

CHAPTER 9

Water accounting for Kanpur metropolitan area in Ganges river basin

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9.1 Introduction

Domestic water supply in most Asian cities is highly unreliable and often inept to take care of needs of the growing population. The major reasons for this condition are poorly maintained water supply and treatment infrastructure; contamination of the supplied water; high “unaccounted for water losses”; and inefficient water pricing, which doesn’t reflect the production cost and scarcity value of the resource (Bassi and Kumar, 2012; Kumar, 2014). The degradation of water supply sources due to pollution is exacerbating the problem. Though substantial amount of money has been pumped into improving the water supply infrastructure in cities of the developing world in recent times, these efforts by and large are still inadequate to meet the growing urban water demands.

In India too, ensuring drinking water security is a major challenge for the water utilities in large cities (Bassi and Kumar, 2012; Kumar, 2014). The challenge is compounded by the water demand from industrial and other competing use sectors (Kumar, 2014). Though a high proportion of population has an access to piped water supply, it is often highly unreliable and supplied water is of poor quality. Further in most of the urban centers, distribution losses alone are in the order of 30%–50% of the total water supplied (ADB, 2007), which further reduces the water available for the end user. The condition is even worse in the informal settlements and slums in the urban areas where basic water and sanitation infrastructure is almost non-existent (Bassi and Kumar, 2012).

The other important aspect of challenges in urban water supply is the treatment of the generated wastewater. Less than 31% of the domestic wastewater from cities and towns is treated in cities of developing countries, compared to 80% in the developed world. Situation in India is not quite different where capacity exists to treat only 37% of the 61,754 million liters of sewage generated per day from urban centers (CPCB, 2016). However, the sewage treatment capacity in the metropolitan cities (population of 1 million and above) is substantially higher (51%) than in Class I cities (population above 100,000 but other than metropolitan cities) and Class II towns (population between 50,000 and 100,000) where it is 18% and 9%, respectively (CPCB, 2009). The actual amount of sewage treated is further low due to inadequate collection system and nonfunctional treatment plants. Thus, a large proportion of the sewage is discharged into water bodies without any treatment. This increases the pollution load in rivers and lakes and makes their water unfit for further use (mainly for domestic use) without treatment. As a result, pressure on groundwater resources to meet the city growing water demand also increases, which further leads to its overabstraction and depletion.

The city of Kanpur, which is one of the important urban centers in the State of Uttar Pradesh, has a similar problem concerning water supply. It is the tenth most populous city in India and one of the key urban and industrial conglomerations on the banks of river Ganges. The city is heavily dependent on the river for meeting its water needs and it also acts as a sink for most of the sewage generated in the city. As per the estimates from the Municipal Corporation, Kanpur city has a domestic water requirement of about 600 million liters per day (MLD), but the existing infrastructure can supply only about 385 MLD. The gap in the supply and the entire industrial water requirement is met by tube wells and hand pumps. However due to overabstraction, groundwater is depleting and most of the wells tapping shallow aquifers do not give sustained yield during peak summers. Also, both the groundwater and surface water resources in the city are heavily polluted. The city produces about 340 MLD of sewage of which only 170 MLD is treated (CPCB, 2013b). The unplanned disposal of domestic waste combined with discharge of untreated or partially treated effluents by the industries (leather, textile, jute, and chemical) directly on land or in the river is resulting in pollution of surface and subsurface water. The average total coliform count in the stretch of river Ganges in Kanpur was observed to be as high as 240,000 MPN/100 mL in summer months. Further, traces of heavy metals such as Cd, Cr, Cu, Fe, Pb, As, Zn, and Mg have also been observed in both surface and groundwater.

The water resources of the city of Kanpur are under tremendous threat due to their overappropriation to meet the growing municipal water demands. The absence of required wastewater treatment infrastructure and poor adherence to environmental protection norms by the industries pose a major threat to the river ecology and aquifers. It also means a huge risk to business, economy, and people's livelihoods, which are dependent on it. This risk is essentially shared between different water users and would require collaborative multistakeholder action at the city level for mitigation. In this backdrop, a study was planned to undertake comprehensive water accounting of Kanpur metropolitan area (KMA); identify present and future risks related to quantity and quality of water supply for domestic and industrial consumers; and analyze the existing institutional and regulatory framework related to urban water management in Kanpur city.

Based on a complete understanding of the water accounts—water supply, water consumption, leakage, wastewater outflows, and the amount of storm water generated of the city—alternative scenarios of urban water management (water supply augmentation, demand management, waste reduction, and pollution control) to reduce the water supply and pollution risks can be generated. Further, based on an understanding of the weaknesses of the existing institutions and policies governing water use and pollution control, institutional and policy alternatives can be evolved, keeping in view the nature of interventions for reducing the risks.

9.2 Methodology

First of all, to estimate the water accounts, water requirements of various competing use sectors in the city were estimated. This was done using data on current population, and current unitary demand in the water sector (for domestic, commercial, and industrial uses) in per-capita terms. The total annual and monthly water withdrawal from surface and groundwater resources in the city by the utility and private parties (housing stocks, hotels, industrial units, etc.) to meet various water demands was estimated as the inflows. The total losses in the system (comprising the technical and administrative losses) were arrived at from the estimates of water use from all approved connections (both metered and unmetered), and total water supplied from source. The “wastewater return flows” from the municipal areas and industrial units into the natural sinks, such as surface water bodies and shallow groundwater, were assessed using the data on estimated effluent load generated by various industries and municipal corporation; the existing

treatment capacity in the city; and the location of the various natural sinks of untreated wastewater.

In order to assess the water-related risks, the risk assessment framework of World Wildlife Fund (WWF), which considers the physical risk (due to water supply gap and water pollution in future) and economic risk (due to regulatory regime and organization reputation), was used. The economic risk was linked to the physical risk. To assess the physical risk, the water supply requirements was estimated for projected future population and economic activities, based on historical growth in population, economic conditions, commercial enterprises, and volume of industrial outputs in the city. The likely future increase in volume of polluting effluents was also estimated, based on realistic assumptions of the potential increase in treatment capacity.

Using data on stream flows, groundwater recharge, water withdrawals, and effluent disposal, the present condition of the natural water system (hydrological system) was ascertained—in terms of depth to groundwater table, water-level fluctuations, degree of groundwater stress, alterations in stream flow regimes, and surface and groundwater quality. From this, what the natural system can yield on a sustainable basis in future (sustainable extraction levels) under a “business as usual scenario” was worked out. Subsequently, the likely future water withdrawal needs from both the surface and groundwater systems were compared against the projected “sustainable extraction levels,” to assess the risk in water supply. Likewise, the future scenarios of wastewater generation, and reuse of untreated wastewater were compared against the future “carrying capacity” of the land and water ecosystems to assess the “pollution risk.” Accordingly, the “economic risk,” in terms of the size of economic activity, which is at stake, was assessed.

Existing institutional and policy framework governing the use of water in the city was analyzed to examine their impacts on water use, including pollution of freshwater bodies. The analysis would include the water supply and water-pricing policies for various sectors; presence of sewage tax; pollution control norms and the administrative mechanisms for their enforcement; urban land ceiling Act; building bylaws; and special rules on rainwater harvesting in urban areas. The exercise also involved consultations with the representatives of the city water utility, the State Pollution Control Board, and other stakeholders.

9.3 Kanpur metropolitan area

Kanpur metropolitan area (KMA) is an urban region on the southern bank of river Ganges in the State of Uttar Pradesh and is one of the oldest industrial

centers of North India. KMA includes area under Kanpur city, Nagar Palika of Unnao and Gangaghat, and Nagar Panchayat of Akbarpur and Bithoor. As per the [Census of India 2011](#), overall spread of the KMA is about 340 km² with an estimated population of about 3.2 million.

The climate in KMA is subtropical with average temperature varying from as low as 8°C during winters to 41°C during summers. The average annual rainfall is about 800 mm and exhibit high interannual variability. About 90% of the rainfall is received during the monsoon months (June to September). The relative humidity ranges from less than 30% in the summer season (March to May) to about 70% during monsoon.

9.3.1 Demographic changes

To analyze the demographic changes over time, details on only Kanpur city were considered as reliable information on the historical changes in KMA was not available. Kanpur city comprises of area under Kanpur Municipal Corporation including its outgrowth, Kanpur Cantonment Board, and Census Towns of Chakeri, Northern Railway Colony, and Armapur Estate. Spatially, Kanpur city has grown by only 4 km² over the last 50 years, i.e., from 296 km² in 1961 to 300 km² by 2011. However, population has almost increased by more than three times from mere 0.96 million in 1981 to 2.9 million in 2011. But, population growth during the last decade has registered a decline. Against a decadal growth of 33% recorded during 1991–2001, it was only 8% during 2001–11 ([Fig. 9.1](#)). As a consequence of exponential growth, population density has gone up from 3243 persons/km² in 1961 to 9666 persons/km² in 2011, thus putting more pressure on the existing natural resources in the city.

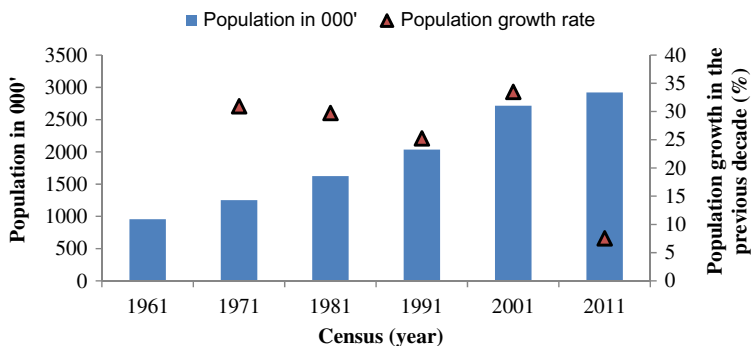


Fig. 9.1 Population growth in Kanpur city. (Source: Authors' own analysis based on data presented in *Census of India, 2011. Decadal Variation in Population Since 1901. Ministry of Home Affairs, Government of India, New Delhi.*)

9.3.2 Industrial growth

Kanpur is a heavily industrialized metropolitan area. By March 2011, there were more than 16,000 registered industrial units set up with a total investment of around US\$ 138 million (Table 9.1). Out of these, nearly 99% are small-scale industries. Also, number of leather processing industrial units was found to be highest. However, almost 47% of the industrial units are either sick or closed (JNNURM, 2006).

Kanpur has a diverse industrial set-up, which has evolved over the years. By the turn of the 20th century, Kanpur had become an industrial center for textile and leather goods (Bansal and Bansal, 1984; Singh, 1990). Due to the lack of rail connectivity in the region, these industries flourished on the banks of the river Ganges to utilize the navigable channels of the river (Singh, 1990). The period from early 1900s to the independence of the country in 1947 saw the emergence of new industries such as sugar, jute, iron and steel, chemicals, etc. (Singh, 1990). Post the country's independence saw a period of consolidation for the existing industries in the region (JNNURM, 2006). Since 1984–85, there has been a steady increase in the

Table 9.1 Details of various industrial units in Kanpur metropolitan area (up to March 2011).

Sr. no.	Industries	No. of units	Investment (in million US\$)
1	Food products and beverages	1221	6.0
2	Cotton textile	371	6.0
3	Hosiery and garments	2445	38.5
4	Wood products	424	5.4
5	Paper products	613	20.8
6	Leather products	2428	10.3
7	Rubber and plastic	611	14.9
8	Chemical	657	6.0
9	Mineral based	141	1.8
10	Basic metal and metal products	168	1.5
11	Engineering units	1215	12.8
12	Electrical machinery and transport equipment	181	2.5
13	Repairing and servicing	3189	3.2
14	Others	3011	8.3
	Overall	16,675	138

Source: Authors' own analysis based on data presented in GoI (Government of India), 2011. Brief Industrial Profile of District Kanpur Nagar. MSME–Development Institute, Ministry of MSME, Government of India, Kanpur.

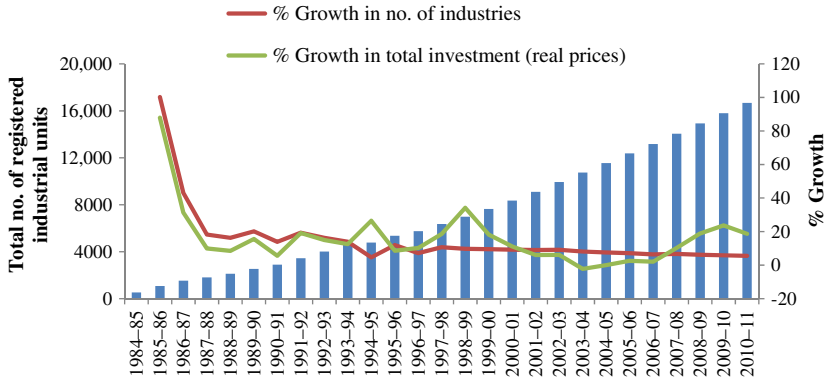


Fig. 9.2 Industrial growth in KMA. (Source: Authors' own analysis based on data presented in Gol (Government of India), 2011. Brief Industrial Profile of District Kanpur Nagar. MSME-Development Institute, Ministry of MSME, Government of India, Kanpur.)

number of industries in Kanpur (Fig. 9.2). However, from 1993 to 1994 onwards, industrial growth rate (in terms of new industries opened every year) has slowed down in comparison to the previous years. Against an average annual growth rate of 2.9% between 1984–85 and 1993–94, it has dipped to 0.47% between 1994–95 and 2010–11. Lack of infrastructure development and inadequate power supply is being identified as one of the reasons for closing down of numerous big and small industrial units since the 1990s (Mishra, 2006). Investment patterns have also shown similar trends. However, post 2004–05, it almost doubled by 2009–10. This indicates that investors are now looking for medium and large-scale industries to have better economies of scale. But it will also put pressure on existing water resources in city to cater to the water demands of large-scale manufacturing units.

Nevertheless, significant growth was witnessed in the small-scale industries segment, which increased from mere 7000 units in 1998 to around 16,000 by 2011. During this period, industries based on leather, light engineering, hosiery and garments, chemicals, and food processing have grown. Number of tanneries alone has increased from 175 units in 1994 to 402 units by 2015. More than 50% of them use chrome tanning process. Untreated effluent from these units is the main source of pollution of the Ganges. Though it is mandatory for tanneries to have an effluent treatment plant within their premises, most of them discharge effluent with only primary treatment. Further, many of these primary treatment plants are nonfunctional. In 1994, UPJN installed a 36-MLD common effluent treatment plant

to treat the effluent from tanneries along with the domestic wastewater to make it more amenable to biological treatment. But since then effluent discharge from tanneries has increased from 9 to 26 MLD, making the plant operation difficult.

9.4 Status of water sources, water supply, wastewater and its treatment in KMA

9.4.1 Surface water: River ganges

Kanpur metropolis forms a part of Ganges sub-basin in the Central Indo-Gangetic Plain. Average annual renewable surface water availability was worked out using the observed streamflows in the stretch of river Ganges passing through KMA. As per the data available from the hydrological station located at Kanpur, the long-term average annual discharge at Kanpur is about 1679 cubic meter per sec (cumec) (O’Keeffe et al., 2012). This means that average annual renewable surface water availability in Kanpur stretch of the river is about 53 billion cubic meters (BCM) per annum. However, there is significant variation in water availability across seasons with average flow being less than 1000 cumec during the lean period (November to May).

As per the water quality monitoring conducted in 2011 by the CPCB, the quality of water in river Ganges deteriorates significantly after passing through Kanpur city (Table 9.2). While the dissolved oxygen (DO) content reduces substantially in the downstream in comparison to the upstream stretch, the biological oxygen demand (BOD) gets doubled. The EC also increases substantially. This indicates presence of greater amount of organic and inorganic effluent entering the river water. Though fecal coliform at the upstream stretch is above the permissible amount (<2500 MPN/100 mL), it increases to almost five times in the downstream stretch. The worsening of river water quality is mainly due to the untreated wastewater from the city, which is drained into the river. Thus, the river water, which leaves the city, is heavily polluted and unusable for further use without treatment and poses a health hazard for the downstream users.

9.4.2 Groundwater

In KMA, ground water occurs under unconfined to confined conditions. Depth to ground water level varies from 6 to 16 meter (m) during premonsoon. During post monsoon, groundwater level shows a minor rise due to replenishment of aquifer by the rainfall. Ground water flow is in the eastern direction of KMA, confirming the effluent nature (getting inflows from

Table 9.2 Results of water quality monitoring of river Ganges at upstream and downstream of Kanpur city (2011).

Sr. no.	Parameter	Water quality monitoring station					
		Kanpur U/S (Ranighat)			Kanpur D/S (Jajmau pumping station)		
		Min	Max	Mean	Min	Max	Mean
1	Temperature (°C)	15.0	32.0	25.8	15.0	32.0	25.8
2	Dissolved oxygen (mg/L)	6.0	12.8	8.6	4.0	11.5	6.9
3	pH	7.4	9.1	8.2	7.1	8.8	8.0
4	Electrical conductivity (µmhos/cm)	48.7	560.1	315.7	54.9	637.3	380.9
5	BOD (mg/L)	3.0	5.5	4.3	6.6	9.6	8.4
6	Nitrate (mg/L)	0.5	4.0	2.0	1.1	4.7	2.8
7	Fecal coliforms (MPN/100 mL)	900.0	28000.0	6666.7	4000.0	93000.0	38941.7
8	Total coliforms (MPN/100 mL)	1100.0	150000.0	31991.7	23000.0	240000.0	151333.0

Source: CPCB (Central Pollution Control Board), 2013b. Pollution Assessment: River Ganga. Central Pollution Control Board, Ministry of Environment and Forests, Government of India, New Delhi.

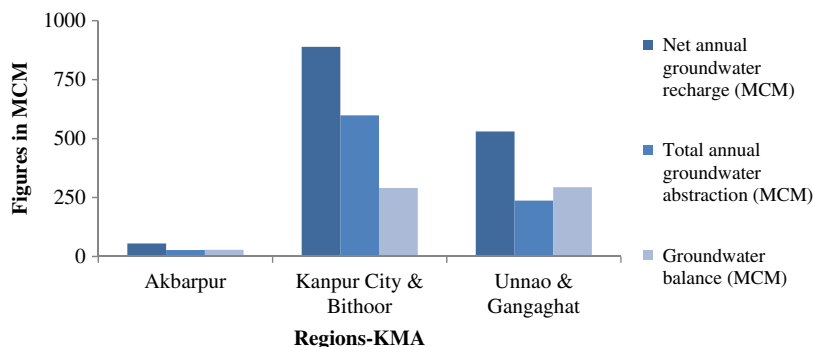


Fig. 9.3 Estimated groundwater availability in KMA. (Source: Authors' own analysis using data from Central Groundwater Board Data, Government of India.)

groundwater) of river Ganges in this stretch. Nevertheless, long-term ground water-level data from the seven observation wells in KMA show a general declining trend with depth to groundwater level going down by up to 9.6 m.

Annual groundwater availability in KMA was estimated from the “per unit area replenishable annual groundwater resources” derived from the corresponding data for the three districts of Kanpur (Kanpur Dehat, Kanpur Nagar, and Unnao) where parts of KMA falls. As per the estimates, net annual groundwater availability in KMA is about 1475 million cubic meters (MCM) and the total annual draft (including for irrigation) is about 863 MCM. This indicates that annually, 612 MCM of groundwater is available for further use. It is highest in Unnao and Gangaghat region followed by Kanpur city and Akbarpur (Fig. 9.3).

Table 9.3 presents the groundwater quality in two industrial areas of Kanpur city. EC was found to be high in Jajmau industrial area where most of the tanneries are located and nitrate was found to be high in Panki industrial area. Apart from fluoride, other parameters were found to be within permissible limits. Fluoride content was found to be high in groundwater in Jajmau in comparison to the Panki industrial area.

9.4.3 Water supply system

Piped water supply in Kanpur city was started in 1892. Responsibility of construction of water supply and sewerage system in Kanpur city is with the Uttar Pradesh Jal Nigam (UPJN), whereas its operation and maintenance is under the purview of Jalkal Vibhag (JV), which is under the

Table 9.3 Groundwater quality in Kanpur city.

Sr no.	Parameter	Location of observation wells					
		Jajmau industrial area			Panki industrial area		
		Min	Max	Mean	Min	Max	Mean
1	Temperature (°C)	27.0	27.0	27.0	27.0	27.0	27.0
2	pH	7.8	7.8	7.8	6.9	6.9	6.9
3	Electrical conductivity (µmhos/cm)	796.4	796.4	796.0	548.2	548.2	548.0
4	BOD (mg/L)	2.4	2.4	2.4	0.8	0.8	0.8
5	Nitrate (mg/L)	2.5	3.2	2.9	34.5	34.5	34.5
6	Fluoride (mg/L)	3.0	3.0	3.0	1.2	1.2	1.2

Source: CPCB (Central Pollution Control Board), 2013a. Status of Water Quality in India—2011. Central Pollution Control Board, Ministry of Environment and Forests, Government of India, New Delhi.

Table 9.4 Different sources of water, installed capacity, and actual supply in Kanpur city.

Sr. no.	Type	Source of raw water	Number	Installed capacity (MLD)	Actual supply (MLD)
1	Surface water	Ganges Channel, Bhaironghat	1	310	210
2	Ground water	Lower Ganges Canal	1	130	50
		Tube wells	135	110	80
		Hand pumps	9830	50	50

Source: Based on data present in Kanpur city development plan.

Kanpur Municipal Corporation (KMC). Against an installed capacity of 600 MLD to draw raw water, about 390 MLD of water is actually supplied through the formal water supply system in the city. The system mostly uses water from river Ganges to meet the domestic and nondomestic water demand. About 130 MLD of abstracted groundwater is also supplied through the same system (Table 9.4). Additionally, 30 MLD of water (mainly from surface water sources) is supplied in the Unnao Municipal limits.

Out of the total water supply, only 255 MLD is treated at the three water treatment plants (Table 9.5). However, groundwater is supplied without any treatment. JV supply water only in the area under the city municipal limits and also sell bulk water to the Kanpur Cantonment Board. For the purpose,

Table 9.5 Existing raw water treatment capacity in Kanpur city.

Sr. no.	Location of treatment plant	Year of installation	Installed capacity (MLD)	Actual running capacity (MLD)
1	Benajhaber	—	310	210
2	Gujaini	2005	30	20
3	Ganges barrage	2005	200	25
	Overall		540	255

Source: Based on data present in Kanpur city development plan.

area under Kanpur Municipal Corporation is divided into four service districts, namely, City, West, South, and East. There is no formal water supply system in rest of the city. In these areas, households depend on private tube wells to meet their domestic and other water demand. Further, all the water requirement by the industries is met by abstraction through private tube wells.

Presently (2011), water supply at the end user level by JV for domestic users having connections is estimated to be around 97 liters per capita per day. This is after accounting for the 30% administrative and the technical losses (UFW) on account of water theft, and old and leaky pipelines. This is much below the norms (135–150 lpcd) suggested in the CPHHEO manual on water supply and wastewater treatment. Water supply in the inner core area is much less than the 97 lpcd, as the pipes are leaky and often supply contaminated water. Hence, water supply in these areas is being augmented by local community-based tube wells or hand pumps. Though there are a large number of private wells in the residential and industrial areas, they are unaccounted and no such data exist with urban local bodies or parastatal agencies.

Under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), a pan-Indian city modernization scheme (2005–14), about US\$ 100 million was sanctioned to support the existing water supply system of KMA. Among others, it included construction of two new water treatment plants (200 MLD each) and about 1746 km of water distribution system covering Kanpur city inner old area (under Phase-I by 2010) and remaining parts of the city (under Kanpur Water Supply Scheme Phase-II by 2012). However, the execution of work was very slow and missed several completion deadlines. As per the last available information, works under Phase-I were completed in June 2016 whereas those under Phase-II are yet to be completed.

9.4.4 Wastewater and its treatment

Estimated sewage generation in Kanpur city is about 339 MLD and that in Unnao town is about 24 MLD (CPCB, 2009). However, the total wastewater generation (including runoff) in KMA is estimated to be about 767 MLD. Apart from use of a minor amount of treated wastewater in irrigation, rest of it and the untreated wastewater is drained into the river Ganges in north and river Pandu (a tributary of Ganges) in south of the Kanpur city. Table 9.6 presents details on wastewater being generated from different regions in KMA. *Sismau* and *Permiya Nalas* contribute to about 50% of total wastewater, which is discharged into river Ganges and river Pandu.

Presently, sewerage system exists only in Kanpur city inner core area but not in the city periphery. Overall, it covers only 29% of the city area, which is being administered under four districts and five different zones. Total length of the main and trunk sewers is 74 km, whereas branch sewer lines are 875 km. There are total 13 sewage pumping stations and 30,000 man-holes. Sewer lines are cleaned by sewer jetting machines, sewer clearing machines, and also manually as per requirement. In other regions of the KMA, sewerage system is nonexistent.

Coverage by sewerage network is highly uneven across the city and is mostly concentrated in the city drainage district (Table 9.7). In South drainage districts too, some parts are covered under the sewerage network. However, in east and west drainage districts, sewerage network is totally nonexistent.

There are four Sewage Treatment Plants (STP) in Kanpur city, and majority of them are in Jajmau where tanneries are located (Table 9.8). Out of these, one 210-MLD STP constructed under JNNURM was commissioned only in 2014 after several delays. Also, there is one treatment plant (19 MLD) in Unnao town. In rest of the KMA, storm water drains carry sewage and

Table 9.6 Amount of wastewater being contributed by different regions in KMA.

Sr. no.	Catchment region	Discharge point	Estimated discharge (MLD)
1	Kanpur city	River Ganges	598.19
2	Unnao	River Ganges	77.76
3	Other areas in KMA	River Pandu	91.27
	Overall	–	767.22

Source: Based on data present in Kanpur city development plan and CPCB (Central Pollution Control Board), 2013b. Pollution Assessment: River Ganga. Central Pollution Control Board, Ministry of Environment and Forests, Government of India, New Delhi.

Table 9.7 Coverage of sewerage network in Kanpur city.

Sr. no.	Waste water generating districts	Area covered by sewerage network	Characteristics of existing sewerage system	Area profile
1	City drainage district	58%	Underground sewerage with its outfall into river Ganges at Jajmau	Tannery cluster is located in this district. Except for the primary treatment plants, which these industries claim to have installed, effluent is discharged directly into the river. Three wastewater treatment plants mainly to treat domestic waste water are located here.
2	South drainage district	30%	Some pockets are covered under the sewerage system	Rest of the area waste water is disposed into open drains. Industrial effluent from Panki area meets the river Pandu separately through industrial drains.
3	West drainage district	20%	Very limited sewerage facilities	Waste water flows into the Pandu river through open drains.
4	East drainage district	0%	No sewerage network	Primarily comprises developing areas

Source: Based on information presented in Kanpur city development plan and ASCI (Administrative Staff College of India), 2013. City Sanitation Plan for Kanpur. Administrative Staff College of India, Hyderabad, India.

industrial wastewater directly into Pandu river or Ganges river. The five plants put together have a wastewater treatment capacity of only 400 MLD, which is only 52% of the total wastewater generated in the KMA. However, actual treatment is further less due to the operational constraints of the plants and only 27% of the wastewater generated is actually treated. Three other STPs, with a combined capacity of 100 MLD, which were to be commissioned during the JNNURM were not completed as of March 2016.

Table 9.8 Details of sewerage treatment plants in Kanpur city.

Location of STP/CETP	Year of commissioning	Technology used	Type of waste water fed	Installed capacity (MLD)	Actual treatment (MLD)	Use of treated water
Jajmau	1989	Up flow Anaerobic Sludge Blanket (UASB)	Domestic	5	4.5	Treated effluent flows into river Ganges
Jajmau	1994	UASB	Domestic and industrial	36	19	Treated effluent irrigates 2200 ha of sewerage farm. Untreated wastewater is discharged into the river Ganges
Jajmau	1999	Activated Sludge Process (ASP)	Domestic	130	100	
Bingawan	2014	UASB	Domestic	210	65.5	Untreated wastewater is discharged into the river Ganges

Source: Based on data presented in CPCB (Central Pollution Control Board), 2013b. Pollution Assessment: River Ganga. Central Pollution Control Board, Ministry of Environment and Forests, Government of India, New Delhi; CPCB (Central Pollution Control Board), 2015. Inventorization of Sewage Treatment Plants. Central Pollution Control Board, Ministry of Environment and Forests, Government of India, New Delhi.

9.5 Institutional framework for urban water management in KMA

In KMA, various agencies are involved in urban water supply works and services. In Kanpur city municipal area, UPJN plans and implements water supply and sewerage related works, whereas JV looks after operation and maintenance of water supply and sewage treatment plants. Kanpur Development Authority and Uttar Pradesh Housing Board are also responsible for planning of water supply works in colonies developed by them (Table 9.9). In other areas of KMA, UPJN is responsible for planning, implementation, and operation and maintenance of water supply works.

However, presence of multiple agencies has not led to efficient management of urban water services as indicated by the shortfall in domestic water supply and existing wastewater treatment capacity in the metropolis. In fact, even after an expenditure of nearly US\$ 82 million under “Ganga Action Plan” (GAP-I and GAP-II) and “JNNURM” on drainage and sewage works, Kanpur city is still struggling to intercept wastewater from the open drains and divert it for treatment. Further, large areas are without any sewerage network. The KMC even find it difficult to run the existing plants as there is extensive load shedding and prefer to simply bypass the wastewater and discharge it without any treatment into the river (CSE, 2014).

While the slow pace in capital works can be attributed to lack of funds, operation and maintenance issues are due to capacity constraints within the KMC. Resistance from UPJN to transfer its function to KMC has also led to

Table 9.9 Various agencies for the provision of urban water supply in Kanpur city.

Service	Institution responsible		
	Planning	Implementation	O&M
Water supply	Uttar Pradesh Jal Nigam (UPJN) for the city municipal area Kanpur Development Authority (KDA) & Uttar Pradesh Housing Board (UPHB) for colonies developed by them District Urban Development Agency (DUDA) for slum area	JV & UPJN DUDA for Slum	JV & UPJN
Sewerage	–	JV & UPJN	JV & UPJN
Storm water drainage	Kanpur Municipal Corporation (KMC) & UPJN	KMC & KDA	KMC

Source: Based on information presented in Kanpur city development plan.

its improper functioning (IIT, 2013). For its financial sustainability, the JV used to depend on water and sewerage charges, which it collected from various consumers. However, only those households, which are within the city municipal limits have formal connections and rest of the areas depend on groundwater, which is presently unaccounted. Most of the industries also have their own tube wells and thus do not depend on JV or KMC for meeting their water requirement.

Further, the technical losses (UFW) on account of old and leaky pipelines from Benajhaber water works are estimated to be about 30% of the total water supplied. The most significant losses are due to huge amount of water wastage and negligible revenue collection from the public utilities (e.g., parks, fire-fighting, etc.) and stand posts, which take away about 10% of the supplied water. Though the water and sewerage recovery has increased to 93%, large proportion of it (nearly 71%) is spent on establishment cost, leaving a meager amount for maintenance of existing old water supply and sewerage system.

The current Central Government has set a target to rejuvenate Ganges under the “Namami Ganga” (Clean Ganges) program, which is aimed at integrating efforts to clean and protect river Ganges in a comprehensive manner with the involvement of the states, urban local bodies, and panchayats. Around US\$ 3.4 billion has been earmarked for the program duration (2014–19). The immediate priority is on: rehabilitation and upgradation of existing sewage treatment plants; creation of more sewerage infrastructure; and abatement of industrial pollution by enforcement of strict environmental norms. Further, there is also a program on urban renewal and retrofitting for 100 cities in India called as “Smart Cities Mission,” which has its focus on adequate water supply and sanitation among others. The total budgetary outlay is about US\$ 15 billion and Kanpur is one of the selected cities. KMA is expected to receive significant funds under these two programs. However, for effective implementation of any such program, various parastatal agencies and utilities involved in water supply and sewerage services need to better coordinate with each other and also put emphasis on timely completion of any new projects taken up.

9.6 Water accounts of KMA

9.6.1 Estimated water demand

During 2001–11, population growth in the KMA has slowed down. Industrial growth has also been affected during the period. Considering the population in 2011, domestic water demand in KMA is estimated to be around

Table 9.10 Water demand by different industries in KMA.

Sr. no.	Category	Estimated daily water demand (KLD/unit)	Total no of units considered	Estimated total water demand (MCM)
1	Textile, dyeing, and printing	213	2816	218.83
2	Tannery	56	2428	49.78
3	Chemical based	82	657	19.61
4	Paper based	1338	3	1.47
5	Dairy	210	2	0.15
6	Distillery	2200	2	1.61
7	Fertilizer	14,000	1	5.11
8	Food products	275	2	0.20
9	Machinery parts	193	2	0.14
10	Sugar	6180	5	11.28
	Overall	617	5918	308

Source: Authors' own analysis based on data presented in GoI (Government of India), 2011. Brief Industrial Profile of District Kanpur Nagar. MSME-Development Institute, Ministry of MSME, Government of India, Kanpur.

175 MCM per annum. This is arrived at by considering the urban water supply norm of 150 liters per capita per day (lpcd) provided in the Central Public Health and Environmental Engineering Organization (CPHEEO) manual on water supply and treatment. Annual water requirement from industrial units is estimated to be around 308 MCM. This is estimated based on the average water requirement by each unit under different categories (Table 9.10). However, only major polluting industries, for which data and information were available, were considered for the estimation. Also, as 47% of the industries were either sick or closed, the estimate is quite close to the actual industrial water demand.

9.6.2 Estimated water supply and use

The total water supply and use in the form of daily water withdrawal from surface and groundwater resources in the KMA by the utility and private parties (housing stocks, hotels, industrial units, etc.) is estimated to be around 529 MCM per annum. Sixty-seven per cent of the water supply by JV is through lifting of river Ganges water and remaining is through groundwater abstraction. Unaccounted for Water (UFW) losses are nearly 30% of the formal water supply.

Details of surface water withdrawal by the public utility are already discussed in the previous section. Estimates of groundwater abstraction in

KMA through private wells are based on the assumption that all the unmet domestic and industrial water demand is fulfilled by withdrawing groundwater through private wells and handpumps.

9.6.3 Summary of annual water account

Water account of KMA is presented in Table 9.11. It considers the total water demand for domestic and industrial purposes, water supply and use, and wastewater return flows (carried by storm water drains), which all are estimated in the previous sections. Overall, there is a huge deficit of around 376 MCM of water (1030 million liters per day) between demand and supply through public supply sources. This unmet demand is met by private groundwater sources (Fig. 9.4).

Around 86% of the total water withdrawal from the natural system by the JV and Unnao Municipality emerges as a domestic sewage in various storm water drains and sewerage channels. Overall, about 280 MCM of

Table 9.11 A summary of annual water account for KMA.

Sr. no.	Particulars	Unit (MCM/annum)
A	Water demand (2011)	
A1	Domestic sector	175
A2	Industrial units	308
	Total (A)	483
B	Water supply and use (2011)	
B1	Withdrawal from surface water resource by the JV	95
B2	Withdrawal from groundwater source by the JV	47
B3	Water supply by Unnao Municipality	11
B4	Estimated withdrawal from groundwater resource through private wells for domestic uses	68
B5	Estimated withdrawal from groundwater resource through private wells for industrial uses	308
	Total (B)	529
C	Administrative and technical losses in water supply by JV and Unnao Municipality (2011)	46
D	Wastewater return flows (2011)	
D1	Estimated domestic sewage generation	132
D2	Wastewater carried by storm water drains (other than domestic sewage but including runoff)	148
	Total (D)	280

Source: Authors' own analysis.

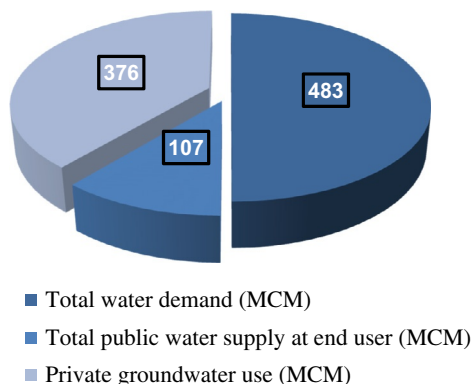


Fig. 9.4 Overall water demand, supply, and use in KMA. (Source: Authors' own analysis.)

wastewater (including runoff) is generated in KMA. However, only 18% is treated and close to 230 MCM is discharged into river Ganges and Pandu without any treatment.

9.7 Water supply management challenges

Risk assessment framework of WWF is used to assess the present and future physical and economic risks (regulatory and reputational) related to quantity and quality of water supply for domestic and industrial consumers.

9.7.1 Physical risks

Physical risks are analyzed from the point of view of future water requirement and the capability of existing water resource base (surface and groundwater) to fulfill it. Various aspects of it are discussed in the next subsections.

9.7.1.1 Future water requirement

Future domestic water requirement was worked out on the basis of guidelines given in the CPHEEO manual on water supply and treatment, which suggests a minimum water supply of 150 lpcd for the urban areas that are connected to a sewerage system. Additionally, 15% of the total water supply is also considered for Unaccounted for Water (UFW) losses. This has an inbuilt assumption that there would be retrofitting of the existing water supply pipelines, with replacement of old leaky pipes by new ones. Future population estimates are based on the average decadal growth rate

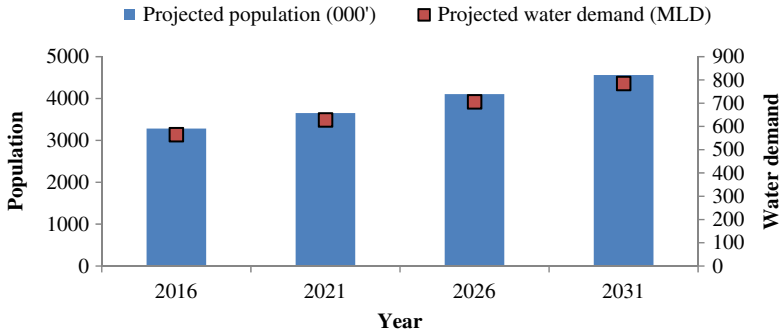


Fig. 9.5 Projected domestic water demand in Kanpur city. (Source: *Authors' own analysis.*)

observed between 1961 and 2011. Thus, considering a norm of 172 lpcd and population growth in the Kanpur city, it is estimated that the water demand for domestic uses will rise to about 785 million liters per day (MLD) by 2031 (Fig. 9.5). However, industrial water demand in KMA is assumed to remain same (844 MLD) as industrial growth (in terms of number of industries) has slowed down significantly and there is increasing trend of sick or closed industrial units.

With the construction of the Ganges Barrage, a permanent and reliable source of water supply is available to provide 1600 MLD of raw water. This is sufficient to cater to the needs of the Kanpur city up to 2031. However, only one pumping and one treatment plant with a capacity of 200 MLD is installed at the site, which is operated and maintained by UPJN. Its capacity utilization is only 12.5% and is expected to increase when more households are connected with the formal water supply system and industries falling within its supply zone will take connections. Further, with a view on availability of raw water at the Barrage site, more raw water pumping and treatment plants can be added at the site. Nevertheless, proper feasibility studies should be undertaken to explore the possibility of expanding or renovating existing distribution system, which can supply water to majority of users in Kanpur city and for bulk water transfer to Unnao municipality and other areas comprising KMA.

9.7.1.2 Availability of renewable water resources

As discussed in the previous sections, average annual renewable surface water availability in Kanpur stretch of the river is about 53 BCM per

annum. However, there is significant variation in water availability across seasons with average flow being less than 1000 cu m/s during the lean period (November to May). Further, estimated net annual groundwater availability in KMA is about 1475 MCM and the total annual draft is about 863 MCM.

Considering the renewable surface water resources and net annual groundwater availability in the metropolitan area, there is not much constraint in meeting existing or future domestic or industrial water demand of KMA in terms of water quantity. However, required physical infrastructure for water conveyance and distribution needs to be in place.

9.7.1.3 Water quality

As highlighted in previous subsections, both surface water and groundwater get heavily polluted by the domestic wastewater and industrial effluents being discharged into the river or on the landmass or into the numerous open drains. While the river water pollution will affect the domestic water supplies, any further adverse changes in groundwater will affect both domestic water supplies and industrial production. This will result in a major repercussion on industrial growth and its contribution to region's economy.

In future, wastewater generation from KMA will further increase with population growth and increased industrial activities. However, it took over 18 years for KMC to install existing sewage treatment facilities (including drainage systems) and since their completion in 2005 no additional STPs have been completed. Further, most of the effluent treatment plants installed by industries provide only primary treatment.

Even if one assumes that in 2016, the proposed plants were completed (addition of about 200 MLD of wastewater treatment capacity) and are operating on their full capacity, a significant amount of wastewater will be discharged into rivers without any treatment from the Kanpur city (Fig. 9.6). As a result, water resources especially surface water will be under risk of getting severely polluted, which will make it unfit for consumption without expensive treatment. This will have a significant cost implication on water supply utilities as the raw water treatment cost will increase. The polluted river water would also have a significant impact on the riverine ecosystem and health of downstream users who depend on it for meeting their domestic water demands.

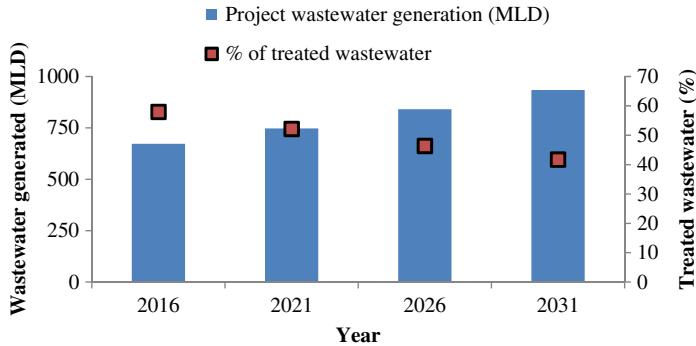


Fig. 9.6 Projected wastewater generation and its treatment. (Source: Authors' own analysis.)

9.7.2 Economic risks

Economic risk can affect any new investments in the region and are mainly associated with the changes in macroeconomic conditions like government regulation or any other adverse events. They are discussed in the following subsections.

9.7.2.1 Regulatory risk

Regulatory risks are general due to change in regulations and law that might affect an industry or a business. In the present case, they are analyzed from the point of view of industries, which are flouting standards pertaining to wastewater quality and are either penalized or closed (voluntarily or involuntarily). These risks are more so important in case of industries operating in KMA because some of these units (especially tanneries located on the banks of river Ganges) have been identified as one of the major sources of water pollution.

The risks of closure or penalties for industries flouting wastewater discharge standards has increased especially after the establishment of the National Green Tribunal (NGT) in 2010, which is empowered to deal with cases relating to environmental protection and conservation of natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property.

In the year 2014, as per the directions of NGT, the Uttar Pradesh Pollution Control Board (UPPCB) inspected the status of water consumption and wastewater generation by the industries located in KMA. As per the

inspection, 15 industries, which do not have an effluent treatment plant, have been closed. Further, 43 industries, which were not having consent^a and were not achieving the prescribed wastewater discharge standards, were ordered to be closed. 99 other industries were found to be under self-closure. Additionally, some 134 industries, which were not having consent though having a proper pollution control system, have been issued show cause notices. Though 19 out of them have applied for the consent, which was subsequently granted by the UPPCB, 109 industries have been ordered to be closed. The electricity and water supply to all the noncomplying industries was also disconnected. Further, UPPCB is being instructed by NGT to regularly monitor and report effluent water quality of all the 19 operating industries (*Source*: NGT order 2014). Thus, these units are also at a risk of closure if not found adhering to the water pollution control norms.

The inspection also found that 700 odd tanneries in Kanpur, which are located on the banks of river Ganges, are one of the largest sources of pollution of river Ganges. The pollutants discharged by them are found to be injurious to human health, biodiversity, and ecology of the river. Though one 36 MLD Effluent Treatment Plant (ETP) has been installed at the tannery cluster near Jajmau, since then number of tanneries have increased by three times and thus a significant proportion of effluent from them is discharged without any treatment directly into river Ganges. Further, some units, which have installed ETPs in their respective units, are practically unoperational because of nonavailability of electricity and cost factor. In the light of this, shifting of these tanneries from the bank of river Ganges is also under consideration. This gain presents a huge regulatory risk to tanneries as there is a possibility that all of them may have to start their operation afresh and may also have to adhere to “polluters pay principle,” which would have huge financial implications. This may also make them less competitive than the industries operating from other cities.

^a Under the provisions of the Water (Prevention & Control of Pollution) Act, 1974 and the Air (Prevention & Control of Pollution) Act, 1981, an entrepreneur running or establishing any industry or process, and discharging effluent/emitting pollutants into any water resources or on land/air and polluting thereby the environmental water/air is required to obtain consent, which needs to be obtained in two phases: (1) “consent to establish,” which is to be obtained prior to establishing any industry or process; and (2) “consent to operate,” which is required once the industry or process plant is established along with the necessary pollution control systems. This consent is given for a particular period, which needs to be renewed regularly.

9.7.2.2 Reputational risk

Reputational risk is associated with losses resulting from damages to a firm's reputation, in lost revenue; and increased operating, capital, or regulatory costs due to an adverse event. In KMA, this risk is generally for tanneries, which are exporting large volume of products but are under watch from pollution control bodies due to their significant contribution to water pollution of river Ganges. Often various national newspapers carry report on the risk, which these tanneries pose to the health of river Ganges. Under such circumstances, other companies or individuals may not like to do business with such industrial units, which are continuously under watch of a Government regulator or have been imposed heavy penalties.

Presently, tanneries attract the highest amount of investment per unit among various industries. They also contribute to 13% of the average annual industrial turnover and employ nearly 25% of the workforce (Table 9.12).

Table 9.12 Industrial cluster wise annual turnover and employment in KMA.

Sr. no.	Industry cluster	No of functional units	Average amount of investment (US\$ thousand per unit)	Annual turnover (US\$ million)	Total no. of people employed
1	Cotton hosiery	467	5.4	39.4	10,680
2	Readymade garments	400	15.4	30.8	10,000
3	Soap & detergent	100	15.4	92.3	4000
4	Paint	50	76.9	15.4	2000
5	Harness & Saddlery	225	30.8	61.5	15,000
6	Footwear	1500	3.1	155.8	45,000
7	Leather and its products	1635	3.8	45	100,000
8	Steel furniture	685	3.1	27.8	50,000
9	Bakery products	378	3.5	7.7	2500
10	Cold storage	100	307.7	7.7	2000
11	Pharmaceutical	75	107.7	33.8	2300
12	Corrugated paper	170	18.5	16.2	2600
13	Textiles	180	1.5	3.1	2500
14	Plastic	100	30.8	123.1	5000
15	Pan Masala	55	32.3	769.2	8000
16	Agro based	174	76.9	1538.5	2500
17	Tannery	420	384.6	461.5	86,000
	Overall	6714	-	3428.8	350,080

Source: Based on data presented in GoI (Government of India), 2011. Brief Industrial Profile of District Kanpur Nagar. MSME-Development Institute, Ministry of MSME, Government of India, Kanpur.

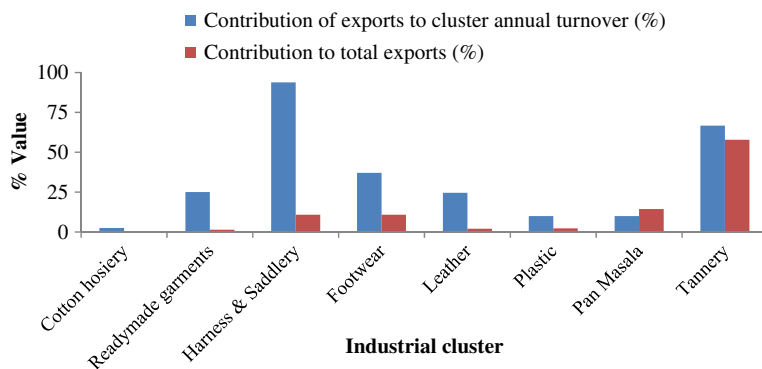


Fig. 9.7 Contribution of exports (value) to annual turnover. (Source: Authors' own analysis based on data presented in Gol (Government of India), 2011. *Brief Industrial Profile of District Kanpur Nagar*. MSME-Development Institute, Ministry of MSME, Government of India, Kanpur.)

With many tanneries facing a risk of closure due to nonadherence to water pollution control norms, there will be a significant impact on region's economy and people's livelihood.

Further, leather exports account for nearly 67% of the annual turnover of tanneries and it also accounts for nearly 58% of the total industrial exports (which is about US\$ 538 million) from Kanpur metropolis (Fig. 9.7). Therefore, closure of such units or lack of demand from importers of such products will create a huge setback for the industrial growth in KMA. Thus, there is a huge reputational risk to industrial sector in Kanpur unless they all take proper consent and adhere to wastewater discharge standards.

9.8 Major findings

The major findings from the desktop study are as follows:

1. Kanpur is a growing metropolitan area. Between 1961 and 2011, the population of KMA has increased at an average decadal growth rate of 25%. However, it slowed down to a mere 8% during the last decade (2001–11). Nevertheless, the average population density of the city had nearly increased threefold, i.e., from 3243 persons/km² in 1961 to 9666 persons/km² in 2011.
2. Kanpur is a heavily industrialized metropolitan area. Total number of industrial units has increased from a mere 537 in 1984–85 to more than 16,000 in 2010–11. Presently, nearly 99% are small-scale industries and the highest numbers of industries are from the leather tanning category.

Number of tanneries has increased from 175 units in 1994 to 402 units by 2015. However, of late, industrial growth has also slowed down. Against an average annual growth rate of 2.9% between 1984–85 and 1993–94, it was 0.47% between 1994–95 and 2010–11. The population growth in the city seems to have been driven by industrial growth.

3. The city has two major sources for water supply, viz., the river water and groundwater. There are also formal and informal water supplies, the latter being managed from privately owned wells.
4. Against an installed capacity of 600 MLD of raw water, only about 390 MLD of water is actually supplied through the formal water supply system in the Kanpur city. Out of this, 33% (130 MLD) is constituted by groundwater. Additionally, 30 MLD is supplied in the Unnao Municipal limits. Almost the entire surface water, which is supplied by the utility, is treated whereas groundwater is supplied without any treatment.
5. The per-capita water supply at the end-user level for households with formal water connections is about 97 lpcd. This is far less than the per-capita water supply norms of 150 lpcd as per the CPHEEO. In other areas of the metropolis, the households depend on private tube wells to meet domestic water needs. Entire industrial water demand is also met by groundwater. It could be reasonably assumed that the domestic water requirement is fully met from tap water and water from private wells. The existing annual water demand for domestic and industrial consumption is estimated to be about 483 MCM. Since the formal water supply is only 153 MCM per annum and 30% is considered to be lost as UFW, the current deficit of around 376 MCM of water (1030 MLD) could be considered to be met by pumping from privately owned tube wells in the city.
6. The total wastewater generation (including storm water runoff) in KMA is estimated to be about 767 MLD. Apart from use of a minor amount of treated wastewater in irrigation, rest of it and the untreated wastewater is directly drained into the river Ganges in north and river Pandu in south of the Kanpur city.
7. Presently, sewerage system covers only 29% of the Kanpur city whereas it is nonexistent in remaining areas. Further, capacity exists to treat only 52% of the total generated wastewater. Actual treatment is further low at 27%.
8. Under the JNNURM project, US\$ 100 million was sanctioned to support the existing water supply system. However, the work execution

was very slow and largely remained incomplete as per the last available information (August 2012). Also, construction of three out of the four sanctioned STPs under JNNURM could not be completed.

9. Average annual renewable surface water availability in Kanpur stretch of the Ganges river is about 53 BCM. Further about 612 MCM of surplus groundwater is also available annually. Therefore, there is not much physical risk for meeting existing or future domestic and industrial water demand of KMA in terms of water quantity (estimated to be about 1629 MLD by 2031). However, required infrastructure for water conveyance and distribution needs to be in place.
10. Nevertheless, water quality is an issue. This is mainly due to limited infrastructure to treat raw water and also because a substantial portion of wastewater is discharged into river or on land mass without any treatment. Therefore, the river water, which is the major supply source, is heavily polluted and can have adverse effect on human health. Groundwater is also contaminated and polluted, which can affect the domestic water supplies and industrial production. In the wake of the Utility not expanding the infrastructure for supply of treated surface water to cover more areas, the dependence on groundwater would only increase.
11. Regulatory risk was found to be high for those industries, which do not conform to pollution control norms and are thus under risk of closure. Already, many industries have been shut by the State Pollution Control Board for noncompliance of effluent discharge norms. Nevertheless, this will accentuate financial burden on the small-scale industries that operate on low profit and can make them less competitive. The long-term negative impact of increasing regulatory risk is evident from the fact that industrial growth in the city had come down remarkably during the past 15–20 years.
12. Reputational risk, associated with losses resulting from damages to industries' reputation, is about US\$ 538 million, which is equal to the estimated annual value of the exports from various industrial clusters in KMA. Tanneries with an average annual export worth US\$ 308 million (58% of the total exports) have the biggest risk as they are under continuous watch of the State regulator for their failure to comply with wastewater discharge standards.
13. Presence of multiple agencies has not produced desired results in terms of efficient management of urban water services as indicated by the shortfall in domestic water supply through public sources and inadequacy of the existing wastewater treatment capacity in the metropolis.

14. The aging water supply infrastructure coupled with high establishment costs has rendered the resource available for maintenance of the existing systems highly inadequate. Capacity constraints within KMC have also been identified as the other major reason for poor O&M of the water supply and sewerage system.

9.9 Conclusion

The water accounting study carried out by us suggests that there is not much physical risk for meeting existing or future water demands vis-à-vis quantity of the supplied water. However, water quality is an issue as the required infrastructure to treat raw water and wastewater is not in place. This scenario poses a major threat to the river ecology and poses a risk to livelihoods of people dependent on the river. The economic risk for the industries alone is estimated to be US\$ 538 million per annum. To mitigate these risks, various parastatal agencies involved in water supply and sewerage services need to coordinate better and also ensure enforcement of strict environmental norms for the industries. With Government of India having substantial budgetary allocation for Clean Ganges Programme and Sustainable Cities Mission, some resources need to be allocated for undertaking similar type of water accounting exercise in other major cities along river Ganges to assess their water risk and water security challenges and to prioritize investments for water supply and wastewater treatment infrastructure, and institutional reforms (laws, policies, and institutional coordination) accordingly.

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