time series images (2000, 2008 and 2016). The outcomes of the analysis are shown below in Table No. 26 below :

Table 25 : Distribution of Landuse/Land Cover in Hindon Basin [2016]

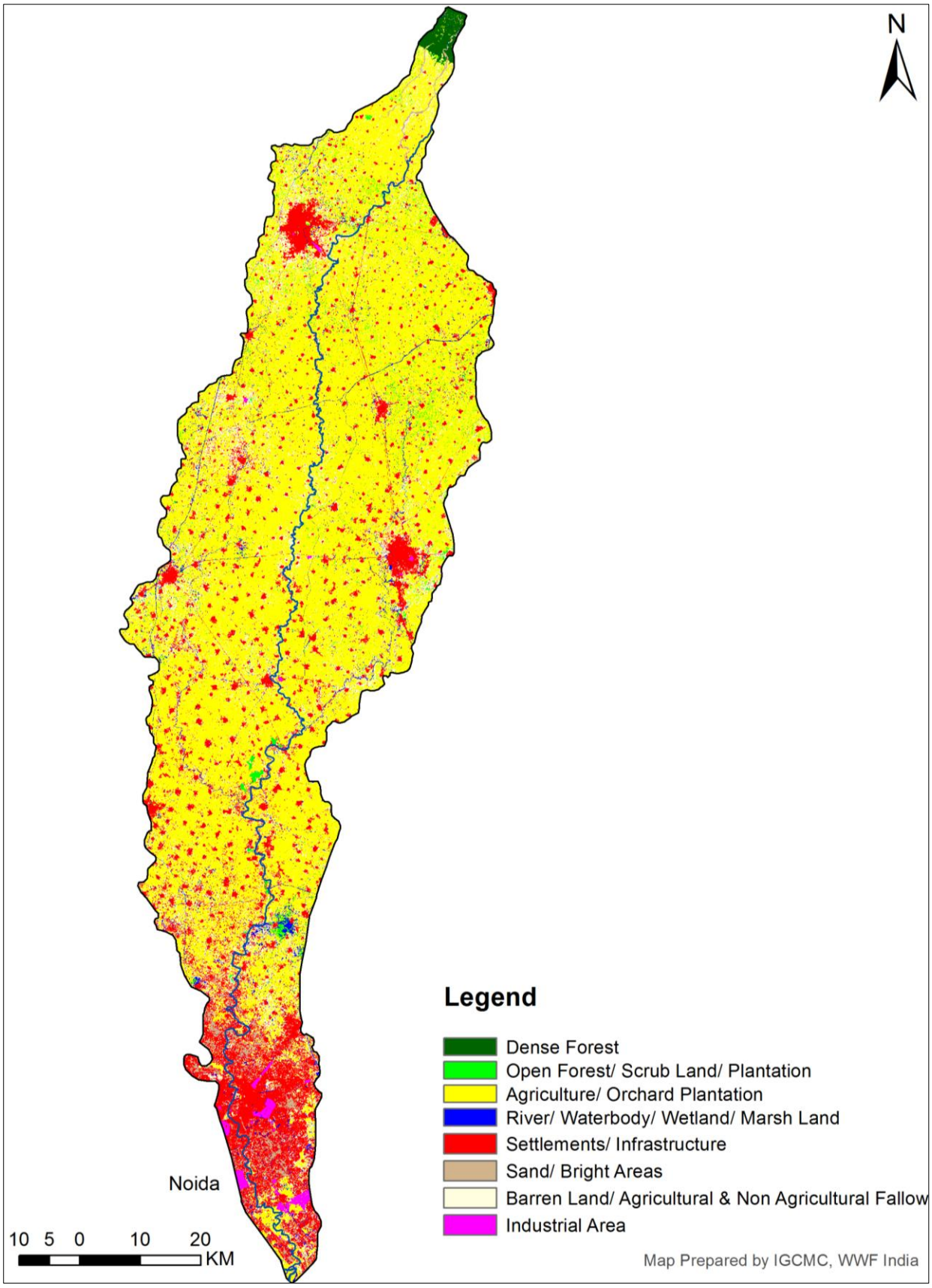
S.No.	Class Name	Land Use /Landcover (Sq. Km.)	In %age
Class-1	Dense Forest	26.04	0.435549
Class-2	Open Forest/ Scrub Land/ Plantation	89.89	1.503514
Class-3	Agriculture/ Orchard Plantation	3930.24	65.73781
Class-4	River/ Water body/ Wetland/ Marshy Land	148.38	2.481827
Class-5	Settlements/ Infrastructure	889.23	14.8734
Class-6	Sand/ Bright Areas	98.05	1.64
Class-7	Barren Land/ Agricultural & Non Agricultural Fallow	767.53	12.83783
Class-8	Industrial Area	29.3	0.490076



Map 35 : Land Use/Land Cover Map [Year 2000]



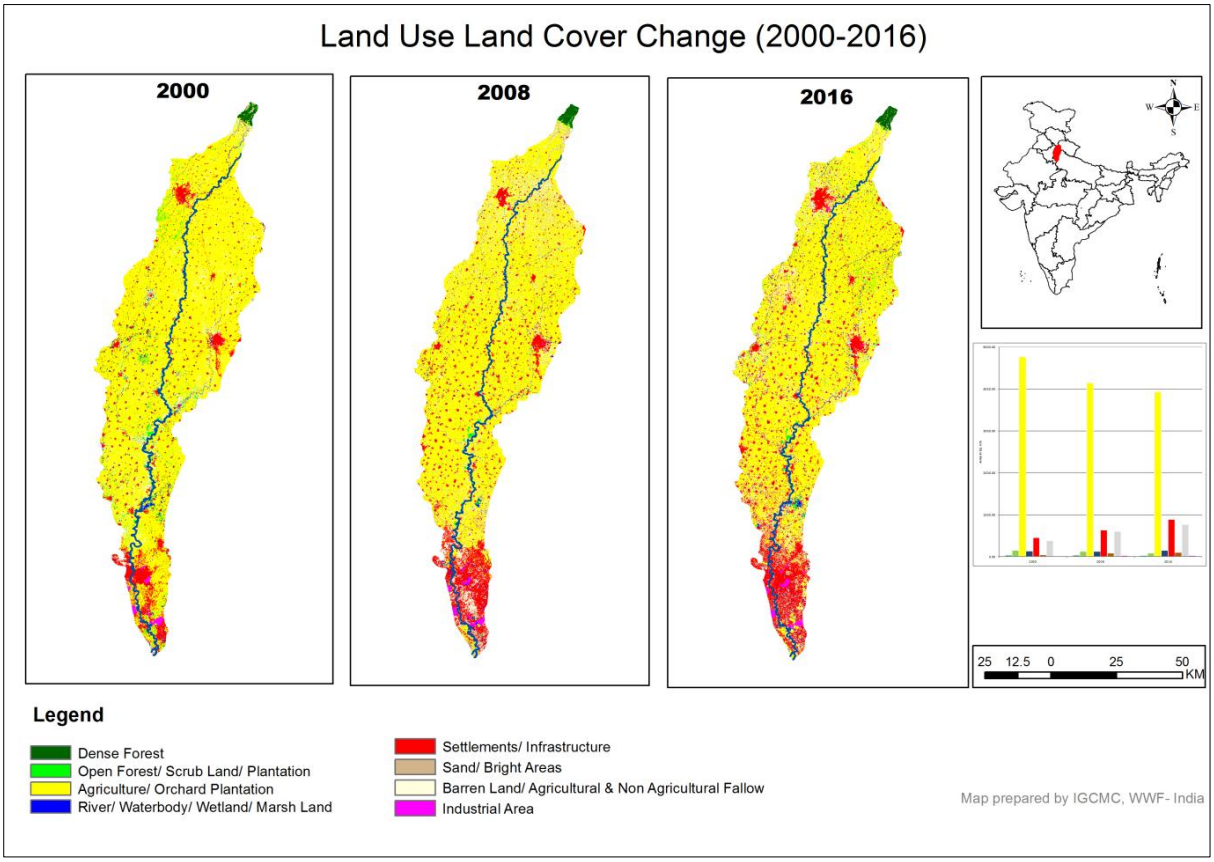
Map 36 : Land Use Land Cover Map [Year 2008]



Map 37 : Land Use Land Cover Map [Year 2016]

Table 26 : Land Use Land Cover Map Change from 2000- 2016

Class Name		2000	2008	2016
		(Area in Sq Km)		
Class 1	Dense Forest	35.50	32.51	26.04
Class 2	Open Forest/ Scrub Land/ Plantation	145.19	125.41	89.89
Class 3	Agriculture/ Orchard Plantation	4771.46	4147.15	3930.24
Class 4	River/ Water body/ Wetland/ Marshy Land	136.38	126.14	148.38
Class 5	Settlements/ Infrastructure	460.36	637.81	889.23
Class 6	Sand/ Bright Areas	44.09	85.62	98.05
Class 7	Barren Land/Agricultural & Non Agricultural Fallow	376.79	601.45	767.53
Class 8	Industrial Area	24.45	27.79	29.30



Map 38 : Land Use Land Cover Change From 2000- 2016

14.2 From Table 25 it can be seen that between 2000 and 2016 :

- Dense forest has reduced by 26.5%
- Open forest has reduced by 38%
- **Forest cover in the basin is a mere <2%**
- Land under agriculture has also declined by 18% or 841 sq.km.
- Urban areas have increased by 93.5% or 400 sq.km.
- Barren/Unproductive lands have increased by 100 % from 420 sq.km. to 867 sq.km.

14.3 The time series in Table 26 also shows that the trend in reduction in forest areas is only accelerating over time. Further that the primary production factor in terms of agriculture

land is showing significant decline whereas increase in urbanized land is nearly of the order of 100%.

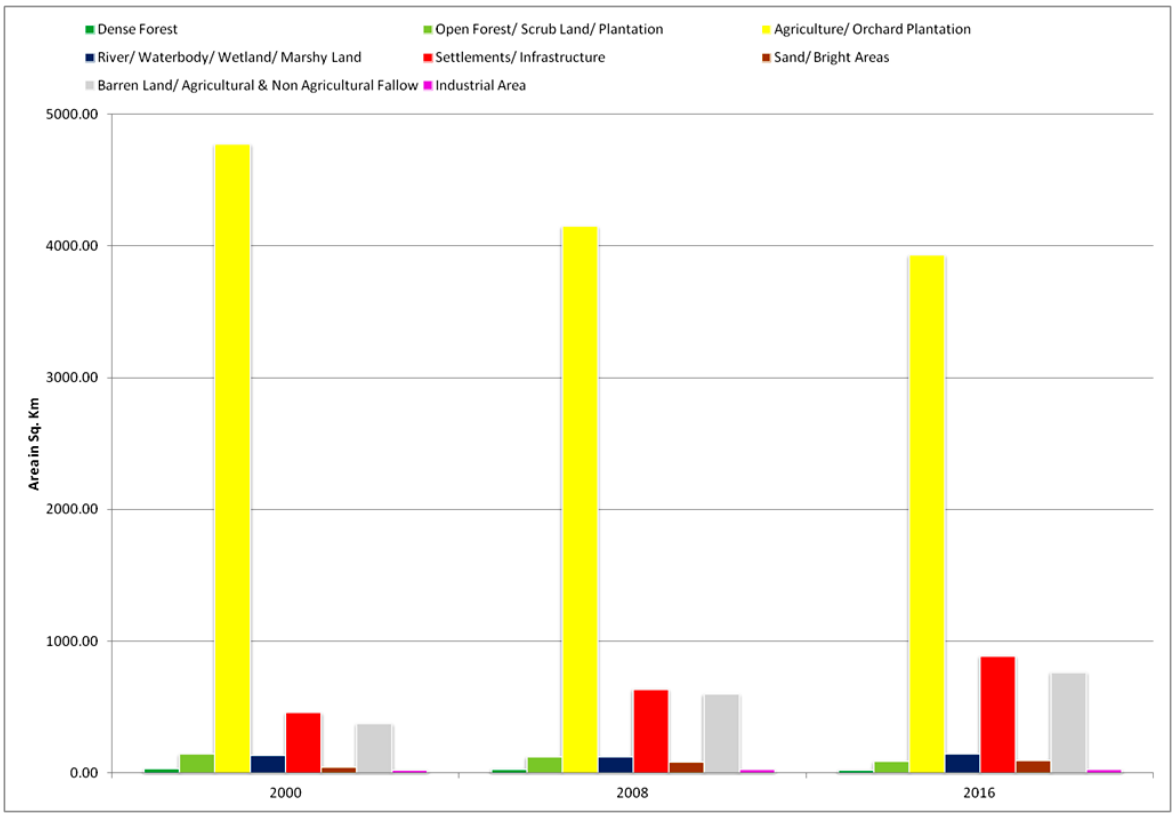
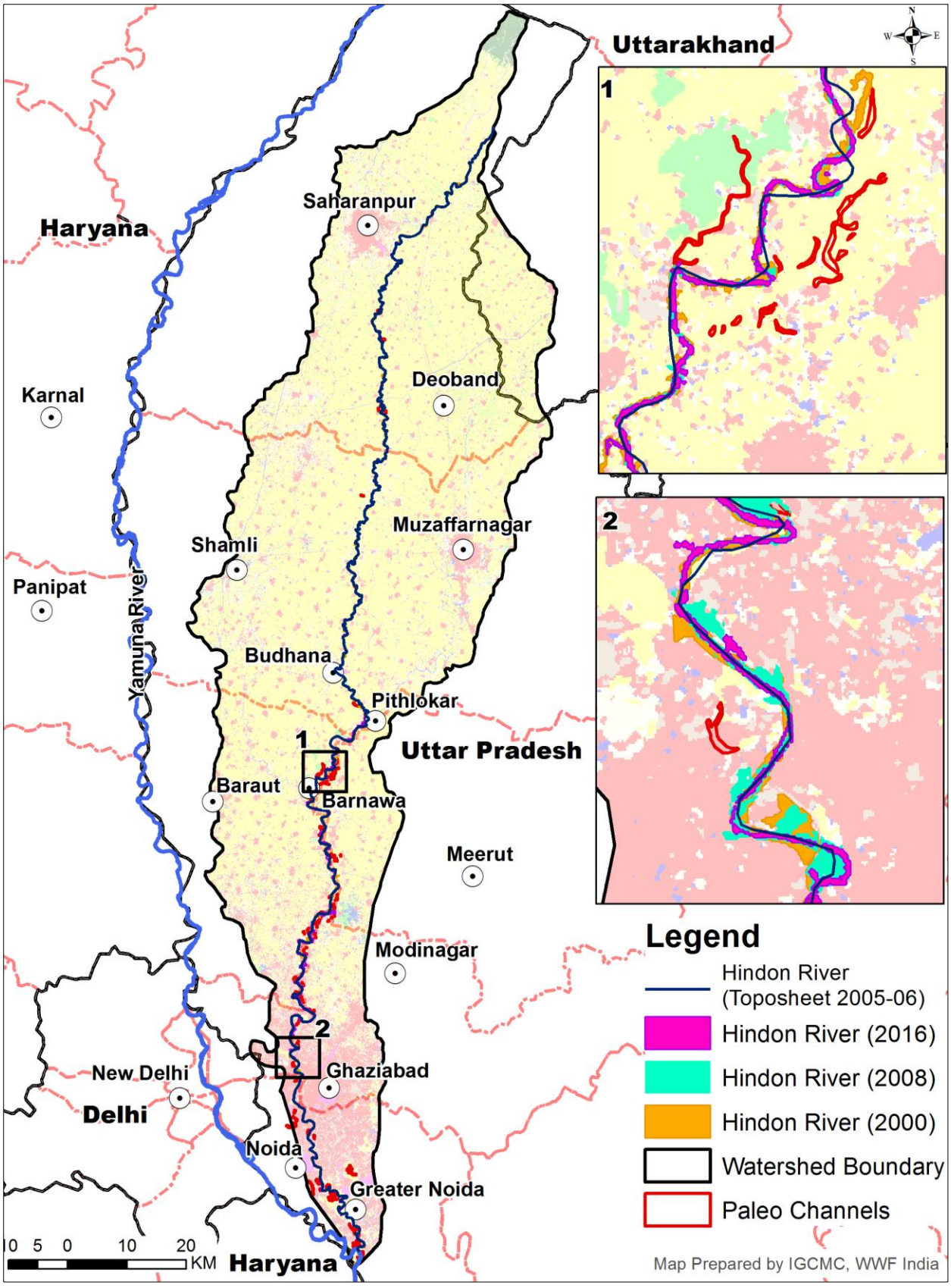


Image 13 : Land Use Land Cover Change Graph from 2000- 2016 (Class wise)

14.4 Abandoned channels of rivers, consequent to their meandering, are known as paleo-channels. Like most rivers flowing across alluvial plains Hindon, too, has wandered, creating paleo channels which are rich groundwater bearing strata and also constitute good recharge zones. Some paleo channels, detected near Barnawa and Ghaziabad in the last 16 years with the help of Landsat satellite imageries are marked in Map No. 39.



Map 39 : Palaeo channels of Hindon River Detected in the Last 16 Years

15.0 Agriculture and Crops

15.1 Agriculture accounts for more than 65% of the total landuse in Hindon basin.

15.2 The three distinct cropping seasons are *Kharif* (July-October), *Rabi* (October-March) and *Zaid* (April-June). Major *Kharif* crops include paddy, maize, millet, moong, urd and, cotton; *Rabi* crops include wheat, gram and mustard and other oilseeds and *Zaid* including harvesting of seasonal fruits and vegetables such as water melon, muskmelon, cucmber, sunflower and sugarcane. According to data from 'Basin Assessment and Planning System' [BAPS] of State Water Resources Agency, UP, for all the 6 major districts of Hindon catchment, wheat and sugarcane are the two most preferred and majorly grown crops.

Table 27 : District -wise Major Crops and Net Cultivated Area [Basin Area]

S. No.	District	Major Crops	Net Cultivated Area (ha) Distt.	Gross Cultivated Area (ha) Distt.	Net cultivated Area (ha) Basin *	Gross Cultivated Area (ha) Basin*
1.	Saharanpur	Sugarcane, Wheat, Rice, Mustard, Maize, Groundnut and Blackgram	2,74,837	4,05,032	1,31,921.76	1,94,415.36
2.	Muzaffarnagar	Sugarcane, Wheat, Mustard, Paddy, and Urd, Gram, Sunflower,Potato, Cotton,Maize,Pea and Arhar	3,26,387	4,72,441	1,63,193.5	2,36,220.5
3.	Meerut	Sugarcane, Wheat, Rice, Arhar and Mustard	1,99,053	3,03,870	23,886.36	36,464.4
4.	Baghpat	Rice, Wheat, Sugarcane, and Oilseed crops. Maize, Jowar, Arhar, Urd, Moong.	1,10,381	1,75,272	68,436.22	1,08,668.64
5.	Ghaziabad	Paddy, Wheat and Sugarcane. Other cultivated crops include pulses and oilseed crops	1,44,684	2,26,571	50,639.4	79,299.85
6.	Gautam Buddha Nagar	Paddy, Wheat, Barley, Bajra and Maize. Others are Urd, Moong, Lentil, Gram, Arhar and Mustard	81,785	1,28,798	18,810.55	29,623.54

** Based on ratio of Basin Area to District Area*

Source: District Profiles of Krishi Vigyan Kendra, UP

15.2 Meerut Gazetteer[23] [1922] mentions that land inundated by Hindon was occassionaly cultivated for *rabi* crops and harvests were of excellent quality. Short inundation increased

[23] Meerut: A Gazetteer being Volume IV of the District Gazetteers of the United Provinces of Agra and Oudh by H.R. Nevill, 1922

soil fertility while heavy flooding would increase saline efflorescence known as *'reh'* which sometimes did not disappear inspite of extensive drainage system undertaken by canal authorities. The Gazeteer states that area under *reh* had spread considerably in Hindan khadir in recent years and large areas could not be ploughed for twenty years or more. River waters were used for irrigating *Rabi* crops and melons in sandy bed of the stream.

15.3 **Saharanpur :** In District Saharanpur, 68 % of the population is engaged in agriculture. **Net cultivated area in basin is 1,31,922 ha.** Major crops include sugarcane, wheat, rice. Other crops are Mustard, Maize, Groundnut and Blackgram. [Source: Krishi Vigyan Kendra, U.P.] As estimated from BAPS [Basin Assessment and Planning System] of State Water Resources Agency, UP, sugarcane and wheat are two major crops cutivated during 2011-12.

Basin Gross Cultivated Area : 1,93,630 Ha
Area Under Wheat : 56,232 Ha
Area Under Rice : 28,592 Ha
Area Under Sugar Cane : 54,802 Ha
Area Under Other Crops : 53,372 Ha (Approx.)

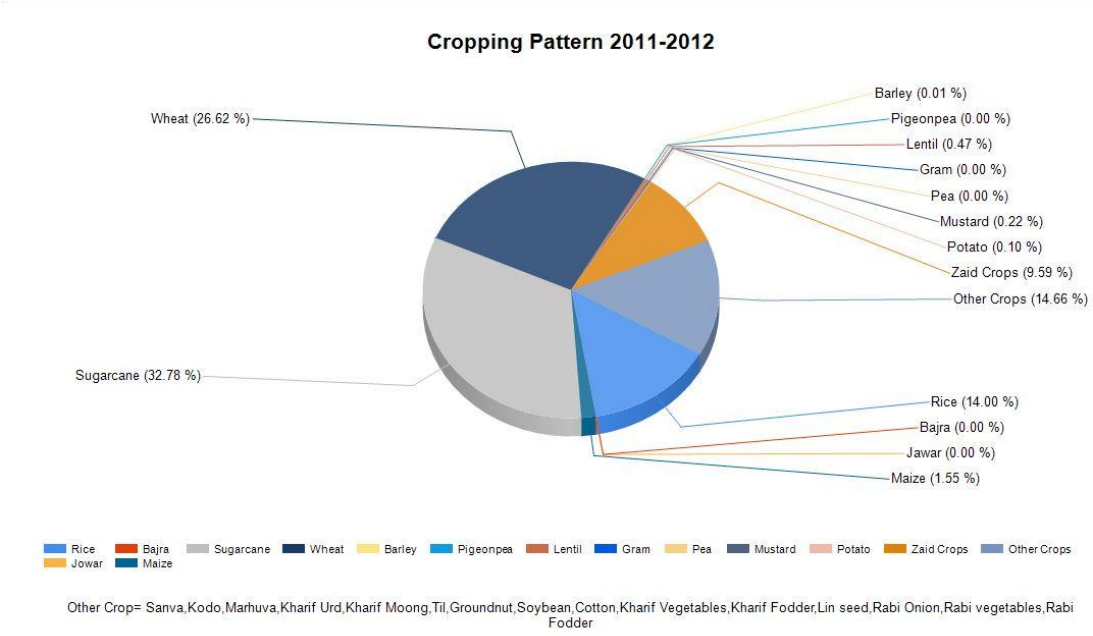


Image 14 : Cropping Pattern (%) in District Saharanpur [2011-12]
[Source: Data generated from BAPS, State Water Resources Agency, Irrigation Dept, U.P.]

15.4 **Muzaffarnagar :** Major crops include sugarcane, wheat, mustard, paddy, and urad. **Net cultivated area in basin is 1,63,193 ha.** Other crops include gram, sunflower, potato, cotton, maize, Pea and Arhar. [Source: Krishi Vigyan Kendra, U.P.] As estimated from BAPS [Basin Assessment and Planning System] of State Water Resources Agency, Uttar Pradesh, Sugarcane and Wheat are two major crops cutivated in Muzaffarnagar Distt. during 2011-12.

Basin Gross Cultivated Area : 2,36,000 ha

Area under wheat : 63,500 ha
Area Under Rice : 11,151 ha
Area under Sugar Cane : 1,00,718 ha
Area under other crops : 60,809 ha

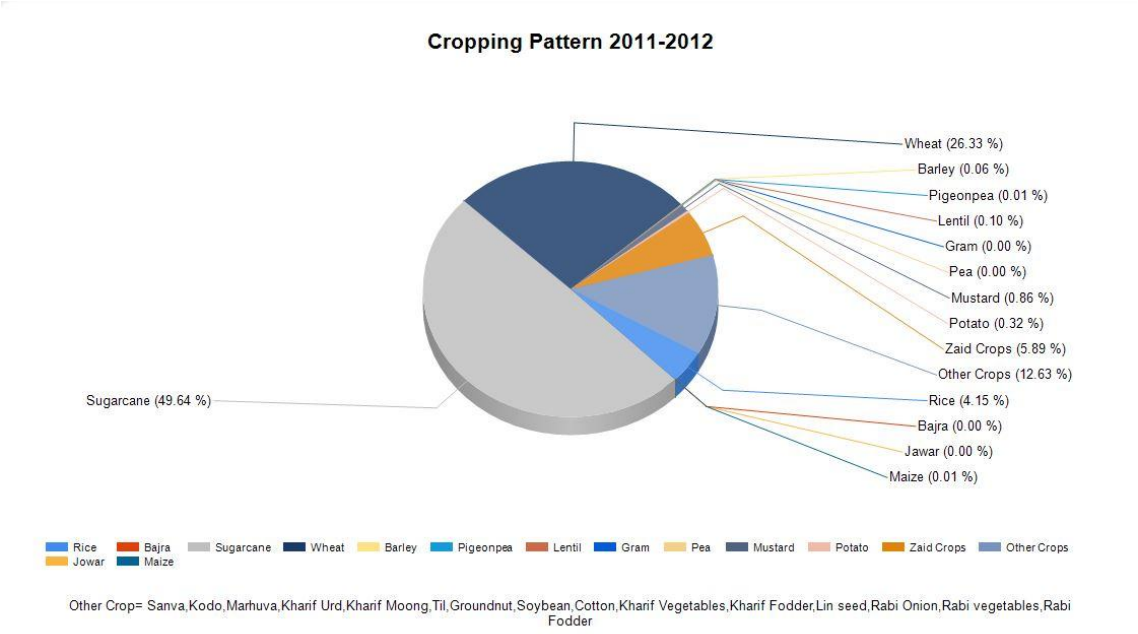


Image 15 : Cropping Pattern (%age) in District Muzaffarnagar [2011-12]

[Source: Report generated from BAPS, Irrigation Dept, U.P.]

15.5 **Meerut :** Major crops include Sugarcane, Wheat, Rice, Arhar and Mustard. **Net cultivated area in basin is 23,886 ha.**

Basin Gross Cultivated Area : 3,03,870 ha
Area under wheat : 9,187 ha
Area Under Rice : 2,087 ha
Area under Sugar Cane : 15, 360 ha
Area under other crops : 18,960 ha

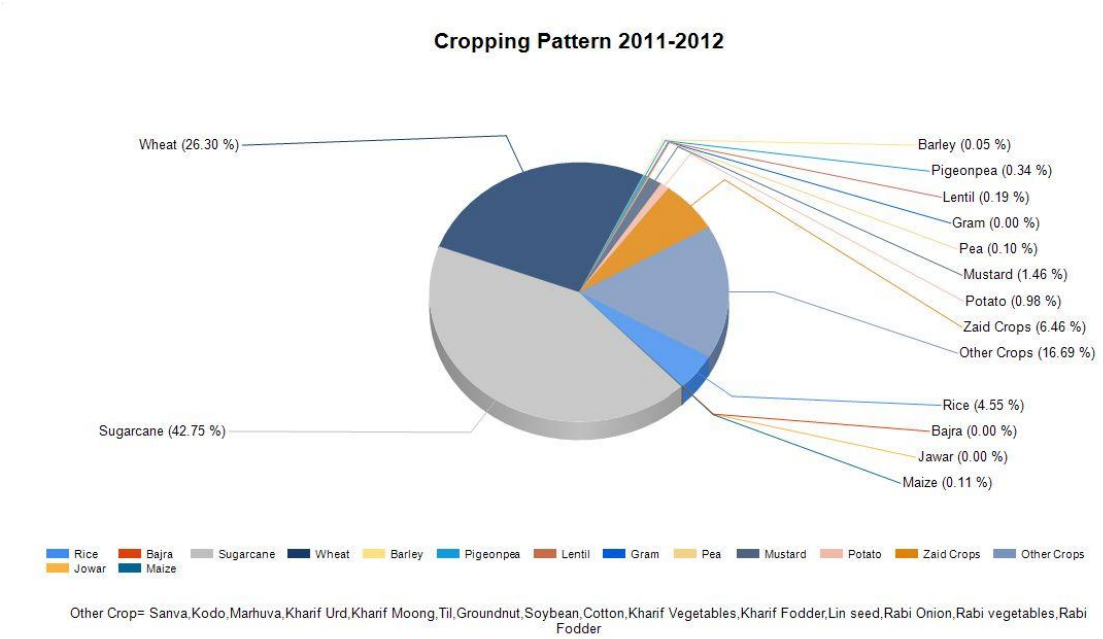


Image 16 : Cropping Pattern (%age) in District Meerut (2011-12)

[Source: Report generated from BAPS, State Water Resources Agency, Irrigation Dept, U.P.]

15.6 **Baghpat :** Major crops are Rice, Wheat, Sugarcane, and Oilseed crops. Others cultivates crops are Maize, Jowar, Arhar, Urd, Moong. **Basin net cultivated area is 68,436 ha**.

Basin Gross Cultivated Area : 1,06,750 ha
Area under wheat : 31,305 ha
Area Under Rice : 1,999 ha
Area under Sugar Cane : 46,388 ha
Area under other crops : 27,222 ha

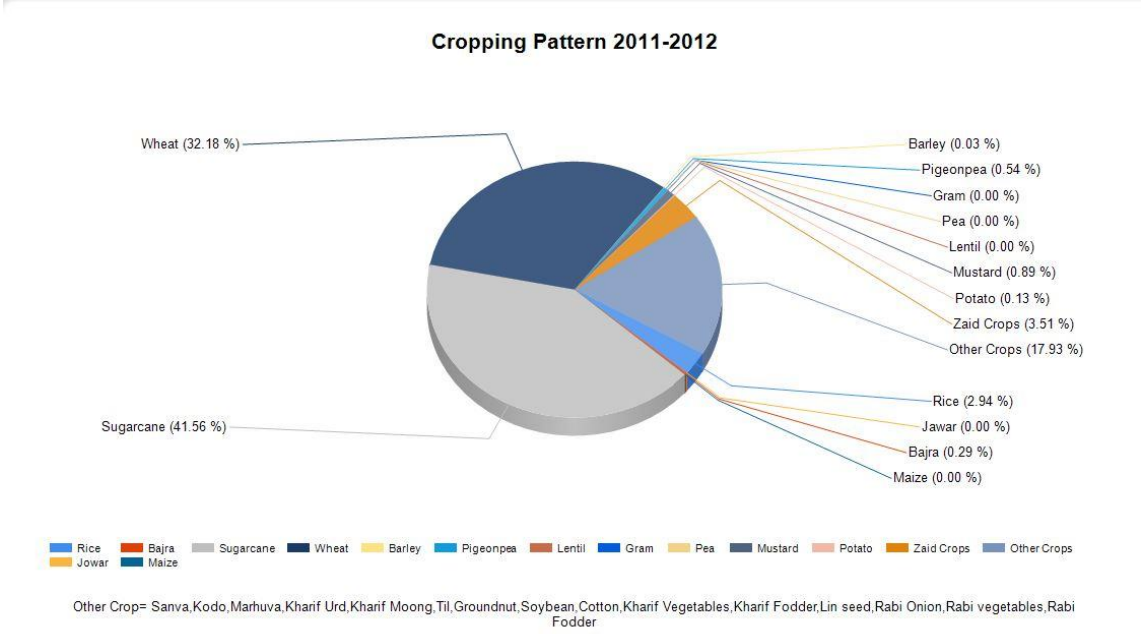


Image 17 : Cropping Pattern (%age) in District Baghpat (2011-12)

[Source: Report generated from BAPS, State Water Resources Agency, Irrigation Dept, U.P.]

15.7 **Ghaziabad :** In Ghaziabad, 56.8% population is engaged in agriculture. Major crops are Paddy, Wheat and Sugarcane. Other cultivated crops include pulses and oilseed crops. **Net cultivated area in basin is 50,640 ha.**

Basin Gross Cultivated Area : 79,300 ha
Area under wheat : 26,642 ha
Area Under Rice : 8,678 ha
Area under Sugar Cane : 22,188 ha
Area under other crops : 21,790 ha

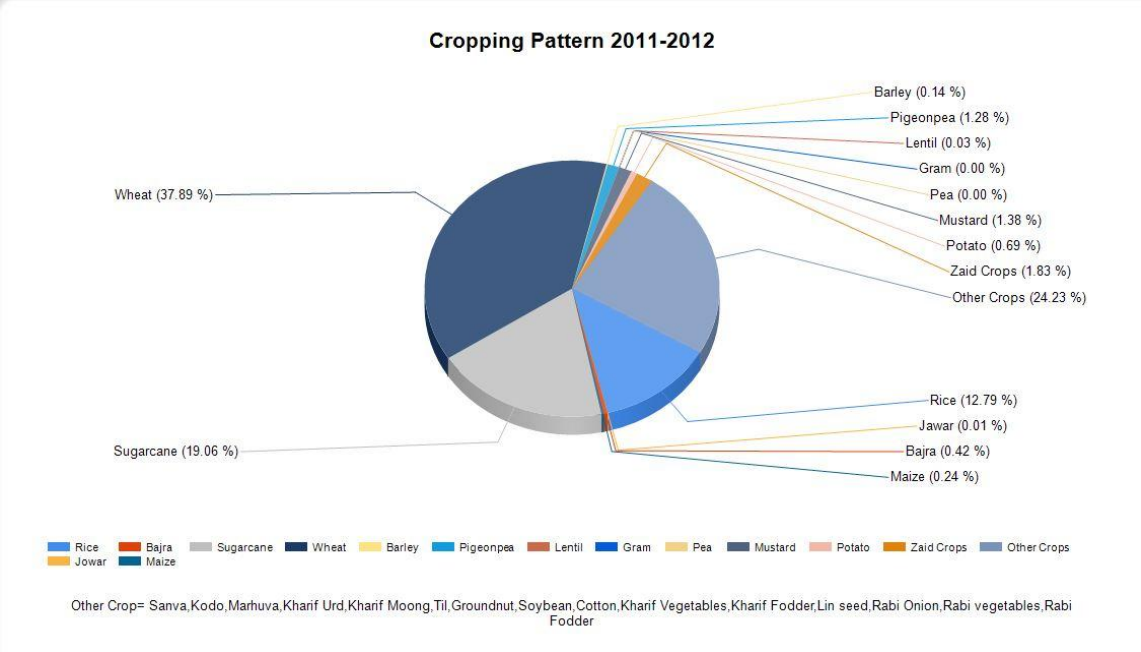


Image 18 : Cropping Pattern (%age) in District Ghaziabad (2011-12)
[Source: Report generated from BAPS, State Water Resources Agency, Irrigation Dept, U.P.]

15.8 **Gautam Buddha Nagar :** Major crops cultivated are Paddy, Wheat, Barley, Bajra and Maize. Others are Urd, Moong, Lentil, Gram, Arhar and Mustard. **Basin net cultivated area is 81,785 ha.**

Basin Gross Cultivated Area : 29,622 ha
Area under wheat : 10,610 ha
Area Under Rice : 3,163 ha
Area under other crops : 15,851 ha

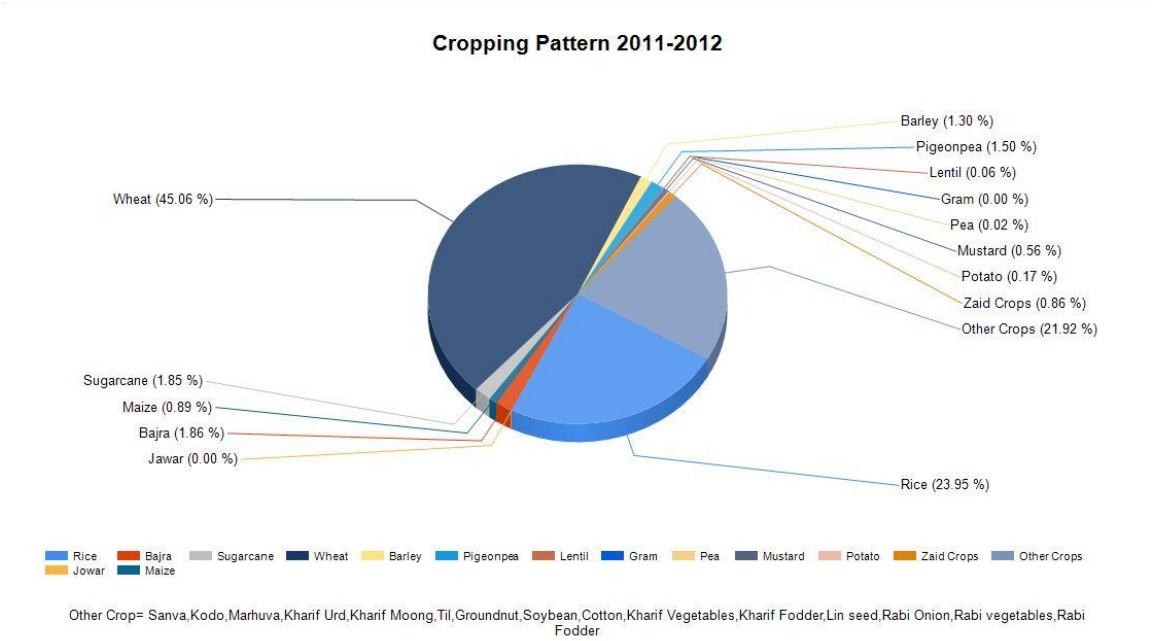


Image 19 : Cropping Pattern (%age) in District Gautam Budh Nagar (2011-12)

[Source: Report generated from BAPS, State Water Resources Agency, Irrigation Dept, U.P.]

15.9 As can be seen cropping pattern in all the Hindon basin districts is influenced by the easy availability of water thus far. The heavy irrigation requirement of the major crops is compounded by the technique of flood irrigation wherein only some of the water reaches the roots whereas much of the water is lost to evaporation.

Table 28 : Standard Irrigation Water Requirement For Crops

Crop	Growing Period (No. of days)	Total Water Requirement		Daily Water Requirement	
		in cm	in inches	in cm	in inches
Jowar	114	64.25	25.70	0.575	0.23
Maize	100	44.50	17.80	0.450	0.18
Rice	93	104.50	41.80	1.075	0.43
Wheat	88	37.00	14.80	0.425	0.17
Groundnut	124	65.25	26.10	0.525	0.21
Linseed	88	31.71	12.68	0.350	0.14
Cotton	202	105.50	42.20	0.525	0.21
Sugarcane	365	237.50	95.00	0.650	0.26
Tobacco	132	98.00	39.20	0.750	0.30
Onion	120	75.00	30.00	0.625	0.25
Potato	88	30.00	12.00	0.750	0.30
Pea	88	30.00	12.00	0.350	0.14
Mustard	88	25.20	10.08	0.300	0.12
Barley	88	25.20	10.08	0.400	0.16
Oat	88	36.00	14.40	0.400	0.16
Ragi	127	74.50	29.80	0.575	0.23

Source: Slideshare.com

Table 29 : Crop-wise Area [Ha] Distribution Across Basin Area District-wise

Crop	Sahrnpr	Muzfrngr	Meerut	Baghpat	Ghzbad	GB Ngr	Total [Ha]
Wheat	56232	63500	9187	31305	26642	10610	**197476**
Rice	28592	11151	2087	1999	8678	3163	**55670**
Sugarcane	54802	100718	15360	46388	22188	-	**239456**
Others	53372	60809	18960	27222	21790	15851	**198004**
Total Gross Cropped Area [Ha]	**192998**	**236178**	**45594**	**106914**	**79298**	**29624**	**690606**

15.10 Table No. 29 shows that Muzzafarnagar part of the basin has the maximum area under agriculture and that sugarcane is the dominant crop.

16.0 Water Budget Of The Hindon Basin

16.1 Based on the above Table No. 29 the basin wise requirement of irrigation water is worked out in Table 30 and it is apparent that sugarcane's areal domination translates into disproportionate share of water resource consumption.

Table 30 : Crop-wise & Distt-wise Basin Irrigation Water Requirement [MCM]

Crop	Saharanpur	Muzzafarngr	Meerut	Baghpat	Gzbad	GB Ngr	Total [MCM] Crop-wise	%age Irr. Water Crop-wise
Wheat	208	235	34	116	99	40	**732**	**9.2**
Rice	300	117	22	21	91	33	**584**	**7.3**
Sugarcane	1315	2417	369	1114	533	-	**5748**	**72.8**
Others*	213	244	76	109	88	64	**794**	**10.05**
Total Irr. Water Basin Distt.	**2036**	**3013**	**501**	**1360**	**811**	**137**	**7894**	**100**
%age Irr Water Consumed District-wise	**26**	**38**	**6.3**	**17.2**	**10.2**	**1.7**	**100**	

Water Requirement of Crops Based On Table 32 * Other crops water requirement taken as 400mm annually

16.2 Table No. 31 shows the estimated domestic water demand which is <5% of the irrigation water demand. An equal amount is being assumed **as industrial water demand** i.e 5% in line with national estimates of sectoral consumption.

16.3 Table No. 32 shows the total annual rainfall endowment of the basin is 4156.24 MCM. This is highly variable if one infers from Tables 8, 9 and 10 and perhaps increasingly so.

16.4 Table No. 19 shows recharge from rainfall as 2896 MCM. The same table shows additional recharge from other sources [canal seepages, irrigation water percolation, return water and effluents] as 2702 MCM or a total recharge of 5598 MCM at District level. Reduced proportionately [on area basis] to basin level the natural recharge works out to 1053 MCM and recharge from other sources to 981 MCM.

16.5 Table No. 19 also shows that the groundwater withdrawal for irrigation is 1701 MCM [which is much lower than the demand estimated in Table No. 35 i.e. 7894 MCM. Thus irrigation from groundwater is meeting only 21% of the irrigation water requirement and thus the balance 79% or 6193 MCM are imported waters from Yamuna [through Eastern Yamuna Canal system] and from Upper Ganga Canal supplies.

Table 31: Domestic Sector Water Consumption In The Basin

District	Urban Pop.	Urban Water Consumption @ 135 lpcd [MCM]	Rural Pop.	Rural Water Consumption @ 100 lpcd* [MCM]	Total Daily Water Consumption [MCM]	Annual Water Consumption [MCM]
Haridwar	-	-	1,45,221	0.0145	0.0145	5.30
Saharanpur	10,66,526	0.145	11,72,147	0.117	0.262	95.63
Muzaffarngr [incl. Shamli]	11,91,312	0.16	14,79,782	0.015	0.175	63.88
Meerut	-	-	2,11,,303	0.021	0.021	7.67
Baghpat	-	-	6,44,362	0.0644	0.0644	23.5
Ghaziabad	31,62,547	0.427	5,43,731	0.054	0.481	175.60
GBudh Ngr	2,13,686	0.021	1,59,253	0.015	0.036	13.14
	56,34,073	**0.753**	**43,55,798**	**0.3**	**1.053**	**384.72**

*Includes water requirement of livestock

Table 32 : Water Resource of Hindon Basin

District	Annual Rainfall [mm]	Catchment Area [Sq.Km.]	Rainfall Volume [MCM]
Haridwar	939.22	290	272.31
Saharanpur	690.62	1802	1243.38
Muzafarngr	688.31	2009	1382.19
Meerut	708.10	321	227.26
Baghpat	641.70	828	530.74
Ghaziabad	691.30	422	291.60
GB Nagar	689.00	303	208.76
Total		**5975**	**4156.24**

16.6 Thus, a complex situation prevails and the imprecise water budget of the basin is conceived in the following table as a tool to understand the sources of the basin water and its sectors of utilization.

Table 33 : Approximate Water Budget Of The Hindon Basin [MCM]

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Annual Rainfall	**Surface Runoff To Hindon**	**GW Recharge From Rainfall**	**Estimated GW Recharge From Canals Only**	**Ganga Water Transfer to Yamuna Via Hindon**	**Irrigation From GW**	**Irrigation From EYC & Ganga Canal**	**Domestic Water Use**	**Industrial Water Use**
4156.24	968	1143	981	No Data	1839	6193	384.72	400
From Table 33	From Table 24	Derived From Table 19	Derived From Table 19		Derived From Table 19	From Table 30 – Col. [6]	From Table 32	In line with national figures

16.7 In Table 38 the data for the amount of water being transferred from Upper Ganga Canal via Hindon to Yamuna is unavailable. At the same time it is assumed that this water transfer is not utilized within the basin except for some unintended recharge.

16.8 A certain amount of directly pumped irrigation from the river channel is accessed by farmers adjacent Hindon inspite of the lean season water being heavily polluted as thus saves them expenses of tubewell operation [now a flat Rs. 2100/- per month per pumpset].

Table 34 : Disposal of The Rainfall Endowment of Hindon Basin [MCM]

Annual Rainfall	Surface Runoff	Evaporation Losses	GW Recharge	Soil Moisture
4156.24	968	1039	1143*	1039
	From Table 28	Generally 25%	Derived From Table 19	Generally 25%

*of which, as per Table-19, 500 MCM seeps to the river system

16.9 From Table 19 we also understand that the basin groundwater exploitation is 100% [on average] therefore the entire groundwater recharge is consumed. In fact more than natural groundwater recharge occurs as a result of recharge from imported water from adjacent basins. Thus, the Hindon Basin is surviving on waters imported from Ganga and Yamuna Basin. Without these imports the current water guzzling cropping pattern in the basin dominated by sugarcane could not have occurred and cannot be sustained. The present cropping pattern has driven the expenditure on the massive canal system which, with its hydrocracy, has aquired a life of its own. The hydrocracy's solutions to Hindon's problems are more canals and more water imports thus bleeding adjacent basins and incurring more and more wasteful expenditure. Such distortions are no longer sustainable and balancing the water demand and supply equation must be managed within the basin as far as possible.

Image 20 : River Edge Farmer Pumping Water From River, Karhera village, Ghaziabad

Image 21 : River Edge Farmer Pumping Water From River, Village Baparsi, Meerut

17.0 Surface Water Pollution

17.1 Hindon River had been a major source of water and livelihood for many people living in its catchment area. Before 1980, people used to drink water from it directly. Villagers recall that one could spot a coin thrown in by devotees easily. But now Hindon has no continuous flow round the year – the lean season flow is effluents/sewage from industries, municipalities which accumulates for months getting washed away only during monsoon. Continuous flow of polluted water has reduced the river to a drain and contaminated the groundwater table in its entire stretch downstream of Saharanpur.

17.2 As per CPCB[24] Report-2015, Hindon is one of the 13 rivers which do not meet water quality criteria limit with respect to BOD and has been classified as 'Priority-I River'. [Monitoring locations exceeding BOD concentration 30 mg/l]

17.3 Hindon receives loads of pollution from various industries and residential sewerage from the towns mainly Saharanpur, Muzaffarnagar, Meerut, & Ghaziabad situated in its basin area.

[24] River Stretches for Restoring Water Quality, Central Pollution Control Board, February 2015

Image 22: Heavy Effluents Discharge Pollutes Hindon Near Barrage, Ghaziabad [Date:08/03/2017]

Table 35 : Thirteen Priortity 'A' Rivers classified by CPCB, 2015

S. No.	RIVER	STRETCH IDENTIFIED	BOD RANGE	PRIORITY CLASS	TOWNS
1.	BETWA	HAMIRPUR TO WAGPURA	3.3	V	HAMIRPUR, JHANSI
2.	GHAGHARA	BARHALGANJ TO DEORIA	3.4-3.6	V	AYODHYA, TANDA, DEORIA
3.	GOMTI	SITAPUR TO VARANASI	3.7-11	III	SITAPUR, LUCKNOW, SULTANPUR
4.	HINDON	SAHARANPUR TO GHAZIABAD	24-80	I	SAHARANPUR, MUZAFFARNAGAR, MEERUT, GHAZIABAD
5.	KALINADI	MUZAFFAR NAGAR TO GULAOTHI TOWN	4-369	I	MEERUT, HAPUR, GULAOTHI, BULANDSHAHR
6.	RAMGANGA	MURADABAD TO KANNAUJ	6.8	IV	MORADABAD, BAREILLY, FARRUKHABAD
7.	RAPTI	DOMINGARH TO RAJGHAT	3.4-3.8	V	GORAKHPUR
8.	RIHAND	RENUKUT TO PIPARI	3.3-7.2	IV	OBRA, RENUKOOT, PIPARI
9.	SAI	UNNAO TO JAUNPUR	3.5-3.7	V	RAEBARELI, BELA PRATAPGARH, JAUNPUR
10.	SARYU	AYODHYA TO	3.2	V	FAIZABAD,

	ELAFATGANJ				AYODHYA
11. GANGA	KANNAUJ VARANASI	TO	3.8-16.9	III	KANNAUJ, KANPUR, ALLAHABAD, MIRZAPUR, VARANASI
12. YAMUNA	ASGARPUR ETAWAH SHAHPUR ALLAHABAD (BALUA GHAT)	TO TO	3.8-41	I	GAUTAM BUDDHA NAGAR (NOIDA & GREATER NOIDA), VRINDAVAN, MATHURA, AGRA, SHAHPUR
13. KOSI	AJEETPUR CHAMRAUL	TO	4.0	V	AJEETPUR, RAMPUR

Source: River Stretches for Restoring Water Quality, Central Pollution Control Board, February 2015

17.4 As per report published on 25th Nov 2016 in Hindustan Times[25], the data shows an even more alarming picture "Total 127 MLD (million litres per day) sewage is discharged at District Saharanpur and 100 MLD is the municipal discharge from neighboring towns. Industrial discharge from paper mills, sugar factories, tanneries and distilleries accounts for 27 MLD. Around 350 factories comprising paper mills, chemical units, and distilleries dump waste in Hindon. 98,000 KL (Kilo litres) of wastewater and effluents are dumped into Hindon at Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad and Gautam Buddha Nagar. 85,000 KL of wastewater and effluents are dumped into tributaries Krishni and Kali. 1,90,000 KL of untreated wastewater and effluents are carried by Hindon every day and is dumped into Yamuna" The data had been sourced from Pollution Control Board and Irrigation Dept. of Uttar Pradesh.

17.5 There are 32 paper manufacturing units, 15 sugar mills, alcohol distillation, dairy and textile units. Out of 32 paper manufacturing units, 24 are located on the Kali (West) alone which joins Hindon at Pithlokar village. Star Paper Mill mucks up the river almost entirely at Saharanpur.

17.6 People have abandoned their handpumps (many have been sealed by district administration) after some villagers suffered from deadly diseases like cancer, neurological, disorders including skin and respiratory infection. During one petition in NGT[26], it was found that arsenic (which cause cancer, paralysis, and other deformities) level was 40 mg/litre in village Jalalpur [Distt. Baghpat] which is 4000 times in excess of the acceptable limit. Taking note of the matter, in 2016, NGT directed state govt. of Uttar Pradesh to provide potable water to the poor farmers of affected districts.

17.7National Green Tribunal (NGT) on 25th August, 2015 issued a directive which imposes fine of Rs 20,000 on any person found throwing garbage in Hindon River. The directions came after a resident of Ghaziabad filed complaint against illegal dumping of construction debris in the Hindon canal as well as on river banks. On Sept 29, 2015 NGT again rebuked Ghaziabad Development Authorities over the same issue.

[25] Troubled Waters of Hindon carry Waste and Sickness. Hindustan Times Nov 25, 2016

[26]http://timesofindia.indiatimes.com/city/meerut/DM-CMO-Baghpat-appear-before-NGT-on-issue-of-water-contamination/articleshow/54105542.cms

17.8 **Again, in January, 2015, following an NGT order, Uttar Pradesh Irrigation Department announced protected status floodplain areas along all rivers in the state. According to the notice issued by the department on January 2015, cities have to demarcate riverbeds within their limits that experienced floods even once in 50 years as floodplains. In rural areas the timeline of floods was suggested for 25 years. As evidently seen, the orders have not been followed and the encroachments are continuously destroying the floodplain areas of the rivers.**

17.9 Floodplain encroachment and solid waste disposal have been the other two threats to the river. Alarmed on the situation, on 6th Oct 2016, National Green Tribunal (NGT) directed Ghaziabad civic agencies to submit action plan for scientific disposal of solid waste.

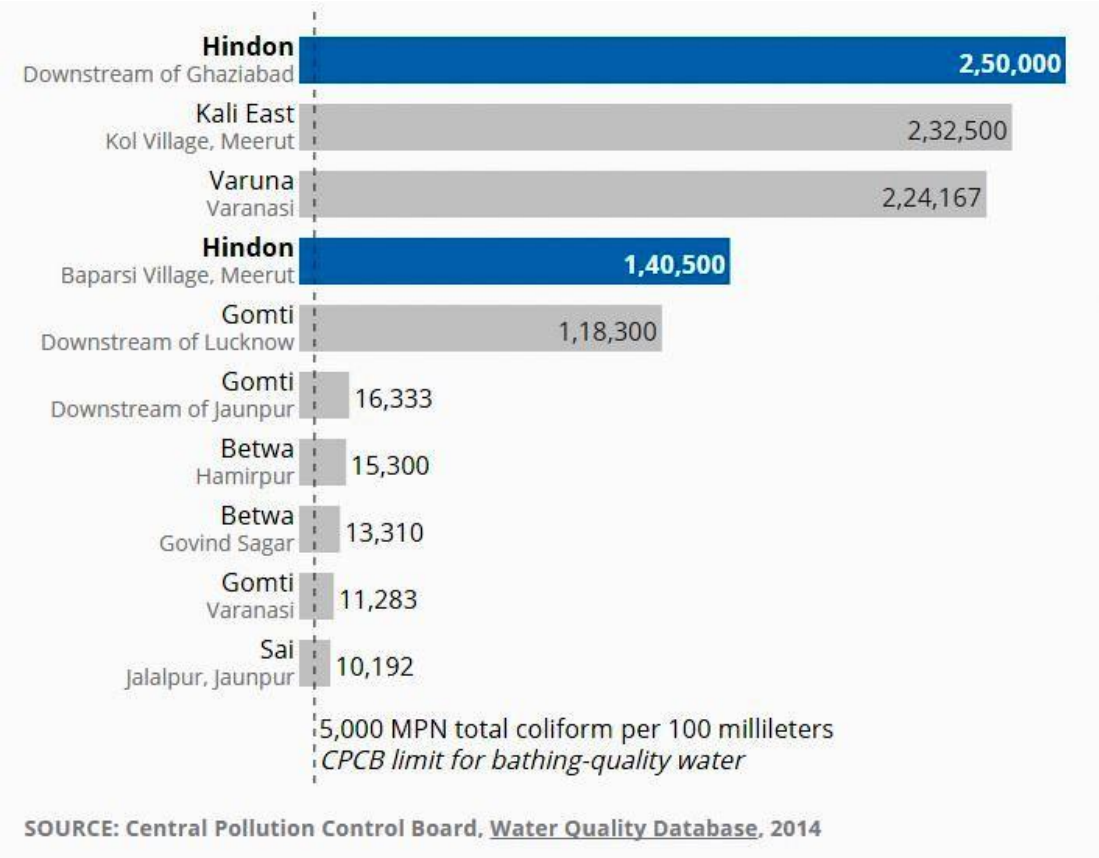


Image 23: Average Total Coliforms at Ten Most Polluted Monitoring Stations in UP

17.10 The following tables provide the time series data of water quality tests in River Hindon. A comparison of the changes would yield the trend.

Table 36 : The Water Quality of the Hindon River (1988-89)

S.No.	Parameters	Values
1	pH	7-8.1
2	High Solids	300- 1200 MG/L
3	TDS	164 - 700 MG/L
4	Hardness	240 MG/L (max) 100 mg/l min

5	DO	3.3 & 7.6 mg/l
6	COD	2 & 23 mg/l
7	BOD	2 mg/l to 18 mg/l
8	Cu	0.1 X 0.6 mg/l
9	Pb	0.45 - 1.5 mg/l
10	Cd	Below acceptable limits
11	Zn	0.15 mg/l (MIN) 0.45MG/L (min)
12	Fe	7.0 mg/l (max)
13	Mn	0.1 mg/l 0.7 mg/l
14	Cr	0.1 mg/l - 0.27 mg/l
15	Arsenic	0.072 m - 0.98 mg/l
16	Hg	0.003 mg/l - 0.04 mg/l
17	N2	1.5 mg/l - 5.8 mg/l
18	MPN Coliform	700 - 24000
19	Total Count Values	250+ to 400,000

Source: "Study on Drainage System and Flood Control including Water Resources in National Capital Region", NCRPB, GoI & WAPCOS, Oct. 1994

17.11 The analysis above [1988-1989] reveals that pH, Cl, Cd, Zn and total hardness are below acceptable limits throughout the year. TDS, Fe, Cu, and Mn, are above acceptable limits and COD, Pb, Cr, As and Hg are above rejection limits throughout the year[27].

Table 37 : Mean Water Quality, 2010

Parameters	DO mg/l	BOD mg/l	Nitrate -N (mg/l)	Nitrite-N (mg/l)	pH	Conductivity (µmhos/cm)	Faecal Coliform (MPN/100 ml)	Total Coliform (MPN/100 ml)
Water Quality Criteria	>4mg /l	>3 mg/l	—	—	6.5-8.5	2250 µmhos/cm	2500 MPN/100 ml	5000 MPN/100 ml
Hindon A/C with River Krishna & Kali near Binauli Town, Meerut	1.2	18.8	0.65	0.17	7.7	516	291250	1935000
Hindon at Ghaziabad	0.3	75	1.09	—	7.1	1256	101333	168333
Hindon at Baparsi Village, Sardhana Budhana Road, Meerut	No value	48	2.84	—	7.3	830	115167	166000

Source : CPCB

17.12 The more downstream the sampling site the worse the parameters. At all the three locations, the values recorded exceed water quality criteria to a greater extent. At

[27] GPO, Ministry of Environment & Forests from a study conducted by University of Roorkee, 1988-89

Ghaziabad value of DO [dissolved oxygen] has gone down to nil, the BoD [Biological Oxygen Demand] value is very high. The total coliform value at all the 3 locations exceeds more than 30 times than normal value of 5000 MPN/100 ml.

Table 38 : Water Quality Data, 2010

District	Months	DO	BOD	Total Coliform (MPN/100 ml)	Faecal Coliform (MPN/100 ml)	Water Quality Index [WQI]
Saharanpur (Downstream) Code No. 1357	Jan	Nil	40	21000	—	—
	Feb	Nil	42	39000	—	—
	Mar	Nil	38	21000	—	—
	Apr	Nil	36	21000	—	—
	May	Nil	42	21000	15000	US
	Jun	Nil	48	21000	15000	US
	July	2.5	40	21000	14000	US
	Aug	1.8	46	23000	12000	US
	Sept	0.4	48	23000	14000	US
	Oct	0.3	46	23000	15000	US
	Nov	0.2	48	23000	15000	US
	Dec	0.5	46	21000	14000	US
Gautam Buddha Nagar (Downstream Kulsera) Code No. 1358	**Months**	**DO**	**BOD**	**Total Coliform (MPN/100 ml)**	**Faecal Coliform (MPN/100 ml)**	**Water Quality Index [WQI]**
	Jan	Nil	52	310000	—	—
	Feb	Nil	70	320000	—	—
	Mar	Nil	47	310000	—	—
	Apr	Nil	73	320000	—	—
	May	Nil	78	310000	220000	US
	Jun	Nil	73	290000	180000	US
	July	Nil	31	280000	160000	US
	Aug	Nil	38	260000	150000	US
	Sept	Nil	42	280000	160000	US
	Oct	Nil	38.6	260000	150000	US
	Nov	Nil	36	260000	140000	US
	Dec	Nil	44	240000	130000	US
Baghpat (Village Baparsi) Code No. 2496	**Months**	**DO**	**BOD**	**Total Coliform (MPN/100 ml)**	**Faecal Coliform (MPN/100 ml)**	**Water Quality Index [WQI]**
	Jan	Nil	45	170000	—	—
	Feb	Nil	44	120000	—	—
	Mar	Nil	52	150000	—	—
	Apr	Nil	54	150000	—	—
	May	Nil	52	150000	110000	US
	Jun	Nil	62	170000	130000	US
	July	Nil	58	120000	84000	US
	Aug	Nil	52	150000	94000	US
	Sept	Nil	56	170000	110000	US
	Oct	Nil	64	120000	94000	US
	Nov	Nil	62	170000	110000	US
	Dec	Nil	65	110000	94000	US
	*S=Satisfactory US=Unsatisfactory					

Source: River Water Quality Assessment Under NWMP Scheme, UP Pollution Control Board

17.13 Table 38 reveals that level of dissolved oxygen (DO) at all the three locations dropped to zero round the year except July to Dec at Saharanpur where it dropped from 2.5 mg/l to 0.5 in December. As per CPCB's standadr it should be above four milligrams per litre. Biological Oxygen Demand (BOD) ranged from 31 to 78 exceeding 28 times than the prescribed value of 3 mg/l. Total and feacal coliforms are far beyond acceptable limits of 5000 MPN/100 ml making overall water quality index (WQI) to be highly unsatisfactory.

Table 39 : Water Quality Parameters [August, 2016]

Parameters									
Sites	pH	EC (µs/cm)	TDS (mg/l)	D.O. (ppm)	Turbidity	Temp (°C)	Phosphate (mg/l)	Nitrate (mg/l)	Coliforms
Balmiki Ashram	7.8	850	330	1.37	200	32.3	2.0	5.4	Present
Hindon pre Krishni	7.6	910	480	1.39	220	36.3	2.2	3.3	Present
Hindon-Krishni Confluence	7	440	210	2.36	17	34.2	3.9	6	Present
Hindon post Krishni	7.05	770	320	0.7	220	34.7	1.8	4.9	Present
Kali at Hindon Confluence	7.6	750	370	4.3	>240	31.9	8.7	5.1	Present
Hindon after Kali Confluence	7.4	780	390	2.4	>240	30.9	3.0	5.8	Present
Maheshpur	7.5	740	360	4.6	100	25	7.6	15	Present
Krishni at Bhanera khemchand before drain	7.2	200	90	3.3	150		2.8	12	Present
Krishni at Bhanera khemchand after drain	5.2	1440	700	2.92	>240	28.3	11.4	14.3	Present
Hindon at Gagalheri, Saharanpur	7.1	280	130	8.30	150	29.3	0.7	Not detected	Present
Kali at 52 Dara near Maleera	7.0	390	180	4.59	150	27.2	1.3	2	Present
Hindon Cut, Ghazibad	7.5	380	300	2.9	150	30.1	0.0	11.3	Present
Hindon at Tilwada	7.5	810	400	1.53	200	30.2	1.6	Not detected	Present
Hindon at Yamuna	7.6	1100	540	0.7	200	30	2	Not detected	Present

Source : INTACH

17.14 **The water quality measurements from August, 2016 at different stretches of the Hindon river and in some stretches of Kali and Krishni do not reveal satisfactory water quality inspite of dilution in the monsoon**. Level of dissolved oxygen was found low at most of the locations except at Gagalhedi at Saharanpur where the river doesnot recieve any industrial discharge. Phosphate and nitrate were detected at most of the locations. Coliforms were also found to be present in all the water samples collected.

Table 40 : Water Quality Parameters [Jan-Feb, 2017]

Parameters Sites	pH	EC (µs/cm)	TDS (mg/l)	D.O. (ppm)	Turbidity	Temp (°C)	Phosphate (mg/l)	Nitrate (mg/l)	Coliforms
Kaluwala Rao (Shivaliks)	8.8	350	160	12.27	12	17.0	Not detected	ND	Absent
Hindon at Gagalhedi	8.9	1060	520	4.27	>240	15.9	1.2	ND	Present
Saharanpur (Dhamola Nala)	7.9	1150	570	1.52	100	14.6	7.1	10.1	Present
Titavi	7.9	1900	940	1.36	200	15.9	4.9	5.2	Present
Baparsi	7.8	1610	770	1.63	200	13.5	5.3	7.1	Present
Balmiki Ashram	7.6	1210	620	1.9	150	16.9	3.9	3.9	Present
Krishni near Shamli	8	1020	590	0.99	150	15.3	4.1	3.9	Present
Hindon at Tilwada	7.1	1340	560	0.7	>240	23	6.3	10.1	Present
Hindon at Yamuna	7.9	1120	540	0.3	>240	23.3	7.2	13.7	Present

Source : INTACH

17.15 The water quality remained poor during the next phase of study (Jan-Feb, 2017). Post-monsoon the flow volume declines and proportionately the pollutant concentration increases. Table 40 clearly brings out the winter season deterioration over the levels of August, 2016 [Table 39].

17.16 The level of dissolved oxygen (D.O.) detected from 0 to 1.9 except at Gagalhedi (4.2 mg/l) and at stream at Kaluwala Rao (12.27 mg/l) where water is extremely clean and is natural source of monsoon torrent to Hindon. Phosphate and nitrate were detected at most of the locations except Kaluwala Rao. Coliforms were also detected in all the samples except at Kaluwala Rao. From Saharanpur onwards, the TDS (Total Dissolved Solids) was observed more than 500 mg/l reaching highest at Titavi in Muzaffarnagar (940 mg/l). The water color was dark yellow in color as observed on 24th May, 2017 apparently due to influents discharge from Titavi Sugar Mill located on left bank of the river. (See Image No.25). Further downstream, TDS was observed receding in value i.e. 770 mg/l at Baparsi and 620 mg/l at Balmiki Ashram (here water from Jani escape dilutes the polluted water of Hindon River). The quality of water again deteriorates as Hindon reaches city of Ghaziabad passing through suburbs of Gautam Buddha Nagar finaly meeting Yamuna near Tilwada village of Gautam Buddha Nagar.

Table 41 : CPCB Standards For Discharge Water Quality on Inland Surface Waters

S.No.	Parameter	Inland Surface Water Standards
1.	Colour and odour	-
2.	Suspended Solids mg/l, max.	100
3.	Particle size of suspended solids	Shall pass 850 micron IS Sieve
4.	pH value	5.5 to 9.0
5.	Temperature	Shall not exceed 5°C above the receiving water temperature
6.	Oil and grease, mg/l max.	10
7.	Total residual chlorine, mg/l max.	1.0
8.	Ammonical nitrogen (as N), mg/l, max.	50
9.	Total Kjedahl nitrogen (as N) mg/l max.	100
10.	Free ammonia (as NH3), mg/l,max.	5.0
11.	Biochemical oxygen demand (3days at 27 0 C),mg/l, max.	30
12	Chemical oxygen demand, mg/l, max.	250
13.	Arsenic (as As).	0.2
14.	Mercury (as Hg), mg/l, max.	0.01
15.	Lead (as Pb), mg/l, max.	0.1
16.	Cadmium (as Cd) mg/l,max.	2.0
17.	Hexavalent chromium (as Cr +6) ,mg/l, max.	0.1
18.	Total chromium (as Cr) mg/l, max.	2.0
19.	Copper (as Cu) mg/l, max.	3.0
20.	Zinc (as Zn) mg/l, max.	5.0
21.	Selenium (as Se)	0.05
22.	Nickel (as Ni) mg/l, max.	3.0
23.	Cyanide (as CN) mg/l, max.	0.2
24.	Flouride (as F) mg/l, max.	2.0
25.	Dissolved phosphates (as P) mg/l, max.	5.0
26.	Sulphide (as S) mg/l, max.	2.0
27.	Phenolic compounds (as C6H5OH) mg/l, max.	1.0
28.	Radioactive materials:	
	a) Alpha emitters micro curie mg/l, max.	10 -7

	b) Beta emitters micro curie mg/l, max.	10-6
29.	Bio-assay test	90% survival of fish after 96 hours in 100% effluent
30.	Manganese	2 mg/l
31.	Iron (as Fe)	3 mg/l
32.	Vanadium (as V)	0.2 mg/l
33.	Nitrate Nitrogen	10 mg/l
34.	Fecal Coliform (MPN/mL)	1,000 desirable 10,000 maximum permissible

Table 42 : Surface Water Quality Standards – Class B of CPCB

Characteristic	**Outdoor Bathing (Organised)**
pH value	6.5 to 8.5
Dissolved Oxygen, mg/l, min	5
Biochemical Oxygen Demand (5 days at 200C), mg/l	3
Total coliform organisms, MPN/100 ml. Max	500
Colour Hazen units	300
Arsenic (as As), mg/l. Max	0.2
Fluorides (as F), mg/l	1.5
Chlorides (as Cl), mg/l	600
Cyanides (as CN), mg/l	0.05

Table 43 : Heavy Metal Tests [March-May 2017]

Parameters (mg/l)	Detection Limit	Krishni at Banat	Krishni at Kabraut	Kali at Muzaffarnagar Town	Kali at Maleera	Hindon at Titavi	Hindon at Pura	Sikka Drain, Shamli	Meerut Road Ind Drain, Ghazibd	Ghaziabad Main Res. Drain	Hindon River at Ghaziabd Barrage
Lead (Pb)	0.002	BDL	BDL	BDL	BDL	BDL	0.028	0.465	BLD	BDL	BDL
Chromium (Cr)	0.005	BDL	BDL	BDL	BDL	0.038	BDL	0.115	1.78	BDL	BDL
Cadmium (Cd)	0.002	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Nickle (Nl)	0.005	BDL	BDL	BDL	BDL	0.02	0.02	0.06	0.09	BDL	BDL

Source: INTACH

Image 24 : Meerut Road Industrial Drain and Residential Drain Merges and Discharge Near Hindon Barrage [Towards Southeast; 08/03/2017]

Image 25 : Yellow Colored Water in Hindon at Titawi, Muzaffarnagar [24/05/2017]

17.17 A study[28] carried out by **People Science Institute, Dehradun** on Hindon River in 2011 for heavy metal concentration and pesticides shows the life threatening picture of the surface

[28] A Study on Water Quality of Hindon River and Its Tributaries Dr Anil Gautam Peoples' Science Institute, Dehradun [Unpublished Report]

water quality. The heavy metals studied include lead, total chromium and cadmium. Lead is a highly toxic element that is released from industrial wastes from printing, dyeing, oil refineries, etc. Chromium is present in industrial wastes of paints, dyes, ceramics, paper industries, etc. Cadmium is present in the wastes of chemical industries, milling and mining wastes, etc.

17.18 The concentration of lead was found to be above acceptable limits at 16 sites out of total 22 sites studied with 4 sites showing very high levels of above 1 mg/l. The chromium levels are much higher than the prescribed limits of CPCB (< 0.10 mg/l) in all the sampling sites. Most of the sites have chromium values between 2-5 mg/l, with 7 sites having very dangerous levels higher than 5 mg/l. In Kali River, the level of chromium is seen to rise in sites which lie immediately after a drain releasing sewage or effluents from a sugar mill. In Krishni River, the chromium levels range between 3.25 and 4.58 mg/l, dipping and rising as and when effluent releasing drains are emptying in to the river. In the Hindon River, the highest level (12.25 mg/l) is seen in HS 12, which lies immediately after the Budhana sewage drain and the Budhana sugar mill drain enter the Hindon River.

17.19 The cadmium levels measured in the sampling sites are within prescribed limits of CPCB (<0.005 mg/l) in 13 out of 22 sites. In the Kali River, all the sites sampled show levels within the acceptable standard. In Krishni River, the site KrS 17 shows the highest value of 0.047 mg/l. In the Hindon River, the levels are high in HS 2, HS 8, HS 7, HS 18, HS 20 and YS 22. The levels fall drastically in HS 19 after HS 18 and in HS 21 after HS 20 probably due to dilution from the Upper Ganga Sub Canal in the first case and due to several sewage drains which may not be having cadmium in the second case.

Table 44: Details Of Sampling Location On River Hindon And Tributaries [PSI]

SN	S.Code	Detail of sampling locations
A	**River Kali West**	
1	KS - 4	50 meters U/S of bridge on road, Manglor to Devband, near villages ie. Chandrapur and Meerkhur
2	KS - 5	200 meters U/S of bridge on road, Saharanpur to Muzaffarnagar, near village Malira
3	KS - 6	D/S of Muzaffarnagar at Tabalshahpeer
4	KS - 14	D/S of village Pitlokar, before about 500 meters from confluence with river Hindon
B	**River Krishni**	
5	KrS -9	D/S of Nanauta industries at village Bhanerha, distt. Saharanpur
6	KrS –10	D/S of village Salfa- Jhal near Banat distt. Muzaffarnagar
7	KrS- 11	D/S of village Budapar distt. Bagpat, after confluence of Ramala sugar mill effluent
8	KrS- 17	Before confluence with river Hindon,D/S of village Barnawa,distt. Meerut
C	**River Hindon**	
9	HS – 1	D/S of out fall of star paper mill, U/S of Saharanpur
10	HS -2	River Damola, before confluence with river Hindon ,D/S of Saharnpur near village Sargthal
11	HS–3	U/S of bridge on road from Budakera to Kashipur,about 2 Km d/s of confluence of river Damola
12	HS-8	About 200 meters U/S of out fall of Titavi Sugar mill

13	HS-7	About 200 meters D/S of out fall of Titavi sugar mill
14	HS-13	U/S of bridge on road Badot to Muzaffarnagar near Budana town
15	HS-12	About 200 meters D/s of out fall of Bajaj sugar mill at Bhasana
16	HS-15	300 D/S of confluence of river Kali west
17	HS-16	D/S of out fall of Paper mill at Sardhana, near village Kalina
18	HS-18	D/S of out fall of sugar mill at village Kinauni, after confluence of river Krishani
19	HS-19	D/ S of Baloni bridge on road from Meerut to Bagpat, 2 km d/s of confluence of Sub canal of upper Ganga canal
20	HS-20	U/S of Hindon barrage at Mohan nagar, Gaziabad
21	HS-21	D/S of Greater Noida near village Momnathal , before confluence with river Yamuna
22	YS-22	River Yamuna, after confluence of river Hindon, near village Tilwada

Source: A Study on Water Quality of Hindon River and Its Tributaries by Dr. Anil Gautam, Peoples' Science Institute, Dehradun [Unpublished Report]]

Table 45 : Heavy Metal Concentrations In River Hindon And Its Tributaries

Sl. No.	Sample code	Concentration of Heavy Metals (mg/l)		
		Lead	Total Cr	Cadmium
CPCB standards for surface water quality (Class-C, Acceptable)		<0.10	<0.10	<0.005
A	**River Kali West**			
1	KS - 4	BDL	**1.88**	BDL
2	KS - 5	**0.36**	**3.02**	BDL
3	KS - 6	**0.70**	**2.83**	0.002
4	KS - 14	**1.12**	**5.80**	0.003
B	**River Krishni**			
5	KrS -9	**0.12**	**3.50**	0.005
6	KrS –10	**0.16**	**3.25**	0.002
7	KrS- 11	**0.14**	**4.58**	BDL
8	KrS- 17	**0.04**	**4.38**	**0.047**
C	**River Hindon**			
9	HS – 1	**0.34**	**1.84**	BDL
10	HS -2	**1.79**	**4.15**	**0.017**
11	HS–3	**1.50**	**3.17**	BDL
12	HS-8	**0.21**	**5.72**	**0.013**
13	HS-7	**0.28**	**6.64**	**0.012**
14	HS-13	BDL	**9.43**	BDL
15	HS-12	0.04	**12.25**	BDL
16	HS-15	**0.92**	**5.65**	BDL
17	HS-16	**0.153**	**4.84**	0.005
18	HS-18	**0.304**	**2.80**	**0.011**
19	HS-19	BDL	**3.02**	0.001
20	HS-20	**0.145**	**4.53**	**0.016**
21	HS-21	0.10	**3.643**	0.002
22	YS-22	**1.12**	**6.78**	**0.014**

Note : Values in bold indicate values exceeding maximum permissible limit or values lower than the minimum prescribed limit

Source: A Study on Water Quality of Hindon River and Its Tributaries by Dr. Anil Gautam, Peoples' Science Institute, Dehradun [Unpublished Report], 2011

Image 26 : Star Paper Mills Ltd. Saharanpur Is One The Major Contributor To Hindon's Pollution

Pesticides:

17.20 Pesticides study was carried out by PSI at the same 22 sites using 11 pesticide standards (shown in Table No.46) which were run on gas chromatograph for analysis. Most of samples were found to have a mix of pesticides. The surface water data thus suggest that most of the pesticides sprayed in the fields run off into the surface water bodies, where they tend to persist. As sampling was carried during the low-flow season, most of the pesticides have shown higher concentration.

Table 46 : Pesticide Concentrations In River Hindon And Its Tributaries

Sample Code	Endo II	α-BHC (µg/L)	β-BHC (µg/L)	γ-BHC (µg/L)	Heptachlor (µg/L)	Heptachlor Epoxide (µg/L)	Fipronil (µg/L)	Endosulfan I (µg/L)	Aldrin (µg/L)	δ -BHC (µg/L)	Endo sulphate	Total
A												
						River Kali West						
KS - 4	-	-	2.9	-	0.45	-	-	-	-	2.39	-	**5.74**
KS - 5	-	-	-	-	-	-	-	-	-	1.98	-	**1.98**
KS - 6	-	1.85	2.8	-	-	-	-	-	-	-	-	**4.65**
KS - 14	-	-	-	-	-	-	1.32	-	-	3.9	-	**5.22**
B												
						River Krishni						
KrS -9	-	-	-	-	0.94	1.44	0.39	-	0.44	2.36	-	**5.57**
KrS –10	-	-	-	-	2.3	3.82	1.46	-	1.3	-	-	**8.88**
KrS- 11	-	-	-	-	-	-	0.47	-	-	-	-	**0.47**
KrS- 17	-	3.3	-	-	-	0.62	1.57	-	-	-	-	**5.49**
C												
						River Hindon						
HS – 1	-	-	-	-	0.65	-	0.28	-	-	0.67	-	**1.60**
HS -2	-		3.20	-	-	2.82	1.4	-	3.36		-	**10.78**
HS–3	-		2.24	-	0.34	0.4	-	-	-	1.6	-	**4.58**
HS-8	-	0.98	2.24	-	-	0.35	-	-	0.57	3.7		**7.84**
HS-7	-	-	0.96	-	0.42	2.6	0.76	-	2.9	2.02	0.26	**9.92**
HS-13	-	-	-	-	-	-		-	-	-	-	**0.00**
HS-12	-	-	-	0.67	1.8	-	1.6	1.4	2.46	5.7	-	**13.63**
HS-15	-	-	-	-	-	1.1	1.7	-	-	-	-	**2.80**
HS-16	-	-	-	-	-	0.34		-	-	-	-	**0.34**
HS-18	-	-	-	-	0.86	0.66	0.82	-	-	1.2		**3.54**
HS-19	-	-	2.10	-	-	-	-	-	-	-	0.75	**2.85**
HS-20	-	-	1.32	-	-	-	-	-	-	-	1.00	**2.32**
HS-21	-	0.52	-	-	-	0.32	-	-	0.32	-	-	**1.16**
YS-.22	0.122	5.05	-	-	1.2	-	0.22	-	-	-	-	**6.59**

Acceptable limit prescribed by CPCB for total pesticides (mg/L) in surface water bodies: <0.0025 mg/l

[Source: A Study on Water Quality of Hindon River and Its Tributaries by Dr. Anil Gautam, Peoples' Science Institute, Dehradun [Unpublished Report], 2011

18.0 Groundwater Pollution

18.1 Ground water pollution due to continued flow of toxic and chemical influents in Hindon River has been a well noted and publicised issue of health crisis throughout the riparian districts. Incidents of deadly diseases like cancer, digestive disorders, skin ailments and physical deformities are of common occurence. Industries like sugar mills discharge sulphur dioxide, hydrochloric acid, magnesium, calcium, lead and phosphates which are toxic in nature.

18.2 As per Newslaundry report[29] of Aug 19, 2016, seventy people had died of cancer in the last three years in Gangnauli village, Baghpat alone. "The effect of the water contamination is so dire that the villagers tie their cattle's mouths while crossing the river. If the cattle drink the water, they die" "If you keep the water in a bottle, it turns red after a while," says one of them. "People are scared of drinking the water." Taking note of the situation, National Green Tribunal (NGT) in 2014 ordered state administration to provide clean drinking water to all affected villages but the same has not been followed seriously even after NGT's ruling twice in 2015 . Locals are forced to buy Reverse Osmosis (RO) equipped water filters to avail clean water which everybody can't afford since most of the villagers are either labourers or small scale farmers.

18.3 UP Pollution Control Board on the orders of NGT in 2015 collected 48 water samples from Baghpat districts and found them to be heavily polluted and contaminated with metals such as lead, manganese and magnesium beyond acceptable limits[30].

Ground Water Contamination & Rising Chronic Diseases

Ground water pollution due to continued flow of toxic and chemical influents in Hindon River and tributaries and rise in cancer cases is one of the highlighted issues throughout the riparian districts. As per Newslaundry report[31] of Aug 19, 2016, seventy people had died of cancer in the last three years in Gangnauli village, Baghpat alone.

People living in villages along the river bank are suffering from chronic diseases such as cancer, digestive ailments, skin problems, and respiratory issues. There is a rising trend of cancer cases in villages such as Maheshpur (Saharanpur), Pithlokar (Situated at Kali-Hindon confluence in Muzaffarnagar), Barnawa (Krishni-Hindon confluence in Baghpat), Baleni (Baghpat), Budhana town (Muzaffarnagar), Sirora Salempur, Jawli, and Farooq Nagar (in Ghaziabad). In Budhana town, rising cases of Hepatitis along with liver disorders are being reported by medical practitioners.

During one petition in NGT[32] , it was found that arsenic (which causes cancer, paralysis, and other deformities) was 40 mg / litre in village Jalalpur of District Baghpat which is 4000 times in excess of the acceptable limit.

[29] On the outskirts of Delhi, a river of doom, 19Aug, 2016, Newslaundary.com
[30] 70 kms from Capital, Bagpat villagers wait for freedom to drink clean water. Catchnews, 12 Aug, 2016

[31] On the outskirts of Delhi, a river of doom, 19Aug, 2016, Newslaundary.com
[32]http://timesofindia.indiatimes.com/city/meerut/DM-CMO-Baghpat-appear-before-NGT-on-issue-of-water-contamination/articleshow/54105542.cms

19.0 Condition Of Flood Plain And Flood Levels

19.1 Severe floods have occurred in the basin following intense rainfall in the past. These years are 1948, 1958, 1964, 1977, 1995, 1996 and 2010. However, records are difficult to come by. Such records would enable demarcation of the floodplain as a measure of disaster zoning as well as protecting lateral integrity of the riverine system.

19.2 In the rural reaches farmers have cultivated the banks right up to the edge of the active lean season channel removing tree cover as well as riparian vegetation. This has destroyed river banks, groundwater recharge zones as well as riparian habitats.

19.3. In urban areas floodplains have been treated as real estate and have been encroached upon by builders with the blessings of the authorities, thus reducing the river to a drain with direct discharge of untreated wastes into the river channel.

Image 27: Level of 1951 Flood on Pier of Rail Bridge U/S of Barrage [204.55 mamsl]

Image 28: Level of 1963 Flood on Old Regulator [204.12 mamsl]

Image 29: Level of 1978 Flood on Pier of Road Bridge U/S of Barrage [205.39 mamsl]

Note : Roads And Buildings Often Fall Within The 1978 HFL [Which May Well Be Considered As One In A Hundred Year Flood]

20.0 Interaction With Residents/Resource Persons

20.1 Direct interaction was held with villagers and resource persons to gain an understanding of the changes in the Hindon basin and how lives had been affected by the transformation of the river

Image 30 : A Banned Handpump at Baghpat [Source: Catchnews]

20.2 **Krishanpal Singh, Village Daula, Baghpat :** Alarmed with the scarcity of drinking water and water pollution, I started working on water issues in 2001. Hindon River which flows in our backyard took my attention first. I have noticed a constant deterioration in its water quality. This river has been an important part of our religious and cultural events. Sadly, people have forgotten that the religious shrines and temples were established due to this river as an indispensible source of life. In 2004, we started with a socio-cultural gathering at Balmiki Ashram, Baleni located on the bank of Hindon with the help Ashram's priest Mahant Lakshya Devanand Maharaj ji. Noticing lack of awareness about water related issues in our society, we started a movement which included '*Padyatras*' (Walks) along the bank of river meeting people and informing them about the importance of water and degrading condition of the Hindon River. The movement also included essay writing, water literacy programmes, in schools, wall graffiti etc. During these walks we learned a lot from people and their interaction with the river.

Image 31: Krishanpal Singh, Showing Hindon Near Balmiki Ashram, Baleni

Image 32 : Karamveer Singh Showing Mill Drain Which Pollutes Krishni Tributary

20.3 **Karamveer Singh, Village Banhera Khemchand, Dist. Nanauta, Saharanpur :** "Krishni River, which is an important tributary of Hindon River flows through our village Bhanera Khemchand. This is perhaps the first place where it gets polluted by discharge coming from nearby distillery and sugar mills. As soon the discharge mixes with Krishni water it becomes red due to high amount of chemicals in it. The mill owners claim to filter the discharge water through STPs but the reality is different. Their claims are not in

compliance with the rules and standards. They discharge untreated water during night when there is no fear of inspection. The ground water has become very poor with high TDS (Total Dissolved Solids) levels. Many villagers are suffering from the cancer, asthma and allergy disorders. Many families have left the village due to fear of these deadly diseases. More than 20 people have died of cancer in a year. We have boycotted many govt. schemes and surveys to bring main issue to the notice of govt. In continuation to this we have also written directly to Prime Minister Office, Delhi. Drinking water has become a major problem as people fear to drink water from hand pumps. "

20.4 **Rajneesh Singh, Village Badgaon near Maheshpur :** The river has become a source of cancer now. In ever nearby village 5-10 people are dying from cancer every year and 30 are suffering from cancer on an average. The ground water has become completely contaminated with toxins. Earlier the water was so clear that one could see the coins thrown by devotees easily. We used to come for bath here 20 years back. Our utensils turns black if left in the courtyard overnight due to toxic gases arising from river. Even guests do not prefer to visit us during summers as their jewellery turns black. Water quality deteriorated gradually as various industries came up in Saharanpur and Muzaffarnagar. Now it's difficult to sit near the river due to foul smell that comes with the wind.

Image 33 : Sikka Salawar Mills Discharge Its Effleunts In Krishni

20.5 **Krishanpal , Sikka Salawar, Shamli :** "The nearby mills effects the crop quality. The ash from electric turbine mill used to blacken all the cauliflower crop forcing local farmers to search for other alternatives"

Image 34 : Dharam Singh Narrates His Experiences of Yamuna and Hindon River

20.6 **Dharam Singh, Tilwada Village, Gautam Budhha Nagar :** "The river Hindon has been a part of our lives just as Yamuna. The water quality deteriorated during last two decades. Now we don't grow crops or vegetables near to the river due to the increased level of toxicity that comes with water during monsoon season."

Image 35 : Ratan Singh Narrating His Experiences of Yamuna and Hindon River

20.7 **Ratan Singh, Tilwada Village :** "Hindon has been an important source of fresh water earlier. We would play near the river whole day. The flood plain area was more like a forest which later got converted into agricultural field with time. Now its image has changed as it brings blackish water full of pollutants. Earlier people from nearby villages used to come for fishing as the catch was plentiful. Now only few people are seen fishing as most of the fish species have vanished due to high degree of pollution. Only Maanghur (Cat fish) and Saul are found at present."

Image 36 : Dharamveer Singh of Gharbara Village Narrates His Experiences

20.8 **Dharamveer Singh, Gharbara, Gautam Buddha Nagar :** "Hindon River carries lots of pollution from Ghaziabad city and drains in Yamuna near our village. Earlier we used to consider ourselves lucky to be near the confluence of these two rivers - though there was always risk during monsoon season. Now the things have changed considerably. River bound activities such as fishing, bathing, irrigation are no more a common sight. People's interaction with river has Surface water as well as ground water quality has gone down."

Image 37 : Ashutosh Sharma, Resident Near Dhamola Nala Narrates His Experiences Living Near Drain

20.9 **Ashutosh Sharma, Kapil Vihara Colony, near Dhamola Nala, Saharanpur :** "I have been watching Dhamola Nala since chilhood. The water quality has worsened over years with its direct impact on ground water. Ground water was available at 40 ft in 1986. Now it's difficult to get good quality of ground water at 200 ft. It's original channel has been encroached at many places. Due to bottleneck affect the water backflows during monsoon and floods enter colony. Filthy odour due to high degree of pollution is another problem along with solid waste disposal by local residents."

Image 38 : Wakeel Ahmed Narrating The Past of Hindon At Titavi

20.10 **Wakeel Ahmed, Farmer, Muzaffarnagar (Underbridge over Hindon at Titavi):** "We have have grown up playing along the river. It's a part of our life memories. Unfortunately it

has changed considerably in last 20 years with decreased water level and pollution in last 10-12 years. Nanauta and Titavi sugar mill discharge their effluents directly into the river and this is what flows round the year now. River receives some fresh water during rainy season. We don't know why the river does not receive water from its upstream area anymore, earlier it used to flow round the year. When we were young, groundwater could be availed from a very shallow depth. We used to simply hit the sand with our feet in order to get fresh drinking water. Hindon was a great source of water for irrigating our fields. With increased pollution we can't use that water anymore. Now we are totally dependent on tube wells for water. The old bridge used to be a spectacle during monsoon season when people from nearby villages would come for fishing. We used to be excited by the variety of fish species and would often ask each other about the kind of fish was caught each day. There were turtles (Dhadal-paatal, kachua) and many snake species. Local fish species were Rohu, Laanchi, Kamaach, Andha, Kirad, Ghegra, Guj, Doli, Manghura etc. Now everything has changed and river flows in the form of 2-3 metres wide drain."

Image 39 : A Washerman Narrating His Problems Due Dgraded Water Quality of Hindon

20.11 **Mohd. Naseem, Washerman, Muzaffarnagar (Near Kali Drain) :** "We are seeing Kali in the same state for the last 25-30 years. Before that the water was clean and used to flow till the edges. People used to come in large numbers for fishing. There were many local fish species which nowhere found now. Now people refrain from giving us their clothes due to poor quality of water. Our daily income has decreased considerably. People get skin allergy and rashes whoever come in contact with the river water now. We are not hopeful of the river being restored to its original state any time soon".

Image 40 : Brahm Singh, A Local Farmer Narrating Past Of The River

20.12 **Brahm Singh, Farmer, Pura Mahadev, Baghpat :** "I have spent my entire life on the bank of this river and have seen it changing from a large gigantic river to a *'Nahar'* of few meters wide. Earlier there was no bridge and people used to cross river on *'Balli'* (locally made small wooden boats). We used to take contracts from government at a price of Rs 30,000 and would charge people 4 *aana* (4 cents) to cross the river. People from our village i.e. Pura Mahadev could use the service at no price. Large number of people would come to fish here from nearby villages and the spectacle was not less than a festival during monsoon. Now people rarely come to visit the river except during the annual fairs at Pura Mahadev temple when they throw large amount of ceremonial debris into the river from this bridge. The khadars of the river were very fertile where we would grow large tracts of melon crops and produce was very rich. Now people refrain from buying vegetables grown at the bank of this river due to high degree of pollution that comes from upstream areas."

Image 41 : Akmal Rahi. A Resident of Budhana Showing Condition of Hindon at Budhana

20.13 **Akmal Rahi, Resident, Budhana :** "Hindon has been an integral part of Budhana's history. Maulana Shaukat Ali Fehm in his book *'Tareekh-e-Hind'* mentions that Ram during his period of vanvaas reached Barnawa crossing through Hindon River in Budhana. It is believed that 'Nadi Wala Mandir' (Temple of the River) situated few metres downstream of bridge is the place where Ram stayed during his journey. Hindon River was one of the main sources of livelihood for many people in the past who were dependent on the melons produce and fish catch. The width of the bridge indicates how wide was the main channel of the river in the past. Now people come here to throw garbage only."

20.14 **Qazi Nadeem Ahmed, Resident, Budhana :** "Hindon River which used to be an identity for Budhana once is dying a slow death now. Besides reduced water flow round the year, it's more of a garbage disposal site now. Dumping of construction debris, solid waste, residential sewerage discharge, spread of Jalkumbhi (Hyacinth) river floodplain area encroachment are major threats surrounding this river at present. We as a part of local NGO 'Bhratiya Ekta Sangathan' want to do something to revive the river but need guidance and help of other groups already involved. I believe active and concerted participation of local citizens and government is important to keep this historical identity alive."

Image 42 :Qazi Nadeem, Showing Dumping Of Construction Waste In Hindon At Budhana

Image 43 : Parvesh Tyagi, A Resident of Ukaoli Village Discusses Problems of Groundwater

20.15 **Parvesh Tyagi, Gram Pradhan, Ukaoli, Budhana :** "Hindon River is around 1 km from our village. It was a boon for us in the past. The water was so clear that one could see the coins thrown by devotees easily. We often used to swim and catch fish in the river. Now the scenario has changed. Filth and industrial discharge flows round the year making it impossible to even pass through it. People in the village are suffering from skin allergies, digestive disorders and cancer. Two former Gram Pradhans (Village Heads) died of cancer. The condition of ground water has changed considerably. Water till the depth of 150 ft. is of bad quality and we rely on submersible pumps which pump out water from much deeper level in order to get clean drinking water."

Image 44 : Residents of Pura Mahadev Village Discussing Water Issues In Their Village

20.16 **Dharamveer Singh, Farmer, Pura Mahadev Village, Baghpat :** "Hindon River was an important feature of our village where Pura Mahadev temple stands today. Devotees used to take bath in this river but unfortunately now nobody talks about the river, not even the priests of the temple. Skin disease are common in the village. Though government has sealed several handpumps due to contaminated water, we believe each handpump in this village has the same quality of water. The groundwater turns red if kept for 10 minutes. People are dependent on RO water (water filtered by reverse osmosis systems) or submersible pumps in order to get clean drinking water"

Image 45 : A Labourer Narrating His Experiences Of The River

20.17 **Ishwar, Labourer, (Near Jani Escape-Hindon River Confluence) :** "I come here near Jani escape for fishing for the last 2 years. Water smells filthy here. I get only Moghra fish here (a kind of Catfish). Other fish species do not survive probably because of poor quality of water which comes from upstream. Also, I believe this fish comes from the water upstream and not with the water that released from Jani escape."

Image 46 : A Doctor Couple Discussing Health Issues Due To Contaminated Water In Budhana

20.18 **Dr. Yaseen Rana and Dr. Seema, Physician, Budhana :** "Hindon River is curse to Budhana. With increased water pollution and solid garbage on its bank it has become a source of diseases. Skin diseases, digestive ailments, and incurable diseases such as Hepatitis (B&C) and cancer are prevalent in the area and in nearby villages. Contaminated ground water due to polluted Hindon River is one of the main causes. We are trying our best to raise environmental awareness in the area but government should come forward and take stringent actions to curb this menace. The situation needs urgent attention as polluted water sources and solid waste dumping are causes of diseases in the area."

Image 47 : A Farmer Discussing Water Pollution Problem in Shamli

20.19 **Pawan Kumar, Farmer, Banat, Shamli (Near Krishni River) :** Farming on the dry floodplains of Krishni River near Banat village, Shamli, Pawan Kumar, a local farmer says : "The water of Krishni is so polluted that if we use it the crops die prematurely. Instead we use water of the drain that joins Krishni or water from borewell to irrigate the crops. We do not touch this water anymore as it causes allergy and skin rashes. It remains same round the year. But, 15-20 years ago the river was full of clean water".

20.20 **Summary :** The interaction with local residents, mostly from close to river banks, has a common thread and refrain. These can be summed up as follows :

- Major deterioration seems to have taken place in last 2 decades
- Absence of pollution in earlier times showed up in terms of water clarity
- That mill owners are not treating their effluents effectively
- Surface pollution is leading to groundwater contamination – handpump water is unsafe for drinking and deeper aquifer has to be tapped
- Most fish diversity has been wiped out owing to pollution and only a couple of pollution tolerant species are to be found – turtles could be found near the river
- In severely polluted locations crops and vegetable growing is avoided close to the river and purchase of vegetables grown next to the river is avoided
- Earlier the river was perennial but now the flow has declined with dry stretches
- Ritual bathing is on the decline with water contact giving rise to skin allergies
- Cancer, hepatitis and other water borne diseases are on the rise especially close to the river

21.0 Some Relevant Economic Aspects Of The Hindon Basin

21.1 With sugarcane production dominating the basin, with a major portion of the working population employed in agriculture, with major sugarcane dependent downstream industries

such as sugar mills, khandsari units, paperboard and ethanol/alcohol units, this subsector of the basin economy constitutes a powerful political lobby.

Table 47 : Total Workers, Cultivators, Agriculture Labour In The Basin

	[1]	[2]	[3]	[4]	[5]
S No.	Basin District	Cultivators	Agriculture Labour	Sugarcane Cultivators [%age of Cultivators]	Sugarcane Labour [%age of Labour]
1	**Saharanpur**	1,08,230	1,33,357	[28.4%]30,737	[28.4%]37,873
2	**Muzafarnagar**	1,68,024	1,61,820	[42.5%]71,410	[42.5%]68,773
3	**Meerut**	24,587	19,311	[33.7%]8,286	[33.7%]6,508
4	**Baghpat**	78,160	46,689	[43.4%]33,921	[43.4%]20,263
5	**Ghaziabad**	56,875	44,277	[28%]15,925	[28%]12,398
6	**GB Ngr**	17,179	11,547	-	-
	Total	**4,53,055**	**4,17,001**	**1,60,279**	**1,45,815**
[2] Derived from Census of India, 2011 and area ratio of basin to district [3] Derived from Census of India, 2011 and area ratio of basin to district [4] Derived from area under sugarcane to total cropped area X [2] [5]] Derived from area under sugarcane to total cropped area X [3]					

21.2 It can be seen from Table No. 47 that the total number of sugarcane cultivators and related labour is 306094 persons or as many families. Multiplied by a factor of 5 the total number of persons dependent on sugarcane farming is 1.5 millions or 15.3% of the basin population. This is a significant number and does not include the indirect employment by way of sugar mills, paper mills, alcohol based industry and transport. The coming mechanization of sugarcane farming is going to hurt the sugarcane labour badly. Moreover any move to curtail sugarcane farming in the basin is bound to run up against powerful political forces.

21.3 The other force at work is the real estate lobby. In previous years the proximity of Ghaziabad to Delhi has seen land prices soaring there compelling all 'vacant land' to be valued as real estate. The returns on such lands was phenomenal and thus floodplains and wetland zones were encroached upon occupied denying the river and water its due space. The same forces are operational in Gautam Budh Nagar and to some extent in Saharanpur.

21.4 All these forces are powerful enough to mould the state authorities into milking the Ganga and Yamuna incrementally for the 'prosperity' of the basin. The State Irrigation Dept. is, of course, more than a willing ally in this effort.

22.0 Hindon Rejuvenation Plan by Uttar Pradesh Government

22.1 In response to the rising pollution levels in Hindon River, Uttar Pradesh Govt. came out with Hindon Rejuvenation Plan and formed a committee comprising of officials from Irrigation and Water Resources Department, UP Pollution Control Board, District Magistrates of the basin districts. The committee had been assigned the task to coordinate with the stake holders and ensure implementation of the rejuvenation work at ground level.

The committee was also assigned the responsibility to identify locations for setting up 50 water quality monitoring stations throughout the stretch of the river from the origin to confluence with River Yamuna.

22.2 [33]Under the central govt. sponsored scheme Yamuna Action Plan (YAP) Phase-1, Rs. 159.35 crore was spent for pollution abatement works for Hindon River in four major towns: Sharanpur, Muzaffarnagar, Shamli and Meerut. The activities included diversion and treatment of sewage, low cost sanitation, improved wood crematoria, afforestation, public awareness programmes etc. A sewage treatment capacity of 269.5 million litres per day (mld) was also created.'

22.3 In July, 2015, in response to the Hindustan Times's[34] five part series- The Hindon Horror highlighting the river's pollution levels and other associated problems, the UP Government took notice and came out with the following solutions :

- Use of surveillance drone to physically examine the river.
- Diverting sewerage water away from the river.
- Construction of checkdams in upper reaches of river to ensure continuous flow in the river
- Revival of water bodies

22.4 Disrict authorities in Gautam Buddha Nagar suggested the inclusion of farmers and promotion of social forestry on flood plains. The proposed revival plan includes of the following :

- Encouraging 'social forestry' by getting locals to carry out plantation drives
- Getting farmers to plant vegetables and flowres and helping them market it with 'Hindon' label.
- Preventing encroachment along the banks and removing illegal constructions.

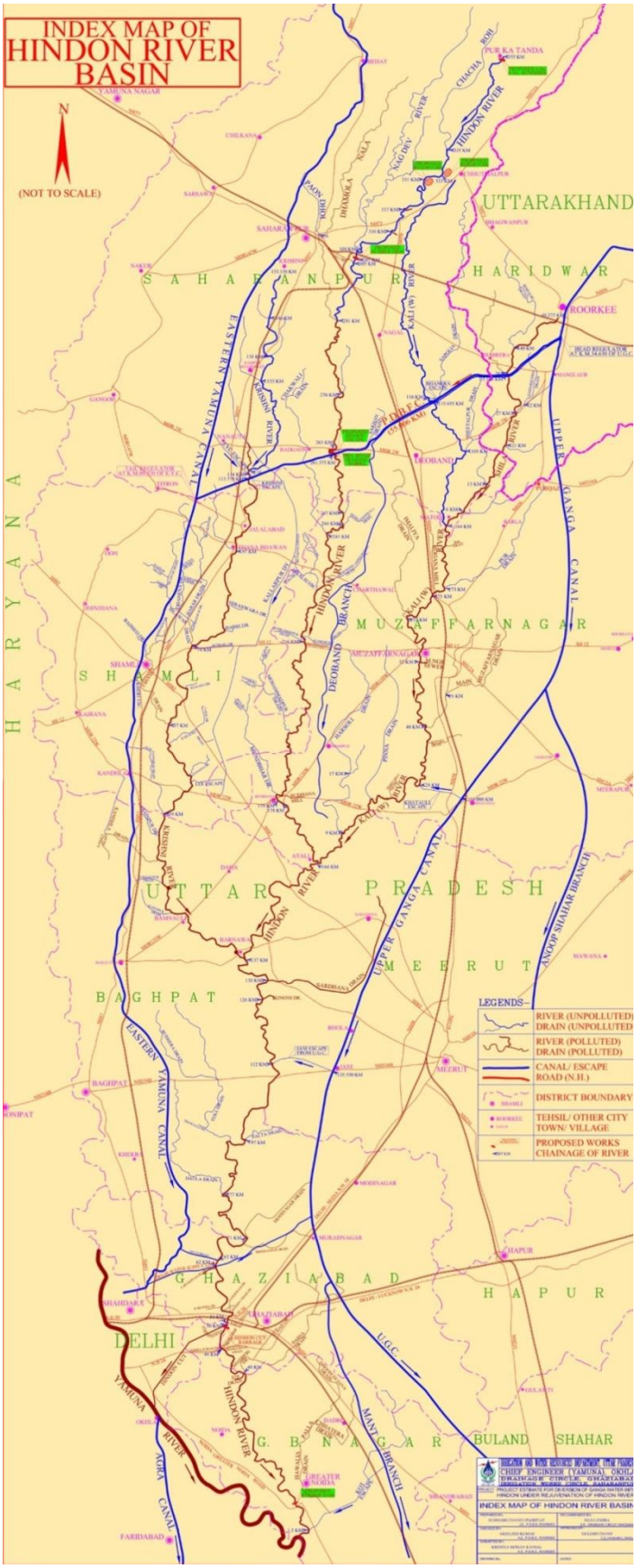
22.5 Hundred acres of Gram Sabha or pasture land lying barren and available for plantation along the river had been suggested for plantation or social forestry :

"The farmers don't perceive this land as useful. Our aim is to help them form a society and plant certain trees, vegetables and flowers that can be financially viable. The all-round development of the river bank is the main goal," — N.P. Singh, District Magistrate, Gautam Buddha Nagar, Uttar Pradesh, [The Hindu[35], 24 July, 2016]

[33] Cleaning of Hindon River. April 28, 2016 Business Standard

[34] UP govt devises all-new Hindon cleanup and revival plan, July 19, 2015 (http://www.hindustantimes.com/india/up-govt-devises-all-new-hindon-cleanup-and-revival-plan/story-SYfE1skJJHRDsLVubpu8aN.html)

[35] New plan to revive encroached, polluted Hindon. The Hindu, 24 July 2016 [http://www.thehindu.com/news/cities/Delhi/New-plan-to-revive-encroached-polluted-Hindon/article14505110.ece]



Map 40: Index Map of Hindon River Basin [I&WRD,Govt. of UP]

22.6 In furtherance of the Hindon rejuvenation plan, the Uttar Pradesh irrigation department has cleared several proposals, including construction of two reservoirs at Buddhakhera Pundhir and Jajner in Saharanpur.

"The construction of two reservoirs, estimated at Rs. 543.13 lakh, was cleared by a committee of Chief Engineers and forwarded to the state administration for financial approval. Further, we have also decided to construct four 'bandhis' (small dams) in the upper reaches of the river at Saharanpur at a cost of Rs. 193 lakh. This will help groundwater recharge in the upper reaches of the river," - CK Verma, Engineer-in-Chief of the UP Irrigation Department at Lucknow [Hindustan Times[36], June 4, 2016]

22.7 At the same time officials also cleared a proposal for construction of a rubber dam at Hasanpur in Saharanpur at a cost of nearly Rs. 3,073 lakh. They have also cleared another proposal of Rs. 2,337.57 lakh for diversion of Ganga water to Hindon and another proposal of Rs. 229.75 lakh for diversion of water to River Krishni, one of the two tributaries of Hindon. A water augmentation structure on Hindon near Noida-Greater Noida Expressway in Gautam Buddha Nagar has also been proposed at the cost of Rs. 5,679 lakh.

22.8 The Ghaziabad district administration identified 32 ponds along Hindon River for rejuvenation in four development blocks - Loni, Rajapur, Murad Nagar and Bhojpur. The move aims at providing sufficient grounwater recharge to revive the river during monsoon season.

The above-mentioned proposals are both capital intensive and completely engineering oriented. Several existing escapes have not revived Hindon's natural flow and are of doubtful efficacy with several question marks :

Should a river be revived by bleeding another river? What happens when that river is exhausted?

Why more canals and dams when the earlier ones have only led to water profligacy ? Are engineering solutions the only solutions ? Will they combat climate change ? Will they bring long lasting positive changes ?

How are ponds to be revived? Will they only be dug up – where will the water come from ?

Will tree planting along banks [is the space available?] prevent soil erosion ?

Will engineering measures bring climate change resilience to declining rainfall and rising temperatures ?

[36] Proposals cleared to rejuvenate Hindon, June 04, 2016 [http://www.hindustantimes.com/noida/proposals-cleared-to-rejuvenate-hindon/story-a1RIR0BtNKwA1CqMWnqZAI.html]

Instead of quick fixes which will only have harmful effects in the long run we need to look at catchment treatment, increasing the abysymally low forest cover, reducing area under sugar cane, increasing irrigation efficiency, increasing urban water use efficiency, recovering the flood plain, changing the very technique of farming to remove chemical inputs and halve the water input.

Chapter II – Biodiversity In And Along Hindon River

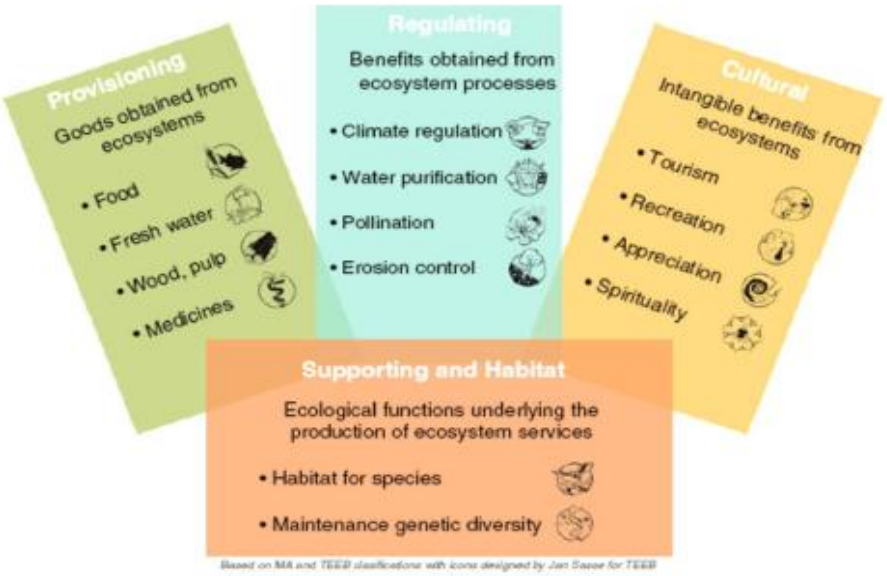
1.0 Biodiversity refers to the totality of genes, species and ecosystem of a region. It is essential for human survival and economic well-being, and plays a prominent role in modulating ecosystem function and stability. The UN Convention on Biological diversity defines biodiversity as "the variability among living organisms from all sources, including *inter alia*, terrestrial, marine and other aquatic ecosystem and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" **(UNEP 1992)[1].**

2.0 Biodiversity varies with changes in latitude or altitude. Latitude represents a geographical gradient including multiple communities as influenced by climatic and environmental conditions. As we move from high to low latitudes, the biological diversity increases. The pattern can be seen in terrestrial, marine and freshwater habitats **(Gaston 2000)[2].**

3.0 With increasing human domination of earth's ecosystems, natural resources are declining in both quantity and quality on a global scale. Nearly half of the earth surface has been transformed by human enterprises, such as agriculture, industry and commerce. Organisms are required for the proper functioning of the earth's ecosystems. Loss of biodiversity would check the evolutionary capability of biota to cope up with environmental changes. Biodiversity loss is now one of the world's most pressing crises. Habitat destruction, over exploitation, pollution and species introduction are the major cause of biodiversity loss **(UNEP 2001a and 2001c)[3].** N-deposition and CO2 loading of atmosphere are among the factors expected to accelerate biodiversity loss in future.

4.0 River biodiversity studies in the country are notoriously rare or are confined to the realm of academic purposes. Reduced water flow, polluted waters, climate changes, vanishing forests, fragmented habitats all come together to reduce eco-system services in all aspects such as provisioning, regulating, supporting and cultural.

1. UNEP (United Nations Environmental Programme). 1992. Convention on Biological Diversity, NA 92-7807, June5, 1992, New York.
2. Gaston, K.J. 2000. Global pattern in biodiversity. Nature 405: 220-227
3 UNEP (United Nations Environmental Programme). 2001a. India: State of Environment2001, UNEP Regional Resource Centre for Asia and the Pacific, UNEP/RRC. AP, Thailand.
UNEP (United Nations Environmental Programme). 2001c. India: An assessment of the status of the World's remaining closed forests. UNEP/DEWA/TR. 01-2. Nairobi, UNEP.



5.0 Biodiversity assessment indicates the nature and place for policy interventions and at subsequent stages offers clear indication of the health of the system. As mentioned in previous chapter, the Hindon river runs from the western districts of Uttar Pradesh viz. Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad, Noida and finally it meets the Yamuna outside Delhi. For Biodiversity assessment 8 accessible sites were chosen along the main stem of Hindon in which Kaluwala Rao (in the uppermost catchment of the river), Gagalhedi and Maheshpur in Saharanpur district, Titavi in Muzaffarnagar, Baparsi in Baghpat, Valmiki Ashram in Meerut, Hindon cut in Ghaziabad and Tilwada in Gautam Buddha Nagar. As has already been noted the forest cover in Hindon Basin is less than 2% and that too of poor quality. Central Pollution Control Board (CPCB)[37] during the development and testing of bio-monitoring methodology in collaboration with Dutch experts has established that the inclusion of bio-monitoring parameters, apart from physicochemical parameters, in water quality monitoring network will enhance the quality evaluation in a cost-effective manner. Among all the biotic components of river, the benthic macro-invertebrates have been considered as the most suitable biological parameter for water quality evaluation. As per the report, Hindon in upper stretches was moderately polluted (Class C) while heavily polluted (Class D) in Muzaffarnagar, Shamli to Muzafarnagar and Saharanpur to Barnawal stretches and severely polluted (Class E) in Surana upstream of Ghaziabad and Shamli – Muzaffarnagar region. These were indicated by macro invertebrates as given in table below:

Table 48: Taxa/Families of Benthic Macro-invertebrates From Tributaries of Yamuna Basin

CLASS C	EPHEMEROPTERA, PLECOPTERA, TRICHOPTERA, ODONATA/ families MOLLUSCA/Viviparidae, Unionidae, Bithynidae, Thiaridae,Lymnaeidae, Planorbidae,Physidae,

[37] Bio-Mapping of Rivers, March 1999; Bio-Mapping Of River Basin - A Case Study On River Yamuna, CPCB

	Sphaeridae, Hydrobiidae, Valvatidae, POLYCHAETA/Nephthyidae, Nereidae HEMIPTERA/Naucoridae, Nepidae, Hydrometridae, Belostomatidae, Pleidae, Corixidae, Gerridae, Notonectidae COLEOPTERA/Dytiscidae, Elminthidae, Psephenidae, Hygrobiidae, Hydrophilidae, Haliplidae, Gyrinidae, Dryopidae CRUSTACEA/Gammaridae, Asellidae, Atydae, Grabsidae DIPTERA/Simulidae, Tipulidae, Ephidridae, Tabanidae, Chironomidae HIRUDINEA/Erpobdellidae, Glossiphonidae OLIGOCHAETA/All families
CLASS D	MOLLUSCA, HEMIPTERA COLEOPTERA OLIGOCHAETA, DIPTERA/All families
CLASS E	DIPTERA/Chironomidae, Syrphidae, OLIGOCHAETA/All families

6.0 We sampled and analysed water samples from Hindon barrage area, the key parameters that were analysed were chemical oxygen demand (COD), biological oxygen demand (BOD) and bioassay. As the river quality has previously been recorded to be Class E, here a few significant parameters were undertaken. The COD and BOD values were 262 mg/lt and 85 mg/lt. respectively. **Bioassay test reported 0% survival of fish after 96 hours. (See Report in Annexure-6)** Bioassay is a aquatic toxicity test. The results show that river water at this location are highly toxic, this is detrimental for survival of aquatic organisms, and therefore for conservation of aquatic biodiversity.

7.0 Uttar Pradesh has forest and tree cover of 21720 sq. km, which is 9.01% of its geographical area. There are about 2,711 species of Angiosperms belonging to 1,088 genera and 185 families found in Uttar Pradesh[38]. The existing flora in Uttar Pradesh can be classified into three categories-

1. Wet tropical desiduous forests.
2. Dry tropical desiduous forests.
3. Tropical throny forests.

According to Assessment of district-wise Forest Cover (as per assessment in 2013-2014), the status of forest cover in these districts are: -

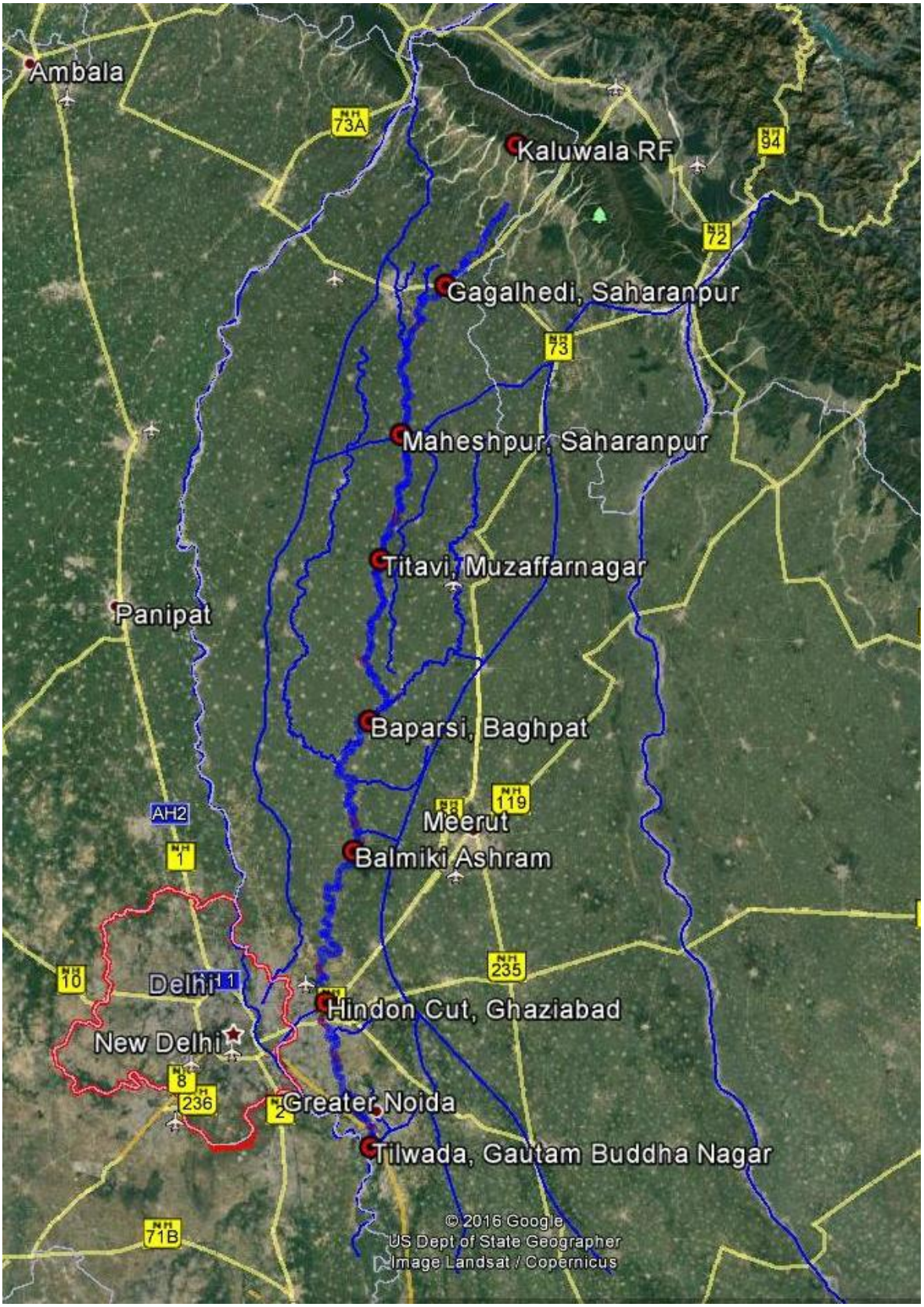
[38] Malik V. The conservation status of Derris scandens (Roxb.) Benth. var. saharanpurensis (Thoth.) Thoth. (Fabaceae), a climber endemic to Saharanpur, Uttar Pradesh, India.
DOI: http://dx.doi.org/10.11609/jott.2820.8.5.8837-8840

Table 49: District-wise Forest Cover in Catchment Districts (as per assessment in 2013-2014)

District	Geographical Area	2013-14 Assessment (Area in Km^2)			
		Very Dense Forest	Moderate Dense Forest	Open Forest	Total
Saharanpur	3689	0	175	200	375
Muzaffarnagar	4008	0	14	27	41
Bagpat	1321	0	5	13	18
Meerut	2590	0	34	32	66
Ghaziabad	2590	0	18	31	49
Gautam Budh Nagar	1442	0	12	24	36

Source: - http://upenvis.nic.in/Database/Forest_838.aspx (*FSI Report 2015)*

8.0 Khadirs and forest areas of Ganges, Jumna and Hindon used to be home to lot of wildlife species. District Gazetteers of Meerut (1922), Muzaffarnagar (1980) and Saharanpur (1981) note the presence of tiger, leopard, antelope, nil gai, fox, wild pig, wolf, jackal, porcupine, hare and monkey. District Gazetteer of Meerut (1922) mentions that leopards were fairly common in the Khadir of Ganges and ravines of the uplands. Pigsticking was a popular sport in Meerut district where a well known annual Khadir-Cup meeting used to take place during March or April and attracted people from all over. Resident as well as migratory game birds used to flock in large numbers. District Gazetteer of Meerut (1922) mentions the presence of a large number of Wild Duck and Teals in places along Burhganga, Hindon and Jumna and in many large size Jhils (seasonal waterbodies) in the interior. Grey Patridge, Quail, Blue Rock Pegions were abundant. Sandgrouse was plentiful in certain seasons and occurred chiefly in the khadirs of Mawana, Hapur and Ghaziabad. There were also occasional sightings of floricans. A brief representation of flora (herbs, shrubs and trees) and fauna (mammals, birds and insects) is described below.



Map 41: Map Highlighting Biodiversity Assessment Sites on Hindon River

Study Site I - Kaluwala Rao, Saharanpur Distt.

9.0 The Saharanpur district comes under Saharanpur forest division. It lies in the upper Indo-gangetic plain. Saharanpur district is located at 2958'N & 7733'E. The study is conducted in mountain ecosystem of the lower Himalayas i.e. in and around Kaluwala Rao Reserve forest near Kaluwala Rao stream (Kaluwala Rao stream is a part of Hindon river). Landform Characteristics of the study area speaks too much about the morphogenesis means development of different fluvial landform due to tectonic activity in the region. These morphogenesis features witness the past history of landform development in the region.

a) FLORA

Table 50: Tree Species Observed At Kaluwala Rao, Saharanpur

S. No.	Species	Common Name	Family
1.	*Shorea robusta*	Sal	Dipterocarpaceae
2.	*Bombax ciliata*	Silk Cotton Tree	Bombacaceae
3.	*Dalbergia sisso*	Shisham	Fabaceae
4.	*Tectona grandis*	Teak	Rhamnaceae
5.	*Murraya koenigii*	Curry Tree	Rutaceae
6.	*Azadirachta indica*	Neem	Meliaceae
7.	*Syzygium cumini*	Jamun	Myrtaceae
8.	*Albizia lebbeck*	Siris	Fabaceae
9.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae

Image 48: Silk Cotton Tree Plantation Leading to Kaluwala Rao Stream [Towards West; 19/01/2017]

Table 51: List of Herbs/Shrubs

S. No.	Species	Common Name	Family	Frequency	% Frequency	Relative Frequency
1.	*Corchorus spp.*	Wild Jute	Malvaceae	0.2	20	2.17
2.	*Adathoda vasica*	Vasaka	Acanthaceae	0.4	40	4.35
3.	*Hyptis suaveolens*	Bushmint	Lamiaceae	1	100	10.87
4.	*Abrus precatorius*	Crab Eye Creeper	Fabaceae	0.4	40	4.35
5.	*Dhatura innoxia*	Dhatura	Solanaceae	0.6	60	6.52
6.	*Lantana camara*	Common Lantana	Verbenaceae	1	100	10.87
7.	*Senna spp.*	Kasunda	Fabaceae	0.8	80	8.70
8.	*Argemone mexicana*	Mexican Poppy	Papaveraceae	0.6	60	6.52
9.	*Solanum xanthocarpum*	Yellow Berried Nightshade	Solanaceae	0.6	60	6.52
10.	*Ageratum houstonianum*	Flossflower	Asteraceae	0.8	80	8.70
11.	*Stellaria media*	Chickweed	Caryophyllaceae	0.4	40	4.35
12.	*Malva parviflora*	Cheeseweed	Malvaceae	0.4	40	4.35
13.	*Sacharaum spontaneum*	Wild Sugarcane	Poaceae	1	100	10.87
14.	*Calotropis procera*	Aak or Rubber Bush	Apocynaceae	0.6	60	6.52
15.	*Cactus spp.*	Cactus	Cactaceae	0.4	40	4.35

Raunkier's (1934) five Frequency classes

Frequency %	Frequency class
0-20	A
21-40	B
41-60	C
61-80	D
81-100	E

$Law\ of\ frequency = A > B > C >=< D < E$

- It means that the species with poor dispersion of frequencies are higher in number than the number of species with higher frequency values.
- In Biotically Disturbed sites the frequency structure is different from the normal.

10.0 The studied area does not follow the law of frequency (Normal condition). The result (A<B>C<D<E) reveals that the area is biotically disturbed. *Hyptis, Lantana, Senna, Ageratum, and Saccharum spontaneum species* with relative frequency 10.87, 8.70, 8.70 and 10.87 dominated the landscape. The groundcover was largely composed of *Cynodon dactylon* (Bermuda grass) and some other species of grass.

11.0 The Presence of opportunistic invasive species like *Hyptis suaveolens*, *Argemone Mexicana, Lantana camera* are showing major impact on the vegetation of the studied area. The introduction of invasive species may lead to the loss of species diversity, increase riparian erosion and also affect the physical structure of the habitat. Although large number of exotic species have become naturalized in India and have affected the distribution of native flora to some extent only a few have conspicuously altered the vegetation patterns of the country.

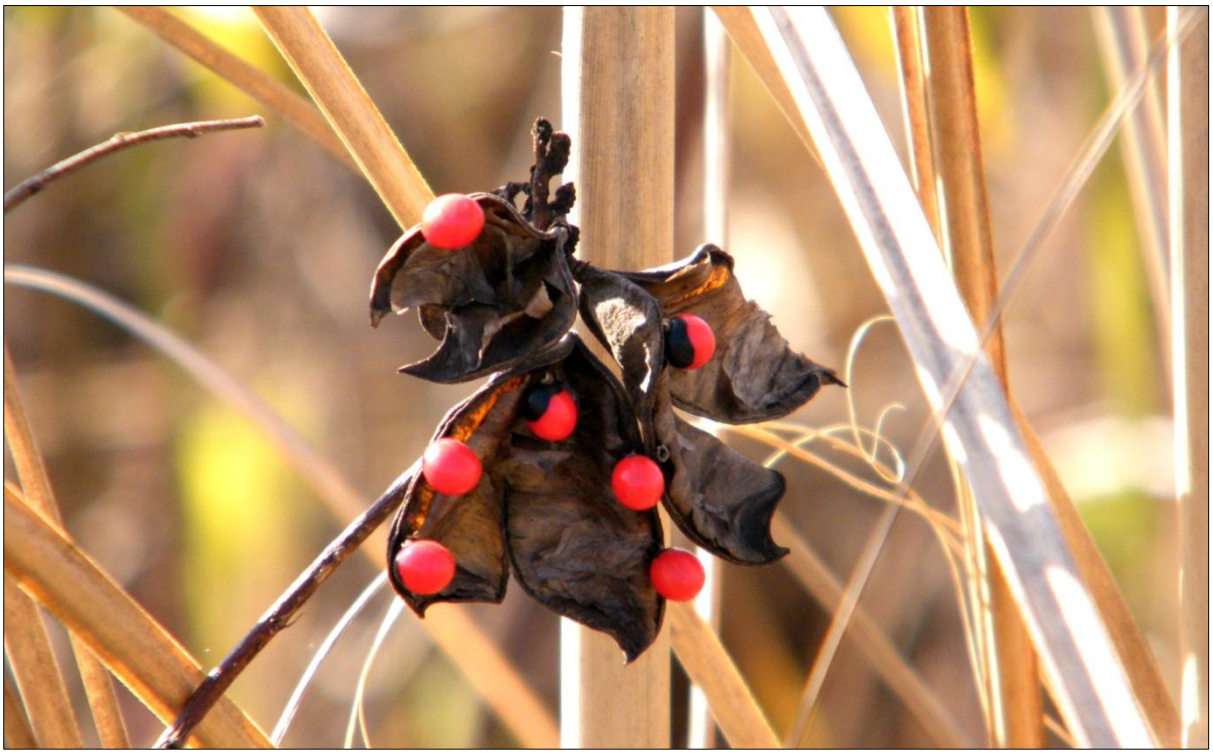


Image 49: Pods of *Abrus precatorius* Plant

b) FAUNA

11.0 During the study period Common fauna sighted includes Rhesus Macaque (*Macaca Mullata*), Gray Langur (*Semnopithecus hector*), Indian Grey Mongoose (*Herpestes edwardsii*), Indian Palm Squirrel (*Funambulus palmarum*)), Sambhar Deer (*Rusa unicolor*), Chital (*Axis axis*). Other fauna regularly encountered by local people includes Indian Monitor Lizard (*Varanus bengalensis*), Common Leopard (*Panthera pardus*), Indian Wolf (*Canis lupus pallipes*), Jungle cat (*Felis chaus*).

12.0 The following birds were sighted during the study period.

Table 52: List of Birds

S. No.	Species	Scientific Name
1.	Indian roller	*Coracias benghalensis*
2.	Black Kite	*Milvus migrans*
3.	Green Bee-eater	*Merops orientalis*
4.	Asian Koel	*Eudynamys scolopacea*
5.	Purple Sunbird	*Cinnyris asiaticus*
6.	Red-vented Bulbul	*Pycnonotus cafer*
7.	Blackwinged Stilt	*Himantopus himantopus*
8.	Yellow-wattled Lapwing	*Vanellus malabaricus*
9.	Oriental Magpie Robin	*Copsychus saularis*
10.	Cattle Egret	*Bubulcus ibis*
11.	Grey Heron	*Ardea cinerea*
12.	Great Cormorant	*Phalacrocorax carbo*
13.	Jungle Babbler	*Turdoides striatus*
14.	White-throated Kingfisher	*Halcyon smyrmensis*
15.	Black Drongo	*Dicrurus macrocercus*
16.	Asian pied Myna	*Gracupica contra*
17.	Brown Rockchat	*Cercomela fusca*
18.	Shikra	*Accipiter badius*
19.	Rose ringed Parakeet	*Psittakula krameri*
20.	Jungle Babbler	*Turdoides striatus*
21.	Egyptian Vulture	*Neophron percnopterus*

Image 50: Indian Roller (Coracias benghalensis)[Date: 19/01/2017]

The Indian Roller

The Indian Roller, also known as Blue Jay is one of the India's most familiar birds. Although still widespread in our area it seems to have declined recently as a breeding species. The main reason for its familiarity is its habit of perching openly often along roadsides. From its perch it will catch insects in flight or pounce on them, as well as small reptiles and rodents, on the ground. Since it feeds mainly on large insects, it is possible that, with more intensive agriculture, the use of poisonous pesticides is the cause of the decline in the breeding birds. The loss of suitable nesting trees is certainly also a contributory factor.

Image 51: Egyptian Vulture Sighted near Dry Stream at Kaluwala [Date: 19/01/2017]

Image 52: Indian Gray Langur (*Semnopithecus hector*) in Mohand Forest Range (Kaluwala Rao) [Date: 19/01/2017]

Image 53: Garra Spp. Fishlings Sighted at Kalauwala Rao in Mohand Forest Range

Study Site II- Gagalheri, Saharanpur Distt.

a) FLORA

Table 53: Tree Species Observed

S. No.	Species	Common Name	Family
1.	*Eucalyptus spp.*	Safeda	Myrtaceae
2.	*Dalbergia sissoo*	Shisham	Fabaceae
3.	*Ficus religiosa*	Peepal	Moraceae
4.	*Ziziphus mummularia*	Ber	Rhamnaceae
5.	*Prosopis juliflora*	Vilaiti Keekar	Fabaceae
6.	*Mangifera indica*	Mango	Anacardiaceae
7.	*Azadirachta indica*	Neem	Meliaceae
8.	*Syzygium cumini*	Jamun	Myrtaceae
9.	*Albizia lebbeck*	Siris	Fabaceae
10.	*Buhinia purpurea*	Kaniar	Leguminaceae
11.	*Morus alba*	White Mulberry	Moraceae
12.	*Albizzia lebbeck*	Siris	Fabaceae
13.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae

Table 54: List of Herbs/Shrubs

S. No.	Species	Common Name	Family	Frequency	% Frequency	Relative Frequency
1.	*Ageratum spp.*	Flossflower	Asteraceae	0.8	80	11.76
2.	*Adathoda vasica*	Vasaka	Acanthaceae	0.4	40	5.88
3.	*Argemone mexicana*	Mexican Poppy	Papaveraceae	1	100	14.71
4.	*Dhatura innoxia*	Dhatura	Solanaceae	0.4	40	5.88
5.	*Lantana camara*	Common Lantana	Verbenaceae	0.6	60	8.82
6.	*Senna Sophera*	Kasunda	Fabaceae	0.4	40	5.88
7.	*Malva parviflora*	Cheeseweed	Malvaceae	0.4	40	5.88
8.	*Stellaria media*	Chickweed	Caryophyllaceae	0.2	20	2.94
9.	*Anagallis arvensis*	Scarlet Pimpernel	Primulaceae	0.2	20	2.94
10.	*Abutilon indicum*	Country Mallow	Malvaceae	0.8	80	11.76
11.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae	0.4	40	5.88
12.	*Achyranthes aspera*	Chirchita	Amaranthaceae	0.8	80	11.76
13.	*Sacharaum spontaneum*	Wild Sugarcane	Poaceae	0.2	20	2.94
14.	*Calotropis procera*	Aak or Rubber Bush	Apocynaceae	0.2	20	2.94

13.0 The studied area does not follow the law of frequency (Normal condition). The result (A<B>C<D>E) reveals that the area is biotically disturbed. Common herb and shrub species observed in the landscape were *Argemone mexicana, Calotropis procera, Achyranthes aspera, Ricinus communis, Sacharaum spontaneum, Malva parviflora* and *Ageratum spp.* The groundcover was largely composed of *Cynodon dactylon* (Bermuda grass) and some other species of grass.

14.0 The use of seed oil of species *ricinus communis* in India has been documented since 2000 BC in lamps and in local medicine as a laxative, purgative, and cathartic in Unani, Ayurvedic and other ethnomedical systems. Traditional Ayurvedic medicine considers castor oil the king of medicine for curing arthritic diseases. The seed contains ricin, a water soluble toxin, which is present in lower concentrations throughout the plant.

b) FAUNA

15.0 Common fauna includes Indian Grey Mongoose (Herpestes edwardsii), Indian Monitor Lizard (*Varanus bengalensis*), Garden Lizard (*Calotes versicolor*), Indian Palm Squirrel (*Funambulus palmarum*), Indian Jackal (*Canis aureus indicus*) and Rhesus macaque (*Macaca mulatta*). Various species of snakes have also been sighted in agriculture fields by farmers. Species of grasshoppers, dragonflies, leaf insects have also been observed during the survey. Local people also mentioned the presence of Indian Flapshell Turtle (*Lissemys punctata*) in the nearby waterbodies as well as river 10-15 years ago.

16.0 The following birds were sighted during the study period :

Table 55: List of Birds

S. No.	Species	Scientific Name
1.	Jungle Babbler	*Turdoides striatus*
2.	Common Hoope	*Upopa epops*
3.	Rock Pegion	*Columba livia*
4.	Black Kite	*Milvus migrans*
5.	Indian Robin	*Saxicoloides fulicatus*
6.	Green Bee-eater	*Merops orientalis*
7.	Asian Koel	*Eudynamys scolopacea*
8.	Purple Sunbird	*Cinnyris asiaticus*
9.	House Sparrow	*Passer domesticus*
10.	Little Cormorant	*Phalacrocorax niger*
11.	White-throated Kingfisher	*Halcyon smyrmensis*
12.	Red-vented Bulbul	*Pycnonotus cafer*
13.	Oriental Magpie Robin	*Copsychus saularis*
14.	Common Myna	*Acridotheres tristis*
15.	White-browed Wagtail	*Motacilla maderaspatensis*
16.	Red-wattled Lapwing	*Vanellus indicus*
17.	Whitebreasted Waterhen	*Amaurornis phoenicurus*
18.	Blackwinged Stilt	*Himantopus himantopus*
19.	Black Ibis	*Pseubidis papillosa*
20.	Cattle Egret	*Bubulcus ibis*
21.	Grey Heron	*Ardea cinerea*
22.	Great Cormorant	*Phalacrocorax carbo*

Image 54: White breasted Kingfisher (*Halcyon smyrnensis*) near Hindon River at Gagalhedi, Saharanpur [Date:09/08/2016]

White breasted Kingfisher or White throated Kingfisher (*Halcyon smyrnensis*)

It is very common and widespread breeding resident in our area. One of the reasons for its success is that it is by no means restricted to water, although every wetland down to the smallest village pond will probably be inhabibated by a pair. It can also be found in open woodland, parks and gardens, along roads and agricultural land. It perches on bare branches of trees, posts and especially wires so it is one of the most familiar birds to observant drivers.

It feeds mainly mainly by pounching on large insects, small reptiles and rodents on the ground. It sometimes takes small birds particularly young fledglings.bit will also take fish by diving from perch but strangely this is rarely observed.

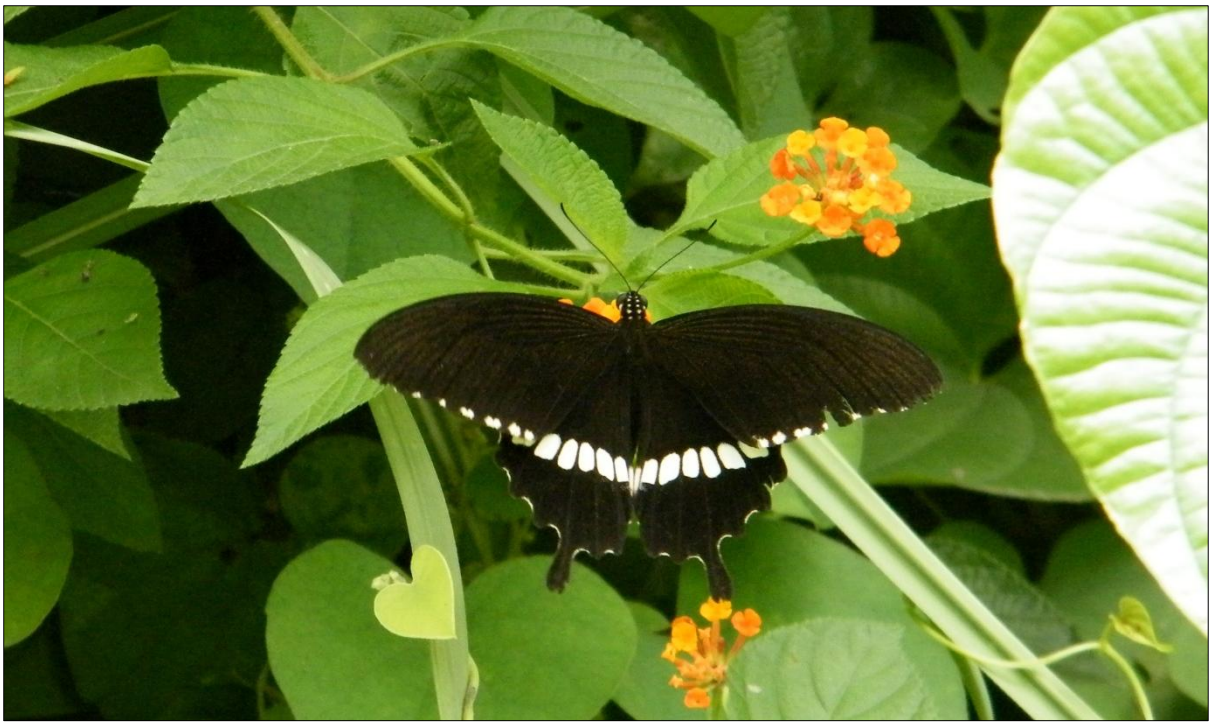


Image 55: Common Mormon Butterfly (*Papilio polytes*) on Lantana vegetation near Hindon River at Gagalhedi, Saharanpur [Date: 09/08/2016]

Study Site III - Maheshpur, Saharanpur Distt.

a) FLORA

Table 56: Trees Observed

S. No.	Species	Common Name	Family
1.	*Azadirachta indica*	Neem	Meliaceae
2.	*Morus alba*	White Mulberry	Moraceae
3.	*Albizzia lebbeck*	Siris	Fabaceae
4.	*Eucalyptus spp.*	Safeda	Myrtaceae
5.	*Mangifera indica*	Mango	Anacardiaceae
6.	*Populus spp.*	Poplar tree	Salicaceae
7.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae

Table 57: List of Herbs/Shrubs

S. No.	Species	Common Name	Family	Frequency	Relative Frequency
1.	*Parthenium hysterophorus*	Congress Grass	Asteraceae	0.5	16.67
2.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae	0.3	10.00

3.	*Abutilon indicum*	Country Mallow	Malvaceae	0.2	6.67
4.	*Solanum indicum*	Common Indian Nightshade	Solanaceae	0.2	6.67
5.	*Calotropis procera*	Aak or Rubber Bush	Apocynaceae	0.3	10.00
6.	*Pergularia daemia*	Pergularia	Asclepiadaceae	0.2	6.67
7.	*Achyranthes aspera*	Chrichita	Amaranthaceae	0.5	16.67
8.	*Sacharum spontaneum*	Wild Sugarcane	Poaceae	0.2	6.67
9.	*Mazus pumilus*	Asian Mazus,	Scrophulariaceae	0.1	3.33
10.	*Ipomea aquatica*	Water Spinach	Convolvulaceae	0.2	6.67
11.	*Cyperus rotundus*	Nut Grass	Cyperaceae	0.2	6.67
12.	*Sonchus oleraceus*	Common Sowthistle	Asteraceae	0.1	3.33

17.0 *Parthenium hysterophorus, Ricinus communis, Calotropis procera, Achyranthes aspera* were major species with relative frequency 16.67, 10.00, 10.00 and 16.67 respectively. The ground cover was composed of Dhoob (*Cynodon Dactylon*) and some members of sedges (Cyperaceae). Congress Grass was dominant (*Parthenium hysterophorus*) among the community. There are Poplar trees on the edge of the river in the agricultural fields. There is noticeable farming and cultivation of such trees in Hindon River bed at this site. The riparian vegetation cover is very less.

18.0 *Parthenium hysterophorus* is absent in Kaluwala Rao and Gagalheri of Saharanpur district. But its presence in Maheshpur shows the invasion of alien species. Parthenium shows the allelopathy thus, it restricts the growth of other species.

Image 56: Poplar Trees Along The Bank Of Hindon River At Maheshpur , Saharanpur

b) FAUNA

19.0 During the field visit Garden Lizard (*Calotes versicolor*), Indian Palm Squirrel (*Funambulus palmarum*) and Rhesus macaque (*Macaca mulatta*) were sighted. As per information conveyed by local people and farmers Indian Jackal (*Canis aureus indicus*) and Indian Hare (*Lepus nigricolli*) frequent the agricultural fields. Presence of Indian Monitor Lizard has also been confirmed. Presence of any turtle or fish species in the river could not be ascertained.

20.0 Various insects species sighted during the survey belonged to the group Butterflies and Moths (Order: Lepidoptera)- Blue Tiger, Plain Tiger and White Orange Tip, Indian Palm Bob butterflies; Grasshoppers and Crickets (Order: Orthoptera), Dragonflies and Damselflies (Order: Odonata)- Coral-Tailed Cloud Wing and Coromandel Marsh Dart were sighted; True Bug (Order: Hemiptera) - Assassin bug was sighted.

21.0The following birds were sighted during the study period.

Table 58: List of Birds

S. No.	Species	Scientific Name
1.	Indian Robin	*Saxicoloides fulicatus*

2.	Blackwinged Stilt	*Himantopus himantopus*
3.	Red-wattled Lapwing	*Vanellus indicus*
4.	Black Kite	*Milvus migrans*
5.	Purple Sunbird	*Cinnyris asiaticus*
6.	Green Bee-eater	*Merops orientalis*
7.	Asian Koel	*Eudynamys scolopacea*
8.	Jungle Babbler	*Turdoides striatus*
9.	House Sparrow	*Passer domesticus*
10.	Common Myna	*Acridotheres tristis*
11.	White-throated Kingfisher	*Halcyon smyrmensis*
12.	Red-vented Bulbul	*Pycnonotus cafer*
13.	Cattle Egret	*Bubulcus ibis*
14.	Common Hoope	*Upopa epops*
15.	White-browed Wagtail	*Motacilla maderaspatensis*
16.	Shikra	*Accipiter badius*

Image 57: Black-winged Stilt at Hindon Bank near Maheshpur [Date: 10/08/2016]

Image 58: Soil Insects Sighted Near Bank of Hindon at Maheshpur [Date: 10/08/2016]

Image 59: Common Leopard Butterfly (*Phalanta phalantha*) Sighted Near Bank of Hindon at Maheshpur [Date: 10/08/2016]

Study Site IV - Titavi, Muzaffarnagar Distt.

a) FLORA

Table 59: Tree Species Observed

S. No.	Species	Common Name	Family
1.	*Eucalyptus spp.*	Safeda	Myrtaceae
2.	*Dalbergia sissoo*	Shisham	Fabaceae
3.	*Ficus religiosa*	Peepal	Moraceae
4.	*Ziziphus mummularia*	Ber	Rhamnaceae
5.	*Prosopis juliflora*	Vilaiti Keekar	Fabaceae
6.	*Mangifera indica*	Mango	Anacardiaceae
7.	*Azadirachta indica*	Neem	Meliaceae
8.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae
9.	*Albizia lebbeck*	Siris	Fabaceae
10.	*Syzygium cumini*	Jamun	Myrtaceae

Table 60: List of Herbs/Shrubs

S. No.	**Species**	**Common Name**	**Family**
1.	*Parthenium hysterophorus*	Congress Grass	Asteraceae
2.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae
3.	*Abutilon indicum*	Country Mallow	Malvaceae
4.	*Solanum indicum*	Common Indian Nightshade	Solanaceae
5.	*Sonchus oleraceus*	Common Sowthistle	Asteraceae
6.	*Pergularia daemia*	Pergularia	Asclepiadaceae
7.	*Achyranthes aspera*	Chrichita	Amaranthaceae
8.	*Sacharum spontaneum*	Wild Sugarcane	Poaceae
9.	*Ipomea aquatic*	Water Spinach	Convolvulaceae
10.	*Solanum indicum*	Common Indian Nightshade	Solanaceae

22.0 Dominant observed her/shrub species were *Parthenium hysterophorus, Ricinus communis, Achyranthes aspera.* The ground cover was composed of Dhoob (*Cynodon Dactylon*) and some other members of sedges (Cyperaceae).

b) FAUNA

23.0 Only Indian Palm Squirrel (*Funambulus palmarum*) was sighted during the field visit. Indian Jackal (*Canis aureus indicus*), Indian Monitor Lizard (*Varanus bengalensis*), Indian Hare (*Lepus nigricolli*) have been sighted by the local people. Presence of any turtle or fish species in the river could not be ascertained. Various insects species sighted during

the survey belonged to the group Butterflies and Moths (Order: Lepidoptera)- Plain Tiger butterfly; Grasshoppers and Crickets (Order: Orthoptera), Dragonflies and Damselflies (Order: Odonata)- True Bug (Order: Hemiptera)

24.0 The following birds were sighted during the study period.

Table 61: List of Birds

S No.	Species	Scientific Name
1.	House Sparrow	*Passer domesticus*
2.	White-throated Kingfisher	*Halcyon smyrmensis*
3.	Cattle Egret	*Bubulcus ibis*
4.	Blackwinged Stilt	*Himantopus himantopus*
5.	Red-vented Bulbul	*Pycnonotus cafer*
6.	Oriental Magpie Robin	*Copsychus saularis*
7.	Red-wattled Lapwing	*Vanellus indicus*
8.	Green Bee-eater	*Merops orientalis*
9.	Indian Robin	*Copsychus fulicatus*
10.	Yellow Wagtail	*Motacilla flava*
11.	Great Cormorant	*Phalacrocorax carbo*
12.	Indian Darter	*Anhinga melanogaster*
13.	Oriental Dove	*Streptopelia orientalis*
14.	Citrine Wagtail	*Motacilla citreola*
15.	Indian Pond Heron	*Ardeola grayii*
16.	Rock Pegion	*Columba livia*
17.	Laughing Dove	*Streptopelia senegalensis*

Image 60: Black Kite Sighted at Titavi Area [Date: 09/08/2016]

Image 61: Blue Pansy Butterfly (*Junonia orithya*) Sighted at Titavi Area [Date: 09/08/2016]

Study Site V - Baparsi, Baghpat

a) FLORA

Table 62: Tree Species Observed

S. No.	Species	Common Name	Family
1.	*Dalbergia sisso*	Shisham	Fabaceae
2.	*Ziziphus mummularia*	Ber	Rhamnaceae
3.	*Prosopis juliflora*	Vilaiti Kikar	Fabaceae
4.	*Mangifera indica*	Mango	Anacardiaceae
5.	*Azadirachta indica*	Neem	Meliaceae
6.	*Syzygium cumini*	Jamun	Myrtaceae
7.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae
8.	*Ailanthus excelsa*	Mahaneem	Simaroubaceae

Table 63: List of Herbs/Shrubs

S. No.	Species	Common Name	Family	Frequency	Relative Frequency
1.	*Sonchus oleraceus*	Common Sowthistle	Asteraceae	0.6	6.25
2.	*Calotropis procera*	Aak or Rubber Bush	Apocynaceae	1	10.42
3.	*Saccharum spontaneum*	Sugarcane Grass	Poaceae	0.4	4.17
4.	*Achyranthes aspera*	Chirchita	Amaranthaceae	0.6	6.25
5.	*Adathoda vasica*	Vasaka	Acanthaceae	1	10.42
6.	*Lantana camara*	Common Lantana/Wild Sage	Verbenaceae	1	10.42
7.	*Cassia occidentalis*	Coffee Senna	Caesalpiniaceae	0.4	4.17
8.	*Abutilon indicum*	Country Mallow	Malvaceae	0.4	4.17
9.	*Ageratum conyzoides*	Goatweed	Asteraceae	0.8	8.33
10.	*Dhatura innoxia*	Dhatura	Solanaceae	0.4	4.17
11.	*Ipomea aquatica*	Water Spinach	Convolvulaceae	0.4	4.17
12.	*Argemone mexicana*	Mexican Poppy	Papaveraceae	0.6	6.25
13.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae	1	10.42
14.	*Zizyphus mummularia*	Jhar Beri	Rhamnaceae	1	10.42

25.0 Major shrub/herb species observed are *Calotropis procera, Ricinus communis, Adathoda vasica Ageratum conyzoides and Zizyphus mummularia* with relative frequency 10.42,

10.42, 10.42, 8.33 and 10.42 respectively. Patches of *Saccharum spontaneum* and *Zizyphus mummularia* were abundant. A few trees of Mahaneem (*Ailanthus excelsa*) and Vilaiti kikar (*Prosopis juliflora*) were also observed on the right bank of the river. Riparian vegetation is sparse and like most other places agriculture fields have been extended in to the main river bed.

Image 62: Mahaneem (*Ailenthus excelsa*) on Hindon Bank at Baparsi, Baghpat

Image 63: Weaver Birds' Nests on Vialiti Keekar (*Prosopis juliflora*) at Hindon Bank, Baparsi, Baghpat

b) FAUNA

27.0 As per information conveyed by local farmers, Rhesus macaque (*Macaca mulatta*), Indian Jackal (*Canis aureus indicus*), Indian Monitor Lizard (*Varanus bengalensis*), Indian Hare (*Lepus nigricolli*), Nilgai (*Boselaphus tragocamelus*) are present in the area. Occasional sightings of frog and toad was also mentioned. Presence of any turtle in the river could not be ascertained but species of Catfish such as Manghur and Singhara believed to be present in Hindon. Past records of fish include Katla, Rohu, Bata and Saul.

28.0 Various insects species sighted during the survey belonged to the group Butterflies and Moths (Order: Lepidoptera)- Catterpillar of butterfly; Grasshoppers and Crickets (Order: Orthoptera), Dragonflies and Damselflies (Order: Odonata) - Ground Skimmer; True Bugs (Order: Hemiptera) - Tree Hopper.

29.0 The following birds were sighted during the study period.

Table 64: List of Birds

S. No.	Species	Scientific Name
1	Purple Sunbird	*Cinnyris asiaticus*
2	Green Bee-eater	*Merops orientalis*

34	Jungle Babbler	*Turdoides striatus*
5	Black Kite	*Milvus migrans*
6	Asian Koel	*Eudynamys scolopacea*
7	Oriental Magpie Robin	*Copsychus saularis*
8	Black Drongo	*Dicrurus macrocercus*
9	House Sparrow	*Passer domesticus*
10	Yellow Wagtail	*Motacilla flava*
11	Common Myna	*Acridotheres tristis*
12	White-throated Kingfisher	*Halcyon smyrmensis*
13	Red-vented Bulbul	*Pycnonotus cafer*
14	Cattle Egret	*Bubulcus ibis*
15	Common Hoope	*Upopa epops*
16	White-browed Wagtail	*Motacilla maderaspatensis*
17	Shikra	*Accipiter badius*
18	House Sparrow	*Passer domesticus*
19	White-throated Kingfisher	*Halcyon smyrmensis*
20	Cattle Egret	*Bubulcus ibis*
21	Blackwinged Stilt	*Himantopus himantopus*
22	Indian Robin	*Copsychus fulicatus*
23	Oriental Dove	*Streptopelia orientalis*
24	Rock Pegion	*Columba livia*
25	Indian Robin	*Saxicoloides fulicatus*
26	Blackwinged Stilt	*Himantopus himantopus*
27	Red-wattled Lapwing	*Vanellus indicus*

Image 64: Red-vented Bulbul Sighted Near Hindon River at Baparsi [Date: 18/01/2017]

Image 65: A Caterpillar Sighted Feeding on Milk Weed Plant Near Hindon River at Baparsi [Date: 18/01/2017]

Image 66: Ladybug (Coccinellidae) Sighted Near Hindon Bank at Baparsi, Baghpat [Date: 18/01/2017]

Image 67: Tree Hoppers Camouflaging Thorns Sighted on the Bank of Hindon, Baparasi [Date: 18/01/2017]

Study Site VI - Balmiki Ashram, Baghpat Distt.

a) FLORA

Table 65: Trees Observed

S. No.	Species	Common Name	Family
1.	*Pithecellobium dulce*	Jungle Jalebi	Fabaceae
2.	*Mangifera indica*	Mango	Anacardiaceae
3.	*Dalbergia sisso*	Shisham	
4.	*Ziziphus mummularia*	Ber	Rhamnaceae
5.	*Prosopis juliflora*	Vilaiti Keekar	Fabaceae
6.	*Azadirachta indica*	Neem	Meliaceae
7.	*Morus alba*	White Mulberry	Moraceae
8.	*Albizzia lebbeck*	Siris	Fabaceae
9.	*Eucalyptus spp.*	Safeda	Myrtaceae
10.	*Mangifera indica*	Mango	Anacardiaceae
11.	*Populus spp.*	Poplar tree	Salicaceae
12.	*Diaspyros cordifolia*	Bistendu	Ebinaceae

Table 66: List of Herbs/Shrubs

S. No.	Species	Common Name	Family	Frequency	Relative Frequency
1.	*Anagallis arvensis*	Scarlet Pimpernel	Primulaceae	0.6	6.98
2.	*Abutilon indicum*	Country Mallow	Malvaceae	1	11.63
3.	*Ageratum houstonianum*	Flossflower	Asteraceae	0.4	4.65
4.	*Dhatura innoxia*	Dhatura	Solanaceae	0.6	6.98
5.	*Lantana camara*	Common Lantana	Verbenaceae	1	11.63
6.	*Cassia occidentalis*	Coffee Senna	Caesalpiniaceae	1	11.63
7.	*Malva parviflora*	Cheeseweed	Malvaceae	0.4	4.65
8.	*Stellaria media*	Chickweed	Caryophyllaceae	0.4	4.65
9.	*Adathoda vasica*	Vasaka	Acanthaceae	0.8	9.30
10.	*Argemone mexicana*	Mexican Poppy	Papaveraceae	0.4	4.65
11.	*Zizyphus mummularia*	Jhar Beri	Rhamnaceae	0.4	4.65
12.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae	0.6	6.98
13.	*Saccharum spontaneum*	Sugarcane Grass	Poaceae	1	11.63

30.0 Major shrub/herb species observed are Abutilon indicum, Lantana camara, Cassia occidentalis, Saccharum spontaneum with relative frequency 11.63 each. Patches of Saccharum spontaneum and Cassia occidentalis, Zizyphus mummularia were abundant. Trees of Sheesham were also observed on the right bank of the river. The emergent vegetation on island was composed of Saccharum sponataneum, Ipomea aquatica, Alternanthera spp., Cynodon dactylon and various other species of grasses.

Image 68: Jungle Jalebi (*Pithecellobium dulce*) Tree at Hindon Bank, Balmiki Ashram

Image 69: Hindon River at Balmiki Ashram

b) FAUNA

31.0 Occasional sightings of Indian Hare (*Lepus nigricolli*), Indian Monitor Lizard (*Varanus bengalensis*) and Rhesus macaque (*Macaca mulatta*) in agriculture fields. Indian Jackal (*Canis aureus indicus*) is a common sighting in the evening. Nil Gai (*Boselaphus tragocamelus*) is commonly seen in nearby agricultural fields. Presence of any turtle in the river could not be ascertained sightings of Indian Flapshell Turtle (*Lissemys punctata*) were common 10-15 years ago. Species of Catfish (mostly Manghur) are present in the river.

32.0 Catfish such as Manghur (*Clarias batrachus*) and Singhara believed to be present in Hindon. Past records of fish include Katla, Rohu (*Labeo rohita*), Bata and Saul.

33.0 Insects belonging to group Butterflies and Moths (Order: Lepidoptera)-; Grasshoppers and Crickets (Order: Orthoptera), Dragonflies and Damselflies (Order: Odonata) were sighted but could not be photographed.

34.0 The following birds were sighted during the study period :

Table 67: List of Birds

S. No.	Species	Scientific Name
1.	Indian Silver Bill	*Euodice malabarica*
2.	White-throated Kingfisher	*Halcyon smyrmensis*
3.	Rock Pegion	*Columba livia*
4.	Black Kite	*Milvus migrans*
5.	Yellow-wattled Lapwing	*Vanellus malabaricus*
6.	Green Bee-eater	*Merops orientalis*
7.	Asian Koel	*Eudynamys scolopacea*
8.	Purple Sunbird	*Cinnyris asiaticus*
9.	House Sparrow	*Passer domesticus*
10.	Little Cormorant	*Phalacrocorax niger*
11.	Indian Robin	*Saxicoloides fulicatus*
12.	Red-vented Bulbul	*Pycnonotus cafer*
13.	Oriental Magpie Robin	*Copsychus saularis*
14.	Common Myna	*Acridotheres tristis*
15.	Jungle Babbler	*Turdoides striatus*
16.	Common Hoope	*Upopa epops*
17.	Black-winged Stilt	*Himantopus himantopus*
18.	Cattle Egret	*Bubulcus ibis*
19.	Grey Heron	*Ardea cinerea*
20.	Spot-billed Duck	*Anas poecilorhyncha*
21.	Rose-ringed Parakeet	*Psittacula krameri*
22.	Black Drongo	*Dicrurus macrocercus*
23.	Indian Peafowl	*Pavo cristatus*
24.	Indian Grey Hornbill	*Buceros bicornis*
25.	Rufous Treepie	*Dendrocitta vagabanda*
26.	House Crow	*Corvus splendens*

27.	Common Myna	*Acridotheres tristis*
28.	Large-billed Crow	*Corvus macrorhyncos*
29.	Red-whiskered Bulbul	*Pycnonotus jocosus*
30.	Ashy Prinia	*Prinia socialis*
31.	Common Tailorbird	*Orthotomus sutorius*
32.	Bank Myna	*Acridotheres ginginianus*
33.	Great Tit	*Parus major*
34.	White Wagtail	*Motacilla alba*
35.	Baya Weaver	*Ploceus philippinus*

Image 70: Flock of Indian Silver Bills (*Lonchura malabarica*) on Hindon Bank near Balmiki Ashram [Date: 17/01/2017]

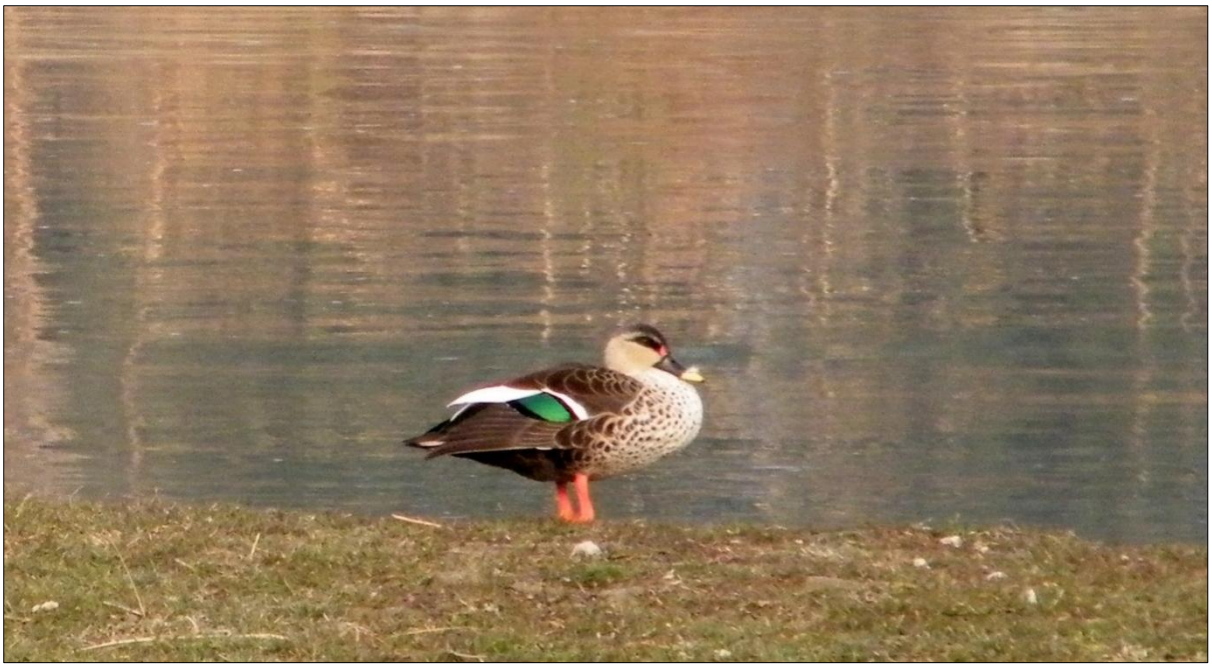


Image 71: Spot-billed Duck (*Anas poecilorhyncha*) on Hindon Bank near Balmiki Ashram

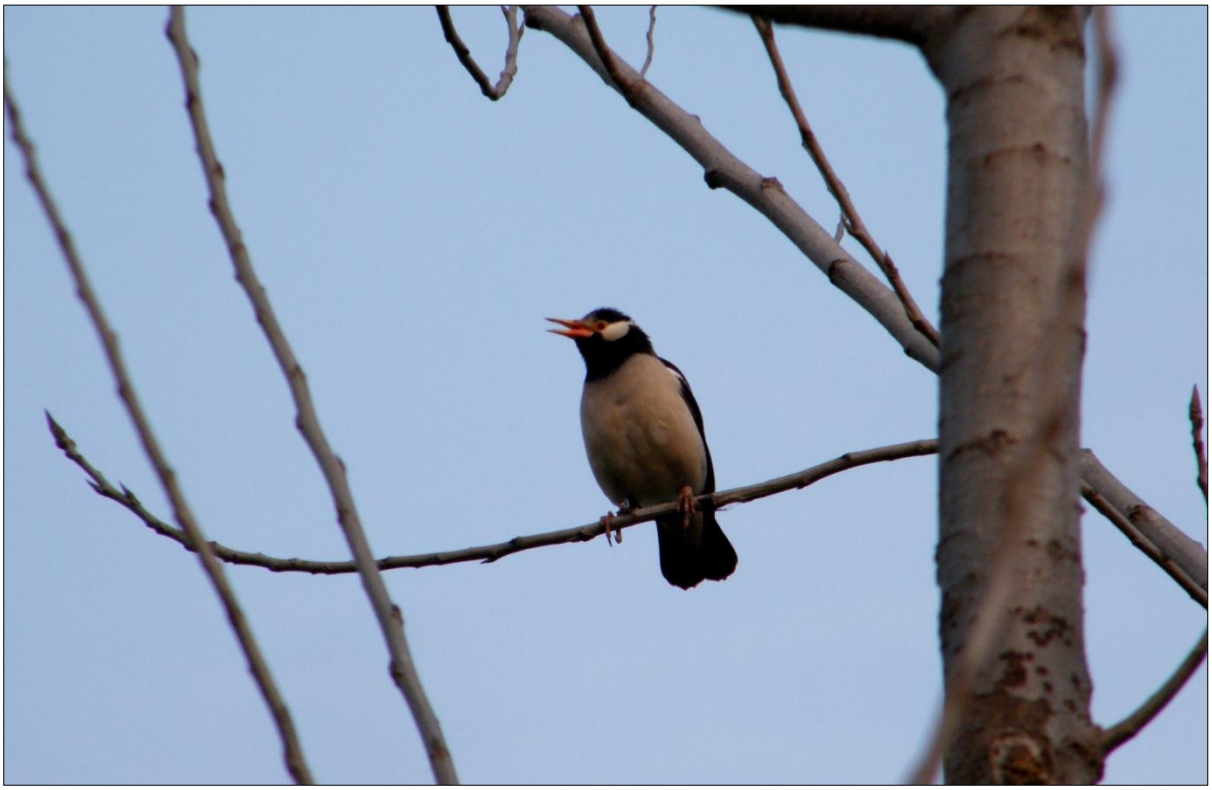


Image 72: Indian Pied Starling (Gracupica contra) on Hindon Bank near Balmiki Ashram [Date: 17/01/2017]

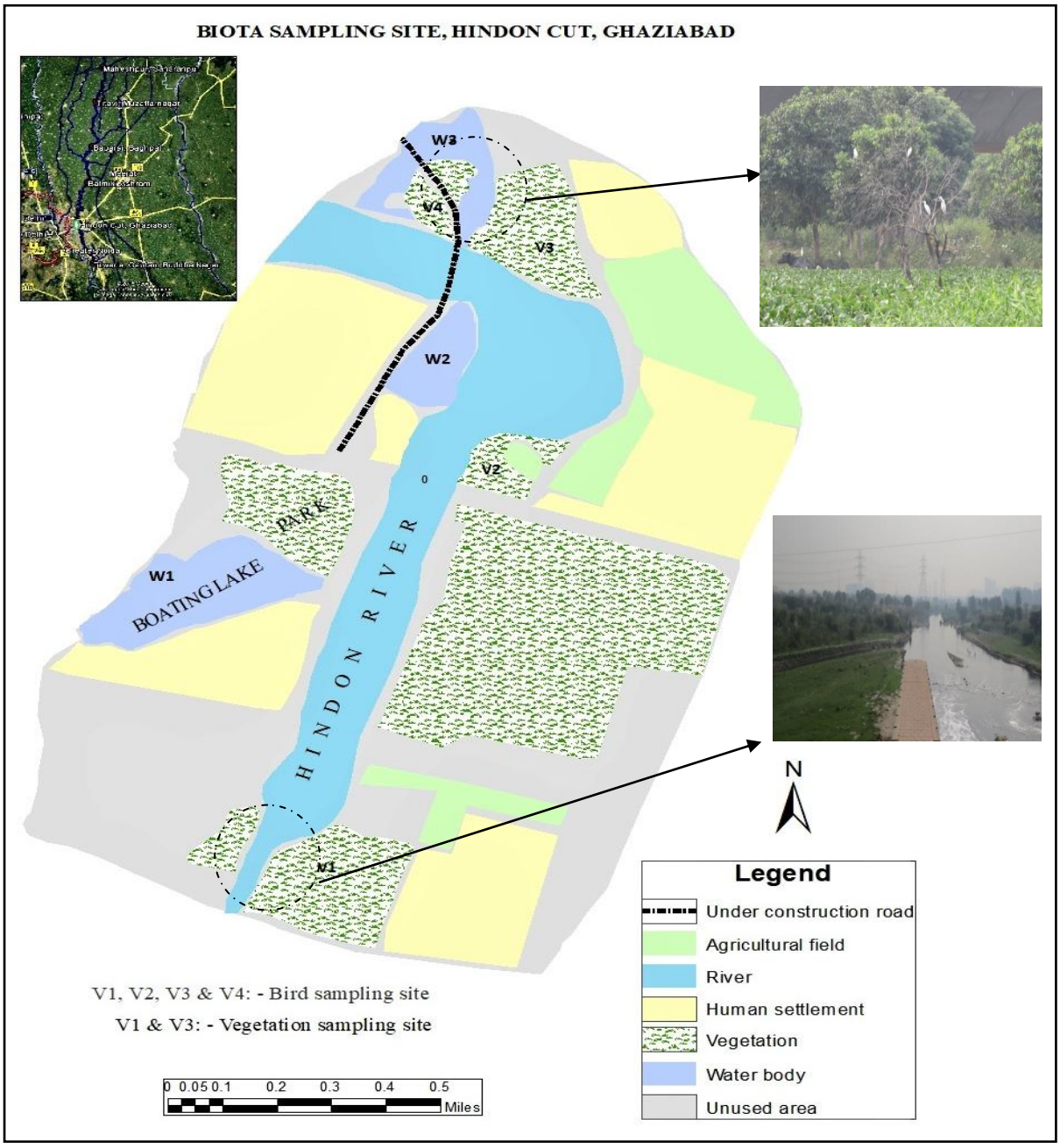
Study Site VII - Hindon, Ghaziabad Distt.

35.0 The district of Ghaziabad is situated in the middle of Ganga- Yamuna doab. As it is connected to National capital Delhi, its temprature and rainfall are similar to Delhi.

Rajasthan's dust storms and snowfall in the Himalayas, Kumaon and Garhwal hills name their impact in the weather regularly. The monsoon arrives in the district during the end of the June or the first week of July and normally it rains till october.

36.0 Ghaziabad is a growing industrial city. Its population having increased mainly on account of its rapid industrialization and its proximity to Delhi. The Natural vegetation near Hindon barrage, Ghaziabad has been degraded due to the rapid pace of urbanization and industrialization. Although, few areas are found between embankments, where there is a chance of growth of biota. Along with these, there are also some areas having a plantation of Arjun trees (*Terminalia arjuna*) i.e. New Forest.

37.0 The structure of sociological order in any community or set of communities cannot be studied by observing each and every individual in an area. Some sort of vegetation sampling has to be done Thus, Biodiversity assessment has been carried out near Hindon river at five different sites with the main focus on riparian vegetation and avian diversity.



a) FLORA

38.0 In the former days a large part of the district was covered with forest of sal and other trees, but since then most of it has been cleared and brought under the plough (District Survey Report-Ghaziabad). Though the district is no longer rich in timber, it can still be described as well wooded, owing to the numerous clumps of mango (*Mangifera indica*), mahua (*Madhuca longifolia*), sal (*Sorea robusta*), and bamboo (*Bambusa arundinacea*). Plantations of fast growing species such as bamboo, Eucalyptus

(*Eucalyptus teritrornis*), mango and shisham (Dalbergia sissoo) have been raised in the district under various afforestation programmes.

39.0 List quadrat sampling technique was used for the purpose of listing the occurrence of tree species in sampling area. While a line transect laid down near embankment of Hindon river for sampling of herb and shrub species in January, 2017 and is repeated again in October, 2017.

Table 68: Tree Species Observed

S. No.	Species	Common Name	Family
1.	*Pithecellobium dulce*	Jungle Jalebi	Fabaceae
2.	*Eucalyptus spp.*	Safeda	Myrtaceae
3.	*Azadirachta indica*	Neem	Meliaceae
4.	*Morus alba*	White Mulberry	Moraceae
5.	*Albizzia lebbeck*	Siris	Fabaceae
6.	*Mangifera indica*	Mango	Anacardiaceae
7.	*Populus spp.*	Poplar tree	Salicaceae
8.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae
9.	*Ziziphus mummularia*	Ber	Rhamnaceae

Table 69: List of Herbs/Shrubs

S. No.	Species	Common Name	Family	Frequency	% Frequency	Relative Frequency
1.	*Saccharum spontaneum*	Sugarcane Grass	Poaceae	0.875	87.5	9.09
2.	*Achyranthes aspera*	Chirchita	Amaranthaceae	0.75	75	7.79
3.	*Adathoda vasica*	Vasaka	Acanthaceae	0.375	37.5	3.90
4.	*Lantana camara*	Common Lantana/Wild Sage	Verbenaceae	0.625	62.5	6.49
5.	*Cassia occidentalis*	Coffee Senna	Caesalpiniaceae	0.75	75	7.79
6.	*Anagallis arvensis*	Scarlet Pimpernel	Primulaceae	0.375	37.5	3.90
7.	*Abutilon indicum*	Country Mallow	Malvaceae	0.375	37.5	3.90
8.	*Ageratum conyzoides*	Goatweed	Asteraceae	1	100	10.39
9.	*Dhatura innoxia*	Dhatura	Solanaceae	0.375	37.5	3.90

10.	*Malva parviflora*	Cheeseweed	Malvaceae	0.625	62.5	6.49
11.	*Ipomea aquatica*	Water Spinach	Convolvulaceae	0.875	87.5	9.09
12.	*Argemone mexicana*	Mexican Poppy	Papaveraceae	0.75	75	7.79
13.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae	0.625	62.5	6.49
14.	*Pergularia daemia*	Pergularia	Asclepiadaceae	0.375	37.5	3.90
15.	*Tridax procumbens*	Coat Button	Compositeae	0.25	25	2.60
16.	*Commelina benghalensis*	Wandering Jew	Commelinaceae	0.25	25	2.60
17.	*Tephrosa purpurea*	Sarpunkha	Fabaceae	0.375	37.5	3.90

40.0 The studied area does not follow the law of frequency (Normal condition). The result (A<B>C<D>E) reveals that the area is biotically disturbed. Patches of *Saccharum spontaneum, Achyranthes aspera, Ageratum conyzoides, Ipomea aquatica, Argemone mexicana* were abundant with relative frequency 9.09, 7.79, 10.39, 9.09, and 7,79 respectively. Patches of Eichhornia, Typha, Alternanthera and Phragmites were also observed on the island towards the right bank of the river. Ground cover was composed of Dhoob (*Cynodon Dactylon*) and some other members of sedges (Cyperaceae).

Table 70: Biodiversity Indices for Species Observed Near Hindon Barrage, Ghaziabad

Name of species	Frequency	% frequency	Density	Abundance	Simpson index	Shannon weiner index
Sida acuta	0.375	37.5	1.125	3.00	0.0144	-0.2618
Xanthium strumarium	0.25	25	0.375	1.50	0.0012	-0.1336
Chenopodium album	0.25	25	0.375	1.50	0.0012	-0.1336
Acaranthas aspera	0.5	50	0.875	1.75	0.0084	-0.2284
Commelina benghalensis	0.375	37.5	2.00	5.33	0.0482	-0.3357
Abutilon indicum	0.625	62.5	1.5	2.40	0.0265	-0.3004
Ribes grossularia	0.25	25	0.25	1.00	0.0004	-0.1005
Parthenium	0.25	25	0.375	1.50	0.0012	-0.1336

hysteriphorous						
Calotrois procera	0.25	25	0.5	2.00	0.0024	-0.1620
Coccinia grandis	0.125	12.5	0.125	1.00	0	-0.0600
Cassia occidentalis	0.125	12.5	0.25	2.00	0.0004	-0.1005
Malvastrum coromandelianum	0.25	25	0.50	2.00	0.0024	-0.1620
Croton bandiplandon	0.25	25	0.625	2.50	0.0040	-0.1868
Total					**D=0.88**	**H=2.29**

Image 73: Wandering Jew (Commelina benghalensis) at Hindon Bank, Ghaziabad

Image 74: Sharpunkha (*Tephrosa purpurea*) at Hindon Bank, Ghaziabad

Image 75 : Lotus flower (Nelumbo nucifera) on Hindon Floodplain area (Rajnagar Ext.- Loni Bypass Road in Ghaziabad [Towards South, Date: 28th Sept. 2016]

b) FAUNA

41.0 As per information conveyed by local farmers, Indian Monitor Lizard (*Varanus bengalensis*), Indian Jackal (*Canis aureus indicus*), Indian Hare (*Lepus nigricolli*), Nilgai (*Boselaphus tragocamelus*) and Rhesus macaque (*Macaca mulatta*) are present in the area. Garden Lizard (*Calotes versicolor*) was sighted frequently during the field visit.

42.0 As per the District Survey Report-Ghaziabad[39] fishes like Mahaser, Hilsa, Saul, Tengan, Parthan, Rasela, Vittal, Rohu, Mirgal,Kata, Labi, Mangur, Cuchia, Eel, Einghi, Mirror Carp, Trout. Occasional sightings of Indian Flapshell Turtle (*Lissemys punctata*) have been reported. During study period after conversation with farmers and field visits it is found that only Manghur (Clarias batrachus) fish species is known to present in the river. It is due to the Fact that the oxygen content of water is very low i.e. less than 1mg/L. So, the survival rate of fishes in that water is very less. Manghur survive in that water because it is an air-breathing fish and is able to manage even is less dissolve oxygen.

43.0 Various insects species sighted during the survey belonged to the group Butterflies and Moths (Order: Lepidoptera) - Plain Tiger; Grasshoppers and Crickets (Order:

[39] http://ghaziabad.nic.in/dgmup/DSR%20Ghaziabad%20.pdf

Orthoptera), Dragonflies and Damselflies (Order: Odonata) - Ground Skimmer; True Bugs (Order: Hemiptera) - Assassin Bug; Beetle (Order: Coleoptera) - Blister Beetle were sighted

44.0 The birds like Purple Heron (*Ardea purpurea*), Purple swamphen (Porphyrio porphyrio), Pond Heron (Ardeola grayii), Black-crowned Night Heron (Nycticorax nycticorax) are sighted near New Forest area (Arjun plantation). Other following birds were sighted during the study period.

Table 71: List of Birds

S. No.	Species	Scientific Name
1.	White Wagtail	*Motacilla alba*
2.	Indian Grey Hornbill	*Buceros bicornis*
3.	Common Tailorbird	*Orthotomus sutorius*
4.	House Sparrow	*Passer domesticus*
5.	Little Cormorant	*Phalacrocorax niger*
6.	White-throated Kingfisher	*Halcyon smyrmensis*
7.	Red-vented Bulbul	*Pycnonotus cafer*
8.	Common Myna	*Acridotheres tristis*
9.	White-browed Wagtail	*Motacilla maderaspatensis*
10.	Red wattled Lapwing	*Vanellus indicus*
11.	Cattle Egret	*Bubulcus ibis*
12.	River Lapwing	*Vanellus indicus*
13.	Grey Heron	*Ardea cinerea*
14.	Blackwinged Stilt	*Himantopus himantopus*
15.	Rose-ringed Parakeet	*Psittacula krameri*
16.	Black Drongo	*Dicrurus macrocercus*
17.	Red-whiskered Bulbul	*Pycnonotus jocosus*
18.	Rufous Treepie	*Dendrocitta vagabanda*
19.	Bank Myna	*Acridotheres ginginianus*
20.	Great Tit	*Parus major*
21.	House Crow	*Corvus splendens*
22.	Large-billed Crow	*Corvus macrorhyncos*
23.	Oriental Magpie Robin	*Copsychus saularis*

24.	Eurasian Collared Dove	*Streptopelia decaocto*
25.	Jungle Babbler	*Turdoides striatus*
26.	Common Hoope	*Upopa epops*
27.	Rock Pegion	*Columba livia*
28.	Black Kite	*Milvus migrans*
29.	Baya Weaver	*Ploceus philippinus*
30.	Rose-ringed Parakeet	*Psittacula krameri*
31.	Indian Robin	*Saxicoloides fulicatus*
32.	Green Bee-eater	*Merops orientalis*
33.	Asian Koel	*Eudynamys scolopacea*
34.	Purple Sunbird	*Cinnyris asiaticus*
35	Purple Heron	*Ardea purpurea*
36	Plain Prinia	Prinia inornata
37	Greater Coucal	*Centropus sinensis*
38	Common Moorhen	Gallinula chloropus
39	Red Avadevat	*Amandava amandava*
40	Scaly-breasted Munia	*Lonchura punctulata*
41	Black-crowned Night Heron	*Nycticorax nycticorax*
42	Pond Heron	*Ardeola grayii*

Purple heron found on water hyacinth bed and their increase may in turn have led to its increase. It is solitary and rather territorial feeder, although several birds may occur spread out in one swamp. If one strays too close another it is driven off with harsh cries. Due to road construction a part of Hindon river is turned into a wetland and is fully covered with water hyacinth. Thus, it provides place for **Purple Swamphen** where they are able to hide.

Image 76: River Purple Heron (Ardea purpurea) Sighted Near New forest Hindon Barrage, Bhaziabad [25/10/2017]

Bird Folk Lore From the rural area

The Red-wattled Lapwing and the battle

The Mahabharat tells the story of a great battle between the pandavas and the Kauravas near the holy city of Kurukshetra in Haryana. It is said that a Red-wattled Lapwing had laid her four eggs in the middle of a field that would be at the centre of battle. As the opposing armies lined up to begin, the mother lapwing approached Lord Krishna and told her of her concern for her eggs. Lord Krishna was so moved he promised her eggs would be safe. The leading fighting elephant was standing close to the eggs. At a word from Lord Krishna, the great bell hanging round the elephant's neck fell exactly over the nest so that the eggs were safely covered. The bell was so heavy that it remained in place throughout the battle. Unfortunately Lord Krishna was so preoccupied that he forgot to remove the bell when the battle was over. The mother lapwing could not move it herself so she was not able to get back to incubating

her eggs. As a result, the eggs died in their shells and ever since then Red-wattled Lapwings have made loud wailing cries in mourning.

The Eurasian Collared Dove and the soldier

This tale is based on the persistent mournful call of this very common Dove, often found in villages. A soldier in the King's army was always on the move because of constant campaigning. He rarely had a chance to visit his young wife at home. One day his battalion happened to be encamped close to his home village. The soldier was given permission to visit his wife for the morning. He arrived at his front door and knocked on it. His wife was busy grinding grain to make flour and she did not hear the knocking over the sound of the grinding. After a time, the husband gave up and went back to his battalion. They moved on the next day to join a fierce battle during which he was killed.

The news of his death reached his wife at the same time as her neighbors told her that her soldier-husband had tried to visit her but she hadn't opened her door to him. The double shock was too much for her and she turned into a dove. Ever since she has called "aya-tha, pisun-thi, gaya-tha" which translates as "he came, I was grinding, he went away".

The Baya Weaver and its strange habits

The Baya is very familiar to rural people and its colonies are often in village palm trees. Some farmers believe that Bayas are afraid that the sky may fall down on him and his family so they sleep with their legs pointing p to stop the sky crushing them. Another strange belief is that they use live glow-worms to light up the inside of their nests. Both stories probably arise from the unusual retort shape of the nest which must be very dark inside. Whatever their origin, they are still widely believed!

Image 77: Garden Lizard Sighted Sighted on Riparian Vegetation Near Hindon Bridge, Ghaziabad [Date:08/08/2016]

Image 78: Blister Beetle Sighted on Riparian Vegetation, Hindon Bridge, Ghaziabad [08/08/2016]

Image 79: Catfish Caught From Hindon Under Karhera Bridge, Ghaziabad [19/08/16]

Study Site VIII - Tilwada, Gautam Buddha Nagar

a) FLORA

Table 72: Trees Observed

S. No.	Species	Common Name	Family
1.	*Prospis juliflora*	Jungli Babool	Fabaceae
2.	*Ziziphus mummularia*	Jhar Ber	Rhamnaceae
3.	*Phoenix sylvestris*	Wild Date Palm	Arecaceae

Table 73: List of Herbs/Shrubs

S. No.	Species	Common Name	Family	Frequency	Relative Frequency
1.	*Parthenium hysterophorus*	Congress Grass	Asteraceae	1	11.90
2.	*Coccinia Grandis*	Ivy Gourd	Cucurbitaceae	0.4	4.76
3.	*Ageratum conyzoides*	Goat Weed	Asteraceae	1	11.90
4.	*Dhatura innoxia*	Safed dhatura	Solanaceae	0.4	4.76
5.	*Cucumis melo*	Kharbuza, Musk melon	Cucurbitatceae	0.4	4.76
6.	*Oxalis corniculata*	Creeping	Oxalidaceae	0.6	7.14

		Woodsorrel			
7.	*Solanum indicum*	Common Indian Nightshade	Solanaceae	0.6	7.14
8.	*Chenopodium album*	Lamb's Quarter	Chenopodiacea e	0.6	7.14
9.	*Ricinus communis*	Castor Oil Plant	Euphorbiaceae	0.6	7.14
10.	*Sacharum spontaneum*	Kaans	Poaceae	0.6	7.14
11.	*Achyranthes aspera*	Chirchita	Amaranthacea e	0.8	9.52
12.	*Ipomea aquatica*	Water Spinach	Convolvulacea e	0.4	4.76
13.	*Fumaria officinalis*	Indian Fumitory	Fumariaceae	0.2	2.38
14.	*Abutilon indicum*	Country Mallow	Malvaceae	0.4	4.76
15.	*Lantana camara*	Common Lanatana/Wild Sage	Verbenaceae	0.4	4.76

45.0 Flora information presented above was collected from the left bank of River Yamuna at the confluence Yamuna-Hindon rivers near Tilwada village, Gautam Buddha Nagar. There is hardly any discernible riparian zone along Hindon river, with agriculture being practiced almost till the edge of river channel. *Parthenium hysterophorus*, *Achyranthes aspera* were observed as dominant representatives. Other common herbs noted were *Oxalis corniculata, Solanum indicum, Chenopodium album, Ricinus communis, and Sacharum spontaneum.* Ground cover was composed of Dhoob (*Cynodon Dactylon*) and some other members of sedges (Cyperaceae).

b) FAUNA

46.0 Nil Gai (*Boselaphus tragocamelus*) are commonly seen in agricultural fields near the River. Indian Hare (*Lepus nigricolli*), Indian Monitor Lizard (*Varanus bengalensis*) and Indian Jackal (*Canis aureus indicus*) are commonly seen on the floodbank of Yamuna and Hindon River. Indian Flapshell Turtle (*Lissemys punctata*) was common 8-10 years ago.

47.0 Occasional sightings of Indian Hare (*Lepus nigricolli*) and Indian Monitor Lizard (*Varanus bengalensis*) in agriculture fields. Indian Jackal (*Canis aureus indicus*) is a common sighting in the evening. Nil Gai (*Boselaphus tragocamelus*) is commonly seen in nearby agricultural fields. Manghur, Common Carp and Tilapia fish species are known to present in the river. Past records of fish include Katla, Rohu, Bata and Saul.

48.0 Insects belonging to group Butterflies and Moths (Order: Lepidoptera)-; Grasshoppers and Crickets (Order: Orthoptera), Dragonflies and Damselflies (Order: Odonata)- Coral-tailed Cloud Wing Dragonfly have been sighted. True Bugs (Order: Hemiptera) - Assassin Bug and Beetle (Order: Coleoptera) - Blister Beetle were also seen during the survey.

49.0 The following birds were sighted during the study period.

Table 74: List of Birds

S. No.	Species	Scientific Name
1.	Oriental Magpie Robin	*Copsychus saularis*
2.	Eurasian Collared Dove	*Streptopelia decaocto*
3.	Jungle Babbler	*Turdoides striatus*
4.	Common Hoope	*Upopa epops*
5.	Rock Pegion	*Columba livia*
6.	Black Kite	*Milvus migrans*
7.	Indian Robin	*Saxicoloides fulicatus*
8.	Green Bee-eater	*Merops orientalis*
9.	Asian Koel	*Eudynamys scolopacea*
10.	Purple Sunbird	*Cinnyris asiaticus*
11.	House Sparrow	*Passer domesticus*
12.	Little Cormorant	*Phalacrocorax niger*
13.	White-throated Kingfisher	*Halcyon smyrmensis*
14.	Red-vented Bulbul	*Pycnonotus cafer*
15.	Common Myna	*Acridotheres tristis*
16.	White-browed Wagtail	*Motacilla maderaspatensis*
17.	Redwattled Lapwing	*Vanellus indicus*
18.	White-breasted Waterhen	*Amaurornis phoenicurus*
19.	Black-winged Stilt	*Himantopus himantopus*
20.	River Lapwing	*Vanellus duvaucelii*
21.	Cattle Egret	*Bubulcus ibis*
22.	River Lapwing	*Vanellus indicus*
23.	Grey Heron	*Ardea cinerea*
24.	Ruddy Shelduck	*Tadorna ferruginea*
25.	Rose-ringed Parakeet	*Psittacula krameri*
26.	Black Drongo	*Dicrurus macrocercus*
27.	Indian Peafowl	*Pavo cristatus*
28.	Red-whiskered Bulbul	*Pycnonotus jocosus*
29.	Rufous Treepie	*Dendrocitta vagabanda*
30.	While Wagtail	*Motacilla alba*
31.	Baya Weaver	*Ploceus philippinus*
32.	Rose-ringed Parakeet	*Psittacula krameri*
33.	While Wagtail	*Motacilla alba*
34.	Indian Grey Hornbill	*Buceros bicornis*
35.	Common Tailorbird	*Orthotomus sutorius*
36.	Bank Myna	*Acridotheres ginginianus*

37.	Great Tit	*Parus major*
38.	House Crow	*Corvus splendens*
39.	Common Myna	*Acridotheres tristis*
40.	Large-billed Crow	*Corvus macrorhyncos*

Image 80: River Lapwing (*Vanellus duvaucelii*) Sighted Near Hindon Bank, Tilwada, Gautam Budh Nagar [02/02/2017]

Image 81: Ruddy Shelduck (*Tadorna ferruginea*) Near Yamuna-Hindon Confluence, Tilwada, GBNgr [02/02/2017]

Ruddy Shelduck (*Tadorna ferruginea)*

The Ruddy Shelduck, or **Brahminy duck,** is a locally common winter visitor from the high altitude lakes of Ladakh and central Asia. The first bird arrives in October, with major arrivals in November and departure in March. There are usually a few stragglers well into May. Numbers seem to vary from year to year and it has certain favoured sites.

Ruddy Shelduck feed on water side vegetation, particularly grass, but will also upend and wade for aquatic animals and plants. They avoid very thick or long vegetation, preferring shallows, muddy margins and grassy sandbars.

They are almost always in pairs or family parties which defend a feeding territory within the loose flock. Excited trumpeting and goose- like honking is often followed by furious 'flight-ins', as the males protest at the relative proximity of other males.

Image 82: Herd of Nilgai (*Boselaphus tragocamelus*) Sighted Near Hindon at Tilwada, GB Ngr [02/02/2017]

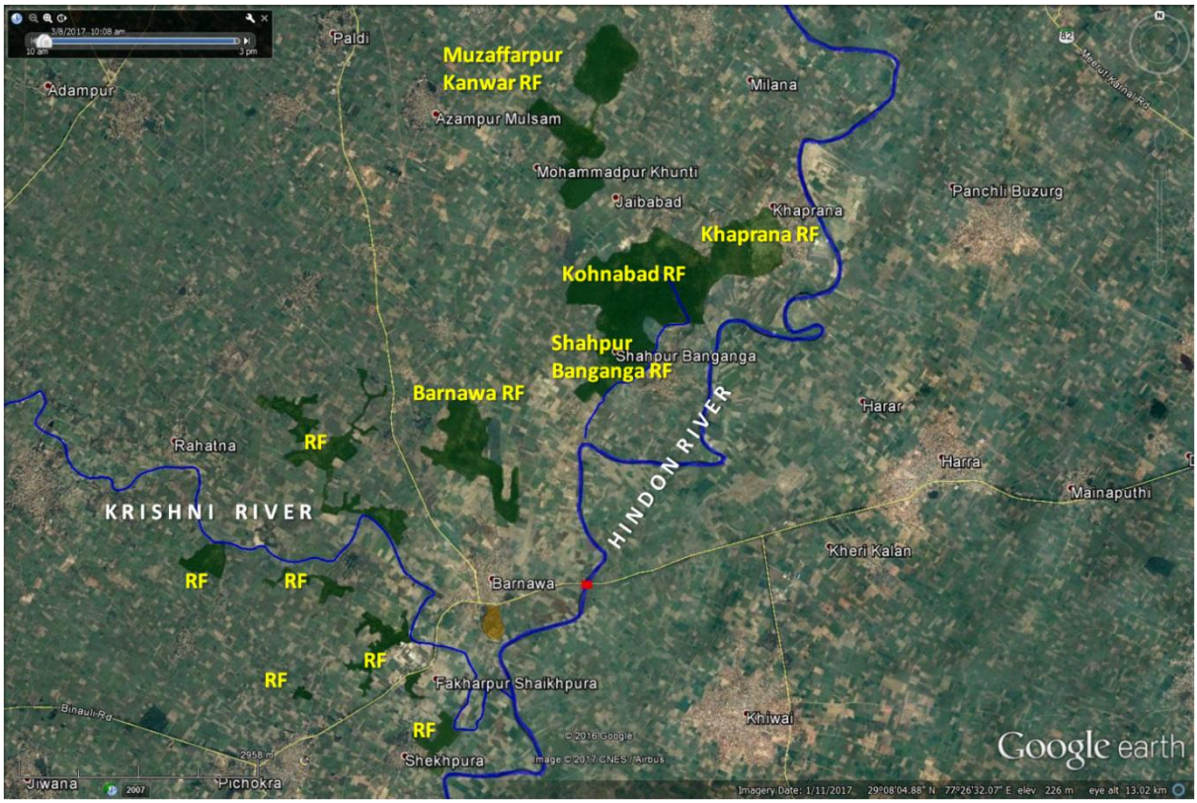
Image 83: Coral-tailed Cloud Wing Dragonfly Near Hindon River, Tilwada, GB NGR [02/02/2017]

Image 84: Blister Beetle Near Hindon River at Tilwada, Gautam Buddha Nagar [23/09/2016]

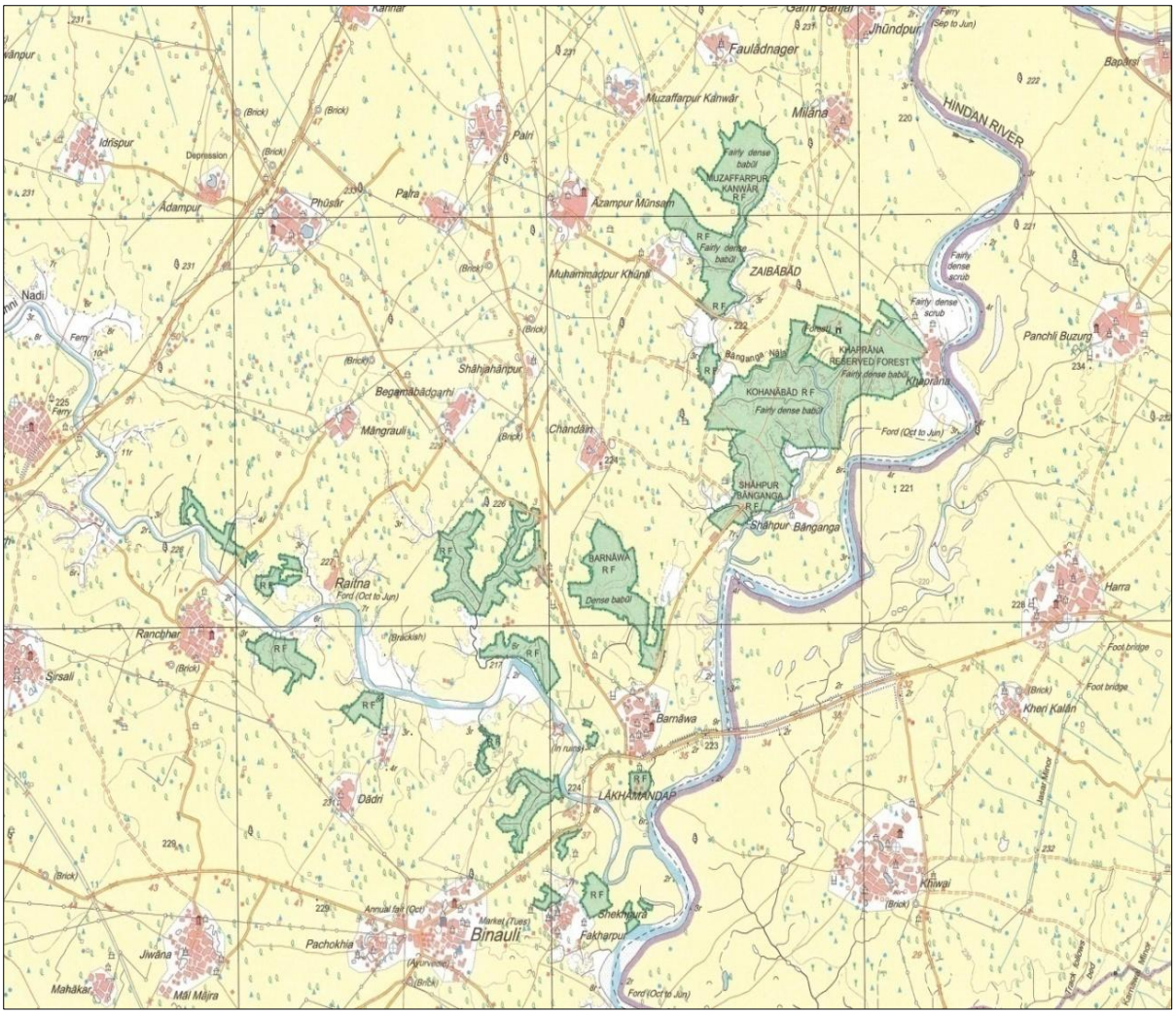
Image 85: : Plain Tiger Butterfly (*Danaus chrysippus*) Near Hindon River, Tilwada, GB Nagar [23/09/2016]

2. Forest Areas of Hindon River Catchment

1. Reserve Forest Areas Near Barnawa



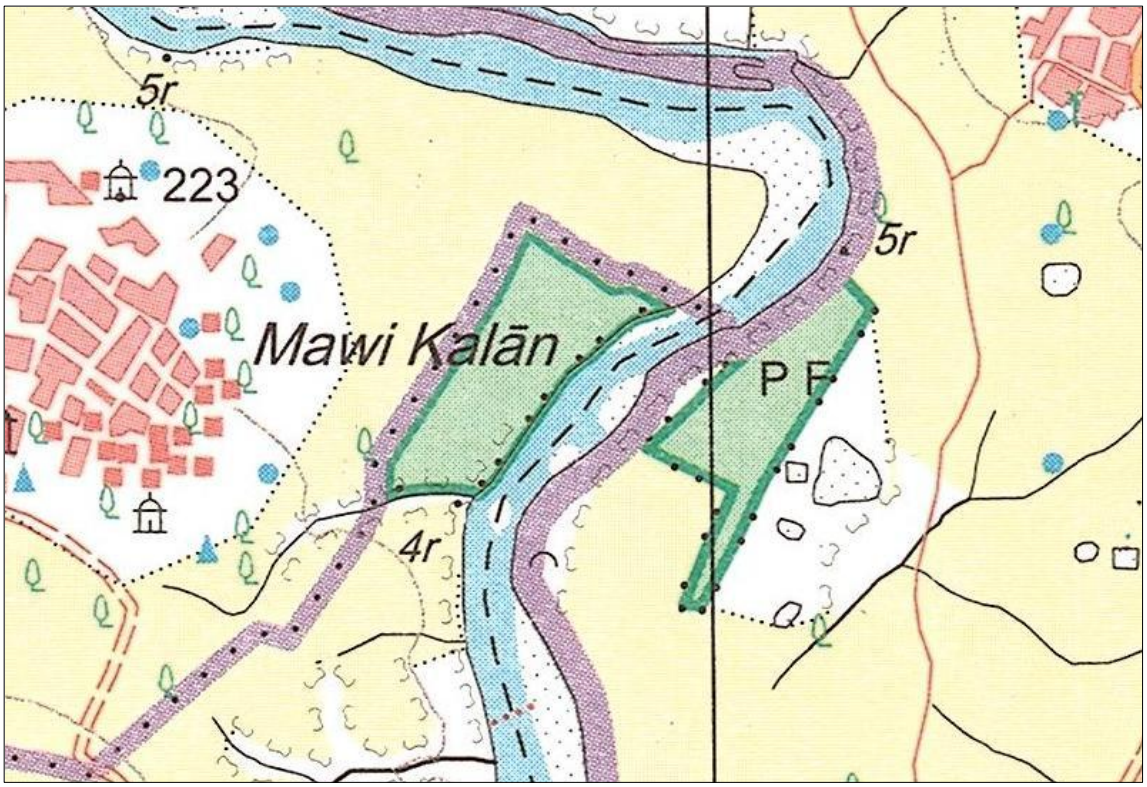
Map 42: Google Earth Image (2016) Showing Reserve Forest Areas Near Barnawa



Map 43: SOI Toposheet (2007) Showing Reserve Forest Areas Near Barnawa

2. Mawi Kalan Protected Forest

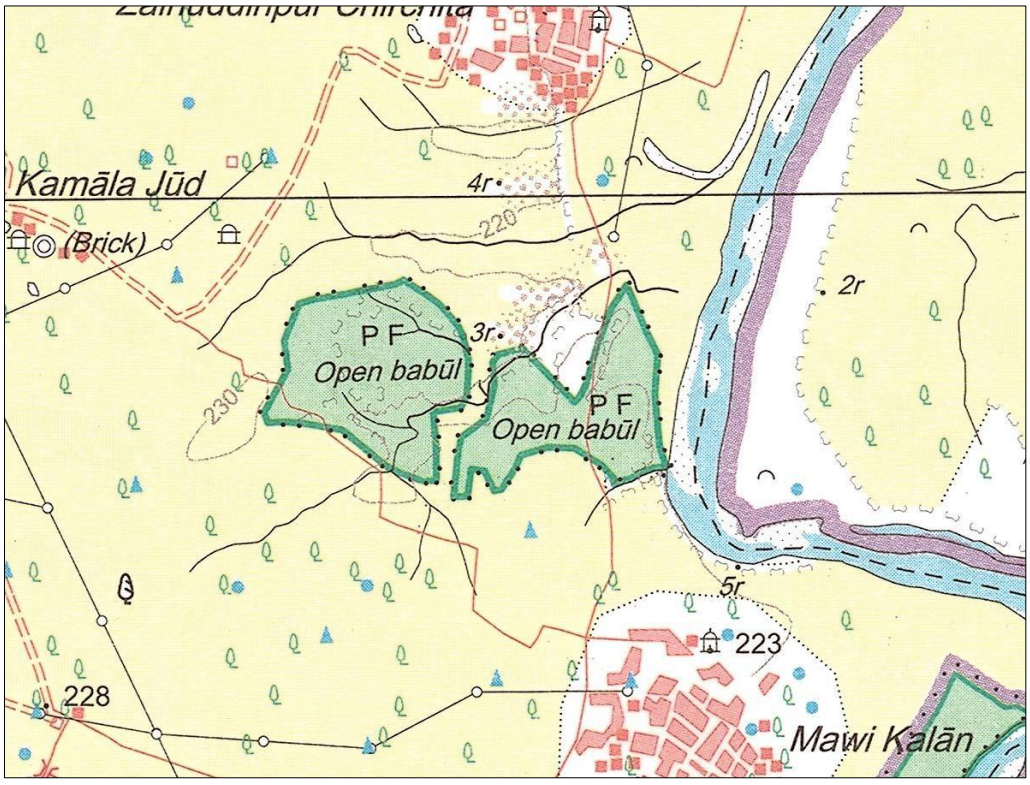
Map 44: Mawi Kalan Reserve Forest on Hindon River Bank [Google Earth Image, 2016]



Map 45: SOI Toposheet (2007) -Mawi Kalan Reserve Forest on Hindon River Bank

3. Open Babul Protected Forest North of Mawi Kalan

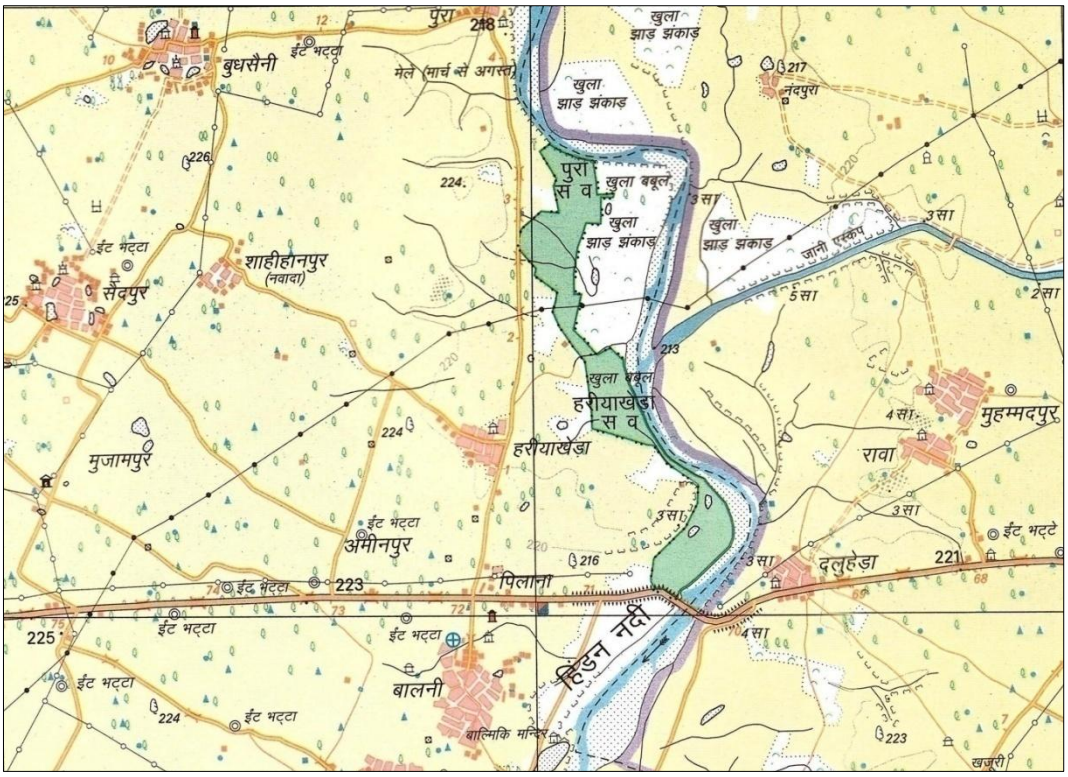
Map 46: Google Earth Image (2016) Showing Open Babul Protected Forest North of Mawi Kalan



Map 47: SOI Toposheet (2007) - Open Babul Protected Forest North of Mawi Kalan

4. Pura and Hariyakhera Reserve Forest

Map 48: Google Earth Image (2016) Showing Pura and Hariyakhera Reserve Forest



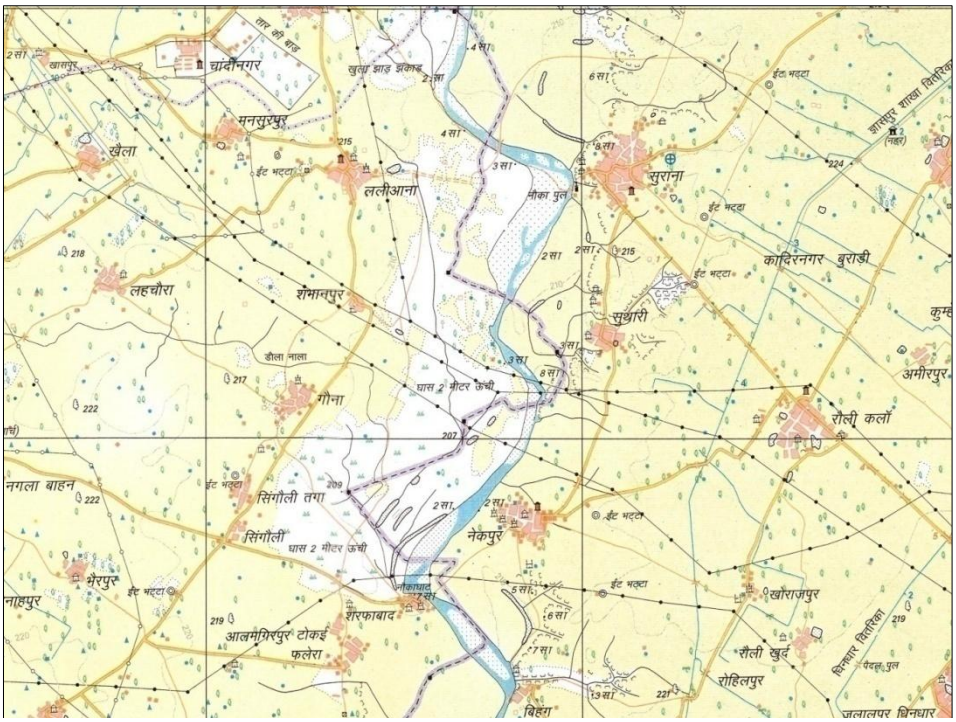
Map 49: SOI Toposheet (2014) - Pura and Hariyakhera Reserve Forest Along Hindon

Image 86: An Inside Glimpse of Pura and Hariyakhera Reserve Forest [18/01/2017]

2.1 Pura and Hariyakhera Reserve Forest is largely composed of Vilaiti Keekar (*Prosopis juliflora*) and is surrounded by agriculture fields from almost all sidesNorthern and Southeeastern boundary which touch the river. Nilgai (*Boselaphus tragocamelus*), Indian Jackal (*Canis aureus indicus*), Indian Hare (*Lepus nigricolli*), Rhesus macaque (*Macaca mulatta*) are common animals who frequent the forest.

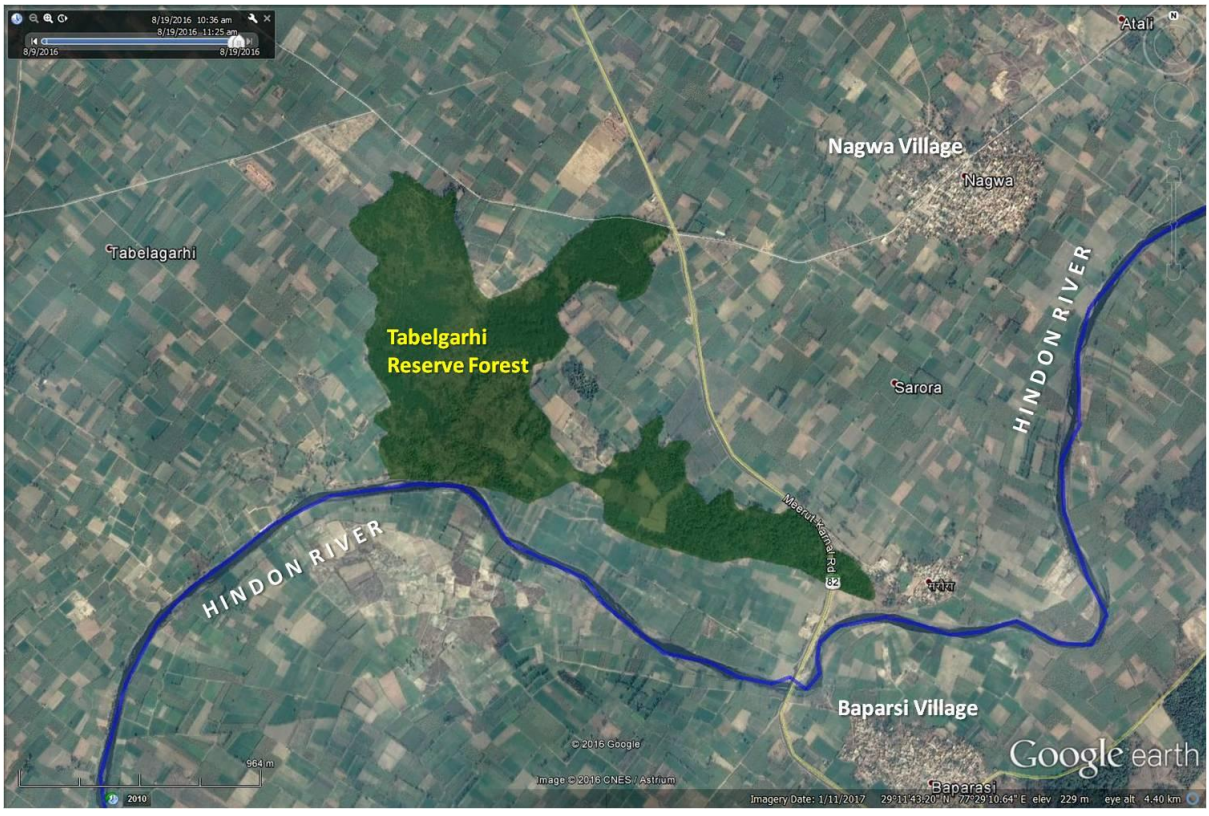
5. Shahbanpur Shrub Area

Map 50: Google Earth Image (2016) Showing Shahbanpur Shrub Area

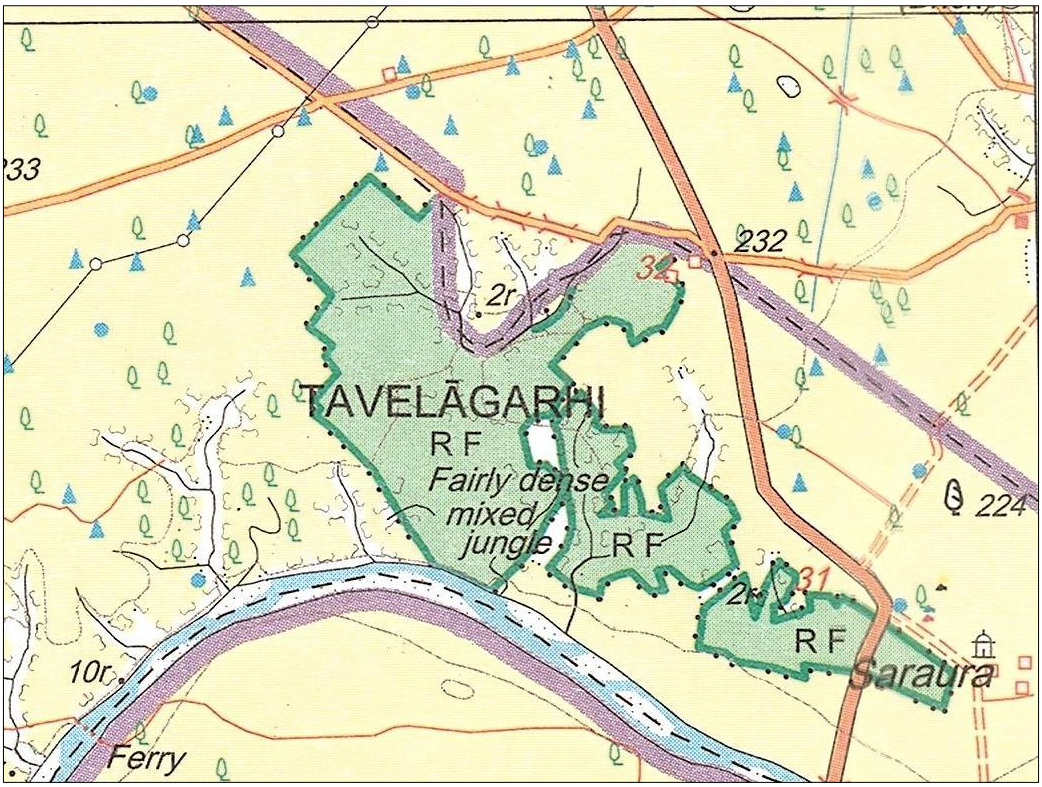


Map 51: SOI Toposheet (2014) Showing Shahbanpur Shrub Area Along Hindon

6. Tabelagarhi Reserve Forest East of Saraura Village



Map 52: Google Earth Image (2016) Showing Tabelagarhi Reserve Forest East of Saraura Village



Map 53: SOI Toposheet (2007) Tabelagarhi Reserve Forest East of Saraura Village

Image 87: Tabelagarhi Reserve Forest as Seen From Hindon River Bank [18/01/2017]

2.2 Tabelgarhi Reserve Forest is largely composed of Teak (*Tectona grandis*) plantation and is surrounded by agriculture fields from almost all sides except Northern and South-eastern boundary which touch the Hindon River. Nilgai (*Boselaphus tragocamelus*), Indian Jackal (*Canis aureus indicus*), Indian Hare (*Lepus nigricolli*), Rhesus macaque (*Macaca mulatta*) are common animals who frequent the forest.

Image 88: An Inside Glimpse of Tabelagarhi Reserve Forest [18/01/2017]

Image 89: Jewel Bug Sighted Inside Tabelagarhi Reserve Forest [18/01/2017]

Image 90: Common Leopard Butterfly Sighted Inside Tabelagarhi Reserve Forest [18/01/2017]

Image 91: Black-shouldered Kite Sighted Near Tabela Garhi Reserve Forest [Date: 18/01/2017]

7.New Forest Area, Ghaziabad

Map 54: Google Earth Image (2016) Showing New Forest Area on Hindon Bank

Image 92: New forest area on Hindon floodplain near Raj Nagar Ext. Road [Towards West, 28th Sept, 2016]

2.3 New forest area is mainly composed of chiefly Arjun trees (*Terminalia arjuna*) and is situated on Hindon floodplain area towards west of Raj Nagar Ext. Road. Common animals are

Indian Jackal (*Canis aureus indicus*), Nilgai (*Boselaphus tragocamelus*), Indian Hare (*Lepus nigricolli*), Rhesus macaque (*Macaca mulatta*).

8. City Forest, Karhera, Ghaziabad

Map 55: Google Image (2016) - City Forest, Karhera on Hindon Bank [East of Hindon Air Base]

Image 93: An Inside Glimpse of City Forest, Karhera on Hindon Bank [Date: 08/03/2017]

Chapter III – Threats & Major Issues

1.1 Several human interventions or their absence over decades have led to the unnatural and deteriorated character of the Hindon river. The river can no longer be considered an integrated eco-system as it functions as a hybrid river-cum-canal with unnatural additions to its flow from parallel Ganga and East Yamuna Canals. The causes of decline of the river eco-system are intricately connected with fundamental basin level factors as well as more visible urban and industrial factors which hog the limelight.

2.0 Basin Level Factors

2.1 **Forest Cover In The Basin** : The data shows that the forest cover in the basin is a mere 2% and that the trend of forest cover is on the decline. It is also shown that :

- Dense forest has reduced by 26.5%
- Open forest has reduced by 38%

2.2 Most of the remnant forest cover is in the extreme north [Shivalik Hills zone] of the basin. Forests are linked to enhanced precipitation as well as in moderating the temperature regime. Our data shows a marked decline in the precipitation levels especially significant in the plains portion of the basin. This negatively impacts surface runoff as well as availability of soil moisture as well as aquifer recharge.

2.3 **Temperature** : A clear rising trend in temperature in most months can be discerned from the data. Although the organized data is readily available only till 2001, once the up to date data is accessed the rising trend would be significantly accentuated]. This has implications for the faster loss in soil moisture post monsoons and for the increased evapo-transpiration losses as also the greater requirement of irrigation water, all impinging on the water budget of the Hindon basin

2.4 **Demography :** Between 2001 and 2011 the basin population has increased by 26.4%. This places an increasing strain on the finite water resources and is mostly sourced from ground water.

2.5 **Groundwater Levels** : The rising levels of groundwater exploitation can only reduce discharge from the aquifers to the river system. This is especially critical for the lean season flow. The depth to water table [Table 22] when read with the topography [Map 13] shows that in the basin districts of the plains the water table depth is below the level of the river channel even as in 2013. The falling trend of water table will affect the lean season flow and certain upstream stretches [where not replenished by transferred waters from Upper Ganga Canal and East Yamuna Canal] have been observed to become dry post monsoon.

2.6 The water table would recede at a much faster clip if it were not for the unintended artificial recharge being affected from the flow of irrigation water, transferred from Ganga [mainly] and Yamuna, and flowing through a well distributed network of majors, distributaries and minors.

2.7 **Flow in the Hindon River :** The flow in Hindon River is a mix of rainfall runoff, groundwater seepage, effluents/wastewater and **majorly transferred water from the Ganga to the Yamuna using Hindon channel as a transfer conduit.** Thus, the river is actually functioning more as a canal rather than a natural stream and has little natural flow, even in the monsoons, and little native biodiversity as it is fed by Ganga waters having a different chemistry. **With these additions it is difficult to establish the natural virgin flow of Hindon at most locations and in any seasons. This also makes it difficult to make an assessment of required e-flows at most locations and in any seasons.**

2.8 **Tributary Streams :** The conditions in the Hindon cannot be considered in isolation ofv the depleted flows and polluted waters prevailing in the tributaries starting with Dhamola Nala onwards. Repair of the Hindon requires restoration of these streams as well to healthy conditions.

2.9 **Cropping Pattern :** Cropping pattern in all the Hindon basin districts is influenced by the easy availability of water thus far. The heavy irrigation requirement of the major crops is compounded by the technique of flood irrigation wherein only some of the water reaches the roots whereas much of the water is lost to evaporation.

2.10 Of the 65% of basin landuse under agriculture 35% of total gross cropped area is under sugar cane cultivation. 34% of gross cultivated area is in Muzzafarnagar Distt [basin part]. **It may be noted that sugar cane cultivation alone is guzzling 72% of total irrigation water**

2.11 Irrigation from groundwater is meeting only 21% of the irrigation water requirement and thus the balance 79% or 6193 MCM are imported waters from Yamuna [through Eastern Yamuna Canal system] and from Upper Ganga Canal supplies. **The basin economy is thus unsustainable on its own resources and totally dependent on bleeding adjacent basins.**

2.12 **Surface Pollution :** Hindon receives loads of pollution from various industries and residential sewerage from the towns mainly Saharanpur, Muzaffarnagar, Meerut, & Ghaziabad situated in its basin area.

2.13 There is laxity regarding enforcement of industrial effluent treatment standards.

2.14 With regards to domestic wastewater the major urban centres are the culprits. Most areas are undersewered on unsewered while treatment facilities are mostly absent and those centralized STPs that have been commissioned are also underperforming for various reasons.

2.15 The pesticides study at 22 sites using 11 pesticide standards showed that most samples were found to have a mix of pesticides. The surface water data suggests that most of the pesticides sprayed in the fields run off into the surface water bodies, where they tend to persist. It is well known that inorganic fertilizers and chemical pesticides not only need a lot of water to dissolve but that they are used in excess and substantial amounts either leach to

the aquifer or find their way into the stream channels as part of surface runoff from the fields.

2.16 **Groundwater Pollution :** Ground water pollution due to continued flow of toxic and chemical influents in Hindon River has been a well noted and publicised issue of health crisis throughout the riparian districts. Incidents of deadly diseases like cancer, digestive disorders, skin ailments and physical deformities are of common occurrence. Industries like sugar mills discharge sulphur dioxide, hydrochloric acid, magnesium, calcium, lead and phosphates which are toxic in nature and to which are added leachates of chemical fertilizers and pesticides.

2.17 As a result of polluted surface water and groundwater there is a cultural disconnect of the people from the river. The river is no longer seen as a place for rituals, for worship, and ist products [fish, vegetables, crops] are best seen to be avoided. It is no longer a giver of life but as a source of deadly disease.

2.18 **Floodplains :** In the rural areas farmers are cultivating right to the edge of the river lean season channel destroying the integrity of the floodplain and its habitat and functions. In urban areas [Saharanpur, Ghaziabad, Greater NOIDA] floodplains have been encroached upon in several places rendering those very areas vulnerable and narrowing the course of the river. Urban floodplains have also been used to dispose garbage and thus present an ugly sight.

2.19 **Biodiversity :** There is hardly any original aquatic fauna in the channel as a result of unnatural conditions prevailing in the Hindonmain stem. Fish populations as well species diversity has declined and accordingly dependent livelihoods have also nearly vanished. With absence of riparian vegetation macro invertebrates and amphibians both declined. The bio-assay test for a sample near Hindon Barrage showed zero percent survival of aquatic fauna. Thus the river ecosystem is no longer functional.

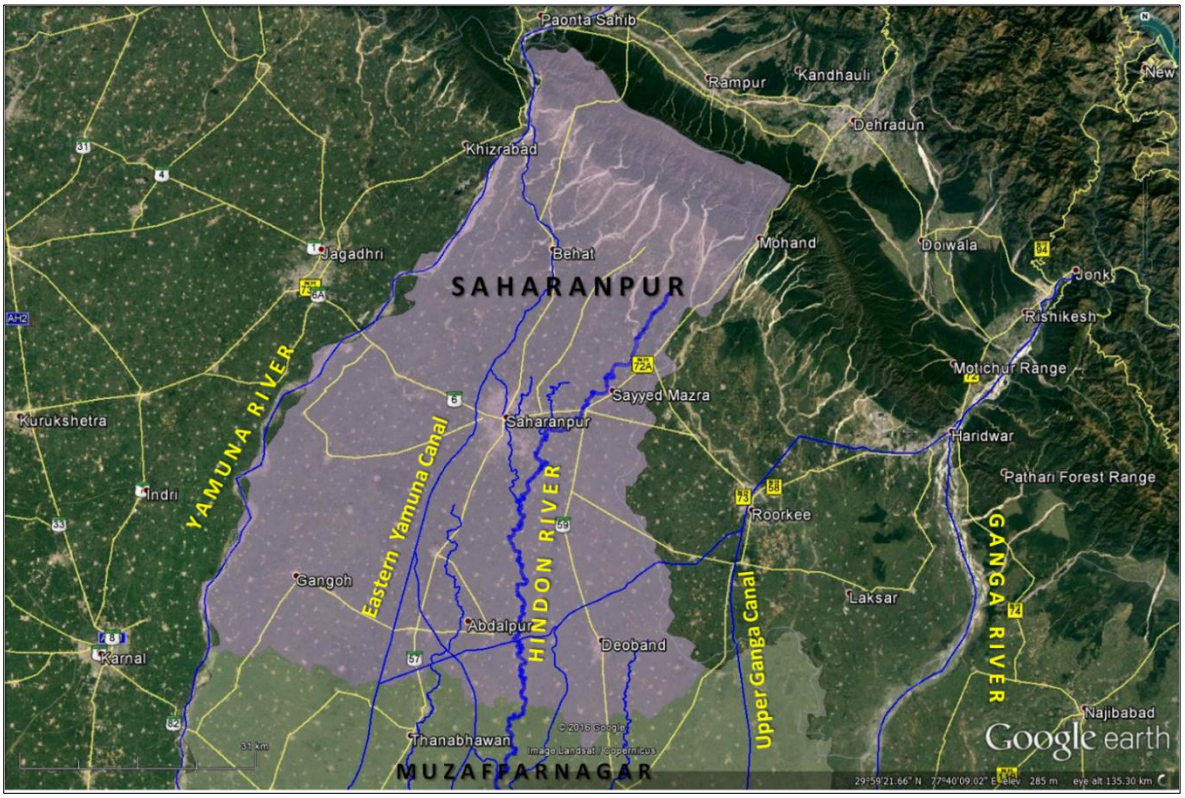
2.20 **Demand Management :** So far thinking about the river is confined to the water flow in the main stem as well as pollution issues arising from industrial effluents and domestic wastewater. The thinking is that water can be tapped endlessly from the Upper Ganga Canal. There is no focus on demand management in various sectors.

2.21 **Lack of Basin Organization :** In the absence of an overarching basin organization the same line departments and administrative jurisdictions address the river from their narrow individual perspectives. The primacy of the hydrological engineering approach has drowned out a holistic perspective. For example the forest department is completely excluded as is the agriculture department. The entire approach to water management in the basin is supply oriented and not demand management oriented.

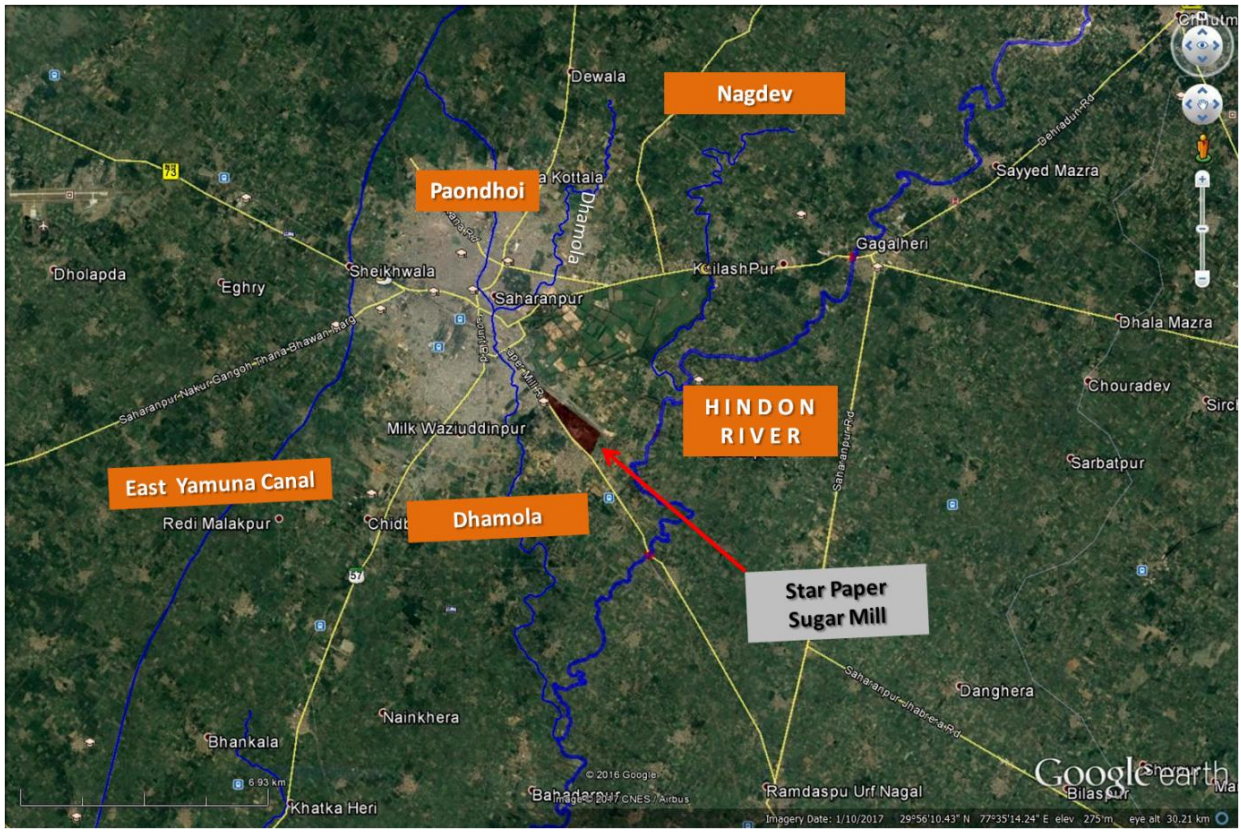
2.22 It would appear that sugarcane lobby is driving the water management in the entire basin.

3.0 Issues In Saharanpur

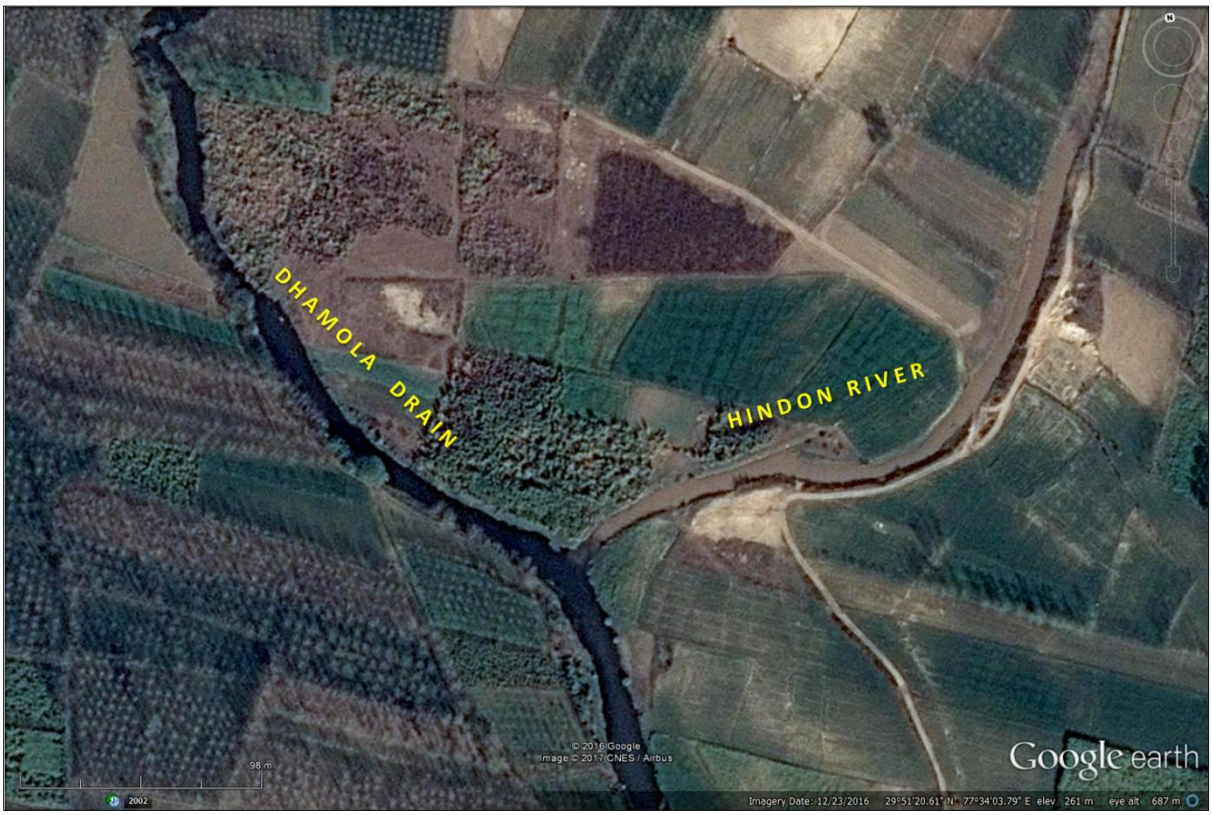
3.1 Municipal sewerage discharge through Paondhoi, Dhamola and Nagdev drains. River floodplain and drains surface area have been encroached in recent years Star Paper Sugar Mill is a major industry which contributes significantly to Hindon River's pollution. Many smaller scale industrial units in Saharanpur discharge their effluents in Paondhoi and Dhamola which eventually join Hindon near Sadholi Hariya village approximately 10 km south of main Saharanpur town.



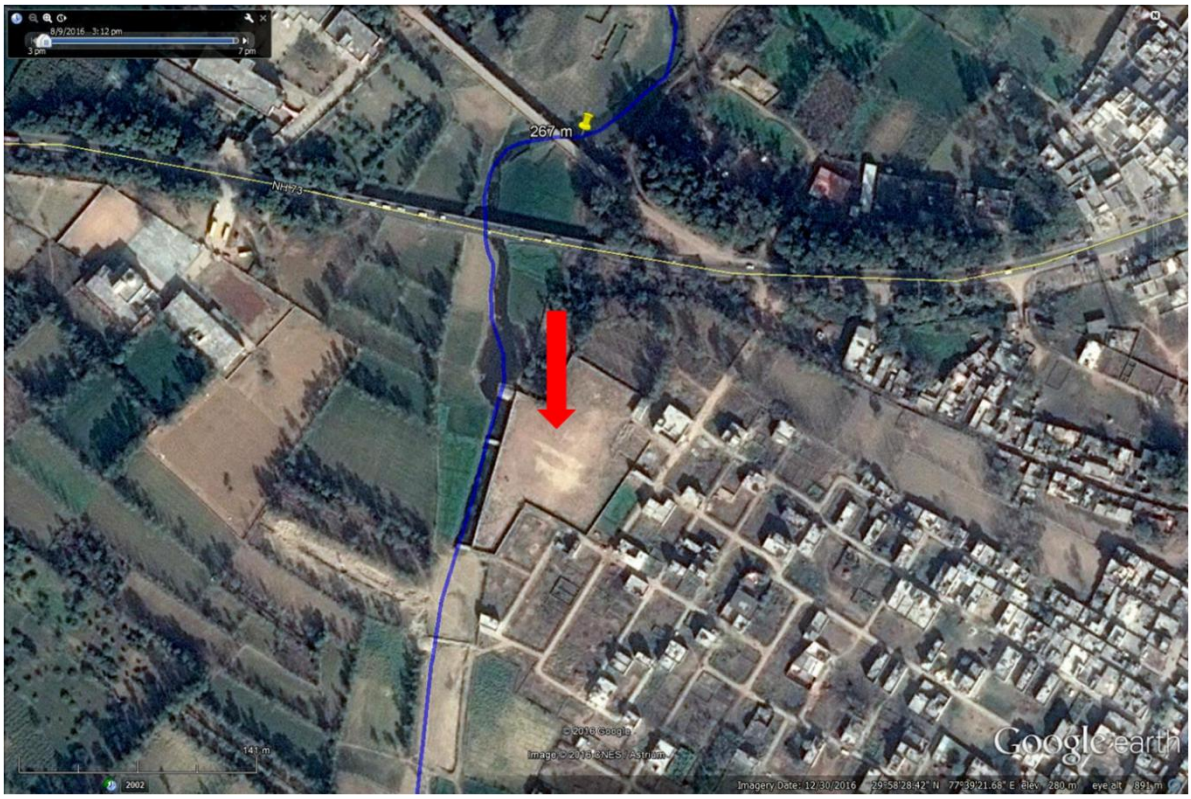
Map 56: Location of Hindon River in Saharanpur District



Map 57 : Location of Drains & Star Paper Sugar Mill at Saharanpur



Map 58 : Visible Difference in Water Color of Dhamola and Hindon at Sadholi Hariya Village



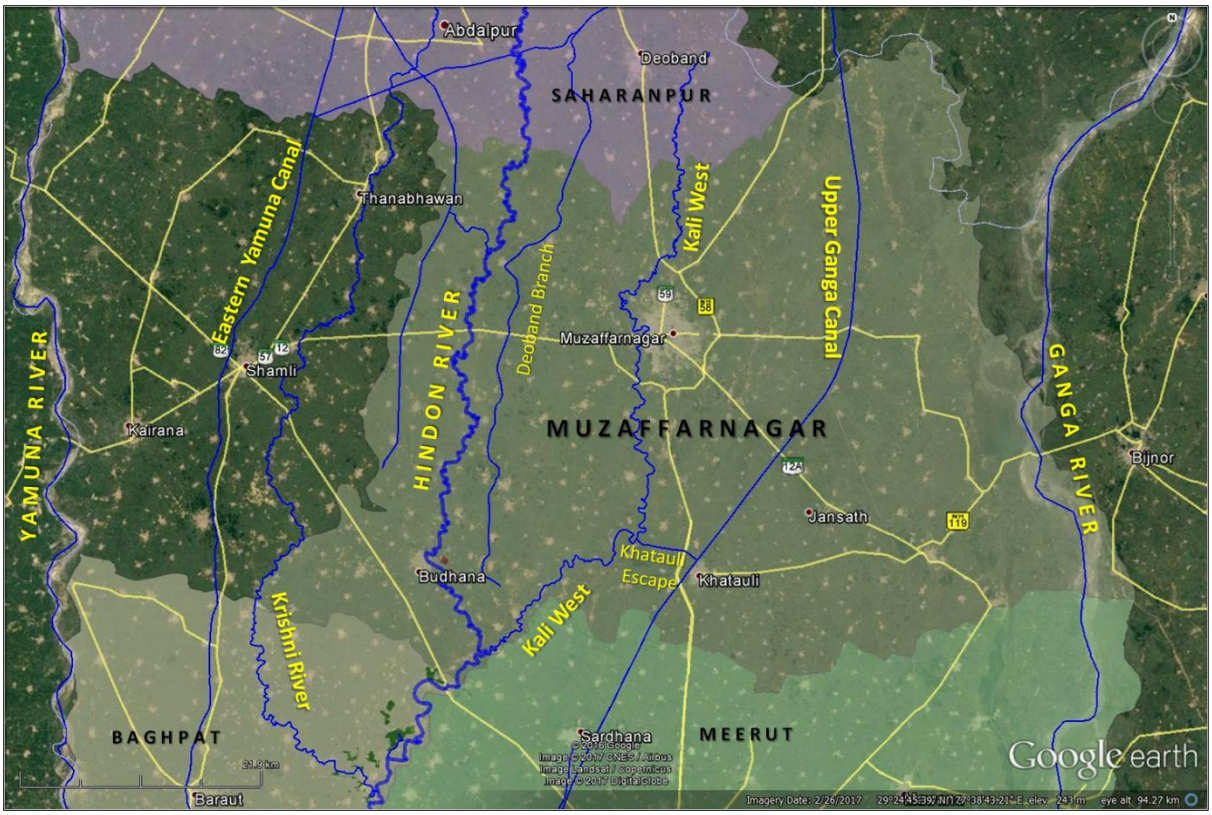
Map 59 : Campus On Floodplain Area Of Hindon Interferes With Natural Course At Gagalhedi, Saharanpur

Image 94 : Campus On Floodplain Area Of Hindon At Gagalhedi, Saharanpur [Towards South, 19/01/2017]

Image 95 : Extended Agricultural Fields into The Hindon River at Gagalheri, Saharanpur [19/01/2017]

4.0 Issues In Muzaffarnagar

4.1 Hindon River flows through western part of the district.. Muzaffarnagar is considered as the most significant contributor of pollution to Hindon. Various factories (sugar mills, tannery, distilleries, paint etc) discharge their untreated effluents in Hindon river. Kali (West), an important tributary of Hindon River also adds untreated industrial discharge round the year. Titawi Sugar Mill near village Titawi and Bajaj Sugar Mill near Budhana are two major industry in the region which discharge their effluent in Hindon. In addition, many smaller and lesser known industries discharge their effluent in Kali River which joins Hindon at Pithlokar village, Muzaffarnagar. As reported from people from Muzaffarnagar town and nearby local villagers, the ground water quality has degraded and people are dependent on submersible pumps or Reverse Osmosis Systems for drinking water. At Budhana, main river channel and floodplain area has been encroached for housing constructions. The river is infested with Water Hyacinth (*Eichhornia crassipes*) which indicates high degree of pollution. Besides receiving residential sewage discharge, the river has become a dumping ground where people throw solid waste garbage and construction debris. The river channel area is encroached by agriculture fields at most of the places along its length.



Map 60 : Location of Hindon River in Muzaffarnagar District

Image 96 : Construction Debris and Solid Waste in Hindon at Budhana

Image 97 : Hindon River is Treated as Dumping Ground at Budhana, Muzaffarnagar

Image 98 : Kali River at MuzaffarNagar Town[24/05/2017]

Image 99 : Kali River Near Village Maleera, Muzaffarnagar [24/05/2017]

Image 100 : Bajaj Sugar Mill, Budhana, Muzaffarnagar

[Source: Bajaj Group]

Map 61 : Location of Bajaj Sugar Mill, Budhana, Muzaffarnagar

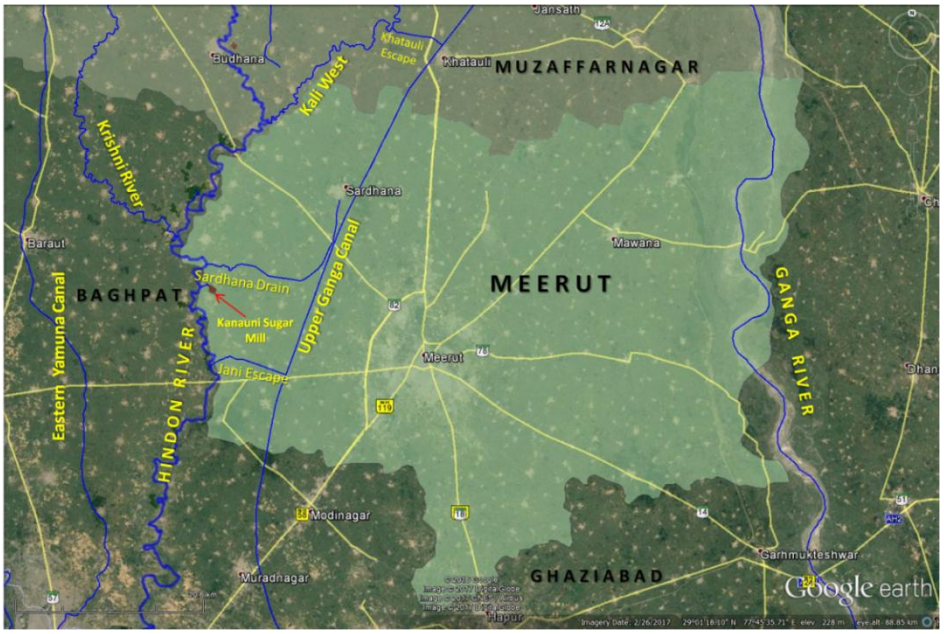
Image 101 : Titawi Sugar Complex, Titawi, Muzaffarnagar

Image 102 : Drain At Begrajpur Which Eventually Falls Into Kali Tributary Of Hindon

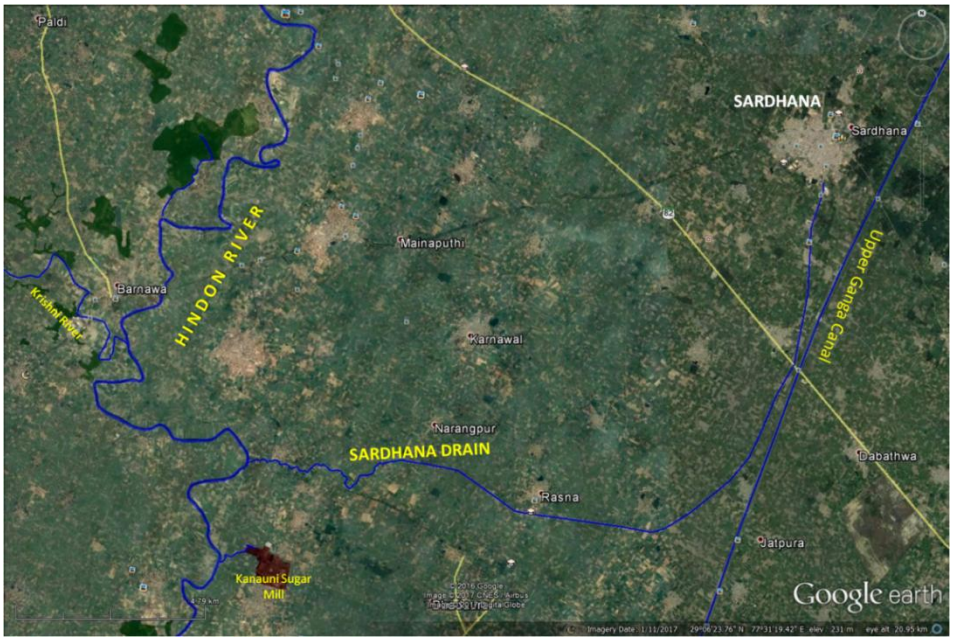
Source: Burhaan Kinu/HT Photos

5.0 Issues In Meerut

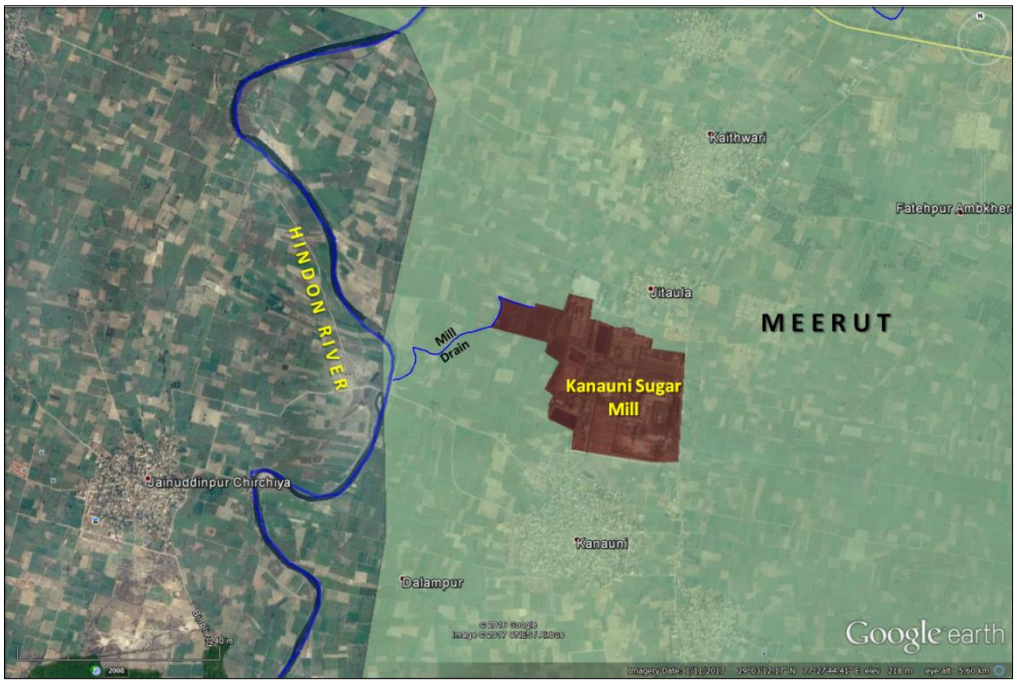
5.1 Hindon River flows on the western most border of Meerut and the main city is around 25 km from the river. There are no immediate threats from the city except Kinauni Sugar Mill which discharges its effluents into the river. It is located about 1 km on the left bank of Hindon River. Another source of effluent discharge is a major drain which comes from Sardhana town and joins Hindon near Kheri Nizd Kalina village around 10 km downstream of Barnawa.



Map 62 : Location of Hindon River in Meerut District



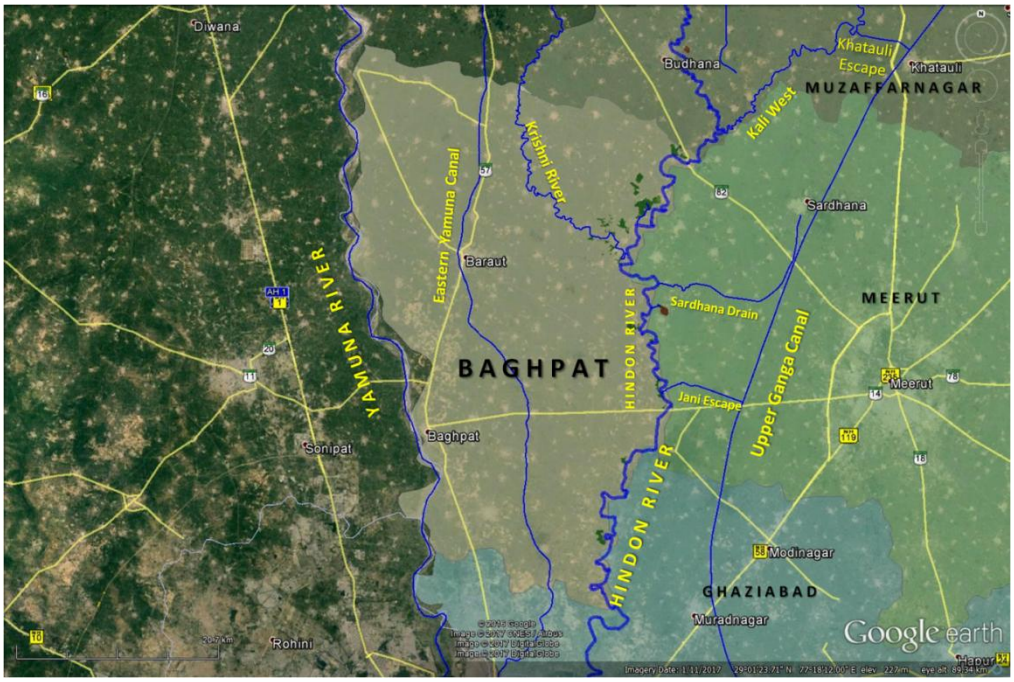
Map 63 : Location of Sardhana Drain



Map 64 : Location of Kanauni Sugar Mill

6.0 Issues In Baghpat

6.1 Hindon River flows on the easternmost border of Baghpat bordering Meerut district. The main Baghpat town is around 25 km from the Hindon river located on the westernmost border of the district near Yamuna River. Contaminated groundwater water apparently due to polluted Hindon is one of the major and highlighted problems being faced by local villagers living on the vicinity of the river. District administration has sealed several groundwater handpumps in the past. See the ground water pollution section in the pollution section above in the report.



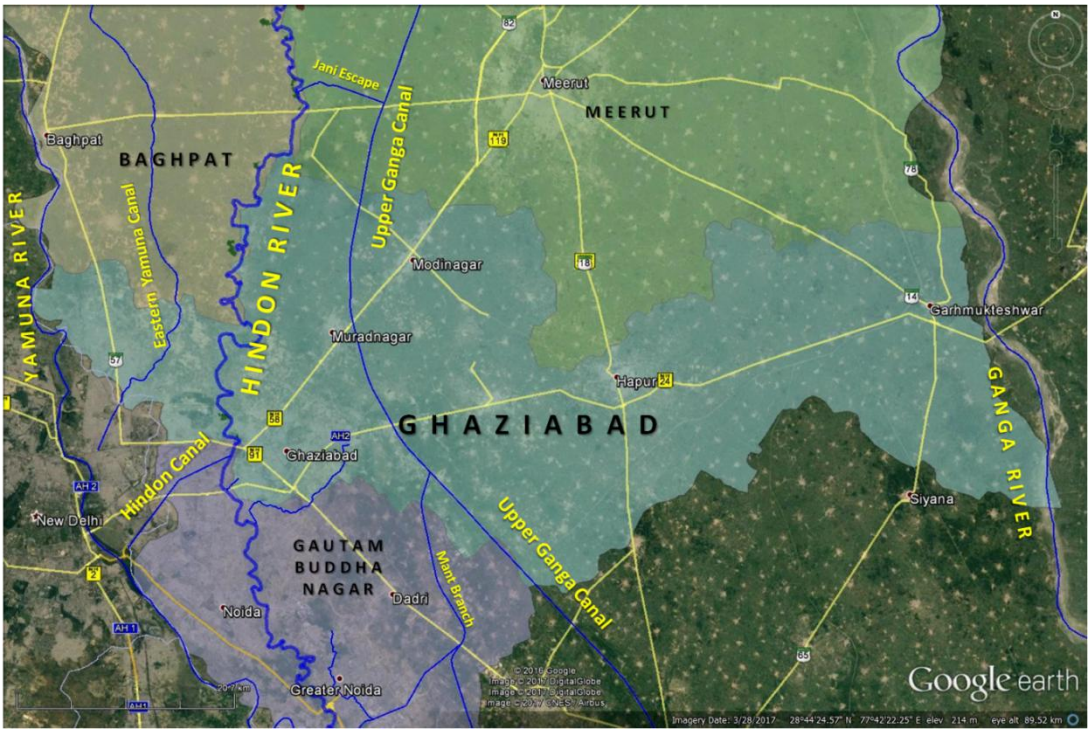
Map 65: Location of Hindon River in Baghpat District

Image 103 : Hindon at Pura Mahadev, Baghpat is Infested with Water Hyacinth

7.0 Issues In Ghaziabad

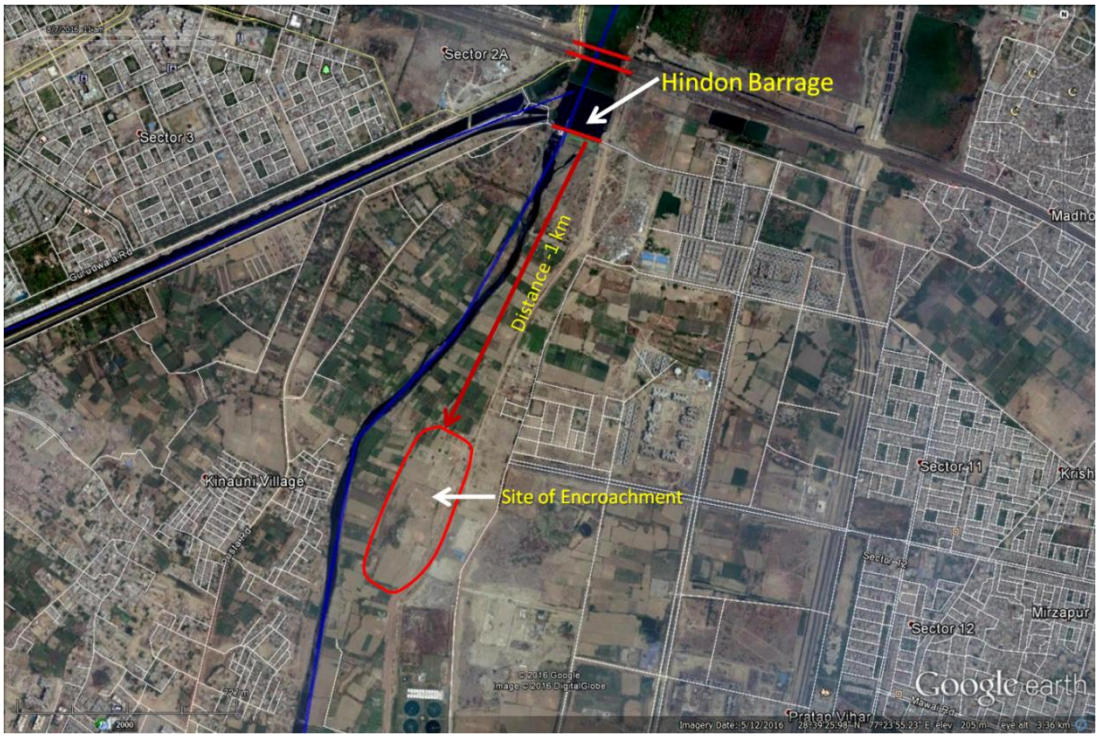
7.1 Hindon River passes through western part of Ghaziabad district after crossing Baghpat upstream. The river is considered most threatened here owing to growing urbanisation and illicit development.Land encroachment and solid waste dumping on Hindon flood plain areas, untreated municipal and toxic industrial effluents discharge direct in the river. Despite, Uttar Pradesh government's notification in March, 2010 to ban the construction activities on river floodplains with stricter compliance of rules regarding development near waterbodies nothing has stopped. In Ghaziabad alone, 11 of the total 52 hectares of waterbodies identified under tehsil has have been encroached by locals and development housing agencies[40].

[40] Land mafia thrives as illegal colonies shrink river space, Hindustan Times, 17 July, 2015 via PressReader .



Map 66 : Location of Hindon River in Ghaziabad District

Image 104 : Hindon Floodplain Area Encroachment by Real Estate at 1 km Donwnstream Hindon Barrage [Date: 08/03/2017]



Map 67 : Site Of Encroachment On Hindon Floodplain

Image 105 :No. Of Illegal Colonies Have Come On The Banks Of Hindon River Near NH-24. Residents Dump Sewage And Sold Waste Directly Into The River.

Map 68 : Illegal Colonies Banks Of Hindon River Near NH-24 As Seen From The Satellite View

Image 106 : Hindon Water Turned Red In 2014 Due To Stone Crushing Units Operating Illegaly On Its Bank Near National Highway -24, Ghaziabad [Photo: Baishali Adak, Mail Online India, 18 Dec 2014]

7.2 As per Mail online[41] news of 18th Dec 2014, the stone crushing units operates illegaly on the bank of Hindon river. They bring gigantic stones from hills, crush them into sand and use

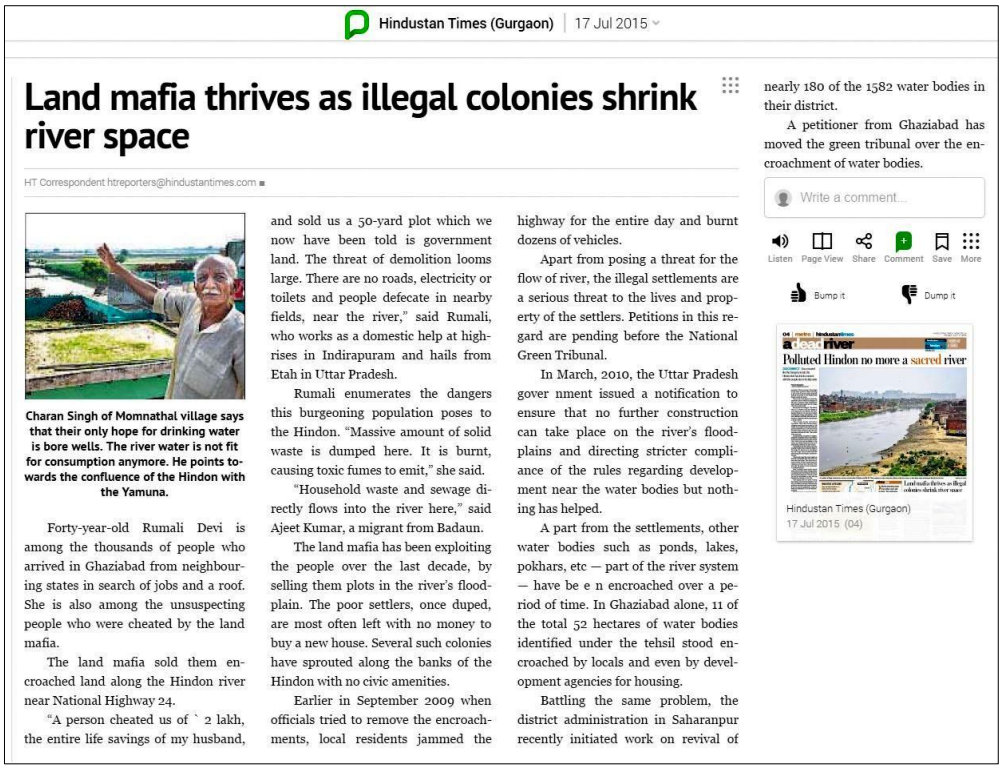
[41] Hindon River runs red with pollution: Health scare for bankside villages as stone-crushing units dump dangerous waste, Mail Online, India, By Baishali Adak, 18Dec, 2014

Hindon's water in the crushing process and then discharge the remaining effluents back into the river.

"We have spent our childhood swimming in the Harnandi, which is its original name. After 1996, when the Ghaziabad Municipal Corporation set up drains which emptied effluents directly into the river, we started noticing the change. It became dirty emitting a foul smell and we stopped using its water for bathing or washing clothes," says Radheshyam, a villager"

- Quoted from news article "Hindon River runs red with pollution: Health scare for bankside villages as stone-crushing units dump dangerous waste", Mail Online India, By Baishali Adak, 18 Dec, 2014.

Image 107 : Locals and activists say the Hindon river pollution is contributing to health issues such as birth defects and skin problems [Baishali Adak, Mail Online India, 18 Dec 2014]



Hindustan Times (Gurgaon) | 17 Jul 2015

Land mafia thrives as illegal colonies shrink river space

HT Correspondent htreporters@hindustantimes.com

Charan Singh of Momnathal village says that their only hope for drinking water is bore wells. The river water is not fit for consumption anymore. He points towards the confluence of the Hindon with the Yamuna.

Forty-year-old Rumali Devi is among the thousands of people who arrived in Ghaziabad from neighbouring states in search of jobs and a roof. She is also among the unsuspecting people who were cheated by the land mafia.

The land mafia sold them encroached land along the Hindon river near National Highway 24.

"A person cheated us of ` 2 lakh, the entire life savings of my husband, and sold us a 50-yard plot which we now have been told is government land. The threat of demolition looms large. There are no roads, electricity or toilets and people defecate in nearby fields, near the river," said Rumali, who works as a domestic help at high-rises in Indirapuram and hails from Etah in Uttar Pradesh.

Rumali enumerates the dangers this burgeoning population poses to the Hindon. "Massive amount of solid waste is dumped here. It is burnt, causing toxic fumes to emit," she said.

"Household waste and sewage directly flows into the river here," said Ajeet Kumar, a migrant from Badaun.

The land mafia has been exploiting the people over the last decade, by selling them plots in the river's floodplain. The poor settlers, once duped, are most often left with no money to buy a new house. Several such colonies have sprouted along the banks of the Hindon with no civic amenities.

Earlier in September 2009 when officials tried to remove the encroachments, local residents jammed the highway for the entire day and burnt dozens of vehicles.

Apart from posing a threat for the flow of river, the illegal settlements are a serious threat to the lives and property of the settlers. Petitions in this regard are pending before the National Green Tribunal.

In March, 2010, the Uttar Pradesh gover nment issued a notification to ensure that no further construction can take place on the river's floodplains and directing stricter compliance of the rules regarding development near the water bodies but nothing has helped.

A part from the settlements, other water bodies such as ponds, lakes, pokhars, etc — part of the river system — have be e n encroached over a period of time. In Ghaziabad alone, 11 of the total 52 hectares of water bodies identified under the tehsil stood encroached by locals and even by development agencies for housing.

Battling the same problem, the district administration in Saharanpur recently initiated work on revival of nearly 180 of the 1582 water bodies in their district.

A petitioner from Ghaziabad has moved the green tribunal over the encroachment of water bodies.

Write a comment...

Listen Page View Share Comment Save More

Bump it Dump it

Polluted Hindon no more a sacred river

Hindustan Times (Gurgaon)
17 Jul 2015 (04)

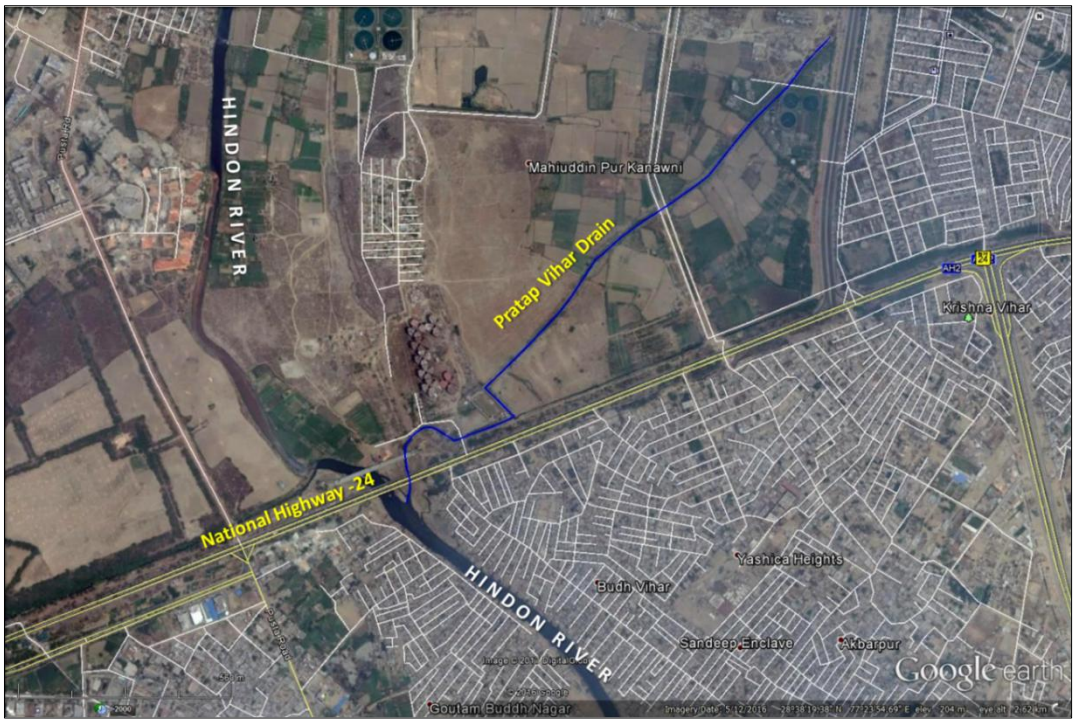
Image 108 : Hindustan Times News Article Highlighting Issues of Hindon River [17July 2015]

Image 109 : Natural Flow of Hindon Blocked With Mud For Elevated Road Construction [Location: Hindon Bridge Hapur Road NH-58; Date: 09/08/2016]

Image 110 : Pillars for Elevated Road Erected in the Hindon 1 km upstream of HajHouse [Photo: Hindon Jal Biradari, Facebook Post, 18 May, 2016]

Image 111 : Pratap Vihar Drain in Ghaziabad Discharge Residential Sewerage in Hindon River

Image 112 : Karhera Drain Discharging Its Effluents In Hindon River On Raj Nagar Ext -Loni Bypass Road, Ghaziabad



Map 69 : Location of Pratap Vihar Drain in Ghaziabad

Map 70 : Location of Meerut Road Industrial Drain and Residential Drain in Ghaziabad

Image 113 : Electric Power Station Near Karhera Bridge, Ghaziabad

Map 71 : Diverted Hindon River Channel by Karhera Bridge at Ghaziabad

Image 114 : Dry River Channel as a Result of Diverted Hindon River Channel by Karhera Bridge at Ghaziabad [Towards Southwest; 08/03/2017]

Image 115 : Disturbed River Channel as a Result of Diverted Hindon River Channel by Karhera Bridge at Ghaziabad [Towards South; 08/03/2017]

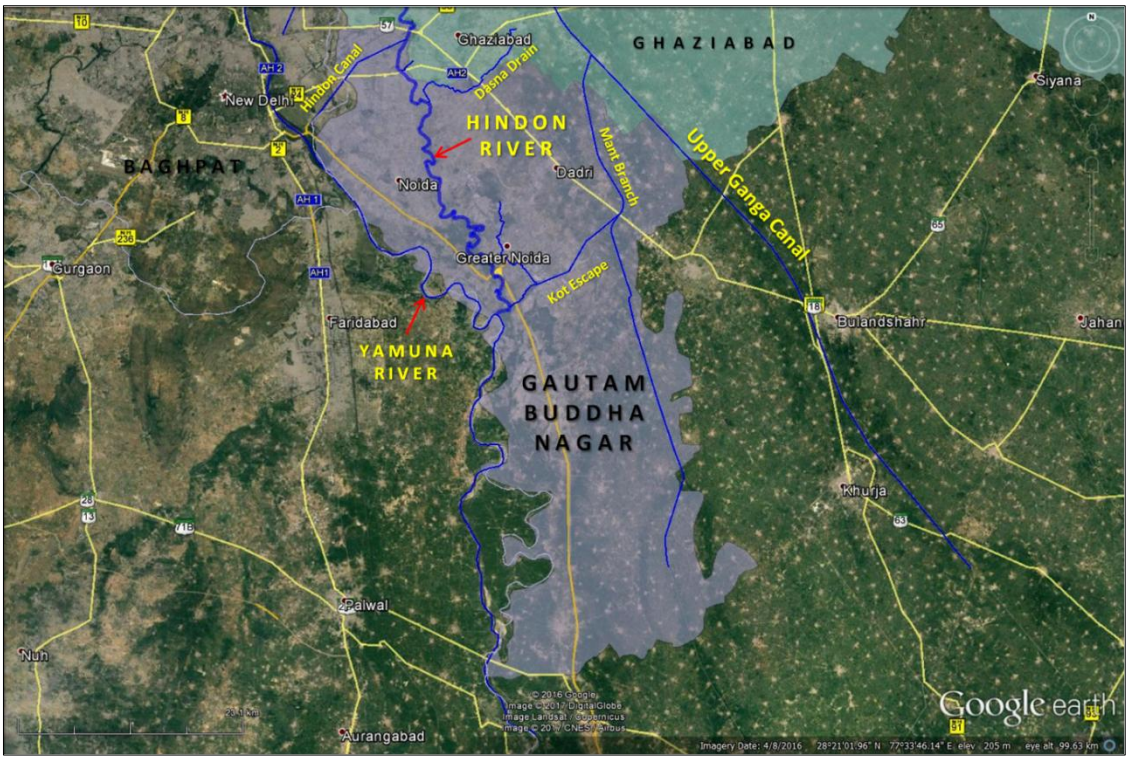
Image 116 : Blocked and Incomplete STP Discharge Pipe at Ghaziabad [Date: 08/03/2017]

Image 117 : Solid Waste Dumping Site Near Hindon River Ghaziabad [Date: 08/03/2017]

Image 118 : Ganga Water Treatment Plant is Located Adjacent Solid Waste Dumping Sites at Ghaziabad [Location 1 km Downstream Hindon Barrage, Ghaziabad]

8.0 Issues In Gautam Buddha Nagar

8.1 Hindon River flows through northwestern part of Gautam Buddha Nagar district of Uttar Pradesh. Illegal constructions on floodplains, solid waste disposal and sewage discharge, over exploitation of groundwater along the banks along 49-km-long stretch of the Hindon in Gautam Budh Nagar district. More structures are coming up on Hindon River. Last year during August 2016, Noida and Greater Noida authorities planned to construct three new roads that will cross the Hindon River to improve the connectivity between the two cities. The bridges will be constructed between Sector 150A in Noida and Sector Chi IV in Greater Noida, Shafipur in Noida and Knowledge Park II in Greater Noida, Sector 148 in Noida with Knowledge Park III in Greater Noida.



Map 72 : Location of Hindon River in Gautam Buddha Nagar District

Map 73 : Newly Constructed Bridge 8 Lane Bridge on Hindon River to Connect Noida & Greater Noida [Source Google Earth, 2016]

Image 119 : Hindon joins Yamuna at Tilwada viilage, Gautam Buddha Nagar near Delhi

Chapter IV – River Restoration Case Studies & Approaches

1.1 In India, concerted efforts on river conservation started with National River Conservation Plan (NRCP), a centrally funded scheme launched in 1985 to combat the pollution of rivers. The major components included construction of STPs, river front development, low cost sanitation, afforestation and catchment area treatment. The program of river cleaning focussed on River Ganga [GAP] and was extended to other major rivers of the country under NRCP scheme in 1995. Yamuna and Gomati Action Plans were approved in April 1993 under Ganga Action Plan Phase - II.

1.2 But after 32 years since inception of the NRCP, the situation of rivers has failed to improve but only worsened while sinking thousands of crores of rupees in the process. The reason for this, perhaps, is the capital energy and engineering intensive nature of the approach focussed mainly on sewage treatment through centralized plants compounded by an absence of a holistic basin management approach. While river pollution has still to be contained adequate flow in the river has simply not been addressed and despite tall talk of 'aviral dhara' [uninterrupted flow] the government persists with destructive dam building. Holistic river studies in the country are rare to be found and [as noted in Chapter I] are narrowly focussed on the water quality aspect of major rivers. Flow data is confined to major rivers and then not available in the public domain.

1.3 Still, before embarking on conservation planning for Hindon River, a survey of projects to revive rivers needs to be attempted for relevant lessons. The case studies have been culled from India and abroad [inspite of the fact that rivers in many foreign lands flow under different pulse conditions than those in the sub-continent].

2.0 Arvari River Rejuvenation

2.1 Arvari River rejuvenation is an oft quoted case study from Rajasthan. Arvari - a 90 km long minor river which flows through the Alwar District was dry for 60 years until a local NGO Tarun Bharat Sangh intervened and revived it early 1990s with the help of local villagers and community leaders of Bhaonta-Kolyala village .

2.2 Johads (earthen check dams) were constructed at the source as well as in the catchment of the river to harvest rainwater in order to improve percolation and raise groundwater level with the largest check dam being a 244 mt. long and 7 mt. high concrete dam in the Aravalli hills.

2.3 By 1995, water level in the wells downstream rose by two to three feet a year after completion of the dam. The intervention revived the local economy by improving water availability for domestic as well as irrigational purposes. Gradually, it became a perennial river with rich aquatic, avifaunal and riparian biodiversity.

2.4 To further manage the river and avoid any conflicts Arvari River Parliament was formed in 1999. The Parliament consists of 2 representatives each from 72 villages. It has framed 11 rules with regard to the use of river waters and its management. A coordination committee

comprising members selected by the Parliament handles the operations and ensures compliance with the rules.

Image 120: Arvari River After Rejuvenation [Source: watermanofindia.blogspot.in]

Image 121: Check Dam On Arvari River, Rajasthan

3.0 Kuttemperoor River - How A Village Panchayat Revived a Dying River

3.1 Kuttemperoor River - a tributary of Pamba and Achankovil rivers flowing through Alappuzha District of Kerala was in a bad state due to pollution and encroachment until it

was revived by Budhanoor Gram Panchayat of the district in early 2017. Seven hundred local people, employed under Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), completed the work in 70 days.

3.2 The once 12 km long, >30 m wide and 2-6m deep river had been reduced in all dimensions by 2005 due to illegal sand mining, waste dumping and acute proliferation of weeds. Alarmed with the uncertain water availability conditions due to regular drought events, the Gram Panchayat decided to intervene and look for long term solutions by reviving the Kuttemperoor River. Intervention required cleaning of bulky weeds and plastic waste from the river bed. After cleaning, water levels in the wells within 5 km radius of the river have improved significantly and river water started flowing normally.

Image 122 : Kuttemperoor River In Its Flow-Less, Weed-Ridden State. [Source: The Indian Express/ May 9, 2017]

Image 123: Kuttemperoor River After Restoration [Source: The Indian Express/ May 9, 2017]

4.0 Kali Bein River Restoration, Punjab

4.1 Kali Bein River is a 160 km long tributary of Beas River [Punjab] and considered holy by Sikh devotees. Due to large scale industrial effluents discharge and fertilizer runoff from fields, the river got severely contaminated and died completely with severe impact on groundwater and farmlands. Six towns and forty villages added their waste into it.

4.2 During 2000, Sant Balbir Singh Seechewal, a local saint, set out to clean the river manually with support from his devotees and villagers. Interventions included educating villagers, local fundraising, removal of aquatic weeds and diversion of water from a nearby canal to restore the flow.

4.3 After its restoration, thousands of hectares of land have been reclaimed from water-logging in Tehsil Dasuya of Hoshiarpur District, from desertification in Kapurthala district, and from floods in the Mand area of confluence of Beas and Satluj rivers.

4.4 Kali Bein River is still under threat from rising industrial and domestic pollution. In 2013 massive fish mortality occurred in the Kali Bein after release of toxic chemicals from the Sutlej River. In the same year, Times of India reported that polluted water was also entering the Bein from a sewage treatment plant in Kapurthala, despite a ban on such actions by district administration.

Image 124: Devotees Removing Weeds From Kali Bein River In Punjab [Source: The Indian Express]

5.0 Sasur Khaderi Rivulet Restoration

5.1 There are two smaller rivulets named Sasur Khaderi listed as 1 & 2 in Fatehpur District of Uttar Pradesh.

5.2 Sasur Khaderi-2 is a 46 km long tributary of Yamuna River which originates from a lake in Fatehpur. Like other many seasonal and ephemeral small rivers and streams in Indiaa, it had completely dried until it revived in 2013 by concerted efforts of District Magistrate Kanchan Verma with the help of local villagers under Central Govt.'s rural employment scheme MNREGA. The rivulet was choked due to siltation and would often cause water logging in adjacent villages during rainy season. During summers the same villages faced water scarcity.

5.3 Interventions required desiltation of the source lake and the main rivulet, construction of check dam and tree plantation around the lake and along the banks of rivulet to prevent further siltation. The task required 4000 labourers and 45 days. After restoration, water started flowing normally in the rivulet saved adjacent agricultural fields and villages from water logging and improved economic condition of the local farmers.

Before **After**

Image 125: Sasur Khaderi-2 Before and After Restoration

6.0 Thames River Restoration, England

6.1 River Thames is the longest river in England measuring 346 km in length. It flows through southern England and rises at Thames Head in Gloucestershire and flows into the North Sea via the Thames Estuary. Around 1950 River Thames started dying due to indiscriminate pollution and was declared 'biologically dead' in 1957 by Natural History Museum, London. Thames River was the carrier of London's waste in those times with industrial waste, untreated sewage, slaughterhouses' waste routed into it. Due to such a filthy state, it got branded as the "Great Stink" due to emitting continuous foul odour. Being dead for years, it regained life and was declared as one of the cleanest rivers in the world after years of restoration efforts.

6.2 Though restoration started early in 1850s with diversion of sewage directly into the outfalls at Beckton and Crossness and leaving central stretch of the river sewage free, the intervention failed due to improper planning with another set of efforts initiated almost hundred years later in 1960s. During these years, improved sewage treatment capacities were installed, industrial discharges and oxygen levels were monitored, biodegradable detergents were introduced with strict legal regulations regarding discharge quality and water use. Gradually over years, the aquatic and riparian habitats and species started thriving in the river with 125 species of fish and more than 400 species of invertebrates now inhabiting the river. Key initiatives that led to the success of the river restoration are:

- Restoration of Thames has been a process of regulation and remedial measures. Strict legislation prevented industry from dumping polluted effluent into the river and its tributaries. Sewage from London and the surrounding area gets treated first and then exported for further processing. Since 1996[42], the Environment Agency has been instrumental in regulating the Thames's waters, setting legislative limits on industrial use

[42] Thames: The tale that the river told, *Independent,* Oct 18, 2010

and ensuring their enforcement. The EU water framework directive, adopted on 23rd Oct 2010 has been a big step in this direction. The EU Water Framework Directive (WFD) establishes a legal framework to protect and enhance the status of aquatic ecosystems; prevent their deterioration and ensure long-term, sustainable use of water resources. (Read section 10.0 below for more information)

- Most of the concretised structures from both banks of the river were removed. Earlier, there was absence of soft surface and riparian vegetation - due to which growth of riparian species was difficult. The Environment Agency, with local authorities along the Thames have been active in removing these concrete barriers and replace them with mud banks allowing reed beds to grow. Gradually, it was learnt that allowing the river to follow its own path helps in growth of species and improves the health of the river. Piles of rubble were used to capture the sediment which helped to provide habitat to many invertebrates and molluscs which are the source of food for many other high order species.

6.3 Efforts to keep the river in healthy state are still on. In order to get rid of plastic and spread awareness, "The Cleaner Thames" campaign was launched in Sept, 2015. Thames Water, a private utility company in charge of London's water supply and waste water claimed that it removes more than 25,000 tonnes of debris from their sewage system every year[43]. During heavy rainfall, sewage water is discharged into the river to prevent flooding which increases the pollution load threatening ecology of the river. New tunnel "Thames Tideway Tunnel" - a major new sewer may provide relief in future.

Image 126: River Thames England Became One of the Polluted Rivers During 1950s [Source: UnicornTheatre]

[43] How the River Thames was brought back from the dead, BBC Earth, 12 Nov. 2015

7.0 Segura River Restoration, Spain

7.1 With 365 mm of rainfall, Segura River Basin located in Western Europe is considered as the driest part of the region. However, it contributes significantly to the agricultural produce of European Union. Large scale effluents discharge due to rapid industrial development coupled with water stressed situation killed Segura River gradually. Especially in 1980s, irrigation activities increased significantly followed by a severe drought period of 1992 to 1995[44] diminished river flow and untreated industrial and urban discharges thus had severe impact on the life of the Segura River with cascading effects especially on the ecology and livelihoods in the middle and lower courses of the river.

7.2 Observing the sorry state of the river for years, a joint initiative was developed between local and central administrative bodies such Regional Water Department, Segura River Authority, town councils and European Union Funds. As a part of restoration process, 100 treatment plants and 350 km of sewer system were built. In addition, a regional Wastewater Reclamation Levy (tax on the discharge of wastewater into the public sewage system) was established as an economic tool to finance their operation, maintenance and monitoring. Single tariff was applied throughout the region with different charges for domestic and industrial discharge on basis of polluter pays principle enforced since 2003.

7.2 Around, 110 cubic hectometre of recycled water is used annually in agriculture. This has been one of the significant contributors in reviving health of the river which accounts for 10% of the annual natural river basin resources. Two wetlands that were linked to the treatment plants revived gradually with visible population of flora and fauna - and have been included in the Ramsar List of Wetlands of International Importance in 2011. Both the sites are important staging and breeding grounds for many species of waterfowl such as internationally endangered Whiteheaded Duck (*Oxyura leucocephala*) and and the vulnerable Marbled Duck (*Marmaronetta angustirostris*). Furthermore, the sites offers habitat to many different species of fish, amphibians, reptiles, invertebrates and mammals. Otter population in Segura River, which became endangered during 1990s because of large scale pollution revived significantly due to improvement in water quality. Their presence indicates improvement is water quality owing to their dependence on aquatic prey such as crabs, fishes and little mammals.

7.3 Two different Life+ programs (European Commission's larger programme for environment and nature) aim to restore the ecosystem linked to the river. *Segura Riverlink program* aims to improve and strengthen the connectivity between natural ecosystems with larger goal to bring them back to their original state while the other programme *Ripisilvanatura* intends to control the expansion of alien invasive species and promote the growth of native vegetation.

7.4 During the period 2001 to 2010, the river transformed into one of the cleanest rivers in Europe. The project was well appreciated and awarded the European Prize in the field of River Restoration by International River Foundation.

[44] Spain: Segura River returned to its health, Global Water Partnership, 2016

8.0 The Murray - Darling Basin, Australia

8.1 The Murray-Darling Basin (MDB) is the widely studied basin in Australia drained by two major rivers i.e Murray and Darling. It covers 14% of Australia providing home to over two million people. It is 3,780 km in length and the total catchment area of the basin is around 1,060,000 sq. km. The Murray-Darling Basin generates about $ 19 billion a year from agricultural produce which includes 50% of Australia's irrigated produce worth around $ 7.1 billion a year.

8.2 Rivers Murray and Darling are culturally important rivers of Australia which have been historically connected with Aboriginal people for 45,000 years. Various cultural sites such as fish traps, middens, ochre sites, scarred trees and rock shelters provide an insight into traditional Aboriginal culture.

8.3 Murray-Darling Basin has been an important water resource for the development of Australian economy. Water is diverted for agricultural, household and urban use. Around 80-90% is used for irrigated agriculture. An average of about 1,375 gigalitres of groundwater is extracted annually.

8.4 In recent decades, the health of the Murray–Darling Basin has been affected by droughts and over-use of water resources. Almost a decade-long millennium drought, starting around 2000, caused significant damage to ecosystems as well as to the economy. It ended with widespread flooding in 2010, resulting in inundation of many floodplains and raising the Basin's water storages from 32% to 81% during 2010–11. The flooding enabled many species to recover from the effects of a long drought but also caused widespread damage to property.

Image 127: Murray-Darling Basin Map [Source: MurrayRiver.com]

8.5 **The key to improving river system's health is creating more natural and variable flows by leaving more water in rivers, wetlands and floodplains. The Australian Government works to improve the health of the basin by investing in water-efficient infrastructure on farms and buying back water. This water is then used to help improve the health of priority sites across the Basin.**

8.6 In response to the millennium drought, in 2007 Australian Govt. came out with a 10 year 'National Plan For Water Security' and asked MD Basin states to transfer their powers to enable the Commonwealth to oversee the management of the MD Basin. Murray-Darling Basin Authority (MDBA) was constituted with responsibilities of setting a cap on the sustainable use of Basin water resources. The Water Act 2007 established the MDBA which is responsible for preparing the Basin Plan which must contain :

- long-term average Sustainable Diversion Limits (SDLs) for the amount of surface water and groundwater that can be taken from Basin water resources
- an environmental watering plan
- a water quality and salinity management plan and
- rules about trading of water

8.7 It has been noted that the social, economic and environmental outcomes of the water resources must not be compromised. The Plan also outlined risks to Basin water resources, such as climate change, and strategies to manage them.

[Source: Murray-Darling Basin Management, Parliament of Australia and Murray–Darling Basin Authority, Commonwealth of Australia, 2017]

Lessons From The Case Studies

The above stated Indian cases demonstrate local level initiatives which in the short term restores river flow. Thus, Arvari River case shows that watershed management, especially in the upper reaches, raises the water table and thereby the groundwater discharge into the river. The case of Kali Bein shows the importance of community mobilization as well as the need to prevent untreated effluent discharge from entering the river. The case of the Kuttemperoor River shows the importance of keeping the active river channel free of chokage to ensure free flow as well as enable efficient drainage which prevents water logging of the fields. The case of Sasur Khaderi rivulet replicates the lessons of the above two cases.

The latter two case studies above also show the effectiveness of deploying MGNREGA scheme for performing several contributory works at the basin level effectively, economically and rapidly.

However, the absence of a basin level approach reduces the robustness and longevity of the interventions. Moreover the monitoring of key aspects such as water flow, water quality and biodiversity has not been maintained thus the robustness and longevity of the improvements remains unsubstantiated.

The Thames River case shows the importance of treating effluents thoroughly before discharge into the river but also of protecting floodplains and riparian areas as also of biological monitoring to assess the health of the river.

The Segura River case shows the importance of a wider basin approach combining ecosystem management, regulatory aspects, managing the water budget holistically.

The Murray Darling Basin study shows the importance of basin management in conserving rivers and the need to have an overarching basin management authority which overrides several hierarchies of spatial and sectoral jurisdiction by giving highest priority to hydrological rejuvenation. The objective of leaving more water in the natural channels and wetlands was identified as the key to improving the river system's health

9.0 Apart from case studies it is important to understand the **principles of basin management** as well as of much clichéd **e-flows**. But first the basin management in which the rest of the world has taken major strides but which in India is in its infancy.

9.1 **Basin Management :** Knowledge of river basin is essential prior to make any river conservation plan. River basin which is synonymously used with drainage basin or catchment area is the portion of surrounding land which sends the water into the river due to natural

geographical gradient. It also constitutes watershed area, tributaries, confluence, source, mouth of the river.

9.2 Barrow[45] (1998) states that efforts to manage rivers date back to 5,000 years or more but the suggestion that a basin could be used as a planning and administrative unit probably first made in 1752 AD[46]. Barrow further states that the idea of coordinating the demands made within a basin was promoted by Sir William Wilcocks when he was planning to regulate the Nile in the 1890s. In Colonial India, irrigation development resulted, by the 19th century, in Command Area Development Authorities, units administering areas supplied with water by a canal system, and in many respects similar to "top-down" forms of RBDPM (i.e. promoted by direct government intervention). Barrow (1998) describes **six major forms of River Basin Development Planning and Management** (RBDPM)

i. Single Purpose : Early efforts were mainly single-purpose: flood control, hydroelectric generation, irrigation supply, etc. Planners and managers faced the need to share water between different users and to reduce conflicting demands. Development efforts are often still essentially "single purpose" (though those involved may claim otherwise). Simple subdivision of water does not deal with conflicting uses and misses opportunities for using water resources exploitation to get integrated development.

ii. Dual purpose : Combining two development goals can be done by making simple, easily monitored tradeoffs, for example, a dam can supply power and control floods. Nowadays, river development is seldom so simple.

iii. Multipurpose : Multipurpose RBDPM seeks to, more-or-less simultaneously, pursue a number of goals. In the past there was a tendency to simply divide up available water resources without assessing conflicts or what would be optimum development (UN, 1955)[47].

iv. Comprehensive : The UN (1976, p. 25)[48] defined comprehensive RBDPM as . . . "a planned, complex, continuous and interdisciplinary process which is controlled on a systems analysis basis." It considers both land and water resources and development and how they interrelate, the goal being optimal development of resources (Thorpe, 1986)[49]. Comprehensive RBDPM puts less emphasis on promoting human welfare than integrated RBDPM.

v. Integrated : There has been some confusion in the literature between integrated and comprehensive RBDPM reflecting the diversity of people interested in it. Integrated and comprehensive approaches share: (i) adoption of a basin-wide program; (ii) multipurpose development; (iii) a comprehensive regional development goal -some see comprehensive RBDPM as an improvement of the integrated approach with a welfare focus. In practice, it makes sense to use the term "integrated" for an approach which goes further than "comprehensive" RBDPM first, to actively use water as a "tool" for social and economic development (Falkenmark, 1985)[50] or "engine of development" and, second, to deal with

[45] Barrow C.J., (1998) River Basin Development Planning and Management: A Critical Review. *World Development.* Vol. 26 No. 1 pp. 171-186

[46] Chorley, R. H., ed. (1969) Introduction to Geographical Hvdrology: Spatial Aspects of the Interactions Between Water Occurrence and Human Activity. Methuen, London.

[47] United Nations (1955) *Multiple Purpose River Basin Development. Part 1. Manual of River Basin Planning.* ESCAFE Series, United Nations, New York.

[48] United Nations (1976) *River Basin Development: Policies and Planning, Vol. I.* Proceedings of a UN Interregional Seminar on River Basin and Interbasin Development September 16-26, 1975, Budapest. UNDP/National Water Authority of Hungary, Washington, DC.

[49] Thorpe, B. R. (1986) Comprehensive basin management in England and Wales. *Water Supply 4(Z), 9-13.*

[50] Falkenmark, M. (1985) Integration in the river basin context. ***Ambio XIV(3),*** 118.

relationships between basin activities, demands, needs, etc. Out of the confusion the integrated approach emerges with a stronger intention of managing the river basin for human welfare. Integrated RBDPM has been promoted by a number of international agencies, e.g., the UN (1958)[51], UN (1976)[52] and the OAS (1978)[53]. There have been successful applications, e.g., the Volga, Dnieper and Rhone Rivers have a degree of integrated RBDPM (UN, 1970, p. 27)[54]. But, unfortunately, many efforts have been failures.

vi. Holistic : Holistic RBDPM tries to consider the entire basin system for the whole projected lifespan of development activities, and examines how components, people, planners and managers interact at all levels (Hennessy and Widgery, 1995)[55]. Mitchell (1989)[56] argued the holistic approach should extend beyond integrated RBDPM to deal with strategic levels of planning and management. Newson (1988, p. 69)[57] hoped that holistic RBDPM could "reform river basin management in the developing world."

- The goals of RBDPM vary from one basin agency to another, but can include:
- To coordinate the use of shared basins (multiusers/interstate/intemation)."
- To avoid environmental degradation.
- To promote sustainable development.
- To integrate land and water management.'
- To promote integrated, optimal development of natural resources, agriculture, infrastructure, social services, etc.'
- To provide comprehensive and decentralized management and planning.
- To decentralise planning and management and make it adaptive.'
- To ensure developments within a basin do not interact in a negative way.
- To focus natural resource benefits for regional development and serve as a regional planning and management strategy.'
- To attract development into a basin/remote area, countering the "pull" of large cities or favoured areas.
- To promote rural development.
- To provide an acceptable management and planning approach that might "side-step" existing stagnant or corrupt arrangements.
- To establish a politically acceptable way of gaining the cooperation of co-riparian states or nations which would probably refuse to surrender authority to other types of agency.
- To integrate environmental dimensions with other aspects of planning and management.'

9.3 Building upon Integrated Water Resource Management[58] by Global Water Partnership, World Wildlife Fund (WWF) came out with "Integrated River Basin Management (**IRBM**) process which **rests on the principle that naturally functioning river basin ecosystems, including accompanying wetland and groundwater systems, are the source of fresh**

[51] United Nations (1958) *Integrated River Basin Development: Report of a Panel of Experts.* UN Department of Economic and Social Affairs, New York.

[52] United Nations (1976) *River Basin Development: Policies and Planning, Vol. I.* Proceedings of a UN Interregional Seminar on River Basin and Interbasin Development September 16-26, 1975, Budapest. UNDP/National Water Authority of Hungary, Washington, DC.

[53] OAS (1978) *Environmental Quality and River Basin Development: A Model for Integrated Analysis and Planning.* Secretary General of the Organization of American States and the Government of Argentina, Washington, DC.

[54] United Nations (1970) *Integrated River Basin Development: Report of a Panel of Experts.* Revised edn., UN Department of Economic and Social Affairs, New York.

[55] Hennessy, J. and Widgery, N. (1995) River basin development, the holistic approach. ***In~emational Water Power and Dam Consrruction 47(5), 24-26.***

[56] Mitchell, B., ed. (1989) *Integrated Water Management.* Belhaven, London.

[57] Newson, M. D. (1988) Applied physical geography: the opportumttes and constraints of environmental issues revealed by river basin management. *Scottish Geogruphical Magazine 104(2), 67-71.*

[58] Integrated Water Resources Management, Global Water Partnership Technical Advisory Committee Background Papers, No. 4, 2000.)

water."IRBM is the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximise the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems."

9.4 The seven key elements to a successful IRBM initiative are :

- A long-term vision for the river basin, agreed to by all the major stakeholders.
- Integration of policies, decisions and costs across sectoral interests such as industry, agriculture, urban development, navigation, fisheries management and conservation, including through poverty reduction strategies.
- Strategic decision-making at the river basin scale, which guides actions at sub-basin or local levels
- Effective timing, taking advantage of opportunities as they arise while working within a strategic framework
- Active participation by all relevant stakeholders in well-informed and transparent planning and decision-making
- Adequate investment by governments, the private sector, and civil society organisations in capacity for river basin planning and participation processes
- A solid foundation of knowledge of the river basin and the natural and socio-economic forces that influence it

10.0 River Basin Management in Europe

10.1 Europe has river basin management plans[59] available in each river basin district for better planning of their water resources. Europe is managing its water resources by close international cooperation between its countries. Since the adoption of European Union Water Framework Directive [WFD] on 23rd October, 2000, all countries of the European Union are using a river basin approach for water management. The EU Water Framework Directive (WFD) establishes a legal framework to protect and enhance the status of aquatic ecosystems; prevent their deterioration and ensure long-term, sustainable use of water resources.

10.2 The Directive provides for an innovative approach for water management based on river basins, the natural geographical and hydrological units, and sets specific deadlines for EU Member States. The WFD addresses inland surface waters (rivers and lakes), transitional waters, coastal waters, groundwater and, under specific conditions, water dependent terrestrial ecosystems and wetlands. It establishes several integrative principles for water management, including public participation in planning and the integration of economic approaches, and also aims for the integration of water management into other policy areas. For better coordination, the WFD calls for the creation of international districts for river basins that cover the territory of more than one EU Member State. EU Member States aim to achieve good status in all bodies of surface water and groundwater by 2015 and 2027 respectively.

[59] River Basin Management Plans - European Commission http://ec.europa.eu/environment/water/participation/map_mc/map.htm

11.0 Europe: RESTORE Project

11.1 Europe may seem to have adequate water resources but in recent years water scarcity and drought have hit the European Union adversely. As per estimates, in 2007 at least 11% of Europe's population and 17% of its territory was affected by water scarcity and droughts altogether have cost Europe a 100 billion Euros in the last 30 years[60]. River ecosystems throughout Europe have been severely impacted by engineering projects for flood protection, navigation, water supply and hydroelectricity. It is estimated less than 20% of Europe's River and floodplains are in their natural state[61].

11.2 Europe started 'RESTORE Project' with the aim of addressing knowledge transfer on river restoration among practitioners in Europe. It aimed to develop network of policymakers, river basin planners, practitioners and experts to share information and good practice on river restoration activities. Restore is UK-based project co-financed by LIFE (the European Union's fund for environment). RiverWiki is another product of the project which is an online interactive database of river restoration case studies from across Europe is a good source of information on European Rivers.

12.0 Sweden: ReMiBar Project

12.1 ReMiBar project[62] aimed to remove the barriers and improve water flow continuity in many smaller rivers and streams in Northern Sweden in order to improve the fish population and ecology of other aquatic species. Target species included Salmon, Freshwater Pearl Mussel, Bullhead and Otter. Financed by EU Commission it started in September, 2011 and **led to the removal of 300 barriers which were obstructing the flow of the smaller rivers and streams.** The project also focussed on various information and education initiatives to increase the awareness of migration barriers in stream crossings among contractors, road managers, landowners and authorities.

13.0 Rivers Restoration Work in USA

13.1 Dam construction has been the major issue concerning rivers in United States. As per statistics by local organisation 'American Rivers', there are an estimated 90,000 dams in the U.S. blocking 600,000 miles of rivers length. Since 1912, many dams [1384 no.s] have been removed.

13.2 In recent years, the dam removal momentum has been strong with 72 dams removed in 2016 along with many culverts. Defunct dams pose safety risk to the lives of people and interfere with fisheries habitats. One of the most popular dam decommissioning controversy had been on Elwha River which wiped out rich population of steelhead trout and salmon from nearly 400,000 fish to less than 3,000. It impacted livelihoods and culture

[60] The EU and India - Partnering to address water challenges, European Union
[61] Restore River Project (http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=3780&docType=pdf)
[62] Remibar, Trafikverket Swedish Transport Administration]

of Elwha Klallam tribe which largely depended on the river fish for food and as an economic resource. After analysis, it was found that only removing the dams could fully restore the ecosystem and these were finally decommissioned in 2011. Floodplain and meadows restoration has been integral part of many river conservation programmes.

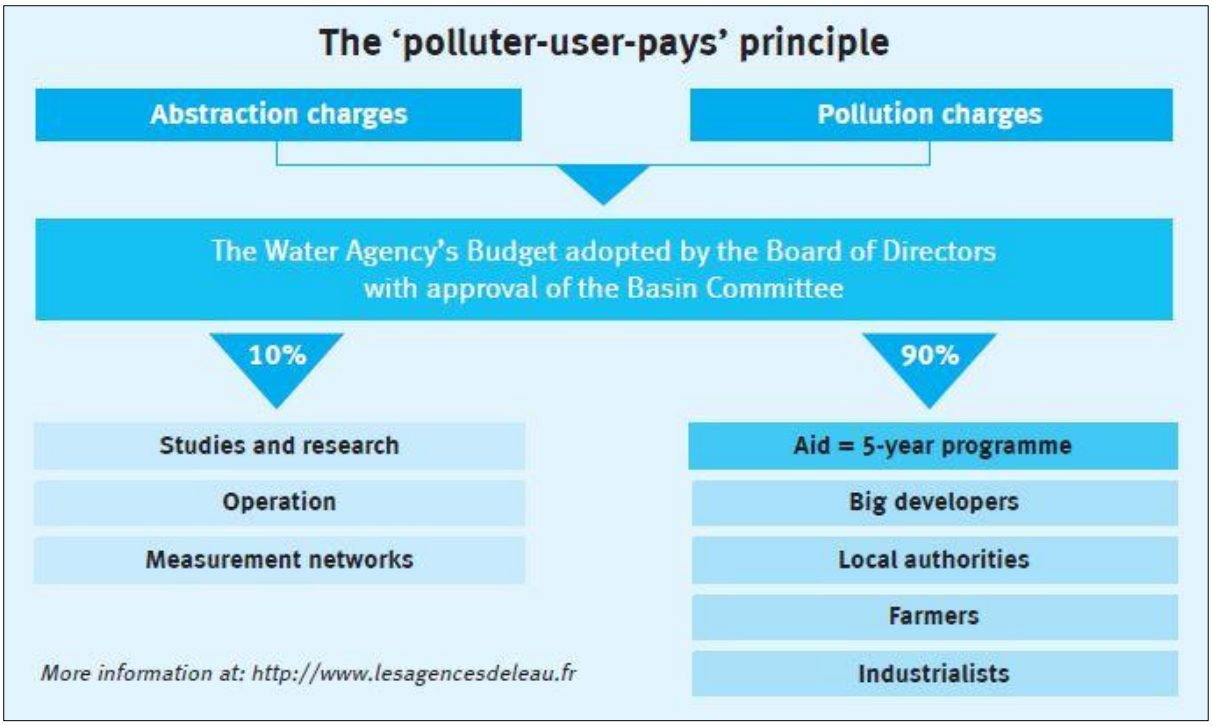
14.0 France: 'Polluter-User-Pays' And 'Water-Pays-For-Water' Principles

14.1 The 1964 French Water Law (modified in 1992 and 2006) set up a Water Agency in each of the six main river basins in France. The Water Agencies are administrative public institutions with civil status and financial autonomy. Agencies are financed on the 'polluter-user-pays' principle. Each Agency levies water charges on withdrawals and discharges that affect water quality and modify the water regime. For industries, the charges are calculated according to the type of industry and the amount of pollution they produce. For domestic users, the charges are calculated for each community according to both permanent and seasonal populations, and are collected from users together with payments for metered water consumption. The rates are determined by each Agency and are adapted according to the priorities and quality objectives defined for each basin. They must be approved by the Basin Committee, a multi-stakeholder platform composed of representatives from the State, local governments and users (industrialists, large regional developers, farmers, water supply and sanitation companies, fishermen, and associations for the protection and conservation of the environment).

14.2 Based on the 'water-pays-for-water' principle, 90% of the funds collected by the Water Agencies are then reallocated as loans and subsidies to local communities, industries, farmers and other groups to :

- abate pollution (construct, extend or improve purification plants and waste water collection systems, introduce cleaner production processes, etc.);
- develop and manage surface water and groundwater; and
- restore and maintain the aquatic environment

14.3 Ten percent of the funds collected were allocated for the operational costs of the Water Agency and River Basin Committee.



Source: A Handbook For Integrated Water Resources Management In Basins, (2009) GWP & INBO

15.0 Germany - Action Plan to Restore Water Courses in Ruhr Basin

15.1 The Ruhr Association Water Quality division manages 77 wastewater treatment plants, 540 storm water storage facilities, 5 reservoirs, 107 pumping stations and 3 hydropower plants. The Water Quantity Division manages 8 dams and reservoirs with an overall storage capacity of 464 million m^3, 7 re-pumping stations and 13 hydropower plants. No major new infrastructure needs to be built. The action plan is, therefore, oriented towards operation, preventive maintenance and repair, and restoring water courses to their natural condition.

15.2 The action plan for repairing the negative effects of existing infrastructure and restoring water courses means **taking measures to allow fish to migrate**. This means dealing with about 1,200 structures that prevent fish migration, such as dams, weirs and sills, along 1,870 km of the basin's watercourses.

15.3 The plan for the next 5 to 10 years concentrates on clearing migration routes along the main river and its larger tributaries, as well as in smaller watercourses in certain sub-basins, to allow fish to bypass weirs and sills. *Source: A Handbook For Integrated Water Resources Management In Basins, (2009) GWP & INBO*]

16.0 China: IWRM in Mekong River Basin [A Transboundary Basin]

16.1 The framework for the Mekong River Commission Strategic Plan 2006-2010 is integrated water resources management (IWRM). One of the key management principles in the strategy is to engage with stakeholders at local, implementation and policy levels.

16.2 **Local level -** The Mekong River Commission (MRC) works with the National Mekong Committees in Laos PDR, Thailand, Cambodia and Viet Nam to foster participation. It does this by educating and raising awareness among stakeholders. The MRC Stakeholder Participation and Communication Plan sets out approaches to engage with a wide range of stakeholder groups at local and national levels.

16.3 **Implementation level -** At the project level, MRC policies allow those who will be affected by a project to influence decisions on project plans, implementation and monitoring. At the programme level, planning in the Basin Development Programme is participatory. And, to monitor the overall work programme, MRC invites partners (through a formal Memorandum of Understanding) to participate as observers at its Joint Committee and Council meetings. MRC development partners are also actively engaged in MRC decision making through governance meetings.

16.4 **Policy level -** Many actors in the Mekong Region wish to contribute to MRC goals and be proactive in policymaking. In 2008, the MRC initiated a regional consultation to come up with general principles for stakeholder involvement at the MRC level and a policy on stakeholder involvement in MRC Governance Bodies. This will broaden political decision making processes and ownership, strengthen regional co-ordination between stakeholders and the MRC, and foster accountability. *Source: A Handbook For Integrated Water Resources Management In Basins, (2009) GWP & INBO*

17.0 Europe: Guidelines for Urban River Vitalisation

15.1 In Europe, REURIS project has been developed for urban river revitalisation in cooperation with experts from Poland, the Czech Republic and Germany. In this project several guidelines were set down to help planners, decision-makers, executing authorities and stakeholders consider the wide range of aspects (ecological, economic and social) relevant to the specific requirements of river revitalisation in an urban environment.

15.2 The guidelines are divided into four basic groups:

- Enhancing the ecological functionality of the watercourse as an ecosystem
- Providing flood protection
- Increasing the residential, cultural and recreational value
- Securing permanently sustainable use of watercourses and their alluvial plains

Table 75: Guidelines For Urban River Revitalisation

	Enhancing The Ecological Functionality Of The Watercourse As An Ecosystem
1.1	Renew the dynamic water regime of watercourses: • Increase the morphological diversity of the river bed as well as the discharge diversity and its

	dynamics. • Modify of the sediment regime through a suitable longitudinal profile of the watercourse. • Lengthen the watercourses
1.2	Renew minor watercourses: • Remove the channelled underground stretches of the watercourses and prevent further channelling. • Shallow the river beds. • Loosen or re-meander straightened river beds in minor watercourses, if possible, according to their historical development.
1.3	Increase the biodiversity of the biotopes in the alluvial plains: • Improve local habitats in response to the local conditions of each river valley. • Remove invasive plant species. • Support the reintroduction of native plant species and habitats.
1.4	Provide migration permeability of watercourses : • Build fish passes. • Provide migration permeability by transversal objects (stepped weirs and chutes), and technical alterations (shallow water column and high flow speed) to the watercourse.
1.5	Prefer nature-like adaptations over technical modifications to the landscape.
1.6	Improve the water quality: • Support the self-cleaning capacity of watercourses. • Add water infrastructure (build separated sewer systems, wastewater treatment plants). • Pre-treat rainwater before it reaches the river. • Eliminate pollution sources.
1.7	Renew and enhance the supplementary plant cover: • Plant indigenous trees, shrubs, reed beds, littoral vegetation, water plants, etc.
2.	**Providing flood protection**
2.1	Mitigate the risk of flood damage: • Adopt the idea that rivers need more space. • Avoid artificial elevation of terrain due to building development in active flood zones.
2.2	Increase the retention capacity of the landscape: • Allow the natural overflow of rivers into the alluvial plains. • Renew and create wetlands, where it is possible. • Implement elements of the systems of ecological stability.
2.3	Decrease direct outflow from the drainage area (especially important for small watercourses): • Increase the rate of rainwater infiltration in the area by allowing its infiltration into the soil profile. • Increase the rate of rainwater retention in the area. • Reuse excessive rainwater in households and the municipal sector.
2.4	Decrease the rate of water outflow from the drainage area: • Increase the coarseness of the alluvial plain by using natural coarse surfaces to reduce the water flow rate.
2.5	Implement technical measures to catch extreme flow rates: • Use retention tanks and dry polders in the river valley.
2.6	Implement technical flood measures in an aesthetically pleasing way.
3.	**Increasing the residential, cultural and recreational value**
3.1	Incorporate water into the city's image as a major landscaping feature of the urbanised space: • Use the alluvial plains as significant urban spaces with a unique potential for recreation and leisure. • Increase the aesthetic value of residential and recreational sites.
3.2	Create sport and recreational paths (greenways) along watercourses: • Combine paths for pedestrians, cyclists, in-line skaters and other non-motorised users,

	following the terrain in the alluvial plains. • Improve the permeability of the city and its connection with the surrounding landscape.
3.3	Build sport and recreational facilities in the alluvial plains: • Create places for short-term recreation of the public along the sport and recreational paths.
3.4	Provide supplementary infrastructure: • Build an information system along the sport and recreational paths (signposts, information boards, panels along educational paths providing information about natural and cultural features and values in the area). • Install street furniture. • Present artefacts and temporary exhibitions.
3.5	Provide public access to the water: • Build play facilities providing interaction with the water element. • Provide possibilities for fishing. • Allow direct public access to the watercourse in some places where it is safe and possible.
3.6	Do landscaping: • Differentiate between watercourse solutions in urbanised areas and open landscape. • Plant tree lanes along sport and recreational paths. • Create new parks.
4.	**Securing permanently sustainable use of watercourses and their alluvial plains**
4.1	Involve the public in green space management and policy-making.
4.2	Improve the applicability of the land use planning process in terms of flood control and watercourse protection: • Use the instrument of land use planning to apply the above-mentioned principles in the revitalisation of watercourses in urbanised areas. • Develop more detailed rules for the use of built-up areas concerning the risk of potential. • Consider flooding. • Build social consensus on actions and engineering measures oriented on public benefit.
4.3	Set guidelines for the installation of small water turbines on watercourses.
4.4	Set rules for water withdrawal to secure a sufficient flow volume for maintaining the dynamic water regime of watercourses.
4.5	Minimise conflicts with infrastructure (bridges, roads, pipelines, etc.).

Source: Urban Rivers - Vital Spaces : Manual For Urban River Revitalisation, REURIS Project Team, 1 June, 2012s
Note: Detailed guidelines and their application in the context of the pilot actions can be downloaded from the project website: www.reuris.gig.eu.

Table 76: Common River Restoration Goals And Common Techniques Used In River Restoration That May Lead To Ecological Improvements.

Restoration Goals	Specific Actions	Mechanistic Assumptions	Likelihood of Success
Improve Water Quality	Planting Riparian Vegetation	Interception of overland flow reduces inputs of sediment and pollutants to stream	Moderate
	Soil conservation practices (e.g. no till farming and cover cropping)	Increase water infiltration and reduces overland flow	High
	Livestock exclusion	Increases plant survival and stream bank integrity	High
	Control point source pollution	Eliminates pollutant inputs	High

	Bank Stabilization	Reduces inputs of sediment from eroding banks	Moderate
	Reconfigure channels	Stabilizes stream bank, reduces erosion, enhances geomorphic complexity	Low
	Storm water Management	Reduces erosive urban flows and associated pollutants	Moderate for low management
Recover Native Species of Interest or Enhance Biodiversity	Manually remove or kill non-native species; stock or re-plant natives	Natives will out-compete or prey on non-natives. Natives will recover in the absence of non-natives	Low
	Enhance in-stream habitat (e.g. pool and riffle construction; addition of boulders or wood)	Habitat is the limiting factor, construction and structuarl additions will last and desired species can colonize the river reach	Low
	Remove barriers to fish passage (e.g. fish ladder isntallation; culvert redesign; fish weirs on irrigation canals)	Passage is the factor limiting species recovery	High for passage Moderate for recovery
	Flow modifications (e.g. controlling the timing for magnitude of reservoir releases, limiting water extractions, adding in-stream flow diversions)	Water amount and/or timing of peak and low flows are primary factors governing species recovery	High if goal is to rewet dry streambed Low for recovery of species
Recover Basic River Functionality	Daylight streams (i.e. directions of a stream into an above-ground channel) Remove dams	Assumes ecological recovery will occur but time to recover depends on the other sources of impairment	High for migratory fisheries in otherwise healthy catchment Limited information on recovery of ecosystem functions

High- Strong empirical evidence and/or qualitative evidence that technique is effective.
Moderate-may be effective depending on the drainage basin context design and level of river degradation.
Low-reports of failure to see river improvements common.

(Source: Palmer & McDonough, 2013, In Sabater & Elosegi (Eds.) River Conservation: Challenges & Opportunities, Fundacion, BBVA, Spain)

Chapter V – Conservation Plan For The Hindon River

1.0 While it is being recognized that river restoration will call for fundamental change in dealing with larger basin level factors, thus far the focus is on the well publicized issue of pollution where the harmful impacts are measurable, visible, with known causes and pinpointed sources and with a neat package of technological solutions in terms of STPs, ETPs, CETPs and with which the govt. departments are most familiar. These solutions readily lend themselves to plans, programs, time frames, budgets and targets, the usual jargon which endears them to funding agencies

2.0 However, when it comes to dealing with dispersed forms of pollution such as domestic wastewater from Class II, III, IV urban settlements as well as fertilizer and pesticides runoff from the fields these solutions are neither technically feasible nor financially viable. Thus, alternative approaches are required here.

3.0 Reclaiming the Hindon's perennial nature with restoring what may be termed as e-flows or minimum adequate flow [difficult to establish] is a complex task which may be considered over a long term horizon and which may have political implications. The data in Chapter III provides pointers to the directions to be taken but these require a high level of consensus amongst the stakeholders and a broad program of action. Assessment of environmental flows considering the social, ecological and economical motivations of the Hindon basin and its stakeholders is critical. Holistic methods like building block methodlogy embedded in stakeholder processes will need to e adopted. It is also critical to reexamine the current water allocations, revise water allocations accounting for environmental flows requirements and the tradeoffs emerging from these will need to be studied well. Environmental flows is defined as quantity, quality and timing of flows required for maintaining the ecological integrity of a river. Therefore, discharge of effluents should not be considered as a constituent of e-flows or *aviral dhara* or unbroken perennial flow.

4.0 The targets and milestones stated in "Hindon 2030: Vision to Action Plan" authored by '2030 Water Resources Group' in December, 2016 are as follows :

Nirmal Dhara: with no pollution flowing into Hindon water bodies in the future, water quality is expected to improve over time. With targeted interventions, the current highly polluted status of Hindon will transform towards surface water quality in compliance with bathing water standards.
Anticipated timelines:
- In 5 years: surface water suitable for industrial and irrigation purposes (class E)
- In 10 years: surface water sustaining wildlife & fisheries (class D)
- In 15 years: surface water suitable for bathing (class C and B)

Aviral Dhara: with judicious water use and water conservation, groundwater aquifers to be recharged sufficiently and ultimately reach sustainable levels. Surface water flow may, during a portion of the year actually reduce to near zero level due to zero discharge from industries and domestic sector. The duration of the period in which there will be hardly any flow (or none at all) in the Hindon river will depend on the groundwater aquifer levels and implementation of zero-liquid discharge policy.

5.0 To achieve these unarguably desirable objectives requires a concrete set of policies and programs. Many of the required steps are suggested in the aforesaid "Hindon 2030: Vision to Action Plan". However, those need to be elaborated as well as fundamental additional actions need to be added. Most measures recommended have multiple impacts. Thus, introduction of sustainable agriculture may result in water conservation, reduced groundwater impacts as well as on pollution from agriculture sector.

Industrial Pollution

6.0 Enough is known about industrial pollution and its remedies and eliminating this problem is more a case of implementation, enforcement and regular honest monitoring. **One of the projects which could be taken up, however, is to train a few local non-govt. bodies in correct sampling methods for industrial effluents and getting the same tested at reputed laboratories in Delhi. This would provide an independent check and balance to testing reports by official agencies. Some allocation of funds may be called for to support this exercise.**

6.0B What is needed is a full compliance with the CPCB Charter on paper and pulp. An analysis of this charter and its enforcement is what is needed. Also, sugar mills need to be linked with their supply chains. Identifying the buyers of sugar from the mills and getting them, mills and the farmers to adhere to international certification norms (Bon Sucro Standards) will be crucial. Bon Sucro is a standard endorsed by companies across the globe and this aims to achieve good practices in work place and environmental practices.

Domestic Wastewater

7.0 STPs often do not function effectively for a variety of reasons one of the most important being lack of sewage which in turn is caused by lack of sewerage systems. Cost of STPs combined with sewerage systems is quite exorbitant. They also represent centralized systems which suit existing bureaucracies. However, the time is now ripe for small scale decentralized treatment systems such as DEWATS, SBT, ABR, Constructed Wetlands and others, which are operating effectively in various parts of the country.

8.0 It is proposed that the decentralized plants be installed in various colonies, institutions and commercial establishments. The Delhi Development Authority byelaw mandates various entities to install on site wastewater treatment units. A similar possibility could be considered for the basin. The treated wastewater should be recycled to the extent possible especially for indirect groundwater recharge.

9.0 Urban wastewater recycling plans should be developed in an integrated manner with wastewater treatment facilities specifically for Saharanpur and Ghaziabad cities. Use of treated wastewater for indirect recharge or substitution of fresh water use, where feasible, should be given primacy. I this regard bi-remediation techniques, especially on drains, and riparian reedbed wetlands along the river banks can be considered,

Agricultural Pollution

10.0 Most chemical fertilizers and chemical pesticides require large quantities of water for dissolution and uptake by plants. In actuality only 25% of the applied material is useful, the rest gets washed out in the rainfall runoff to waterbodies, streams and rivers, resulting in surface and groundwater pollution, entering into food chains, as well as overwhelming the aquatic ecosystem.

11.0 Promotion of sustainable farming techniques based solely on increasing organic content in the soil and avoidance of chemical inputs has several benefits including elimination of chemical fertilizers. Similarly, herbs based organic pesticides can substitute for pesticides. These measures would eliminate water pollution from agricultural sources.

12.0 Programs to promote sustainable farming [already successful in other parts of the country] need to be undertaken. **An appropriate strategy would be to promote and support pilot demonstration projects in each village combined with training programs for farmers in relevant technologies. These pilot projects would serve as nuclei radiating multiplier effects in the agricultural landscape. An effective program can be elaborated and would need to be supported.**

Cropping Pattern

13.0 The **sustainable agriculture program** indicated above has multiple benefits as follows :

- ❖ It improves soil health and productivity
- ❖ It improves crop resilience to climatic variations
- ❖ It **reduces water use by almost 50%**
- ❖ It reduces input cost of the farmer [water, chemicals, labour] enhancing his margins

14.0 **Systematic Intensification of Crops [SIC]** : This system is increasingly gaining currency on account of its combination of increased productivity along with 30% - 40% reduction in water requirements. This system is proven and needs to be rapidly promoted to reduce groundwater extraction as well as use of fresh Ganga water for irrigation purposes. Agricultural universities need to be pressed into service to train farmers in the technique and support pilot projects in the field.

15.0 **SIC in Sugarcane :** Sugarcane is the most water guzzling crop in the basin. Systematic intensification of sugarcane has been successfully demonstrated in India to enhance yield whilst reducing water requirement by >30%. Once again this would result in decreased pressure on the aquifer as well as the imported water from Ganga Canal.

16.0 With regards to **sugarcane acreage** it is recommended that to start with the area under sugarcane in the basin should be frozen to limit groundwater extraction. The discouragement to sugarcane cultivation may be in the form of financial disincentive or water cess. The number and capacity of sugar mills in the basin should also be frozen so as to act as a disincentive to bring additional area under sugarcane cultivation.

Water Conservation, Water Use Efficiency, Recycling

17.0 Water consumption in urban and rural areas must be reduced well below accepted norms. For this it is recommended that :

- Under Swachh Bharat Mission dry composting toilets should be introduced on a large scale – this will not only reduce direct water requirement but also negate the need for sewer systems and sewerage
- A massive program for replacement of taps and shower heads with efficient dispensing devices needs to be undertaken

Table 77: Estimated Water Saving By Water Efficient Fixtures

Fixture	Water Use In Standard Fixtures	Water Efficient Fixtures	Water Saved
WC	Single flush toilet uses 10-13 liters/flush	Dual flush toilet in 3/6 and 2/4 liter models	4-11 liters/flush
Urinals	4 liters; 10-13 liters/flush it is toilet pan is used	Sensor operated adjustable flush	2.2-10 liters per flush
Taps	10-18 liters/minute depending on pressure	Sensor taps	5.5-15.5 liters/minute
Showers	10-15 liters/minute	Flow restrictors	4-20 liters/minute

Source: Down To Earth [15 October, 2010]

Note : A 2009 survey by Tata Consulting Engineers conducted in Mumbai found that by using simple water-efficient fixtures, a five member household could save [on an average] over 400 litres of water every day

18.0 **Recycling** : Treated domestic effluents must be recycled. This should be considered for Saharanpur and Ghaziabad cities. Recycled water can be used in several sectors such as industry, power plants, bus terminals, railway stations, horticulture, construction, cooling towers, fire stations, etc. To the extent possible industry should be mandated to reuse recycled water especially their own treated effluents.

19.0 These measures would contain the human water demand in the basin and reduce pressure on the aquifer.

Groundwater Extraction

20.0 Raising the water table is the only way of restoring the perennial virgin flow in the lean season. **As water demand is curtailed in the basin consequent to the measures outlined in the previous sections it would be a wise strategy to reduce groundwater pumping and rely mainly on the water imported from the adjacent canal systems thus allowing the water table to build up.** This would result in greater base flow. The higher the water table the greater the lean season base flow [this is generally true of alluvial soils]. In this regard the implementation of soon to be issued guidelines for issuance of NOC for groundwater extraction may prove helpful.

21.0 Mapping of effluent and influent streams is the first step. Groundwater recharge without this information will not be beneficial in enhancing baseflows

Forest Cover

22.0 **Forest cover is an abysymal <2% in the basin. The quality of the existing forests is also deteriorated from dense to open and scrub categories. It is an established fact that dense and widespread forest cover enhances precipitation, arrests runoff, moderates temperature and provides habitat to pollinators resulting in agricultural productivity. Therefore, it is indeed a prime necessity to improve the quality of existing forest cover as well as enhance the area under forest cover in the basin.**

23.0 Accordingly, the Forest Dept. should be involved in the Hindon Committee. As a first step the re-densification of the Kaluwala Rao forests on the Shivalik slopes should be taken up on priority. Similarly other protected/reserve forests in the basin should similarly be addressed in short time frame.

24.0 The increase in forest cover is a challenging issue in view of the unavailability of land in the public domain. The first issue in this regard is the location of forest cover. It is recommended that forest cover be increased in a wide swathe [perhaps 2 km. wide] along the watershed line on both the eastern and western sides.

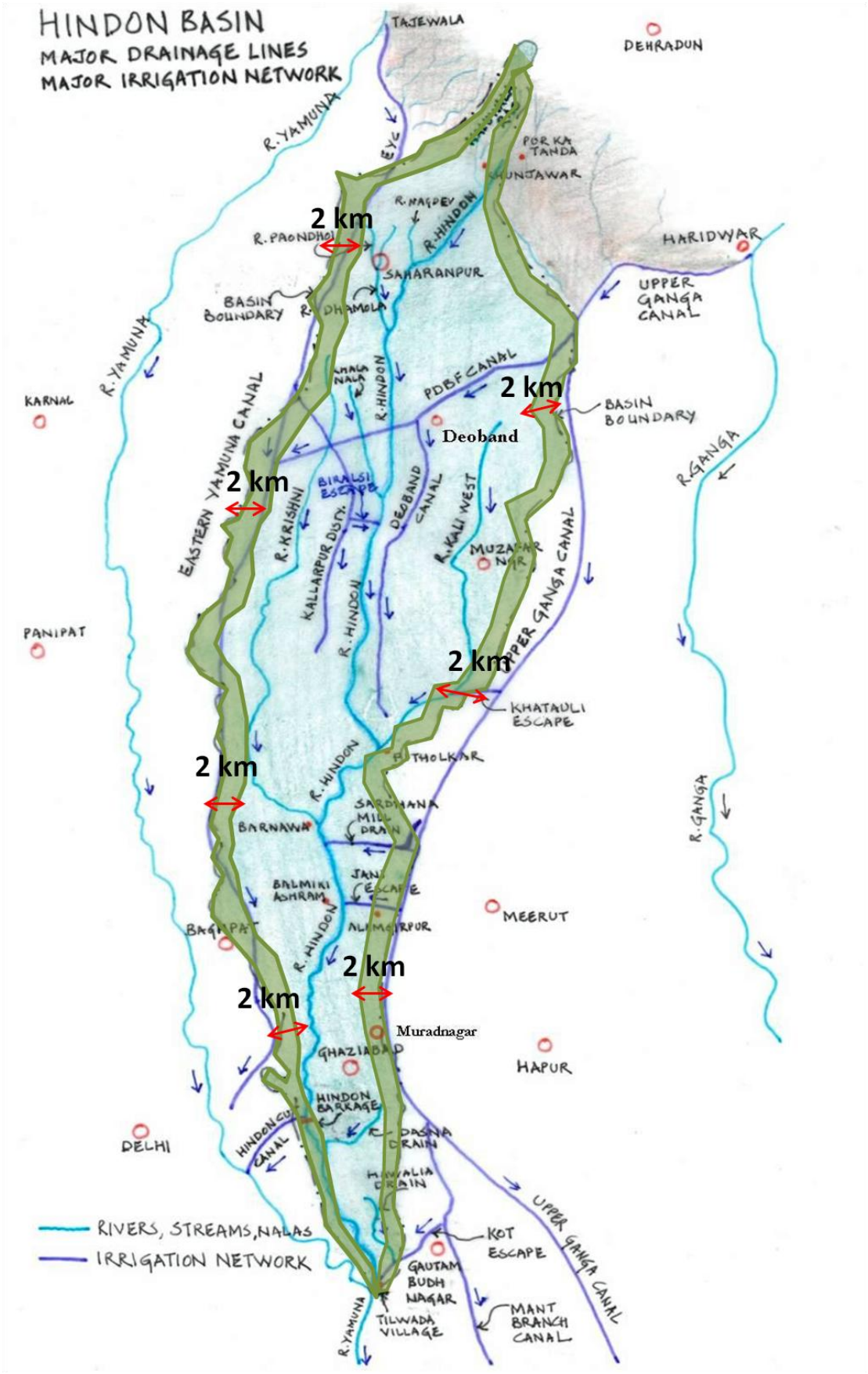
25.0 Without transfer of land from private hands it is suggested that cultivators located in this wide swathe [2 km wide] should be persuaded to adopt agro-forestry practices. This would require significant hand holding, financial support during transition period, extension services from ICAR Institutes.

National Agro Forestry Policy [2014] Extracts

It is also recognized that agroforestry is perhaps the only alternative to meeting the target of increasing forest or tree cover to 33 per cent from the present level of less than 25 per cent, as envisaged in the National Forest Policy (1988).A major role for agroforestry is emerging in the domain of environmental services. Agroforestry is known to have the potential to mitigate the climate change effects through microclimate moderation and natural resources conservation in the short run and through carbon sequestration in the long run. Agroforestry species are known to sequester as much carbon in below ground biomass as the primary forests, and far greater than the crop and grass systems.

26.0 As this agro-forestry belt is developed along the watershed line increased sub-soil flows along the hydraulic gradient towards the central drainage line [i.e. Hindon] should manifest.

27.0 **Urban Forests :** All Class I – IV settlements should have urban forest patches well dispersed and linked through patch corridors as part of the urban biodioversity layer of their masterplans. These would moderate micro-climates while adding to forest/tree cover in the basin.



Map 74 : Proposed Agroforestry Belt Along Watershed Line

River Regulation Zone [RRZ]

28.0 **River Regulation Zone :** The draft RRZ has still to be notified by the MoWR or MoEF & CC and perhaps may never be notified in its present form. All the same it has many beneficial elements which the Hindon Committee would do well to adopt. Foremost amongst these is the space reserved for the river within its **once in a 100 years flood line. This buffer should be kept sacrosanct and free from construction activities.** In the case of Hindon and its tributaries this would not be a very wide space [30m – 60m] on either bank widening out towards the southern reach of the river.[refer diagram].

29.0 This riparian zone, which is the flood plain, may have a narrow strip of riparian vegetation [grasses, weeds, shrubs, about 15-25m wide] as a biodiversity habitat. This would protect the river banks from erosion as well as filter out field pollutants from reaching the active flowing channel.

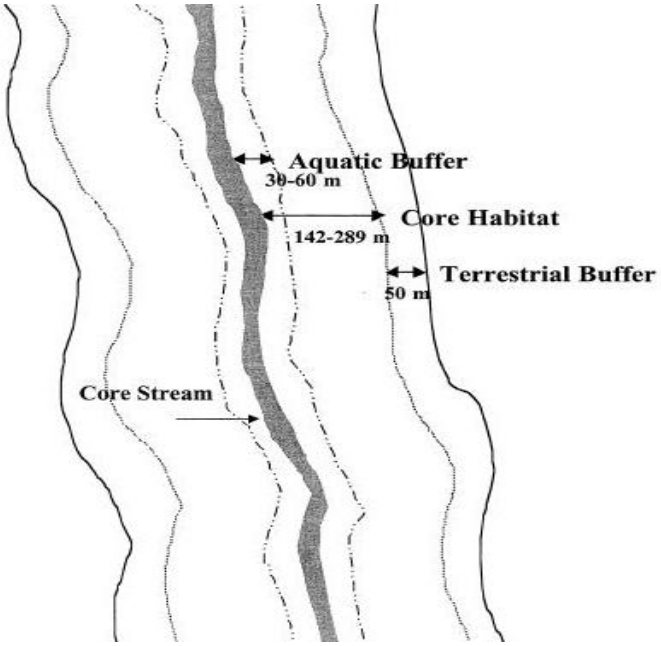


Image 128: Recommended Buffer Zones Around Stream Channels

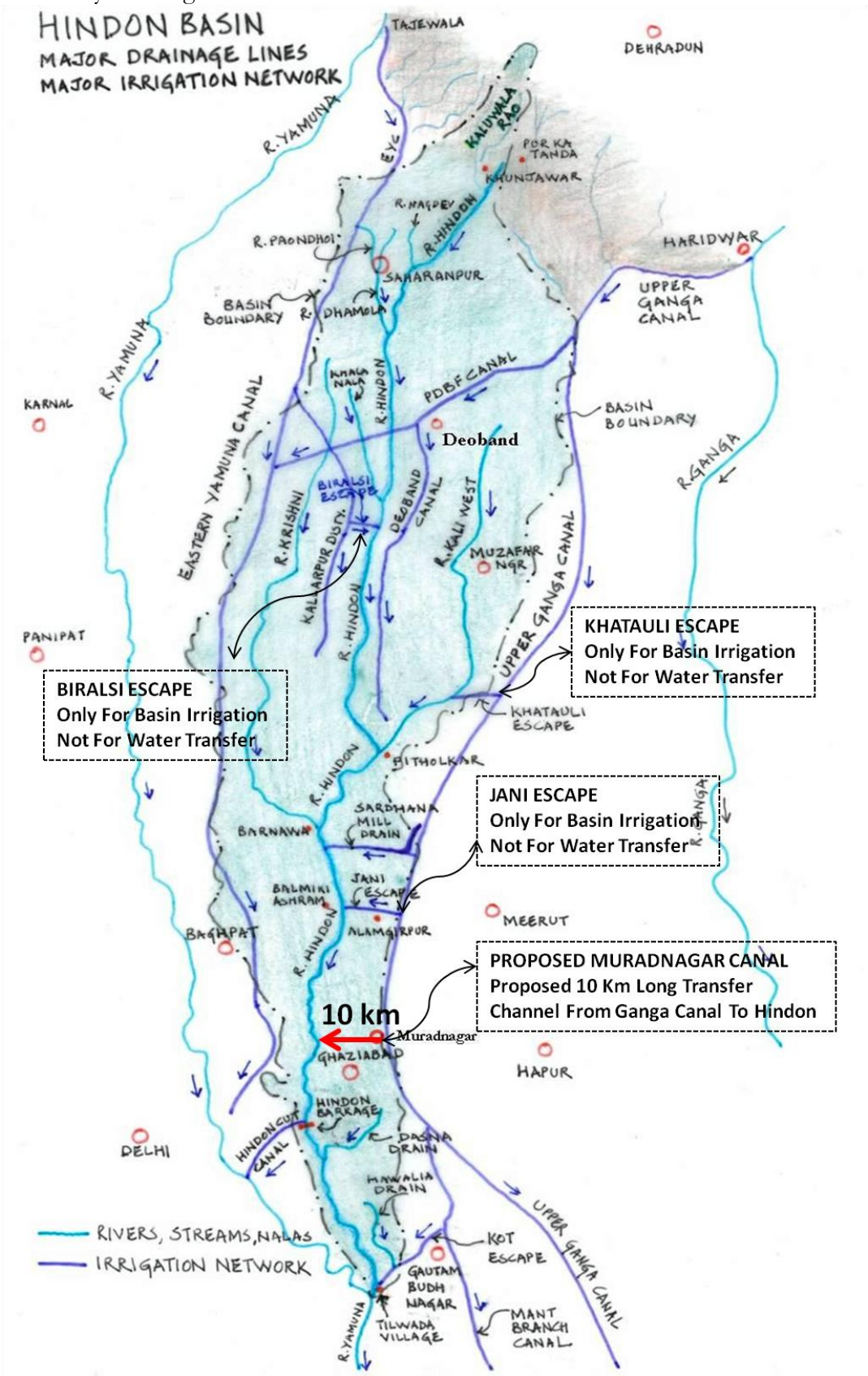
E - Flow

30.0 Detailed database development with regards to groundwater budget, flow measurement at various locations and in various seasons over a prolonged period of, say, 5 years, plus data on imported water and sewage flows would help to build an integrated hydrological model of the system enabling policy interventions.

31.0 It is also suggested that the transfer of Ganga waters to Hindon :

- through Khatauli escape can be withdrawn over a longish time frame as water requirement dips through efficiency gains.
- through Jani Escape may be substituted by a new 10 km channel running in a south-west direction from south of Muradnagar skirting Ghaziabad city on its north.

- The empty beds of these escapes may be filled with Ganga water or local floodwaters or treated wastewaters, separately or in combination and used as 365 days recharge zones



Map 75: Recommended Buffer Zones Around Stream Channels

32.0 **This would enable almost 90% of the river length [312 km from point of origin] to flow as a natural river without artificial additions to the flow. Only then consideration and estimation of e-flow can take place**

33.0 **Downstream of Hindon Barrage :** This stretch of the river channel needs to be restored to its natural status with revival of its virgin flow, floodplain wetlands, riparian vegetation and flood plain buffer. On account of low flows there has been an accretion of silt deposition which may have to be removed by dredging.

34.0 **Tributaries :** Without addressing the tributaries [Kali West and Krishni as also smaller streams such as Paondhoi and Dhamola] the best results would not be obtained. Some of the above stated remedial measures may have to be directly applied to the tributary streams as well.

Bio-monitoring Plan

35.0 **Biological indicators of a healthy river would have to be monitored on a regular basis. The return of micro-organisms, original fish species, amphibians, etc. would demonstrate the effectiveness of the river conservation plan.**

36.0 The bio-monitoring plan would have to be elaborated for different reaches of the river as well as for different seasons. This would have to be a separate detailed exercise which would be accomplished by trained local groups [NGOs, students,, academics]. The field observations would be fed into a central online database for obtaining a holistic picture of the basin level improvements.

37.0 **Detailed Project Reports** : The following detailed project reports would be required :

A. Plan for Decentralized Wastewater Treatment Plants to be provided in the basin, settlement-wise and location wise. This would include space identification, technology, costing, ensuring stakeholder participation and financial sustainability
B. Prepare recycling plan for Saharanpur and Ghaziabad
C. Prepare water efficiency devices introduction plan for major settlements
D. Forestry plan for densification of existing protected forests including species, time frame, costs, working plans
E. Sustainable agriculture propagation : Identifying pilot demonstration fields at the block level, carrying out soil investigations, preparing a 3 year program of action
F. SIC – Prepare plan to involve various agriculture universities and ICAR institutes as well as competent NGO partners for propagating SIC in sugarcane, rice, wheat
G. Agro forestry belt : Prepare plan to involve various agriculture universities and ICAR institutes as well as competent NGO partners for propagating agroforestry in the peripheral belt
H. Preparing conservation plans for tributaries
I. Demarcating the RRZ on plan and ground and highlighting it
J. Preparing conservation plan for Hindon d/s of barrage

K. Seriously consider water transfer through proposed Muradnagar Escape and using all other channels for macro-water harvesting

L. Prepare Bio-monitoring plan in terms of training, reporting, equipment, partners, financial support, data bank and dissemination

M. Prepare conservation plans for major temple/cultural sites on the river

IMPACT / RECOMMENDATIONS	Pollution Abatement (Surface And Groundwater)	Reduced Freshwater Demand	Increase In Water Table/ Groundwater Recharge	Increased Agricultural Productivity	Enhanced Precipitation Potential	Temperature Moderation	Revival Of Biodiversity	Restoration Of Natural Flow / E. Flow	Time Horizon (Years)
Effective Treatment Of Industrial Effluents	●						●		3
Effective Treatment Of Domestic Wastewater	●						●		5
Sustainable Farming Practices		●	●	●			●		7
Systematic Intensification Of Crops (Paddy & Wheat)		●	●	●					5
SIC In Sugarcane		●	●	●					5
Cropping Pattern (Sugarcane Acreage)		●	●						1
Water Conservation	●	●	●						
Dry Composting Toilets	●	●	●						5
Effective Water Use Devices	●	●	●						3
Recycling Treated Waste Water	●	●	●						7
Increase Forest Cover In Forest Areas			●		●	●	●	●	5
Introduce Agro-forestry Practices Along Watershed Ridge Belt			●	●	●	●	●	●	7
Increase Land use - Urban Forests			●		●	●	●	●	5
Implement River Regulation Zone							●	●	5
Restoration Of Natural Flow			●				●	●	
Khatauli Escape								●	3
Jani Escape								●	5
New Escape (Muradnagar-Gbd)								●	5
Hindon Eco-restoration D/S Of Barrage								●	5
Eco-restoration Of Tributaries								●	
Kali (West)									3
Krishni	●								3
Paodhoi									3
Bio-monitoring Plan									2
Time Horizon (Years)	7	10	15	7	12	12	10	15	

Image 129: Recommendations, Impact and Time Plan Matrix

38.0 **Governance Issues :** Hindon basin is just the right scale at which the first basin management model in the country can be worked out. **What is being recommended is a landscape approach at the basin level which requires a certain amount of erasure of jurisdictional and sectoral boundaries. This requires a high degree of coordination amonst all stakeholders [official, private as well as individuals]. The individual administrative units, line departments, research institutions and NGOs have to work hand in hand towards common goals.** This requires :

- A strongly empowered Hindon Basin Organization [HBO] which must be duly supported by the State Govt or International Agency with funding support

- The HBO must also include, other than the current participants, the Forest Dept., the State Groundwater Board, agricultural institutes
- The HBO would need to carry out a massive effort in spreading awareness and influencing the behaviour of the many actors in the basin
- The HBO could make use of the structure of District Committees mandated under the Ganga Authority Notification

****

Annexures

ANNEXURE- 1: Primary Water Quality Criteria

The Central Pollution Control Board has classified water resources of the country according to their uses for setting water quality objectives for different water bodies. The classific system is as follows:

S.No.	Designated Best Use	Class	Criteria
1	Drinking water source without conventional treatment but after disinfections	A	1) Total coliform organisms MPN/100mL shall be 50 or less. 2) pH between 6.5 and 8.5 3) Dissolved oxygen 6 mg/l or more 4) Biochemical oxygen demand 2 mg/l or Less
2	Outdoor bathing (organised)	B	1) Total coliform organisms MPN/100ml shall be 500 or less 2) pH between 6.5 and 8.5 3) Dissolved oxygen 5 mg/l or more
3	Drinking water source with conventional treatment followed by disinfection	C	1) Total coliform organisms MPN/ 100ml shall be 5000 or less 2) pH between 6 and 9 3) Dissolved oxygen 4 mg/l or more 4) Biochemical oxygen demand 3 mg/l or Less
4	Propagation of wild life, fisheries	D	1) pH between 6.5 and 8.5 2) Dissolved oxygen 4 mg/l or more 3) Free ammonia (as N) 1.2 mg/l or less
5	Irrigation, industrial cooling, controlled waste disposal	E	1) pH between 6.0 and 8.5 2) Electrical conductivity less than 2250 micro mhos/cm 3) Sodium absorption ratio less than 26 4) Boron less than 2mg/l

Source: Polluted River Stretches in India: Criteria and Status, Central Pollution Control Board (CPCB)

Annexure-2 River Health Methodology Evolved by India Rivers Week

RIVER BASIN APPROACH

1. River basin approach for assessing the state of health of a river involves assessments at following levels to ensure holistic assessment:
• Key tributary (Left bank, Right bank)
• Sub basin (Unit of Assessment)
• River Basin
Number of parameters termed as contributors and indicators shall be assessed as part of the exercise.
The aim of the exercise is to suggest measures for
a) Amelioration of the past adverse impacts on river's health
b) Address current threats
c) Identify wild rivers to help them remain wild
d) Prevent adverse impacts if any of future actions/plans
The report shall express the state of health (of contributors & indicators) in three colors. **BLUE** for 'Healthy' state; **PINK** for 'Threatened' state and **RED** for 'Sick' (compromised, critical or destroyed) state. An additional **GREY** (information defi cient) has been suggested requiring further research / collection of information.
Report card for the entire river basin shall be expressed as a matrix of **BLUES**, **PINKS**, **REDs** and **GREYs** for the diff erent Units of Assessment.
On a map of the river system, the entire unit of assessment or the main stem of the river in the Unit of Assessment could be colored RED, PINK or BLUE.

NOTE: There was a suggestion at the Plenary that the three colors may be changed to RED (Critical), YELLOW (Threatened) and GREEN (Safe). This is very much possible if the consensus is on this change, although since we are dealing with predominantly an aqueous system, color BLUE seems to be more appropriate.

UNIT OF ASSESSMENT

Ideally, the unit of assessment should be the entire basin.
But the vastness of the tract, results in large size of the river basins as well as the length of just the main-stem of a river makes it necessary to pre-determine the size of the unit of assessment to be expressed in terms of suitable points on the main-stem of the river, whose upstream basin shall be subjected to assessment keeping in mind that while no details are lost the exercise remains doable.

NOTE: Following suggestions regarding the unit of assessment were made at the plenary:
1. This is based on catchment / sub catchment, rather than as an arbitrary cut-off point on the main stem. This was presumably done to maintain the integrity of the catchment / sub catchment while implementing the recommendations.
2. State borders may be kept in mind while deciding on the unit of assessment. This is presumably on the ground that the trans-border actions (for uniform implementation of recommendations) might not be feasible.

Regarding 1) since the cut-off point has been suggested as the meeting point of a key tributary with the

main stem, it more or less takes care of the need to consider the integrity of the catchment / sub catchment. However, if catchment / sub catchment boundaries are well known / defi ned and relevant information for assessment purposes is available / accessible, the same would of course be the best Unit of Assessment.

Regarding 2) the practical aspect of it is well placed and would be ideal if the political boundaries follow watershed. However, in cases where political boundaries are arbitrary or follow a stream, the integrity of the catchment / sub catchment would remain a issue.

KEY TRIBUTARY

A tributary less than or equal to 150 km but more than 10 km in length (small streams or nalla are normally seasonal with an assumption that they have no signifi cant impact (except in the rainy season) in most cases on the overall health of the river*) shall be termed as a key tributary.

NOTE: Any tributary in excess of 150 km in length shall qualify to be a separate unit for assessment.

**Any small tributary (nalla) within an urbanized/industrialized setting and which over time instead of being seasonal is now known to carry polluted water for greater part of the year shall qualify to be assessed as a key tributary.*

NOTE: There was a suggestion at the plenary that leaving out small tributaries of length less than 10 km is not advisable and that they may also be assessed

Well, the inclusion of each stream joining the main stem as a key tributary (although desirable and even sometimes necessary in view of the "caveat" as made above) it might make the exercise rather unwieldy, prolonged and impractical.

NOTE: It is reiterated that the fi gures (150 km and 10 km etc) are NOT sacrosanct since the size of rivers vary considerably. These may be defi ned in tune with the local conditions.

CONTRIBUTORS

a. Structures impacting the longitudinal connectivity [dams (including HEPs), barrages, anicuts, bridges etc]
b. Structures impacting the lateral connectivity (embankments)
c. Infl uences impacting (positive or negative) the integrity of the river system
• Catchment vegetal cover
• Wildlife Protected Areas, sites of archaeological, historical, biological and cultural importance
• Agricultural practices
• Urbanisation & industrialisation
• Encroachment and conversion of fl ood plains
• Mining (sand, boulder, coal & metals)
• Dredging
• Unsustainable extraction of biomass (plants and animals)
• Unsustainable extraction of water (Surface and Groundwater)
• Deleterious cultural practices (mass congregation, idol immersion etc)
• People's actions (civil society actions for protection and conservation)
d. Climate Change

INDICATORS

• State of biodiversity
• Seasonal discharge (water, sediment, biota) at key locations
• Status of pollution (surface and ground water)
• Flow (water & silt & BD) & salinity ingress at estuary/delta
• People's connect (river based livelihoods & cultural practices)
• River confl icts.

NOTE:
1. There was a suggestion made at the plenary that the "tenure rights" (of local people, especially of tribals and forest dwellers) over land should be included as one of the contributor. While the logic is sound as secure tenures encourages locals to take better care of their charge, the formulation of the suggestion into a doable exercise (unless these tenures are large sized and community based) is required.

2. There was a suggestion made at the plenary that not all contributors or indicators might carry the same kind of impact on the health of the river system and hence a graded / weighted assessment / marking is in order.

Yes, this is very true and in due course once good information base is at hand a weighted system should be possible to bring in.

1. STAGE ONE

ASSESSMENT

b. Determine the units of assessment within the river basin
c. Within the unit of assessment, identify and list key tributaries (left bank and right bank)
d. Within the unit of assessment list dams, barrages, anicuts on the main-stem as well as the key tributaries
e. Within the unit of assessment collect and collate the following (background) information
i. Forested / well vegetated tracts
ii. National Park, Sanctuaries, Community Conserved Areas
iii. Notable geo-morphological, cultural, archeological, biological sites
iv. Well known springs / surface water bodies (lakes, ponds etc)
v. Status of GW blocks (safe, semi-critical, critical, over exploited)
vi. State of GW pollution
vii. Point source/s of pollution (towns / cities, polluting industry, industrial estates etc)
viii. Non point source like agricultural (chemical) run off
ix. Pollution resulting from cultural practices (mass congregation, idol immersion etc)
x. Industry / Industrial area / Developmental project [e.g industrial area/estates/ SEZs, power plants, highways/expressways, Intensive tourism development, ports, commercial river transportation, new capital (urbanization) project, air fi elds etc]
xi. River stretch submerged under reservoir (if any)
xii. Downstream dried stretch of the river (if any) resulting from water diverted / abstracted into tunnel or canals at dams / barrages / anicuts
xiii. Embankment/bunds, fl oodplain conversion (other than traditional and seasonal farming)
xiv. Sand/boulder mining etc
xv. Mineral mining (coal, bauxite, iron, copper etc)

xvi. Prospecting / drilling for oil and gas
xvii. Salinity ingress in the estuary/delta
xviii. Existing or simmering confl icts over the river
xix. Any other interesting feature of the river worth highlighting (eg., tributary less long stretch of the main stem river; waterfall; channel braiding etc)
xx. Any other notable aspect with potential of impact on the river health (eg., river stretch forming Inter-state border etc)

2. STAGE TWO

ASSESSING THE UNIT

A. Contributing Factors

1. CATCHMENT VEGETAL COVER [Reason: *Loss or lack of vegetal cover from land use change or deforestation results in reduced base fl ows and unhindered storm time run off s – Dysfunctional naturalness*]
Assessment: (Resource: Good basin vegetal maps, Google earth / Bhuvan or any other similar images, Forest Survey of India Reports, other published reports etc may be used)
1. Good vegetal (forests/grasslands) cover within the Unit – **BLUE**
2. Entire terrain within the unit is rocky or naturally barren – **BLUE**
3. Vegetal cover within the unit is climatically/historically sparse - **PINK**
4. Vegetal cover honey-combed* (less than 25% of the area) within the unit – **PINK**
5. More than 25% of the vegetal cover honey-combed within the unit – **RED**
6. No information – **GREY**

** honey-combed vegetal cover is the state of green cover opened up (for farming, mining, developmental project etc) at several non contiguous places within a larger well forested block*

2. DAMS [Reason: *Dams break river's unfettered fl ow – Aviralta*]
Assessment: (Resource: Good basin maps, Google earth / Bhuvan or any other similar images, National register of large dams, etc may be used)
a. No dam on main stem river / key tributaries within the Unit – **BLUE**
b. One dam (existing, sanctioned or planned) on main stem river or less than 50% of the key tributaries with dams – **PINK**
c. More than one dam on main stem river or more than 50% of the key tributaries with dams – **RED**
d. No information - **GREY**

3. BARRAGES / ANICUTS [Reason: *Barrages / Anicuts break river's unfettered fl ow – Aviralta*]
Assessment: (Resource: Published report, good basin maps, google earth, or any other similar images to be used)
a. No barrage / anicut on main stem river / key tributary – **BLUE**
b. Barrage/s with downstream unfettered environmental fl ow ensured round the year – **BLUE**
c. Barrage/s with abstracted water not returning / returning to the river in polluted form – **RED**
d. Anicut on main stem river or key tributary with distance more than 50 km* – **BLUE**
e. Anicut on main stem river or key tributary after less than 50 km but more than 20 km – **PINK**

f. Anicut on main stem river or key tributary after less than 20 km – **RED**
g. No information - **GREY**
*NOTE: *this distance is suggestive, could vary from river to river and is open to studies and suggestions*
4. RIVER SIDE EMBANKMENTS* [Reason: *Embankments break river's capacity to spread water, silt and biota over its fl ood plain, among other impacts - Aviralta]*
Assessment: (Resource: Published report, Google earth of any other similar image etc)
a. No embankment on main stem river or key tributary – **BLUE**
b. 25% of length of main stem river or key tributary embanked – **PINK**
c. More than 25% of length of main stem river or key tributary embanked – **RED**
d. No information - **GREY**

*NOTE: * where applicable*

5. CITIES with (more than 1 lakh population) [Reason: *Cities on one hand become the catalyst for activities (construction of dams, embankments, fl ood plain conversion and encroachment, sand mining etc) that compromise the health of the river and on the other produce waste that rivers are unable to assimilate as part of their self cleansing ability – Aviralta, Nirmalta, ecological and geological integrity*]
Assessment: (Resource: Published information with Basin map or Google earth or similar images, etc)
a. No city in the unit of assessment – **BLUE**
b. City that is not polluting (good city management) in any manner – **BLUE**
c. One city with polluting foot print in the unit of assessment – **PINK**
d. More than one city with polluting foot print in the unit of assessment – **RED**

6. POLLUTING INFLUENCES (Industries, mining (sand, boulder, coal, metal) etc)
[**Reason**:
Polluting infl uences degrade the river's ecology – Nirmalta]
Assessment: (Resource: Information from Pollution Control Boards or reliable source)
a. No polluting infl uence in the unit of assessment – **BLUE**
b. Polluting infl uence with zero discharge (assessed and reported in a transparent and participatory manner) in the unit of assessment – **BLUE**
c. One Industrial estate or polluting mining activity, but with low footprint in the unit of assessment – **PINK**
d. Large sized Industrial estate or polluting mining activity with high footprint in the unit of assessment – **RED**
e. No information – **GREY**

7. NON POINT POLLUTING INFLUENCES (Chemical agriculture)
Assessment: (Resource: published information on per capita consumption of chemical fertilizer, insecticides, pesticides etc)
a. Practice of largely natural / organic farming in the unit of assessment – **BLUE**
b. Low level of chemical farming in the unit of assessment – **PINK**
c. High level of chemical farming in the unit of assessment – **RED**
d. No information – **GREY**

8. STATUS OF GROUND WATER [Reason: **Ground water (GW) is fed by (effl uent) and feeds (infl uent) the river as a natural cycle. – Aviralta & Nirmalta*]
Assessment: (Resource: CGWB district GW atlas, CGWA Dark (over exploited) and Grey (critical & semi-critical) zone/block notifi cations or other reliable published / unpublished source)

a. No GW in dark zone or less than 10% area in GW grey zone (block) in the unit of assessment – **BLUE**
b. One GW dark zone (block) or 10 - 15% area in GW grey zone (block) in the unit of assessment – **PINK**
c. More than one GW dark zone (block) or more than 15% are in GW grey zone (block) in the unit of assessment – **RED**
d. No information - **GREY**

9. STATUS OF SURFACE WATER BODIES [Reason: *Traditional surface water bodies like ponds, tanks also exhibit effl uent and infl uent action vis a vis the river- Aviralta & Nirmalta]*
Assessment: (Resource: Reliable preferably published (media reports etc) information sources)
a. Traditional water bodies (ponds, tanks, *baolis* etc) are sustained and in use – **BLUE**
b. Traditional water bodies (ponds, tanks, *baolis* etc) are in decline (1/4th lost) – **PINK**
c. Traditional water bodies (ponds, tanks, *baolis* etc) have been abandoned (3/4th lost) – **RED**
d. No information – **GREY**

10. PEOPLE'S ACTION FOR THE RIVER [It is the proactive action by people for their river that
ensures a river's long term sustainability and a healthy state]
Assessment: (Reliable source including media reports)
a. High level (One prominent or more than 2 small sized people's organizations active in diff erent sub basins in the basin) of people's connect with their river – **BLUE**
b. Low level (Less than 5 small sized people's groups/organizations active in the basin) people's connect with their river – **PINK**
c. Absence (No report of any people's groups / organizations active in the basin) of people's connect with their river – **RED**
d. No information – **GREY** (Research Needed)

B. Indicators

(*Shall reinforce or validate the threat status arrived at the contributing factor stage and assessed at the river basin/sub-basin/Unit of Assessment scale*)
11. KEYSTONE BIODIVERSITY (fi shes, turtles, crocs, dolphin, trees etc)
Assessment: (Published source or reliable source like the local fi sherman, to be the basis)
a. Present in healthy populations – **BLUE**
b. Present in decreasing numbers – **PINK**
c. Absent – **RED**
d. No information – **GREY** (Research Needed)

12. HISTORICAL SEASONAL DISCHARGE AT KEY LOCATIONS
Assessment: (As reported by CWC or a published source)
a. No decrease – **BLUE**
b. Traditional springs are secure and functional – **BLUE**
c. Nominal or low decrease (upto 25% of historical value) – **PINK**
d. High decrease (more than 25% of historical value) – **RED**
e. No information – **GREY** (Research Needed)

13. STATUS OF POLLUTION (Surface and Ground water)
Assessment: (As reported by the CPCB / CWC / SPCB / published source)
a. No pollution (Water of A quality) – **BLUE**

b. Low pollution (Water of B&C quality) – **PINK**
c. High pollution (Water of D&E quality) – **RED**
d. No information – **GREY** (Research Needed)

14. PROTECTED AREAS / SPECIAL SITES (archaeological, cultural, biological etc)
Assessment: (Published source)
a. More than one PA / Special site or one PA of large size covering large part (more than 50%) of the River Basin – **BLUE**
b. One PA / Special site – **PINK**
c. No PA / Special site – **RED**
d. No information – **GREY** (Research Needed)

15. FLOW IN RIVER AT ITS MOUTH (ESTUARY/DELTA) [Reason: River at its mouth represents
the net eff ect of all that has happened upstream – Aviralta & Nirmalta]
Assessment: (Resource: Published or reliable material / information etc)
a. Good, wholesome fl ow (water and sediments) round the year – **BLUE**
b. Flow only during the monsoon or polluted fl ow round the year – **PINK**
c. No fl ow or polluted fl ow only during the monsoon – **RED**

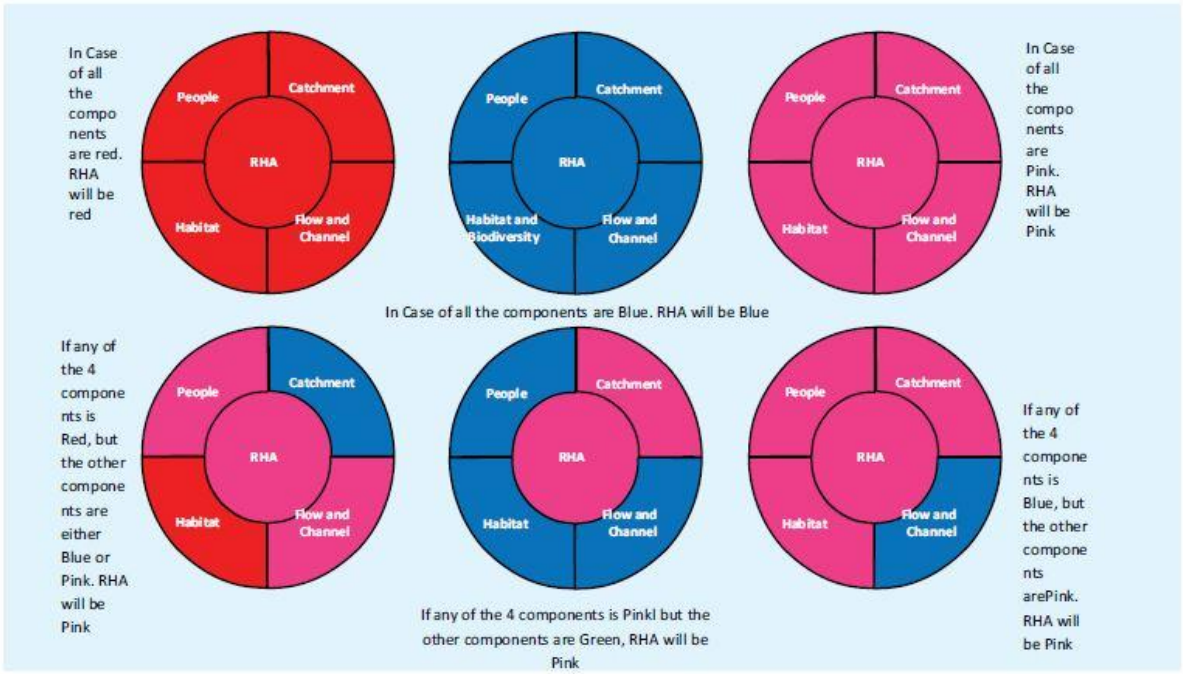
16. SALINITY INGRESS IN THE ESTUARY/DELTA*
Assessment: (Published source)
a. No salinity ingress – **BLUE**
b. Notable (upto 25% of historical levels) salinity ingress – **PINK**
c. High (more than 25% of historical levels) salinity ingress – **RED**
d. No information - **GREY** (Research Needed)
**Applicable only for river stretches with an estuary/ delta*

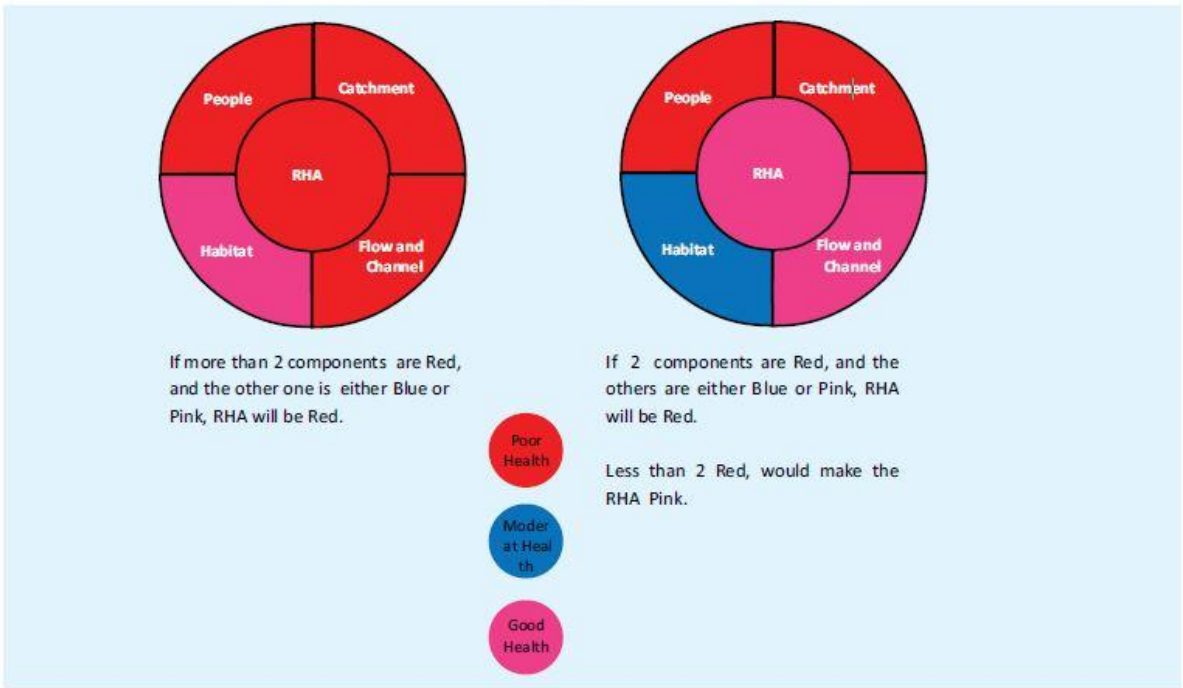
17. PEOPLE'S CONNECT WITH THE RIVER
Assessment: (Resource: Reliable sources of information, including media reports)
a. Traditional (Riverine) livelihoods and cultural relationships with the river are sustained – **BLUE**
b. Traditional (Riverine) livelihoods and cultural relationships with the river have dwindled – **PINK**
c. Traditional (Riverine) livelihoods and cultural relationships with the river have ceased – **RED**
d. No information – **GREY** (Information needed)

18. CONFLICTS OVER THE RIVER
Assessment: (Published or reliable source)
a. No confl icts – **BLUE**
b. Simmering or emerging confl icts – **PINK**
c. High confl icts – **RED**
d. No information - **GREY** (Research Needed)
NOTE: All fi gures mentioned above are subject to change after discussion.

NOTE:
• An observation was made in a break out group by a participant that the information as available from the CGWB on the safe, semi-critical and critical blocks is tentative and often not reliable and do not truly refl ect or conform to the local conditions on the ground.
• This is a serious matter. However, so long as we do not have anything better or CGWB develops better

monitoring mechanisms, there is little else to go by. However, wherever better and ground based information is available that may be preferred over the CGWB reports.





Annexure - 3 : State Water Policy, Uttar Pradesh, May 1999

Objectives

1. Ensure preservation of the scarce water resources to optimize the utilization of the available resources.
2. Bring about qualitative improvement in water resource management, which should include user's participation and decentralization of authority.
3. Maintain water quality, both surface and underground, to establish norms and standards.
4. Promote formulation of projects as far as and wherever possible on the concept of both surface and ground water as a unitary resource, ensuring multipurpose use of the water resource. This would inter alia consist of the following main uses
   - Provide adequate water for drinking and domestic use.
   - Provide water for irrigation.
   - Maximize hydropower generation within the constraints imposed by other users.
   - Provide water for industries including Agro industries.
   - Provide water for navigation, recreation, health and for others uses.
5. Ensure ecological and environmental balance while developing water resources.
6. Promote equity and social justice and among individuals and groups of users in water resource allocation and management.
7. Ensure self-sustainability in water resource development.
8. Ensure Flood Management and drainage as integral part of water resource development.
9. Provide substantive legal framework for management.
10. Provide a Management information System (M.I.S.) for effective monitoring of policy implementation.
11. Promote research and training facilities in the water resource sector.
12. Provide mechanism for the resolution of conflicts between various users.

Annexure - 4 : Sustainable Development Goals-6 [SDG-6] of United Nations' Global Goals

"Ensure availability and sustainable management of water and sanitation for all"

SDG6 Targets

1. By 2030, achieve universal and equitable access to safe and affordable drinking water for all
2. By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
3. By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
4. By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
5. By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
6. By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
7. a. By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
8. b. Support and strengthen the participation of local communities in improving water and sanitation management

Facts and figures

1. Since 1990, well over two billion people have gained access to improved sources of drinking water, and 116 countries have met the MDG target for drinking water supply.
2. More than 700 million people still remain without access to improved sources of drinking water, nearly half of whom are in sub-Saharan Africa.
3. Some 2.5 billion people do not have access to adequate sanitation.
4. In the 20th century, water withdrawal grew by almost twice the rate of population increase.
5. In the coming decades, one-third of the world's population – many living in the semi-arid regions of Asia and in sub-Saharan Africa – will experience severe water scarcity.
6. About two billion people worldwide depend on groundwater, which includes about 300 transboundary aquifer systems.
7. Agriculture is by far the largest user of water, accounting for almost 70 percent of all water withdrawals, and up to 95 percent in developing countries.
8. While irrigated agriculture represents 20 percent of total cultivated land, it contributes 40 percent of total food produced worldwide.

9. The demand for water for irrigation is projected to increase by around 5 percent by 2050.
10. Depending on the diet, from 2 000 to 5 000 litres of water are needed to produce the food consumed daily by one person.

Annexure-5: Integrated River Basin Management [IRBM] by WWF

"Integrated river basin management (IRBM) is the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximise the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems."

WWF believes that IRBM is the most promising vehicle for employing the tools necessary to meet and overcome the global water crisis.

The seven key elements to a successful IRBM initiative are:

- A long-term vision for the river basin, agreed to by all the major stakeholders.
- Integration of policies, decisions and costs across sectoral interests such as industry, agriculture, urban development, navigation, fisheries management and conservation, including through poverty reduction strategies.
- Strategic decision-making at the river basin scale, which guides actions at sub-basin or local levels.
- Effective timing, taking advantage of opportunities as they arise while working within a strategic framework.
- Active participation by all relevant stakeholders in well-informed and transparent planning and decision-making.
- Adequate investment by governments, the private sector, and civil society organisations in capacity for river basin planning and participation processes.
- A solid foundation of knowledge of the river basin and the natural and socio-economic forces that influence it.

Annexure-6: Result of Bioassay, COD, BOD Tests From Sample Collected Near Hindon River at Hindon Barrage, Ghaziabad

Sophisticated Industrial Materials Analytic Labs. Pvt. Ltd.

AN ISO 9001 CERTIFIED, NABL ACCREDITED, MoEF & BIS RECOGNISED GOVT. APPROVED TEST HOUSE

5.10 F-01

TEST REPORT

PARTY CODE : I/DLH/11181
INDIAN NATIONAL TRUST FOR ART AND CULTURAL HERITAGE
71, LODHI ESTATE, NEW DELHI-110003

REPORT NO. : SN1018000117
REF. NO. : NS
REF. DATE : NS
DT.RECD : 18/10/2017

SAMPLE NAME : WATER SAMPLE

RESULTS OF ANALYSIS
Reference : Party's Requirement

DESCRIPTION : One Water sample was collected by us on 18/10/2017

SAMPLING DATE : 18/10/2017 SAMPLE QTY. : 1 LTR.

S.No.	Parameters	Units	Results	Protocols
1.	Chemical Oxygen Demand	mg/L	262	IS:3025 (P-58)
2.	Biochemical Oxygen Demand (for 3 days at 27 Deg C)	mg/L	85	IS:3025 (P-44)
3.	Bio-Assay	NA	0 % survival of fish after 96 hours in 100 % effluent water	IS : 6582

Date of performance : 18/10/2017 to 23/10/2017
NA - Not Applicable

SAMPLE COLLECTED BY US

DATE : 23/10/2017 ANALYST AUTHORISED SIGNATORY

REMARKS
1. Results listed refer only to the tested sample & applicable parameters. Endorsement of products is neither inferred nor implied.
2. Liability of laboratory is limited to the invoiced amount only. Any dispute arising out of this report shall be subject to Delhi jurisdiction only.
3. The Report shall not be reproduced either in full or part without the written approval of laboratory.
4. Sample shall be disposed off after issue of Test Report unless specified.
5. A complaint register is available with the laboratory.

Neeraj Gupta

Page : 1 of 1

Works : A-3/7, Mayapuri Indl. Area, Ph.-II, New Delhi-64 (Unit I) RZE-220-221, Gali No. 9, Nihal Vihar, Nangloi, New Delhi-41 (Unit II)
Tel.: +(91) - (11) 43854300 Fax: +(91) - (11) 43854330 • CIN : U74899DL1988PTC031785
E-mail : testing@simalab.co.in, amc@simalab.co.in, projects@simalab.co.in, Website : www.simalab.com SIMA

Bibliography

Gupta S (2012) Drinking Water Quality: A Major Concern in Rural India (Some strategies towards cleaner water and the draft water policy2012). BARNOLIPI- An Interdisciplinary Journal 1: 22492666.

Gupta SK, Deshpande RD (2004) Water for India 2050: First order assessment of available options. *Curr Sci* 86: 1216-1224.

MEA (Millenium Ecosystem Assessment) 2005. Ecosystem and Human Wellbeing: Synthesis. Island Press, Washington. 155 pages

Syvitski, J.P.M., Kettner, A.J., Hannon, M.T., Hutton, E.W.H., Overeem, I., Brakenridge, G.R., Day, J., Vörösmarty, C., Saito, Y., Giosan, L., Nicholls, R.J., 2009. Sinking deltas due to human activities. Nature Geoscience 2, 681–689.

H Gupta et al , *The role of mega dams in reducing sediment fluxes*: A case study of large Asian rivers, Journal of Hydrology, 2012

National Disaster Management Guidelines: Management of Urban Flooding, National Disaster Management Authority, Govt. of India, September, 2010

Rivers for Life - Proceedings of the International Symposium on River Biodiversity: Ganges, Brahmaputra-Meghna River System, IUCN, 2014

Report of the Working Group on Rivers, Lakes and Aquifers In Environment and Forests for the Eleventh Five Year Plan (2007-2012), Planning Commission, Govt. of India, April 2007

Massachusetts Rivers Protection Act, 1996, [http://www.mass.gov/eea/agencies/massdep/water/regulations/massachusetts-rivers-protection-act-about.html]

Thorpe, B. R. (1986) Comprehensive basin management in England and Wales. *Water Supply 4(Z), 9-13.*

River Basin Management Plans - European Commission http://ec.europa.eu/environment/water/participation/map_mc/map.htm

Burt, T. "The Silent River: The Hydrological Basis for River Conservation" In: Sabater, S. & Elosegi, A., River Conservation - Challenges and Opportunities (2013), Fundacion BBVA

United Nations (1958) *Integrated River Basin Development: Report of a Panel of Experts.* UN Department of Economic and Social Affairs, New York.

United Nations (1976) *River Basin Development: Policies and Planning, Vol. I.* Proceedings of a UN Interregional Seminar on River Basin and Interbasin Development September 16-26, 1975, Budapest. UNDP/National Water Authority of Hungary, Washington, DC.