Chapter 2
Brief Overview of the Yamuna River Basin and Issues

Abstract This chapter presents the current status of the Yamuna river basin as well as brief description of its catchments. This chapter also includes the various issue related to water in terms of water quantity, quality, wastewater and environmental flow.

The Yamuna River is one of the important and sacred rivers of India. It is the largest tributary of the River Ganga. It originates from Yamunotri glacier in the Mussoorie range of the lower Himalayas, and after traversing 1,376 km joins the river Ganga at Allahabad. The drainage area of the Yamuna basin is 366,220 sq km, which comprises part of seven states, viz. Uttarakhand, Himachal Pradesh, Uttar Pradesh, Haryana, Delhi, Rajasthan and Madhya Pradesh (Table 2.1). The Yamuna River has four main tributaries in the Himalayan region: Rishi Ganga, Hanuman Ganga, Tons, and Giri. In the plains, the main tributaries are the Hindon, Chambal, Sind, Betwa and Ken (Fig. 2.1).

The river water is generally used for irrigation, drinking and industries as well as for mass bathing, laundry, cattle bathing, and secretion of the cremation ash. The construction of diversion structures at regular intervals (Hathinikund, Wazirabad, Okhla, Gokul, etc.) for irrigation, domestic and industrial water supply, has largely modified the flow regime of the river. The inflow of wastewater either treated or partially treated in the river further aggravates the water quality problem of the river. Though the green revolution was important for food security, but lack of regulation in the groundwater abstraction has led to ground water table depletion causes damage in causal linkage between surface and ground water, resulting change in surface water dynamics during the lean season of the river. This is the main reason of dry river segments observed between Hathinikund and Palla (Delhi).

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Table 2.1 Details of catchment area and state of Yamuna river basin

State	Area in Yamuna basin (km^2)	Area in major sub-basin (km^2)					
		Hindon	Chambal	Sind	Betwa	Ken	Others
Uttarakhand	3,771 (1.1 %)	–	–	–	–	–	3,771 (3.74 %)
Himachal Pradesh	5,799 (1.7 %)	–	–	–	–	–	5,799 (5.76 %)
Uttar Pradesh	70,437 (20.4 %)	7,083 (100 %)	452 (0.32 %)	748 (2.89 %)	14,438 (30.12 %)	3,336 (13.66 %)	44,380 (44.06 %)
Haryana	21,265 (6.1 %)	–	–	–	–	–	21,265 (21.11 %)
Rajasthan	102,883 (29.7 %)	–	79,495 (56.87 %)	–	–	–	23,388 (23.22 %)
Madhya Pradesh	140,208 (40.6 %)	–	59,838 (42.81 %)	25,131 (97.11 %)	33,502 (69.88 %)	21,090 (86.34 %)	647 (0.64 %)

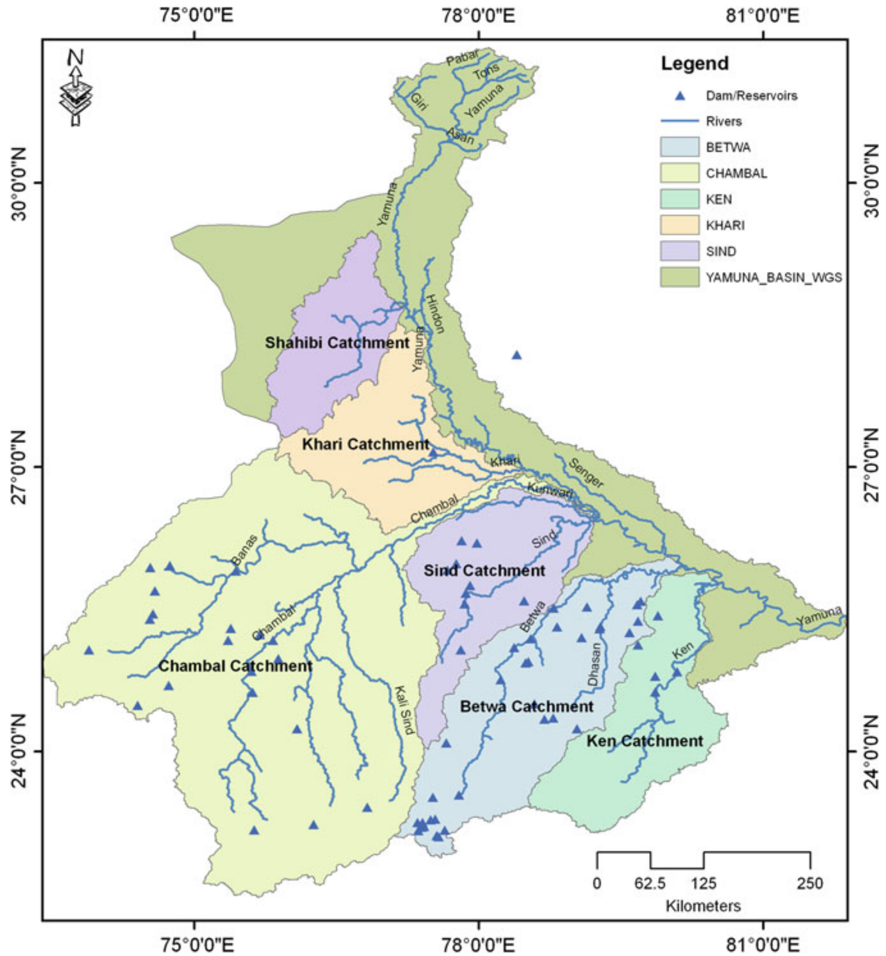

Fig. 2.1 Catchments of the Yamuna river basin and major tributaries

2.1 Issues and Challenges

The major issues and the challenges of the Yamuna river basin may be categorized as water resources, water quality and wastewater generation. These issues are briefly elaborated in the following sections.

2.1.1 Water Resources

Since independence, the population in the Yamuna basin has been increased by 2.5 times, and to ensure the food security, various irrigation schemes have been subsequently developed. Currently, the irrigated area in the basin has become 2

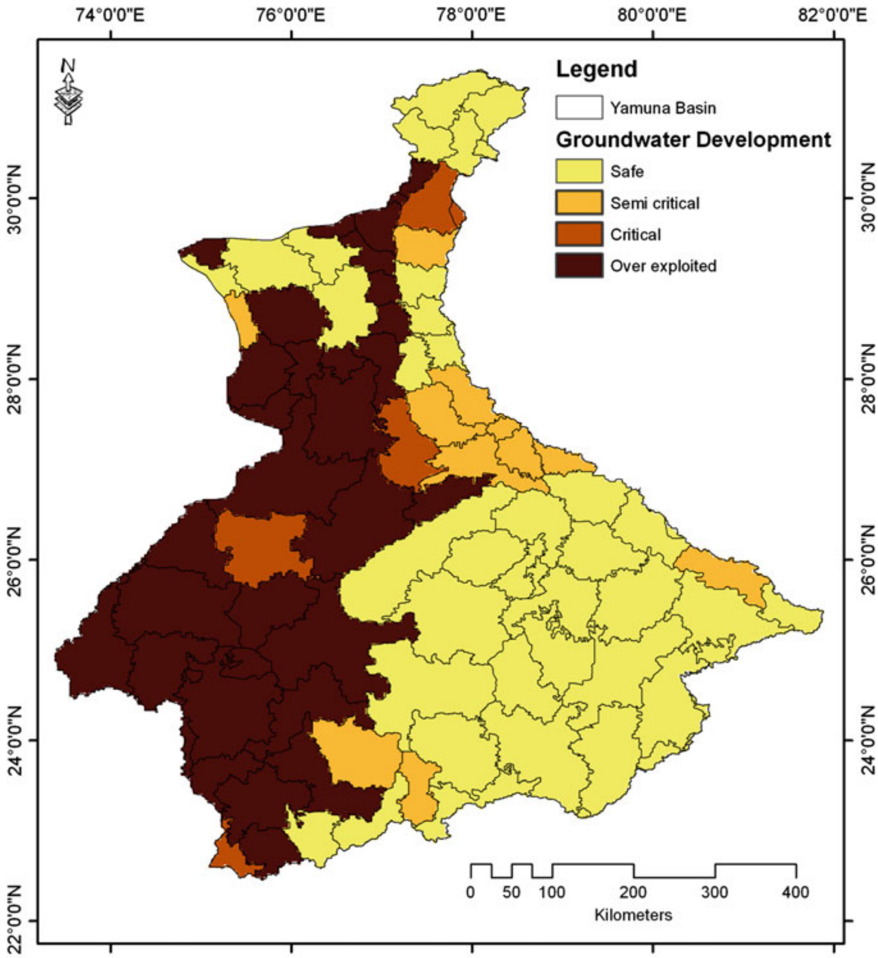

Fig. 2.2 Stages of ground water development in the basin (Rai et al. 2011)

times as compared to the year 1950. Also, during 60 years since 1950, the contribution of groundwater resources for irrigation has been triplicated. A net share of surface and groundwater for irrigation has now been become 37 and 57 % instead of 60 and 20 % in 1950s. The rest of the irrigation water is met by other sources like ponds, tanks, *anicuts*, etc.

The increasing groundwater development in the basin is a major concern in sustainable water resources planning and management. The district-wise stage of ground water development in the basin is depicted in Fig. 2.2, which clearly indicates that eastern and south-east part of the basin has already been overexploited in terms of CGWB classification (CGWB 2010). The right bank portion of the main Yamuna River is also under semi-critical to overexploited category of

Table 2.2 Mean monthly flows of Yamuna river at various locations (Rai et al. 2011)

Months	Mean monthly flows (m^3/s)				
	Paonta	Kalanaur	[a]DRB	[a]Agra	Pratappur
June	84.9	35.9	37.8	27.0	356.8
July	302.4	287.8	248.3	157.2	2,426.8
August	595.5	604.8	630.9	505.9	6,608.4
September	399.3	389.6	453.3	504.6	6,230.7
October	104.5	89.6	93.3	157.2	1,166.7
November	53.2	52.1	57.8	81.0	569.0
December	40.7	11.9	35.8	43.6	466.7
January	40.7	11.9	34.3	29.8	366.2
February	56.2	10.3	33.5	28.9	392.6
March	71.7	43.7	28.0	20.9	345.3
April	30.8	17.7	42.4	27.0	356.8
May	40.3	17.2	24.3	17.4	242.6

[a] Though the flow is available but water quality is very poor

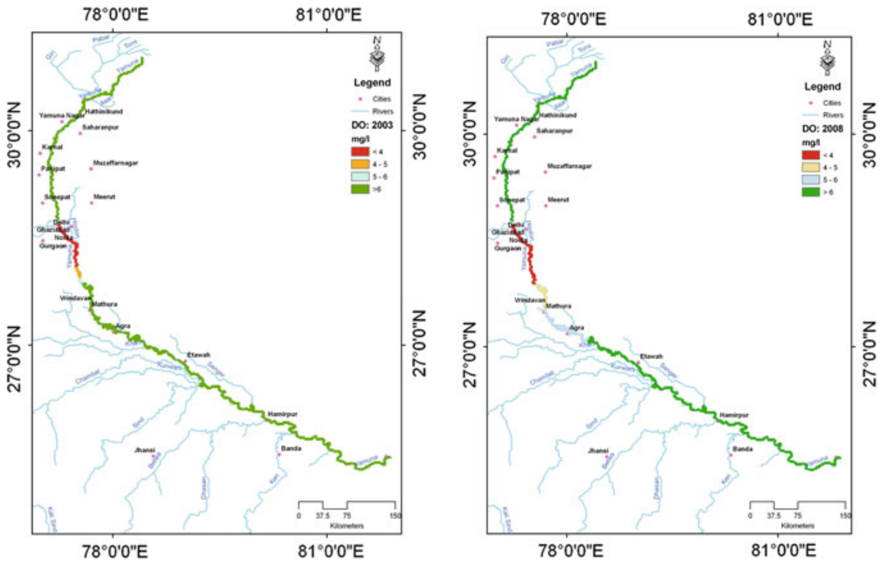

Fig. 2.3 Comparison of water quality profile for the year 2003 and 2008 (Rai et al. 2011)

stage of ground water development starting from Yamunanagar to Etawah, this led to termination in the causal linkage between the groundwater and the river runoff.

The current water use and the analysis of 10 years (2000–2009) of hydrological data (both surface water and groundwater) reveal that entire basin is under water deficit (approximately 34.54 BCM of deficit). However, the Ken River (surplus of 3.27 BCM) and the Upper Himalayan (surplus of 4.6 BCM) catchments have

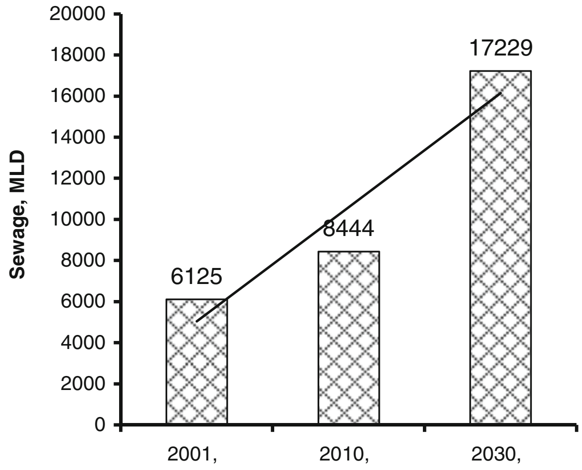

Fig. 2.4 Projection of wastewater generation

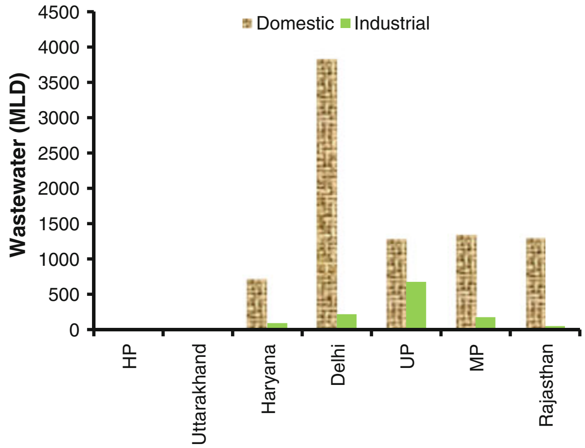

Fig. 2.5 State-wise domestic and industrial wastewater

surplus water resources because of its poor land capabilities. The mean monthly flows available at various discharge measurement sites are specified in Table 2.2.

2.1.2 Water Quality

Analysis of the secondary data collected from Central Pollution Control Board (CPCB) and primary sampling at various locations in the Yamuna River reveals that water quality is gradually deteriorating and will tend to deteriorate if not managed properly. This can be seen through the comparison of DO profile of the Yamuna River for the year 2003 and 2008 (Fig. 2.3), which indicates that polluted stretch in the Yamuna River, is gradually increasing.

Table 2.3 Wastewater generation and treatment capacity of YAP towns

Cities/towns	Bank	Volume of WW (MLD)	Treatment capacity (MLD)
Yamunanagar	R	45	35
Saharanpur	L	45	38
Muzaffarnagar	L	40	32.5
Karnal	R	60	48
Panipat	R	60	45
Sonepat	R	45	30
Delhi	R/L	3,800	2,330
Gurgaon	R	45	30
Faridabad	R	140	115
Ghaziabad	L	150	126
Noida	L	90	70
Vrindavan	R	5	4.5
Mathura	R	35	28
Agra	R	190	90
Etawah	R	13	10
Allahabad	L	223	89
Total		4,986	3,121

2.1.3 Wastewater Generation

Wastewater inflow in the river Yamuna is major source of pollution, which is governed by population, water supply, sewerage network and collection, efficiency of the relevant infrastructure, etc. Currently, 8,444 MLD of wastewater is generated in the basin, out of which about 4,458 MLD is discharged directly into the Yamuna river and about 1,200 MLD is discharged into its tributaries remaining 2,786 MLD is either disposed of on land or used for irrigation. Due to population growth, this wastewater generation will be further aggravated (Fig. 2.4). Delhi alone generates about 3,743 MLD of wastewater, which is 44 % of the entire sewage generated in the basin and 84 % of the sewage being discharged into the Yamuna along its entire course.

State-wise wastewater generation is shown in Fig. 2.5, which demonstrates that the Uttar Pradesh is highest contributor of industrial waste in the Yamuna River through Hindon River and Hindon-cut.

On the sewage treatment front, Delhi has highest sewage treatment capacity of 2,330 MLD which is about 68 % of the total sewage treatment capacity in the basin (Table 2.3). However, there is still a large gap between generation and treatment in Delhi itself. Though, several STPs have been installed along the river course with a designed capacity of the order of 2,332.25 MLD for Delhi, 327 MLD for Haryana, and 403.25 MLD for Uttar Pradesh. But, the river quality of the river is not yet improved as the treatment capacity is neither adequate nor effectively utilized. Main issues related to sewage management are:

Table 2.4 Environmental flow requirement of various reaches of Yamuna river

Month	Release from Hathinikund (Hathinikund to Palla) (m^3/s)	Release from Wazirabad (Wazirabad to Okhla) (m^3/s)	Release from Okhla (Okhla to Agra) (m^3/s)	[a]Net release from Hathinikund for maintaining the environmental flow up to Agra (m^3/s)	From Agra (Agra to Etawah) (m^3/s)	From Etawah (Etawah to Allahabad) (m^3/s)
January	36.8	14.5	42.4	82.2	63.8	91.6
February	40.4	14.7	45.5	89.9	67.8	98.8
March	47.2	12.3	36.7	78.4	54.9	86.3
April	37.0	17.6	48.4	88.0	69.7	89.2
May	39.2	11.0	33.8	73.8	51.1	60.7
June	46.4	15.99	45.5	89.5	66.6	89.2
July	121.8	83.3	117.3	188.5	196.8	606.7
August	227.2	189.0	221.1	318.0	435.4	1,707.3
September	155.6	162.4	209.5	323.6	409.0	1,507.5
October	63.0	36.4	115.3	167.6	182.4	301.4
November	48.5	22.4	69.4	113.8	107.4	137.7
December	36.8	15.0	47.0	87.0	72.9	116.7

[a] The net release accounts the ecological flow of previous reach which will carry forward to the next reach

- STPs capacity is inadequate as compared to the generated sewage.
- STPs are in general practically not meeting their compliance.
- Under running of most of the STPs due to lack of sewer connections.
- Improper drainage system.
- Excess BOD concentration coming to the plant due to inadequate water supply, etc.

Considering the current status of generation and treatment capacity of Delhi alone, even if treated effluent quality is achieved at 10 mg/l BOD for the entire existing treatment capacity, still BOD load would be 179 t/d, which may result in BOD concentration of 46 mg/l in the final effluent and not complying with the prescribed standards. Even if the entire sewage of Delhi is treated to a level of 5 mg/l of BOD, still the BOD load in the final effluent would be 19.4 t/d, which may continue to impair the water quality of the river.

2.1.4 Environmental Flow

Environmental flow is an important issue for the river Yamuna, and an attempt was made to estimate it for different stretches in different months. In the study, various hydrology based methodology was investigated. A hydraulic method (Rai et al. 2011), which accounts for seepage and evaporation losses, ecological requirement and water requirement for pollution assimilation was used to estimate the

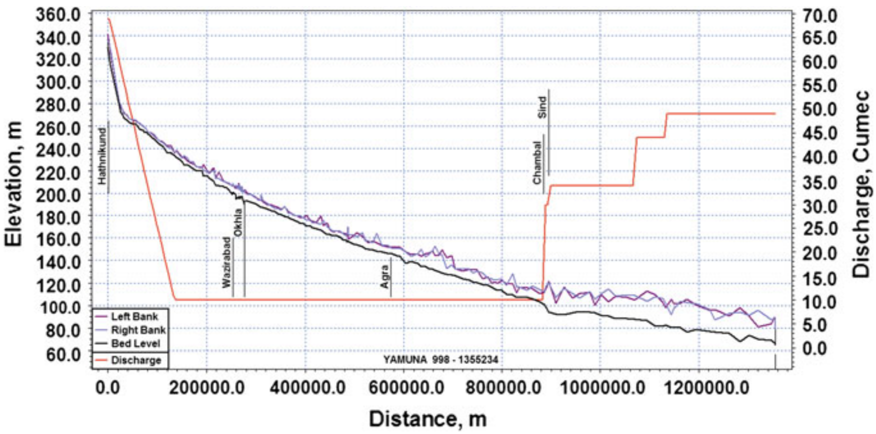

Fig. 2.6 Flow profile of the Yamuna with Hathinikund release of 70 m^3/s

stretch-wise environmental flow requirement. The estimated minimum environmental flow release from the Hathinikund barrage without considering the dilution water for pollution assimilation was 73.8 m^3/s (Table 2.4), which is approximately equal to the 50 % of mean minimum flow available at Hathinikund.

The base line environmental flow was also simulated using the MIKE 11 model without considering the water resources development in the river Yamuna, and it was appeared that approximately 70 m^3/s of flow is required to be released (i.e. minimum release) from the Hathinikund barrage to maintain the ecological flow of the river up to Etawah (i.e. before the confluence of river Chambal (Fig. 2.6). However, this quantity of water for maintaining the ecological flow is really a great challenge because of other priority uses of water such as drinking and irrigation.

2.2 Summary of the Yamuna River Catchments

Based on the analysis of climate, topography, landuse, geology, population status, etc., problems and their possible solution is summarized in Table 2.5.

Considering this large spatial variation of the water related problems/issues in the basin (Table 2.5), the public awareness and partnership campaign was planned for different catchments. The methodology adopted and the case studies are presented in subsequent chapters.

Table 2.5 Summary of the physiographic and climatic conditions of the sub-basin

Variables	Upper Himalayan	Hindon	Hathinikund to Delhi
Mean rainfall (mm)	1175	887.0	650.0
Climate	Humid	Semi-arid to sub-humid	Semi-arid
Mean slope (m/km)	28.528	<0.70	<0.80
Hydrogeology	Hilly and Tarai	Recent alluvium	Recent to older alluvium
Geology	Soft rock and Tarai	Alluvium	Alluvium
Groundwater development	White	White to grey	Grey to dark
Cropping intensity (%)	118–167	132–167	148–212
Population density (per sq km), census-2001	12–300	600–2000	100–800
Population density along the river	Population density along the river course is varying between 800 and 9,412; which causing major environmental damage to the river.		
Economy	Horticulture + Agriculture	Agriculture + Industries	Agriculture + Industries
Pollution sources	Domestic Industries (Scattered source)	Industries Domestic	Domestic Industries
Major water problem	–	Quality	Quantity and quality
Solution	Construction of environmental reservoir for riparian ecosystem maintenance Soil conservation	Wastewater management Crop planning Improvement in irrigation efficiency	Crop planning Improvement in irrigation efficiency Groundwater recharge Wastewater management River training work for water augmentation through weirs across the river

Variables	Chambal	Sind	Betwa	Ken
Mean Rainfall (mm)	783.7	848.3	1064.9	1125.0
Climate	Semi-arid to sub-humid	Semi-arid to sub-humid	Semi-arid to moist sub-humid	Sub humid to humid
Mean Slope (m/km)	1.704	1.066	1.063	1.5527

(continued)

Table 2.5 (continued)

Variables	Chambal	Sind	Betwa	Ken
Hydrogeology	Older alluvium Consolidated sedimentary Crystalline (Igneous and metamorphic) Deccan trap	Older alluvium Consolidated sedimentary Crystalline (Igneous and Metamorphic) Deccan trap	Consolidated sedimentary Crystalline (Igneous and metamorphic) Deccan trap	Older alluvium Consolidated sedimentary Crystalline (Igneous and metamorphic)
Geology	Hard rock	Hard rock	Hard rock	Hard rock
Groundwater development	Mostly dark	White to grey	White to grey	White to grey
Cropping intensity (%)	105–212	105–132	105–167	105–148
Population density (per sq km), census-2001	100–300	100–600	100–600	100–600
Economy	Agriculture + Livestock	Agriculture + Livestock	Agriculture + Livestock	Agriculture + Livestock
Pollution sources	Domestic (Scattered source)	Domestic (Scattered source)	Domestic (Scattered source)	Domestic (Scattered source)
Major water Problem	Quantity	Quantity	Quantity	Quantity
Solution	Crop planning Improvement in irrigation efficiency Soil conservation Water harvesting and groundwater recharge through shaft	Crop planning Improvement in irrigation efficiency Soil conservation Water harvesting and groundwater recharge through shaft	Crop planning Improvement in irrigation efficiency Soil conservation Water harvesting and groundwater recharge through shaft	Crop planning Improvement in irrigation efficiency Soil conservation Water harvesting and groundwater recharge through shaft

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