नमामि गंगे

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Socio-Ecological
Status of
KALI RIVER

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SOCIO-ECOLOGICAL PROFILE OF KALI RIVER

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INTRODUCTION

The Kali River, a right bank tributary of the mainstem Ganga, is a non-perennial river that flows only during the monsoon season (Khan 1987; Vidhyarthi et al. 2020; Rana 2021). Also known as the East Kali, the River originates in the Muzzafarnagar district (Khan 1987). It has a total length of ~604 km and its basin covers an area of about 9612 km^2. It flows through eight districts of Uttar Pradesh before it confluences with the Ganga River near Kannauj (Khan and Khan 2019). The river flows in a zigzag (sinuous) manner, hence it is also known as *Nagin*. Being a non-perennial river, it flows during monsoon through rainwater and groundwater recharge, which is nearly absent during non-monsoon. During non-monsoon, industrial effluent and sewage discharge are the primary water source of this River (Khan 1987; Umar et al. 2008). With a depleting water table due to decades of groundwater overexploitation and other anthropic factors in the upper stretch, Kali River retains its ephemeral nature even in downstream stretches of Bulandshahr district (Khan and Khan 2019). Over 1200 villages and several big cities and towns are situated on its banks, whose majority population depends on the River for agriculture or industrial purposes (UPPCB 2019; CPCB 2022).

COURSE OF THE RIVER

The Kali River originates in Antwara village, Jansath Tehsil of district Muzzaffarnagar, Uttar Pradesh (Figure 1). At present, the river is dried and it retains its natural flow after receiving water from the Khatauli drain, which mostly carries industrial effluents as well as domestic sewage (UPPCB 2019). It traverses through the eight districts of Uttar Pradesh, namely Muzaffarnagar, Meerut, Ghaziabad, Aligarh, Etah, Bulandshahr, Farukhabad, and Kannauj (Khan and Khan 2019; Vidhyarthi et al. 2020). The Kali River submerges in the Ganga River in Kannauj district of Uttar Pradesh (27° 0' 45.34"N, 79° 59' 6.76"E) (Rana 2021). The Kali River primarily carries industrial and domestic wastewater discharged from nearby towns such as Muzaffarnagar, Meerut, Hapur, Ghaziabad, Bulandshahar, Aligarh, Kasganj, and Kannauj, which turns it into one of the polluted rivers of Uttar Pradesh (Singh et al. 2020; CPCB 2022). In total, 26 identified drains contribute to the pollution of the river along its entire stretch. The river experiences a significant pollution load between Muzaffarnagar and Bulandshahar, resulting in substantial disturbances to the vegetation patterns in these areas. However, two Ganga canals that carry freshwater merge with the Kali River, which helps in the improvement of its water quality through dilution. These two canals confluence with the Kali River at Khurja, downstream of Bulandshahar, and near Nadrai Bridge, upstream of Kasganj. As a result of the dilution, healthier vegetation can be observed in these locations. During monsoon, the Kali River receives many small seasonal streams throughout its course (Khan 1987) (Figure 2).

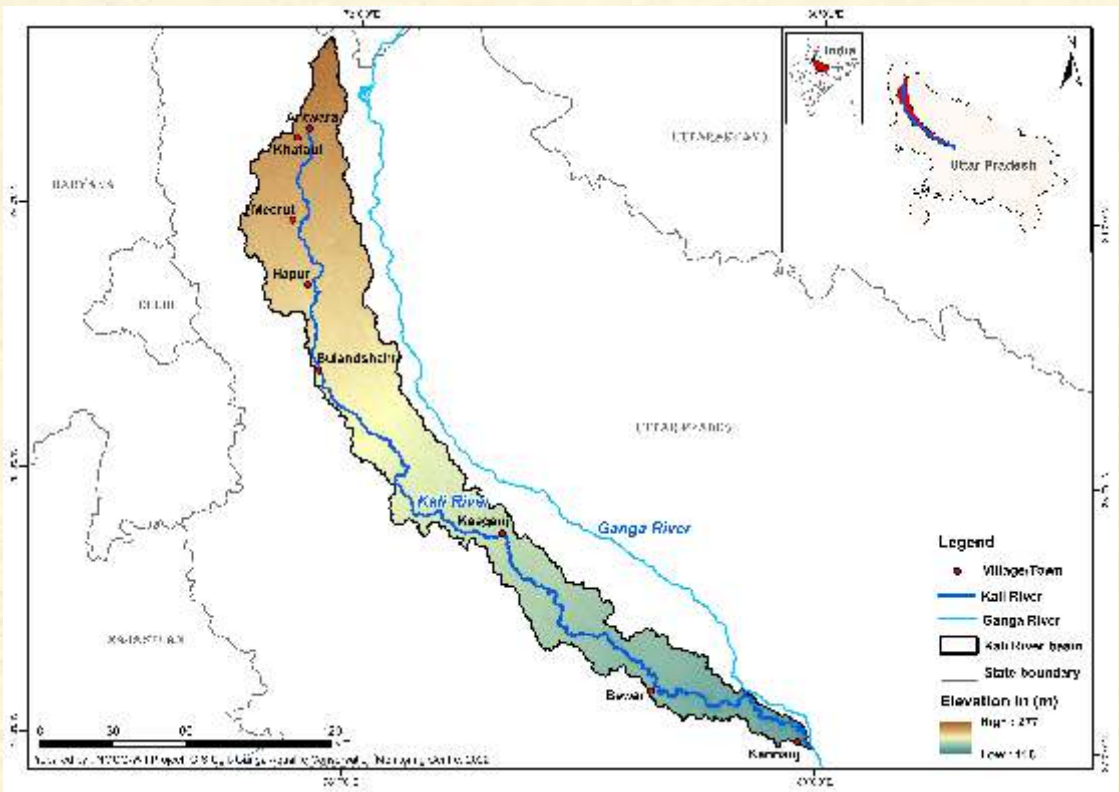

Figure 1. Course of the Kali River

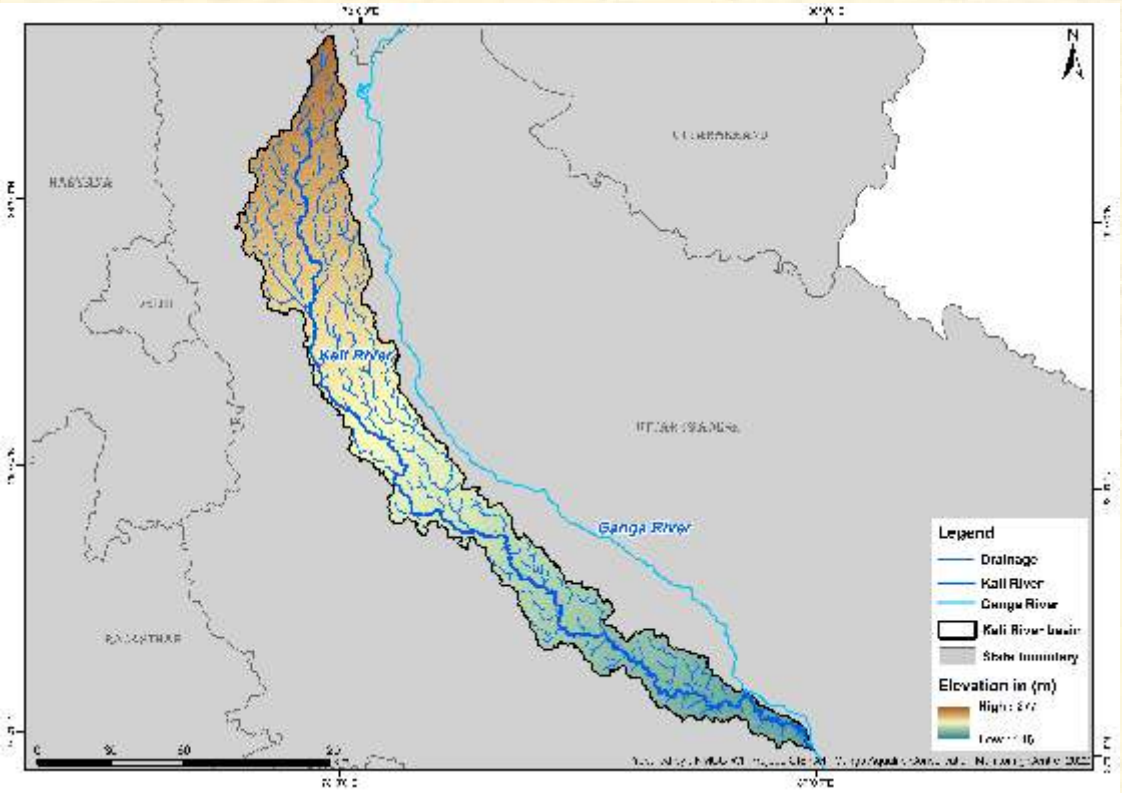

Figure 2.
Drainage pattern of Kali River

GEOLOGY AND GEOMORPHOLOGY

The Kali, a rain-fed river system, lies within the Ganga-Yamuna interfluve. The Kali River basin is composed of fluvial sediments made up of sand, clay, and calcite concretions of Quaternary age, locally known as 'Kankar' (Khan and Khan 2019). These alluvial deposits are divided into older and younger alluvial. The younger alluvium is confined to river banks and low-lying areas that frequently flood during the monsoon season (Rana, 2021). The thickness of these alluvial sediments is approximately 380 mt, which lies beneath the Vindhyan group of rocks (Khan and Khan 2019).

SOIL TYPE

According to FAO-UNESCO (1977), the Kali River system is mainly represented by Levisols, which cover 74.99% of the total catchment area from west to east of the River. The remainder of the catchment area is represented by 7.82% Fluvisols and 17.19% of Cambisols. Fluvisols is found in the north and southern parts, and Cambisols occur in the Southern part of the catchment. The soil type in the basin is mostly comprised of loam to silty loam and free of carbonates (Khan and Khan 2019).

CLIMATE

The climate of the Kali River is humid sub-tropical with three distinct seasons: summer (March-May), winter (November-February) and rainy (June-October) (Singh and Rao 2020; Rana 2021). The maximum temperature reaches up to 41°C in May and drops to 8°C in January (Singh and Rao 2020). The average annual rainfall along the river is 840-1000 mm. Approximately 80% of the annual rainfall is received from the south-west monsoon between July and September (Khan and Khan 2019; Rana 2021).

LAND USE AND LAND COVER

Based on NRSC data (2008-09 and 2018-19), two Land Use and Land Cover (LULC) maps of the Kali River basin were prepared (Figures 3a & 3b). The LULC of the Kali River basin can be divided into 11 categories: built-up, kharif crop, rabi crop, double/triple crop, fallow land, plantation, deciduous forest, degraded/ scrub forest, grassland, wasteland, and waterbodies. In 2008-09, the Kali River basin was dominated by 58.73% of double/triple crop, followed by 11.45% of kharif

crop, 9.26% of rabi crop, 6.84% of built-up area, 5.24% of fallow land, 4.6% of plantation, 2.7% of wasteland, 1.01% of waterbodies, 0.15% of deciduous forest, 0.01% of degraded/scrub forest and grassland. In 2018-19 the basin was dominated by 52.34% of double/triple crop, followed by 10.82% of kharif crop, 17.79% of rabi Crop, 7.84% of built-up area, 4.64% of fallow land, 4.66% of plantation, 1.04% of wasteland, 0.76% of waterbodies, 0.15% of deciduous forest, 0.01% of degraded/scrub forest and grassland. LULC change detection analysis revealed that over ten years, there was an increase of 8.35%, 0.94%, and 0.06% in the rabi crop, built-up area and plantation, respectively. While a decrease of 6.39%, 1.66%, 0.63%, 0.6% and 0.25% in the double/triple crop, wasteland, kharif crop, fallow land and waterbodies, respectively, was noted between the two assessment years (Figures 3a & 3b and Table 1).

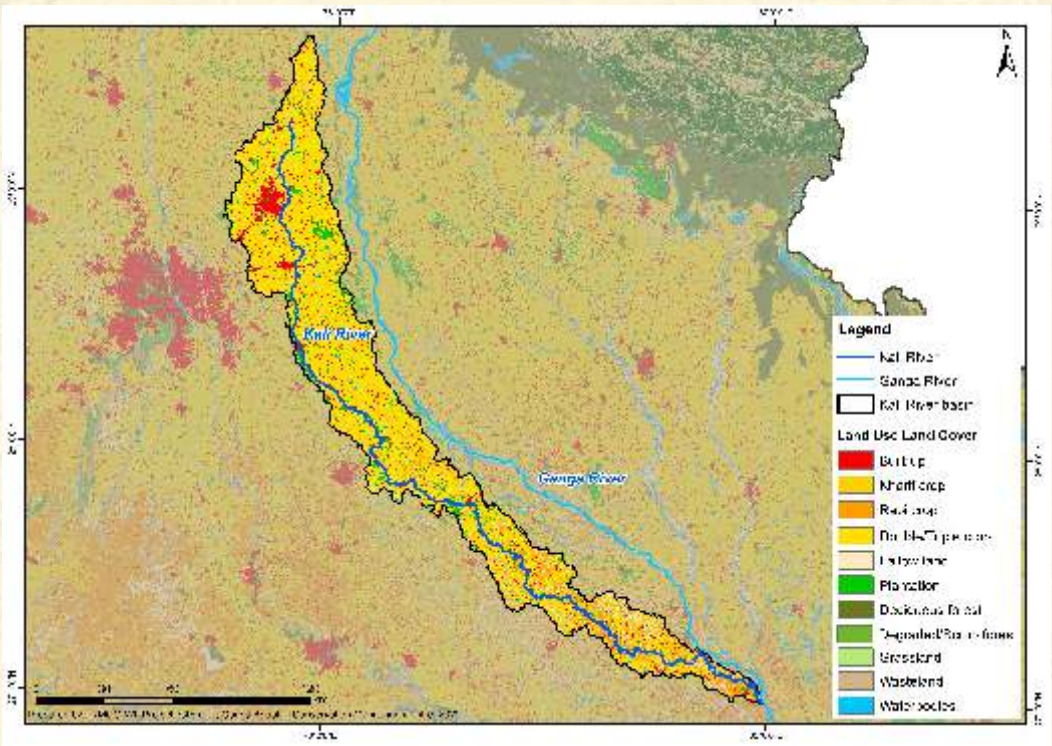

Figure 3a. LULC of Kali River basin in 2008-09

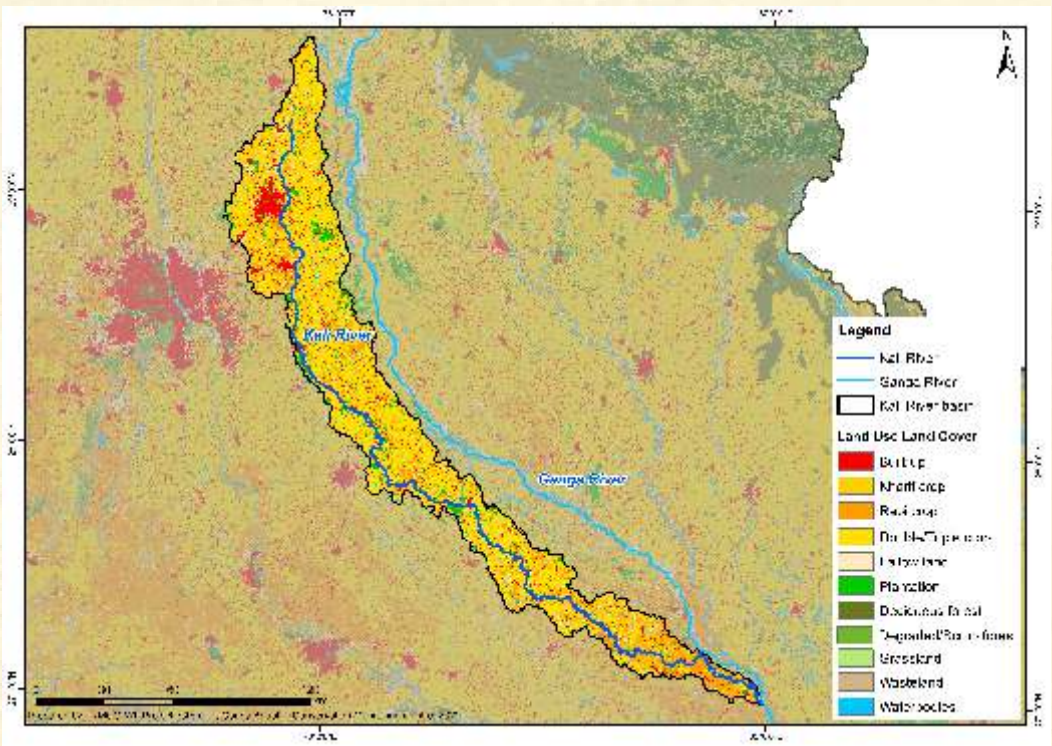

Figure 3b. LULC of Kali River basin in 2018-19

Table 1. LULC statistics of Kali River basin (2008-09, 2018-19) and Decadal Change Detection

LULC Classes	(2008-09) Area in km²	(2008-09) Area in %	(2018-19) Area in km²	(2018-19) Area in %	Area Change in km²	Area Change in %
Built-up	657.26	6.84	747.97	7.78	90.71	0.94
Kharif crop	1100.85	11.45	1039.9	10.82	-60.95	-0.63
Rabi crop	890.19	9.26	1710.15	17.79	819.96	8.53
Double/Triple crop	5645.08	58.73	5030.24	52.34	-614.84	-6.39
Fallow land	503.96	5.24	446.23	4.64	-57.73	-0.6
Plantation	442.33	4.6	448.36	4.66	6.03	0.06
Deciduous forest	14.81	0.15	14.65	0.15	-0.16	0
Degraded/Scrub forest	0.71	0.01	0.75	0.01	0.04	0
Grassland	1.39	0.01	1.28	0.01	-0.11	0
Wasteland	259.3	2.7	100.32	1.04	-158.98	-1.66
Waterbodies	97.03	1.01	73.06	0.76	-23.97	-0.25
Total Area	**9612.91**	**100**	**9612.91**	**100**		

Source: NRSC (2009; 2019)

FOREST COVER

According to the Forest Survey of India (2015; 2019), the basin of the Kali River is dominated by non-forest cover, followed by open forest and moderately dense forest (Figures 4a & 4b). From 2014 to 2019, an increase of 0.14% and 0.07% was recorded for the open forest and moderately dense forest, respectively. However, a decrease of 0.21% was recorded for non-forest area (Table 2).

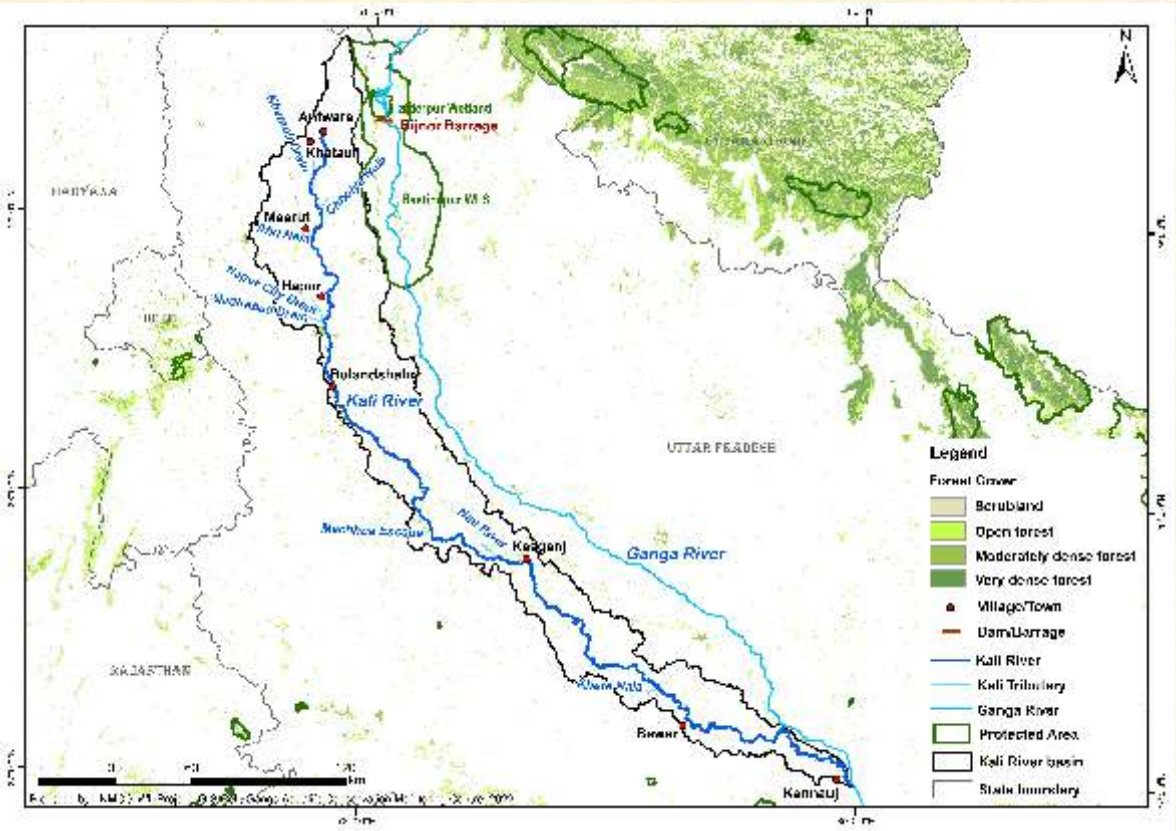

Figure 4a. Forest Cover of Kali River basin in 2014

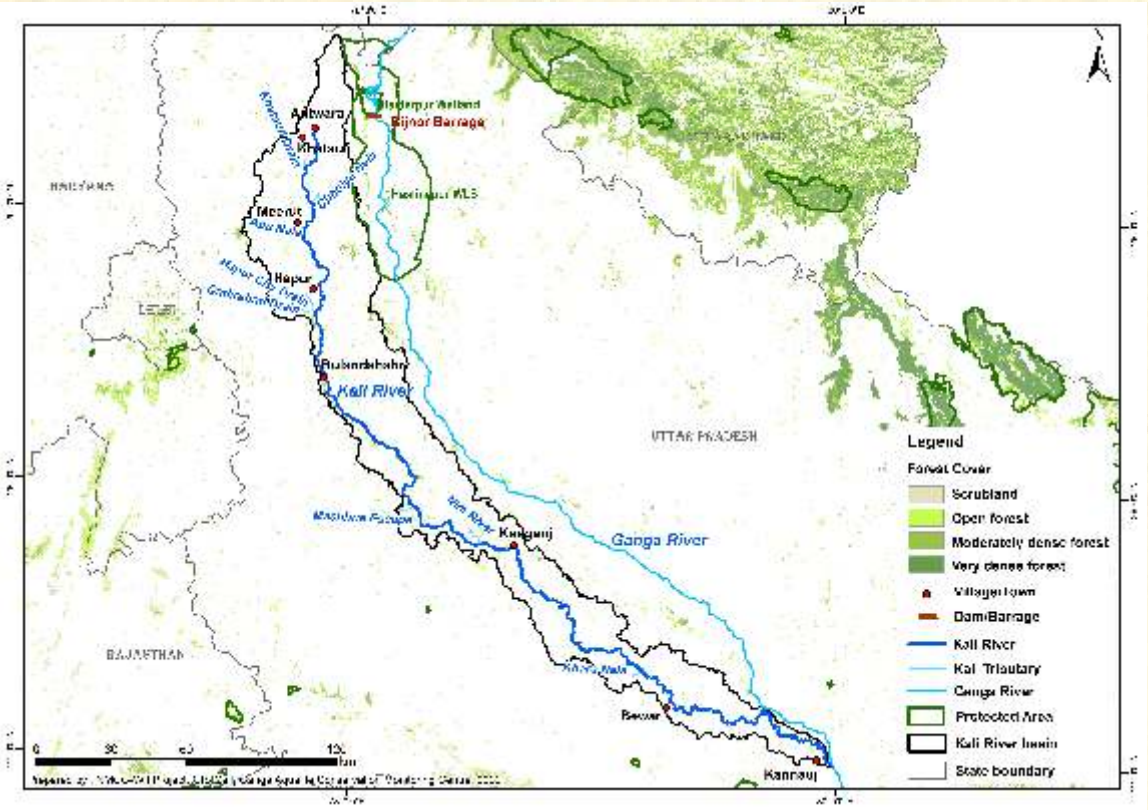

Figure 4b. Forest Cover of Kali River basin in 2019

Table 2. Summary statistics of the forest cover of Kali River basin from 2014 to 2019

Forest Cover Classes	(2014) Area in km²	(2014) Area in %	(2019) Area in km²	(2019) Area in %	Area Change in km²	Area Change in %
Scrubland	0	0	0	0	0	0
Open Forest	169.33	1.76	182.96	1.9	13.63	0.14
Moderately Dense Forest	48.22	0.5	54.36	0.57	6.14	0.07
Very Dense Forest	0	0	0	0	0	0
Non-forest	9395.36	97.74	9375.59	97.53	-19.77	-0.21
Total Area	**9612.91**	**100**	**9612.91**	**100**		

Source: FSI (2015; 2019)

BIOGEOGRAPHY, FLORA AND FAUNA

The Kali River flows through the Gangetic Plains biogeographic zone and the Upper Gangetic Plains (7A) biotic province. These areas experience distinct wet and dry periods, which influence the vegetation that flourishes along the riverbanks. The vegetation profile along the Kali River mainly consists of a mix of riparian, scrub, and agricultural plants, with some forested pockets found in regions where water is more readily available. The extent of forest cover in an area significantly influences the riparian habitat and riverine vegetation, impacting water quality, biodiversity, soil stability, and the overall health of the ecosystem. The Kali River Basin in Uttar Pradesh is classified into three forest categories according to the Champion and Seth (1968) classification system: Tropical Moist Deciduous Forests, Tropical Dry Deciduous Forests, and Tropical Thorn Forests.

The Tropical Moist Deciduous Forest, found in Kali River basin's part that receives moderate to high rainfall during the monsoon season the forest used to be dominated by Sal (*Shorea robusta*), Teak (*Tectona grandis*), Rose wood (*Dalbergia*

sissoo) and *Bamboosa* spp. The major portion of the Kali River Basin primarily is represented by tropical dry deciduous forests (Group 4B), especially in its semi-arid and sub-humid regions. Dominant tree species in this area include *Acacia nilotica* (Indian gum Arabic tree), *Acacia catechu* (kachu), *Boswellia serrata* (Indian frankincense), and *Tamarix* spp. (salt cedar), shrubs like *Ziziphus* spp. (Ber) and grasses such as *Cenchrus ciliaris*. Some part of the Kali River Basin has tropical thorn forests (Group 5), which are found in the drier and more arid regions of the Kali River Basin. These forests are dominated by thorny trees and shrubs that are adapted to extreme heat and limited rainfall. The common species representing this forest type are *Prosopis juliflora*, *Acacia senegal* (gum arabic tree), *Capparis decidua*, and *Carissa carandas*.

According to Narayan and Agrawal (2015), the dominant plant Families observed along the bank of the River are *Poaceae, Leguminosae, Asteraceae, Malvaceae, Cyperaceae, Moraceae, Amaranthaceae*, and Myrtaceae. Frequently encountered tree species are *Tectona grandis, Terminalia arjuna, Cassia fistula, Acacia catechu, A. nilotica, Azadirachta indica, Ficus religiosa, F. benghalensis, Bombax ceiba, Butea monosperma, Madhuca longifolia, Pithecellobium dulce, Azadirachta indica, Trewia nudiflora*, and *Melia azedarach*. The dominant shrub species found in the basin are *Ipomoea carnea, Calotropis procera, Ricinus communis, Lippia alba, Abuliton indicum, Clerodendrum viscosum, Lantana camara, Urena lobata, Murraya koenigii,* and *Tamarix ericoides*. Dominant herb species in the basin are *Grangea maderaspatana, Parthenium hysterophorus, Cannabis sativa, Tridax procumbens, Gnaphalium luteoalbum, Sphaeranthus indicus, Cirsium arvense, Blumea lacera, Ageratum conyzoides, Solanum* spp., *Nicotiana plumbaginifolia, Phyla nodiflora, Lindernia dubia,* and *Basella alba*. Dominant grass species in the Basin are *Cynodon dactylon, Cyperus rotundus, Saccharum benghalensis, S. spontaneum, Typha aungustifolia, Phragmites karka, Vetiveria zizanioides, Fimbristylis* spp., *Schoenoplectiella juncoides, Juncus bufonius*, and *Arundo donax*. Dominant aquatic plant species found in the basin are *Nymphaea nouchali, Nymphaea pubescens, Hydrilla verticillata, Pontederia crassipes, Vallisneria natans, Potamogeton crispus, Lemna perpusilla, Spirodela polyrhiza, Pistia stratiotes,* and *Ranunculus aquatica*.

The introduced (exotic) plant species along the Kali River Basin are *Peperomia pellucida, Dichanthelium acuminatum, Paspalum dilatatum, Urochloa mutica, Potederia crassipes, Euphorbia hirta, Euphorbia heterophylla, Mimosa pudica*, and *Leucaena leucocephala*. (Narayan and Agrawal 2015). Singhala et al. (2016) reported 52 plant species dominated by weeds and ruderals aboveground and belowground of the Kali River. Species dominance is influenced by the season, as *Cynodon dactylon, Sida acuta, Digitaria adscendens* and *Parthenium hysterophorus* are the dominant species during the rainy season, whereas weeds like *Parthenium hysterophorus* and *Rumex dentatus* are prevalent during the winter season.

In Ichthyofauna, some species of fish are found in the Kali River, namely, *Labeo bata, Heteropneustis fossilis, Punctius ticto* (Malik 2014; Mouarya 2016), and *Channa striatus* (Fatima et al. 2015). To date, a lack of scientific studies on the flora and fauna of the Kali River makes it one of the least studied rivers in the Ganga River basin.

CONSERVATION STATUS

Hastinapur Wildlife Sanctuary (HWS), which was notified as a Protected Area in 1986 under Section 36 A of the Wild Life (Protection) Act of 1972, falls in the Kali River basin. Approximately a 60 km stretch of the Kali River flows through Hastinapur Wildlife Sanctuary with its basin area of 14.27 km^2. This Sanctuary supports aquatic species such as the Critically Endangered gharial (*Gavialis gangeticus*), the Endangered Gangetic dolphin (*Platanista gangetica*), and the Vulnerable smooth-coated otter (*Lutrogale perspicillata*) (Khan and Abbasi 2015). Apart from aquatic species, swamp deer (*Rucervus duvaucelli*), hog deer (*Axis porcinus*), blackbuck (*Antilope cervicapra*), nilgai (*Boselaphus tragocamelus*), wild boar (*Sus scrofa*), golden jackal (*Canis aureus*), jungle cat (*Felis chaus*), and fishing cat (*Prionailurus viverrinus*) reside in the sanctuary area (WII-GACMC 2018). The HWS supports 117 bird species from 44 families, including the Endangered Indian skimmer (*Rynchops albicollis*) and black-bellied tern (*Sterna acuticauda)*, and Vulnerable sarus crane (*Grus antigone*) (Khan et al. 2013).

LIVELIHOOD

The Kali River basin is primarily dominated by agricultural land, and the basin has a large number of agro-based industries. The inhabitants of the Basin rely primarily on agriculture. During the Kharif season (July to October), the main crops grown in the region are jawar (*Sorghum bicolor*), bajra (*Pennisetum glaucum*), and makka (*Zea mays*). During the Rabi season (October to March), irrigated fields are used for growing wheat (*Triticum aestivum*), rice (*Oryza sativa*), and sugarcane (*Saccharum officinarum*), while rainfed fields are used for growing peas (*Pisum sativum*), mustard (*Brassica nigra*), barley (*Hordeum vulgare*), and other cereals and pulses (Singh and Rao 2020).

DEMOGRAPHY

The Kali River basin supports a human population of 74.83 Lakh. (GOI 2011). There are 40 blocks from 11 districts of Uttar Pradesh (Muzaffarnagar, Meerut, Ghaziabad, Bulandshahr, Aligarh, Mahamaya Nagar, Kashiram Nagar, Etah, Farrukhabad, Mainpuri and Kannauj) that fall in the river basin. Hapur, with a 3.2 lakh human population, is the most populated of these blocks and Bulandshahr, with a 14.96 lakh human population, is the most populated district of the Kali River basin (Figure 5 and Table 3).

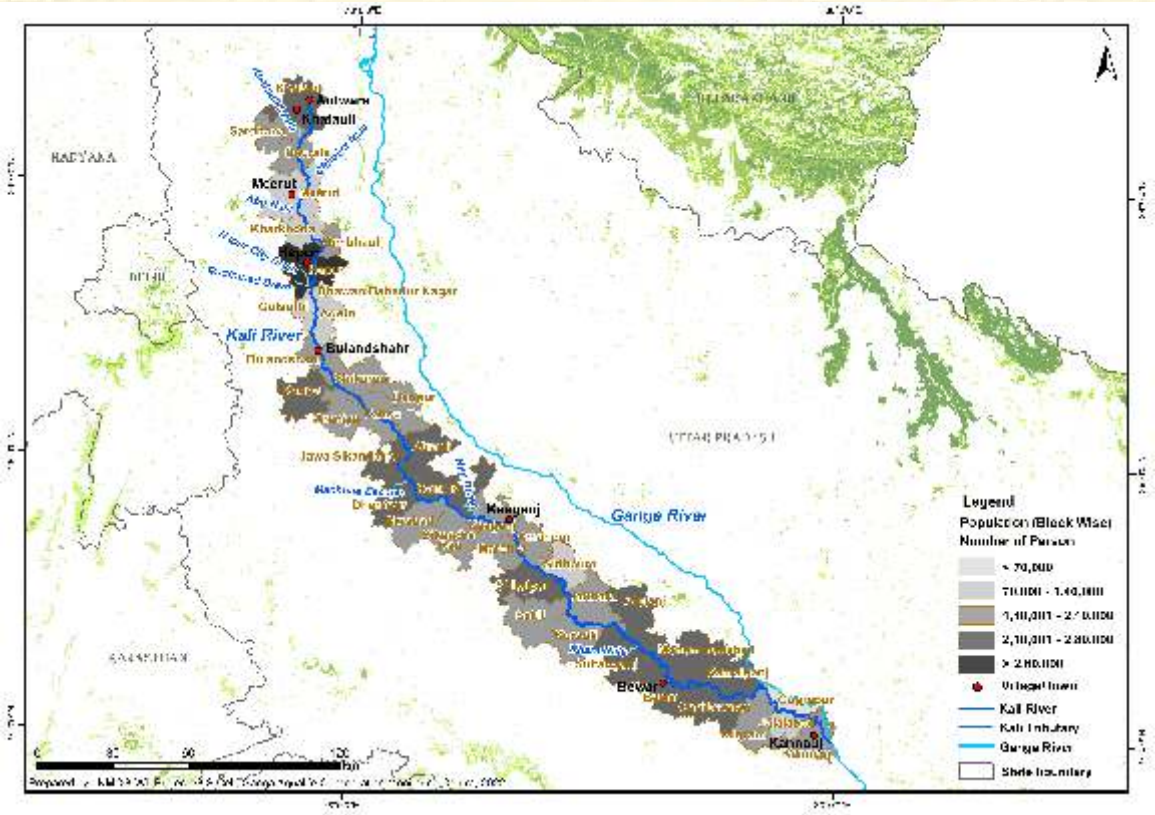

Figure 5. Human population status of Kali River Basin (2011)

Table 3. Block-wise human population statistics of the Kali River basin for 2011

S.no	District	Block	Population	Population %
1	Muzaffarnagar	Khatauli	276356	3.69%
2	Meerut	Sardhana	147181	1.97%
3		Meerut	73990	0.99%
4		Daurala	140934	1.88%
5		Kharkhoda	122096	1.63%
6	Ghaziabad	Simbhaoli	201663	2.69%
7		Hapur	317004	4.24%
8	Bulandshahr	Bhawan Bahadur Nagar	106664	1.43%
9		Gulaothi	105690	1.41%
10		Agoto	123571	1.65%
11		Bulandshahr	201602	2.69%
12		Shikarpur	167443	2.24%
13		Khurja	252512	3.37%

S.no	District	Block	Population	Population %
14		Danpur	186090	2.49%
15		Pahsu	197701	2.64%
16		Araniya	155489	2.08%
17	Aligarh	Atrauli	210515	2.81%
18		Jawa Sikandarpur	268492	3.59%
19		Gangiri	268795	3.59%
20		Dhanipur	220956	2.95%
21		Akrabad	170766	2.28%
22	Mahamaya Nagar	Sikandra Rao	158365	2.12%
23	Kanshiram Nagar	Amanpur	145866	1.95%
24		Sidhpura	131574	1.76%
25		Kasganj	198020	2.65%
26	Etah	Mareha	147819	1.98%
27		Shitalpur	239671	3.20%
28		Jaithara	195617	2.61%
29		Aliganj	237721	3.18%
30		Sakit	201488	2.69%
31	Farrukhabad	Mohammadabad	259396	3.47%
32		Kamalganj	277306	3.71%
33	Mainpuri	Kuraoli	150362	2.01%
34		Sultanganj	212392	2.84%
35		Bewar	211333	2.82%
36	Kannauj	Chhibramau	230064	3.07%
37		Gugrapur	69237	0.93%
38		Jalalabad	102516	1.37%
39		Talgram	194284	2.60%
40		Kannauj	205380	2.74%
		Total	**7483921**	**100%**

Source: Census of India: Government of India, 2011

THREATS

Along its course, the Kali River is intersected by 26 drains from various sources (domestic, industrial, and mixed). The River's pollution load is reduced at two sites where the upper and lower Ganga canals, carrying the freshwater, meet the River (Rana 2021). About 94 industries (sugar, distillery, chemical, pulp and paper, electroplating, slaughter house, and textile) are situated in Muzaffarnagar, Meerut, Hapur and Gulaothi town of Bulandshahar along the course of the Kali River. The River receives a huge amount of domestic and industrial wastewater every day, which leads to deterioration of its water quality and makes it unsuitable for aquatic fauna (UPPCB 2019; CPCB 2022). Chlorinated organic, suspended solids, and organic wastes (emitted by pulp and paper mill effluents), phenols and mineral oils (emitted by the petrochemical industry), and other difficult-to-treat pollutants (carcinogenic) are also among the released industrial pollutants (Vidhyarthi et al. 2020). The River's self-purification capacity is deteriorating as it receives 148 tonnes of industrial and domestic waste on a daily basis from these 26 drains along the Kali River (Rana 2021; UPPCB 2019). There is no functional forest since the basin is dominated by agricultural land, resulting in agricultural sprays, heavy metals and pesticide runoff

affecting the river's health (Jha et al. 2005; Singh et al. 2021). Furthermore, unplanned construction in and around the river beds and wetlands has accelerated the disappearance of the River (Singh and Rao 2020).

CONSERVATION IMPLICATIONS

The tributaries of the Ganga River are known to increase channel and habitat complexities, depth and change in substrate composition, which helps to increase the mainstem diversity (Benda et al. 2004; Fernandez et al. 2004). Besides contributing to the flow and aquatic diversity of the mainstem, the tributaries also contribute to the pollution load to the mainstem. Thus, conservation actions taken for the mainstem should also be applied to the tributaries. The water quality and quantity of the Kali River have deteriorated day by day due to industrial and agriculture wastewater being dumped into it (Singh et al. 2020; 2021). There should be strict regulatory norms for discharging industrial effluents into the River. The construction of wetlands and the installation of Sewage Treatment Plants (STPs) are necessary steps to reduce the sewage treatment gap and to maintain the overall quality of the River. CPCB (2022) had identified high high-priority stretch between Meerut and Kannauj that requires special intervention to reduce pollution influx in the Kali River. Bioremediation, phytoremediation, oxidation ponds, and other techniques may also be effective in treating industrial wastewater. Biodiversity parks and community-based eco-tourism should be developed to raise local participation, aligning with river conservation. An electric incinerator should be erected to prevent unburned ashes from entering the flowing river. Farmers must adopt natural farming techniques to prevent or limit the use of fertilizer and pesticide, which would reduce the pollution load on the River (UPPCB 2019; Singh et al. 2021).

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