FROST & SULLIVAN

Assessment of the Industrial Water and Wastewater Treatment Solutions Market in India

June 2022

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Chapter 1: Water Scenario of India

India is at an exciting phase in its economic development, and concomitant opportunities are unfolding in the water and wastewater sector. Ambitious gross domestic product (GDP) growth targets of around 7.0 to 8.0% also present a challenge for the government in sharing depleting water resources among three key sectors: agricultural, domestic, and industrial. After infrastructure, water supply and sanitation are the next growth industries in India. A 2020 report by World Wide Fund for Nature (WWF)[1] predicts that by 2050, 30 Indian cities will witness severe water risk due to the increase in population and economic activities. NITI Aayog is a policy think tank of the Government of India that provides directional and policy inputs and designs strategic and long-term programs for the sustainable development of India, including water and wastewater-related programs and initiatives. A report that it published predicts that 40%[2] of Indians will not have access to safe drinking water by 2030, creating demand for water and wastewater treatment solutions for domestic and industrial applications.

1. Macroeconomic Growth Outlook

India has emerged as one of the fastest-growing major economies in the world with a robust democracy and strong institutions. While India suffered a steep economic decline due to COVID-19, the International Monetary Fund (IMF) expects growth to revive quickly and remain high till 2025. Market-friendly policies that safeguarded the country from the subdued global economy, improved macroeconomic fundamentals, and robust capital inflow have contributed to the country's economic growth over the last decade.

Real GDP at current prices was INR 232.15 lakh crore[3] in FY2022 as per the National Statistical Office (NSO). In FY2021, just like other national economies India's was negatively impacted by the COVID-19 pandemic. In response to the pandemic, the central and state governments undertook a number of preventive measures such as nationwide lockdowns, quarantines, and night curfews that placed restrictions on commercial and industrial activities and domestic and international travel. The lockdowns and restrictions that continued for a major part of FY2021 have had a wide-ranging impact on employment, business, trade, manufacturing, and services. The real GDP growth rate in CY2020 declined to -6.6% from 3.7% in CY2019 as per a May 2022 IMF report. India posted a V-shaped recovery between the last quarter of CY2020 and first quarter of CY2021 and recorded a growth rate of 8.9% in CY2021. The recovery was driven by the gradual and phased unlocking of industrial activity, an increase in investments, and growth in government expenditure.

The May 2022 IMF report forecasted 8.2% growth for CY2022 and 6.9% for CY2023; near-term (CY2022–CY2023) growth would be led by pent-up domestic demand and favorable export

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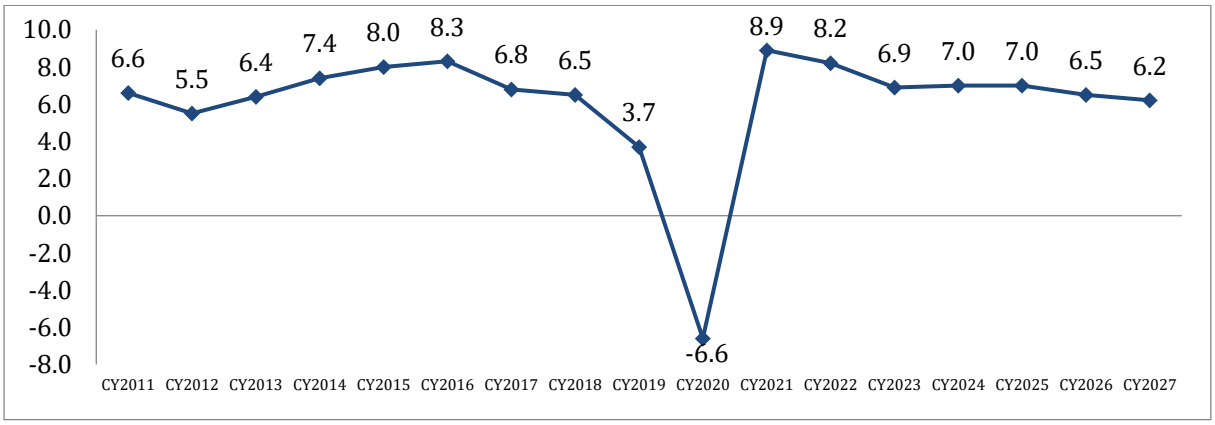
[1] https://www.wwfindia.org/?19602/Cities-across-the-globe-face-an-alarming-rise-in-water-risks

[2] https://www.niti.gov.in/sites/default/files/2019-06/Final%20Report%20of%20the%20Research%20Study%20on%20%20Composite%20Water%20Resources%20Management%20Index%20for%20Indian%20States%20conducted%20by%20Dalberg%20Global%20Development%20Advisors%20Pvt.%20Ltd_New%20Delhi.pdf

[3] https://pib.gov.in/PressReleasePage.aspx?PRID=1788380

demand. The IMF estimates medium-term growth to stabilize at 7.0% in CY2024 and CY2025 after a peak of 8.9% in CY2021. In the long term (beyond CY2025), growth would be driven by investments in infrastructure, the services and manufacturing sectors, and exports.

Exhibit 1: Real GDP Forecast, India, CY2011–CY2026 (Percentage)

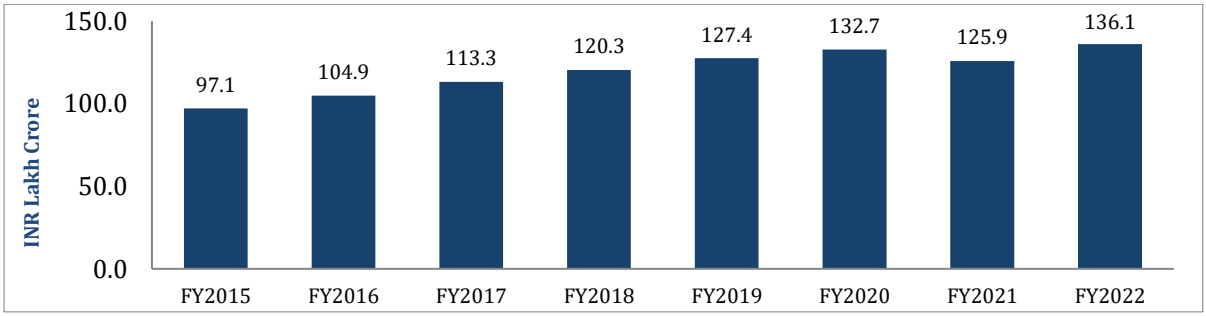


Source: IMF May 2022 Report

1.1. Gross Value Add and Contribution by Sector

Gross value add (GVA) is an economic productivity indicator that provides the monetary value for goods and services produced in the country after deducting the cost of all inputs and raw materials that directly contribute to that production. GVA adjusts GDP by the impact of subsidies and taxes on products and services. The real GVA at constant prices stood at INR 132.7 lakh crore in FY2020, recording a compound annual growth rate (CAGR) of 6.4% from FY2015 to FY2020[4]. The real GVA declined by 5.2% in FY2021 because of the COVID-19 pandemic and rebounded in FY2022 due to the growth in the mining, manufacturing, utility, construction, and services sectors to INR 136.1 lakh crore, registering a growth rate of 8.1% from FY2021[5].

Exhibit 1.1(a): GVA at Constant Prices, India, FY2015–FY 2022



Note: GVA is estimated at constant prices with 2011-2012 as the base year. Constant prices refer to the real value that is corrected for price changes/inflation in relation to the base year.

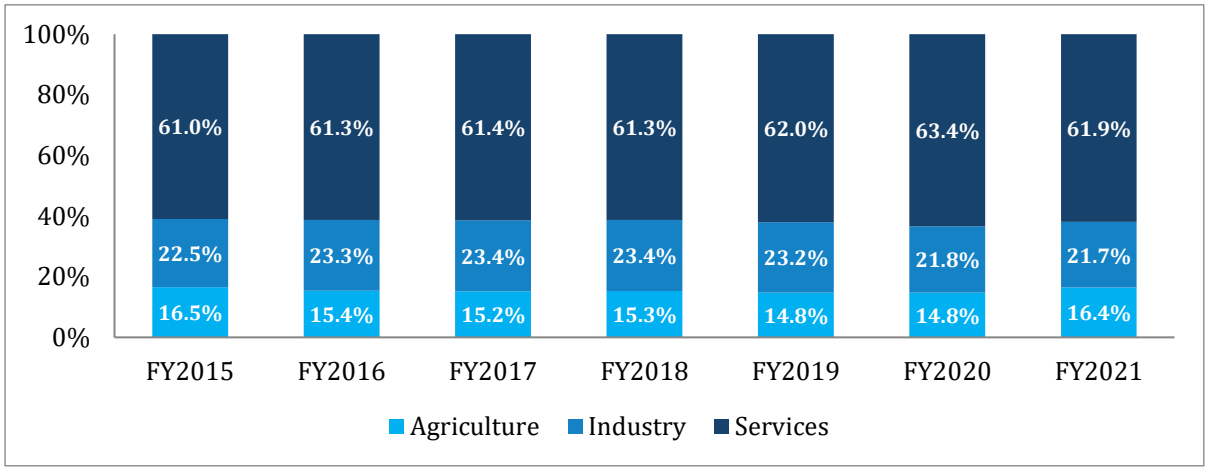
Source: Reserve Bank of India (RBI)

[4] https://www.rbi.org.in/scripts/PublicationsView.aspx?id=20408

[5] https://pib.gov.in/PressReleasePage.aspx?PRID=1829784

Government of India measures GVA by three major sectors at the aggregate level – agriculture, industry, and services. This segmentation is different than the water resource segmentation. Agriculture includes farming, fishing, and forestry. Industry includes mining, quarrying, manufacturing, electricity, gas, water supply, and construction. Services consist of trade, hotels, transport, communications, public administration, real estate, and others. The services sector accounted for 61.9% of the GVA in FY2021 followed by the industrial sector at 21.7%. The services sector is the key growth driver of the Indian economy. The sector's GVA contribution stood at 63.4% in FY2020 (prior to the pandemic), up from 61.0% in FY2015. The growth in all economic sectors has resulted in higher demand for water resources and drives the demand for water and wastewater treatment solutions in India.

Exhibit 1.1(b): GVA Contribution by Sectors at Constant Prices (base year 2011-2012), India, FY2015–FY2021



Source: RBI

1.2. India's Water Resources

India's total utilizable water resource is pegged at 1,122 billion cubic meters (BCM) per year by the Ministry of Jal Shakti. Water resources in India refer to surface water (e.g., rivers, lakes, ponds) and groundwater only and does not include water from desalination and recycle and reuse techniques. Of the total utilizable water, 761 BCM was consumed by all end-user segments in 2018[6]. As per a 2019 NITI Aayog Composite Water Management Index report[7], India is suffering from the worst water crisis in its history because of the its inefficienct waste management methods, and it is only going to worsen. The report projects that by 2030 the country's water demand will be twice the available supply, implying severe water scarcity for hundreds of millions of people.

Exhibit 1.2(a): Land and Water Resources, India, 2020

Geographical area	328.74 million hectares

[6] Food and Agriculture Organization of the United Nations (Note: 2018 is the latest data set available from credible published sources)

[7] https://www.niti.gov.in/sites/default/files/2019-08/CWMI-2.0-latest.pdf

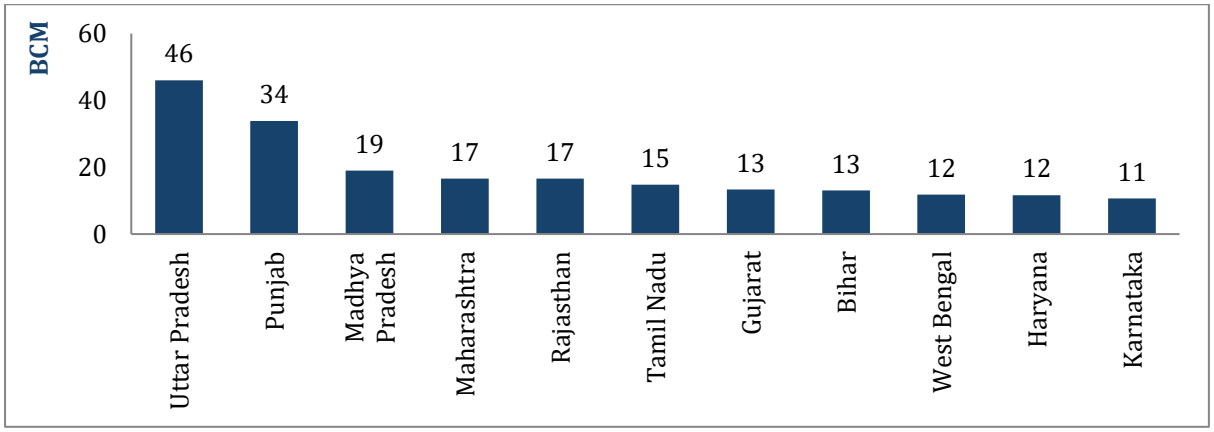
Average annual precipitation	3,880 BCM
Annual utilizable water availability	1,122 BCM
Estimated annual utilizable surface water	690 BCM
Estimated annual utilizable groundwater	432 BCM

Source: Ministry of Jal Shakti and Central Water Commission report titled *Abstract on Water Sector-2020*[8],

The NITI Aayog Composite Water Management Index report 2019 estimated India's total water demand to be 1,498 BCM by 2030. This projection compared with the estimated availability of 1,122 BCM indicates an overall deficit of 376 BCM. It highlights the fact that India must urgently take effective measures today to curb the scarcity of water in the future. This urgency would drive significant growth for the water and wastewater treatment business in India.

Of the 432 BCM of available groundwater, 245 BCM[9] was extracted annually for industrial, agricultural, and domestic use as per the Central Ground Water Board – Ministry of Jal Shakti report 2020. The states using the most groundwater in 2020 were Uttar Pradesh, Punjab, and Madhya Pradesh.

Exhibit 1.2(b): Major States Extracting Groundwater, India, 2020



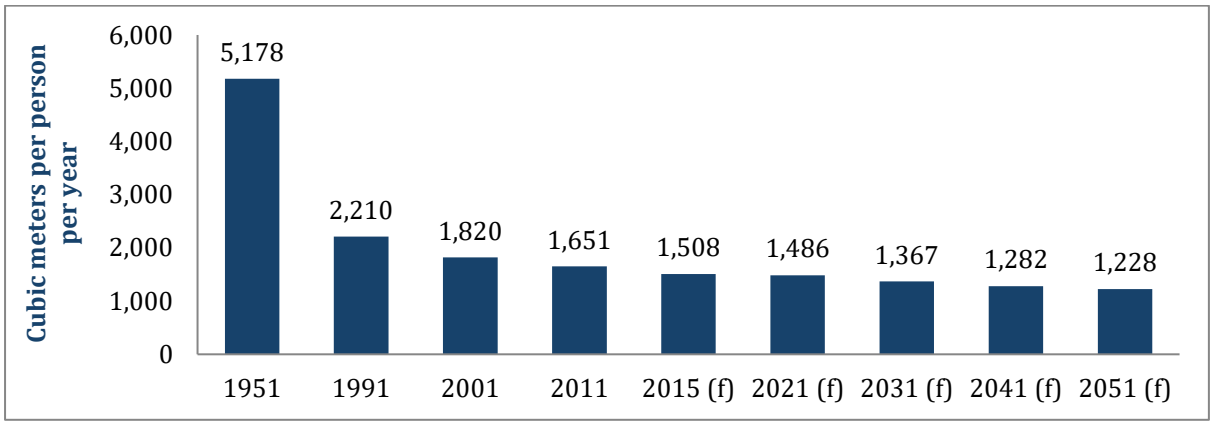
Source: Central Ground Water Board's report on Dynamic Ground Water Resources of India 2020

The Falkenmark water stress index, the most commonly used measure for water scarcity globally, states that water availability below 1,700 cubic meters (m^3) per person per year is considered to be a water stress condition and below 1,000 m^3 per person per year to be water scarcity. Ministry of Jal Shakti states that the per capita water availability in India dropped drastically between 1951 (5,178 m^3/person/year) and 2001 (1,820 m^3/person/year) and has been decreasing ever since. With increasing pollution, climate change, high total dissolved solids (TDS) due to a low water table, and inefficient water management, the per capita water availability would drop further to 1,228 m^3 by 2051.

[8] http://cwc.gov.in/sites/default/files/abstract-water-sector-2020.pdf

[9] http://cgwb.gov.in/documents/2021-08-02-GWRA_India_2020.pdf

Exhibit 1.2(c): Per Capita Water Availability Forecast, India, 1951–2051



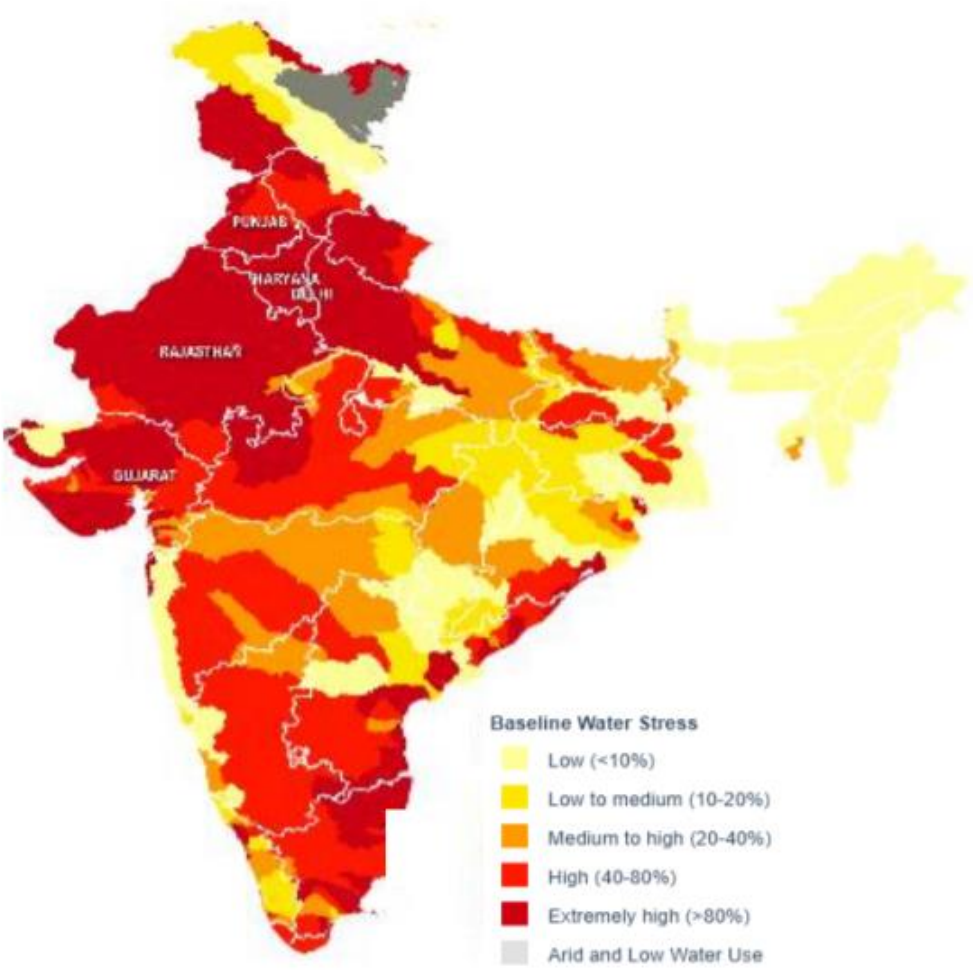
f –forecast; Source: Abstract on Water Sector-2020 by Ministry of Jal Shakti[10]

Decreasing per capita water availability has resulted in water scarcity/water stress. India is currently ranked 120 among 122 countries in water quality index as per a report published by Water Aid[11], a nonprofit organization that works toward increasing access to clean water and hygiene. Changing weather patterns and natural calamities such as droughts have resulted in overexploitation of groundwater resources.

[10] http://cwc.gov.in/sites/default/files/abstract-water-sector-2020.pdf

[11] https://www.wateraid.org/in/media/wateraid-launches-beneath-the-surface-the-state-of-the-worlds-water-2019-to-mark-world-water

Exhibit 1.2(d): Water Stress, India

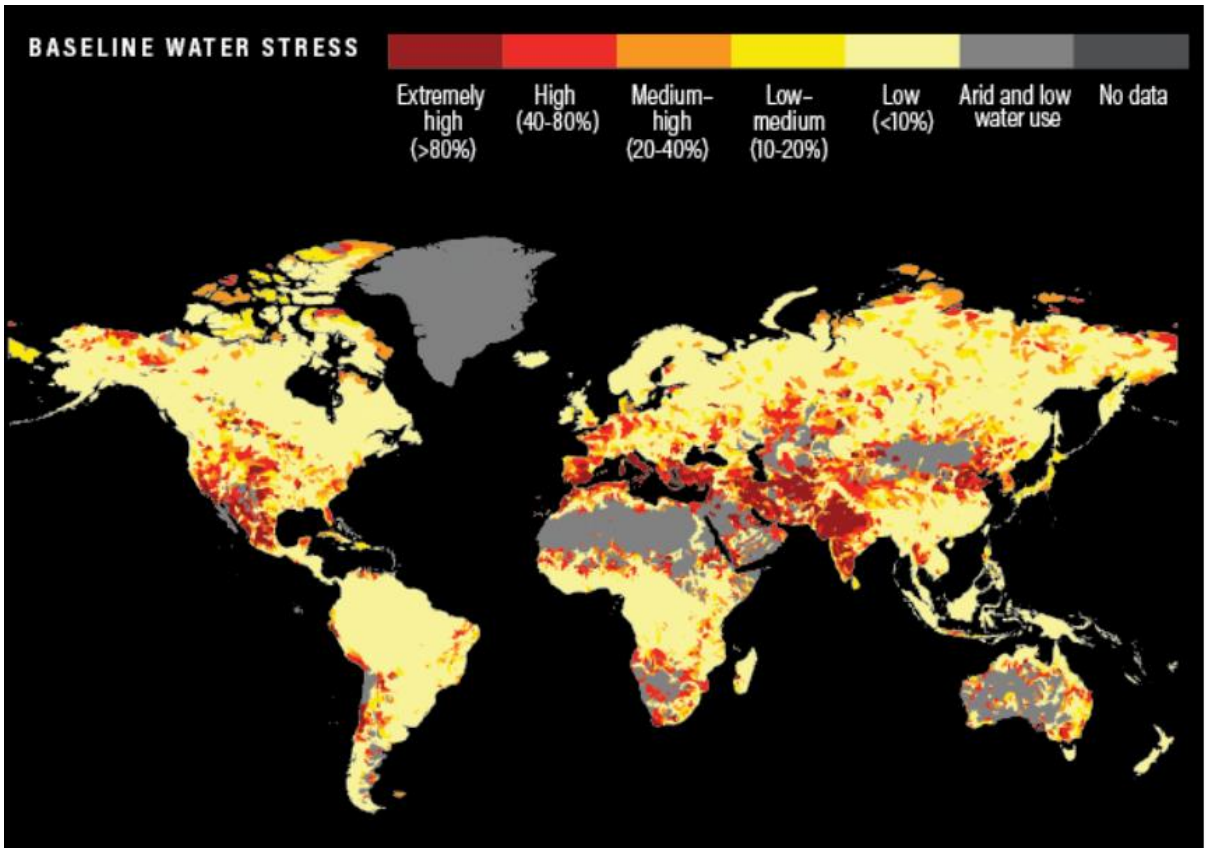


Source: NITI Aayog Composite Water Resource Management Report 2019[12]

India is among 17 countries that face "extremely high" levels of water stress in the world as per a World Resources Institute (WRI) survey in 2019. India withdraws more than 80% of its available supply on average every year.

[12]https://www.niti.gov.in/sites/default/files/2019-08/CWMI-2.0-latest.pdf, https://www.niti.gov.in/sites/default/files/2019-06/Final%20Report%20of%20the%20Research%20Study%20on%20%20Composite%20Water%20Resources%20Management%20Index%20for%20Indian%20States%20conducted%20by%20Dalberg%20Global%20Development%20Advisors%20Pvt.%20Ltd_New%20Delhi.pdf

Exhibit 1.2(e): Water Stress, Global, 2019



Source: WRI[13]

India ranks 13th for overall water stress levels and has more than three times the population of the other 16 extremely highly stressed countries combined. The Middle East and South Asia are the most water stressed area on Earth.

Exhibit 1.2(f): Ranking of Extremely High Water Stress Countries, 2019

Rank	Country	Rank	Country
1	Qatar	11	San Marino
2	Israel	12	Bahrain
3	Lebanon	13	India
4	Iran	14	Pakistan
5	Jordan	15	Turkmenistan
6	Libya	16	Oman
7	Kuwait	17	Botswana
8	Saudi Arabia		
9	Eritrea		
10	United Arab Emirates		

Source: WRI

[13] https://www.wri.org/insights/17-countries-home-one-quarter-worlds-population-face-extremely-high-water-stress

Water Contamination

Groundwater in India is contaminated with fluoride, arsenic, nitrates, iron, and other heavy metals. Pesticides and fertilizers used in agriculture cause groundwater contamination when harmful chemicals leach into the soil, and disposal of untreated effluents from industrial companies results in toxins seeping into the groundwater tables.

Chronic health issues such as cancers and organ failures can result. Higher traces of arsenic, lead, and copper can result in dental issues, and a high presence of fluoride in drinking water can cause skeletal fluorosis. Excessive mercury in groundwater that is used for drinking and cooking can result in neurological damage.

Contaminated water also has a social and economic impact. The United Nations International Children's Emergency Fund (UNICEF) estimates that waterborne diseases cause an economic burden of approximately USD 600 million[14] (INR 46,770 million[15]) per year in India.

Contamination also impacts industrial water quality. When contaminated groundwater is used in the industrial process, pollutants could affect the quality of the final manufactured product or cause process equipment to malfunction. For example, if ground water is not treated properly it can result in scale formation or corrosion in boilers used for power generation. Frequent equipment maintenance would have an impact on plant OPEX. To overcome these challenges, most of the industrial end users install water treatment systems to produce process water as per their industry standards.

[14] https://www.unicef.org/india/what-we-do/clean-drinking-water

[15] USD 1 = INR 77.95

Exhibit 1.2(g): Water Contamination by State, India

State/UT	Salinity (electrical conductivity above 3000 micro mhos/ cm)	Fluoride (above 1.5 mg/l)	Nitrate (above 45 mg/l)	Arsenic (above 0.01 mg/l)	Iron (above 1mg/l)	Heavy metals: lead (above 0.01 mg/l)	Heavy metals: cadmium (above 0.003 mg/l)	Heavy metals: chromium (above 0.05 mg/l)
Andhra Pradesh	■	■	■	■	■			
Telengana	■	■	■	■	■	■	■	■
Assam		■		■	■			
Arunachal Pradesh					■			
Bihar		■	■	■	■			
Chhattisgarh	■	■	■	■	■	■	■	■
Delhi	■	■	■	■		■	■	■
Goa					■			
Gujarat	■	■	■	■	■			
Haryana	■	■	■	■	■	■	■	■
Himachal Pradesh			■	■				
Jammu &Kashmir		■	■	■	■	■	■	
Jharkand		■	■	■	■	■		
Karnataka	■	■	■	■	■			
Kerala	■	■	■		■	■		■
Madhya Pradesh	■	■	■	■	■	■		
Maharastra	■	■	■		■	■		
Manipur		■		■	■			
Meghalaya		■			■			
Nagaland		■			■			
Odisha	■	■	■	■	■			■
Punjab	■	■	■	■	■	■	■	■
Rajasthan	■	■	■	■	■	■		
Tamil Nadu	■	■	■	■	■	■	■	■
Tripura					■			
Uttar Pradesh	■	■	■	■	■	■	■	■
Uttarakhand			■		■			
West Bengal	■	■	■	■	■	■	■	■
Andaman and Nicobar Islands	■				■			
Daman and Diu	■		■	■				
Puducherry			■					

Legend:

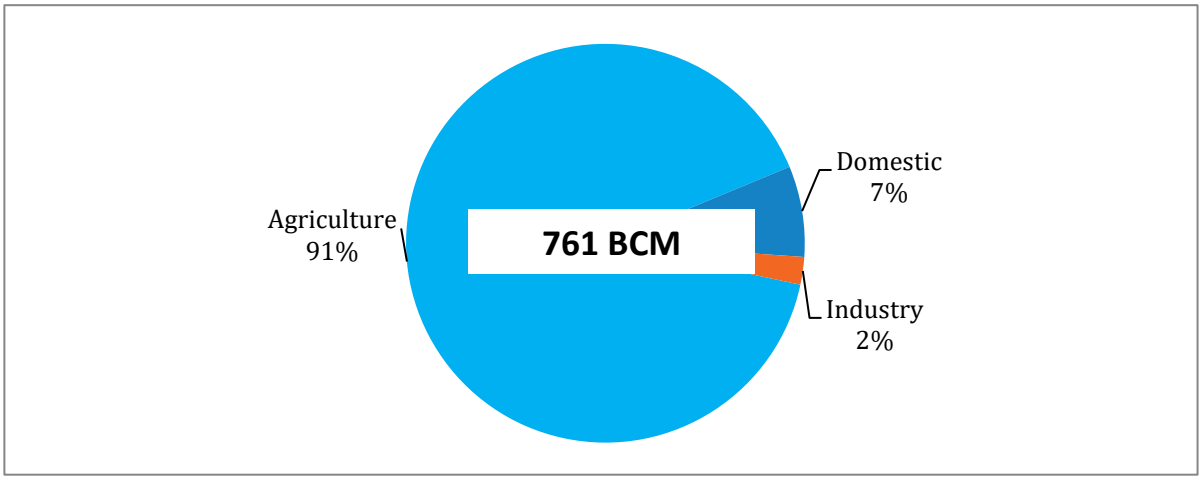
■ Contamination

Source: Central Pollution Control Board (CPCB); Frost & Sullivan analysis

1.3. Water Use by Economic Sector

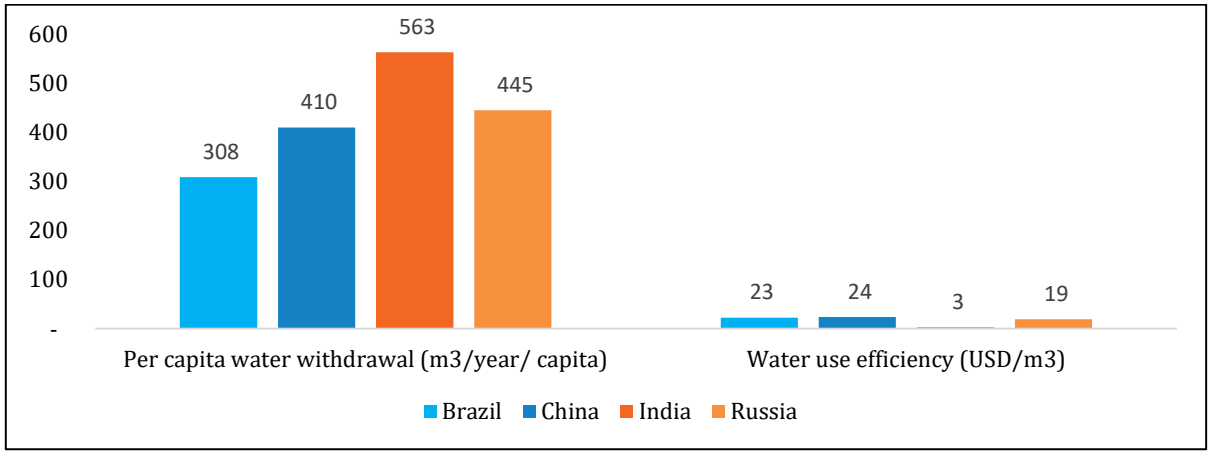
Most water in India is for agricultural use, followed by domestic and industrial use. Of the 761 BCM of water consumed in 2018, 688 BCM was for agriculture, 17 BCM for industry, and the remaining 56 BCM for domestic use. As per the Food and Agriculture Organization of the United Nations, among the developing nations of Brazil, Russia, India, and China, India has the highest per capita water withdrawal and the lowest water use efficiency, making its economic activities very water intensive. Water use efficiency refers to the value of economic product produced (in USD) for one m^3 of water consumed.

Exhibit 1.3(a): Sectoral Water Use, India, 2018



Source: Food and Agriculture Organization of the United Nations (Note: 2018 is the latest published and credible data set available for water consumption by economic sector)

Exhibit 1.3 (b): Per Capita Water Withdrawal and Water Use Efficiency, 2018



Source: Food and Agriculture Organization of the United Nations (Note: 2018 is the latest published and credible data set available for water consumption by economic sector)

Comparison with Global Usage Pattern: Low water use efficiency contributes to India's severe water crisis. Advanced treatment technologies and wastewater recycling solutions would help the nation to reduce water stress and achieve water sustainability.

Exhibit 1.3(c): Water Usage by Sector, Selected Countries, 2018

Parameters	India	China	Brazil	Russia	USA	Germany
Total water withdrawal per capita (m^3/person/year)	563	410	308	445	1,358	343
Agriculture water withdrawal (BCM/year)	688	385	38	19	176	0.4
Industrial water withdrawal (BCM/year)	17	134	10	29	210	18
Domestic water withdrawal (BCM/year)	56	79	17	17	58	10

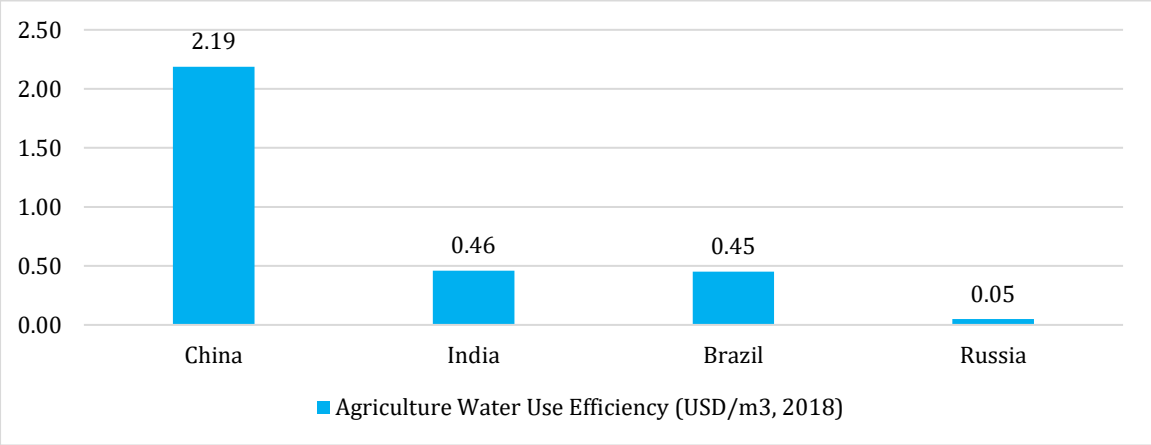
Source: Food and Agriculture Organization of the United Nations (Note: 2018 is the latest published and credible data set available for water consumption by economic sector)

The lack of an efficient pricing mechanism for the agriculture sector or volume-based pricing system for domestic water consumption has resulted in inefficienct water management practices.

1.4. Water Use Issues

Agriculture: India uses about 688 BCM of water for agricultural purposes. There is strong growth in agricultural exports from India; principal commodities such as wheat, non-basmati rice and soya meal witnessed exports growth in revenue terms of 727%, 132% and 132% respectively between FY2020 and FY2021. This growth in agricultural output would create demand for water over the long-term.

Exhibit 1.4(a): Agricultural Water Use Efficiency, Global



Source: Food and Agriculture Organization of the United Nations (Note: 2018 is the latest published and credible data set available for agriculture water use efficiency)

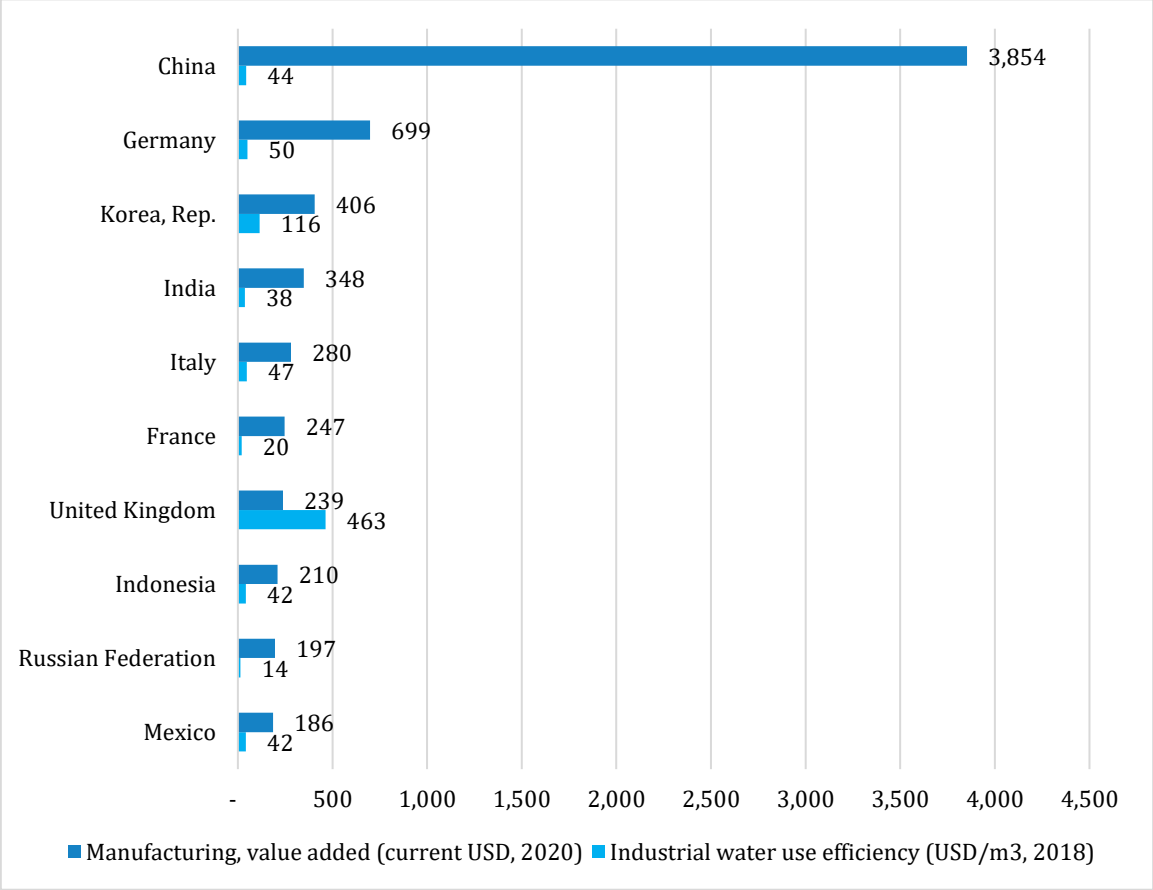
Major Indian crops such as rice, wheat, and sugarcane are all high consumers of water. This, along with the conventional agricultural practices the water footprint of crops in India remains high. For example, India consumes 2,850 m3 of water per ton of rice produced, while the global average is 1,325 m3 of water for every ton of rice.

Government-allocated irrigation water and groundwater are the major sources for agriculture. Given the uneven distribution of water resources in terms of rainfall, surface water reservoir etc., several parts of the country are dependent on groundwater for irrigation and the sources are overexploited, resulting in lower-quality water due to brackish water intrusion into aquifers and issues in water allocation for other economic activities such as manufacturing.

Water in the Industrial Sector

India ranked 4th in terms of manufacturing value add as per the World Bank in 2020, followed by China, Germany, and South Korea. Manufacturing value add refers to the net output of manufacturing sector after adding up all outputs and subtracting intermediate inputs. India consumed around 17 BCM of water in 2018 and is not very efficient at water usage and conservation techniques in the industrial sector when compared with developing economies such as China, as measured by the industrial water use efficiency by Food and Agriculture Organization of the United Nations. The major water-consuming industries in India are power generation, steel, zinc, and oil refineries.

Exhibit 1.4 (b): Manufacturing Value Add and Industrial Water Use Efficiency, Selected Countries



Source: Food and Agriculture Organization of the United Nations (Note: 2018 is the latest published and credible data set available for water consumption by economic sectors) and World Bank (Note: 2020 is the latest published and credible data set available for manufacturing value add by country)

Water use efficiency in the industrial sector in India is much lower than China, Germany, and South Korea. A major challenge is water availability or physical risk (this refers to the risk associated with the non-availability of water and the quality of water available to an end-user industry). From 2013 to 2016, 14 of the major 20 thermal power plants had to be closed temporarily due to lack of water for operations, and the estimated revenue loss was USD 1.4 billion[16] (INR 109.13 billion).

With the higher consumption of water, wastewater generation and management are another concern. At least 60% of the water consumed by the industrial sector is generated as wastewater at the end of the production process. This translates to an effluent generation of 10 BCM a year (considering the water consumption of 17 BCM in 2018). Growing investments in the industrial sector and regulations for wastewater management would increase the demand for water and wastewater treatment solutions market in India. Given the water scarcity and its direct implications on the operations of an industrial facility, the demand for recycle and reuse systems would remain high in the long term.

1.5. Water Policies, Regulations, and Authorities

The Ministry of Jal Shakti formed in May 2019 with the merger of the Ministry of Water Resources, River Development, and Ganga Rejuvenation and the Ministry of Drinking Water and Sanitation. The Ministry of Jal Shakti is the apex organization responsible for the development of water policies. Water management has been receiving more policy attention in the last decade because of scarcity concerns.

- **The National Water Policy, 2012**[17] was drafted by the Ministry of Water Resources with the purpose of governing the planning and development of water resources in India. The first version was launched in 1987, and it was updated in 2002 and 2012. Salient features of the policy:
    - Emphasize the need for a national water framework law and legislation for effective development of interstate rivers and other water bodies.
    - Treat water as an economic good to promote its conservation and efficient use.
    - Establish a system to benchmark water use across different end-user segments.
- **The National Mission for Clean Ganga, 2014** is a flagship program launched with a budget outlay of INR 20,000 crore to control pollution, conserve, and rejuvenate Ganga River.
- **The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), 2015** program was launched to increase the cultivable area with complete access to irrigation facilities, reduce wastage of water, and increase water use efficiency in the agriculture sector.

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16 https://www.business-standard.com/article/opinion/industrial-growth-could-flounder-on-water-119092000035_1.html

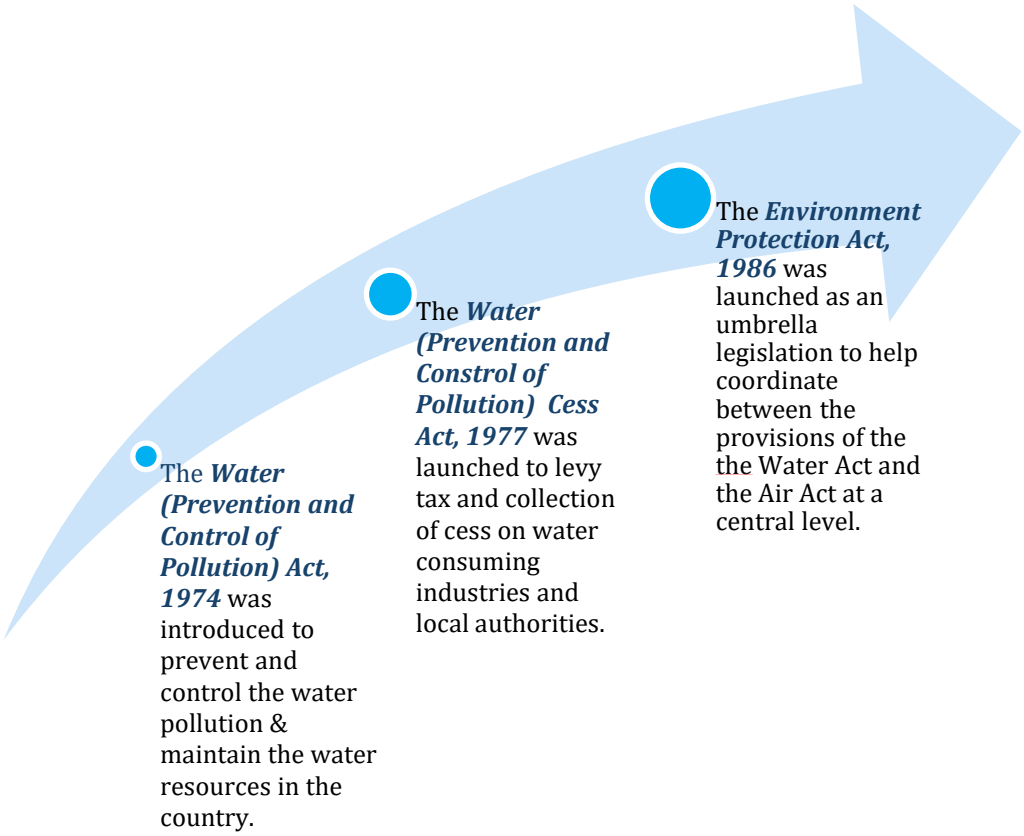
17 http://jalshakti-dowr.gov.in/sites/default/files/NWP2012Eng6495132651_1.pdf

- **The Jal Jeevan Mission, 2019**objective is to provide "functional household tap connections" (FHTC) to every rural home by 2024.
- **India's first river linking project approved in 2021** would connect Ken River in Madhya Pradesh with Betwa in Uttar Pradesh.

Three major regulations govern wastewater discharge and disposal in India. They are

- Water (Prevention and Control of Pollution) Act, 1974
- Water (Prevention and Control of Pollution) Cess Act, 1977
- Environment Protection Act, 1986 (EPA)

Exhibit 1.5: Regulations Impacting Wastewater Treatment, India



Pollution control boards are the apex organizations implementing and monitoring the regulations in India.

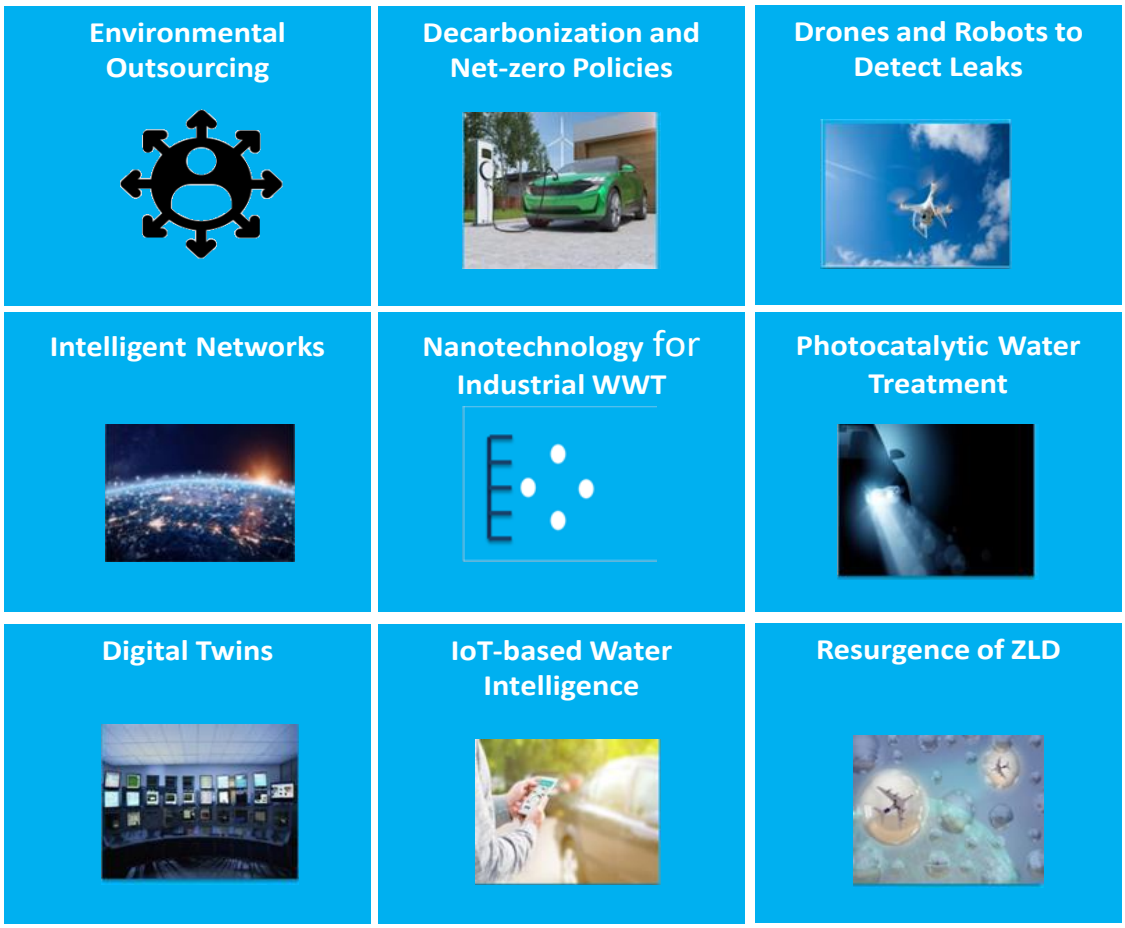
- The Central Pollution Control Board (CPCB) serves as a field formation and provides technical services to the Ministry of Environment, Forest, and Climate Change (MoEFCC) for the provisions of the Environment (Protection) Act, 1986; Water (Prevention and Control of Pollution) Act, 1974; and the Air (Prevention and Control of Pollution) Act, 1981.
- State Pollution Control Boards (SPCBs) look after the interest of the state in which they function. They implement directives from the CPCB and all acts that are enacted from time to time. SPCBs employ teams of scientists and laboratories to monitor air, soil, and water quality through samples collected from industrial areas.

The National Green Tribunal (NGT) is a quasi-judicial body that takes care of the effective and expeditious disposal of cases relating to environmental protection, enforcement of legal rights relating to the environment, relief, and compensation for damages to persons and property, and related matters. Such regulations and their implementation act as a key enabler for the growth of the wastewater treatment solutions among industry end-users in India.

Chapter 2: Global Water and Wastewater Treatment Solutions Market Analysis

The COVID-19 pandemic has revitalized the importance of resilient and future-ready water and wastewater infrastructure. Municipalities and industries around the world have begun adopting net zero, decarbonization, and circularity goals to become sustainable, resilient, and future ready. Internet of Things (IoT)-based solutions have become vital in helping end users achieve their net zero targets; net zero target refers to achieving balance between the greenhouse gases emitted into the atmosphere and the greenhouses gases removed from it. Utilities and industries have significantly increased their investments in adopting smart online sensors for real-time monitoring of assets and advanced artificial intelligence (AI)-based data analytics platforms to optimize the system on a real-time basis. The key focus is on reducing energy consumption and improving energy efficiency. End users are further focusing on the circularity of both water and sludge. Nutrient and energy recovery from sludge has received fresh impetus, especially in the Asia- Pacific (APAC) region. Europe and North America are set to significantly invest in treating emerging pollutants, while treated wastewater reuse will be the major agenda in APAC, North America, Latin America, and the Middle East. Zero liquid discharge (ZLD) technologies with disruptive solutions now enable recovery and reuse of minerals and salts from the brine. The global water and wastewater treatment solutions market is set to grow by 5.3% to USD 801 billion in 2022.

Exhibit 2: Water and Wastewater Industry Trends

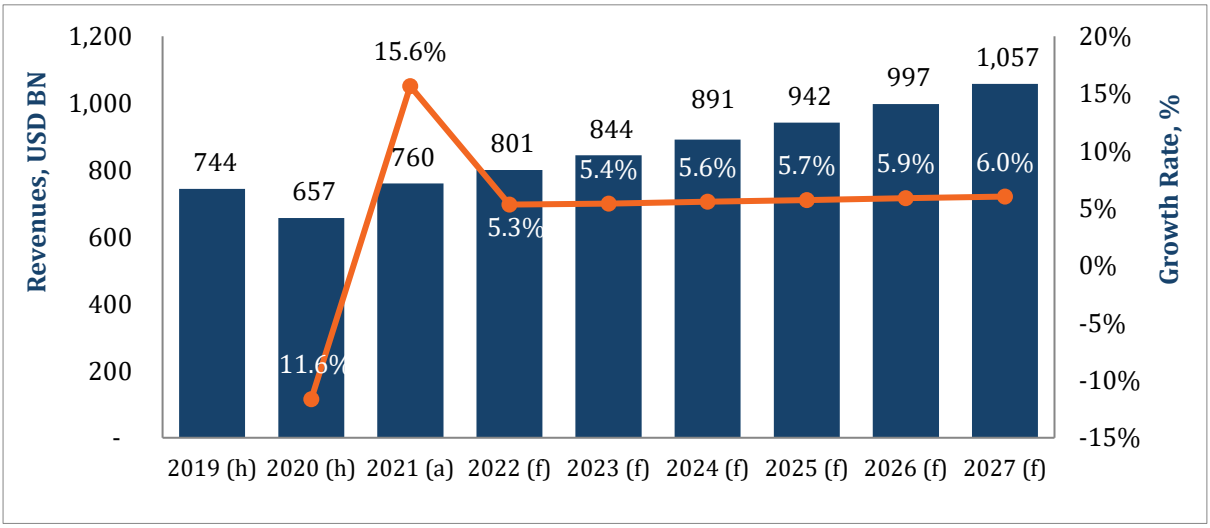


Source: Frost & Sullivan

2. Market Size and Segmentations

The global water and wastewater treatment solutions market size refers to the revenue from sales of water and wastewater treatment systems and services such as operation and maintenance (O&M), spares, and chemicals. Frost & Sullivan valued the global market at USD 760 billion in CY2021 and expects it to grow at a CAGR of 4.7% from CY2022 to CY2027 to reach USD 1,057 billion.

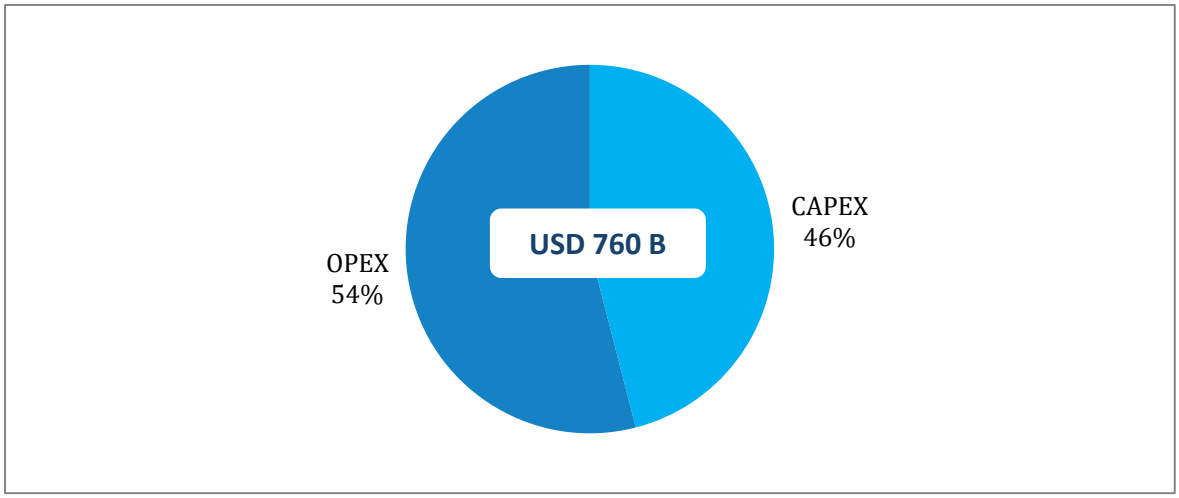
Exhibit 2(a): Water and Wastewater Treatment Solutions Market Size: Historical and Forecast, Global CY 2019-2027



h-historical, a-actual, f-forecast; Source: Frost & Sullivan Analysis

Capital expenditure (CAPEX), which refers to systems and includes design, engineering, construction, water and wastewater treatment technology, process control, and management, accounted for 46% of 2021 revenue. The remaining 54% was operational expenditure (OPEX), including O&M services, spares, and chemicals.

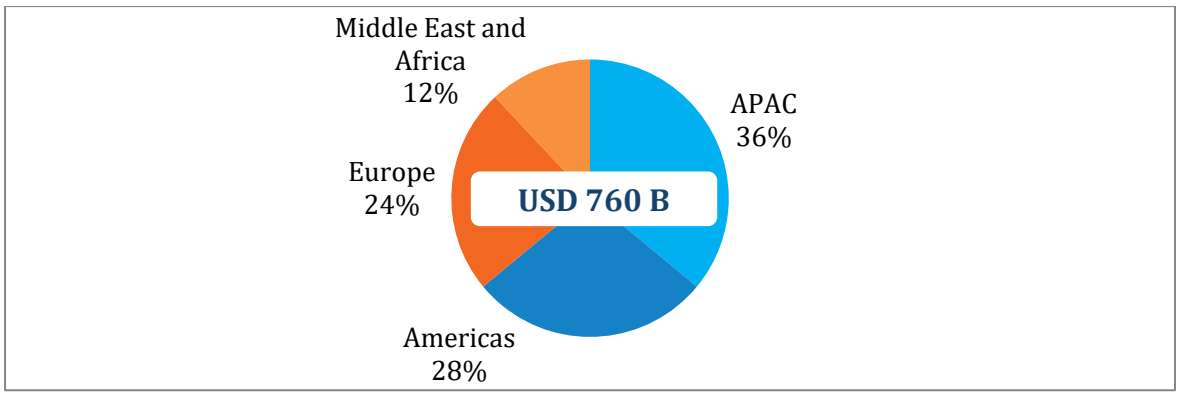
Exhibit 2(b): Water and Wastewater Treatment Solutions Market Size by CAPEX and OPEX, Global, CY2021



Source: Frost & Sullivan Analysis

APAC is the largest market for water and wastewater treatment solutions, contributing 36% of revenue in CY2021. The demand from the region is driven by rapid urbanization in developing Asian economies including China, India, Vietnam, and Indonesia. Growing manufacturing and services sectors are creating demand for recycling and reuse systems. Other factors that are contributing to the growth of the market are improving standards of living, water scarcity, and emergence of more stringent water-related laws and regulations, particularly for effluent discharge. River cleaning initiatives in India, China, Indonesia, and the Philippines have led to stronger enforcement of regulatory compliance, and imposition of recycling and reuse systems with the provision of subsidies or incentives for implementation.

Exhibit 2(c): Water and Wastewater Treatment Solutions Market Size by Region, CY2021



Source: Frost & Sullivan Analysis

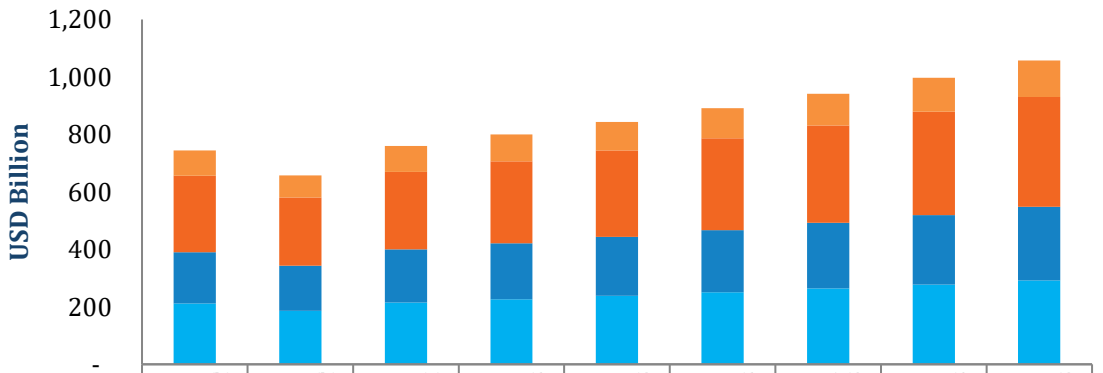
Americas, which includes North, Central and South America, is the second-largest region for water and wastewater treatment solutions. Enforcement of stringent regulations for effluent discharge is the key factor driving growth in North America. Increasing demand for electricity and growing investments in the food & beverage and pharmaceutical industries are contributing to the growth. Revised effluent treatment standards by the US Environmental Protection Agency (EPA) for coal power plants, chemicals, plastics, and metal finishing plants have mandated pre-treatment. Mining is one of the key segments driving demand for water and wastewater treatment solutions in South America. Industries in Brazil, Colombia, Mexico, and Argentina have the need to invest in the rehabilitation of their wastewater treatment systems to enable water recycling and reuse to improve their environmental compliance.

Europe's water and wastewater treatment solutions market will be driven by population and rehabilitation of major water infrastructure assets due to ageing, particularly in Germany, the United Kingdom, France, and Italy. The key industries that will drive the market growth are food & beverage, pharmaceuticals, chemical, power generation, and hi-tech engineering. The European Green Deal implemented in 2021 has major implications for the water sector. One of the main objectives is to implement a circular economy model that would boost the wastewater treatment solutions market as industries would be encouraged to revamp their facilities to enable circularity. Sustainability goals and the increasing demand for smart operational intelligence in the water sector would drive the growth and adoption of smart IoT-based solutions in the long term.

In the Middle East and Africa, growing population, increasing self-sustainability in manufacturing, and diversification of economic growth from oil-based activities are creating

demand for water and wastewater treatment solutions. The Gulf Cooperation Council (GCC) is continuing its efforts to diversify its industries as a key part of its long-term economic sustainability strategy. Dependence on desalination for fresh water and sustainability targets would promote the need for reuse and recycle systems. Tanzania, Kenya, Nigeria, Ethiopia, and Egypt are gradually becoming manufacturing hubs and hot spots for the mining and petrochemical industries which increases water demand and the need for water and wastewater treatment solutions.

Exhibit 2(d): Water and Wastewater Treatment Solutions Market Forecast by Region, 2019–2027

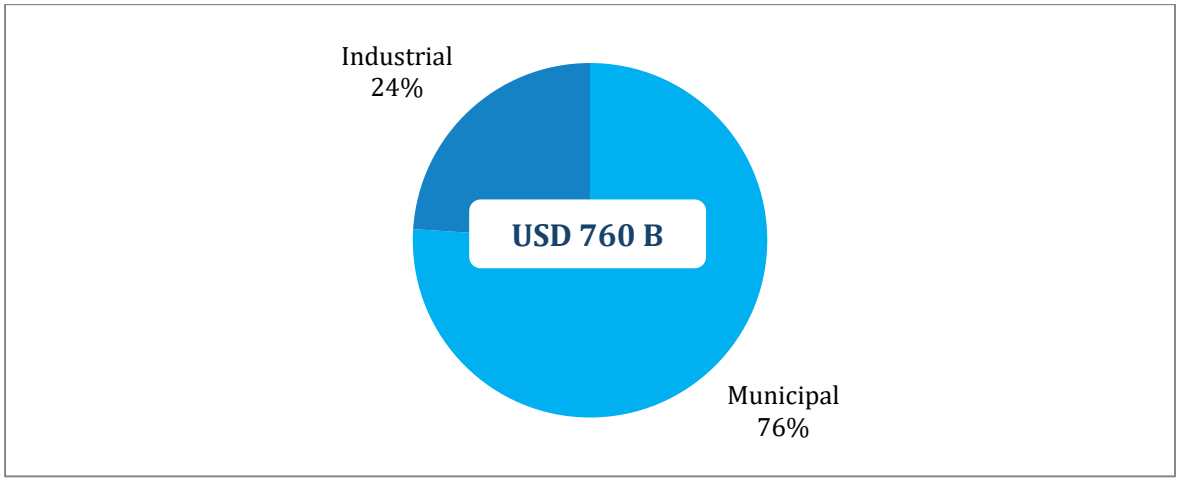


	2019 (h)	2020 (h)	2021 (a)	2022 (f)	2023 (f)	2024 (f)	2025 (f)	2026 (f)	2027 (f)
MEA	87	77	90	95	99	105	111	118	126
APAC	267	236	270	285	301	319	338	360	383
Europe	179	157	185	195	206	217	229	242	255
Americas	211	187	215	226	238	251	264	278	293

h-historical, a-actual, f-forecast; Source: Frost & Sullivan Analysis

The municipal segment contributed 76% of global revenue, amounting to USD 580 billion in CY2021. The industrial segment accounted for 24%, or USD 180 billion.

Exhibit 2(e): Water and Wastewater Treatment Solutions Market Size by End-user Segment, Global, CY2021



Source: Frost & Sullivan Analysis

Exhibit 2(f): Top Insights – Industrial Water and Wastewater, Global

Region	Economic Insights	Regulatory Insights

Middle East and Africa	The GCC is redoubling its efforts to diversify its industries as a part of its long-term economic sustainability strategy. Key industries that are gradually expanding through direct foreign investment are metals, chemicals, plastic-based products, electrical products, fertilizers, and automobiles. Industrial diversification has led to increasing investment in desalination and water reclamation projects. African countries are gradually becoming manufacturing hubs and hot spots for the mining and petrochemical industries, which increases water demand.	GCC countries have well-established policies that allow independent development and implementation of water treatment and desalination projects. Wastewater treatment and reuse of treated wastewater are mandated to improve long-term sustainability. Most African countries lack both cohesive regulation and enforcement capability to regulate industrial wastewater discharges, but industries get the least priority during droughts, which has led them to implement their own desalination or water treatment systems.
APAC	The region will lead in terms of demand for new industrial water and wastewater treatment systems due to revived growth and expansion of the manufacturing sector, especially in India, China, Vietnam, and Malaysia.	Developing Asian countries such as Cambodia, Laos, Sri Lanka, Bangladesh, and Thailand will offer opportunities due to fresh industrial growth alongside regulatory enforcement due to highly sensitive environments. River cleaning initiatives in India, China, Indonesia, and the Philippines have led to regulations being more stringently enforced and the imposition of ZLD with the provision of subsidies or incentives for its implementation will continue to drive demand in these countries.
North America	Private non-hazardous liquid waste management companies are set to grow in terms of volume handling capacity due to stringent enforcement of discharge regulations by the US EPA and local agencies and industries' tendency to outsource waste management. This will lead to capacity expansion of common effluent treatment plants, especially in the United States. As-a-service business models will become common as stringent regulations will require high CAPEX.	The US EPA is set to make more stringent regulations for wastewater discharge from coal power plants, especially regarding heavy metal content in the effluent. This would push more coal power plants to adopt advanced membrane-based solutions and ZLD systems to ensure compliance. The EPA has also revised effluent limitations for chemicals, plastics, and metal finishing industries regarding per- and polyfluoroalkyl substances (PFAS) discharges, and meat and poultry industries regarding its nutrient discharge.
South America	Guyana, the Dominican Republic, Brazil, Mexico, Colombia, Peru, and Chile would register rapid growth in 2022, primarily due to mining. The mining industry will provide new growth opportunities. There will be a rise in demand for wastewater treatment systems and desalination to mitigate environmental concerns and improve sustainability.	The lack of cohesive regulatory policies will continue to impact the adoption of advanced treatment technologies, but water stress and pressure by investors on export-oriented industries will gradually drive growth, especially for water reclamation systems. Mining companies that are under pressure due to the loss of freshwater rights will increasingly depend on desalination, with industrial polices expected to support private investment into desalination. They also will be more open to build, operate, and transfer (BOT) or as-a-service business models.
Europe	Europe will witness a snap back in growth in 2022 after the disruption created by the COVID-19 pandemic. Germany, the United Kingdom, France, and Italy will be growth hot spots due to new investments into rehabilitation of treatment facilities. Food and beverage, pharmaceutical, chemical, power generation, and hi-tech engineering will continue to be the main customers for industrial water and wastewater treatment systems.	Europe's circular economy action plan (the Green Deal) has identified water as one of the primary targets for investment and implementation. Most industrial establishments will start by revamping their existing facilities to ensure circularity.

Source: Frost & Sullivan Analysis

Additional insights on China Water and Wastewater Treatment Market:

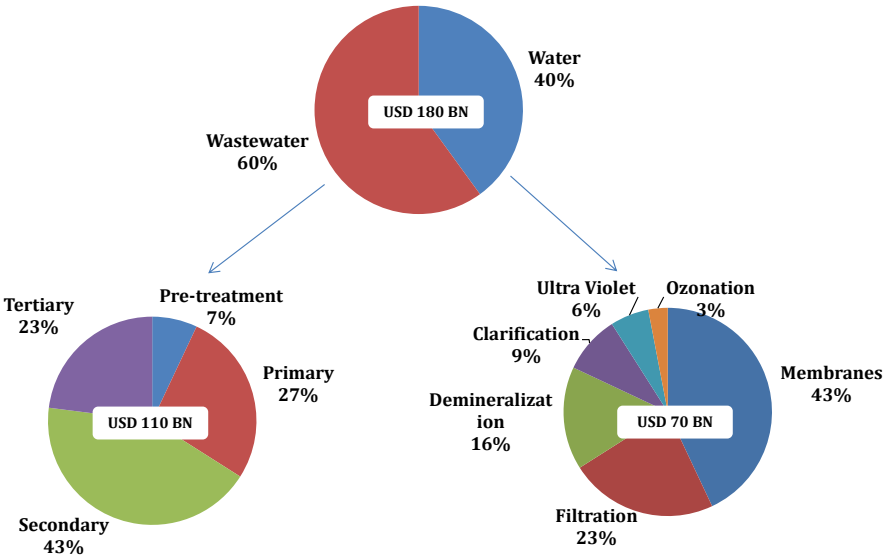
- China is one of the major markets in the APAC region and key factors driving the demand for water and wastewater treatment solutions in the country and growing

investments in industrial segment, rapid urbanization, and government initiatives to provide incentives for water conservation measures.

- Manufacturing, power generation, and oil & gas are some of the key industrial segments expected to drive the demand for water and wastewater treatment equipment in China over the next 5 years.
- As per Frost & Sullivan's analysis, the market is expected to witness a growth of around 7-9% from 2022 to2025.

2.1. Industrial Water and Wastewater Treatment Solutions Market Insights

Exhibit 2.1(a): Industrial Water and Wastewater Treatment Solutions Market Size by Application and Technology, Global, CY2021



Source: Frost & Sullivan Analysis

Wastewater treatment plants developed for industrial areas across the world were analysed by Frost & Sullivan to understand their treatment technology. Water reuse plants from industrial and municipal segments were studied to understand the different technologies that industries adopted for wastewater reuse.

Exhibit 2.1(b): Industrial Wastewater Treatment Technologies

Preliminary Treatment	Primary Treatment	Secondary Treatment	Tertiary Treatment	Zero Liquid Discharge
▪ Bar Screen ▪ Grit Chamber ▪ Oil Skimmer ▪ Corrugated Plate Interceptors	▪ Clarifiers ▪ Coagulators ▪ Tube Settler/Lamella Clarifier ▪ Dissolved Air Flotation (DAF) ▪ High Rate Solid Contact Clarifier (HRSCC) ▪ Pipe Flocculator	▪ Activated Sludge Process (ASP) ▪ Extended Aeration System (EAS) ▪ Sequential Batch Reactor (SBR) ▪ Moving Bed Bio Film Reactor (MBBR) ▪ Membrane Bioreactor (MBR) ▪ Upflow Anaerobic Sludge Blanket (UASB)	▪ Filtration ▪ Membrane Processes: • Multi Filtration (MF) • Ultrafiltration (UF) • Nano filtration (NF) • Reverse Osmosis (RO) • Forward Osmosis (FO) ▪ Ozonation	▪ Multi Effect Evaporators (MEE) ▪ Mechanical Vapour Recompression (MVR) ▪ Multiple Effect Distillation (MED) ▪ Waste Heat Evaporator (WHE) ▪ Agitated Thin Film Dryer (ATFD) ▪ Crystallizer

List of plants analysed for best practices in wastewater treatment technology:

- Wastewater Reclamation Plant, Amata Nakorn Industrial Estate, Chonburi, Thailand
- Jeddah 1st Industrial City, Saudi Arabia
- Shanghai Xinjiang Wastewater Treatment Plant, China
- Tannery Effluent Treatment Plant, Netherlands
- AstraZeneca Effluent Plant at Avlon Works, Avonmouth, United Kingdom

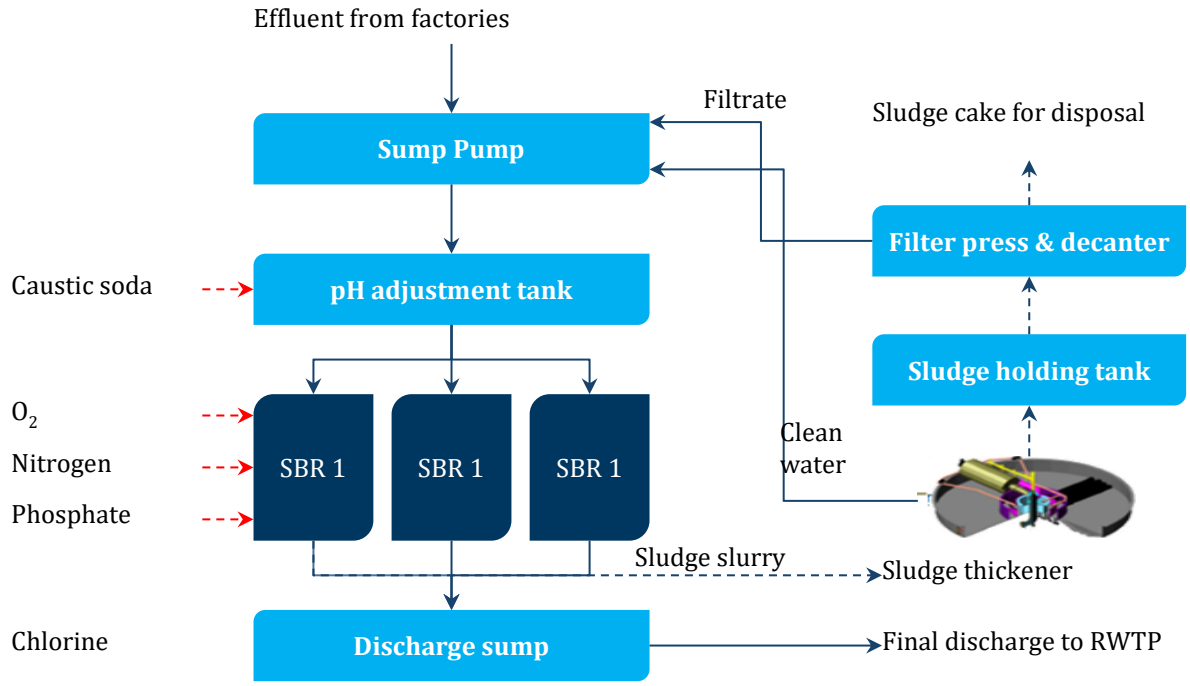
Case Study 1: Wastewater Reclamation Plant, Amata Nakorn Industrial Estate, Chonburi, Thailand

General information:

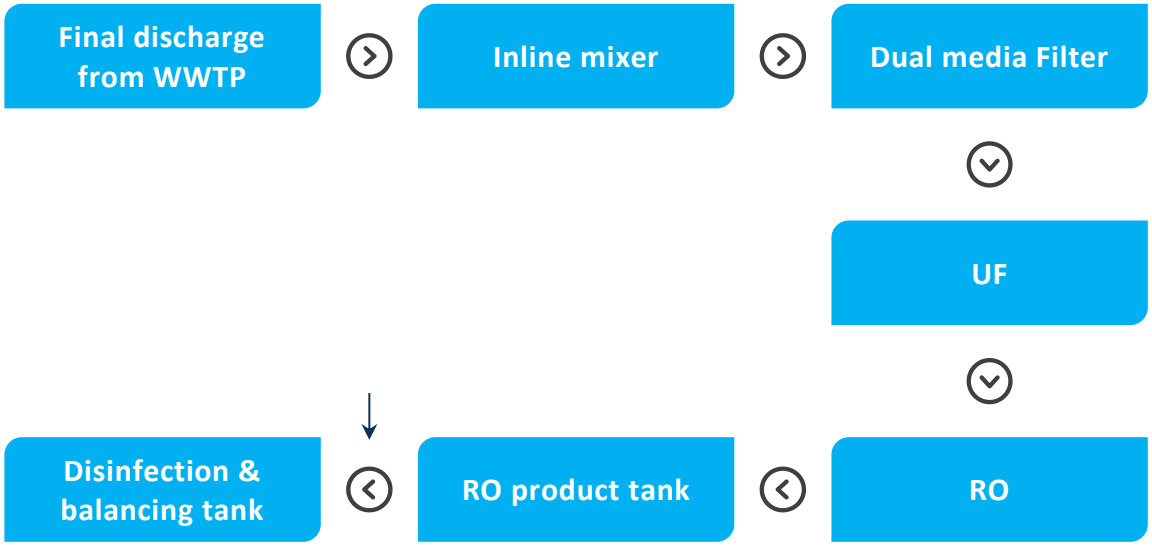
- Industrial estate is 24 million square meters (m^2) with 450 industry lots and 398 factories in operation.
- Industries present in the area are automotive, chemicals, plastics, paper, steel and metals, and food products.
- The project is a BOT concession between Amata Water Co. Ltd. and AnuRak Water Treatment Facilities (wholly owned by Ranhill) with a 25-year concession period.

Wastewater treatment:

- The industrial area has an integrated water and wastewater system. Wastewater generated from the factories is collected and sent to the centralized wastewater treatment plant.
- Wastewater treatment plant capacity: 24,000 m^3/day
- Water reclamation plant: 10,000 m^3/day
- Operator: Amata Water Co. Ltd. and AnuRak Water Treatment Facilities
- Operational status: Fully functional plant
- Technology: RO



Water reclamation technology



Other technology highlights (clarification/filtration):

- Combined DAF clarification and filtration
- High-rate process
- Continuous operation
- Fully automated operation

Membrane plant:

- Overall recovery rate: 63%
- Automatic control including programmable logic controller (PLC), starter, and breaker
- Spiral wound membrane, low energy element
- Clean in place (CIP) system

Exhibit 2.1(c): Quality of Treated Effluent - Wastewater Treatment Plant

Parameter	Influent	Effluent
pH at 25°C	5.5-9.0	6.8-7.3
Temperature	<40°C	<40°C
Total dissolved solids (milligram (mg)/liter (L))	1,200–1,500	1,200–1,500
Biological oxygen demand (BOD) (mg/L)	250	3–10 (20)
Chemical oxygen demand (COD) (mg/L)	375	40–100 (120)
Total suspended solids (mg/L)	200	6–12 (50)
Zinc (mg/L)	5	<0.5
Oil and grease (mg/L)	10	<1

Exhibit 2.1(d): Quality of Treated Effluent - Water Reclamation Plant

Parameter	Influent	Effluent
pH at 25°C	5.5-9.0	6.5
Temperature	<40^{0}C	<35^{0}C
Total dissolved solids (mg/L)	1,500	45–50
Total suspended solids (mg/L)	<50	<0.5
Zinc (mg/L)	<5	0.02
Iron(mg/L)	<5	0.01

Source: Confederation of Indian Industries (CII) presentation on Wastewater reclamation at industrial parks, 2016

Case Study 2: Jeddah 1st Industrial City, Saudi Arabia

General information:

This plant treats industrial wastewater at Jeddah 1st industrial city spread across 12.0 million m² of land. Companies in the industrial area manufacture rubber, plastic, refined petroleum products, and chemical materials.

- Capacity: 25,000 m³/day
- Engineering, procurement, and construction (EPC) contractors: Muhaidib Contracting Co., Saudi Berkfeld (Wetico)
- O&M contractor: Industrial Cities Development & Operating Company (ICDOC)
- Operational status: Fully Operational
- Technology: Activated sludge (Carrousel System)
- Average daily production: 4,274 m³/day
- Maximum daily production: 7,331 m³/day

Exhibit (Case Study 2): Flow Diagram of Jeddah Industrial Wastewater Treatment Plant

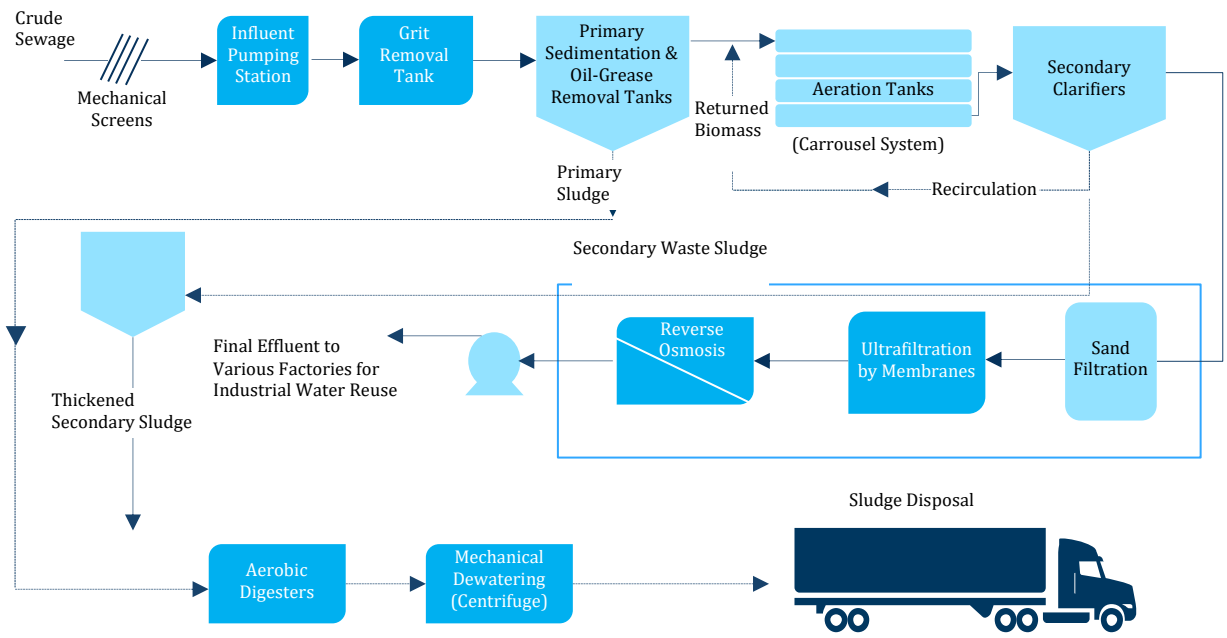


Exhibit 2.1(e): Designed Influent and Effluent Characteristics

Parameter	Influent	
pH	5–11	6–9
COD	3,000mg/L (75,000 kg/d)	150 mg/L
BOD	1,500mg/L (37,500 kg/d)	25 mg/L
Suspended solids	2,000mg/L (50,000 kg/d)	15 mg/L
Total Kj. nitrogen	60mg/L (1,500 kg/d)	10 mg/L

Exhibit 2.1(f): Water Quality

pH	7.3
Total dissolved solids	69 mg/L
Chloride	17 mg/L
Total hardness	13 mg/L

Reuse potential:

- The wastewater treatment plant provides secondary effluent to various factories for industrial water reuse. This secondary effluent is further treated at the individual factories for their use.
- The water is reused by carpet, glass, and paper manufacturers.

Sludge management:

- Secondary sludge is well digested. The sludge retention time in the Carrousel System is in the range of 12 to 20 days.
- Primary sludge is thickened and digested in the aerobic digesters for more than 15 days.
- All sludge is dewatered by centrifuge.

Source: http://www.sawea.org/pdf/Moafaq%20Ibrahim%20Al%20Suqair%20-%20Rehabilitation%20of%20Jeddah%20Industri.pdf

Case Study 3: Shanghai Xinjiang Wastewater Treatment Plant, China

General information:

- The wastewater treatment plant is serving a petrochemical industrial park in Luntai county. The park is one of the four largest chemical/petrochemical production centers in Shanghai.
- The wastewater treatment plant uses United Envirotech Limited's (UEL's) advanced Membrane Bioreactor (MBR) technology to lower pollution levels.

Wastewater treatment plant details:

- The plant is built on 37 acres, with a filtering area of almost 1,400 m^2.
- The treated water is used for industrial cooling water and miscellaneous municipal uses.
- Capacity: 100 million litres per day (MLD) (2 plants with 50 MLD capacity each)
- Year of commissioning: April 2011
- CAPEX (Phase 1): 300 million yuan
- Technology: MBR

Exhibit (Case Study 3): Water Treatment Technology Flow Chart

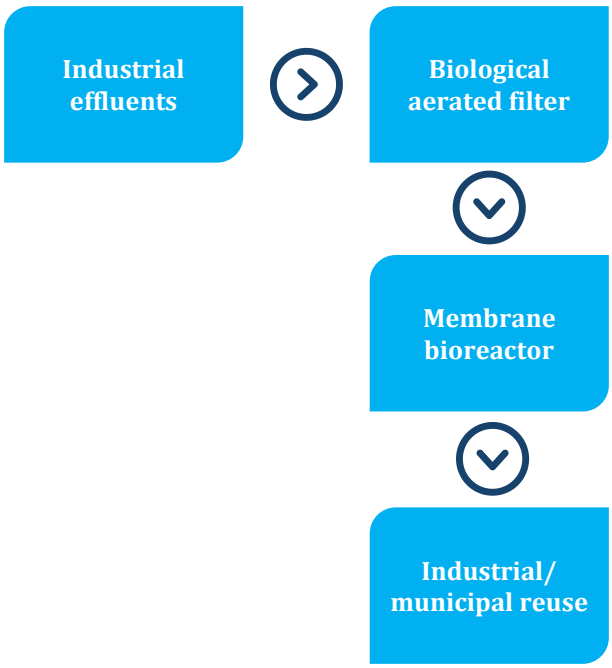


Exhibit 2.1(g): Quality of Treated Effluent

Wastewater Treatment Plant	
Parameter	**Effluent**
BOD_5 (mg/L)	< 20
Total nitrogen (mg/L)	< 20
Total suspended solids (mg/L)	< 20
NH4-N at > 12°C (mg/L)	< 8
NH4-N at < 12°C (mg/L)	< 15

Source: https://www.wwdmag.com/channel/casestudies/addressing-china%E2%80%99s-wastewater-discharge-standards

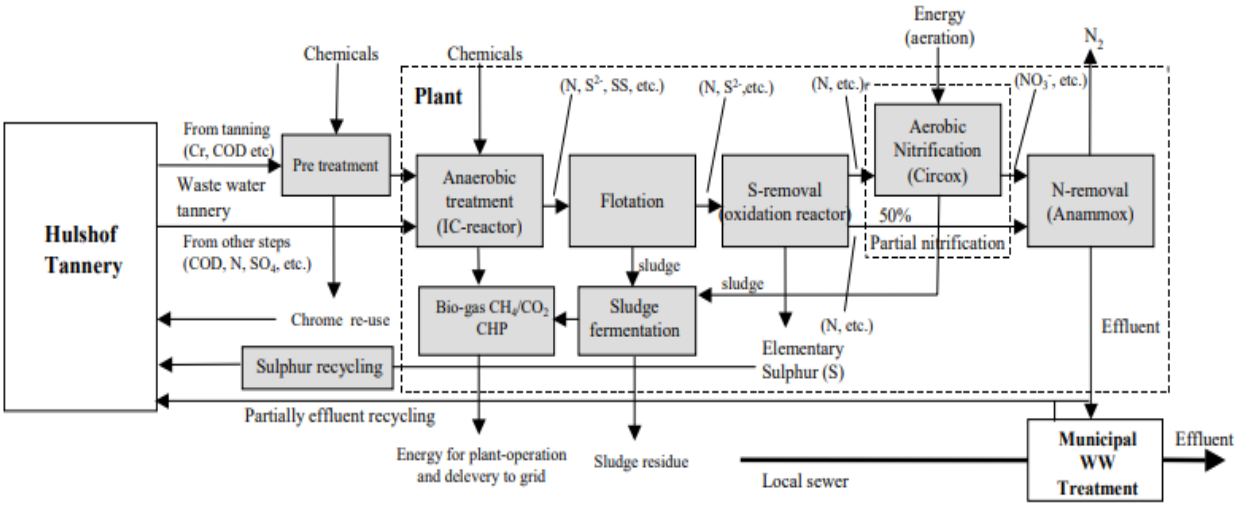
Case Study 4: Tannery Effluent Treatment Plant, Netherlands

General information:
The plant has a smart combination of treatment technologies for the complex tannery effluent realizing high reduction rates (surface water discharge levels).

Wastewater treatment:

Tannery effluent treatment using an innovative, integrated, and compact biological and physical treatment plant.

Exhibit (Case Study 4): Wastewater Treatment Technology Flowchart



Source: Report on "Global good practices in industrial wastewater treatment and disposal/reuse, with special reference to common effluent treatment plants" by CPCB

Case Study 5: AstraZeneca Effluent Plant at Avlon Works, Avonmouth, United Kingdom

General information:

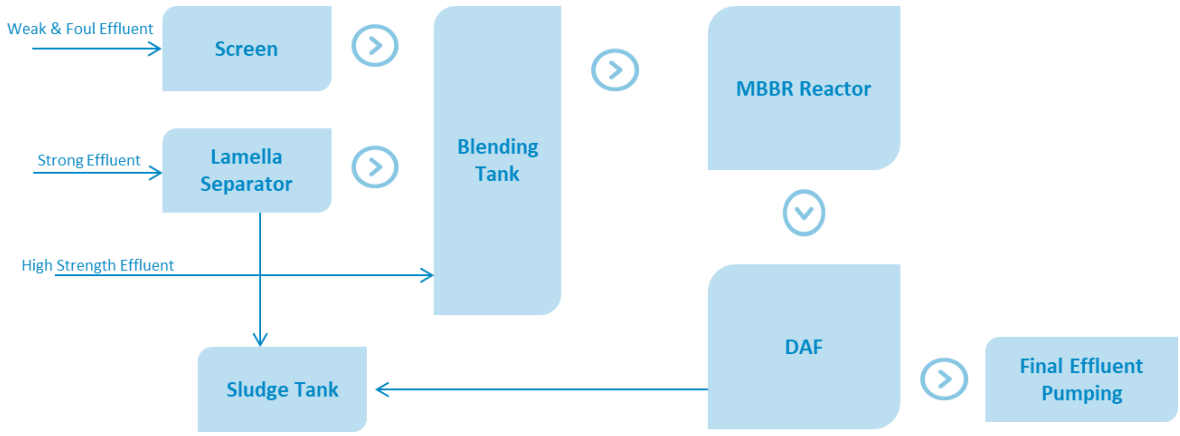
AstraZeneca implemented Anox's MBBR technology that provides a robust treatment process, and this is followed by chemical phosphate removal and a DAF system. The wastewater flow rate ranges from 500 to 2,500 m^3/day.

Wastewater treatment

The biological treatments use Natrix suspended carriers in a mixed bed biofilm reactor process. Biosolids from this process are flocculated and removed by dissolved air flotation.

- Capacity: 500 3,000 m^3/day
- Operational status: Fully functional plant
- Technology: Biological treatment, MBBR, DAF

Exhibit (Case Study 5): Wastewater Treatment Technology Flowchart



Source: Report on "Global good practices in industrial wastewater treatment and disposal/reuse, with special reference to common effluent treatment plants" by CPCB

2.2. ZLD Market Overview

Freshwater scarcity is one of the most critical global challenges in recent times and is posing a threat to water security, economic growth, and the environment. Globally several industrial and municipal facilities draw enormous amounts of fresh water while generating substantial wastewater. The resulting wastewater requires sufficient treatment to mitigate the negative impacts on aquatic ecosystems and human health. Also, with the advent of the circular economy approach, industries have started to develop and implement recycling and recovery practices to improve resource efficiency. ZLD enables the recovery of usable water and treated contaminants from wastewater before reducing it to solid waste, thereby nullifying the harmful environmental impacts. ZLD is achieved by using multiple water treatment technologies to treat the concentrated contaminants present in industrial and municipal wastewater. This includes RO, FO, membrane distillation, MVC, and electrodialysis.

North America and Europe have the most stringent regulations and high ZLD implementation. APAC is experiencing water shortages both in the form of scarcity and stress, especially in China and India, so there is significant potential for ZLD systems across all industries in the region.

Market Drivers

Drivers
Stringent regulations and policies regarding wastewater discharge
Technological advancements in treatment systems
Increasing public awareness and concerns
Water scarcity
Social and demographic trends impacting the ZLD market

Circular economy
Climate change

Stringent regulations and policies regarding wastewater discharge:

- Stringent legislation and policies such as the European Union Urban Wastewater Treatment Directive (UWTD) and the Integrated Pollution Prevention and Control (IPPC) Directive are the principal legislation that regulate the disposal of wastewater from various industries.
- Existing and new regulations in each region encourage industries to consider complete recycling of water and recovery of valuable materials. Incentives and noncompliance penalties will further prompt industries to adopt ZLD technologies.
- Technological advancements will continue, making both ZLD and minimum liquid discharge more affordable and ideal for a wide range of industrial and municipal applications, especially with tightening regulations for brine disposal.

Technological advancements in treatment systems:

- Advancements and innovations in thermal systems, membrane distillation systems, and FO technology will significantly reduce overall operational costs. Development of advanced water treatment technologies will drive demand for affordable ZLD packages. Industries with high water consumption and significant wastewater output are under growing pressure to adopt sustainable water recovery strategies. This, in turn, is driving innovations and advancements that leverage cost-effective ZLD technologies.

Increasing public awareness and concerns:

- Greater public awareness about wastewater pollution will drive ZLD implementation across the globe. For instance, several industrial and wastewater discharge pipeline projects were cancelled due to public protests in China. Qidong city in China protested a paper mill project that proposed to discharge the wastewater into the sea in 2018 and eventually the project was cancelled by the regulators[18]. This growing public concern will urge industries all over the world to adopt ZLD systems as a best practice solution and build a sustainable environment.

Water scarcity:

- In regions with high to extreme water stress, and in countries where intensifying growth and industrialization present mounting risks to water quality, industries that use large volumes of process water and generate highly contaminated waste streams are increasingly required to reduce water consumption. These trends, which are evident in China, India, and the United States, are driving the introduction of stricter environmental regulations that necessitate the use of ZLD. As governments continue to emphasize the need to protect water resources, address rising concerns related to water scarcity, and target heavy metals and

[18] https://ejatlas.org/conflict/planned-industrial-waste-pipeline-project-of-oji-paper-in-qidong-jiangsu-china

other toxic contaminants in wastewater discharges, the use of ZLD systems is anticipated to increase.

Social and demographic trends impacting the ZLD market:

- In India and China, where the industrial water recovery ratio is exceptionally low, present opportunities for ZLD. Developing technologies that can overcome cost barriers and offer sustainable ZLD operations will prove successful in such water-stressed countries.
- Municipal and industrial end users are increasing rapidly due to population growth and investments in industrial segment, and they are looking for sustainable water recycling solutions. India and China are trying to adopt ZLD for industrial parks and thermal power plants.
- In China, the government is stepping up efforts to tackle industrial water pollution and is looking for ZLD technologies that can handle higher volumes of industrial production.
- Industrialization in APAC, North America, and Europe have increased the demand for energy significantly. Companies implementing energy efficient ZLD technologies will have better market opportunities as the government in these countries are emphasising on energy efficiency.

Circular economy:

- The circular economy concept enables the optimal use of water and treat the wastewater to return it to the system, to make it more environmentally and economically sustainable.
- To make water consumable, it is necessary to keep it in a closed loop under ZLD conditions. This will increase the volume of water reused. Circular water management is becoming a frequent practice among both industries and companies to support circular economy.

Climate change:

- Climate change increases water scarcity by altering precipitation intensity and patterns. Greater flooding and precipitation will increase erosion rates and wash soil pollutants into waterways. This will, in turn, drive the demand ZLD implementation.
- ZLD systems in industrial facilities can help meet increasing water demand and produce high-purity water for reuse.

2.3. Global Regulatory Overview

United States: The US EPA enacted the Clean Water Act in 1972 and introduced the National Pollutant Discharge Elimination System (NPDES) permit program to regulate the discharge from industries. The Clean Water Act is a pioneering regulation with a comprehensive list of more than 65 pollutants monitored.

The NPDES permit program addresses water pollution by regulating industries that discharge pollutants into waters bodies.

- The program authorizes state governments to abate water pollution from direct and indirect discharges from industries. Originally, the NPDES permitting, compliance, and enforcement program focused on pollution from large, individual sources such as factories and sewage treatment plants. The specific requirements in the permits are determined by a complex system of regulation that begins with federally established effluent guidelines.
- The regulations govern the discharge of effluents from point sources that include two classes of industrial facilities: direct dischargers, which discharge effluent directly into

water bodies; and indirect dischargers, which discharge effluent into a municipal sewer network.

Construction Grants Program: Federal financial support is provided to develop Publicly Owned Treatment Works (POTWs), i.e., wastewater treatment plants owned and operated by municipalities and local sewer districts.

The national pre-treatment program, under NPDES, controls non-domestic discharges from industrial and commercial establishments into municipal sewer systems.

- The EPA is responsible for identifying standards applicable to each industrial segment and then adopting and implementing them.
- Effluent limitations guidelines (ELG) and pre-treatment standards are the federal standards developed by the EPA for specific industrial segments.

Exhibit 2.3(a): US Industrial Wastewater Regulations

	General and specific standards	Categorical pre-treatment standards	Local limits
All industrial users	✓		May apply; depends on POTW ordinance and permit provisions
Significant industrial users	✓		Generally apply; may depend on allocation method
Categorical industrial users	✓	✓	Generally apply; may depend on allocation method

The US EPA has introduced changes to the NPDES permit program to better address water quality problems. A highlight is a framework in which compliance with regulations and permits can be achieved through accountability, self-monitoring, and electronic reporting.

Exhibit 2.3(b): Summary of US Regulations

Discharge Standards	Discharge standards are elaborately given for all industry categories and all types of pollutants. The standards have been specified for point sources.
Incentives/Support	The EPA continues to research the best technologies to be adopted to abate industrial wastewater pollution.
Emphasis on Reuse	The Waste Recovery Act only addresses solid waste, with no emphasis on reuse of liquid industrial waste.
Penalties	Statutory noncompliance leads to industrial license cancellation. The EPA has developed a framework for statute-specific approaches to penalty assessments with respect to violations against the Clean Water Act.

Source: Frost & Sullivan Analysis

Germany: Germany adopts the EU directives for industrial effluent management. The country has implemented the regulations through an effective effluent taxation system. Regulations are more focused on harmful discharge into water bodies and municipal sewers and are applicable

to all public and private wastewater disposal companies. Highlights from Directive 2010/75/EU of the European Parliament and the Council of 24 November 2010 on Industrial Emissions:

- In accordance with the regulations of the EU, the German Wastewater Regulation defines this State of the Technical Art with respect to municipal wastewater, as well as regarding wastewater from several industries.
- German legislation demands that the quality of wastewater must meet the State of the Technical Art when it is discharged into the waters (57 (1) of the German water conservation law).
- Direct discharges: These companies discharge their wastewater via their own sewerage and wastewater treatment plant into the water bodies.
- Indirect discharges: These companies discharge their wastewater—if necessary, after pre-treatment—via a public sewerage (as a rule a sewer system and a mechanical-biological treatment plant) into the water bodies.
- In addition to the requirements on the spot of discharge into water bodies, there are specific demands on wastewater of given industry segments before this sewage is mixed with another wastewater. These regulations relate to industries emitting harmful substances, such as heavy metals, mineral oil, chlorinated hydrocarbons, cyanides, and complexation agents

Regulations have established industrial wastewater discharge standards for a wide range of industries in Germany

Exhibit 2.3(c): Industrial Sewage Discharge Standards by Industry Type, Germany

Branch of Industry	BOD	COD	NH4-N	N total	P total
Dairy	25 mg/l	110 mg/l	10 mg/l	18 mg/l	2 mg/l
Refinery of edible oils	38 g/t	200 g/t	-	30 mg/l	4.5 g/t
Prod. of refresh. drinks	25 mg/l	110 mg/l	-	-	2 mg/l
Fish processing	25 mg/l	110 mg/l	10 mg/l	25 mg/l	2 mg/l
Production of sugar	25 mg/l	200 mg/l	10 mg/l	30 mg/l	2 mg/l
Production of cellulose	30 mg/l	25 Kg / t	-	10 mg/l	2 mg/l
Chemical industry	-	90% red.	-	50 mg/l	2 mg/l
Prod. of hydrocarbons	25 mg/l	120 mg/l	-	25 mg/l	1.5 mg/l
Textile industry	25 mg/l	160 mg/l	10 mg/l	20 mg/l	2 mg/l

Stringent standards are applicable for discharge of wastewater (industrial) into municipal sewage treatment plants. General demands on industrial and commercial sewage:

- Intermittent wastewater discharges that can overstrain the sewer hydraulically have to be avoided.
- Wastewater that is less polluted than the expected effluent of the sewage treatment plant (STP) should be discharged into the waters directly.

Substances that can affect the function of municipal sewerage and sewage plants must not be dumped:

- Solid waste (trash, rubble, sludge, ash, kitchen stuff)
- Hardening substances (cement, lime, plaster, synthetic resin)
- Inflammable or potentially explosive substances (fuel, alcohol)
- Corrosive and poisonous substances (acid, lye, biocides)
- Mineral and animal or vegetable oils and fats
- Substances that form harmful gases such as hydrogen sulfide (H_2S), hydrogen cyanide (HCN), and chlorine
- Animal feces (dung, liquid manure)

German law mandates for the register of industrial polluters to gauge the potential danger of an industrial polluter. The key functions include:

- Direct control and supervision of wastewater-relevant industrial plants and enterprises.
- Supervision of junctions in the sewerage network to locate conspicuous/illegal effluents to define the relevant enterprises by the polluter register
- Tracking of illegal sewage discharges

The following parameters are monitored:

- Sewerage (hydraulic, solid substances, grease and fat, explosive hydrocarbons)
- Health protection and safety (temperature, pH-value, H_2S, mineral oil, cyanide, benzol, phenol)
- Environment of the municipal sewerage (status of sewerage, utilization of STP, development, odor problems)
- Wastewater treatment and sludge disposal (Carbon /Nitrogen /Phosphorous-relation, grease and fat, mineral oil, heavy metals, Adsorbable Organic Halides (AOX), biocides)
- Constructions in sewerage and sewage treatment plants (temperature, pH-value, H_2S, sulfate, ammonia)
- Local conditions (storage of dangerous substances, risk of accident)

Exhibit 2.3(d): Summary of Regulations, Germany

Discharge Standards	Discharge standards are elaborately given for all industry categories and all types of pollutants. The standards have been specified for point sources
Incentives/Support	Regulation focuses more on monitoring and restricting hazardous waste into public sewer and not incentives.
Emphasis on Reuse	No emphasis on reuse of Industrial waste. The industry unit at its will could come up with technologies to reduce hazardous disposal.
Penalties	Effluent tax system

Source: Frost & Sullivan Analysis

2.4. Climate Change and its Impact on the Water Sector

An increase in evaporation, high precipitation received as rain rather than snow, changes in the duration of seasons, rising water temperatures, and a decrease in water quality in interior and coastal areas are the major implications on water resources because of climate change. The increase in evaporation could result in declining water quantity across many regions. Severe and frequent droughts could be another implication. This would increase the pressure on governmental organizations to effectively distribute water resources among agriculture, industrial, and municipal end users.

The Intergovernmental Panel on Climate Change (IPCC), part of the United Nations, is responsible for creating awareness of human-induced climate change and expects global warming of at least 1.5^{0}C within the next two decades, which would result in radical changes in the water cycle and increase the Earth's temperature. Changing water cycles could result in already wet regions getting more rainfall and arid parts of the world facing severe droughts. The IPCC also states that for every additional 1°C of global warming, rainfall would intensify by 7%. Climate change's impact on water resources would be felt throughout the world. An effective way to manage/mitigate water availability issues caused by climate change is adopting recycling and reuse solutions.

2.5. Digitalization/IoT in Water Sector

Factors driving digitalization globally include

- **Efficiency and sustainability:** Energy and chemical costs are the major OPEX components of a water and wastewater utility. Conventional operation methods are unsustainable and cost intensive. New regulatory polices/initiatives aim to improve efficiency and sustainability. Smart water solutions through automation, analytics, and intelligence enable system optimization that improves efficiency and sustainability.

- **Improved return on investment:** Lack of funding and timely investments have led to aging water infrastructure that is inefficient, has suboptimal performance and generates low return on investment (ROI). AI/advanced data analytics platforms enable water utilities to make intelligent business decisions for new build, repair, or rehabilitation projects. These smart solutions offer virtual operations, intelligent resource optimization, and asset management that significantly improve ROI.
- **Resilience to climate change (smart is the new green):** Water stress is most common in rapidly urbanizing areas. Climate change and its effect on water resources have significantly impacted economic growth. Smart solutions can provide customers with predictive and prescriptive intelligence and effectively improve the resilience of the infrastructure and minimize the damage to the environment.
- **Customer experience:** Public and regulatory scrutiny of water utilities is increasing. Providing quality services along with resource accountability has become top priority and is spurring the implementation of smart water metering and non-revenue water (NRW) loss management projects.

Digitalization is the focal point of innovation across the water industry value chain.

Exhibit 2.5(a): Industrial Wastewater Treatment Technologies

	Abstraction-water/ wastewater treatment and reuse	Trading	Transmission and distribution	Retail	Consumption
Big data, IoT, Cloud, AI and ML	Predictive maintenance	Trading optimisation	Autonomous grids	Tariff optimisation	Active water management
Connection and integration	Storage; Recycled water integration	Leakage management		Smart metering; Grid optimisation	Demand response
Cyber security	Water cyber security				
New business models	Decentralised water	Automated trading	Micro-grids		
Customer engagement tools	Peer-to-peer (P2P) models			Commercial and industrial water optimization	Home water management

Source: Frost & Sullivan Analysis

IoT trends in water and wastewater utilities: Challenges that accelerate IoT adoption are

- **Environment/regulatory pressure and compliance cost:** Climate change, water pollution, water stress, and drought along with enforcement agency scrutiny and regulatory pressures are pressuring utility managers to improve infrastructure efficiency and environmental sustainability.
- **NRW loss:** NRW losses globally exceed USD 39 billion (INR 3040.11 billion) each year. Service disruptions and compromised service quality due to NRW loss have caused significant economic and environmental impact on water utilities.

- **High operating cost:** Rising OPEX (especially energy and chemical costs for treatment and pumping) is a financial burden for most publicly owned water utilities. Utilities across the globe are exploring multiple solutions to optimize their operating cost.
- **Aging infrastructure:** One of the top reasons for poor compliance also significantly impacts system efficiency, supply, and demand. The high cost of rehabilitation and the long lead time for implementation have led utilities to explore asset condition monitoring and management solutions.
- **Repair or replacement challenge:** Budgetary constraints affect decisions to repair or replace equipment or assets, which ultimately can impact system performance. These decisions require expertise and experience.

Exhibit 2.5(b): IoT Solutions and Benefits for Utilities

Solution	Benefits
Smart meters and sensors	• Continual smart water quantity and quality monitoring and smart leak monitoring and detection help water utilities in compliance tracking, safety monitoring, and NRW reduction to increase process system efficiency and save energy and chemicals. • Smart connectivity enables seamless digital data transfer and a two-way communication between the sensor and utility operator. It enables complete system automation enhanced by machine learning and AI. It significantly improves data transparency. • Smart analytics provides benefits such as efficient resource allocation and budgeting, customer data and billing management, and predictive and preventive maintenance that could enhance equipment and infrastructure life. • Data-driven prescriptive maintenance and decision intelligence enables utility operators to make economical, efficient, and sustainable decisions.
Smart connectivity	
Smart analytics	
Smart intelligence	

IoT trends in water and wastewater treatment plants: Challenges that accelerate IoT adoption are

- **Quality and safety monitoring:** Treatment facilities are accountable for the safety and quality of the treated water or wastewater. Non-compliance with quality or discharge regulations could result in severe penalties or be a public health risk.
- **Process control:** High organic loading, flow variations, and industrial pollutants affect the efficiency of media, membrane, biological, or any other water and wastewater treatment technology and could disrupt the treatment process and compromise quality and safety.

- **Chemical and energy efficiency:** Energy and chemical costs saddle water and wastewater treatment plant OPEX, so efficiency is crucial to a facility's long-term sustainability.

Exhibit 2.5(c): IoT Solutions and Benefits for Treatment Plants

Solution	Benefits
IoT water quality and measurement sensors	• IoT sensors include advanced communication modules that transmit data to the control system. The sensors have a two-way communication capability and can self-calibrate, provide diagnostics, be remotely monitored, and offer near-real-time system visualization. Digitalization has enabled predictive maintenance and continual sensor health monitoring. • Data analytics platforms enable real-time system optimization and fine tuning to significantly improve process efficiency and optimize chemical and energy consumption. Advanced analytics platforms also provide decision and predictive intelligence. AI-based platforms completely automate plant operations or assist in virtual operation, significantly enhancing infrastructure sustainability.
Smart analytics and AI	

IoT use in India's water and wastewater sector is low but has high potential for growth given the severe water stress and challenges. IoT solutions can effectively monitor water resources and assets and would enable optimal municipal and industrial water management. Another factor driving the adoption of IoT in India are companies' environmental, social and governance (ESG) practices and efforts to meet UN Sustainability Development Goals (SDG).

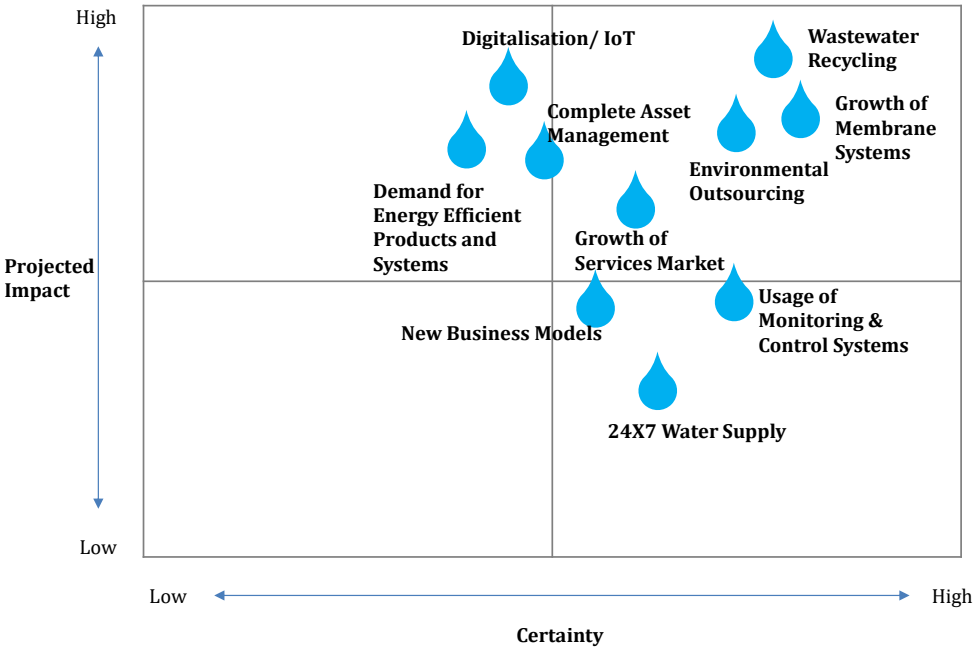
Chapter 3: Indian Water and Wastewater Treatment Solutions Market Analysis

3. Market Overview

The Indian water and wastewater treatment solutions market is in the growth stage with the industrial and municipal segments offering opportunities. High industrial growth, rapid urbanization and associated economic activities, and groundwater depletion will contribute to market growth in the coming years.

The market is switching gears from price to value. With more private participation, the number of BOT and build, own, operate, and transfer (BOOT) projects spanning 15 to 30 years is on the rise. These projects reshape the market landscape from price-driven to value- and performance-oriented. Public-private partnerships (PPP) in the municipal segment offer a solution in which private companies, municipalities, and consumers benefit. Private companies receive business opportunities to design and deliver innovative solutions, while municipalities and consumers benefit from improved efficiencies and effectiveness through innovation, responsibility-sharing, and financing.

Exhibit 3: Water and Wastewater Market Trends



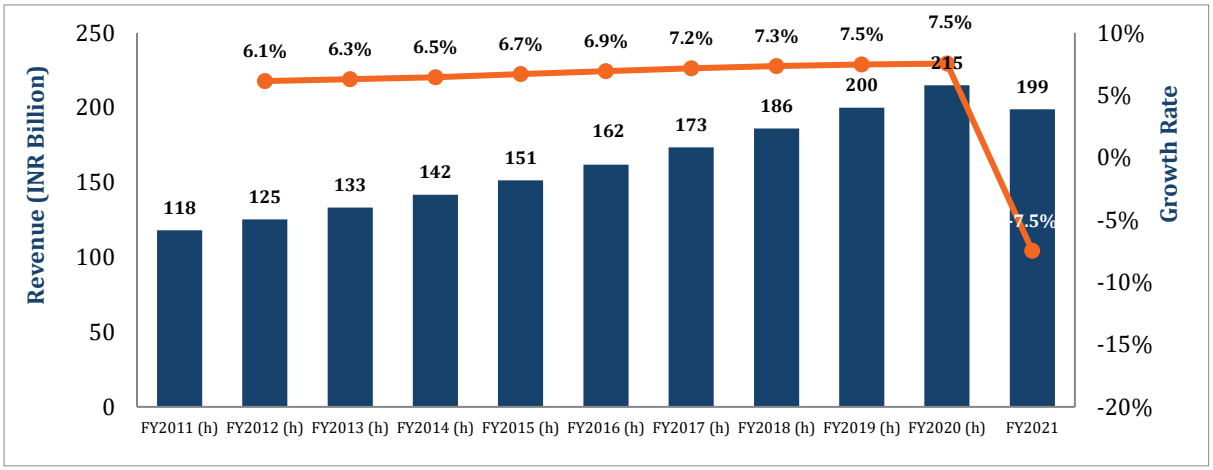
Source: Frost & Sullivan Analysis

New business models further drive market growth. Municipal corporations/ urban local bodies (ULB) have been procuring projects through a hybrid annuity model (HAM) that combines EPC and BOT models. The Indian government will contribute 40% of the project cost in annual payments while private companies will foot the bill for the remaining 60%. For example, the Sarai 14 MLD STP in Haridwar was developed through a HAM in 2019 under the National Mission for Clean Ganga (NMCG). The success of HAMs could help municipal organizations overcome financial constraints and accelerate the demand for water infrastructure in India.

Market value stood at INR 199 billion in FY2021. The estimate includes revenue from water and wastewater treatment systems/equipment and services sold to municipalities and industries

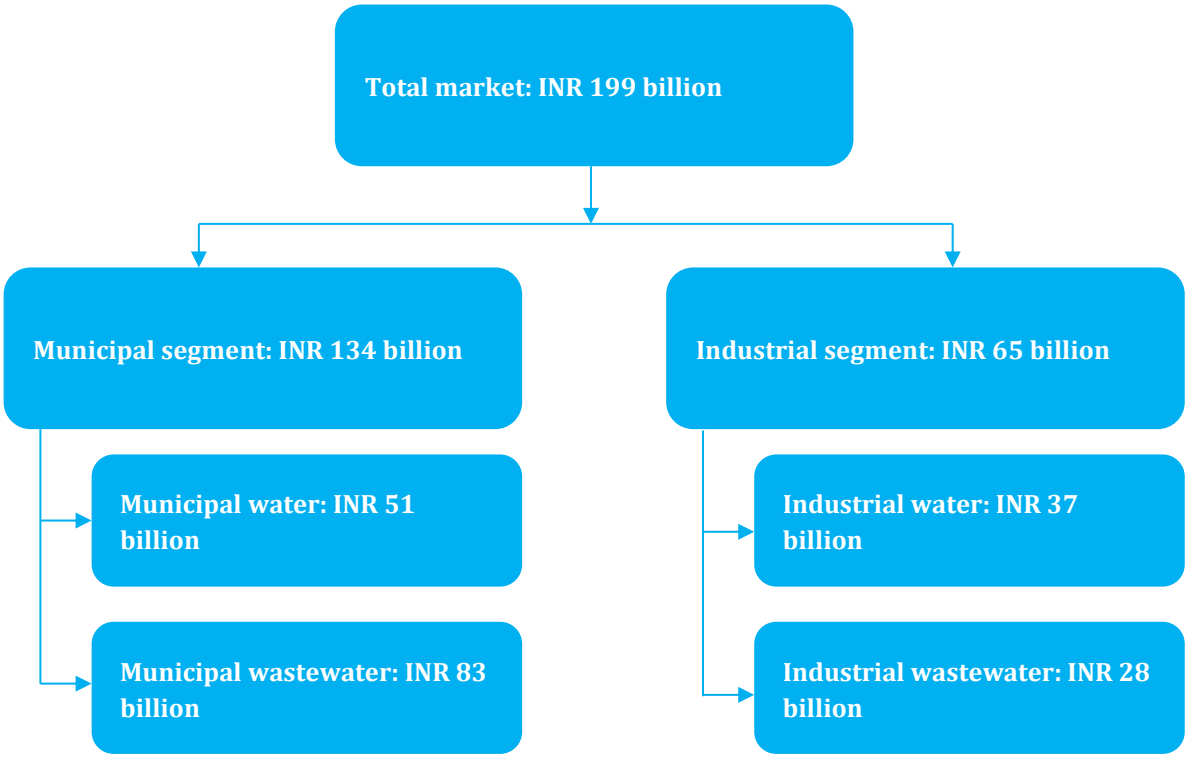
only but does not include the commercial and residential segment and revenue from water networks, pumping stations, wastewater networks, and other water infrastructure projects such as irrigation networks and reservoirs.

Exhibit 3(a): Water and Wastewater Treatment Solutions Market Size, India, FY 2011–FY2021



h-historical, a-actual; Source: Frost & Sullivan Analysis

Exhibit 3(b): Water and Wastewater Treatment Solutions Market Size and Segmentation, India, FY2021



Source: Frost & Sullivan Analysis

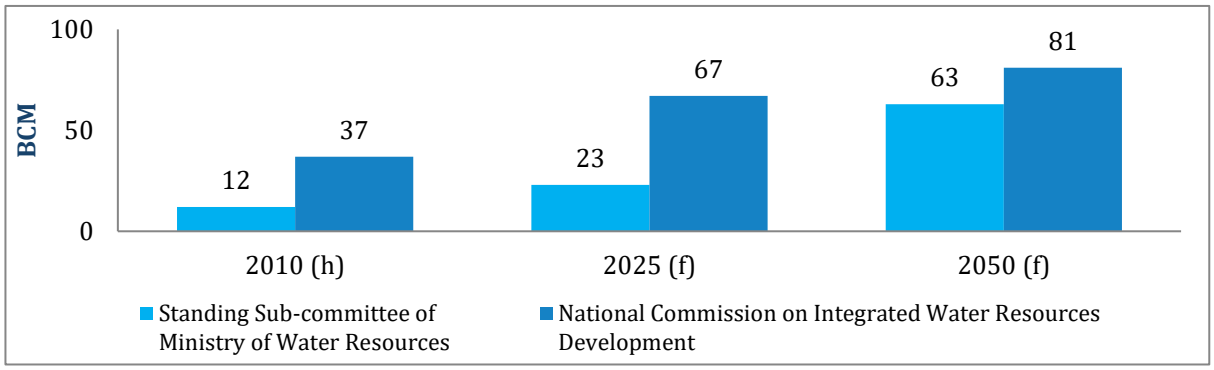
3.1. Market Drivers and Restraints

Drivers
Increasing demand for industrial process water
Rising population and increasing per capita consumption
Aging infrastructure and its low operational efficiency
Water scarcity or lack of water availability
Limited wastewater network coverage and treatment infrastructure
Water cross-contamination
Pollution control regulations
Government policies and initiatives
SDGs and recycling systems
Initiatives/regulations to control ocean/sea outfall discharge practised in coastal areas

Source: Frost & Sullivan

Increasing demand for industrial process water: Economic diversification to reduce India's dependence on the services sector is accelerating industrial growth, especially in power, oil and gas, refineries, and chemicals and petrochemicals. Industries in the country are likely to adopt global best practices because product quality is a competitive factor and power, chemical and petrochemical, and pharmaceutical companies require high-purity water. The demand for industrial process water will increase with India's industrial output, driving the need for industrial effluent treatment.

Exhibit 3.1(a): Industrial Water Requirements by End Users, India, 2010–2050



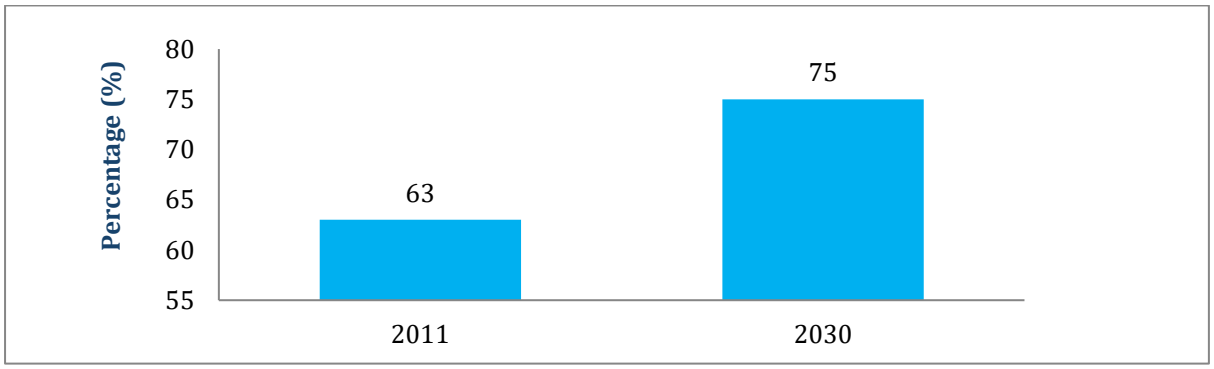
h-historical, f-forecast

Source: Environment Statistics India, 2011; Central Statistical Office; Ministry of Statistics and Program Implementation, Government of India[19]

Note: This is the most recent published, government and credible source available for projected water demand by users including industrial segment.

Rising population and per capita consumption: Urban India is the epicenter of industrial growth and population. As the population grows, municipal corporations and ULB find it difficult to provide basic amenities such as water and sanitation. Groundwater levels have decreased in several urban areas following poor and uneven rainfall patterns and overexploitation of resources. Central Ground Water Board (CGWB) analysed the decline in ground water levels by comparing the CGWB data from November 2020 with the decadal average from 2010 – 2019 and the results state that 33% of the ground water tables monitored have recorded a 0 – 2 meter decline in ground water levels. Cities such as Delhi, Chennai, Indore, Coimbatore, Madurai, Vijayawada, Dehradun, Jaipur, Allahabad, Ghaziabad, Kanpur, and Lucknow have registered a ground water decline of more than 4 meters. Coastal cities opt for seawater RO desalination to overcome water shortages – for example Chennai city has developed two desalination plants. A growing population also drives industrial growth, pushing up industrial water demand in India.

Exhibit 3.1(b): GDP Contributions of Urban Areas, India, 2011 and 2030



Source: Census 2011, Ministry of Urban Development's Smart Cities Mission Statement & Guidelines 2015[20]

Note: This is the most recent, published, government and credible source available for urban GDP contribution.

Aging infrastructure and low operational efficiency: India has long followed a build-neglect-rebuild approach in its water and wastewater infrastructure, resulting in suboptimal operations. India has a sewage treatment installed capacity of 26,869 MLD as of 2020 and about 1,406 MLD[21] is non-operational. The inability to retrofit and replace wastewater treatment plants because of tight budgets has led to poor performance in existing infrastructure. With municipal corporations and ULBs lacking the necessary workforce for plant O&M, the retrofit and O&M of existing STP present growth opportunities for water and wastewater service providers.

[19] https://www.nabard.org/auth/writereaddata/tender/2010165456All_India_Projected_Water_Demand.pdf

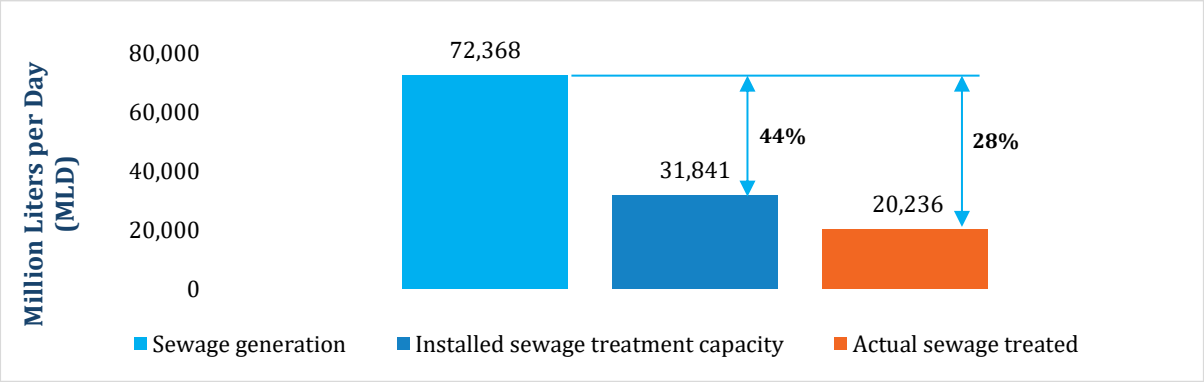
[20] https://policy.asiapacificenergy.org/sites/default/files/smartcityguidelines.pdf

[21] https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTIyOF8xNjE1MTk2MzIyX21lZGlhcGhvdG85NTY0LnBkZg==

Water scarcity or lack of water availability: Water shortages in India have an adverse impact on industry, which could lead to production cuts and revenue loss. The physical risks related to the availability and quality of water are extremely high for industries such as textiles, pharmaceuticals, food and beverages, and pulp and paper and are spurring investments in industrial wastewater treatment and recycling systems.

Limited wastewater network coverage and treatment infrastructure: Domestic sewage treatment in urban areas is insufficient, with only 28% of generated wastewater undergoing treatment in urban India as per a CPCB report titled *National Inventory of Sewage Treatment Plants* published in March 2021[22]. CPCB has identified highly polluted river stretches to be in and around large urban areas. Growth opportunities to build wastewater treatment capacity exist, especially for wastewater recycling and reuse for applications such as process water, landscaping, and toilet flushing.

Exhibit 3.1(c): Sewage Generation and Treatment Capacity, Urban India, 2020



Note: the % values indicate the gap in treatment capacity

Source: CPCB *National Inventory of Sewage Treatment Plants* report published in March 2021

Water cross-contamination: Water distribution systems in India are old – for example, some pipelines in Delhi are more than 50-60 years old[23], and because of lack of proper maintenance there is higher probability of cross-contamination, which makes the water unfit for direct consumption and creates the need for further treatment.

Pollution control regulations: Water laws and regulations are becoming increasingly stringent and requiring compliance from industries. Many states such as Bihar offer tax breaks to start-ups to establish wastewater treatment facilities. The Indian government also provides loans at zero-percent interest on a case-by-case basis. With greater regulatory compliance and awareness, more companies will adopt water and wastewater treatment systems and stop discharging waste effluents directly into water bodies.

Government policies and initiatives: With water becoming a scarce commodity, the Indian government develops water policies and undertakes initiatives to reduce water stress. It

[22] https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTIyOF8xNjE1MTk2MzIyX21lZGlhcGhvdG85NTY0LnBkZg==

[23] https://indianexpress.com/article/cities/delhi/continuous-water-supply-delhi-jal-board-households-pipelines-leakages-5599397/

established the National Water Mission (NWM) in 2011 to ensure that a considerable share of industrial water demand is met through recycling effluents and domestic sewage. The NWM also caters to coastal cities' water requirements through seawater desalination. The government has initiated the rejuvenation of national rivers, such as the Ganga and Yamuna, with Namami Gange and the National River Conservation Plan (NRCP). It also strives for sustainability through Swachh Bharat Mission, Jal Jeevan Mission, and National Smart Cities Mission, which would create demand for water and wastewater equipment. Under the national infrastructure pipeline (NIP), INR 2.79 trillion worth of water and wastewater treatment projects are expected to be implemented as of May 2022[24] by the Government of India.

SDGs and recycling systems: Industrial sustainability and climate actions address water and energy challenges, with some companies committed to reducing their resource consumption and waste generation.

Initiatives/regulations to control ocean/sea outfall discharge practised in coastal areas: A decade ago the most common practice for industrial effluent discharge was disposal in nearby oceans/seas, but regulators are taking steps to prevent this. The National Green Tribunal directed all coastal states and union territories to submit action plans to the CPCB to prevent discharge of sewage and industrial effluents from wastewater generators in seas.

Restraints
Slow implementation of regulations
Fragmented market

Source: Frost & Sullivan Analysis

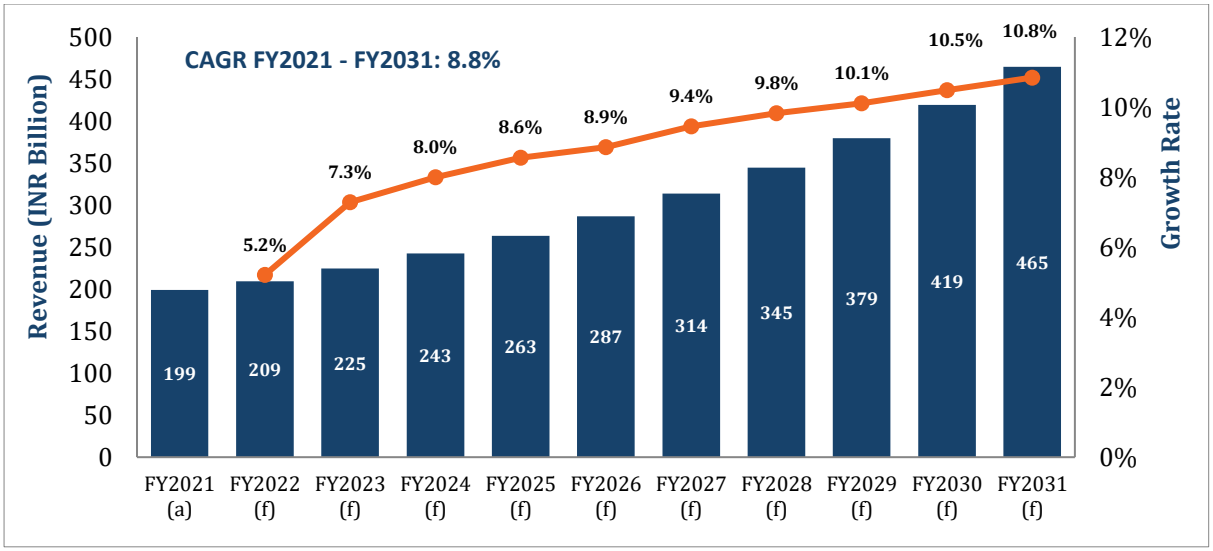
Slow implementation of regulations: Although India has a roadmap for efficient water management, it is slow in carrying out reforms and policies. Bureaucratic hurdles, lack of proper delivery systems, and inadequate staffing are critical issues that need to be addressed by ULB/ municipal corporations at the implementation level. The CPCB formulates policies while the SPCB implements regulations. Inconsistent and delayed regulatory enforcement has become the norm because two separate boards are responsible for framing and implementing regulations.

Fragmented market: Numerous small and medium-sized companies try to outdo each other by offering systems at low prices, triggering price wars. End users' price sensitivity and the broad base of small and medium-sized companies in end-user segments such as food and beverage, pharmaceuticals, and textiles prevent market consolidation.

Based on the above analysis, Frost & Sullivan forecasts the water and wastewater treatment solutions market in India to grow at a CAGR of 8.8% from FY2021 to FY 2031 and reach INR 465 billion.

Exhibit 3.1(d): Water and Wastewater Treatment Solutions Market Forecast, India, FY 2021–FY2031

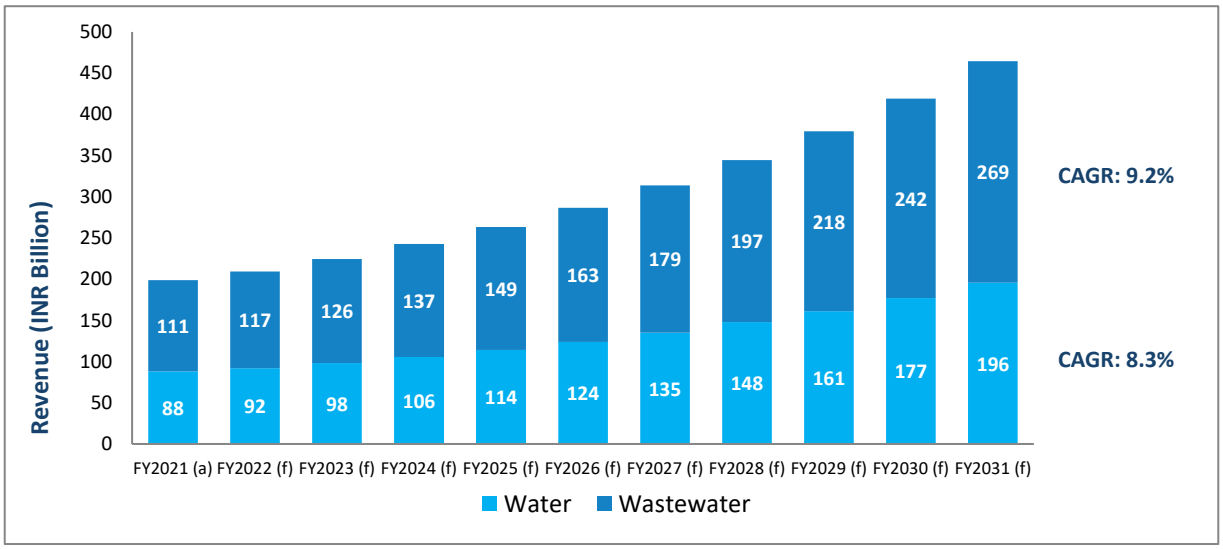
[24] https://indiainvestmentgrid.gov.in/sectors/water-and-sanitation/water-treatment-plants



a-actual, f-forecast; Source: Frost & Sullivan Analysis

Frost & Sullivan projects wastewater treatment solution revenue to grow at a CAGR of 9.2% and water treatment solutions revenue at a CAGR of 8.3% from FY2021 to FY2031.

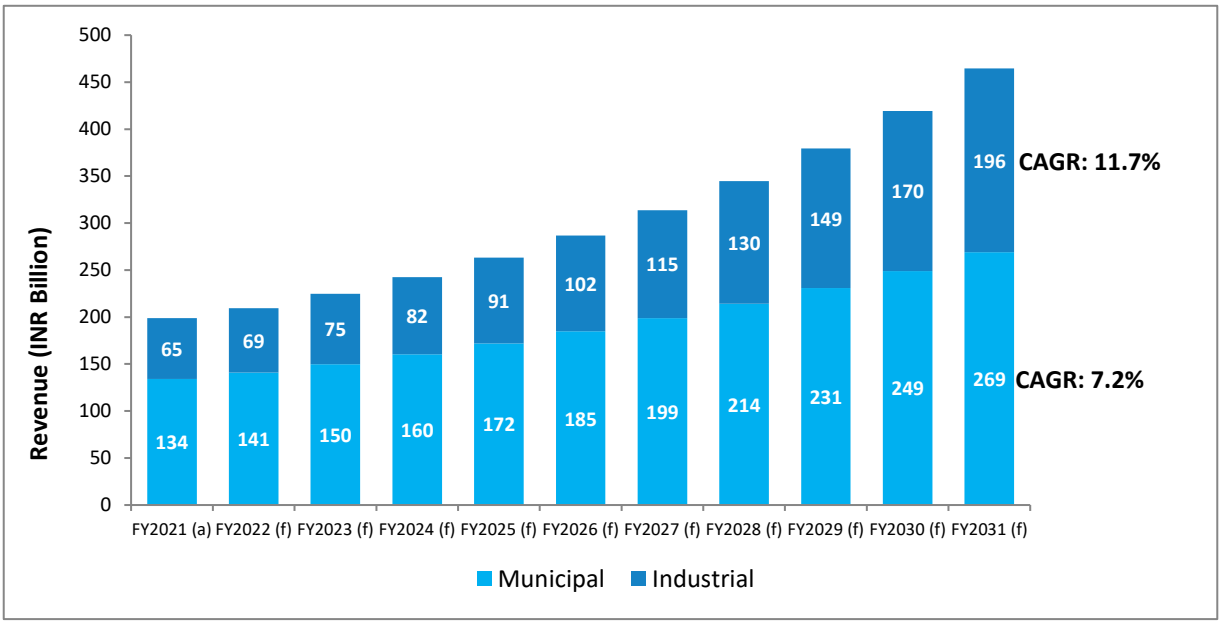
Exhibit 3.1(e): Water and Wastewater Treatment Solutions Market Forecast by Application, India, FY 2021–FY2031



a-actual, f-forecast; Source: Frost & Sullivan Analysis

Frost & Sullivan anticipates that the industrial segment revenue, backed by investments and regulations, will increase at a CAGR of 11.7% from FY2021 toFY2031, which is higher than the projected municipal segment CAGR of 7.2%.

Exhibit 3.1(f): Water and Wastewater Treatment Solutions Market Forecast by End-ser Segment, India, FY 2021–FY2031



a-actual, f-forecast; Source: Frost & Sullivan Analysis

3.2. Leachate Treatment for Municipal Solid Waste Landfill Management: An Opportunity for Wastewater and Recycling Systems

The most common methods of municipal solid waste (MSW) disposal in India are landfilling or open dumping. More than 3,000[25] open landfills in India have exceeded their capacity but remain operational. These sites are unscientifically constructed and cause irreversible damage to the environment because of leachate. Leachate treatment in India is at a nascent stage and most is untreated. Leachate management is regulated, but enforcement is not effective and compliance is minimal. The number of leachate treatment systems would increase in the future owing to the anticipated effective implementation of regulations, with the focus on sustainability and UN SDGs acting as a catalyst and creating opportunities for wastewater treatment solution providers in major urban clusters.

Regulations for Leachate Management in India

Exhibit 3.2(a): Disposal of Treated Leachate, India

Parameter	Standards (mode of disposal)		
	Inland surface water	Public sewers	Land disposal
Suspended solids, mg/l, max	100	600	200
Dissolved solids (inorganic) mg/l, max	2,100	2,100	2,100

[25] "Clean it Right, Dumpsite Management in India" report published by Centre for Science and Environment in 2020 (https://www.cseindia.org/content/downloadreports/10487)

pH value	5.5–9.0	5.5–9.0	5.5–9.0

Source: CPCB (https://cpcb.nic.in/uploads/MSW/SWM_2016.pdf)

Case Studies of Leachate Treatment at Municipal Landfills in India

- Bruhat Bengaluru Mahanagara Palike (BBMP):
  - BBMP has two leachate treatment plants, one at Bellahalli quarry pit and the other at Doddabidarakallu.
  - Bellahalli plant has a capacity of 1.2 lakh liters and Doddabidarakallu has a capacity of 25,000 liters.
  - Treatment process[26]:
    - Stage 1: Raw leachate is processed in a "boomtube resonator" where the pollutants are broken down into elemental state.
    - Stage 2: Output from stage 1 has pollutants that are separated as suspended solids of very fine particles. This is stored in a collection tank and the finer particles are made bigger with a thickener.
    - Stage 3: Water is pumped to settle the bigger particles, which are later removed as sludge and dried in a drying bed.
    - Stage 4: A filter feed pump is used to pump water to a multi-stage dual media filter and specialized activated carbon filtration system.
    - Stage 5: Water is processed through a specialized industrial filtration system that provides clean and fresh water.

BBMP is in the process of setting up three more leachate treatment plants at Bommanahalli, Chikkanagamangala, and Doddabidarikallu.

Leachate Management Technologies

Exhibit 3.2(b): Selected Leachate Management Technologies

Area (Landfill)	Country	Technology
Lapeyrouse-Fossat	France	Inlet-> coagulation flocculation-> aerobic treatment-> ozonation-> outlet
Saint-Etienne	France	Inlet-> coagulation flocculation-> biological nitrification denitrification-> chemical precipitation-> ozonation-> outlet
Bagnols-en-Forêt	France	Inlet-> coagulation flocculation -> UF membrane -> bioreactor-> ozonation
Southwest (Anonym1)	Finland	Filtration and active carbon
Lahti (Hollola)	Finland	Artificial soil filtration
Skedsmokorset (Böler)	Norway	SBR
Fifholt (new landfill cell)	Iceland	Sand bed filtration

[26]https://www.thehindu.com/news/cities/bangalore/more-leachate-treatment-plants-likely/article24247192.ece

Odayeri Treatment Plant	Turkey	Equalization tank-> primary clarifier-> pump-> anoxic tank-> aerobic tank-> ultrafiltration-> nanofiltration

Source: Frost & Sullivan Research[27]

3.3. Overview of Major Companies

Entities in the water and wastewater value chain that come together to provide water management solutions to end users include technology providers, component suppliers, and water EPCs for projects and services. A technology provider could also be a water EPC that bids for contracts independently and after a win will procure components from the open market and install and commission the water or wastewater treatment plant for the client, or a water EPC and technology provider could form a partnership on a case-to-case basis.

More than 250 companies compete in the Indian water and wastewater space and provide diverse systems and services to a vast number of end-user segments such as power, oil & gas, petrochemicals, food & beverage, metals & mining etc. Extensive competition on the pricing front exists at the unorganized level especially in the wastewater treatment equipment segment.

Ion Exchange, VA Tech Wabag, Concord Enviro, Degremont, Suez, Doshion Veolia Water Solutions, Ramky Infrastructure, and Hindustan Dorr-Oliver are the leading companies in the market.

Very large companies are characterized by their ability to provide turnkey solutions and end-to-end water management solutions. Medium and small companies are witnessing competition depending on their ability to provide cost competitive systems, and industry-specific water and wastewater solutions.

[27] https://www.researchgate.net/profile/Christian-Coste/publication/268335921_LANDFILL_LEACHATE_TREATMENT_CASE_STUDIES/links/5a4224b8aca272d294570134/LANDFILL-LEACHATE-TREATMENT-CASE-STUDIES.pdf, https://www.sciencedirect.com/science/article/pii/S2666016420300700, https://www.researchgate.net/publication/265416262_Landfill_leachate_treatment_a_case_study_for_Istanbul_City

Exhibit 3.3: Competitive Structure, India, 2021

Segment	Characteristics	Revenue	Key Participants (Examples)
Very Large Players	Offer turnkey water and wastewater treatment solutions; have industrial and municipal engineering, design, manufacturing, and project management expertise; primarily focus on large municipal projects	More than INR 5,000 Mn	VA Tech Wabag, SPML Infra Limited, L&T Water Division, Ion Exchange
Large Players	Can offer turnkey industrial solutions; some offer high-purity process water for pharmaceutical and food and beverage clients	INR 1,000 – INR 5,000 Mn	Thermax, IVRCL, Ramky Infrastructure, Triveni Engineering, Concord Enviro
Small & Medium Players	Have localized operations and limited capacities and project management abilities except for companies such as Voltas Water Solutions and Permionics that stand out in this space.	Less than INR 1,000 Mn	Permionics Membranes, Sun Enviro Technologies, TSA Process Equipments, APF Water Systems, Komal Industries, Morf India

Source: Frost & Sullivan Analysis

The high growth of Indian water and wastewater sector is attracting renowned water and wastewater technology providers from around the world that either operate directly through subsidiary offices or form joint ventures, technology licensing agreements, or project-specific alliances with Indian companies. Foreign companies have the advantages of cost competitiveness, experience, and references. Water EPC companies look for foreign alliances especially for technology transfer, partnerships with main plant contractors/civil contractors to bid for large industrial and municipal projects, utility management practices, instrumentation, and rehabilitation technologies.

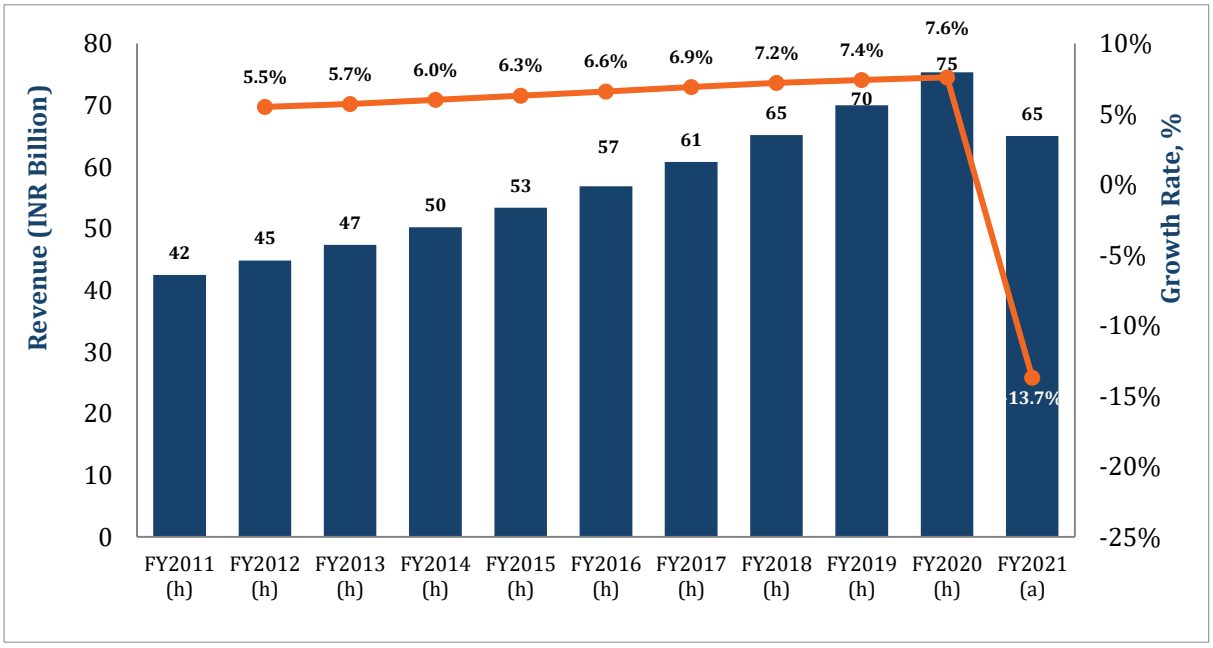
Chapter 4: Indian Industrial Water and Wastewater Treatment Solutions Market Analysis

4. Market Overview and Segmentation

The industrial water and wastewater treatment solutions market was valued at INR 65 billion in FY2021. The market recorded a CAGR of 6.6% from FY2011 to FY2020. The pandemic contributed to a 13.7% decline in FY2021.

Industrial demand would grow as investments in infrastructure, such as the Delhi–Mumbai Industrial Corridor Project (DMIC) catalyse growth in the food and beverage, engineering, metals, textile, chemicals and petrochemicals, automobiles, electrical, and electronics industries. India is a fast-growing location for the power industry, and new initiatives such as the Petroleum, Chemical, and Petrochemical Investment Region (PCPIR) to develop the country's downstream oil and gas industry will support market growth.

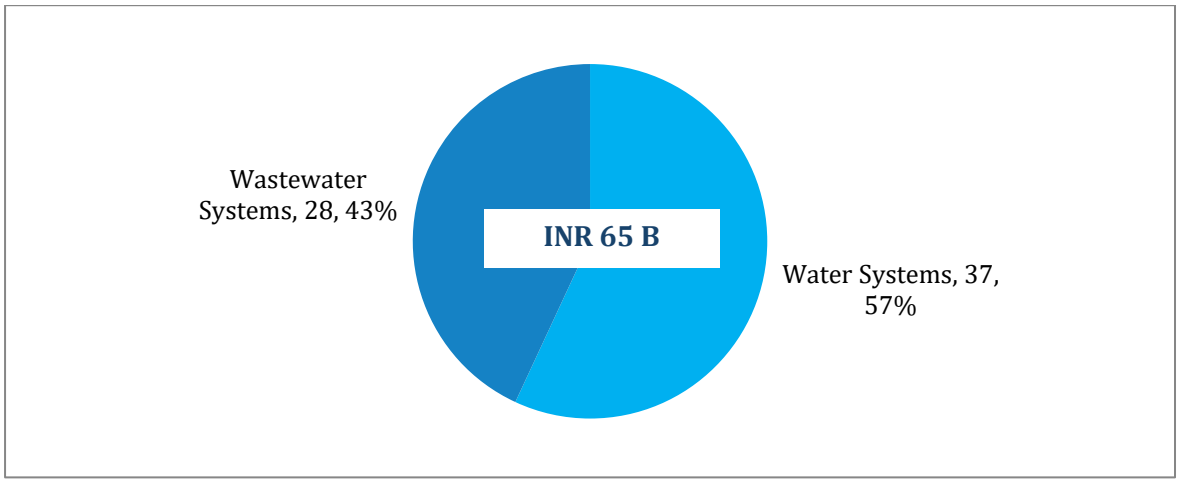
Exhibit 4(a): Industrial Water and Wastewater Treatment Solutions Market Size, India, FY 2011–FY2021



h-historical, a-actual; Source: Frost & Sullivan Analysis

Market Segmentation by Application: Industrial water treatment includes applications for process water used in manufacturing and is directly related to the end product's output and quality. Over the last decade, end users have slowly shifted from conventional water treatment technologies (e.g., filtration, demineralization, softeners) to RO membrane-based systems. Increasing high-purity water demand, health awareness, and globalization propel the growth of membrane-based systems. Industrial wastewater treatment includes treating the effluent by-product of various processes. Industrial regulations drive the growth of the wastewater treatment equipment market.

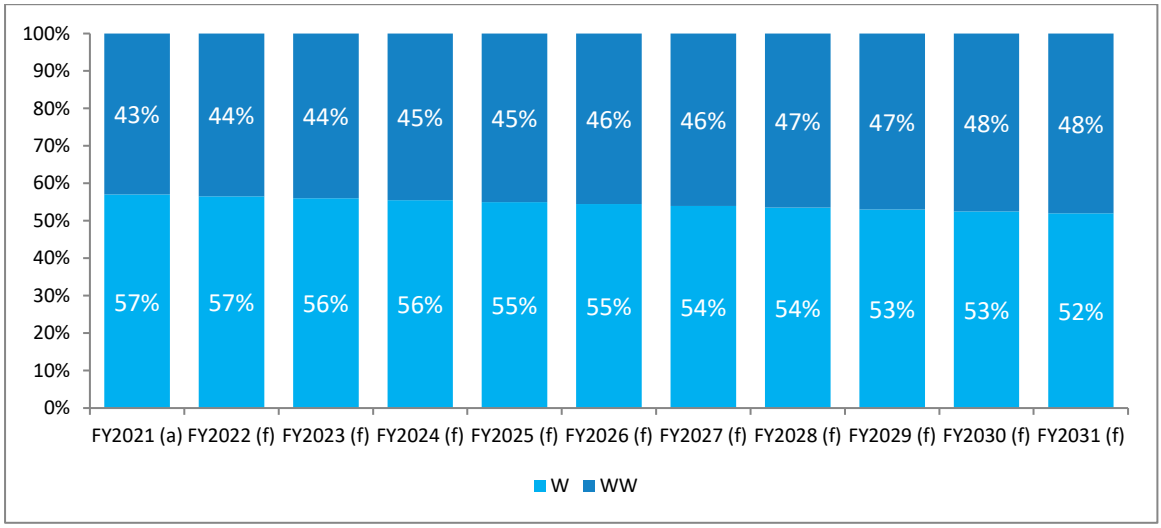
Exhibit 4(b): Industrial Water and Wastewater Treatment Solution Market Size by System Type, India, FY2021



Source: Frost & Sullivan Analysis

Wastewater treatment solutions would witness higher growth than water treatment solutions because of regulations and end-user sustainability initiatives.

Exhibit 4(c): Industrial Water and Wastewater Treatment Solutions Market Size Forecast by Application, India, FY 2021–FY2031

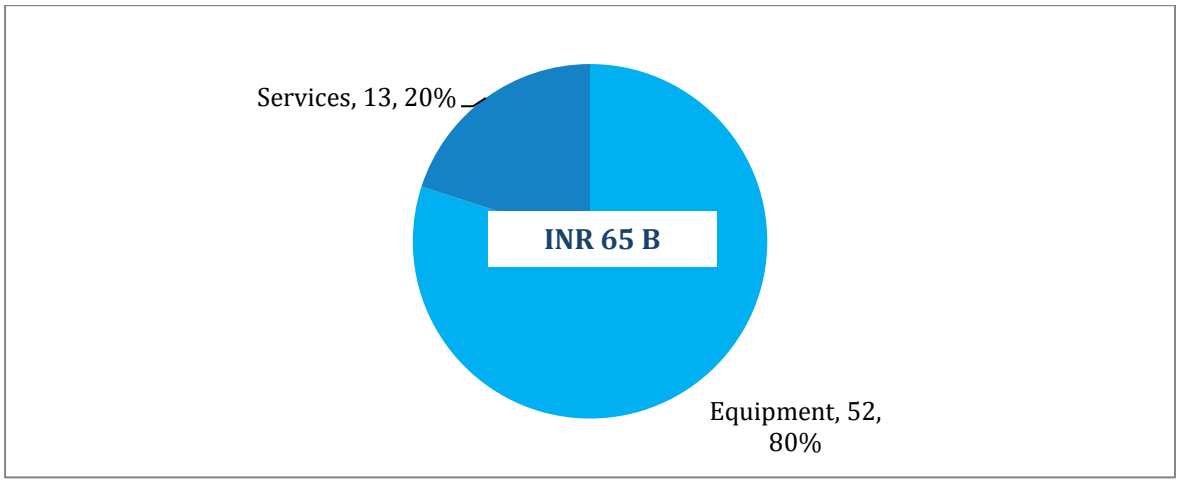


a-actual, f-forecast; Source: Frost & Sullivan Analysis

Market Segmentation by Equipment and Services: Services accounted for 20% of industrial revenue in FY2021. Providers may offer

- Annual maintenance contracts (AMC)
- O&M contracts
- On-time services (OTS) contracts
- Water audit and inspection (A&I) contracts
- Performance monitoring contracts (PMC)

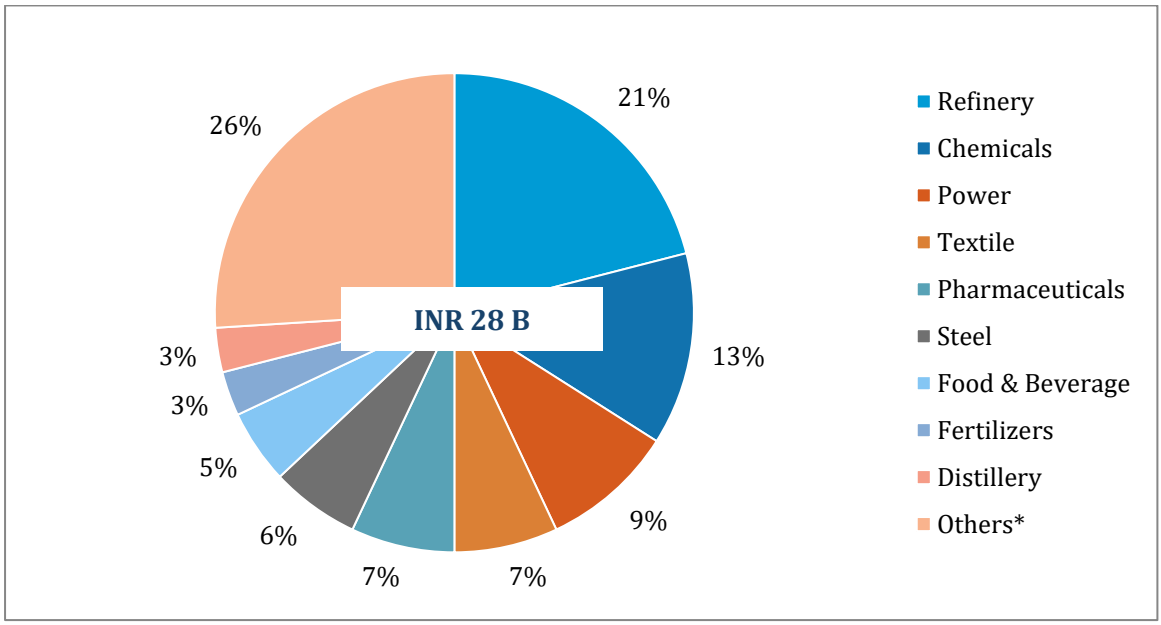
Exhibit 4(d): Industrial Water and Wastewater Treatment Solutions Market Size by Equipment and Services, India, FY2021



Source: Frost & Sullivan Analysis

Industrial Wastewater Treatment Market Segmentation by End-user Segment: Refineries have been the largest end user of industrial wastewater treatment, propelled by. investments in capacity addition and Bharat Stage (BS) VI conversion projects and larger ticket sizes. Chemical, power, textile, pharmaceutical, food and beverage, fertilizer, and distillery companies are other major users. The steel industry used to be a major revenue contributor, but its share has declined owing to the lack of investment in the industry.

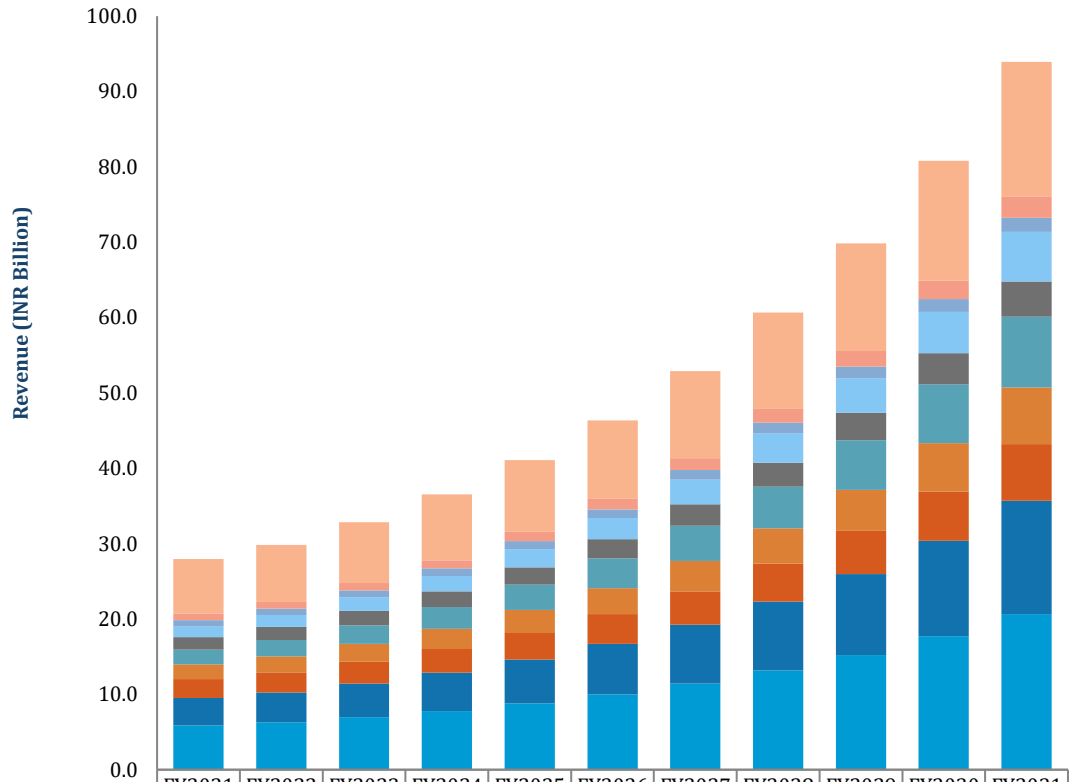
Exhibit 4(e): Industrial Wastewater Treatment Solutions Market Size by End-user Segment, India, FY2021



*automobiles, pulp and paper, plastic, rubber, glass and ceramics, engineering and fabrication

Source: Frost & Sullivan Analysis

Exhibit 4(f): Industrial Wastewater Treatment Solutions Market Forecast by End-user Segment, India, FY 2021–FY2031

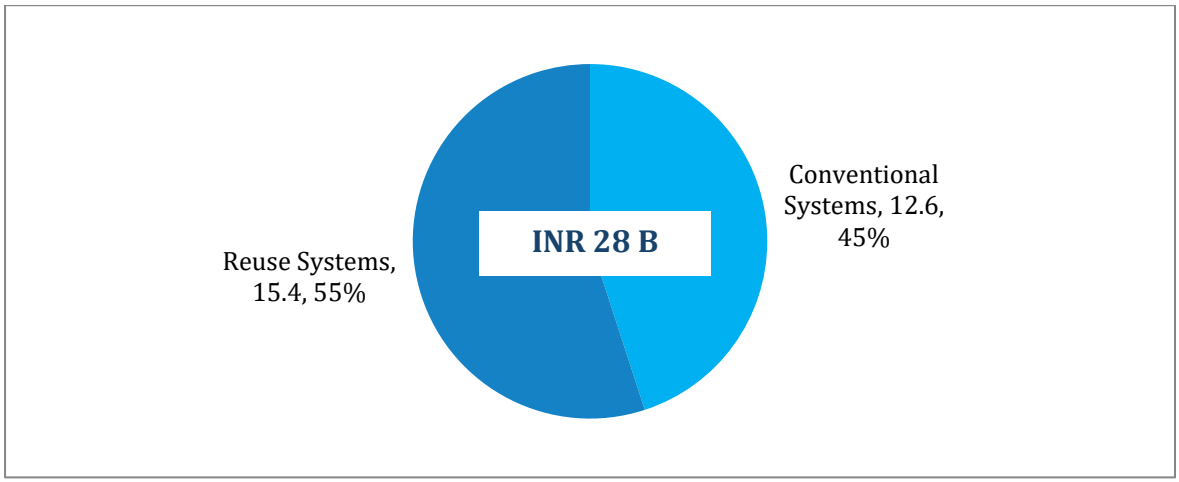


	FY2021 (a)	FY2022 (f)	FY2023 (f)	FY2024 (f)	FY2025 (f)	FY2026 (f)	FY2027 (f)	FY2028 (f)	FY2029 (f)	FY2030 (f)	FY2031 (f)	CAGR
Others	7.3	7.5	8.1	8.7	9.5	10.4	11.5	12.8	14.2	15.9	17.8	9.4%
Distillery	0.8	0.9	1.0	1.1	1.2	1.4	1.6	1.8	2.1	2.4	2.8	12.9%
Fertilizers	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.7	1.9	8.4%
Food & Beverage	1.4	1.6	1.8	2.0	2.4	2.8	3.3	3.9	4.6	5.5	6.6	16.7%
Steel	1.7	1.8	1.9	2.1	2.3	2.6	2.9	3.2	3.6	4.1	4.7	10.8%
Pharmaceuticals	2.0	2.2	2.5	2.9	3.4	3.9	4.7	5.5	6.6	7.8	9.4	17.0%
Textile	2.0	2.1	2.4	2.7	3.0	3.5	4.0	4.7	5.4	6.4	7.5	14.4%
Power	2.5	2.7	2.9	3.2	3.5	3.9	4.4	5.0	5.7	6.5	7.5	11.6%
Chemicals	3.6	4.0	4.5	5.1	5.8	6.7	7.8	9.2	10.8	12.7	15.0	15.3%
Refinery	5.9	6.3	7.0	7.8	8.8	10.0	11.4	13.2	15.2	17.7	20.7	13.4%

a-actual; f-forecast; Source: Frost & Sullivan Analysis

Industrial Wastewater Treatment Market Segmentation by Conventional and Reuse Systems: Conventional wastewater or effluent treatment and disposal methods include the activated sludge process, aeration systems, and upflow anaerobic sludge blanket reactors. Reuse systems treat wastewater to be reused in either the same process or for other applications. As the demand for fresh water rises, many end users recycle wastewater for non-potable applications. Industries also recycle and reuse wastewater as process water. Notable technologies for wastewater treatment and recycling are MBR and ZLD. In recent years, demand for ZLD systems has increased. Frost & Sullivan estimates that ZLD systems contributed close to 5% of the industrial wastewater market revenue in India in FY2021.

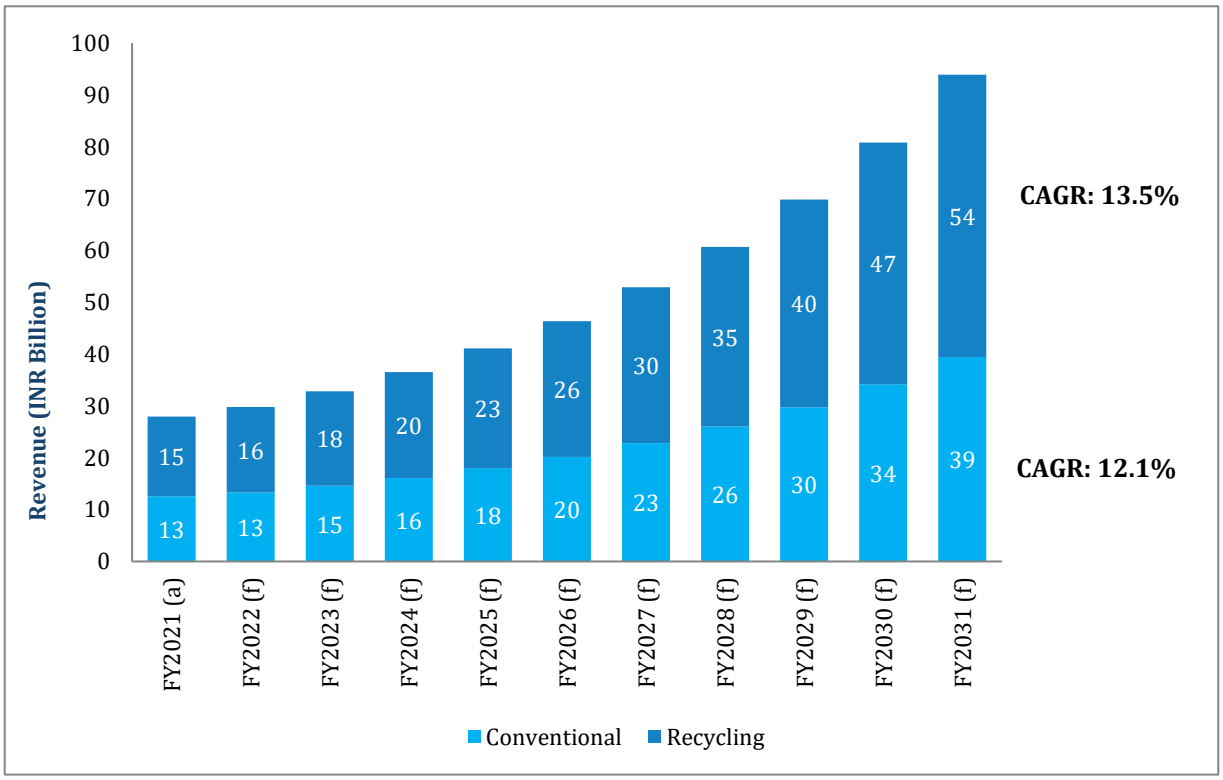
Exhibit 4(g): Industrial Wastewater Treatment Solutions Market Size by System Type, India, FY2021



Source: Frost & Sullivan Analysis

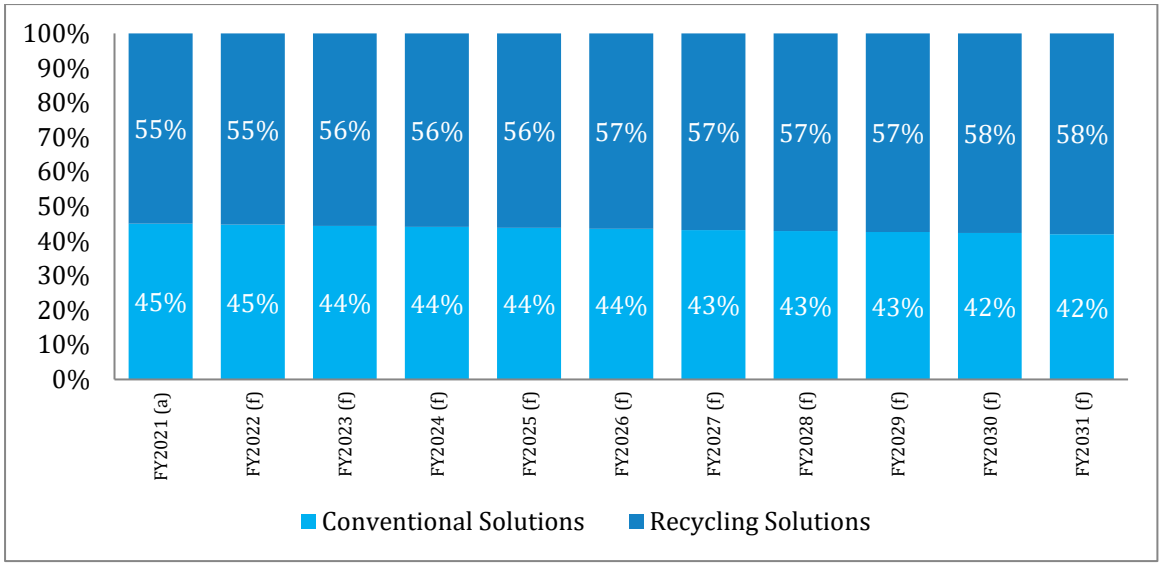
Frost & Sullivan forecasts that recycling solution revenue will increase at a CAGR of 13.5% from FY2021 to FY2031 and reach INR 54.5 billion, while conventional solution revenue will reach INR 39.4 billion at a CAGR of 12.1% over the same period.

Exhibit 4(h): Industrial Wastewater Treatment Solutions Market Forecast by Application, India, FY 2021–FY2031



a-actual, f-forecast; Source: Frost & Sullivan Analysis

Exhibit 4(i): Industrial Wastewater Treatment Solutions Market: Revenue Share Forecast by Application, India, FY 2021–FY2031



a-actual, f-forecast; Source: Frost & Sullivan Analysis

4.1. Market Drivers

Industrial Sector Growth and Government Initiatives: Robust domestic demand, a growing middle class, a young population, and a high return on investment that make India an attractive manufacturing destination.

The country is on course to emerge as a hi-tech manufacturing hub with global majors GE, Siemens, HTC, Toshiba, and Boeing having either established or planning to establish manufacturing plants in the country, attracted by India's more than 1 billion consumers and rising purchasing power.[28]

COVID-19 had a severe impact on India's manufacturing sector, whose GVA share declined to 13.8% in Q1 FY2021 from 17.5% in Q1 FY2020. Manufacturing sector growth rate dropped to 39.3% in Q1 FY2021 and continued to decline for six consecutive quarters because of a lack of demand and a structural crisis worsened by pandemic-induced lockdowns[29].

However, India's manufacturing sector witnessed the strongest growth in July 2021, amid improved demand and easing of some local COVID-19 restrictions. The IHS Markit India Manufacturing Purchasing Managers' Index (PMI), which measures the performance of India's manufacturing sector, increased from 48.1 in June to 55.3 in July. A score above 50 indicates expansion, whereas a score below 50 indicates contraction.[30]

The Index of Industrial Production (IIP), prepared by the Central Statistics Office to measure the activity in mining, manufacturing, and electricity, is another benchmark. The manufacturing IIP was at 116.9 between April 2020 and March 2021. In Q4 FY2021 the sector recorded increase in

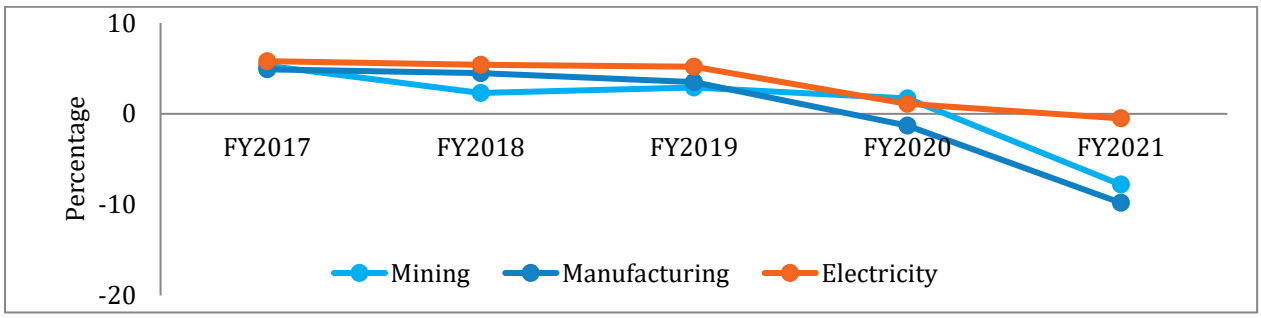
[28] https://www.ibef.org/industry/manufacturing-sector-india.aspx

[29] https://thewire.in/economy/the-impact-of-covid-19-on-indias-manufacturing-sector

[30] https://www.financialexpress.com/economy/indias-manufacturing-sector-sees-strongest-rate-of-growth-in-three-months-in-july/2302299/

sales, showing signs of recovery. As of September 2021, IIP stands at 127.9 with a base of 2011-2012[31].

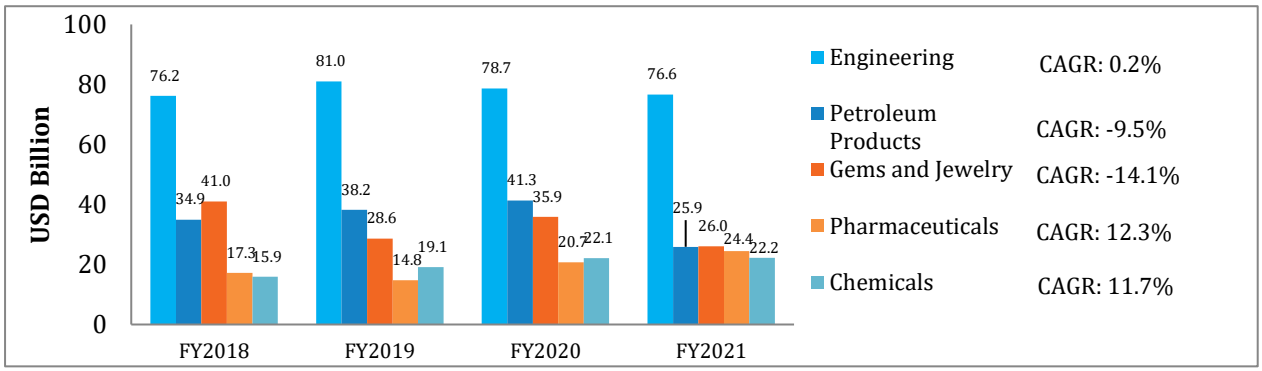
Exhibit 4.1(a): Annual IIP Growth Rates by Sector, India, FY2017 – FY2021 (Percentage)



Source: Central Statistics Office, Ministry of Statistics and Programme Implementation

Manufacturing exports have been contributing to the growth of the Indian economy. Merchandise exports from industries such as engineering, petroleum products, gems and jewelry, pharmaceuticals, and chemicals stood at USD 175 billion (INR 13,641.51 billion) in FY2021. Although this value is less than that recorded in FY2020, the value has certainly improved over the past few months, with the exports valued at USD 11.45 billion (INR 892.54 billion) in April 2021 as against USD 5.24 billion (INR 408.47 billion) in April 2020.

Exhibit 4.1(b): Export Performance of Selected Industries, India, FY2018–FY2021



Source: IBEF[32]

With the launch of the Make in India campaign, the Government of India is facilitating investment, fostering innovation, enhancing skill development, protecting intellectual property, and developing best-in-class manufacturing infrastructure in the country. Government of India expects the campaign to play an important role in the economic development of the country by utilizing the Indian talent base, creating additional employment opportunities, empowering the secondary and tertiary sector, and encouraging investments from around the world.

[31] IEBF Manufacturing Report May 2021, Central Statistics Office, Ministry of Statistics and Program Implementation

[32] https://www.ibef.org/download/Manufacturing-May-2021.pdf

The program has identified the ease of doing business index, by World Bank, as a major boost to entrepreneurship; India's ranking on the index improved to 66th in 2020[33] from 142nd in 2015[34]. Thus, initiatives are being taken to remove the outdated laws and regulations, making bureaucratic processes easier and the government more transparent.

The Make in India 2.0 program, which succeeds the Make in India, has identified 27 sectors for growth, including aerospace and defense, automotive and auto components, pharmaceuticals and medical devices, biotechnology, capital goods, textiles and apparel, chemicals and petrochemicals, electronics system design and manufacturing (ESDM), leather and footwear, food processing, gems and jewelry, shipping, railways, construction, and new and renewable energy.

Make in India has had a positive effect on the economy in terms of foreign direct investment (FDI) in manufacturing plants, boosting local employment. Since the program's launch in 2014, FDI has increase, with inflow of USD 83.57 billion[35] (INR 6,514.41 billion) in FY2022 and USD 81.97 billion (INR 6,389.68 billion) in FY2021. FDI in manufacturing increased 76% in FY2022.

Production Linked Incentives (PLI) Scheme was announced in March 2020 and updated in November 2020 to create national manufacturing champions. The schemes' objectives are to scale up domestic manufacturing facilities, increase import substitution through domestic production, and generate employment opportunities. The PLI scheme provides turnover-linked incentives to investors upon meeting investment, capacity, and turnover criteria.

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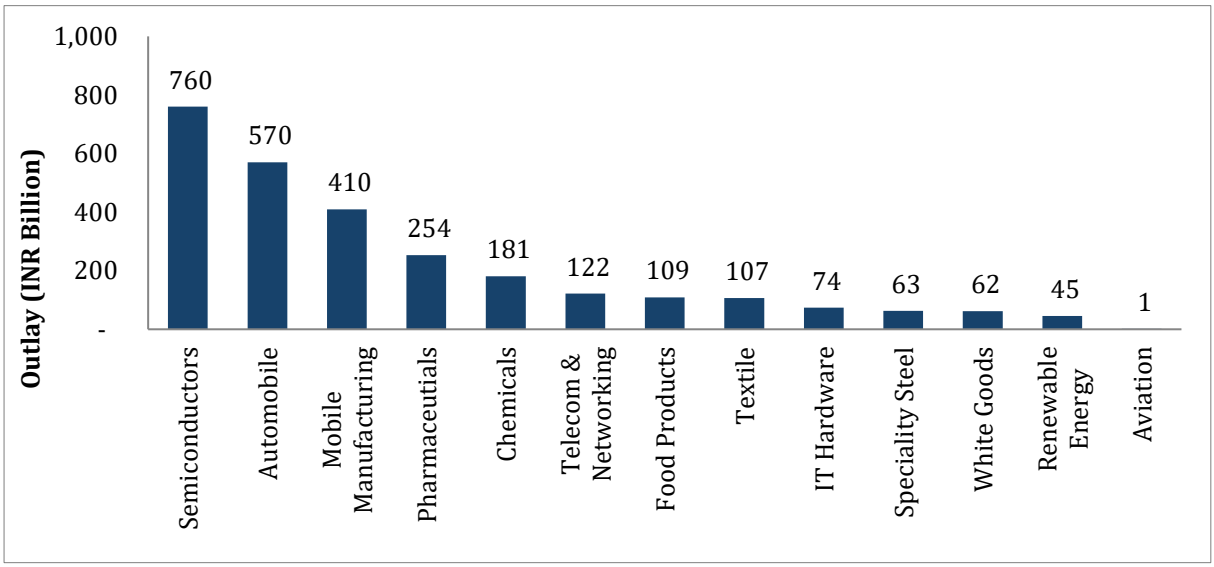
[33] https://documents1.worldbank.org/curated/en/688761571934946384/pdf/Doing-Business-2020-Comparing-Business-Regulation-in-190-Economies.pdf

[34] https://www.doingbusiness.org/content/dam/doingBusiness/media/Annual-Reports/English/DB15-Full-Report.pdf

[35] https://economictimes.indiatimes.com/news/economy/finance/fdi-inflow-hits-all-time-high-of-usd-83-57-billion-in-2021-22/articleshow/91688456.cms

Exhibit 4.1(c): PLI Scheme Financial Outlay by Sector, India, 2021

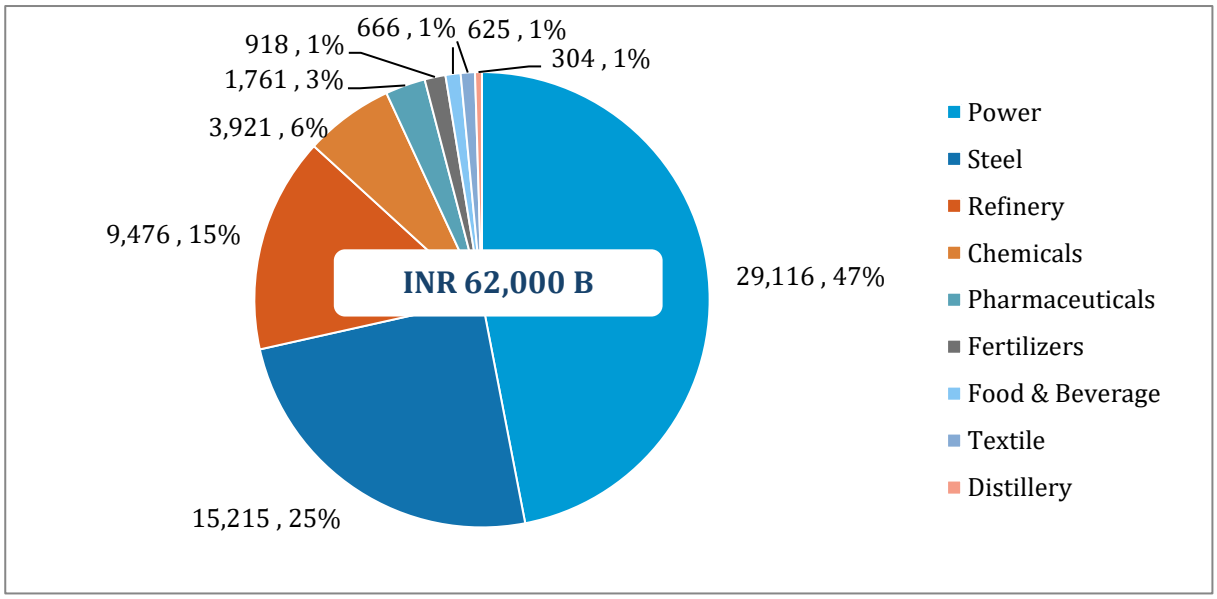


Source: Government of India, Bloomberg

4.2. End-user Sector Outlook

India would witness huge industrial investment, at around INR 62,000 billion, between 2022 and 2030.

Exhibit 4.2(a): Investments by End-user Industry, India, 2022–2030



Source: Center for Monitoring Indian Economy (CMIE) CapEx Database

Refineries: India is the third-largest energy and oil consumer in the world after China and the United States. India has a refining capacity of 249 million metric tons per annum (MMTPA) and would reach 298 MMTPA[36] by 2025. State refining companies are expected to invest INR 2 trillion (USD 26.96 billion) to boost oil refining capacity by 20% by 2025. Growing demand for energy and petroleum products in India would support this investment.

Chemicals and petrochemicals: The Indian chemicals industry was valued at USD 178 billion (INR 13,875.37 billion) in FY2019 and would grow at a CAGR of 9.3% to USD 304 billion by FY2025[37] (INR 23,697.26 billion). By 2025, chemical demand is predicted to grow at a rate of 9% per year and contribute USD 300 billion (INR 23,385.45 billion) to the country's GDP. Petrochemicals revenue would record a CAGR of 7.5% from FY2019 and FY2023. The Indian chemicals and petrochemicals sector would receive an investment of INR 8,000 billion (USD 103 billion) by 2025[38].

The Indian government launched the Petroleum, Chemicals and Petrochemical Investment Regions (PCPIRs) Policy to accelerate investments in the sector. About 350,000 people[39] were employed in direct and indirect activities related to PCPIRs at the end of 2020. In December 2020, the PCPIR policy was redesigned for the 2020–2035 and investments worth INR 10,000 billion (USD 142 billion) are targeted by 2025 and INR 20,000 billion (USD 284 billion) by 2035 in all PCPIRs across the country[40].

Power: A growing population along with increasing electrification and per capita usage are driving the demand for investments in power plants in India. The Government of India has identified power as a sector of focus to promote sustained industrial growth. Government initiatives such as the Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY) and Integrated Power Development Scheme (IPDS) would boost investments in the segment. FDI of 100% is allowed in the power sector. Total FDI inflow reached USD 15.36 billion (INR1,197.34 billion) between April 2000 and June 2021[41].

Textiles: India's textile industry is one of the oldest of the Indian economy. Domestic clothing and textiles contribute an average of 5% of India's GDP and 7% of the industry's production in terms of value and 12% of its export income[42]. About 6% of the world's largest technical textile manufacturers are in India. India is also the world's second-largest silk manufacturer in 2020 as per International Sericultural Commission of the United Nations[43]. The textile industry would

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[36] https://www.reuters.com/world/india/indian-firms-plan-invest-27-bln-boost-refining-capacity-by-2025-2021-08-04/

[37] IBEF Chemical Industry Report February 2022

[38] https://www.business-standard.com/article/news-cm/indian-chemical-industry-to-see-investments-of-rs-8-lakh-crore-by-2025-121031700925_1.html

[39] IBEF Chemical Industry Report February 2022

[40] IBEF Chemical Industry Report February 2022

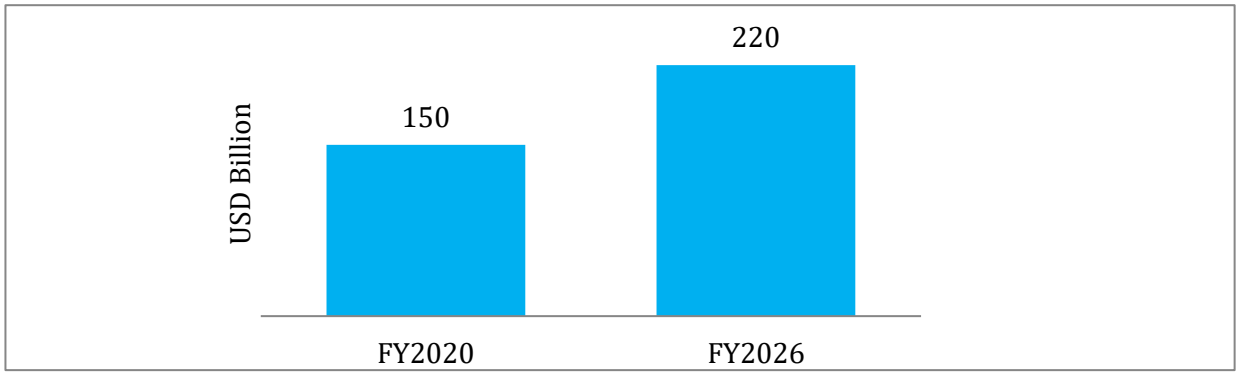
[41] https://www.ibef.org/download/Power-March-2021.pdf

[42] Investindia.gov.in

[43] https://inserco.org/en/statistics

reach USD 220 billion (INR 17,149.33 billion) by FY2026, growing at a CAGR of 6.6% from FY2020 to FY2026[44]. Strong policy support such as the National Textile Policy to facilitate the sector adopt global best practices and increase exports, would drive investments in the sector. The Government of India approved INR 44.45 billion in October 2021[45] to establish seven integrated mega textile parks to boost domestic manufacturing.

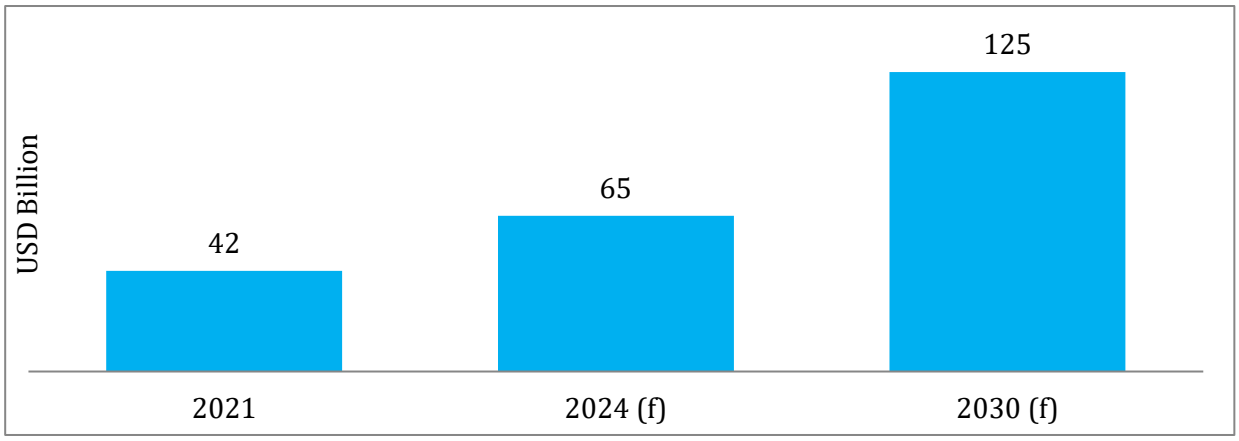
Exhibit 4.2(b): Textile Market Forecasts, India, 2020 and 2026



Source: IBEF Report on Pharmaceutical Industry, December 2021

Pharmaceuticals: India is a significant and rapidly expanding supplier in the global pharmaceuticals industry. It is the world's largest supplier of generic medicines by volume, accounting for an annual average of 20%, and meets 60% of global demand for vaccines[46]. The Indian Economic Survey 2021 projects that the domestic market revenue is expected to triple in the next decade.

Exhibit 4.2(c): Pharmaceutical Market Forecasts, India, 2021, 2024 & 2030



[44] https://www.ibef.org/download/Textiles-and-Apparel-January-2021.pdf

[45] https://timesofindia.indiatimes.com/business/india-business/union-cabinet-approves-setting-up-of-7-mega-integrated-textile-region-and-apparel-parks-with-rs-4445-crore-outlay/articleshow/86809413.cms

[46] Investindia.gov.in (https://www.investindia.gov.in/sector/pharmaceuticals)

f-forecast; Source: IBEF Report on Pharmaceutical Industry, July 2021

India relies on imports for bulk drugs that are processed to produce generic medicines. To achieve self-sufficiency and reduce the reliance on imports, the Department of Pharmaceuticals launched a PLI scheme to promote domestic manufacturing by establishing greenfield plants with a total outlay of INR 69.40 billion from FY2021 to FY2030[47]. Various companies have made commitments for domestic production and 49 applications[48] were approved as of March 2022.

Pharmaceutical companies are trying to strengthen their market position and expand by heavily investing in R&D activities. India plans to set up an INR 1 trillion fund to encourage companies to manufacture pharmaceutical ingredients locally by 2023. More investments in the segment would increase the demand for water and wastewater treatment solutions.

Metals and minerals: Increasing infrastructure development and automotive production in India are driving demand for metals and minerals. The electricity and cement industries are also supporting the industry's growth. Demand for iron and steel is on the increase in residential and commercial construction. Significant growth opportunities for new iron ore, bauxite, and coal mining capacity. With the launch of the National Mineral Policy 2019 and the Mines and Minerals (Development and Regulation) Amendment Act 2021, India presents a major opportunity for investors.

Food and beverage: This industry is one of India's largest employers and contributes about 3% (annual average) of India's GDP[49]. The food ecosystem offers enormous opportunities for investment with favorable economic policies, attractive fiscal stimuli, and growth in food retail. Under the Mega Food Parks Scheme, 41 food parks (refers to food processing infrastructure near the farms) have been approved by the government while 22 are operational as of 1 April 2021[50].

4.3. Market Forecasts

The industrial water and wastewater treatment solutions market in India is forecasted to grow at a CAGR of 11.7% from FY2021 to FY2031 and reach INR 196 billion.

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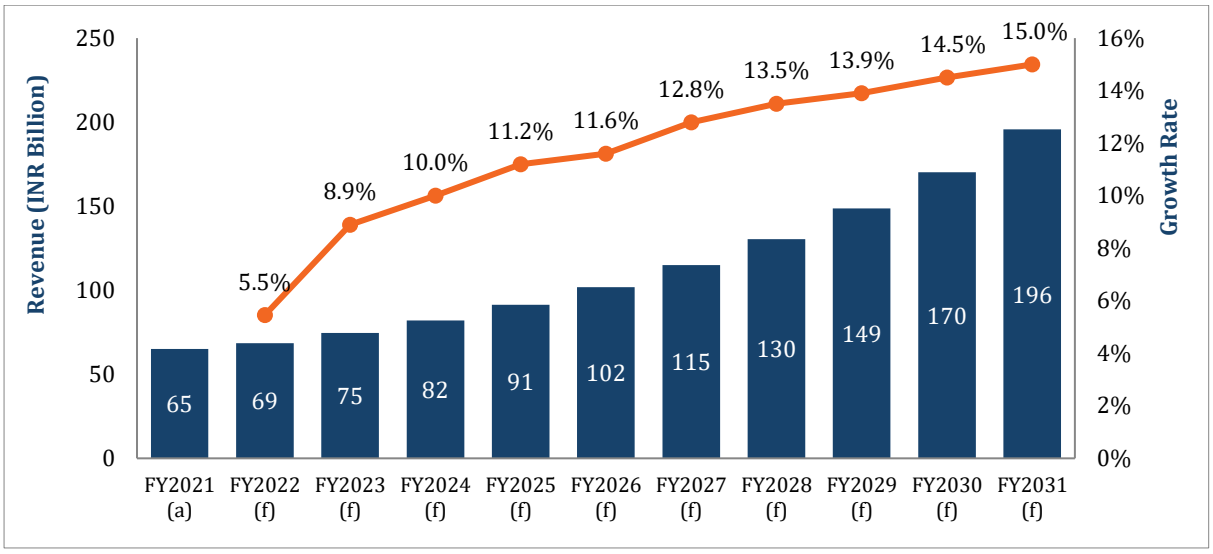
[47] https://pib.gov.in/PressReleasePage.aspx?PRID=1704143

[48] https://www.businesstoday.in/latest/policy/story/govt-approved-49-applications-under-pli-scheme-for-bulk-drugs-327884-2022-03-30

[49] https://www.ibef.org/blogs/future-of-indian-food-and-beverage-industry-post-pandemic

[50] https://www.mofpi.gov.in/Schemes/mega-food-parks

Exhibit 4.3: Industrial Water and Wastewater Treatment Solutions Market Forecast, India, FY 2021–FY2031

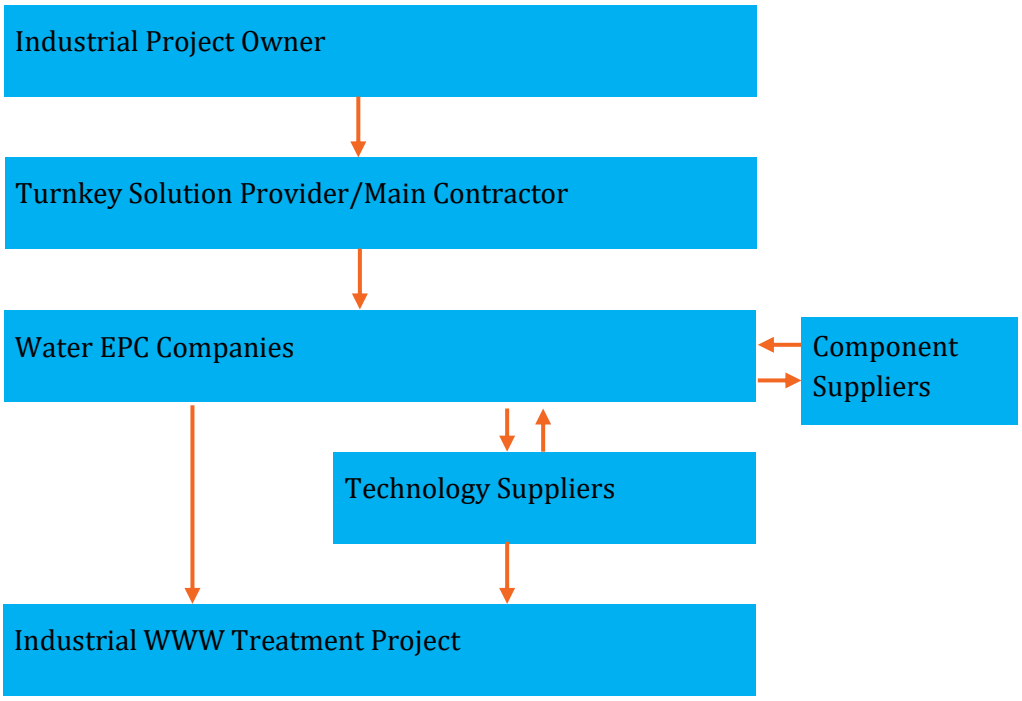


a-actual, f-forecast; Source: Frost & Sullivan Analysis

4.4. Value Chain Analysis

In new industrial projects, the main contractor subcontracts water and wastewater treatment systems to water EPC companies for design, manufacture, installation, and commissioning. Water EPCs either fabricate a few of the components or procure them from suppliers. In small industrial set-ups, the end user directly approaches treatment equipment suppliers for its plant needs. Large end users also take this approach during expansions. Dealers occasionally sell equipment.

Exhibit 4.4(a): Value Chain Analysis, India



Source: Frost & Sullivan Analysis

End users make the final decision about the technology and turnkey solution providers. Water EPCs cannot wield direct influence in the purchase process, but can exert indirect influence by promoting their solutions over competing ones.

The most important criteria for shortlisting industrial water EPCs include CAPEX, OPEX (especially power consumption), product warranties, and past references.

- CAPEX consists of equipment price and installation cost. Given the high cost of advanced systems such as RO, end users prefer vendors with low quotations for RO systems, as Indian clients are highly price sensitive.
- End users have a long-term perspective when selecting treatment equipment providers and consider power consumption and consumable replacement costs. The les power a plant consumes, the higher the profit margin.

Exhibit 4.4(b): Project Value Chain Analysis

Design	Water and wastewater treatment systems are designed based on input/feed water quality, end application, and effluent quality.
Component Manufacturing	A few water EPC companies manufacture membrane modules, evaporators, and other major components in-house, but the common practice is to procure components from other suppliers.
System Integration & Installation/ Commissioning	This stage consists of assembling all the components at the client site based on the design and commissioning the system.
Operation & Maintenance	O&M activities are commonly outsourced to water EPC companies. Contract duration varies from 1 year to more than 10 years. Municipal contracts are usually for 10 or more years. The most common industrial contract duration is around 3 years.
Internet of Things	This includes solutions for O&M, real-time monitoring, and remote monitoring of assets, primarily for industrial plants

Source: Frost & Sullivan Analysis

4.5. Risks and Challenges

- **Fragmented market:** Small, local, providers often quote much lower prices than the larger, organized participants and are attractive options for smaller, price-sensitive enterprises.

- **Lack of technical expertise:** Lack of trained workforce in operating and maintaining effluent treatment plants reduces the efficacy of plants. Unscientific repair methods by in-house personnel have increased the downtime and confidence in suppliers is negatively influenced.
- **Slow pace of implementation:** Bureaucratic hindrances and lack of seriousness in implementing reforms to impart thrust to the industrial sectors.
- **Cost-conscious end users:** Many industrial end users resort to low-cost and low-tech methods. Though the water and wastewater treatment has evolved technologically, it is restricted to a few industries in which top- quality water is a necessity.

Chapter 5: Indian Industrial Wastewater Recycling/Reuse Market Analysis

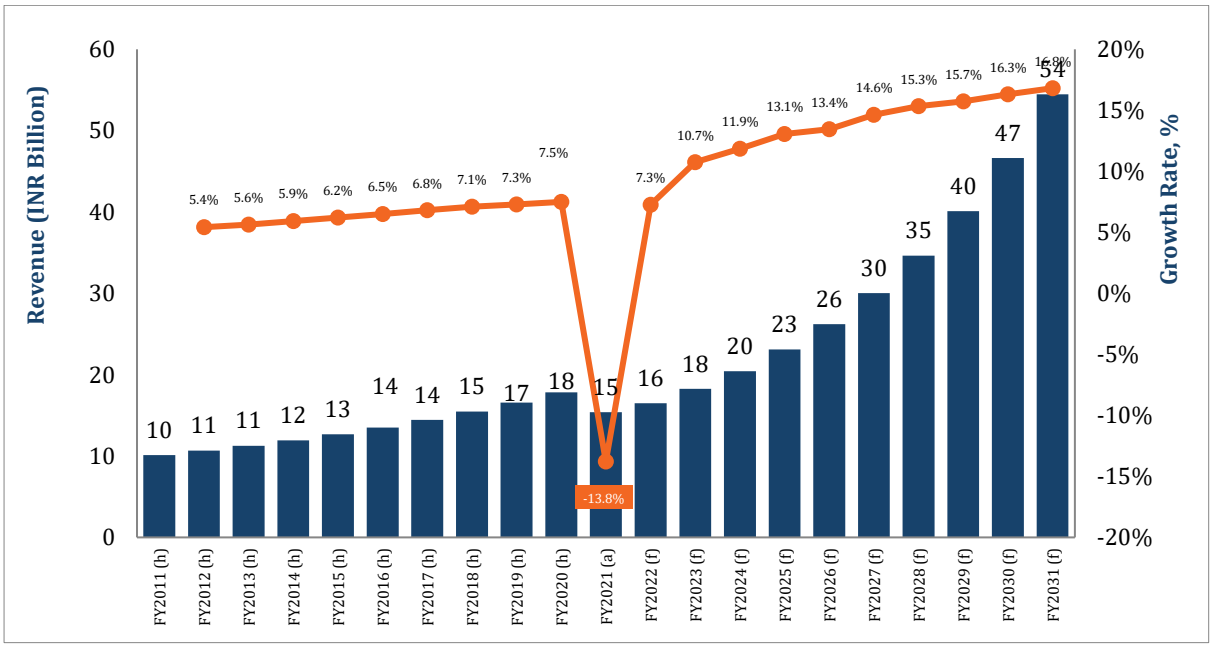
5. Overview of Wastewater Recycling and Reuse in Industries in India

Wastewater recycling and reuse in India is in the growth stage and driven by regulations associated with wastewater disposal. The high cost of recycling and reuse systems, which has been a major factor limiting growth, is being outweighed by the high cost of wastewater disposal and penalties associated with non-compliance. Other factors that are driving the growth are

- Increasing water scarcity
- Technological improvements in water recovery using recycle and reuse systems
- Water from conventional sources becoming more expensive than recycled water
- A growing tendency among foreign companies to only import industrial products that follow sustainable production processes
- Awareness of environmental problems and SDG initiatives

Frost & Sullivan projects that market revenue will increase from INR 15.1 billion in FY2021 to INR 54.5 billion in FY2031 at a CAGR of 13.5%. In FY2021, equipment or systems accounted for 70 to 75% of revenue and the remaining 25 to 30% was from O&M services.

Exhibit 5(a): Recycling and Reuse Solutions Market Size and Forecasts, India, FY 2011–FY2031



h-historical, a-actual, f-forecast; Source: Frost & Sullivan Analysis

Recycling/ZLD implementation today is based on either court orders or SPCB/State Environment Impact Assessment Authority (SEIAA) directions. The CPCB classifies industrial operations in India based on their pollution levels into Red, Orange, Green, and White categories[51]. About 85 industrial sectors were classified under the Red category and only 18 implemented ZLD in India by 2020.

The Indian manufacturing sector is characterized by a large base of small and medium sized enterprises that, given their low scale of operations, do not have necessary funds to install wastewater treatment systems. To address this issue, regulators and industry associations use the Common Effluent Treatment Plants (CETP) concept in industrial zones or hubs where individual companies can discharge their wastewater for treatment. About 190 CETPs existed in India as per the latest CPCB update in 2018[52], including around 40 CETPs developed in the tannery/textile industry. About 60 CETPs are not meeting TDS/COD norms. Most industrial clusters are accused of polluting rivers and groundwater, and 88 CETPs were involved in litigation on pollution/non-compliance issues during 2020. The NGT has taken upriver pollution issues seriously, which has increased recycle and reuse system demand.

Exhibit 5(b): Industries That Have Adopted Recycling and Reuse, India

S.No.	Industry	Adoption Rate
1	Distilleries	High
2	Leather tanneries	High
3	Fertilizers	High
4	Chlor-alkali plants	High
5	Dye and dye intermediate units	High
6	Pesticides	High
7	Pharmaceuticals	High
8	Sulfuric acid	High
9	Breweries	High
10	Textile dyeing	High
11	Paints and pigments	High
12	Pulp and paper	Medium
13	Thermal power plants	Medium
14	Iron and steel	Medium
15	Oil refineries	Medium

[51] https://cpcb.nic.in/openpdffile.php?id=TGF0ZXN0RmlsZS9MYXRlc3RfMTE4X0ZpbmFsX0RpcmVjdGlvbnMucGRm

[52] https://cpcb.nic.in/status-of-cetps/, http://www.indiaenvironmentportal.org.in/content/468537/cpcb-report-on-cetps-and-stps-16092020/

16	Zinc smelting	Medium
17	Copper smelting	Medium
18	Aluminum smelting	Medium
19	Petrochemicals	Medium
20	Sugar	Low
21	Cement	Low
22	Ceramic	Low
23	Glass	Low

Note: Industry names are per CPCB's classification

Source: Frost & Sullivan Analysis

No central regulations/standards exist for the implementation of recycling and reuse or ZLD systems in India, but NGT initiatives have driven the implementation of ZLD in a few states. As per a National Mission for Clean Ganga report, several states have adopted ZLD systems.

- Tamil Nadu: All pollution industries as defined by CPCB have implemented ZLD.
- Maharashtra: All industries have implemented ZLD and no industry is allowed to discharge treated/untreated effluents into rivers.
- Odisha: Twelve out of 22 industries have implemented ZLD.
- Uttarakhand: Two highly polluting industries have adopted ZLD.
- Punjab: CETPs and the electroplating industry have implemented ZLD

A few states, such as Haryana, Gujarat, Maharastra, Tamil Nadu, Uttar Pradesh, Rajasthan, Karnataka, have developed a policy for recycle and reuse, which will drive demand for ZLD systems.

Exhibit 5(c): End-user Industry Technology Options and Potential for ZLD Solutions, India

Industry	ZLD Treatment Options	ZLD Potential
Distillery	• RO/MEE • Incineration • Biocomposting	High
Tannery	• RO • MEE	High
Pulp and paper	• RO • NF/UF • Evaporator, concentrator/crystallizer	Medium - High
Pharmaceuticals	• Filtration • RO • MEE • Incinerators	High
Textiles	• Filtration • Adsorption • RO • MEE	High
Refineries	• RO	Medium
Fertilizer	• RO	Medium

Dye and Dye Intermediates	• MEE	High

Source: CPCB and Frost & Sullivan Research

5.1. Recycle and Reuse Technologies Overview

The major recycling and reuse technologies adopted in India are

- MBR
- RO-based systems
- Evaporation technologies (multiple effect evaporator [MEE], mechanical vacuum compressor [MVR], waste heat evaporators [WHE])

Other technologies available in the country include agitated thin film dryer (ATFD), incinerator, and solvent extraction.

Exhibit 5.1(a): Recycling and Reuse Technologies: Applications, Advantages and Disadvantages, India

Technology	Advantages	Disadvantages	Applications
MBR	Recycled water from MBR has better quality than common technologies such as MBBT and SBR.	• CAPEX is higher than conventional wastewater treatment technologies. • Membrane must be replaced every 5 years because of fouling.	• Textiles • Refineries • Fertilizer • CETP
RO	• The most effective recycle and reuse technology with less consumption of chemicals when compared with ion exchange technology. • Treated water quality is very high and is fit for usage in industrial process applications.	• CAPEX and OPEX are very high. • Membrane replacement due to fouling. • CAPEX involved in solutions for RO reject water.	• Power • Refineries • Textiles • Fertilizers • Chemicals • Other industries
MEE	Time-tested technology for achieving ZLD.	High OPEX due to steam requirement.	• Pharmaceutical • Textile • Pesticide • Dyes and dye intermediates • Steel • Fertilizer
MVR	Lower CAPEX when compared with MEE as this technology does not require steam.	Preferred only when heat/ steam energy is not available in the industrial process.	Textile
WHE	• Made using corrosion-resistant materials • Low CAPEX and OPEX • High-quality distillate • Long equipment life	Temperature control is a concern.	• Power • Refineries • Textiles • Fertilizers • Chemicals • Other industries
Solvent extraction (air stripper)	• Well-proven technology for solvent removal. • Cost-effective solution for solvents with low solubility in water.	This technology is only effective when large volumes of solvent with low solubility in water are available for treatment.	• Pharmaceuticals • Pesticide • Chemicals
Solvent extraction (stream stripper)	Efficiency is higher than air stripper method.	High OPEX due to scaling issue, which requires periodic cleaning.	• Pharmaceuticals • Pesticide • Chemicals
Crystallizer	Effective technology to recover salts such as sodium sulfate, sodium chloride, sodium thiosulphate, and zinc sulfate.	High OPEX due to scaling and corrosion issues, which require frequent cleaning.	All industries
ATFD	High evaporation rate	High OPEX due to scaling and corrosion issues, which require frequent cleaning.	• Dye and dye intermediates • Textiles • Pharmaceuticals
Incinerator	Effective on wastewater that has very high COD and is difficult to biodegrade.	High OPEX due to high energy consumption.	• Dye and dye intermediates

			• Pharmaceuticals • Pesticides

Source: Gujarat Pollution Control Board (2016)[53]

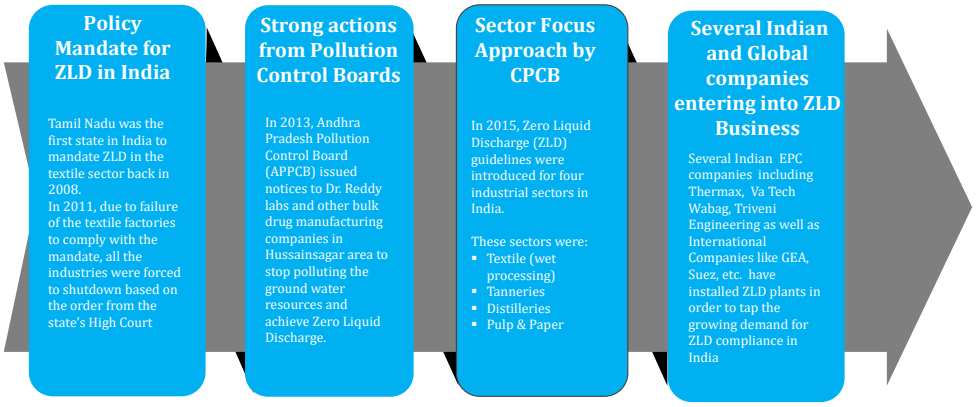
5.2. ZLD Evaporator Market Highlights

The Indian ZLD evaporator business has seen significant growth in the past decade backed by strong regulatory enforcements and water scarcity issues. As per Frost & Sullivan estimates, ZLD evaporators accounted for close to 9% of industrial wastewater treatment solutions market revenue in India in FY2021. Three major ZLD evaporator technologies are available in Indian market:

- MEE systems are simpler systems requiring a high thermal energy input in the form of heat or steam.
- MVR systems are complex. Output is better but CAPEX is higher.
- WHE systems are compact and efficient as they use waste heat from the industrial process for evaporation.

Between MEE and MVR, MEE is preferred because of the low CAPEX.

Exhibit 5.2(a): ZLD Evaporator Growth Enablers, India



Source: Frost & Sullivan Analysis

The chemicals industry has been the largest end user of ZLD evaporators in India because any impurities in water may result in an unintended chemical reaction. ZLD evaporator systems are commonly used in textile industry wet processes such as dyeing. The pharmaceutical industry is in third place in installations. Food and beverage companies, power plants, refineries, sugar factories, and distilleries also use ZLD evaporators.

The compact and efficient WHE technology is available for industries that generate wastewater with high levels of contaminants and corrosive constituents. WHE technology offers lower O&M costs. The Global Climate Partnership Fund (GCPF) partnered with the Confederation of Indian Industry–Green Business Center (CII-GBC) to evaluate ZLD systems' energy consumption patterns in various industries and concluded that WHE technology consumes less energy.

[53] http://www.gcpcenvis.nic.in/Manuals_Guidelines/zld_seminar.pdf

Exhibit 5.2(b): Energy and Carbon Emission Comparisons for ZLD Technologies, India, 2021

Technology	Energy/kiloliter(in kWh)	CO_2 kiloliter(in kg)
MEE	899	128
High pressure reverse osmosis (HPRO) + MEE	227	46
HPRO + WHE	24	21
% savings with HPRO + MEE	74.7%	64.1%
% savings with HPRO + WHE	97.3%	83.3%

Source: Cast Study from Honda Motorcycle & Scooters conducted by CII - GBC

Chem Process, Concord Enviro, Mazda Limited, Ketav Consultants, Mojj Engineering Systems, SSP Private Limited, Unitop Aquacare Limited, Praj Industries, Chemin Enviro, Spray Engineering Devices, and Arvind Envisol are prominent companies operating in this space.

5.3. Technology Innovations for Industrial Wastewater Treatment

Membrane technologies are gaining traction in industrial wastewater treatment because of their higher efficiency in treating COD, biological oxygen demand (BOD), total suspended substance, and organic compounds compared with conventional wastewater treatment. Membrane technologies require less space and are modular. Two types of membrane technologies—MBR and membrane distillation—are common in industrial wastewater treatment. Membranes are packed in modules with reactors and the membranes are plate and frame, tubular, spiral wound, and hollow fiber. The scale of operations and amount of wastewater to be treated dictates the construction method.

Developments in membrane technologies are

- Hybrid microfiltration (MF)-osmosis membrane for environmentally friendly wastewater treatment:
  - The combination of MF and osmosis membrane eliminates the need for the nitrification and denitrification process because it enables the effective removal of nitrogen. This reduces the operating cost.
  - The hybrid membrane technology reduces the risk of membrane fouling compared with a pure microfiltration membrane technology.
  - As a clean technology, hybrid membranes are emerging as a viable alternative to treat complex industrial wastewater because they eliminate the need for conventional tertiary treatment.
  - The MF-osmosis membrane (reverse and forward osmosis) is used in pharmaceutical and detergent applications to remove organic compounds. While it also has potential in

pharmaceutical and detergent wastewater treatment, it requires further study to make it cost effective.

- UF and NF hybrid membranes:
  - UF-RO and NF-RO membranes demonstrate higher efficiency in removing oil, grease, and phenol compounds than a pure form of UF and NF membrane.
  - The hybrid membranes have a higher rejection rate of COD and BOD than the pure forms.
  - The energy-efficient technology removes the need for tertiary treatment and the pre-treatment process and reduces the risk of membrane fouling.
  - The UF or MF membrane has the potential to be a highly efficient treatment process, but further study is required to establish safety and efficiency in prolonged use.

Other developments include ultra-high pressure RO membranes that operate at more than 50% higher pressure than those available today. These membranes are being deployed in ZLD industrial effluent treatment process.

Chapter 6: Competitive Analysis

6. Industrial Wastewater Treatment Solutions Market: Major Players and Market Share Analysis

More than 100 companies compete in India's industrial wastewater treatment market.

Exhibit 6(a): Competitive Structure of Industrial Wastewater Treatment Market, India, 2021

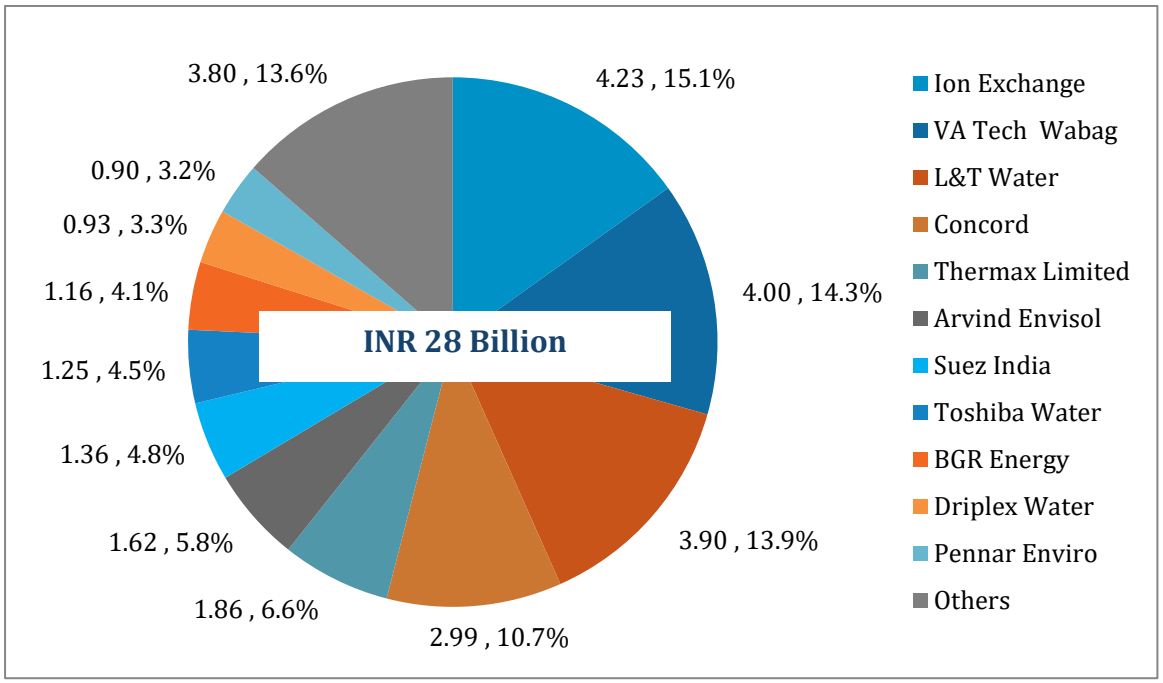
	Large	Medium	Small
Number of Players	10	15-20	100+
Revenue Range	More than INR 100 crore	INR 15–100 crore	Less than INR 15 crore
Characteristics	• Expertise across water industry, including municipal segment in many instances • Larger project capacity and ticket size • Adopters of new technologies through international tie-ups	• Higher specialization in industrial wastewater treatment • Smaller project capacity (as much as a few MLD)	• Suppliers of KLD-scale treatment plants, including modular and packaged ETPs • Limited range of technology options available with supplier
Key Companies	• VA Tech Wabag • L&T Water • Ion Exchange • Thermax • Suez • Arvind Envisol • Concord Enviro • BGR Energy • Toshiba Water	• Paramount • Praj Industries • Ketav Consultants • Triveni • Aquatech Asia • Wipro Water • Marcuras • Unitop Aquacare • Chemprocess • Murugappa Organo • Mazda Ltd. • Mojj Engineering	• ClearWater • Pacques India • IDE Technologies • Raj Water Technology • Aldee Water • Ionic Engineering
Target End-user Segments	• Petroleum refineries and petrochemical complexes • Steel mills • Power plants	• Pharmaceuticals • Textiles • Chemicals • Pulp and paper	• Food processing including sugar, dairy, tobacco • Electrical and electronics manufacturing • Other medium- and small-scale industries

Source: Frost & Sullivan Analysis

Ion Exchange was the industrial wastewater treatment market leader in India with a 15.1% market share in FY2021. Close to 86% of the market is served by Ion Exchange and 10 other large-scale players: VA Tech, L&T, Thermax, Suez, Concord Enviro, Arvind Envisol, Toshiba, BGR Energy, Driplex Water and Pennar Enviro. Medium-scale players cater to about 9% of the market. Paramount, Praj, Ketav, and Triveni are prominent players in this category. Small-scale players together cater to about 5% of the market.

Ion Exchange was established in 1964 as a subsidiary of UK-based Permutit before becoming a wholly owned Indian company in 1985. By integrating process technologies, design, engineering, and project management capabilities, Ion Exchange offers single-source responsibility solutions in water and environmental management. It has a robust solution portfolio catering to municipalities, industries, infrastructure, institutions, and urban and rural residences and communities. Its end-to-end solutions for the water and wastewater treatment value chain include wastewater treatment, water pre-treatment, industrial process water, water recycling, ZLD solutions, seawater desalination, sewage treatment, and packaged drinking water. In addition to establishing itself in key Indian cities, it has a global presence with more than 36 sales and service facilities and 100 channel partners. It has 50 patents and marketed more than 100 solutions globally. It exports its products to Africa, Japan, the Middle East, Russia, Southeast Asia, Europe, the United Kingdom, the United States, and Canada.

Exhibit 6(b): Market Share Analysis of Industrial Wastewater Treatment Market, India, 2021



Source: Frost & Sullivan Analysis

VA Tech Wabag is a multinational company with a presence on four continents. It has three dedicated R&D centers in Switzerland, Austria, and India. It provides water treatment solutions across municipal drinking water, municipal sewage, industrial water, industrial effluents, desalination, and reuse and recycling. The technology-focused company has more than 90 intellectual property (IP) rights. Its end-to-end solutions include design, engineering, technology, civil construction, and O&M. Civil construction is outsourced to other service providers. It has executed more than 6,000 municipal and industrial projects. Notable projects in India include in Uttar Pradesh Jal Nigam (plant O&M), Agra and Ghaziabad (plant O&M), Howrah (STP), Kanpur (CETP), Koyambedu (O&M), and Chennai (tertiary treatment RO plant [TTRO]), and with the Kolkata Metropolitan Development Authority and Jajmau Tannery Effluent Treatment Association.

Third-place L&T Water has more than 40 years of experience in infrastructure development. The company has presence in India, Sri Lanka, the Middle East, and Africa. The company caters

to municipal and industrial end users and provides a wide range of services including wastewater treatment and recycle and reuse systems. Its strengths are process knowhow, detailed engineering capabilities, in-house engineering capabilities, and project management skills.

Exhibit 6(c): Industrial Wastewater Treatment Market: Strengths and Weakness Analysis of Top 3 Companies, India

Company	Strengths	Weakness
Ion Exchange	• Credibility • Vast experience across a wide range of industries • Access to all types of technologies • Focus on training • Strong marketing and sales channels • Good customer service	• Slow response to market • Selective in terms of projects • Poor financial strength
VA Tech Wabag	• Access to a vast range of technologies • Strong leadership • Global scale • Excellent track record in municipal segment • Investments in R&D	• Limited focus in industrial segment
L&T	• Knowledge and experience to execute large-scale municipal projects • Global experience • Strong financial position	• Limited focus in industrial segment

Source: Frost & Sullivan Analysis

6.1. Industrial Wastewater Recycling and Reuse Solutions Market: Competition Mapping

Major companies providing wastewater recycling and reuse solutions to industries include Arvind Envisol, Concord Enviro, KEP Engineering, Suez, Aquatech, Thermax, and Ion Exchange. Large and medium-sized companies in the Industrial Wastewater Treatment segment are mapped below to highlight their presence in recycling and reuse solutions market.

Exhibit 6.1(a): Industrial Wastewater Recycling and Reuse Solutions Providers, India, 2021

Company	Conventional Wastewater Treatment Solutions	Recycling and Reuse Solutions
Ion Exchange	✓	✓
Thermax	✓	✓
Suez	✓	✓
Arvind Evisol	✓	✓
Praj Industries	✓	✓
Triveni	✓	✓
Aquatech Asia	✓	✓
Wipro Water	✓	✓
Murugappa Organo	✓	✓
Concord Enviro	✓	✓
KEP Engineering	✓	✓
Enviro Control Private Ltd	✓	✓
Waterleau	✓	✓
Apec Ecotech	✓	✓
VA Tech Wabag	✓	
L&T Water	✓	
UEM	✓	
BGR	✓	
Driplex	✓	
Pennar Enviro	✓	
Paramount	✓	
Ketav Consultants	✓	
Marcuras	✓	
Unitop Aquacare	✓	
Chemprocess	✓	
Mazda Ltd.	✓	
Mojj Engineering	✓	
Clear Water	✓	
Pacques India	✓	
IDE Technologies	✓	
Raj Water Technology	✓	
Aldee Water	✓	
Ionic Engineering	✓	

Source: Frost & Sullivan Analysis

Exhibit 6.1(b): Company Mapping across the Project Value Chain, India, 2022

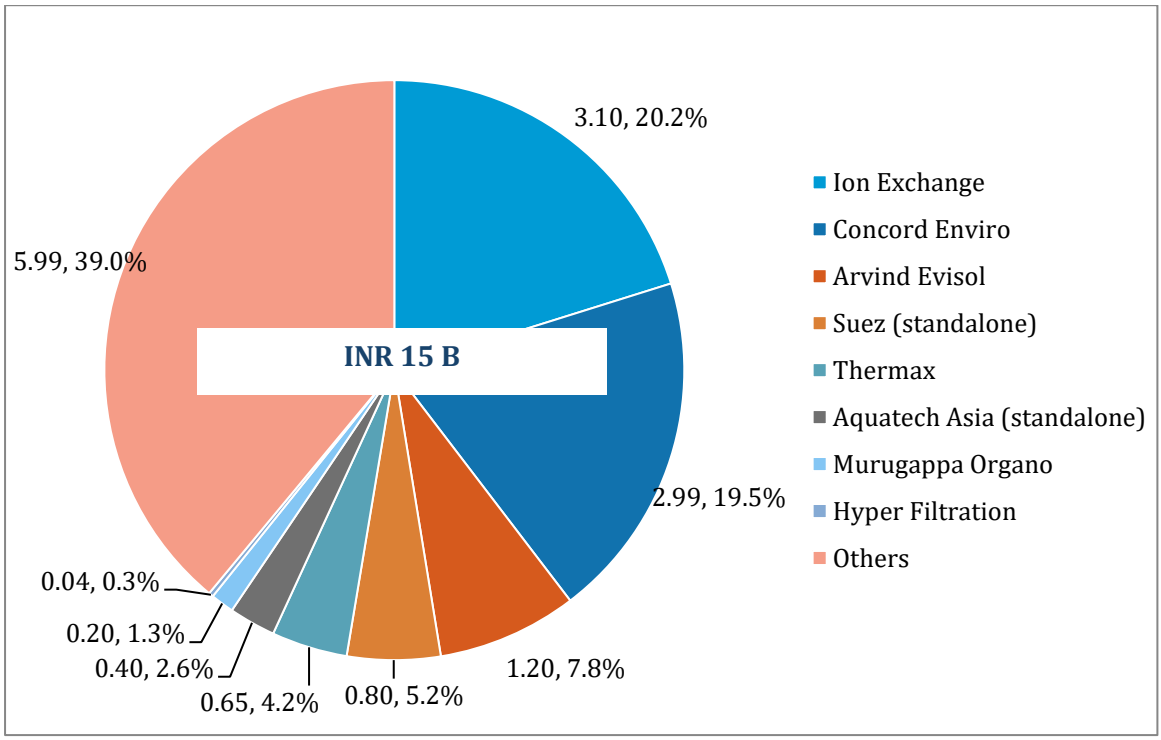
Company	Value Chain for Recycling and Reuse Solutions				
	Design	Component Manufacturing	Integration & Installation/ Commissioning	O&M	IoT
Concord Enviro	✓	✓	✓	✓	✓
Thermax	✓	✓	✓	✓	✓
Wipro Water	✓	✓	✓	✓	✓
Ion Exchange	✓	✓	✓	✓	
Arvind Evisol	✓	✓	✓	✓	
Murugappa Organo	✓	✓	✓	✓	
Triveni	✓	✓	✓	✓	
Aquatech Asia	✓	✓	✓	✓	
KEP Engineering	✓	✓	✓	✓	
Enviro Control Private Ltd	✓	✓	✓	✓	
Apec Ecotech	✓	✓	✓	✓	
Hyper Filtration	✓		✓	✓	
Suez	✓		✓		✓
Praj Industries	✓	✓	✓		
Decknomet	✓		✓		
Waterleau		✓			
Gradiant India Pvt Ltd		✓			
Permionics Membranes		✓			
Alfa Laval		✓			

Legend		High Expertise in Recycling Solutions		Medium Expertise in Recycling Solutions		Low Expertise in Recycling Solutions

Source: Frost & Sullivan Analysis

The major industrial wastewater recycling and reuse EPC companies are Ion Exchange, Concord Enviro, Arvind Envisol, Thermax, and Suez, holding a combined 56.9% market share in FY2021.

Exhibit 6.1(c): Industrial Wastewater Recycle and Reuse Solution Market: Revenue Share Analysis, India, 2021



Source: Frost & Sullivan Analysis

Concord Enviro was the second-largest solution provider in FY2021 for industrial water recycle and reuse systems in terms of revenue. The integrated provider of wastewater reuse and ZLD solutions conducts several value chain activities in-house, including design, component manufacturing, installation/commissioning, O&M, and digitalization. In FY2022, Concord provided O&M services to more than 60% of its client base, developing long-term relationships and creating value for customers. Its strengths are its value chain capabilities, which include in-house membrane casting and evaporator manufacturing. It was the first company to introduce ultra-high pressure RO membranes, which have the capability of high recovery rates, in India. Its WHE solutions reduce customers' energy and operating expenditure. Concord also provides digitalization solutions (including IoT) using sensors, particularly for O&M services.

Exhibit 6.1(d): Industrial Wastewater Recycling: Company Mapping across Key Value Chain Technologies, India, 2022

Company	MBR	RO	MEE	MVR	WHE	ATFD
Ion Exchange	✓	✓	✓			
Concord Enviro	✓	✓	✓		✓	
Arvind Envisol	✓	✓	✓	✓	✓	✓
Suez	✓					
Thermax	✓		✓	✓		✓
Aquatech Asia	✓	✓	✓			
Murugappa Organo	✓	✓	✓			
Hyper Filtration	✓	✓	✓			✓

Legend		High Expertise		Medium Expertise		Low Expertise

Source: Company Websites

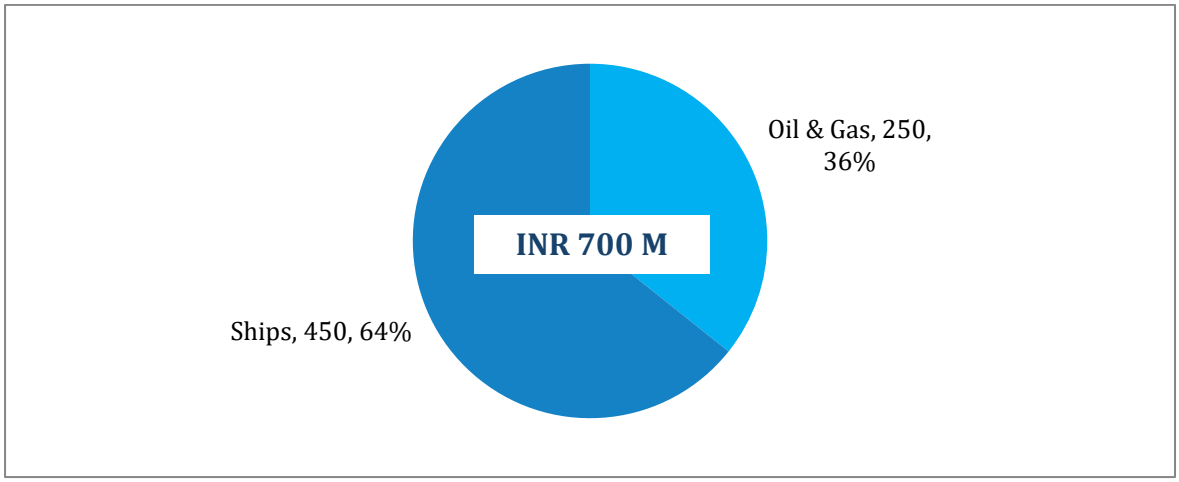
Chapter 7: Offshore Desalination Market Outlook

Offshore desalination refers to providing water and wastewater treatment systems to

- Offshore oil and gas platforms
- Ships: This includes government defence war ships, Indian navy, Indian coast guard, merchant, and cargo ships

Frost & Sullivan estimates the market opportunity to be around INR 700 million in FY2021 and Ships is the largest segment, contributing to about 64% of the total opportunity.

Exhibit 7(a): Offshore Desalination Market Size by End-user Segment, India, FY2021



Source: Frost & Sullivan Analysis

7. Oil and Gas Offshore Desalination Market Insights

Key applications for desalination systems are for drinking water only. This industry requires reliable equipment and quality is a top criterion in vendor selection. Desalination systems are procured through a limited tender process. End users have a prequalified list of vendors and the invitation to bid is only sent to them. Notable customers are the Oil and Natural Gas Corporation (ONGC) and large EPC companies such as Afcons. The size of the desalination systems used for drinking water applications varies from 30,000 – 100,000 tons per day.

Vendors include Concord Enviro, Meco, Parker Hannifin, C'treat (ITT), and Alfa Laval. Most companies import complete kits, but Concord Enviro manufactures locally and has more than 20 years of experience in this market.

7.1. Ships Desalination Market Insights

Desalination systems in defense warships and navy ships are mainly used for drinking water and technical-grade water for turbine washing, steam boilers, and battery recharging. The desalination systems are customized equipment to withstand mechanical shocks, have a very low electronic signature/noise generation, and are not impacted by magnetic fields.

End-user organizations float tenders for procurement, and invitations to participate are sent only to prequalified vendors/ suppliers. The highly regulated manufacturing process includes rigorous inspection and type testing procedures by the Directorate of Quality Assurance.

Top vendors include Concord Enviro, Techno Process Equipment, Tas Engineering, SLCE, and Tecnicomar. Concord Enviro is a leading supplier with a service base in Gujarat, Kerala, Vizag, Chennai, Port Blair, and Andaman.

7.2. Opportunity Outlook

Offshore desalination is a niche market, and investments in new builds and retrofits, particularly in the defense/ navy are opportunities in the long term. The Make in India initiative and compliance with manufacturing regulations act as entry barriers.

Exhibit 7.2(a): Indicative List of Defense/Government Investments, India

Entity	Project Name	Cost (INR Million)	Project Status	Project Type
Goa Shipyard Ltd.	Goa Shipyard Two Warships Construction Project	142,500	Under Implementation	New Unit
Government of Andhra Pradesh	Visakhapatnam Shipbuilding Facility Project	8,000	Announced	New Unit
Ministry of Defense	Defense Submarine Manufacturing Project (under P-75I plan-Diesel Electric Submarines)	430,000	Announced	New Unit
Ministry of Defense	Kochi Eight Anti-Submarine Warfare Shallow Water Crafts Construction Project	63,113	Under Implementation	New Unit
Ministry of Defense	Kolkata Shipyard Eight Anti-Submarine Warfare Shallow Water Crafts Construction Project	63,113	Under Implementation	New Unit
Ministry of Defense	Landing Platform Docks (LPD) Defense Manufacturing Project	Not available	Under Implementation	New Unit
Ministry of Defense	Mazagon Guided Missile Destroyers (Warships) Project (under P-15B plan)	225,000	Under Implementation	New Unit
Ministry of Defense	Pipavav Defense Naval Offshore Patrol Vessels Shipbuilding Project (under P-21 plan)	Not available	Under Implementation	New Unit
Ministry of Defense	Visakhapatnam Fleet Support Ships (FSS) Project	152,574	Under Implementation	New Unit

Source: CMIE CapEx database

Chapter 8: Overview of Environment, Social, and Governance Reporting and Investing

8. Introduction

Environmental, social, and governance (ESG) is an approach that companies undertake to be socially responsible and align their wealth and value creation activities with the interests of the environment and the larger stakeholder group that includes workers, communities, customers, and shareholders.

- Environmental deals with aspects that enable or play a role in the conservation of land, water, air, and natural resources. Examples include climate change and carbon emissions, air and water pollution, biodiversity, deforestation, energy efficiency, waste management, and water scarcity.
- Social deals primarily with people and professional relationships. Criteria include customer satisfaction, data protection and privacy, gender and diversity, employee engagement, community relations, human rights, and labor standards.
- Governance charts out the standards for running a company such as board composition, internal practices, regulatory compliance, audit committee structure, executive compensation, and political contributions.

Sustainability standards published by the Global Reporting Initiative (GRI) are the most used ESG framework globally. Standards of the Sustainability Accounting Standards Board (SASB) and the Task Force on Climate-related Disclosures (TFCD) also are used globally. International investors adhere to one or more of these frameworks.

8.1. ESG Reporting Framework in India

The Companies Act 2013 introduced the first ESG disclosure requirements for companies in India. It mandates that organizations include a report on energy conservation along with their annual financial disclosures, and include disclosures on opportunities, threats, risks, and concerns as part of their annual reports under Regulation 34(3) of the SEBI Listing Obligation and Disclosure Requirements (LODR) Regulation, 2015. To further strengthen ESG reporting, SEBI amended Regulation 34(2)(f) of the LODR Regulations to introduce the business responsibility and sustainability report (BRSR) framework in May 2021.

India introduced new ESG reporting requirements from FY2023 for the top 1,000 listed companies (by market capitalization) in the country, stipulating a BRSR containing detailed ESG disclosures.

Exhibit 8.1 (a): Key ESG metrics required by BRSR, India

Metric	Key Performance Indicators
General	• Primary business activities including products and services • Market presence in terms of geography, locations of manufacturing plants, and customer types • Export businesses and contribution to overall company revenue • Investments in technology and R&D that impact ESG performance • Trade and industry connections Other key disclosures: • Summary of material responsible business conduct issues • ESG targets or commitments, action plan, and achievements • External assessment or evaluation of ESG policies
Environmental	• Material impact analysis • Energy consumption, conservation measures taken, and output achieved • Water consumption, conservation measures adopted, and results achieved • GHG emissions - Scope 1 to 3 and initiatives deployed for emission reduction • Overview of waste management, 3Rs (reduce, reuse and recycle) and wastewater management including reuse • Sustainable value chain and sourcing • Environmental impact assessments and life cycle assessments on projects, products, and services • Initiatives under extended producer responsibility (EPR) • Compliance with environmental laws and regulations Other key disclosures: • Business continuity and disaster management plans
Social	• Median remuneration and minimum wages for employees • Employee retention rates • Unions and associations for employee welfare • Health and safety-related risk assessments and disclosures • Human rights-related activities and disclosures • Employee training programs • Details on employee benefits such as insurance and retirement settlements • Employee grievance programs/activities and disclosures • Corporate social responsibility-related activities, initiatives, investments, beneficiaries • Data privacy issues
Governance	• Governance structure • Anti-corruption policies • Bribery-related policies • Conflict of interest and resolution practices and disclosure

Many leading Indian companies have started to measure and report ESG targets as part of their annual reports or sustainability reports. The investor community also is influencing the ESG reporting practice by urging organizations to invest in social causes rather than only business activities that generate commercial returns. India was the first country to mandate corporate social responsibility and demand ethical commitments from businesses. Common ESG practices in other countries are

- Listed companies in the United Kingdom must publish GHG emissions, diversity, and human rights under the Companies Act 2006. Under the Corporate Governance Code 2012,

organizations with a premium listing of equity shares should publish a report on how they implement the main principles of the governance code.

- Disclosure of Non-financial and Diversity Information as part of the European Commission is a regulation related to ESG reporting in the European Union. This requires companies to report material environmental, social, and employee-related matters.
- The US Securities and Exchange Commission (SEC) has made it compulsory for all listed companies to report their environmental compliance expenses. The New York Stock Exchange (NYSE) mandates that listed companies must follow and report a business conduct code and ethics.
- China's Environmental Information Disclosure Act, 2008 requires companies to disclose environmental information. Companies listed on the Shanghai Stock Exchange are required to publish a report on environmental status of the companies.

ESG practices associated with water and wastewater stakeholders:

- End-user industries focus on water conservation through rainwater harvesting, process improvements to reduce water consumption per unit of output produced, reducing freshwater consumption, reusing/recycling wastewater, and ZLD.
- Water and wastewater treatment solution providers focus on reducing product and system energy consumption and improving water recovery rates through wastewater recycling.
    - Concord Enviro was one of the largest ZLD solution provider in India in FY2021 in revenue terms. Through its recycling solutions, Concord Enviro has been supporting its clients achieve water conservation and sustainability.

Exhibit 8.1(b): Industrial Wastewater Recycling: Leading Companies' Financial Metrics, FY2021

Metric	Ion Exchange	Concord Enviro	Arvind Envisol	Suez	Thermax
Overall Revenue (INR Billion)	15	3	2	5	49
Export as a Percentage of Overall Revenue	42%	36%	0%	0%	35%
Revenue from Recycling Business (INR Billion)	3	3	1	1	1
Gross Margins	26%	49%	27%	17%	31%
EBITDA	14%	14%	4%	6%	6%
Profit after tax	10%	6%	2%	3%	4%
Return on capital employed	46%	12%	6%	20%	10%
Return on equity	28%	7%	5%	8%	6%
Working Capital Days	74	204	169	114	106

Note: Gross margin = (Revenue from operations - Cost of goods sold) / Revenue from operations; EBITDA = (Profit after tax + Tax expenses + Finance cost + Depreciation and amortisation – Other income)/ Revenue from operations; Profit after tax (PAT) = Net income/ Revenue; Return on capital employed (ROCE) = Earnings before interest and taxes / Capital employed. Capital employed = Shareholder's funds + Total debt – Cash & cash equivalents; Return on equity (ROE) = Net income or PAT/ Shareholder funds; Working capital days = (Current assets – Current liabilities) *365/ Revenue

Source: Annual Reports, Investor Presentations

Exhibit 8.1(c): ESG Contribution, FY2021

Company	Revenue from Industrial Recycling Solutions (INR Billion)	CAPEX ZLD Revenue from Industrial Recycling Solutions (INR Billion)	CAPEX Benchmark for ZLD Systems (INR per m^3)	Wastewater Recycled (m^3)
Ion Exchange	3.1	0.76	150,000	5,063
Concord Enviro	3.0	1.68	150,000	11,200
Arvind Envisol	1.2	0.34	150,000	2,240
Suez	0.8	0.16	150,000	960
Thermax	0.7	0.14	150,000	840

Methodology:

Step 1: Estimate the total revenue for each company from ZLD system sales considering CAPEX sales only. O&M revenues are excluded. The source of information to estimate ZLD CAPEX revenue is primary discussion with stakeholders.

Step 2: Benchmarks of ZLD system unit costs were sourced from industry experts.

Step 3: By applying the industry CAPEX benchmarks on the ZLD CAPEX revenue, Frost & Sullivan estimated the indicative total wastewater treated and recycled by each company.

Source: Frost & Sullivan Analysis

8.2. ESG Investing

The ESG investment strategy channels investments to companies that meet stringent ESG standards. ESG investing is at a nascent stage in India. Major ESG funds in India are:

- Aditya Birla Sun Life ESG Fund
- Axis ESG Fund
- ICICI Prudential ESG Fund
- Kotak ESG Opportunities Fund
- Mirae Asset ESG Sector Leaders ETF
- Quantum India ESG Equity Fund
- SBI Magnum Equity ESG Fund

Appendix 1: CAPEX Investments by End-user Industry

Indicative List of Investments in Refinery Segment, 2022–2030

Company Name	Project Name	Cost (Rs. Million)	Project Status	Industry Group	Ownership Group	Project Type
Haldia Petrochemicals Ltd.	Balasore Integrated Refinery & Aromatic Complex Project	736,880	Announced	Refinery	State and Private Sector	New Unit
Haldia Petrochemicals Ltd.	Kakinada SEZ Refinery & Petrochemicals Complex Project	736,880	Announced	Refinery	State and Private Sector	Expansion
Reliance Industries Ltd.	Jamnagar Refinery Crude-to-Chemical Unit Project	700,000	Announced	Refinery	Reliance Group [Mukesh Ambani]	New Unit
Al Qebla Al Watya Pvt. Ltd.	Thoothukkudi Oil Refinery Complex Project	490,000	Announced	Refinery	Private (Indian)	New Unit
Kakinada Refinery & Petrochemicals Pvt. Ltd.	Kakinada Petroleum Refinery Project	329,010	Announced	Refinery	G M R Group	New Unit
Hindustan Petroleum Corp. Ltd.	Kakinada SEZ Cracker Unit (Greenfield Petrochemical Complex) Project	320,000	Announced	Refinery	Central Govt. - Commercial Enterprises	New Unit
Petronet L N G Ltd.	Dahej Propane Dehydrogenation Plant Project	125,000	Announced	Refinery	Central Govt. - Commercial Enterprises	New Unit
Reliance Industries Ltd.	Hazira Petrochemical Complex Debottlenecking and Expansion Plant Project	100,000	Announced	Refinery	Reliance Group [Mukesh Ambani]	Expansion
Indian Oil Corpn. Ltd.	Paradip Needle Coker Unit Project	11,700	Announced	Refinery	Central Govt. - Commercial Enterprises	Modernization
Chennai Petroleum Corp. Ltd.	Manali Catalytic Dewaxing & Modification of Hydrocracker Unit Project	10,720	Announced	Refinery	Central Govt. - Commercial Enterprises	Expansion
Indian Oil Corp. Ltd.	Paradip Refinery Aviation Gasoline Manufacturing Plant Project	920	Announced	Refinery	Central Govt. - Commercial Enterprises	New Unit

Source: CMIE CapEx

Indicative List of Investments in Chemicals Segment, 2022–2030

Company Name	Project Name	Cost (Rs. Million)	Project Status	Industry Group	Ownership Group	Project Type
Adani Enterprises Ltd.	Vandh & Tunda Coal to PVC Manufacturing Plant Project	349,000	Announced	Polymers	Adani Group	New Unit
Bharat Petroleum Corp. Ltd.	Rasayani Ethylene Cracker Plant Phase 2 Project	266,967	Announced	Organic Chemicals	Central Govt. - Commercial Enterprises	New Unit
S R F Ltd.	Dahej PCPIR Chemicals Manufacturing Plant Project	75,000	Announced	Other Chemical Products	Private (Indian)	New Unit
South Eastern Coalfields Ltd.	Dankuni Coal To Methanol Plant Project	58,000	Announced	Organic Chemicals	Central Govt. - Commercial Enterprises	New Unit
Mitsu Pvt. Ltd.	Vapi Chemicals, Pharma & API Manufacturing Plant Project	50,000	Announced	Other Chemical Products	Private (Indian)	New Unit
U P L Ltd.	Shahapur Pesticide Ingredients Manufacturing Plant Project	50,000	Announced	Pesticides	Rajju Shroff Group	New Unit
Fertilisers & Chemicals, Travancore Ltd.	Kochi Ammonia-Urea Complex Project	46,000	Announced	Inorganic Chemicals	Central Govt. - Commercial Enterprises	New Unit
Indian Oil Corp. Ltd.	Panipat Styrene Monomer Project	45,540	Announced	Organic Chemicals	Central Govt. - Commercial Enterprises	New Unit
Indian Oil Corp. Ltd.	Panipat Refinery & Petroleum Complex Maleic Anhydride (MAH) Manufacturing Plant Project	41,240	Announced	Organic Chemicals	Central Govt. - Commercial Enterprises	New Unit
G H C L Ltd.	Sutrapada Greenfield Inorganic Complex (Soda Ash Facility) Phase 1 Project	30,000	Announced	Soda Ash	Dalmia Group	New Unit
National Aluminium Co. Ltd.	Paradip Second Captive Caustic Soda Project	30,000	Announced	Caustic Soda	Central Govt. - Commercial Enterprises	New Unit
Colourtex Industries Pvt. Ltd.	Saykha Dyes and Dyes Intermediates Manufacturing Plant Project	20,000	Announced	Dyes & Pigments	Private (Indian)	New Unit
Gujarat Fluorochemicals Ltd.	Dahej Electric Vehicle Battery Chemicals and Applications Project	20,000	Announced	Inorganic Chemicals	Inox Group	New Unit

Source: CMIE CapEx

Indicative List of Investments in Power Segment, 2022–2030

Company Name	Project Name	Cost (Rs. Million)	Project Status	Industry Group	Ownership Group	Project Type
Deoghar Mega Power Ltd.	Deoghar Ultra Mega Power Project	350,000	Announced	Conventional Electricity	Central Govt. - Commercial Enterprises	New Unit
Pancheshwar Development Authority	Pancheshwar Multipurpose Hydel Power Project	331,080	Announced	Conventional Electricity	State Govt. - Statutory Bodies	New Unit
Moher Power Ltd.	Jambusar Gas Based Project	252,000	Announced	Conventional Electricity	Reliance Group [Anil Ambani]	New Unit
Kamala Hydro Electric Power Co. Ltd.	Kamala (Subansiri Middle) Hydel Power Project	201,407	Announced	Conventional Electricity	Om Prakash Jindal Group	New Unit
Greenko Energies Pvt. Ltd.	Sukhpura Standalone Pumped Storage Hydel Power Project	200,302	Announced	Conventional Electricity	Private (Indian)	New Unit
Greenko Energies Pvt. Ltd.	Ippagudem Pumped Storage Power Project	182,030	Announced	Conventional Electricity	Private (Indian)	New Unit
Bharatiya Nabhikiya Vidyut Nigam Ltd.	Fast Breeder Reactor (FBR-3,4,5 & 6) Power Project	180,000	Announced	Conventional Electricity	Central Govt. - Departmental Undertaking	New Unit
Kutchh Power Generation Ltd.	Bhadreshwar Coal Based Power Project	170,000	Announced	Conventional Electricity	Adani Group	New Unit
Ghogarpalli Integrated Power Co. Ltd.	Kalahandi Ultra Mega Power Project	160,000	Announced	Conventional Electricity	Central Govt. - Commercial Enterprises	New Unit
Power Finance Corp. Ltd.	Tamil Nadu Second Ultra Mega Power Project	160,000	Announced	Conventional Electricity	Central Govt. - Commercial Enterprises	New Unit
Andhra Pradesh Power Generation Corp. Ltd.	Cuddapah Nuclear Power Plant Project	150,000	Announced	Conventional Electricity	State Govt. - Commercial Enterprises	New Unit

Source: CMIE CapEx

Indicative List of Investments in Textiles Segment, 2022–2030

Company Name	Project Name	Cost (Rs. Million)	Project Status	Industry Group	Ownership Group	Project Type
Trident Ltd.	Punjab Textile Park Project	20,000	Announced	Other Textiles	Trident Group	New Unit
M C P I Pvt. Ltd.	Bhadrak Polyester Continuous Polymerization & Allied Yarn Project	19,705	Announced	Manmade Filaments & Fibers	Private (Foreign)	New Unit
Vardhman Textiles Ltd.	Spinning Cotton Yarn Capacity Expansion Project	14,000	Announced	Cotton & Blended Yarn	Vardhman Group	Expansion
Sangam Ventures Ltd.	Bhilwara Spinning, Weaving, Garments & Processing Units Project	13,640	Announced	Cotton & Blended Yarn	Private (Indian)	Expansion
Kitex Garments Ltd.	Sitarampur Apparel (Kids Wear) Facility Project	12,930	Announced	Ready-made Garments	Private (Indian)	New Unit
Avgol Nonwovens India Pvt. Ltd.	Halol Nonwoven Fabric (Technical Textile) Project	10,000	Announced	Cloth	Private (Foreign)	New Unit
Nitin Spinners Ltd.	Bhilwara Cotton Yarn, Knitted Fabric & Woven Fabrics Expansion Project	9,500	Announced	Cotton & Blended Yarn	Private (Indian)	Expansion
Southern Gujarat Chamber of Commerce & Industry	Pinjrat (Surat) Textile Processing Park Project	8,000	Announced	Other Textiles	Private (Indian)	New Unit
Trident Ltd.	Himachal Pradesh Textile Park/Unit Project	8,000	Announced	Other Textiles	Trident Group	New Unit
Jay Jay Mills (India) Pvt. Ltd.	SIPCOT Perundurai & Tiruppur Cotton Fabrics Project	6,520	Announced	Cloth	Private (Indian)	New Unit
Best Corporation Pvt. Ltd.	Hoshangabad Cotton Spinning, Hosiery, Knitting & Processing Unit Project	6,200	Announced	Cotton & Blended Yarn	Private (Indian)	New Unit

Source: CMIE CapEx

Indicative List of Investments in Pharmaceuticals Segment, 2022–2030

Company Name	Project Name	Cost (Rs. Million)	Project Status	Industry Group	Ownership Group	Project Type
Government of India	Raigad Bulk Drug Park Project	300,000	Announced	Drugs & Pharmaceuticals	Central Government	New Unit
Government of Punjab	Bhatinda Pharmaceutical Park Project	18,000	Announced	Drugs & Pharmaceuticals	State Government	New Unit
Government of Karnataka	Kadechur Bulk Drug Pharma Park Project	14,780	Announced	Drugs & Pharmaceuticals	State Government	New Unit
Government of India	Haroli Bulk Drug Park Project	11,900	Announced	Drugs & Pharmaceuticals	Central Government	New Unit
Aarti Industries Ltd.	Jhagadia Greenfield Synthetic Organic Chemicals Plant Project	11,140	Announced	Drugs & Pharmaceuticals	Alchemie Group	New Unit
Haryana State Industrial & Infrastructure Development Corporation Ltd.	Panipat Bulk Drug Park Project	10,000	Announced	Drugs & Pharmaceuticals	State Govt. - Commercial Enterprises	New Unit
Jubilant Generics Ltd.	Vilayat Active Pharmaceutical Ingredients Manufacturing Plant Project	9,000	Announced	Drugs & Pharmaceuticals	Jubilant Bhartia Group	New Unit
Government of Tamil Nadu	Cheyyar Active Pharmaceutical Ingredients (API) Park Project	7,700	Announced	Drugs & Pharmaceuticals	State Government	New Unit
Jags Pharma Pvt. Ltd.	Nalagarh Pharma Park Project	7,500	Announced	Drugs & Pharmaceuticals	Private (Indian)	New Unit
Ivanhoe Cambridge	Genome Valley R&D Center Project	7,462	Announced	Drugs & Pharmaceuticals	Private (Foreign)	New Unit
Schott Kaisha Pvt. Ltd.	Jambusar Vial Manufacturing Plant Expansion Project	6,050	Announced	Drugs & Pharmaceuticals	Private (Indian)	Expansion
A C G Universal Capsules Pvt. Ltd.	Aurangabad Capsules Manufacturing Plant Project	6,000	Announced	Drugs & Pharmaceuticals	Private (Indian)	New Unit

Source: CMIE CapEx

Indicative List of Investments in Steel Segment, 2022–2030

Company Name	Project Name	Cost (Rs. Million)	Project Status	Industry Group	Ownership Group	Project Type
Jindal Steel & Power Ltd.	Angul Steel Plant Phase 2 Project	1,199,520	Announced	Steel	Om Prakash Jindal Group	Expansion
Arcelormittal Nippon Steel India Ltd.	Kendrapada Greenfield Integrated Steel Plant Project	1,022,750	Announced	Steel	Private (Foreign)	New Unit
Bhushan Power & Steel Ltd.	Rengali Integrated Steel Plant Expansion Project	550,000	Announced	Steel	Private (Indian)	Expansion
J S W Utkal Steel Ltd.	Dhinkia (Jagatsinghpur) Integrated Steel Plant Project	550,000	Announced	Steel	Om Prakash Jindal Group	New Unit
Jindal Steel & Power Ltd.	Raigarh Integrated Steel Plant Expansion Project	456,970	Announced	Steel	Om Prakash Jindal Group	Expansion
Steel Authority of India Ltd.	Rourkela Steel Plant Capacity Expansion Project	410,000	Announced	Steel	Central Govt. - Commercial Enterprises	Expansion
Adani Enterprises Ltd.	Mundra Integrated Steel Mill Project	369,860	Announced	Steel	Adani Group	New Unit
Arcelormittal Nippon Steel India Ltd.	Hazira Steel Plant Capacity Expansion Project	351,450	Announced	Steel	Private (Foreign)	Expansion
Rashtriya Ispat Nigam Ltd.	Visakhapatnam High End Steel Manufacturing Unit Project	350,000	Announced	Steel	Central Govt. - Commercial Enterprises	New Unit
Arcelormittal Nippon Steel India Ltd.	Kidiabet Steel City & Industrial Cluster Project	300,000	Announced	Steel	Private (Foreign)	New Unit
Arcelormittal Nippon Steel India Ltd.	Suvali Steel Plant & Captive Port Project	300,000	Announced	Steel	Private (Foreign)	New Unit
Government Of Telangana	Bayyaram (Khammam) Steel Plant Project	300,000	Announced	Steel	State Government	New Unit
Arcelor Mittal India Pvt. Ltd.	Jharkhand Steel Phase 1 Project	260,000	Announced	Steel	Private (Foreign)	New Unit
Steel Authority of India Ltd.	Durgapur Steel Plant Capacity Expansion Project	250,000	Announced	Steel	Central Govt. - Commercial Enterprises	Expansion

Source: CMIE CapEx

Indicative List of Investments in Food & Beverage Segment, 2022–2030

Company Name	Project Name	Cost (Rs. Million)	Project Status	Industry Group	Ownership Group	Project Type
Government of Tamil Nadu	Tindivanam Food Park Project	20,000	Announced	Processed Foods	State Government	New Unit
Hindustan Unilever Ltd.	Chennai Food Processing Unit (Nutritional & Beverage Products) Project	19,000	Announced	Processed Foods	Unilever (F) Group	New Unit
A B Mauri India Pvt. Ltd.	Pilibhit Yeast Manufacturing Plant Project	11,000	Announced	Processed Foods	Chhabria M.R. Group	New Unit
Varun Beverages Ltd.	Supa Food Processing Unit Project	8,200	Announced	Processed Foods	Private (Indian)	New Unit
Jai Hind Sugar Pvt. Ltd.	Achegaon Integrated Sugar Plant Expansion Project	7,912	Announced	Sugar	Private (Indian)	Expansion
I T C Ltd.	Uttar Pradesh Mega Food Processing Plant Project	7,600	Announced	Processed Foods	I T C (F) Group	New Unit
Milky Mist Dairy Food Pvt. Ltd.	Erode Food Processing Unit Project	6,000	Announced	Processed Foods	Private (Indian)	New Unit
Bindals Papers Mills Ltd.	Changipur Integrated Sugar Plant Project	5,695	Announced	Sugar	Private (Indian)	New Unit
Shivneri Sugars Ltd.	Nhavi Bk (Koregaon) Sugar Factory Expansion Project	5,200	Announced	Sugar	Private (Indian)	Expansion
Gujarat Ambuja Exports Ltd.	Sitarganj Greenfield Corn Wet Milling Plant Project	5,000	Announced	Other Agricultural Products	Gujarat Ambuja Proteins Group	New Unit
Gujarat Co-operative Milk Marketing Federation Ltd.	Rajkot (Saurashtra Region) Dairy Plant Project	5,000	Announced	Dairy Products	Cooperative Sector	New Unit

Source: CMIE CapEx

Indicative List of Investments in Fertilisers Segment, 2022–2030

Company Name	Project Name	Cost (Rs. Million)	Project Status	Industry Group	Ownership Group	Project Type
Gopalpur Ports Ltd.	Gopalpur Fertiliser and Petrochemical Industries Plant Project	20,000	Announced	Fertilisers	Private (Indian)	New Unit
Chambal Fertilisers & Chemicals Ltd.	Gadepan Technical Ammonium Nitrate Manufacturing Plant Project	11,700	Announced	Fertilisers	Birla K.K. Group	New Unit
Fertilisers & Chemicals, Travancore Ltd.	Udyogamandal Urea Project	9,400	Announced	Fertilisers	Central Govt. - Commercial Enterprises	New Unit
Rashtriya Chemicals & Fertilizers Ltd.	Thal DAP/NPK Manufacturing Plant Project	9,145	Announced	Fertilisers	Central Govt. - Commercial Enterprises	New Unit
Agrocel Industries Pvt. Ltd.	Dhordo Marine Chemicals, Fertilisers Plant Expansion Project	6,000	Announced	Fertilisers	Excel Industries Group	Expansion
Krishana Phoschem Ltd.	Jhabua Chemical Fertiliser and Synthetic Organic Chemicals Manufacturing Plant Project	5,000	Announced	Fertilisers	Private (Indian)	New Unit
Solaris Chemtech Inds. Ltd.	Ratadia Marine Chemicals, Fertilisers, Organic Chemicals Plant Expansion Project	5,000	Announced	Fertilisers	Excel Industries Group	Expansion
Indian Farmers Fertiliser Co-op. Ltd.	Phulpur Nano Fertiliser Manufacturing Plant Expansion Project	1,950	Announced	Fertilisers	Cooperative Sector	Expansion
Gujarat State Fertilizers & Chemicals Ltd.	Vadodara Ammonium Sulphate Manufacturing Plant Project	800	Announced	Fertilisers	State Govt. - Commercial Enterprises	New Unit
Vidarbha Co-operative Marketing Society Ltd.	Umred Greenfield SSP/GSSP/Granulated Fertiliser Mixtures/Phosphate Rich Organic Manure Plant Project	550	Announced	Fertilisers	Co-operative Sector	New Unit
Rajureshwar Industries Pvt. Ltd.	Jalna SSP, GSSP, Sulfuric Acid & LABSA Manufacturing Unit Project	402	Announced	Fertilisers	Private (Indian)	New Unit

Source: CMIE CapEx

Indicative List of Investments in Distillery Segment, 2022–2030

Company Name	Project Name	Cost (Rs. Million)	Project Status	Industry Group	Ownership Group	Project Type
Indian Oil Corp. Ltd.	Balgopalpur Grain Based Distillery & Co-generation Power Plant Project	8,700	Announced	Beer & Alcohol	Central Govt. - Commercial Enterprises	New Unit
Som Distilleries Pvt. Ltd.	Sehatganj New Grain & Molasses Based Distillery Plant Project	8,550	Announced	Beer & Alcohol	Private (Indian)	New Unit
Luna Chemical Inds. Pvt. Ltd.	Dahej Ethanol Plant Project	6,500	Announced	Beer & Alcohol	Private (Indian)	New Unit
Hindustan Petroleum Corp. Ltd.	Umerkote Grain Based Distillery Plant Project	5,000	Announced	Beer & Alcohol	Central Govt. - Commercial Enterprises	New Unit
U P L Ltd.	Dahej Ethanol Plant Project	5,000	Announced	Beer & Alcohol	Rajju Shroff Group	New Unit
Shree Renuka Sugars Ltd.	Ethanol Manufacturing Plant Expansion Project	4,500	Announced	Beer & Alcohol	Private (Foreign)	Expansion
Indian Cane Power Ltd.	Uttur Molasses Based Distillery & Co-generation Power Plant Project	4,397	Announced	Beer & Alcohol	Private (Indian)	New Unit
Shree Renuka Sugars Ltd.	Ajra Ethanol Manufacturing Plant Expansion Project	4,000	Announced	Beer & Alcohol	Private (Foreign)	Expansion
Dhampur Sugar Mills Ltd.	Rajpura Molasses/Grain Based Distillery Plant Project	3,258	Announced	Beer & Alcohol	Dhampur Sugar Mills Group	New Unit
Shri Bajrang Agro Processing Ltd.	Jalso Grain & Molasses Based Distillery Plant Project	3,250	Announced	Beer & Alcohol	Private (Indian)	New Unit
Chandigarh Distillers & Bottlers Ltd.	Banur Grain Based Distillery & Co-generation Power Plant Project	3,000	Announced	Beer & Alcohol	Private (Indian)	Expansion
Premier Alcobev Pvt. Ltd.	Bamra Block Grain Based Distillery & IMFL Bottling Plant Project	2,750	Announced	Beer & Alcohol	Private (Indian)	New Unit
Dalmia Bharat Sugar & Inds. Ltd.	Grain Based Distillery Plant Project	2,630	Announced	Beer & Alcohol	Dalmia Group	New Unit
Mash Bio-fuels Pvt. Ltd.	Panimura Ethanol, ENA, Co-generation Power Plant & Bottling Plant Project	2,580	Announced	Beer & Alcohol	Private (Indian)	New Unit
Dhampur Sugar Mills Ltd.	Meerganj Molasses Based Distillery & Co-Generation Power Plant Project	2,500	Announced	Beer & Alcohol	Dhampur Sugar Mills Group	New Unit

Source: CMIE CapEx

Appendix 2: Competitor Profiles

Ion Exchange

Company Snapshot	Ion Exchange is a pioneer in water treatment solutions in India with a legacy of more than 5 decades and a strong international presence. Ion Exchange offers complete water treatment solutions for a wide variety of industries, institutions, municipalities, and communities. Ion Exchange is the largest environmental solutions provider and one of the few companies that offer a complete range of products and technologies to numerous industries..
Key Facts	• Founded: 1964 • Headquarters: Mumbai, Maharashtra, India • Key locations in India: Bengaluru, Chennai, Vizag, Hyderabad, Pune, Kolkata, New Delhi, Chandigarh • Employees (global): 2,000
Key Services	Raw water treatment technologies include flocculation, disinfection, clarification, and filtration. Process water treatment technologies include softener, dealkalizers, demineralizers, RO, electro deionization, forward osmosis, and multieffect evaporators. Post treatment technologies include chemical dosing systems, deaerators, condensate polishing, side stream filters, boiler water chemicals, and cooling water chemicals. Specialty process chemicals and enzymes include a wide range of process chemicals for industries including ceramic, sugar, paper, mining, textile, oil and gas, and pharmaceuticals. Wastewater treatment includes screening, oil and grease removal systems, biological process systems, advanced oxidation systems, tertiary systems, and selectively adapted bacteria cultures. A complete ZLD solution comprises advanced MBRs, UF and RO, forward osmosis, an oil membrane brine concentrator, and evaporators. Solid waste management includes thickeners, centrifuge, decanters, belt filter press, and filter press Hygiene and sanitization services include sanitization chemicals and dispensers.
Recent Developments	Ion Exchange inaugurated its new research & development center in Patancheru, Telangana in 2019

Source: Company websites and news articles

Suez

Company Snapshot	Suez has provided more than 750 state-of-the-art water and wastewater treatment plants for municipal corporations and industries, About 7.5 billion liters of safe drinking water produced in Suez-run treatment plants every day cater to 55 million people. One billion liters of wastewater from cities and industries are treated using advanced technology.
Key Facts	• Founded: 1978 • Headquarters: Gurugram, Haryana, India • Key locations in India: Bengaluru
Key Services	Products and services include biological treatment, biosolids, biowaste, clarifiers, disinfection, oxidation, evaporators, and crystallizers. Chemical programs include boiler water chemicals, chemical processing treatment, cooling water chemicals, industrial process treatments, and membrane chemicals. Asset management programs combine data and analytics to help water treatment professionals prevent unplanned downtime, increase asset reliability, extend asset life, and optimize operations. The ChemSure Chemical Delivery Service includes a fleet of more than 110 vehicles and 40 workers who are certified by the regulatory body to deliver chemical solutions in a safe, professional, cost-efficient, and timely manner. Water services include emergency response solutions, asset care services, expert guidance services, operations outsourcing, offsite treatment, temporary mobile water and wastewater treatment solutions. Waste management services for municipal and industrial end users
Recent Developments	Suez won two contracts worth 60 million euros in 2020 to design, build, and operate 775 MLD water treatment plant and treated water reservoir including a pumping station at TK Halli Water Complex in Bangalore. The project is expected to be completed in 2023. In 2019, Suez won a contract to rehabilitate and operate the drinking water distribution system of the city of Mangalore in the state of Karnataka. The contract was worth 72 million euros.

Source: Company websites and news articles

Thermax

Company Snapshot	Thermax Group provides sustainable solutions in the energy and environment sector. Its business portfolio comprises products that enable heating, cooling, water and waste management, and specialty chemicals. The company also designs, builds, and commissions large boilers for steam and power generation, turnkey power plants, industrial and municipal wastewater treatment plants, waste heat recovery systems, and air pollution control projects.
Key Facts	• Founded: 1974 • Headquarters: Pune, Maharashtra, India • Key location in India: Pune • Employees (Global): 3,627
Key Services	• Water and wastewater treatment, ZLD, and desalination solutions. • Steam engineering • Outsourced utility delivery services on BOOT • O&M • Boiler and heater services • Cooling services
Recent Developments	• Thermax inaugurated a new manufacturing facility in Sri City, Andhra Pradesh. (January 2019) • Thermax launched 'atoM', a completely modularised and ultra-compact sewage recycle system to treat sewage water efficiently in confined spaces. (October 2020)

Source: Company websites and news articles

Arvind Envisol

Company Snapshot	Arvind Envisol is a key company in water and wastewater management space across ETP, STP, and desalination, high-purity, and drinking water treatment. It provides a one stop solution that includes products and services.
Key Facts	• Founded: 2008 • Headquarters: Ahmedabad, Gujarat, India • Key locations in India: Mumbai, Chennai, New Delhi
Key Services	• Wastewater primary treatment solutions include Clarifiers, tube settlers, high-rate solid contact type clarifiers, and dissolved air flotation. • Secondary/biological treatment solutions include extended aeration systems, sequential batch reactors, MBBR technology, MBR, and upflow anaerobic sludge blanket reactors. • Tertiary treatment solutions include filtration systems, membrane-based TDS reduction, and advanced oxidation systems. • Evaporators for ZLD systems • Sludge management technologies include filter, belt, and screw presses and centrifuges. • Treatment plant solutions include ETP, STP, PSTP, ZLD, and SWT systems.
Recent Developments	The company recently partnered with the Government of Ethiopia to set up a Zero Liquid Discharge (ZLD) water treatment plant at the Hawassa Industrial Park (2019)

Source: Company websites and news articles

Aquatech Asia

Company Snapshot	Aquatech Asia is a major company in water purification technologies for the industrial and infrastructure sectors. Its primary focus is on desalination, water recycle and reuse, and ZLD. Aquatech executed more than 1,000 water management projects in more than 60 countries.
Key Facts	• Founded: 1986 • Headquarters: Pune, Maharashtra, India • Key locations in India: Pune
Key Services	• Desalination products include membrane technologies, mechanical vapor compression, multieffect distillation, multistage flash, and spray film technology. • ZLD installations include stand-alone thermal/evaporative processes, membrane processes, or hybrid systems. • Recycle and reuse technologies include physical chemical and filtration treatment, biological treatment, evaporation and crystallization, ion exchange and demineralizers, and electro deionization. • Wastewater treatment solutions • Industrial process water technologies leverage thermal, ion exchange, membrane-based, and raw water processes. • Membranes modules – RO, MBR etc. • Total water management –services include chemical services, water technologies, and managed operations. • O&M
Recent Development	• FEDI technology was used in Egypt's first ZLD Plant (March 2019) • Aquatech partners with OXY on one of the largest produced water treatment system in the world.

Source: Company websites and news articles

Murugappa Water Technology & Solutions

Company Snapshot	Murugappa Group is one of India's leading business conglomerates. The group has 28 businesses including nine listed companies. Murugappa Water Technology & Solutions manufacturers water and wastewater treatment systems for industries such as pharmaceuticals, sugar, food and beverage, textile, chemicals, and others
Key Facts	• Founded: 1900 • Headquarters: Chennai, Tamil Nadu, India • Key locations in India: Chennai • Employee size (global): 90+ specialized engineers
Key Services	• Murugappa provides RO, UF, NF, and MBR membranes; aerators; clarifiers; thickeners; flash mixers; flocculators and agitators; and packaged STP systems for water and wastewater treatment. • O&M entails maintenance and troubleshooting of water and wastewater plants. • Refurbishment of existing facilities allows for performance improvement or capacity enhancement. • Plant audits to assess plant performance and check the condition of critical equipment to his ensure that clients avoid unnecessary downtime. MWTS also conducts pilot testing of technologies. • Available chemicals include coagulants, flocculants, membrane cleaners, and evaporator chemicals. • MWTS provides and manages spares including RO membrane and associate accessories, cartridge filters, UF membranes, pumps and blowers, clarifiers, HRSCC, thickeners, floating aerators, and agitators.
Recent Development	• The company launched new MF modules named KLEAN-PF/PV

Source: Company websites and news articles

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