REPORTS AND DATA

GLOBAL WATER AND WASTEWATER TREATMENT MARKET

FORECAST TO 2033

By Type, By Offering, By Equipment, By Application, By End-Use

13th June 2024

ABOUT US

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. MARKET SYNOPSIS

1.1. DEFINITION OF WATER AND WASTEWATER TREATMENT

Water treatment pertains to the systematic set of procedures employed to enhance the purity and safety of water by mitigating, eliminating, or diminishing the presence of impurities, pollutants, and undesired substances. The goal of water treatment is to make water safe and suitable for various purposes, including drinking, industrial processes, irrigation, and recreational activities. This process involves a series of physical, chemical, and biological processes that target specific contaminants such as suspended solids, microorganisms, dissolved chemicals, and metals. Water treatment helps ensure the protection of public health, preservation of ecosystems, and the sustainable use of water resources.

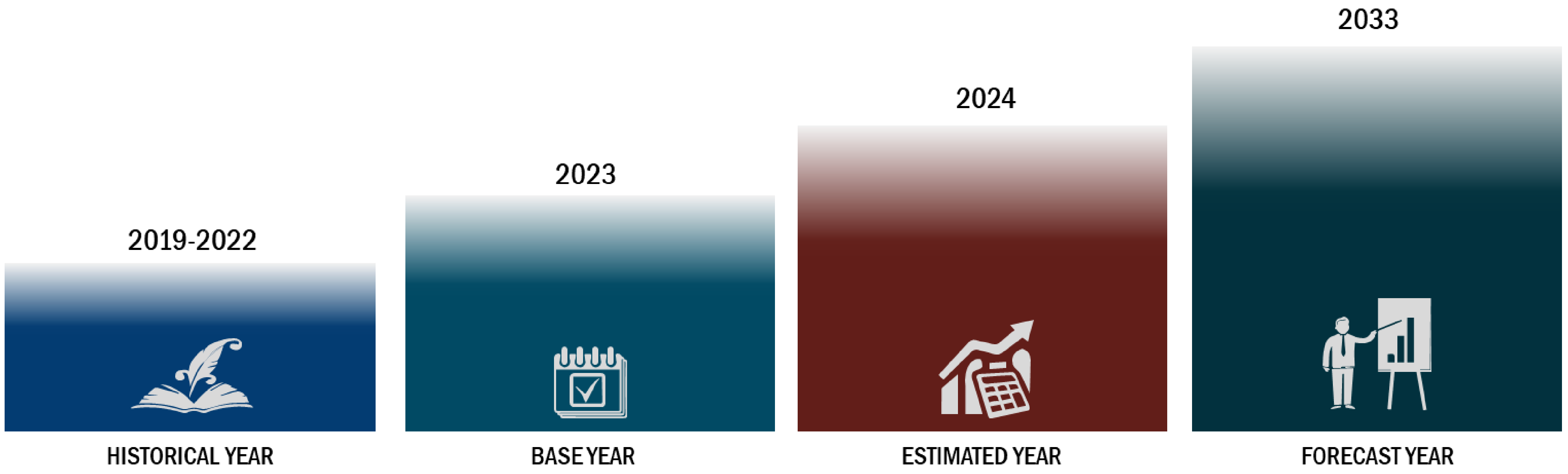
Wastewater treatment involves eliminating pollutants from used or polluted water, ensuring its safe return to the environment or potential reuse. The process includes primary, secondary, and tertiary treatment stages, effectively purifying the water for release into rivers, lakes, oceans, or non-drinking applications like irrigation and industry. The core objective is to safeguard public health, ecosystems, and water quality, mitigating human-induced environmental harm.

1.2. RESEARCH SCOPE & PREMISE

The report provides market value for the base year 2023 and a yearly forecast from 2024 to 2033 in terms of Revenue (USD Million). Market for each segment is present for India for the above-mentioned forecast period.

Key industry dynamics, regulatory scenario, and future markets of Water and Wastewater Treatment market are analyzed to understand their impact on demand for the forecast period. Growth rates have been estimated using correlation, regression, and time-series analysis.

FIGURE 1. YEARS CONSIDERED IN THE STUDY



1.3. RESEARCH METHODOLOGY

A research methodology is a systematic approach for assessing or conducting a market study. Researchers tend to draw on a variety of both qualitative and quantitative study methods, inclusive of investigations, surveys, secondary data and market observation.

Such plans can focus on classifying the products offered by leading market players or simply use statistical models to interpret observations or test hypotheses. While some methods aim for a detailed description of the factors behind an observation, others present the context of the current market scenario.

1.3.1. SECONDARY RESEARCH MODEL

Extensive data is obtained and cumulated on a substantial basis during the inception phase of the research process. The data accumulated is consistently filtered through validation from the in-house database, paid sources as well reputable industry magazines.

A robust research study requires an understanding of the overall value chain. Annual reports and financials of industry players are referred thoroughly to have a comprehensive idea of the market taxonomy.

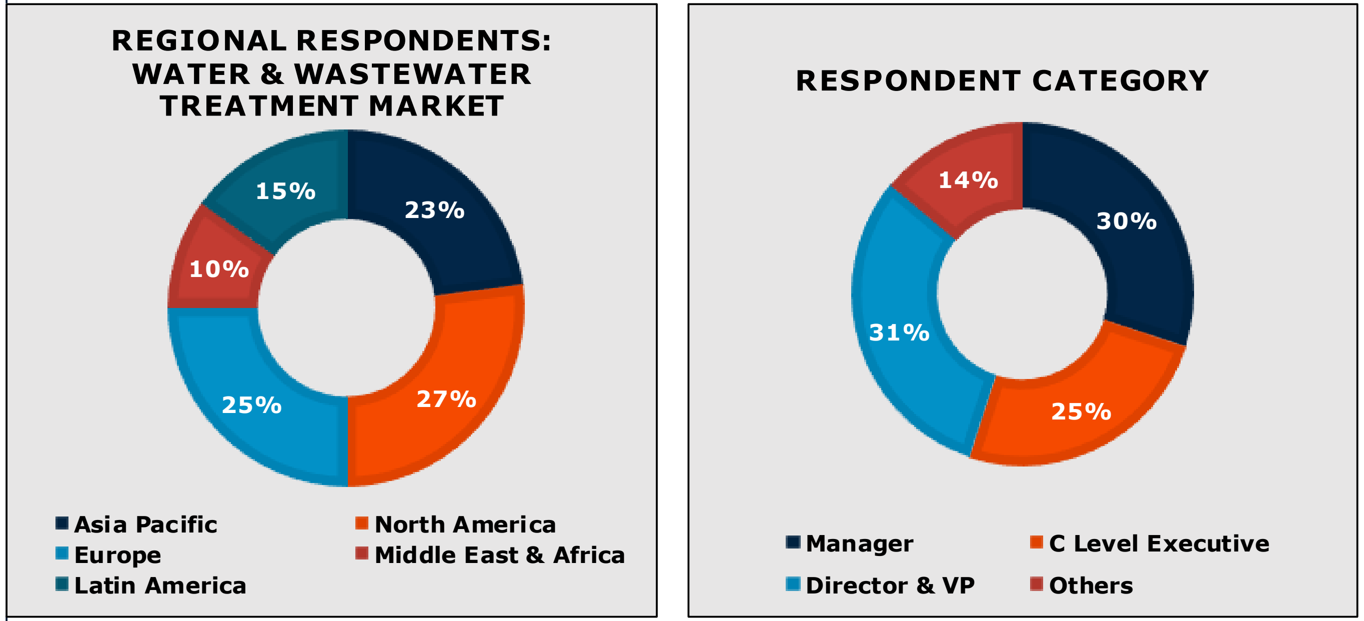
1.3.2. PRIMARY RESEARCH MODEL

Post conglomeration of the data obtained through secondary research; a validation process is initiated to verify the numbers or figures. This process is usually performed by having a detailed discussion with the industry experts. Discussions with the subject matter experts were conducted to obtain quantitative and qualitative information and validate our market research findings.

However, we do not restrict our primary interviews only to the industry leaders. Our team covers the entire value chain while verifying the data. A significant number of suppliers and stakeholders are interviewed to make our findings authentic. The current trends, which include the drivers, restraints, and opportunities, are also derived through the primary research process.

FIGURE 2. PRIMARY INTERVIEW BREAKDOWN: INDIA WATER AND WASTEWATER TREATMENT MARKET

Primary Interview Breakdown : Water And Wastewater Treatment Market



Stakeholder(s)	
Stakeholder Domain	**Percentage**
COO/EVP/VP/Executives	47%
Manufacturer/Project Management Executives	38%
Industry Experts	15%

1.4. MARKET ESTIMATION

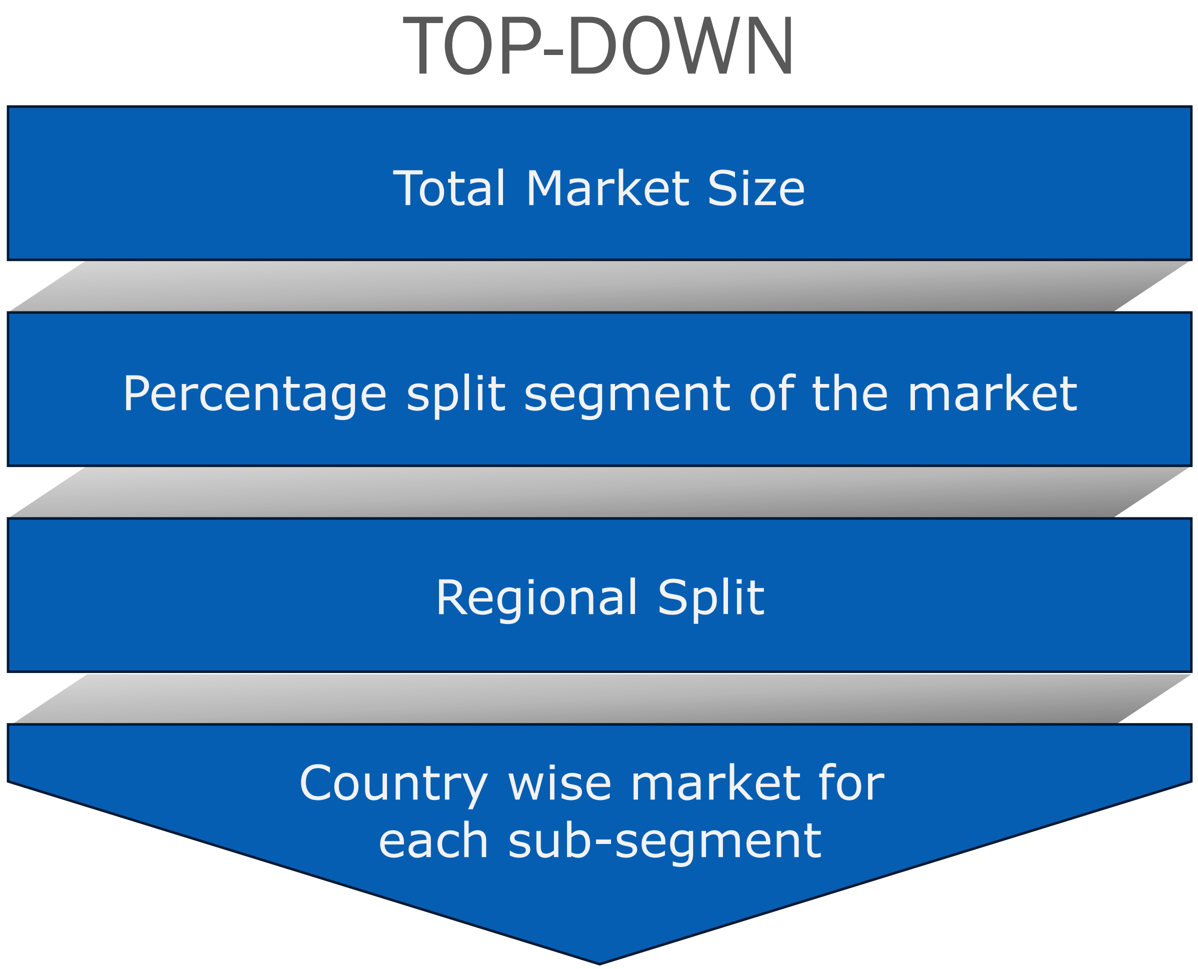
The market estimation is conducted by analyzing the data collected through both secondary and primary research. This process involves market breakdown, bottom-up and top-down approach.

Moreover, while forecasting the market a comprehensive statistical time series model is designed for each market. Macroeconomic indicators have been taken into consideration to understand the current trends of the market. The process of data triangulation method to arrive at the final market estimates verifies each data point.

Top-down, as well as the bottom-up approach, were used for the estimation and validation of the global market. These methods were applied extensively for the estimation of the market size of the sub-segments as well. Key stages for the market estimation included:

- Identification of the key players in the industry through extensive secondary research.
- Determination of the industry's supply chain and market size (in terms of value) through primary and secondary research processes.
- Determination of percentage shares, splits, and breakdowns of each sub segments using secondary sources and its validation through primary sources.

FIGURE 3. TOP-DOWN APPROACH



1.4.1. MARKET SHARE BASED APPROACH

The global as well as key regional market players involved in the market were identified through extensive research. The market share of major players for the total product was estimated in a manner that approximately 80% of the products market was covered. The market revenue was then extrapolated to reach the global market value for the market.

Brand-wise regional market for each player was estimated on the basis of the products offered by the companies present in each region/country. Along with products, the analyst also covered the regional as well as end-use market trends to determine the forecasts.

Thus, the regional/country-wise market was estimated for each product segment for each End-Use.

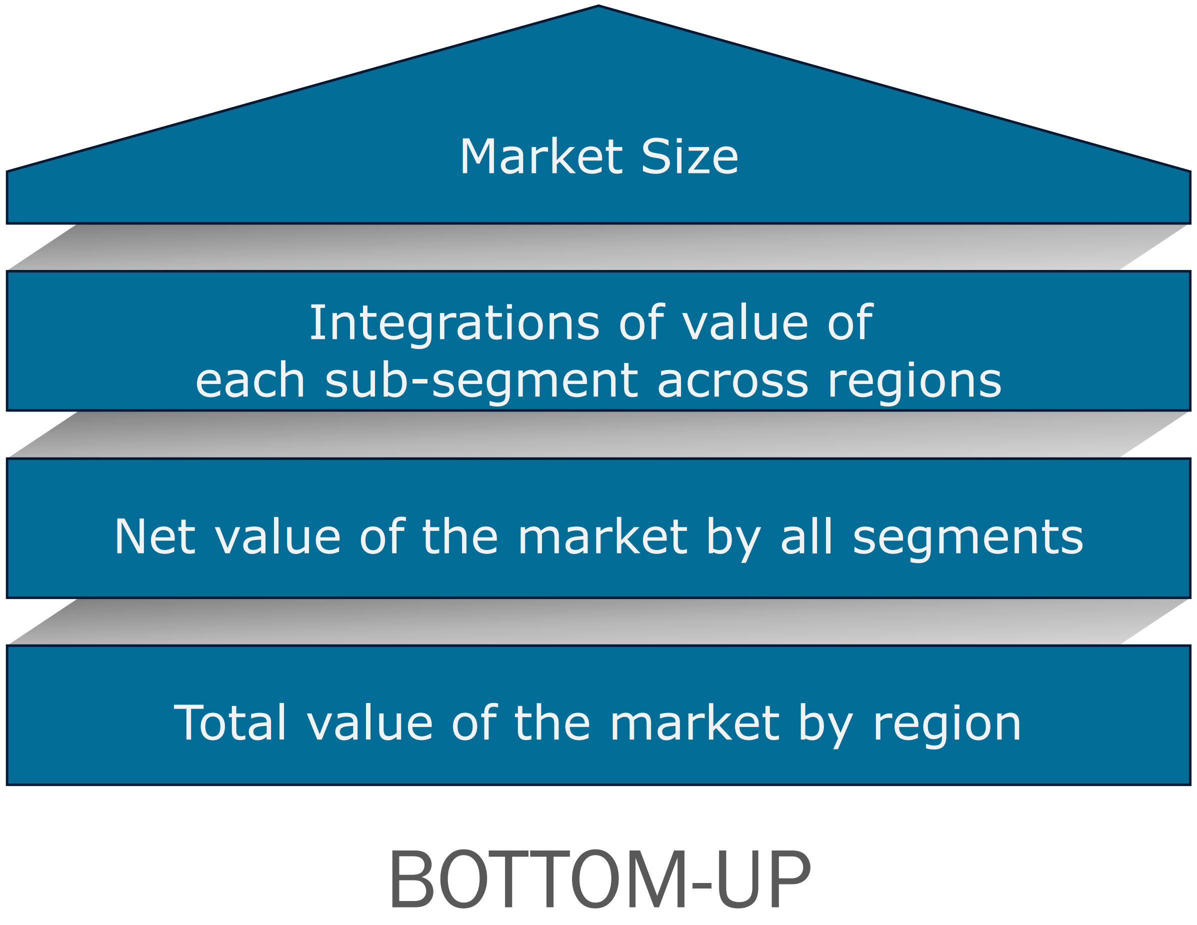
1.4.2. END-USE BASED APPROACH

The average selling price (ASP) of each product was determined. A comprehensive analysis was carried out to obtain average selling prices of all materials of products offered by market players operating in an individual region/country. The obtained data were used to calculate the average selling price for each product material. Furthermore, Volume consumption for each product material was determined in each region/country.

Market revenue was estimated using average selling price and the volume consumption of products for each End-Use segment in every region/country.

The market values from both the approaches were triangulated to calculate the global market value.

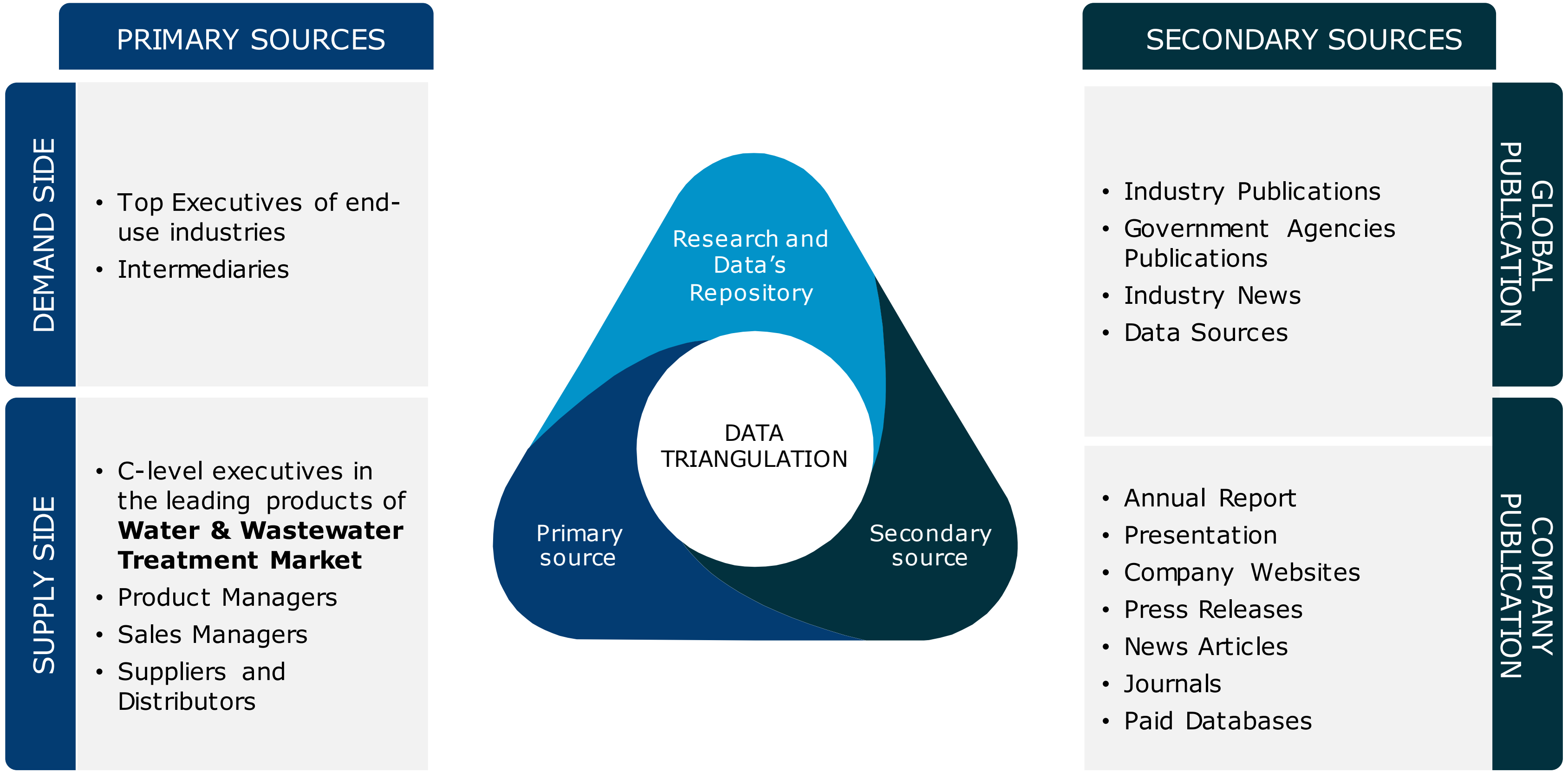
FIGURE 4. BOTTOM-UP APPROACH



1.5. DATA TRIANGULATION

The process of data triangulation method was applied to arrive at the final market estimates verify each data point. Upon estimation of the global market size using the market size estimation approaches as explained above; the market was split into several segments and sub-segments. To complete the overall market estimation process and reach accurate statistics of the individual market segment and sub-segment, the data triangulation and market breakdown processes were applied, wherever applicable. The data was triangulated by studying various factors and trends from both the production side and consumption sides in the industry. Moreover, while forecasting the market a comprehensive statistical time series model was designed for the market. Macroeconomic indicators were taken into consideration to understand the current trends of the market.

FIGURE 5. DATA TRIANGULATION



Source: Journals & Articles, Press releases, Company websites, Investor presentations & Whitepapers, Annual Reports, Primary Interviews, and Reports and Data

1.6. ASSUMPTIONS & LIMITATIONS

Parameter	Description
Market Value	**For the Water and Wastewater Treatment market study value is considered in USD Billion**
Exchange Rate	**The exchange rate fluctuations are assumed to be stable enough, that it does not have a significant effect on market forecasts**
Price	**Average Selling prices are considered**
Economic & Political Stability	**It is assumed that all countries have economic & political stability**

2. WATER AND WASTEWATER TREATMENT MARKET OVERVIEW

2.1. EXECUTIVE SUMMARY

The Global Water and Wastewater Treatment market is expected to grow at a CAGR of 6.10% in terms of value to reach USD 521.97 Billion in 2033 from USD 306.332 Billion in 2024.

The global water and wastewater treatment market is experiencing a significant surge in demand, driven by several key factors that underscore the critical importance of efficient and sustainable water management practices. One of the primary drivers behind this uptick in demand is the escalating need for clean and potable water due to population growth, urbanization, and industrialization. As the world's population continues to expand, particularly in urban areas, the strain on existing water resources intensifies, necessitating robust treatment solutions to ensure the availability of safe drinking water and to mitigate environmental pollution.

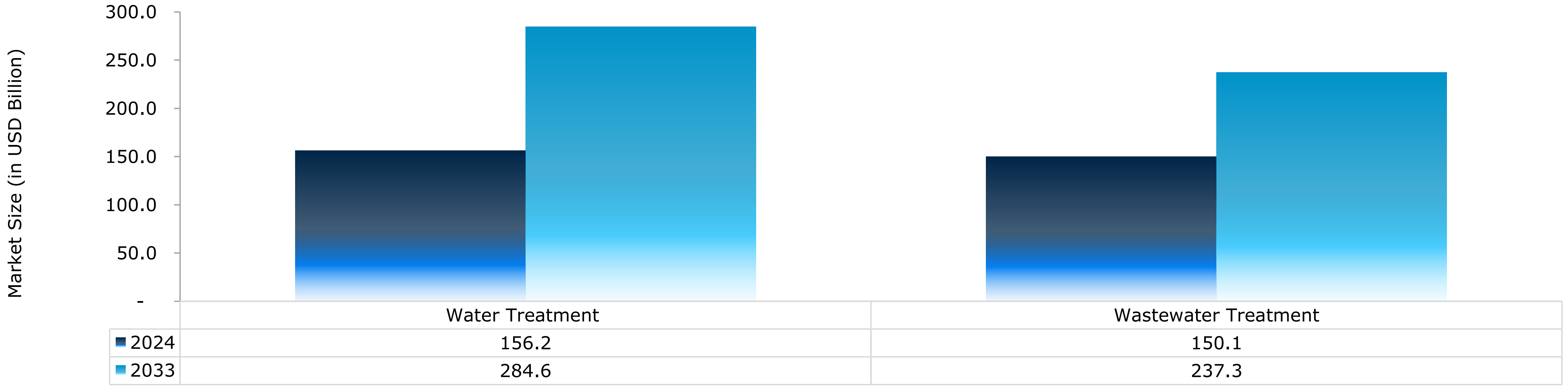
Furthermore, increasing awareness about water-related health risks and environmental degradation has prompted governments, regulatory bodies, and industries to prioritize water treatment initiatives. Stringent regulations and standards regarding wastewater discharge and water quality have propelled investments in advanced treatment technologies and infrastructure upgrades across various sectors such as municipal, industrial, and commercial. These regulations aim to curb waterborne diseases, protect ecosystems, and promote sustainable water usage practices.

The rise of digitalization and technological advancements has also played a pivotal role in driving the demand for water and wastewater treatment solutions. The integration of digital technologies, such as Internet of Things (IoT), artificial intelligence (AI), and data analytics, has revolutionized the water industry by enabling real-time monitoring, predictive maintenance, and optimization of treatment processes. This digital transformation has not only enhanced operational efficiency but also reduced operational costs and improved overall system performance.

Moreover, increasing concerns about water scarcity and climate change have spurred investments in water reuse and recycling technologies. Water-stressed regions are turning to innovative solutions like desalination, membrane filtration, and advanced oxidation processes to reclaim and treat wastewater for non-potable purposes such as irrigation, industrial processes, and groundwater recharge. These technologies not only alleviate pressure on freshwater sources but also contribute to sustainable water management practices and environmental conservation.

In addition to technological advancements, the growing emphasis on sustainability and environmental responsibility has led to the adoption of green and eco-friendly water treatment solutions. Manufacturers and service providers are developing energy-efficient treatment processes, utilizing renewable energy sources, and implementing circular economy principles to minimize waste generation and maximize resource recovery. These initiatives align with global sustainability goals and contribute to reducing the carbon footprint of water and wastewater treatment operations.

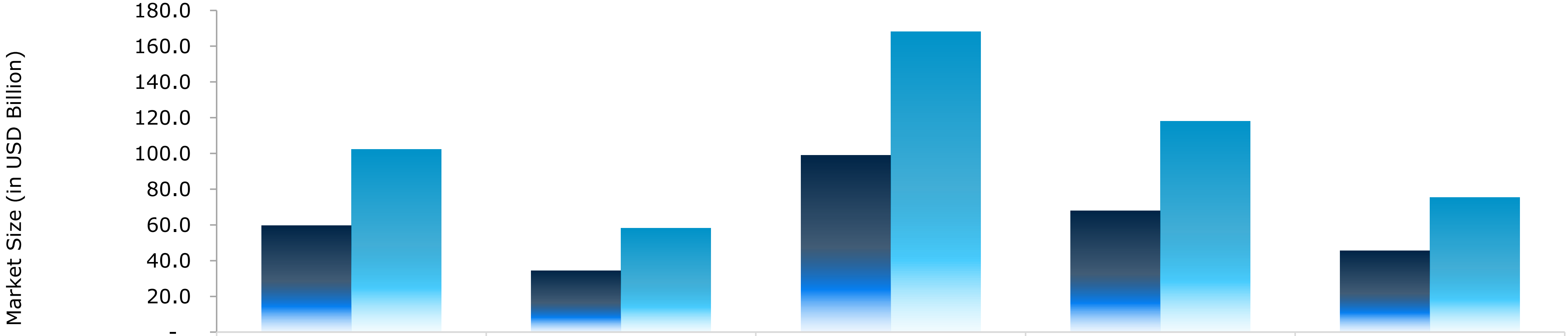
FIGURE 6. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: TYPE (IN USD BILLION)



Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

Based on type, the water treatment segment is expected to have major share in the water and wastewater treatment market with a CAGR of 6.89% in terms of value. The demand for water treatment services and technologies has been steadily increasing due to several key factors driving the need for clean and safe water. One of the primary drivers is the growing global population, which puts immense pressure on water resources. As more people inhabit urban areas and industrialization expands, the demand for fresh water for drinking, industrial processes, and agricultural activities rises significantly. This demographic shift has led to a heightened awareness of the importance of water quality and the need for effective treatment solutions. Furthermore, increasing environmental regulations and standards have mandated stricter requirements for wastewater discharge and water quality management. Governments and regulatory bodies across the globe are enforcing stringent guidelines to ensure that water bodies are protected from pollution and contamination. This has spurred industries, municipalities, and communities to invest in advanced water treatment technologies to meet compliance standards and reduce their environmental impact.

FIGURE 7. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: OFFERING (IN USD BILLION)



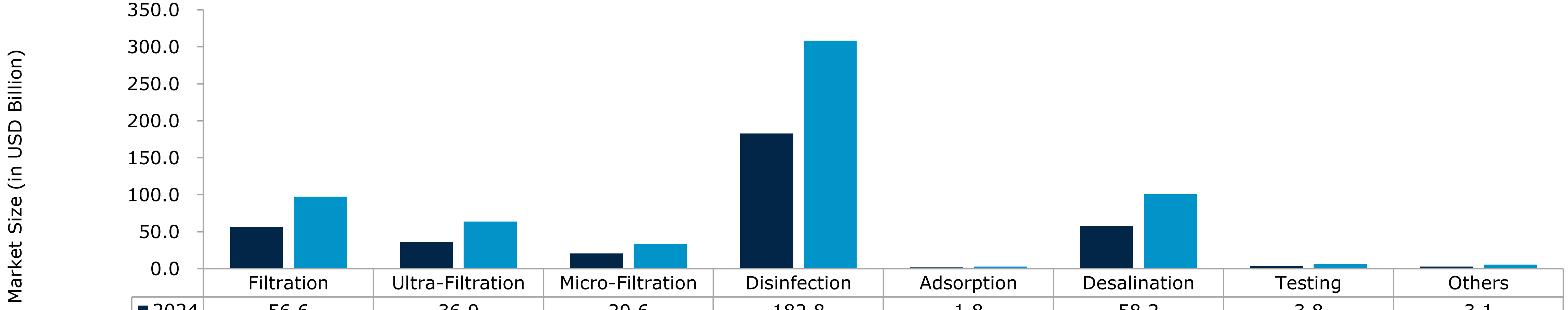
	Treatment Technologies	Treatment Chemicals	Process Control and Automation	Design, Engineering, and Construction Services	Operation and Maintenance Services
2024	59.6	34.4	99.0	67.9	45.5
2033	102.3	58.1	168.2	118.0	75.4

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

Based on offering, the treatment technology segment is expected to grow at the highest rate in the water and wastewater treatment market with a CAGR of 6.19% in terms of value. The increasing global demand for water and the growing awareness of environmental sustainability have propelled significant advancements in water and wastewater treatment technologies. Among these, several key technologies have seen a surge in demand due to their effectiveness in addressing diverse water treatment challenges. The Activated Sludge Process (ASP) remains one of the most widely used and trusted methods for treating wastewater. Its popularity stems from its ability to efficiently remove organic matter and nutrients from wastewater, making it suitable for both municipal and industrial applications. ASP involves the use of microorganisms in aerobic conditions to break down organic pollutants, resulting in cleaner effluent discharged back into water bodies or reused for various purposes. With stricter regulatory standards and increasing wastewater volumes, the demand for ASP systems continues to rise, especially in urban areas facing rapid industrialization and population growth.

Another technology gaining traction is the Membrane Bio Reactor (MBR), known for its compact footprint and high-quality effluent production. MBR combines biological treatment with membrane filtration, offering superior solids retention and effluent quality compared to conventional activated sludge systems. Its ability to remove pathogens, suspended solids, and contaminants makes it ideal for applications requiring stringent water quality standards, such as water reuse, potable water production, and sensitive ecological areas. The increasing focus on water reuse and resource recovery drives the demand for MBR systems across various sectors, including municipal, industrial, and commercial facilities.

FIGURE 8. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: EQUIPMENT (IN USD BILLION)

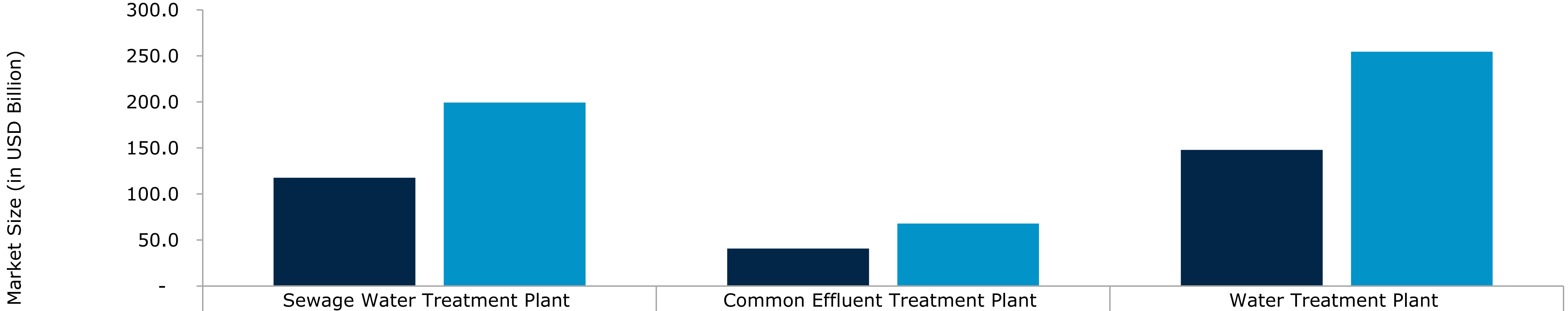


	Filtration	Ultra-Filtration	Micro-Filtration	Disinfection	Adsorption	Desalination	Testing	Others
2024	56.6	36.0	20.6	182.8	1.8	58.2	3.8	3.1
2033	97.4	63.7	33.7	308.5	3.1	100.9	6.5	5.6

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

Based on equipment, Disinfection segment is expected to have major share in the water and wastewater treatment market with a CAGR of 5.99% in terms of value. Disinfection equipment plays a critical role in eliminating harmful pathogens, bacteria, viruses, and other contaminants from water and wastewater streams. With growing concerns about waterborne diseases and environmental pollution, there is a greater emphasis on the adoption of disinfection solutions that can achieve high levels of microbial reduction. Technological advancements in disinfection equipment have also contributed to the increased demand. Innovations such as ultraviolet (UV) disinfection, ozone treatment, and advanced oxidation processes (AOPs) offer highly effective and environmentally friendly alternatives to traditional disinfection methods like chlorination. These technologies provide rapid and targeted disinfection without the formation of harmful disinfection byproducts (DBPs), addressing both health and environmental concerns.

FIGURE 9. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: APPLICATION (IN USD BILLION)

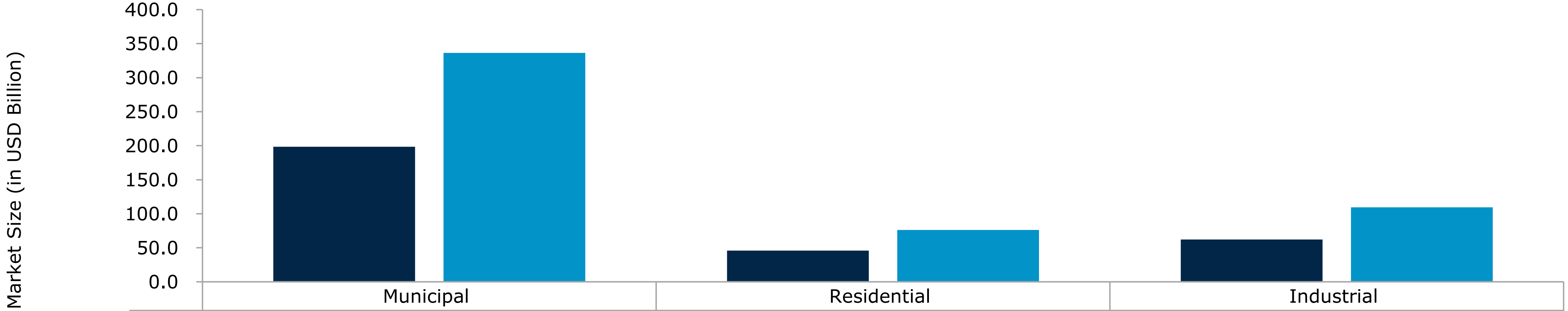


	Sewage Water Treatment Plant	Common Effluent Treatment Plant	Water Treatment Plant
2024	117.8	40.7	147.8
2033	199.3	68.0	254.6

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

Among the applications segments, the water treatment plant segment is expected to account for a significantly large revenue share and register a CAGR of 6.23% during the forecast period. As populations grow and urbanization accelerates, the strain on water resources intensifies, necessitating advanced treatment technologies to ensure water safety and sustainability. Water treatment plants play a pivotal role in addressing this challenge by employing various processes. Furthermore, the demand surge is driven by heightened environmental consciousness and regulatory compliance. Governments worldwide are enacting stricter regulations on wastewater discharge, compelling industries and municipalities to invest in robust treatment infrastructures. This trend is particularly pronounced in industries like chemicals, pharmaceuticals, and manufacturing, where stringent effluent standards necessitate advanced treatment processes such as reverse osmosis, ultraviolet disinfection, and advanced oxidation.

FIGURE 10. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: END-USE (IN USD BILLION)

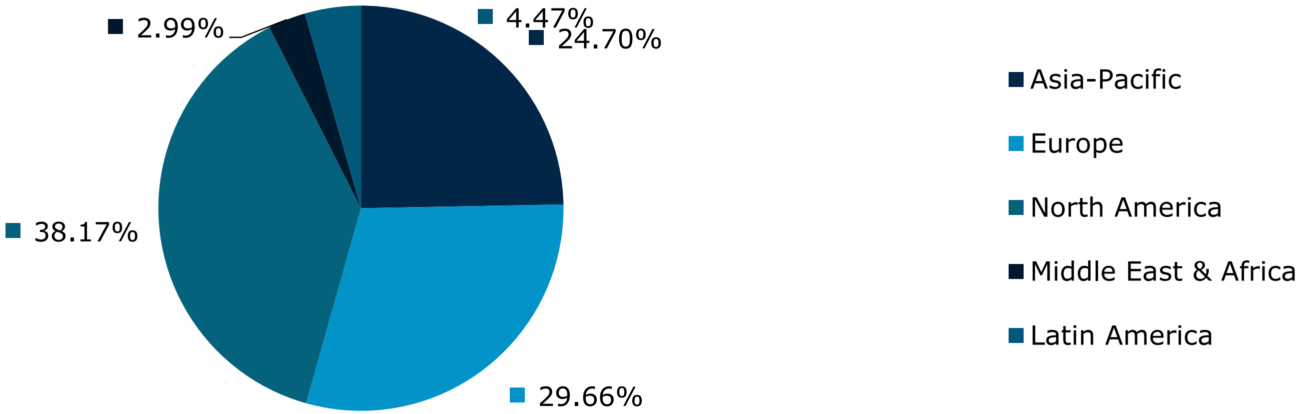


	Municipal	Residential	Industrial
2024	198.5	45.8	62.1
2033	336.3	76.2	109.4

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

Based on end-use, the municipal segment is expected to have major share in the Water and Wastewater Treatment market with a CAGR of 6.04% in terms of value. The municipal sector is experiencing a significant surge in demand for water and wastewater treatment solutions, driven by several key factors. One of the primary drivers is the ever-growing urban population, leading to increased pressure on water resources and heightened environmental concerns regarding wastewater discharge. This trend has compelled municipalities to invest heavily in advanced treatment technologies to ensure water quality compliance with stringent regulatory standards. Furthermore, rising public awareness about water scarcity and pollution has spurred demand for sustainable and efficient treatment methods. Municipalities are increasingly adopting innovative technologies such as membrane filtration, advanced oxidation processes, and biological treatment systems to achieve higher purification levels and minimize environmental impact. Additionally, the integration of digitalization and automation in water and wastewater treatment plants has become imperative for optimizing operations, reducing costs, and enhancing overall performance. Moreover, the aging infrastructure of many municipal water and wastewater facilities requires upgrades and modernization to meet current demands and future growth projections. This includes investments in asset management, energy-efficient equipment, and smart monitoring systems to ensure reliable and resilient water supply and sanitation services.

FIGURE 11. INDIA WATER AND WASTEWATER TREATMENT MARKET: REGION 2024 (IN USD MILLION)



Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

Based on region, North America is expected to have major share in the Water and Wastewater Treatment market. One of the primary drivers is the growing population in urban areas, leading to higher water consumption and wastewater generation. Municipalities and industries alike are facing stricter regulatory requirements for water quality and environmental protection, prompting investments in advanced treatment technologies. Moreover, aging infrastructure and the need for upgrading existing treatment facilities are contributing to the surge in demand for modernized water and wastewater treatment solutions. In response to these challenges, the water and wastewater treatment industry in North America is witnessing a rise in innovative technologies and approaches. Advanced processes such as membrane filtration, ultraviolet disinfection, and advanced oxidation are gaining traction for their effectiveness in treating contaminants and meeting regulatory standards. Additionally, the adoption of smart water technologies, including IoT-enabled sensors and real-time monitoring systems, is enhancing operational efficiency and optimizing resource utilization in treatment plants.

TABLE 1. SOME OF THE MAJOR INDIA WATER AND WASTWATER TREATMENT COMPANIES PROFILED IN THE REPORT ARE AS FOLLOWS:

COMPANY	HEADQUARTERS
VA Tech Wabag	India
Thermax India	India
LARSEN & TOUBRO LIMITED	India
ion exchange India ltd	India
Triveni Engineering & Industries Limited	India
Voltas limited	India
Toshiba Water Solutions Private Limited	India
Khilari Infrastructure Pvt Ltd	India
Vishvaraj Environment Pvt. Ltd.	India
Aquatech International LLC	United States

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

3. INDICATIVE METRICS

3.1. THE MACRO INDICATORS

3.1.1. RISING DEMAND FOR WATER

Globally, there has been a consistent uptick in water usage by approximately 1% annually over the past four decades (AQUASTAT, n.d.). This surge is predominantly observable in middle- and lower-income nations, particularly those categorized as emerging economies (Ritchie and Roser, 2017). Such an escalation is attributable to a confluence of factors including population expansion, socioeconomic advancements, and shifts in consumption patterns. Notably, regions with the highest per capita water withdrawals include Northern America and Central Asia (FAO, 2022).

Between 2010 and 2018, municipal withdrawals experienced a 3% increase, while agricultural withdrawals surged by 5%, now constituting 72% of the total withdrawals. Conversely, industrial withdrawals witnessed a 12% decline, primarily due to enhanced water efficiency in cooling processes, notably in thermal power production (FAO, 2022). Groundwater accounts for half of the water volume withdrawn globally for domestic purposes and approximately 25% for irrigation (United Nations, 2022). Despite fluctuations, total water withdrawals per capita remained stagnant or decreased from 2000 to 2018, with exceptions noted in Central America, the Caribbean, South America, and Southeast Asia. These trends are expected to persist as populations burgeon, partly due to overall improvements in water productivity, particularly in agriculture, and partly due to heightened water scarcity in densely populated arid regions (FAO, 2022).

Predicting future demand trends is challenging. The trajectory of water demand is highly contingent on location, reflecting evolving usage patterns across municipal, industrial, and agricultural sectors. Municipal demand expansion is primarily propelled by enhanced water supply and sanitation services, especially in regions striving to address existing deficiencies. Industrial water demand is driven by water-intensive processes, notably in manufacturing and energy production, which tends to escalate with industrialization. However, advancements in water efficiency can lead to subsequent demand reductions. Agricultural water usage hinges on factors such as soil conditions, climate, crop types, and irrigation practices, while also being influenced by competing uses and availability constraints, as well as food consumption patterns and trade dynamics (FAO, 2022).

These global aggregates overshadow significant local and regional variations. For instance, in Europe, agriculture accounts for only 30% of withdrawals, while municipalities and industries constitute 26% and 45%, respectively. Conversely, in South Asia, agriculture comprises 91% of withdrawals, with municipalities and industries accounting for 7% and 2%, respectively (FAO, 2022). The actual growth in water demand will heavily rely on the implementation of measures to enhance water use efficiency across these diverse sectors.

3.1.2. GROWING NEED FOR WASTEWATER TREATMENT

The significance of wastewater treatment is increasingly recognized due to its pivotal role in various policy frameworks and global initiatives. From the New Urban Agenda to the Paris Agreement on climate change, and from the Sendai Framework for Disaster Risk Reduction to the Kunming-Montreal Global Biodiversity Framework, water emerges as a critical element with multifaceted benefits. Notably, water cooperation is emphasized for fostering global peace and security, as highlighted by the High-Level Panel on Water and Peace in 2017 and the Council of the European Union in 2018. Furthermore, initiatives like the UNESCO World Water Assessment Programme's Water and Gender Working Group underscore the importance of water management in promoting gender equity.

With approximately one-third of the world's population residing in water-stressed areas, and projections indicating potential displacement of up to 700 million people by 2030 due to water scarcity, the urgency to address water-related challenges is evident. Moreover, water scarcity can exacerbate shortages of other critical resources, as noted by the World Economic Forum in 2023.

The declaration of the International Decade for Action on Water for Sustainable Development (2018-2028) by the United Nations General Assembly further underscores the global commitment to tackling water challenges. Within this framework, Sustainable Development Goal 6, focusing on wastewater management and resource recovery for reuse, assumes a central role. Despite the increased attention given to SDG 6 and water-related issues within the 2030 Agenda, cooperation on wastewater management still faces challenges in gaining visibility in international processes. The review of SDG 6 by the high-level political forum on sustainable development in 2018 revealed that current efforts are insufficient to achieve the targets by 2030.

In many regions, achieving the ambitions set forth in SDG 6 will necessitate institutional reforms to establish regulatory frameworks capable of mobilizing resources, fostering innovation, and providing necessary incentives to support unconventional approaches. As we reach the midpoint of the Water Action Decade, the 2023 United Nations Water Conference in New York, co-hosted by the Kingdom of the Netherlands and Tajikistan, provides an opportunity to comprehensively assess progress towards SDG 6. With only seven years remaining until the goals expire, the imperative to address the entire water cycle and move towards a net-zero water industry is emphasized. This endeavor requires collaboration across sectors and governance scales to ensure effective water management and sustainable development.

3.1.3. WASTEWATER REUSE AND CLIMATE CHANGE

The intersection of water security and climate change is of paramount importance in achieving the Sustainable Development Goals (SDGs). Addressing this challenge necessitates the adoption of climate-resilient, circular solutions, as highlighted by the Intergovernmental Panel on Climate Change (IPCC) in 2022. Projections indicate an escalation in the variability of weather patterns and precipitation due to climate change, resulting in approximately half of the global population encountering severe water scarcity for at least one month annually (IPCC 2022). Such scarcity disproportionately affects vulnerable demographics, including women, children, and the elderly, exacerbating challenges related to access to safe water.

For instance, the escalating water scarcity adversely impacts agricultural activities, particularly in the informal sector upon which women often rely, thereby heightening their vulnerability to income and food security issues. Furthermore, extreme climatic conditions disrupt the infrastructure and operation of wastewater collection and treatment services. Moreover, the wastewater sector contributes significantly to greenhouse gas (GHG) emissions through the organic decomposition process, emitting methane and nitrous oxide, potent GHGs, particularly in the short term. Globally, wastewater and sludge management activities generate approximately 257 million tonnes of carbon dioxide equivalents, with almost half originating from energy-related emissions. Additionally, on-site sanitation contributes 267 million tonnes of carbon dioxide equivalents. Notably, nitrous oxide emissions from sewered wastewater treatment constitute 32% of total emissions. The degradation of organic matter during wastewater treatment accounts for approximately 1.57% of global GHG emissions and 5% of global non-carbon dioxide GHG emissions.

Furthermore, conventional wastewater treatment processes are energy-intensive, consuming about 3% of global electricity consumption. As nations strive to expand wastewater treatment capacities in alignment with SDG 6.3, these energy-related figures are anticipated to escalate. Urbanization trends have already led to a 400% increase in emissions from domestic wastewater between 2000 and 2014, underscoring the imperative for substantial enhancement in treatment capabilities by 2030 to meet set targets.

Recognizing water's pivotal role in climate action, the Conference of the Parties to the United Nations Framework Convention on Climate Change in November 2022 (COP 27) emphasized the need for a holistic, circular approach to water management. There is growing recognition of the potential contribution of wastewater management and reuse to both adaptation and mitigation efforts (Water and Climate Coalition 2022). This underscores the opportunity for fostering collaboration among climate and water stakeholders to address these pressing challenges (United Nations 2023a).

4. GLOBAL MICRO-ECONOMIC OVERVIEW

4.1. GLOBAL MACROECONOMIC OVERVIEW

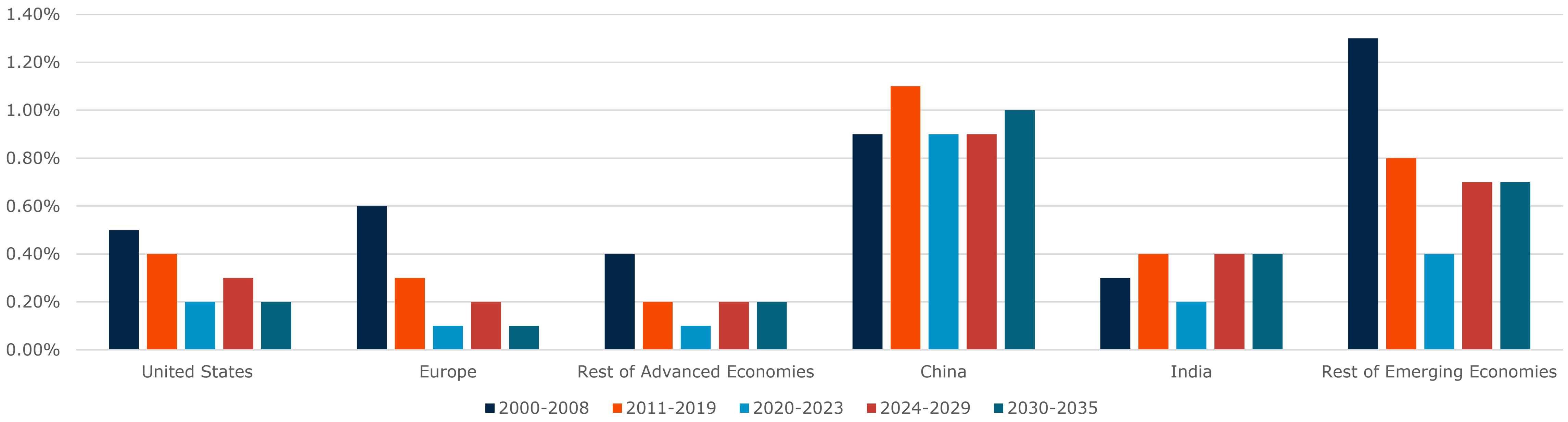
4.1.1. INSIGHT INTO ADVANCED ECONOMIES AND EMERGING MARKETS & DEVELOPING ECONOMIES

4.1.1.1. GLOBAL GDP

Advanced economies and emerging markets & developing economies offer distinct insights into the global economic landscape. Advanced economies, such as the United States, Germany, and Japan, boast developed financial systems, high per capita income, and advanced technologies. These economies drive global growth, innovate new products and services, and attract significant investments. They possess sophisticated infrastructure, well-developed institutions, and stable political environments, facilitating business operations and encouraging foreign direct investment. Furthermore, advanced economies prioritize research and development, education, and innovation, fostering technological advancements and enhancing productivity.

On the other hand, emerging markets and developing economies, including Brazil, India, and South Africa, showcase rapid economic growth potential and a large consumer base. These economies experience various challenges like infrastructure gaps, income inequality, and political instability. However, they offer promising investment opportunities due to their expanding middle class, abundant natural resources, and favorable demographics. Emerging markets often serve as manufacturing hubs and play a vital role in the global supply chain. They attract multinational corporations seeking cost advantages and market expansion.

FIGURE 12. REGIONAL CONTRIBUTIONS TO GLOBAL GDP GROWTH (AVERAGE ANNUAL % CHANGE)



Source: World Bank Data, GST Council of India, Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank Company Annual Report, Primary Interviews, Reports and Data

The global real GDP growth is projected to decline to 2.6 percent in 2023 from 3.3 percent in 2022. Europe, Latin America, and the US are the regions experiencing the most weakness, while Asian economies are expected to be the primary drivers of global growth due to reopening dynamics and lower inflationary pressures. The global GDP growth is anticipated to slow down further to 2.4 percent in 2024, mainly influenced by stagnant growth in the US.

Areas of weakness in the global economy include housing, bank lending, and the industrial sector. However, the strength in other sectors, particularly service-sector activities and labor markets, compensates for these weaknesses. First-half data for 2023 have exceeded expectations, leading to upward revisions in the full-year forecast for many economies. Despite inflationary pressures only moderately decreasing, tight monetary policies persist, making interest rate cuts unlikely for many central banks. The expectation remains for a slowdown in growth in the latter half of 2023 and the first half of 2024. While country-specific deviations may occur, businesses should prepare for a deceleration in global economic growth moving forward. The global economy is projected to experience relatively slow growth of around 2.5 percent for 2023-2024, reflecting a shift to a slower growth environment for the next decade, estimated at an average annual pace of 2.6 percent compared to the pre-pandemic decade's average of 3.3 percent.

Regional Insights:

- East Asia and Pacific: The growth rate is expected to decrease to 5.1% in 2022, followed by a slight increase to 5.2% in 2023.
- Europe and Central Asia: The growth rate is predicted to decline to 3.0% in 2022 and further decrease to 2.9% in 2023.
- Latin America and the Caribbean: The growth rate is projected to slow down to 2.6% in 2022 and experience a slight increase to 2.7% in 2023.
- Middle East and North Africa: Growth is forecasted to accelerate to 4.4% in 2022 before decelerating to 3.4% in 2023.
- South Asia: The growth rate is expected to accelerate to 7.6% in 2022 and then decrease to 6.0% in 2023.
- Sub-Saharan Africa: Growth is forecasted to slightly accelerate to 3.6% in 2022 and further rise to 3.8% in 2023.

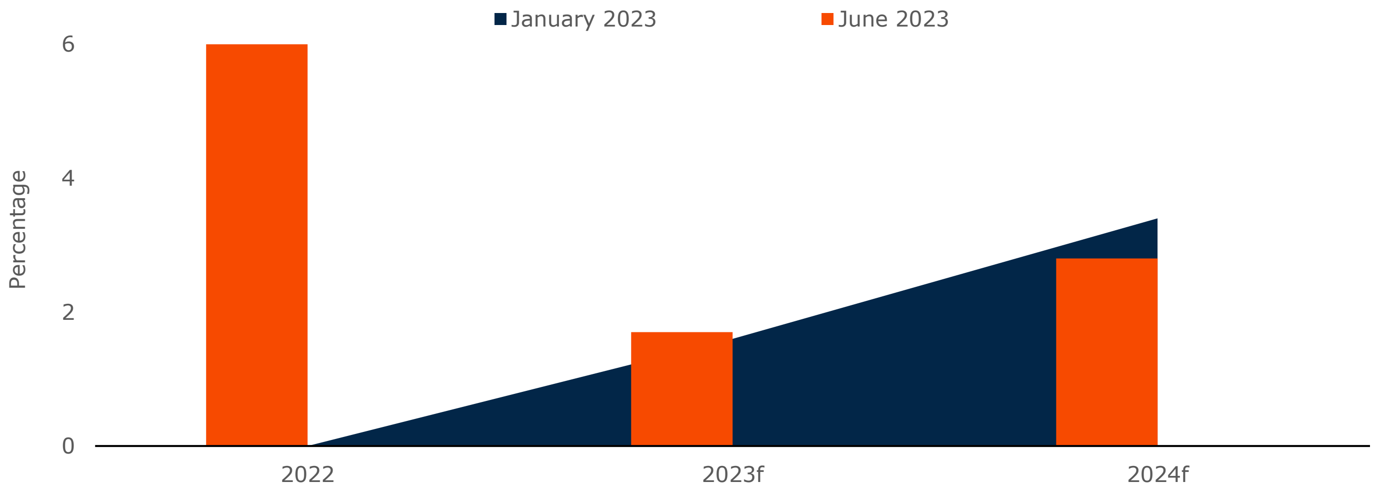
These projections highlight the diverse economic conditions across regions, indicating the need for tailored strategies and policies. Policymakers and businesses should closely monitor these trends to adapt and respond effectively to the changing economic landscape.

4.1.1.2. GLOBAL GDP AND TRADE ANALYSIS

Global trade is being dampened by subdued global demand and the continued rotation of consumption toward services. Energy prices have eased considerably since their peak in 2022 as a result of weaker global growth prospects and a warmer-than-usual winter, which reduced demand for energy for heating. Core inflation around the world has been persistent, resulting in continued monetary tightening. EMDE financial conditions continue to be restrictive, with less creditworthy borrowers facing greater financial strains.

Global growth in the trade of goods decelerated during the first half of 2023, mirroring the weakening trend in global trial production. In contrast, services trade continued to strengthen as mobility restrictions resulting from the pandemic were eased. The arrival of international tourists is projected to reach approximately 95 percent of 2019 levels in 2023, a significant increase from the 63 percent recorded in 2022 (UNWTO 2023). Pressures on global supply chains have subsided due to a decline in goods demand and improved global shipping conditions.

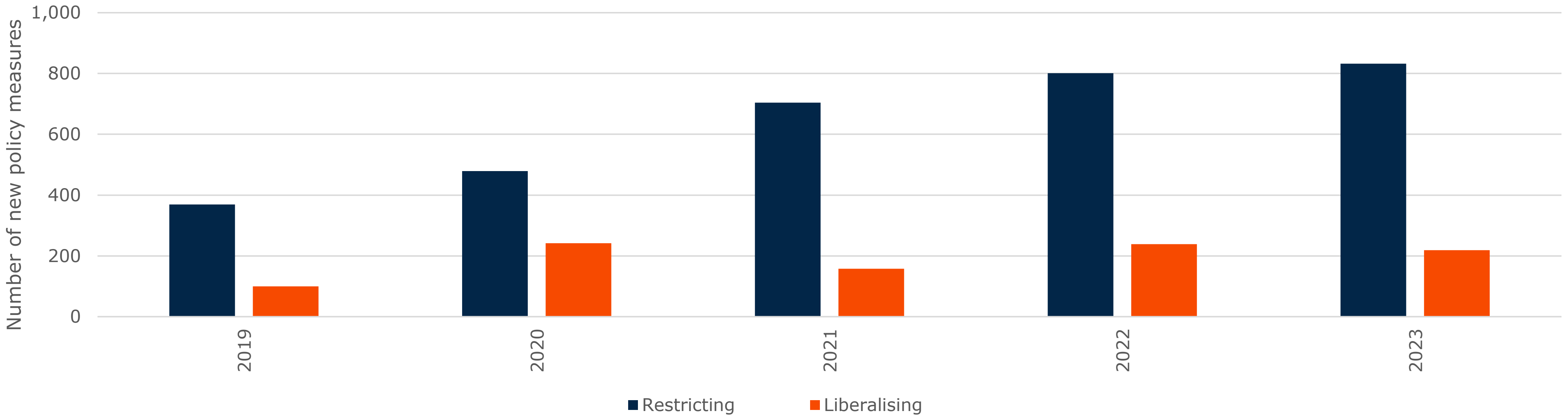
FIGURE 13. GLOBAL TRADE (% OF 2022 & 2023 FORECAST)



Source: OECD estimates, GST Council of India, Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank, World Bank, Company Annual Report, Primary Interviews, Reports and Data

The Global Supply Chain Pressures Index and suppliers' delivery times reached their lowest levels in nearly four years during the first half of 2023, with expectations of remaining low. Throughout the pandemic, trade growth was supported by a shift in demand composition towards tradable goods and away from less trade-intensive services. However, as demand gradually returns to its pre-pandemic structure, trade growth has slowed. Additionally, the recovery in China is anticipated to be primarily driven by services, limiting the positive spillover effects on its trading partners' demand for goods and commodities. The increasing number of restrictive trade measures reflects escalating geopolitical tensions and efforts by major economies to adopt more inward-focused policies. In the long term, these factors are likely to reshape global supply chains and elevate trade costs.

FIGURE 14. GLOBAL NEW TRADE MEASURES: IN NUMBERS



Source: OECD estimates, GST Council of India, Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank, World Bank, Company Annual Report, Primary Interviews, Reports and Data

Consequently, the responsiveness of global trade to output changes, which had already declined in the 2010s compared to previous decades, is expected to further decrease. Against this backdrop, global trade growth is forecasted to decelerate from 6 percent in 2022 to 1.7 percent in 2023. Once global consumption returns to its pre-pandemic balance between goods and services, trade is predicted to recover to 2.8 percent in 2024, only slightly outpacing GDP growth. The trade outlook faces several downside risks, including weaker-than-expected global demand, tighter global financial conditions, escalating trade tensions among major economies, mounting geopolitical uncertainties, and a further rise in protectionist measures.

4.1.1.3. GLOBAL INFLATION IMPACT

In most economies that adhere to an inflation-targeting approach, the current inflation rate exceeds the target set by central banks. As of April, the global median headline inflation stood at 7.2 percent, a decrease from its peak of 9.4 percent in July 2022. This decline can be attributed to favorable base effects resulting from lower commodity prices and reduced pressures in the supply chain. The moderation in energy prices has also contributed to a slightly milder global inflation in the first quarter of 2023. However, measures of core inflation indicate that the decrease in inflation has been slow, suggesting that the trend of disinflation observed since last year has not made significant progress.

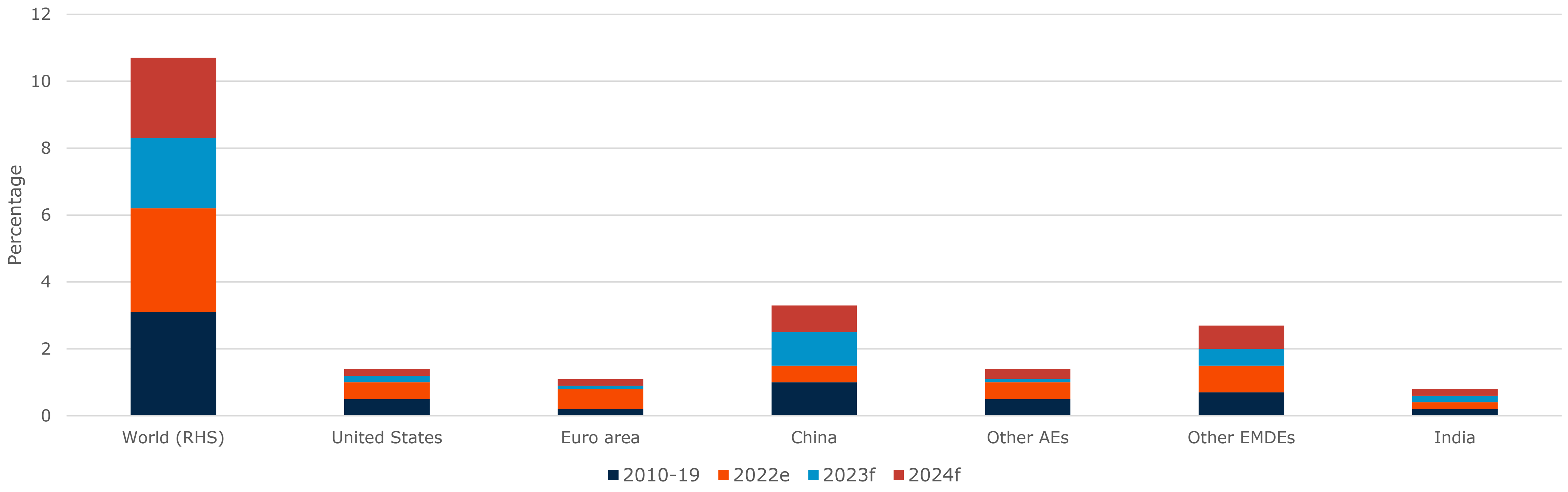
In recent months, emerging market and developing economies (EMDEs) have experienced a slowdown in median core inflation, while advanced economies have seen an increase. Despite improvements in supply chain pressures and declining energy prices, high inflation in advanced economies is primarily driven by excessive demand. Lingering supply capacity issues may also contribute to this situation. In Europe, energy prices hold particular influence as they impact broader prices and contribute to inflation persistence. The discontinuation of fiscal programs that have helped mitigate price spikes for end-users may further worsen this situation. The absence of economic slack, coupled with the ability of firms and workers to exercise pricing power, has made inflation more responsive to economic activity. Market-based measures of long-term inflation compensation in some advanced economies, such as the euro area, have increased despite a decline in oil prices. This suggests a higher risk of inflation remaining above the target level. Consumer surveys indicate that medium-term inflation expectations in the United States and the euro area have remained relatively stable in 2023.

In EMDEs, inflation is either accelerating or stabilizing at elevated levels. Responses to recent shocks, such as wage indexation to inflation and untargeted fossil fuel subsidies, have contributed to widespread inflationary pressures. Sustained high inflation could pose significant challenges for EMDEs, as inflation expectations in these economies are generally less stable and more influenced by current inflation rates compared to advanced economies. Forecasts indicate that EMDEs with inflation-targeting central banks are more likely to successfully reduce inflation in the long term. The reopening of China's economy is not expected to have a significant impact on global inflation. Although domestic inflation in China may increase due to stronger economic activity, it is limited by labor market slack and a recovery that is less dependent on commodities compared to previous periods of rapid growth.

4.1.1.4. GLOBAL OUTLOOKS AND RISKS

Global growth is expected to slow this year as credit conditions tighten due to ongoing monetary tightening and banking sector stress in advanced economies. The drag from tighter financial conditions is becoming increasingly apparent and is expected to peak this year. Inflation has proved persistent but should decline as demand slows and commodity prices moderate, provided longer-term inflation expectations remain stable. Stress in systemically important banks could lead to financial crisis and protracted economic losses. Unexpected persistence in core inflation or further commodity price shocks could result in greater -than-expected monetary tightening and hence increase the risk of a resurgence of financial stress. In the longer term, the slowdown in the fundamental drivers of growth may be exacerbated by trade fragmentation and intensified climate change.

FIGURE 15. CONTRIBUTIONS TO GLOBAL GROWTH: IN PERCENTAGE



Source: OECD estimates, GST Council of India, Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank, World Bank, Company Annual Report, Primary Interviews, Reports and Data

Bank balance sheets have sustained losses from recent economic weakness and the unusually rapid rise in interest rates. This could be exacerbated by declines in house prices, which are already taking place in countries accounting for half of global activity. The nature of banking sector vulnerabilities varies, with greater risks in some regions associated with potential loss of liquidity, and others suffering from low bank profitability or limited capital buffers. Financial stress scenarios center on a sharp tightening of financial conditions in advanced economies equivalent to 30 percent of that seen during the 2007-09 global financial crisis. In the first scenario, advanced economy stress does not lead to major spillovers, and the global economy avoids recession as central banks loosen policy, with inflation declining more rapidly than the baseline. In the second scenario, substantial spillovers lead to global financial stress. This pushes the global economy into recession, with inflation falling below target in many countries despite aggressive policy loosening.

Inflation forecasts have been repeatedly revised up—further such revisions could lead to more monetary tightening. Spillovers to emerging market and developing economies (EMDEs) from rising U.S. rates are especially severe when they reflect a more hawkish Federal Reserve, an important feature of the latest tightening cycle. Further increases in bond yields would make borrowing unaffordable for many EMDEs. Global potential growth may decline more than expected. On the upside, continued resilience in advanced-economy labor markets could boost consumption.

5. INDIAN MICRO-ECONOMIC OVERVIEW

5.1. INDIAN MACROECONOMIC OVERVIEW

The global economy was improving after the COVID-19 pandemic slowed down. However, the conflict between Russia and Ukraine in February 2022 caused problems. It disrupted supply chains, made finances tighter, and raised prices of important goods. This had effects like global economic indicators showing contraction, money moving away from certain countries, currency values dropping, and trade imbalances increasing. The IMF lowered its predictions for global economic growth in 2022. While inflation is getting better, actions to control it are also slowing down economies, especially in developed countries. The IMF now expects global growth to drop from 3.4% in 2022 to 2.8% in 2023 before rising to 3% in 2024.

Despite these challenges, India's economy continued to grow in the fiscal year 2023. This was because of its strong economic basics and quick actions taken by the government and the Reserve Bank of India. India's economy grew by 7.2% in FY23, which was the highest among major economies. This growth was even better than what was expected earlier. The fourth quarter of the fiscal year had particularly good growth compared to other countries. Year-on-year growth in real GDP for Q4 of FY23 was estimated at 6.1%, higher than the 4% growth in Q4 of FY22 and the 4.5% growth in Q3 of FY23. Sequentially, growth in Q4 of FY23 was 8.4%, up from 3.7% in the previous quarter, showing that growth momentum was maintained.

In the fourth quarter of FY23, the GDP growth showed improvement across the board, addressing concerns about the recovery of consumption and investment demand to levels seen before the pandemic. Real Private Final Consumption Expenditure (PFCE) has exceeded pre-pandemic levels, boosted by pent-up demand. Public sector capital expenditure has also increased significantly over the past three years, along with favorable credit conditions, leading to real Gross Fixed Capital Formation (GFCF) surpassing pre-pandemic levels. All sectors of the economy show signs of strengthening.

The agriculture sector saw a record-high growth rate in Q4 of FY23, partly due to higher estimates of rabi production. Favorable conditions are expected for kharif sowing in FY24, with a forecast of normal monsoon and sufficient resources. Despite global challenges such as supply chain disruptions and high raw material costs, India's manufacturing sector remained in an expansionary phase throughout FY23. Growth in the sector faced a temporary slowdown in Q2 and Q3 due to increased input costs, but recovered in Q4 supported by reduced input costs, rising demand, and improved capacity utilization. This revival in manufacturing led to a rebound in the industrial sector overall.

The services sector also showed resilience in FY23, particularly driven by contact-intensive services. The removal of mobility restrictions, pent-up demand release, and widespread vaccination coverage contributed to the sector's recovery to pre-pandemic levels. PMI Services remained in expansion territory, supported by increased new business and orders, though there were concerns about rising input and raw material prices. Key drivers of growth in this sector include trade, hotels, transport, communication, broadcasting, financial services, real estate, and professional services.

According to the World Employment and Social Outlook 2023 by the International Labour Organization (ILO), global job markets are still in the process of recovering, especially in advanced economies. However, in India, despite the challenges posed by the pandemic, there has been an increase in the number of people joining the workforce, along with a rise in the labor force participation rate (LFPR), which is in line with the trend before the pandemic. This growth is largely attributed to the presence of a significant informal sector that relies on daily wages and income, which helped offset the negative impacts of the pandemic. As a result, the Worker Population Ratio (WPR) has continued to rise.

Despite temporary spikes in urban unemployment rates (UR) during pandemic-induced lockdowns, the overall rural-urban combined unemployment rate has decreased from 2017-18 to 2021-22. In 2022-23, the urban unemployment rate consistently decreased each quarter, indicating a steady increase in employment levels across the country. This decline in urban unemployment has also led to growth in employment opportunities, particularly in the construction sector, enabling rural migrants to find work in urban areas.

In contrast, labor markets in many advanced economies are experiencing tighter conditions compared to pre-COVID-19 times, leading to a decrease in labor force participation. The LFPR in high-income countries remained lower in 2022 than in 2019. However, in India, the LFPR increased to 55.2 percent in FY22, up from 54.9 percent in FY21 and 53.5 percent in FY20. Similarly, the Worker Population Ratio also saw an upward trend, reaching 52.9 percent in FY22. This growth can be attributed to robust economic expansion, supported by well-managed fiscal policies and increased public spending on infrastructure projects. Consequently, the unemployment rate declined to a five-year low of 4.1 percent in FY22, with consistent decreases observed in both rural and urban areas.

5.1.1. TREND IN GDP AND GVA

TABLE 2. GROSS DOMESTIC PRODUCT, CONSTANT PRICES, 2019-2024

Year	GDP (% Growth)
2019	3.87%
2020	-5.83%
2021	9.05%

2022	7.24%
2023	6.33%
2024	6.29%

Source: International Monetary Fund, World Economic Outlook Database, October 2023, Reports and Data

TABLE 3. INDIAN GDP, 2022-2026 (FORECASTED)

Year	GDP (INR LAKHS)	GDP GROWTH
2022	188,509,313,200.00	8.63%
2023	209,467,238,000.00	8.39%
2024	231,742,175,500.00	8.18%
2025	256,049,744,900.00	8.09%
2026	282,500,969,500.00	7.99%

Source: Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank Company Annual Report, Primary Interviews, Reports and Data

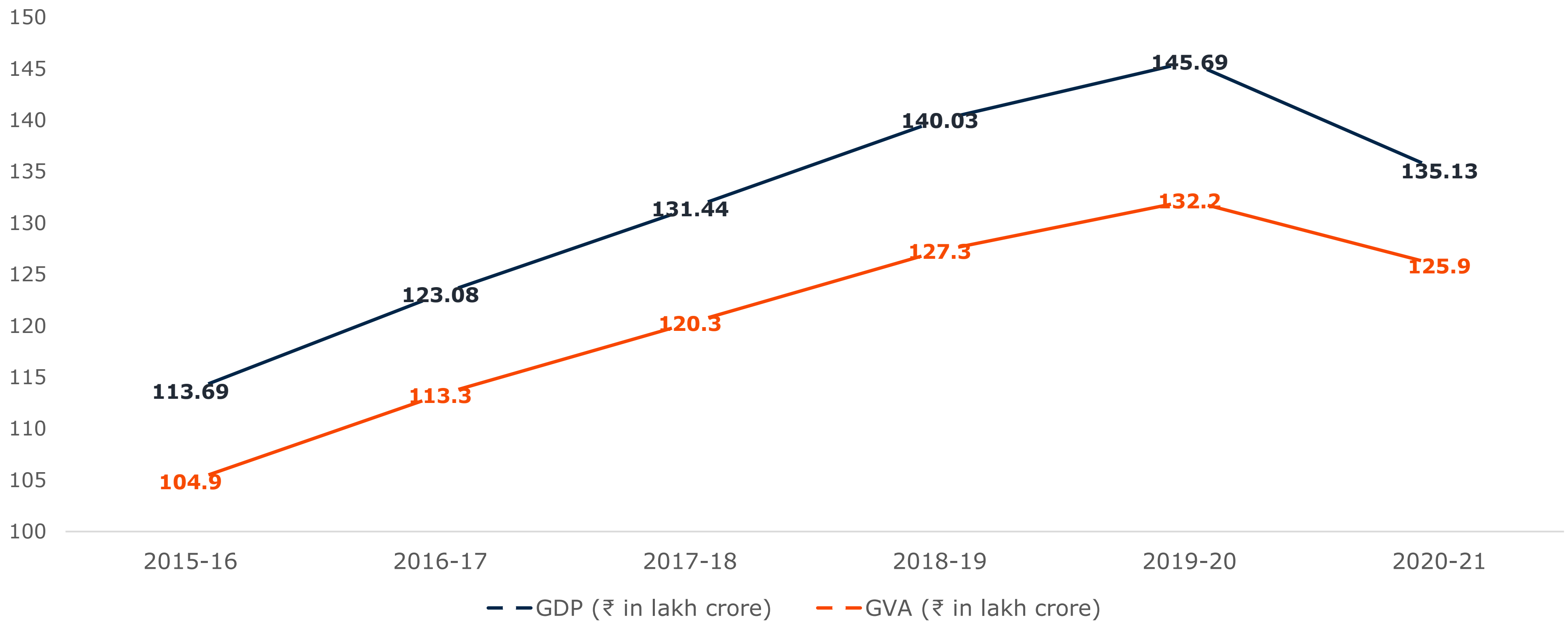
5.1.2. PER CAPITA GDP, INCOME AND PER CAPITA CONSUMPTION (PAST & OUTLOOK)

TABLE 4. GDP PER CAPITA, 2017-2020 (HISTORICAL), 2021-2023 (FORECASTED)

Year	GDP Per Capita (INR)
2017	172,628.48
2018	184,780.21
2019	202,066.75
2020	197,130.66
2021	234,963.36
2022	264,033.10
2023	302,257.16

Source: World Bank, Bureau of Indian Standards, Company Annual Report, Primary Interviews, Reports and Data

FIGURE 16. GDP AND GVA [AT CONSTANT (2011-12) PRICES]



Source: Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank Company Annual Report, Primary Interviews, Reports and Data

Gross Domestic Product (GDP) measures the annualized change in the inflation-adjusted value of all goods and services produced by the economy. It is the broadest measure of economic activity and the primary indicator of the economy’s health. The most important and the fastest growing sector of the Indian economy are services. Trade, hotels, transport and communication; financing, insurance, real estate, and business services, and community, social and personal services account for more than 60% of GDP. Agriculture, forestry, and fishing constitute around 12% of the output but employs more than 50% of the labor force. Manufacturing accounts for 15% of GDP, construction for another 8%, and mining, quarrying, electricity, gas, and water supply for the remaining 5%.

Real GDP or GDP at Constant (2011-12) Prices in the year 2022-23 is estimated at INR 159.71 lakh crore, as against the First Revised Estimates of GDP for the year 2021-22 of INR 149.26 lakh crore. The growth in real GDP during 2022-23 is estimated at 7.0 per cent as compared to 9.1 per cent in 2021-22. 4. Nominal GDP or GDP at Current Prices in the year 2022-23 is estimated at INR 272.04 lakh crore, as against the First Revised Estimates of GDP for the year 2021-22 of INR 234.71 lakh crore. The growth in nominal GDP during 2022-23 is estimated at 15.9 per cent as compared to 18.4 per cent in 2021-22. 5. GDP at Constant (2011-12) Prices in Q3 2022-23 is estimated at INR 40.19 lakh crore, as against INR 38.51 lakh crore in Q3 2021-22, showing a growth of 4.4 percent. GDP at Current Prices in Q3 2022-23 is estimated at INR 69.38 lakh crore, as against INR 62.39 lakh crore in Q3 2021-22, showing a growth of 11.2 percent.

Gross value added (GVA) is defined as the value of output less than the value of intermediate consumption. While GVA gives a picture of the state of economic activity from the producers' side or supply side, the GDP gives the picture from the consumers' side or demand perspective. A sector-wise breakdown provided by the GVA measure can better help the policymakers decide which sectors need incentives/stimulus or vice versa. As with all economic statistics, the accuracy of GVA as a measure of overall national output is heavily dependent on the sourcing of data and the fidelity of the various data sources in capturing the vast labyrinth of activities that constitute a nation’s economic life. To that extent, GVA is as susceptible to vulnerabilities from the use of inappropriate or flawed methodologies as any other measure.

5.2. OVERVIEW OF CONSTRUCTION GVA (2012-2023)

According to IBEF, the construction market (USD 1.42 trillion) by 2027 expanding at a compound annual growth rate (CAGR) of 17.26% during the 2022-2027 forecast period. The Indian construction industry serves as a pivotal driver of the nation's economic growth. It plays an indispensable role in propelling overall development by laying the foundation for various projects. The emphasis placed on robust infrastructure by the government underscores its paramount significance. Anticipated to exhibit a Compound Annual Growth Rate (CAGR) of 17.26% through 2022, the Indian construction sector is on track to reach an impressive valuation of USD 738.5 billion. Noteworthy is its contribution: 55% to the steel industry, 15% to the paint industry, and 30% to the glass industry. Prominent growth sectors within this industry include export cargo (10%), highway construction/widening (9.8%), power generation (6.6%), import cargo (5.8%), and cargo handling at major ports (5.3%).

Foreign Direct Investment (FDI) in this sector has amounted to USD 25.66 billion between April 2000 and March 2020, as per the records of the Department for Promotion of Industry and Internal Trade (DPIIT). Moreover, the Indian construction industry's growth trajectory has surged, with a projection of 5.6% during 2016-20 compared to 2.9% during 2011-15. By 2022, India is poised to ascend as the world's third-largest construction market. Facilitating this objective, the Indian government has been actively crafting and implementing policies aimed at expediting the time-bound creation of top-notch infrastructure across the nation. This extends from power plants and bridges to dams, roads, and urban development ventures.

The Indian construction industry's prowess is evident on multiple fronts. In 2018, the World Bank's Logistics Performance Index (LPI) ranked India at 44 out of 167 countries, and in 2019, the nation secured the second position in the Agility Emerging Markets Logistics Index. Notably, 2019 witnessed significant mergers and acquisitions within the Indian construction sector, totaling USD 1.461 billion in deals. The most substantial private equity investment of USD 1.9 billion was executed in the acquisition of Pipeline Infrastructure India by Canadian asset management firm Brookfield. Demonstrating its dynamism, the National Highways Authority of India (NHAI) accomplished the construction of a record-breaking 3,979 kilometers of highways alongside the nation's electricity production reaching 1,252.61 billion units. However, the endeavor to achieve a USD 5 trillion economy by 2025 and fulfill the aspirations of its enterprising populace necessitates a continuous focus on constructing and enhancing existing infrastructure.

The National Infrastructure Pipeline (NIP): To advance this aim, a pioneering initiative led by a High-Level Task Force under the aegis of the Secretary of the Department of Economic Affairs (DEA) and the Ministry of Finance culminated in the formation of the National Infrastructure Pipeline (NIP). The NIP is a groundbreaking whole-of-government initiative dedicated to enhancing project preparation and attracting investments into infrastructure. Its mission revolves around bestowing world-class infrastructure upon Indian citizens, thus augmenting their quality of life. Central to the NIP's mandate is cultivating a favorable environment for substantial private investment in infrastructure across all levels of government. This initiative aspires to conceptualize, implement, and manage public infrastructure projects in alignment with efficiency, fairness, inclusivity, and disaster resilience goals.

The NIP introduces a streamlined institutional, regulatory, and implementation framework for infrastructure development. This framework adheres to global best practices and standards, leveraging cutting-edge technology to enhance service quality, efficiency, and safety within the Indian construction industry. In effect, the NIP is set to bolster the implementation of more infrastructure projects and generate employment opportunities. Its overarching aim is to elevate citizens' quality of life by providing equitable access to infrastructure, thereby fostering more inclusive growth.

Role of Developed Infrastructure and NIP: Developed infrastructure serves as a catalyst for heightened economic activity within a nation. The NIP is strategically poised to fortify this dynamic by offering well-prepared projects, curtailing aggressive bidding, and mitigating project delivery failures. It also ensures enhanced access to financial resources. For financial institutions and investors, the NIP instills confidence by virtue of its comprehensive project preparation and competent authority-led project monitoring.

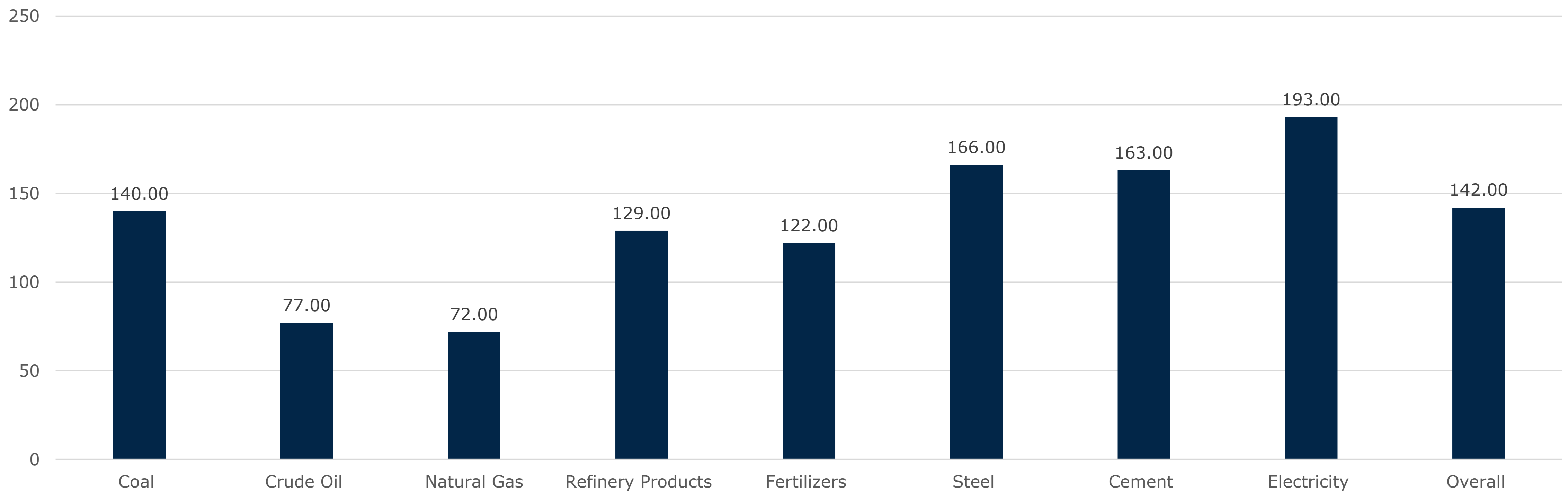
Government Endeavors: The Government of India, as of April 2020, has laid out a formidable roadmap for constructing roads valued at INR 15 lakh crore (USD 212.80 billion) over the ensuing two years. This endeavor is harmonious with the Union Budget 2020-21, which earmarked INR 1,69,637 crore (USD 24.27 billion) to propel transport infrastructure development. In addition, the Ministry of Housing and Urban Affairs and the Indian Railways have been allocated INR 50,040 crore (USD 6.85 billion) and INR 72,216 crore (USD 10.33 billion) respectively. The energy sector and communication sector have also been designated investment opportunities worth USD 300 billion over the next decade and INR 38,637.46 crore (USD 5.36 billion) to develop post and telecommunications departments.

Strategic Initiatives: Notably, the government's strategic initiatives such as "Housing for All" and the "Smart City Mission" underscore its commitment to surmounting bottlenecks within the infrastructure sector. These endeavors collectively contribute to the holistic and transformative growth of India's construction landscape.

5.3. INFRASTRUCTURE SECTOR BUDGET ALLOCATION OVERVIEW (2023-2024)

The government's commitment to strengthening India's infrastructure continues to be evident in the Budget for the fiscal year 2023-24. With a steadfast focus on development, numerous initiatives and investments have been earmarked to transform and enhance the country's infrastructure landscape. Here are some of the key highlights from the budget allocation for the infrastructure sector:

FIGURE 17. INFRASTRUCTURE INDEX OF 8 CR. INDUSTRIES FY23 (TILL SEP-22)



Source: IBEF, International Water Association, Company Annual Reports, Primary Interviews, and Reports and Data

- **Capital Investment Boost:** In an ambitious move, the budget allocates a significant capital investment of Rs.10 lakh crore (USD 122 billion), marking a 33% increase. This surge in investment corresponds to 3.3% of the GDP and is nearly three times the amount allocated in the fiscal year 2019-20, reflecting the government's dedication to infrastructure development.
- **Railway Advancements**: A monumental leap is seen in the allocation for the Railways sector, with a capital outlay of Rs. 2.40 lakh crore (USD 29 billion) - the highest ever recorded. This substantial increase, approximately 9 times the 2013-14 allocation, underscores the government's commitment to modernizing and expanding the country's rail network.
- **Boosting Private Investment**: Recognizing the importance of private investment in infrastructure development, an Infrastructure Finance Secretariat is being established. This initiative aims to foster opportunities for private investment in various sectors, including railways, roads, urban infrastructure, and power.
- **Encouraging State Investment**: The government's commitment to encouraging state-level investments is evident through the extension of a 50-year interest-free loan to state governments. This move aims to incentivize investment in infrastructure and complementary policy actions, with a significantly enhanced outlay of Rs. 1.3 lakh crore (USD 16 billion).
- **Critical Transport Connectivity**: Identifying the importance of last and first-mile connectivity for vital sectors such as ports, coal, steel, fertilizer, and food grains, 100 critical transport infrastructure projects are set to be initiated with a substantial investment of Rs. 75,000 crores (USD 9 billion), including contributions from private sources.
- **Enhancing Air Connectivity**: The government aims to improve regional air connectivity by reviving 50 additional airports, heliports, water aerodromes, and advance landing grounds.
- **Urban Infrastructure Development Fund (UIDF)**: To support urban infrastructure development in Tier 2 and Tier 3 cities, the establishment of the Urban Infrastructure Development Fund (UIDF) is announced. Managed by the National Housing Bank, this fund will leverage resources from priority sector lending shortfall.

- **Technology and Education Focus**: To promote indigenous AI capabilities, three centers of excellence for Artificial Intelligence will be established in prominent educational institutions. Additionally, a Digital Public Infrastructure for agriculture will be developed to provide farmer-centric solutions and foster growth in the agri-tech industry.
- **Healthcare and Education Expansion**: Significant steps are being taken to bolster the healthcare and education sectors. Plans include establishing 157 new nursing colleges in conjunction with existing medical colleges and setting up a National Digital Library for Children and Adolescents.
- **Infrastructure for North-Eastern Region**: Allocations for the development of the North-eastern region are emphasized, with funding provided for initiatives such as PM DevINE and Northeast Special Infrastructure Development Scheme (NESIDS).
- **Leveraging Global Investment**: The infrastructure sector is drawing substantial Foreign Direct Investment (FDI), evident from investments in construction and development projects.

The infrastructure sector has become the biggest focus area for the Government of India. India plans to spend USD 1.4 trillion on infrastructure during 2019-23 to have a sustainable development of the country. The Government has suggested investment of Rs. 5,000,000 crores (USD 750 billion) for railways infrastructure from 2018-30. India's GDP is expected to grow by 8% over the next three fiscal years, one of the quickest rates among major, developing economies, according to S&P Global Ratings. India and Japan have joined hands for infrastructure development in India's Northeast states and are also setting up an India-Japan Coordination Forum for development of Northeast to undertake strategic infrastructure projects for the region.

5.4. INDUSTRIAL GROWTH AND TREND IN PRODUCTION

Industrial production refers to the output of industrial establishments and covers sectors such as mining, manufacturing, electricity, gas and steam and air-conditioning. This indicator is measured in an index based on a reference period that expresses a change in the volume of production output. The Denta Properties and Infrastructure Pvt. Ltd. would benefit from the GoI's 'Aatmanirbhar Bharat Abhiyaan', or Self - Reliant India, campaign, which provides a range of incentives to attract and localise manufacturing and production in the country.

The Production-Linked Incentive (PLI) Scheme is an initiative launched by the Government of India to boost domestic manufacturing across various sectors. The objective of the PLI scheme is to encourage local production and reduce import dependence. Under the scheme, the government offers financial incentives to eligible companies based on their production levels and performance. In the context of the blow molding industry, the PLI scheme can have a positive impact by incentivizing companies to expand their manufacturing capabilities and increase production of blow-molded products in India. This, in turn, can help reduce the country's reliance on imports of such products and create more job opportunities. The scheme offers financial incentives to eligible companies that meet certain performance criteria, such as minimum investment, production, and quality standards.

Further, the GOI has recently announced Production Linked Incentive (PLI) Scheme for the pharmaceutical sector. The objective of the PLI scheme for the pharmaceutical sector is to promote domestic manufacturing and reduce import dependence in the industry. The scheme is aimed at promoting the production of high-value drugs, APIs (active pharmaceutical ingredients), and medical devices. The PLI scheme for the pharmaceutical sector has a budgetary allocation of Rs. 15,000 Crore and is expected to attract significant investment in industry. The financial year of 2022-2023 being the first year of production for the PLI Scheme, DoP has ear marked Rs 690 crore as the budget outlay. The scheme is expected to create more than 20,000 jobs and help India become a global manufacturing hub for pharmaceuticals. As of January 31, 2023, sales of about INR 36,000 cr have been reported by the select 55 applicants. The Department of Pharmaceuticals also implements two other PLI schemes, namely PLI for Bulk Drugs and PLI for Medical Devices, which have achieved significant milestones in the first year of implementation.

Moreover, On May 17, 2023, the Union Cabinet, led by Prime Minister Shri Narendra Modi, granted approval for the introduction of the Production-Linked Incentive (PLI) Scheme 2.0 for IT Hardware, aimed at enhancing India's manufacturing capabilities and promoting exports under the Atmanirbhar Bharat initiative. The scheme was officially notified on May 29, 2023, and starting from June 01, 2023, applications for the PLI Scheme 2.0 for IT Hardware will be accepted. The primary objectives of the PLI Scheme 2.0 for IT Hardware are to bolster and expand the manufacturing ecosystem in India by encouraging local production of components and sub-assemblies. It also allows for a longer period for developing the domestic supply chain. The scheme offers increased flexibility and options for applicants, tying incentives to incremental sales and investment thresholds to further encourage growth. Notably, the scheme includes incentives for semiconductor design, IC manufacturing, and packaging as well. The approved budget for the PLI Scheme 2.0 for IT Hardware is INR 17,000 crore. It is anticipated that this scheme will result in a total production worth approximately INR 3.35 lakh crore, attracting an additional investment of INR 2,430crore in the electronics manufacturing sector, and generating around 75,000 additional direct job opportunities.

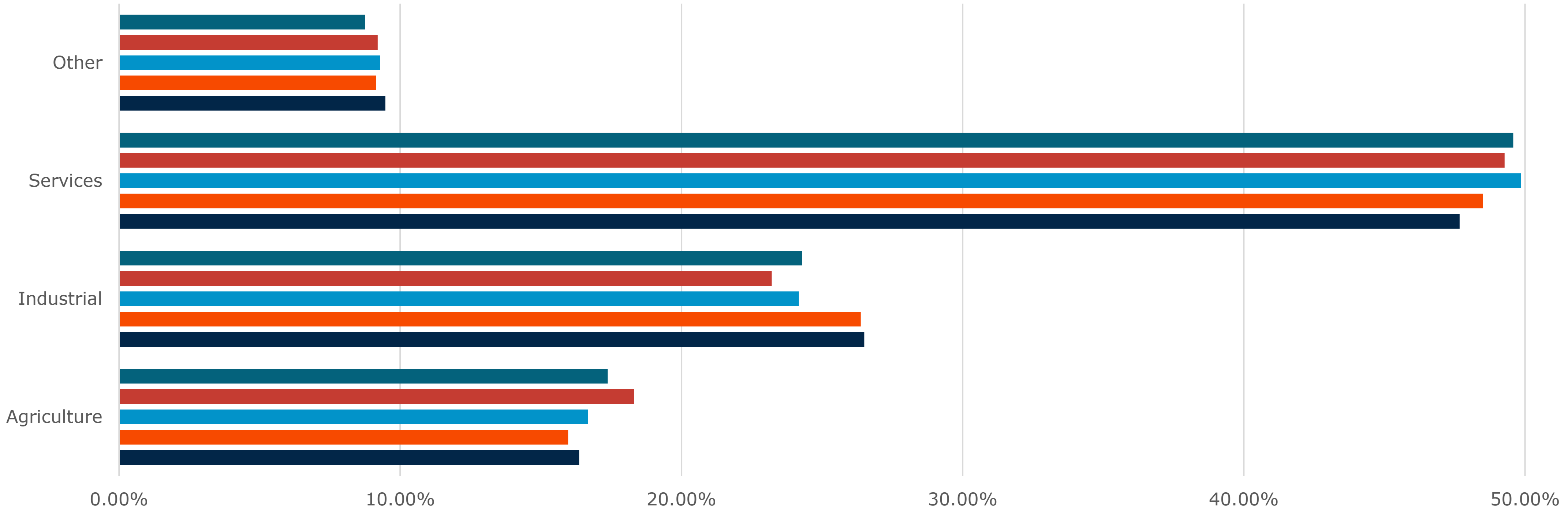
Additionally, it is expected that GOI has also announce PLI Scheme chemicals sector. The objective of the PLI scheme for the chemical sector is to boost domestic manufacturing and reduce import dependence in industry. The scheme is aimed at promoting the production of high-value chemicals and specialty chemicals, which are currently being imported. Under the Union Budget 2023-24 the government allocated INR 173.45 crore to the Department of Chemicals and Petrochemicals. PLI schemes have been introduced to promote Bulk

Drug Parks, with a budget of INR 1,629 crore. Moreover, the scheme also aims to encourage local companies to set up or expand existing manufacturing units along with focusing on inviting foreign companies to set up manufacturing units in India. Increased production, sales and export by companies availing the PLI Scheme in these sectors would increase the demand for our industrial packaging products. Its future expansion plans have been formulated considering these growth opportunities and Company is geared up to exploit these for the benefit of all its stakeholders.

Further, the Quick Estimates of the Index of Industrial Production (IIP) for February 2023, based on the 2011-12 scale, indicate a value of 138.7. The individual sector indices for Mining, Manufacturing, and Electricity for the same month are 129.0, 136.8, and 174.0 respectively. It should be noted that these Quick Estimates are subject to revision in future releases, following the revision policy of IIP. Based on the Use-based classification, the indices for February 2023 are 139.7 for Primary Goods, 104.4 for Capital Goods, 143.2 for Intermediate Goods, and 164.0 for Infrastructure/Construction Goods.

Additionally, the indices for Consumer durables and Consumer non-durables in February 2023 are 108.4 and 154.3 respectively. Detailed information on the Quick Estimates of the Index of Industrial Production for February 2023, categorized by sector and 2-digit level of National Industrial Classification (NIC-2008), as well as by Use-based classification, can be found in Statements I, II, and III respectively. Statement IV provides month-wise indices for the past 12 months, categorized by industry groups (based on the 2-digit level of NIC-2008) and sectors, to aid users in understanding the changes in the industrial sector. The indices for January 2023 have undergone the first revision, while those for November 2022 have undergone the final revision, taking into account the updated data received from the source agencies. The Quick Estimates for February 2023, the first revision for January 2023, and the final revision for November 2022 have been compiled with response rates of 92 percent, 94 percent, and 95 percent respectively.

FIGURE 18. SHARE OF INDIAN GDP BY SECTOR

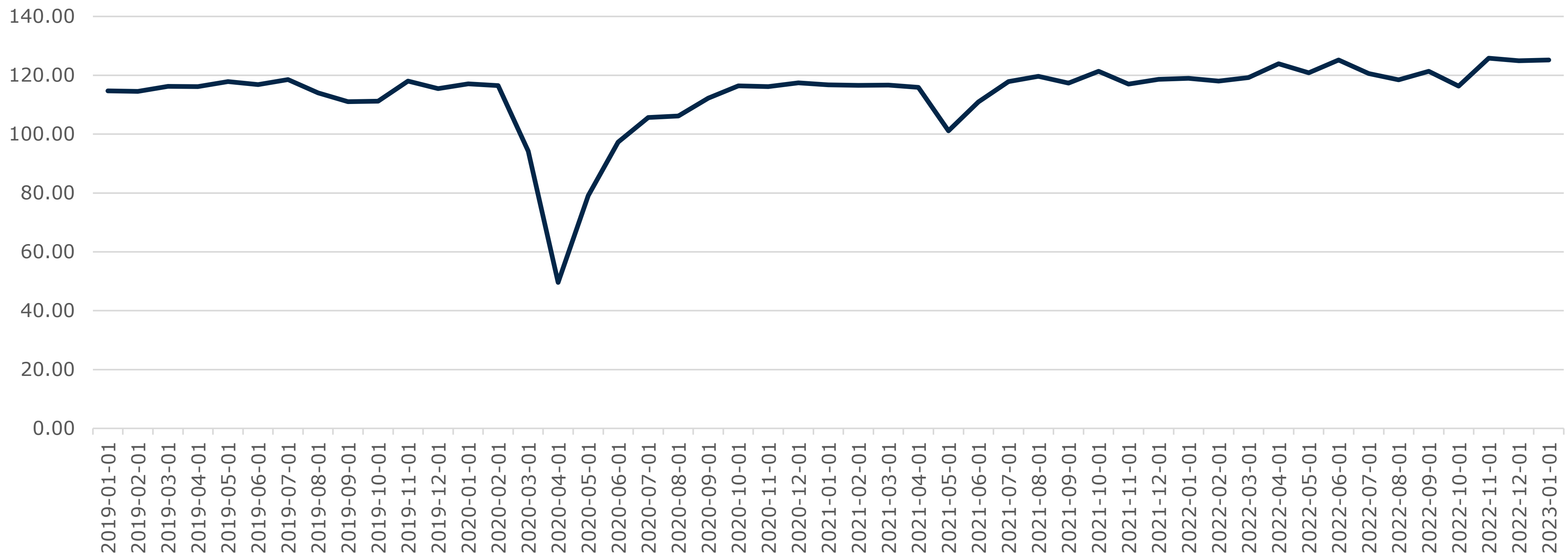


	Agriculture	Industrial	Services	Other
2021	17.38%	24.29%	49.58%	8.75%
2020	18.32%	23.21%	49.27%	9.20%
2019	16.68%	24.18%	49.86%	9.28%
2018	15.97%	26.38%	48.51%	9.14%
2017	16.36%	26.50%	47.67%	9.47%

Source: JSTOR, Bureau of Indian Standards, Company Annual Report, Primary Interviews, Reports and Data

Manufacturing has emerged as one of India's fastest growing sectors. The government in the region has been adopting several policies to ensure an increased production of goods and to make India a self-reliant economy. For instance, the Make in India program has been launched to map India as a manufacturing hub and make the Indian economy globally recognized. Through the scheme, the government aims to create 1,000 lakh new jobs in the industry by 2022. Moreover, the region is also likely to become a high-tech manufacturing center as global giants such as GE, Siemens, HTC, Toshiba and Boeing have established or are in the process of establishing manufacturing facilities in India with the help of Make in India. Similarly, to expand its smartphone assembly industry and improve its electronics supply chain, in March 21, the government announced cash incentives of more than INR 750,000 lakhs to each company which will set up chip fabrication units in the country.

FIGURE 19. INDIA INDUSTRIAL PRODUCTION (2019-2023)

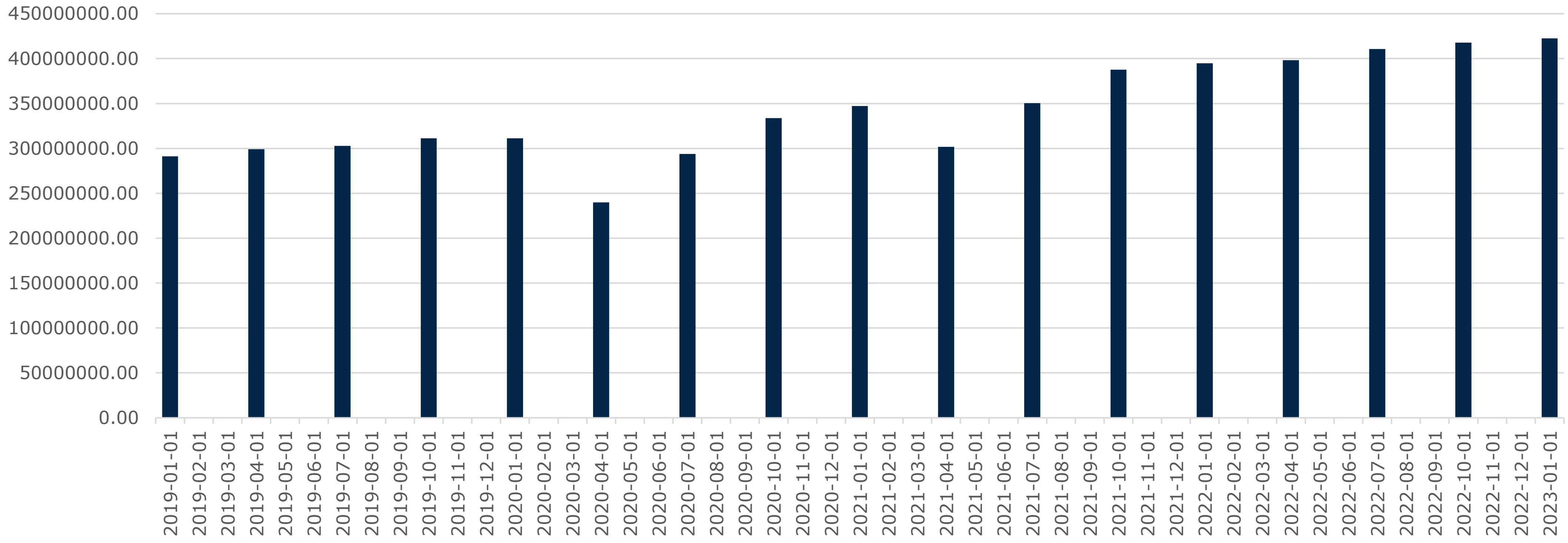


Source: Trading Economies, Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank Company Annual Report, Primary Interviews, Reports and Data

The region is also gradually progressing on the road to Industry 4.0 through the Government of India’s initiatives. For instance, the Smart Advanced Manufacturing and Rapid Transformation Hubs or SAMARTH Udyog Bharat 4.0 is an Industry 4.0 initiative of Ministry of Heavy Industry & Public Enterprises, Government of India under its scheme on Enhancement of Competitiveness in Indian Capital Goods Sector. The adoption of this scheme is likely to increase productivity, efficiency and quality in processes, and also ensure greater safety for workers by reducing jobs in dangerous environments. The scheme would also aid in enhancing decision making with data-based tools and improve competitiveness by developing customized products.

5.4.1. TREND ANALYSIS OF PRIVATE FINAL CONSUMPTION EXPENDITURE (PFCE) AND OUTLOOK

FIGURE 20. PRIVATE FINAL CONSUMPTION EXPENDITURE IN INDIA, QUARTERLY, SEASONALLY ADJUSTED (INR LAKH)



Source: Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank Company Annual Report, Primary Interviews, Reports and Data

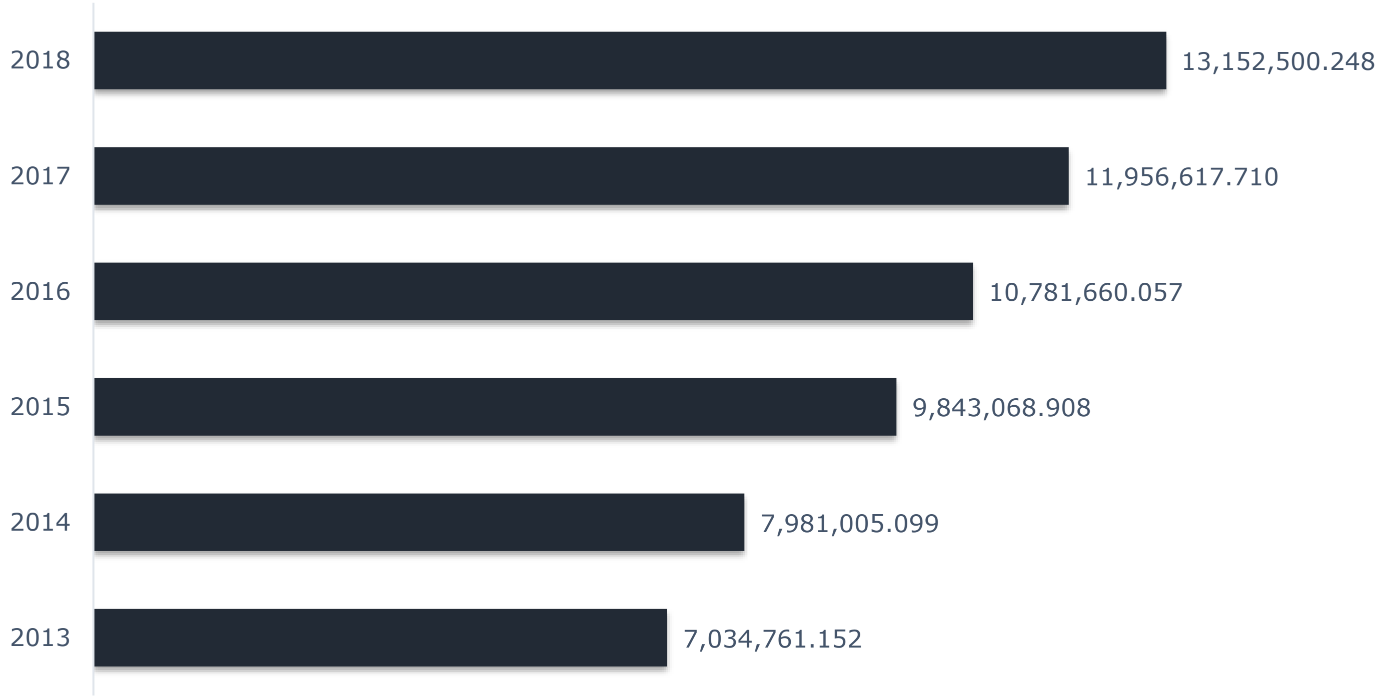
India’s private final consumption expenditure (PFCE) declined by six% in nominal terms to Rs.115.7 lakh crore in 2020-21 from Rs.123.1 lakh crore in 2019-20. Consumption expenditure growth has been slowing through the last decade. Growth in PFCE that averaged at 16.2% per annum during 2010-14, fell to 12.1% per annum during 2014-17 and further down to 10.5% per annum during 2017-20.

The PFCE was also a predominant source of fall in India’s real GDP in 2020-21. It declined faster than the fall in overall GDP. Contribution of PFCE to real GDP fell to 55.95% in 2020-21 from 57.1% in 2019-20. This shrinking of consumption expenditure has a direct impact on the intermediate industries that feed India’s consumption engine. Industries like steel, fibers, chemicals and services such as transport, trade and finance will face headwinds as the PFCE shrinks. A sharp fall in PFCE also indicates a fall in the standard of living of people of India in general and a possible rise in poverty. A return to earlier PFCE levels would require growth to accelerate and employment and household incomes to rise. But this is a significant challenge. The recent fall in per capita real PFCE is so steep that India needs to catch-up from its levels three years ago.

Purchasing power of households got eroded severely during 2020-21 due to a fall in income and high inflation. The year witnessed large-scale job and income losses. The average number of people employed reduced from 4,089 lakhs in 2020-19 to 3,877 lakhs in 2020-21. The average for 2020-21 glosses over big losses and gains as the informal workers moved in and out of the labor market in response to the lockdowns and their relaxations during the year. The impact of these movements was severe on household incomes.

5.4.2. TREND ANALYSIS OF DISPOSABLE HOUSEHOLD INCOME AND OUTLOOK

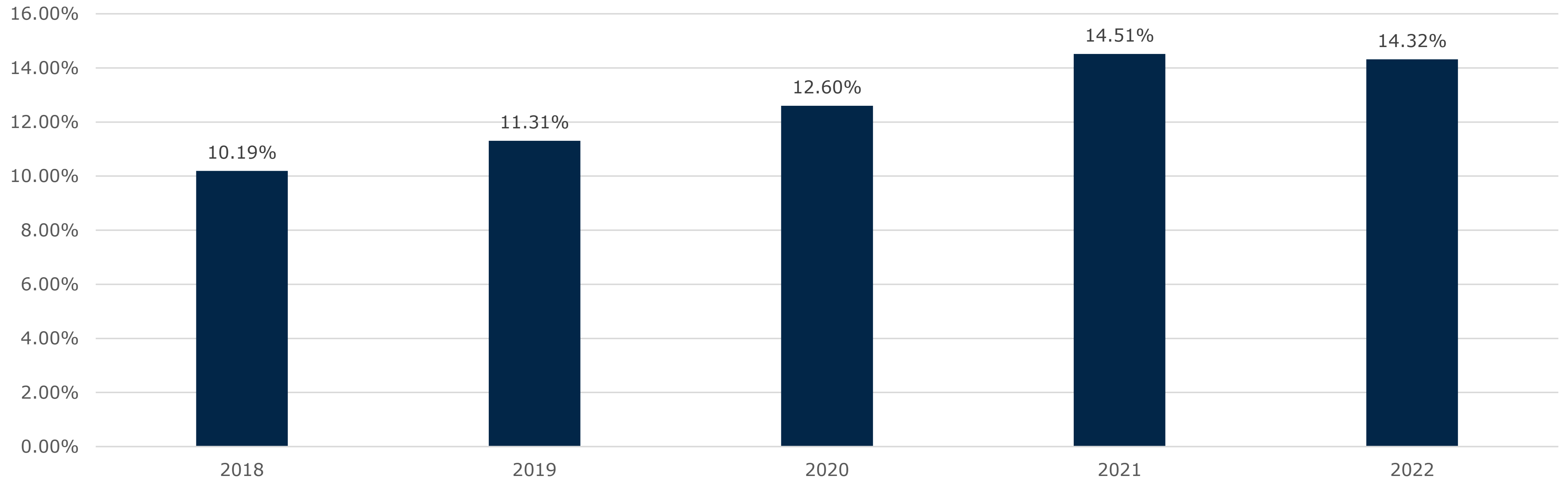
FIGURE 21. GROSS NATIONAL DISPOSABLE INCOME (INR LAKHS)



Source: GST Council of India, Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank Company Annual Report, Primary Interviews, Reports and Data

Disposable income is closest to the concept of income as generally understood in economics. Household disposable income is income available to households such as wages and salaries, income from self-employment and unincorporated enterprises, income from pensions and other social benefits, and income from financial investments (less any payments of tax, social insurance contributions and interest on financial liabilities). ‘Gross’ means that depreciation costs are not subtracted. Household income in India was drastically impacted due to the coronavirus (COVID-19) lockdown as of April 2020. There was a significant decrease in the level of income with households reporting a fall in income from about nine% in late February to a whopping 45.7% in mid-April. Rise in income saw a contrasting trend indicating similar results; from 31% in late February to 10.6% on April 2020.

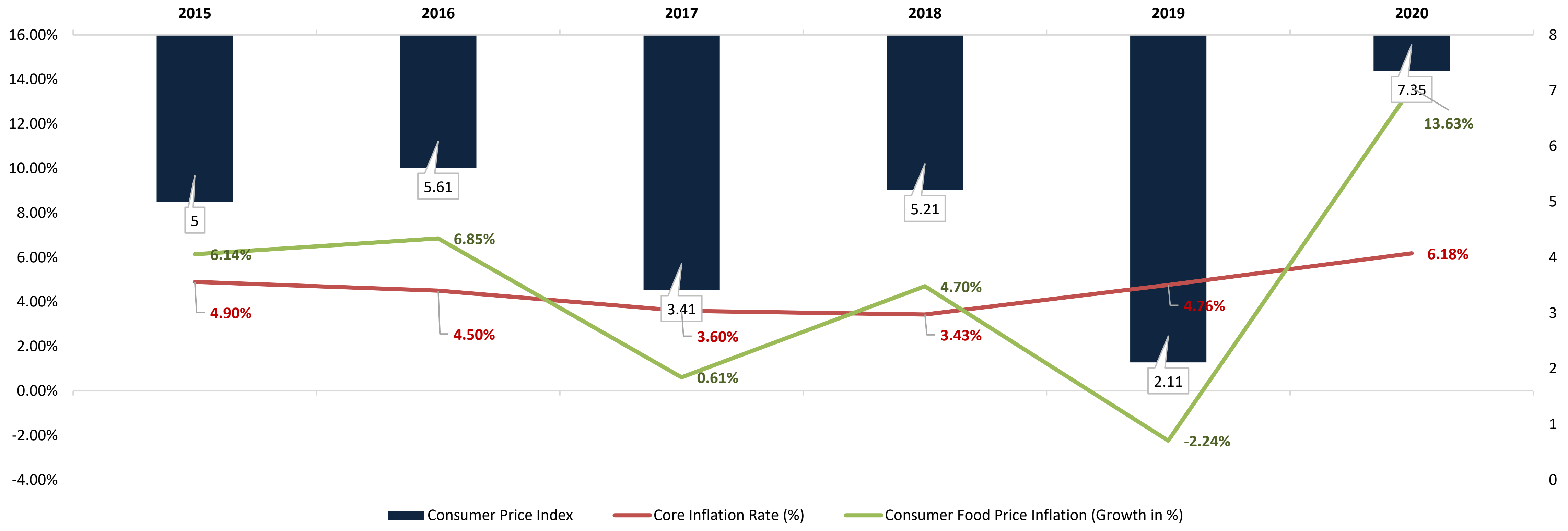
FIGURE 22. INDIA'S HOUSEHOLD DEBT: % OF GDP



Source: GST Council of India, Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank Company Annual Report, Primary Interviews, Reports and Data

5.5. CONSUMER PRICE INFLATION WITH DISAGGREGATION INTO CORE AND FOOD INFLATION

FIGURE 23. CONSUMER PRICE INDEX VS. CORE INFLATION RATE VS. CONSUMER FOOD PRICE INFLATION GROWTH



Source: GST Council of India, Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank Company Annual Report, Primary Interviews, Reports and Data

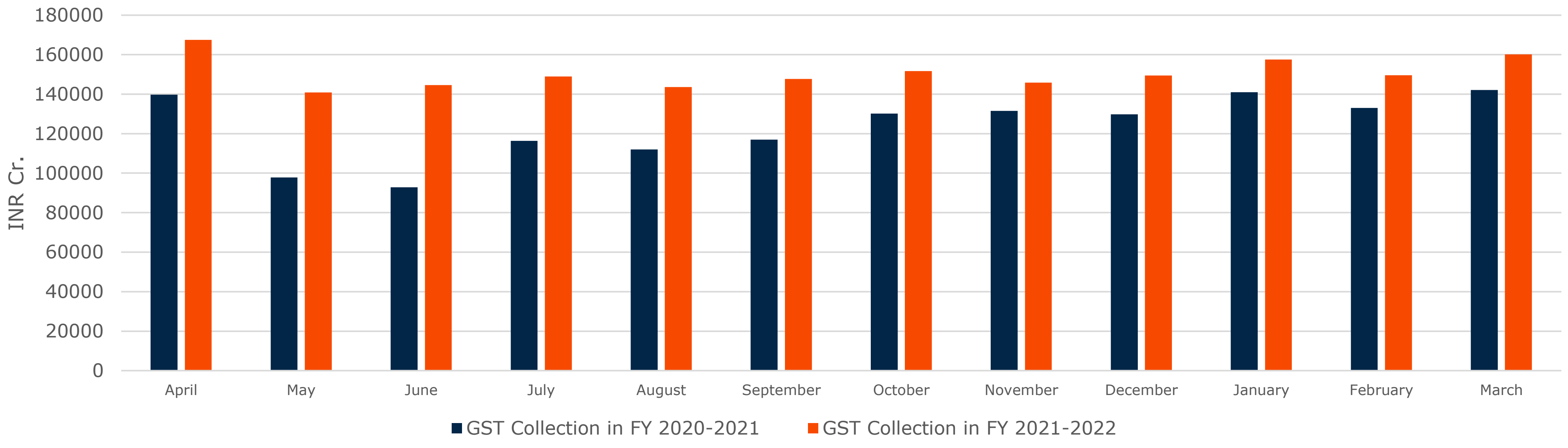
Consumer price inflation in India went through three phases in 2022. A rising phase up to April 2022 when it crested at 7.8 per cent, then a holding pattern at around 7.0 per cent up to August 2022 and then a decline to around 5.7 per cent by December 2022. The rising phase was largely due to the fallout of the Russia-Ukraine war and a shortfall in crop harvests due to excessive heat in some parts of the country. Prompt and adequate measures by the Government of India and the Reserve Bank of India (RBI) have reined in the rise in inflation and brought it within the Central Bank’s tolerance limit. In contrast, major Western countries, which pumped stimulus during the pandemic periods, continue to grapple with high levels of inflation.

The rise in prices is a constant concern for policymakers because it disproportionately affects the general population. This issue is particularly felt in developing economies where essential items make up a larger portion of people's expenses compared to developed countries. In India, inflation has been relatively stable, staying below the Reserve Bank of India's target rate of 4 percent between 2017 and 2019. However, in 2020, disruptions in the supply chain caused inflation to exceed the upper limit of 6 percent set by the RBI. The COVID-19 pandemic had a greater impact on the supply of essential goods, food, medicine, and industrial products, leading to increased cost-push inflation in the country. As the pandemic subsided, a conflict between Russia and Ukraine caused inflation worldwide, primarily driven by soaring prices of crude oil and other commodities. Prices reached a ten-year high, putting a strain on household budgets and prompting central banks to tighten monetary policies. Developed economies, faced with an ailing global economy and unprecedented inflation rates, had no choice but to raise interest rates.

The US Federal Reserve's rate hikes resulted in a stronger US dollar, making fuel imports more expensive. The IMF projects that inflation in advanced economies will rise from 3.1 percent in 2021 to 7.2 percent in 2022, the highest since 1982. In September 2022, the Euro area experienced a rate of 10.0 percent, while the US reached its highest inflation rate in 40 years at 9.1 percent in June 2022, which later moderated to 6.5 percent in December 2022. The UK witnessed a 9.2 percent annual price rise in December 2022, and Germany experienced inflation of 8.6 percent in the same month. Among emerging markets, Brazil saw a moderation in price trends, but Turkey faced inflation rates above 80 percent from August to November 2022, which slightly declined to 64.3 percent in December 2022. The war exacerbated the effects of a strong recovery in demand for goods and services following the pandemic. In emerging markets and developing economies (EMDEs), inflation is expected to have increased from 5.9 percent in 2021 to 9.9 percent in 2022, according to the IMF's projections in October 2022.

5.6. GST COLLECTIONS AND THEIR TREND

FIGURE 24. TREND IN GST COLLECTION (INR CRORE)



Source: GST Council of India, Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank Company Annual Report, Primary Interviews, Reports and Data

The month of March 2023 witnessed a significant milestone in India's tax landscape as the gross Goods and Services Tax (GST) revenue collection crossed the INR 1.5 lakh crore mark for the fourth time in the current fiscal year. This accomplishment, coupled with record-breaking Integrated GST (IGST) collections, reflects the strength and effectiveness of the GST system implemented in the country. This write-up presents an overview of the revenue collection figures for March 2023, highlights the growth compared to the previous year, discusses return filing trends, and provides state-wise data for GST collections.

Revenue Collection Figures for March 2023: In March 2023, the gross GST revenue collected amounted to INR 1,60,122 crore. The revenue distribution breakdown includes INR 29,546 crore for Central GST (CGST), ₹37,314 crores for State GST (SGST), INR 82,907 crore for IGST (including INR 42,503 crore from the import of goods), and INR 10,355 crore for cess (including INR 960 crore from the import of goods). Notably, the IGST collection reached its highest-ever level during this month.

Settlements and Total Revenue for CGST and SGST: As part of regular settlements, the government allocated INR 33,408 crore to CGST and INR 28,187 crore to SGST from IGST. Consequently, the total revenue for the Centre and the States for March 2023, after the IGST settlement, stood at INR 62,954 crore for CGST and INR 65,501 crore for SGST.

Growth Comparison and Return Filing Trends: The revenues generated in March 2023 exhibited a 13% increase compared to the GST revenues recorded in the same month of the previous year. Import of goods contributed to an 8% growth in revenue, while domestic transactions (including import of services) demonstrated a 14% surge in revenue compared to March of the preceding year. Moreover, the month of March 2023 witnessed the highest-ever filing of returns, with 93.2% of statement of invoices (in GSTR-1) and 91.4% of returns (in GSTR-3B) for February being filed by March 2023. These figures reflect a substantial improvement from the corresponding month in the previous year, which saw filing rates of 83.1% and 84.7% for statement of invoices and returns, respectively.

Gross Collection Figures for FY 2022-23: The total gross collection for the fiscal year 2022-23 reached INR 18.10 lakh crore, with an average monthly collection of INR 1.51 lakh crore. This represents a remarkable 22% increase in gross revenues compared to the previous year. In the final quarter of the fiscal year, the average monthly gross GST collection amounted to INR 1.55 lakh crore, surpassing the average monthly collections of INR 1.51 lakh crore, INR 1.46 lakh crore, and INR 1.49 lakh crore in the first, second, and third quarters, respectively.

5.7. INDIAN ECONOMY OUTLOOK & ECONOMIC IMPACT OF COVID-19 ON INDIAN ECONOMY

The pandemic's impact on India was evident in a large GDP decline in FY21. Despite the Omicron wave of January 2022, the Indian economy began to recover the next year, FY22. Since the pandemic's onset in January 2020, the third wave has had less of an impact on Indian economic activity than the prior waves. Mobility enabled by localised lockdowns, rapid vaccine coverage, light symptoms, and speedy recovery from the virus all helped to keep economic output losses to a minimum in the January-March quarter of 2022. As a result, output in FY22 surpassed its pre-pandemic level in FY20, putting the Indian economy ahead of many other countries in terms of full recovery. The Omicron variant experience inspired cautious optimism that it was possible to remain physically mobile and engage in economic activities despite the epidemic. Thus, FY23 began with the firm confidence that the pandemic was rapidly fading, and that India was prepared to expand significantly and quickly return to its pre-pandemic growth path.

Some of the key highlights include.

- The growth rates of Primary sector (comprising Agriculture, Forestry, Fishing and Mining & Quarrying), Secondary sector (comprising Manufacturing, Electricity, Gas, Water Supply & Other Utility Services, and Construction) and Tertiary sector

(Services) have been estimated as 3.9 %, 12.0 % and 8.8 respectively in 2021-22 as against a growth of 2.4 %, -0.2 per cent and -8.2 %, respectively, in the previous year. The growth in real GVA during 2021-22 is on account of growth in 'Mining and Quarrying', 'Manufacturing', 'Electricity, Gas, Water Supply & Other Utility Services', 'Construction', 'Trade, repair, Hotels and Restaurants', 'Transport, Storage and Communication & Services related to Broadcasting' and 'Other services' as may be seen from Statement 4.2B. However, 'Agriculture, Forestry and Fishing', 'Financial Services', 'Real Estate, Ownership of Dwelling & Professional Services' and 'Public Administration and Defence' have witnessed modest growth during this period.

- Services account for more than half of the Indian economy and was the most impacted by the COVID-19 related restrictions, especially for activities that need human contact. Although the overall sector first contracted by 8.4 % in 2020-21 and then is estimated to grow by 8.2 % in 2021-22, it should be noted that there is a wide dispersion of performance by different sub-sectors. Both the Finance/Real Estate and the Public Administration segments are now well above pre-COVID levels. However, segments like Travel, Trade and Hotels are yet to fully recover. It should be added that the stop-start nature of repeated pandemic waves makes it especially difficult for these sub-sectors to gather momentum.
- India's exports of both goods and services have been exceptionally strong so far in 2021-22. Merchandise exports have been above INR 2,21,80,863 Lakhs for eight consecutive months in 2021-22, despite a rise in trade costs arising from global supply constraints such as fewer operational shipping vessels, exogenous events such as blockage of Suez Canal and COVID-19 outbreak in port city of China etc. Concurrently, net services exports have also risen sharply, driven by professional and management consulting services, audio visual and related services, freight transport services, telecommunications, computer and information services. From a demand perspective, India's total exports are expected to grow by 16.5 % in 2021-22 surpassing pre-pandemic levels. Imports also recovered strongly with revival of domestic demand and continuous rise in price of imported crude and metals. Imports are expected to grow by 29.4 % in 2021-22 surpassing corresponding pre-pandemic levels.

- Inflation would likely slow to 5% in FY2023, assuming oil and food prices remain stable, and then to 4.5% in FY2024 as inflationary pressures ease. In tandem, monetary policy is likely to be tighter in FY2023 as core inflation remains high, before becoming more flexible in FY2024. The current account deficit is expected to fall to 2.2% of GDP in fiscal year 2023 and 1.9% in fiscal year 2024. Goods export growth is expected to decrease in FY2023 before rebounding in 2024, as production-linked incentive schemes and initiatives to improve the business environment, such as reduced labour regulations, boost performance in electronics and other sectors of industrial growth. Growth in service exports has been strong, and it is likely to continue to boost India's overall balance of payments position.

5.8. CURRENT GEOPOLITICAL SENARIO

Since 2020, the global economy has been hit by at least three major shocks, breaking from the past pattern of severe but spaced-out economic shocks. The pandemic caused a contraction of the global output, followed by the Russian-Ukraine conflict leading to worldwide inflation and synchronized policy rate hikes by central banks, including the Federal Reserve. This led to an appreciation of the US Dollar and wider Current Account Deficits (CAD) in net importing economies, as well as lower global growth forecasts for 2022 and 2023 by the IMF, due to persistent inflation and the frailties of the Chinese economy. The rising debt of the non-financial sector in advanced economies, combined with monetary tightening and persistent inflation, may lead to a financial contagion and elevated downside risks to the global outlook.

Post the pandemic, the global economic recovery was progressing until the Russia-Ukraine conflict started in Feb 2022, disrupting the restoration of supply chains and trade. This conflict has now lasted almost a year and caused as many disruptions as the pandemic did in two years. The prices of key commodities such as oil, gas, fertilizers, and wheat skyrocketed, worsening inflationary pressures fueled by large fiscal stimuli and accommodative monetary policies. Inflation in advanced economies, which received most of the global fiscal expansion and monetary easing, reached historical highs. Rising commodity prices also led to higher inflation in emerging markets, which were previously experiencing lower inflation due to their governments' calibrated fiscal stimulus to address the 2020 contraction.

The Indian economy has recovered from the pandemic and is poised for growth in FY23, outpacing many other nations. However, it faced inflation challenges in FY23, exacerbated by the European strife. The government and RBI, along with easing global commodity prices, managed to bring retail inflation within the RBI's upper tolerance target in November 2022. The depreciating rupee, although better than most currencies, remains a challenge, with the possibility of further policy rate hikes by the US Fed. The CAD may also persist due to elevated global commodity prices and strong growth momentum in the Indian economy.

Despite challenges, India is projected to be the fastest-growing major economy at 6.5-7.0% in FY23 by agencies worldwide. The optimistic growth forecasts are driven by the resilience of the Indian economy, seen in the rebound of private consumption as the leading driver of growth. This uptick in consumption has increased production activity and capacity utilization across sectors. The near-universal vaccination coverage overseen by the government, along with the world's second-largest vaccination drive involving over 2 billion doses, has brought people back to the streets to spend on contact-based services and lifted consumer sentiments, leading to a prolonged rebound in consumption.

6. MARKET SEGMENTATION & IMPACT ANALYSIS

6.1. SEGMENTATION ANALYSIS

Type	Offering	Equipment	End Use
•Water Treatment •Sewage Treatment •Effluent Treatment	•Treatment Technologies •*Activated Sludge Process* •*Membrane Bio Reactor* •*Moving Bed Bio Reactor* •*Sequencing Batch Reactor* •*Upflow Anaerobic Sludge Blanket Reactor* •*Submerged Aerated Fixed Film Reactor* •*Other Treatment Technologies* •Treatment Chemicals •*Corrosion Inhibitors* •*Scale Inhibitors* •*Biocides & Disinfectants* •*Coagulants & Flocculants* •*Chelating Agents* •*Anti-Foaming Agents* •*Ph Adjusters and Stabilizers* •*Others* •Process Control and Automation •Design, Engineering, and Construction Services •Operation and Maintenance Services	•Filtration •Disinfection •Adsorption •Desalination •Testing •Others	•Municipal •*Government and Public Utilities* •*Local Communities* •Industrial •*Power Generation* •*Oil and Gas* •*Food and Beverage* •*Chemicals* •*Pharmaceuticals* •*Others*

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

The estimations have been provided in terms of revenue (USD Million) on the India level, with 2023 as the base year and a forecast period from 2024 to 2033.

6.2. WATER AND WASTEWATER TREATMENT MARKET

Global water and wastewater treatment is a critical industry that plays a pivotal role in ensuring environmental sustainability and public health worldwide. With increasing urbanization, industrialization, and population growth, the demand for clean water and effective wastewater treatment solutions has escalated dramatically. This industry encompasses a wide range of technologies, processes, and services aimed at purifying water for various uses and treating wastewater to remove contaminants before discharge into the environment. The overarching goal is to conserve water resources, protect ecosystems, and mitigate health risks associated with contaminated water supplies.

One of the primary drivers of growth in the global water and wastewater treatment industry is the rising awareness of water scarcity and pollution. As freshwater sources become more limited and polluted due to industrial activities, agriculture, and urban runoff, the need for efficient water treatment solutions becomes increasingly urgent. Governments, industries, and communities are investing heavily in advanced water treatment infrastructure and technologies to address these challenges. Additionally, stringent regulations and environmental standards are driving the adoption of innovative water treatment processes to meet quality requirements and ensure compliance.

The market for water and wastewater treatment is highly diverse, comprising various segments such as municipal water treatment, industrial water treatment, and wastewater recycling. Municipal water treatment focuses on supplying clean and potable water to urban populations, employing processes like filtration, disinfection, and desalination. Industrial water treatment, on the other hand, caters to the specific needs of industries such as manufacturing, power generation, and pharmaceuticals, where water quality requirements are often more stringent due to the nature of operations and discharge regulations. Wastewater recycling is gaining prominence as a sustainable solution to reduce water consumption and minimize environmental impact by treating wastewater for reuse in industrial processes, irrigation, and non-potable applications.

The global water and wastewater treatment industry is witnessing a surge in demand for advanced technologies and solutions that improve efficiency, reduce energy consumption, and enhance treatment capabilities. Membrane technologies, including reverse osmosis (RO), ultrafiltration (UF), and nanofiltration (NF), are gaining traction for their ability to remove contaminants at the molecular level, producing high-quality water suitable for various applications. Membrane bioreactors (MBRs) combine biological treatment with membrane filtration, offering superior effluent quality and smaller footprint compared to conventional treatment systems. Advanced oxidation processes (AOPs) such as ozonation and UV disinfection are becoming essential for removing emerging contaminants like pharmaceuticals and microplastics from water sources.

The increasing focus on sustainable water management practices is driving innovation and investment in water recycling and reuse technologies. Water scarcity in arid regions and drought-prone areas has spurred the development of advanced water reclamation systems that treat wastewater to a quality suitable for agricultural irrigation, landscaping, and industrial processes. Reuse of treated wastewater not only conserves freshwater resources but also reduces the strain on traditional water supplies, promoting circular economy principles and environmental sustainability.

6.3. SUSTAINABLE WASTEWATER TREATMENT PLANTS (WWTPS) IN INDIA

Traditionally, Wastewater Treatment Plants (WWTPs) have focused on pollutant removal from wastewater. However, a paradigm shift is underway, with WWTPs evolving into resource recovery facilities. This transition is driven by new technologies that are not only economically viable but also contribute to sustainable development and green energy production.

The Power of Renewables: Solar on Site

Harnessing renewable energy sources like solar power is a key strategy for wastewater treatment plants (WWTPs) aiming to reduce their environmental impact and operational costs. Installing solar panels on rooftops can significantly decrease a WWTP's reliance on the electrical grid for its electricity needs. This approach is gaining momentum, as highlighted by a 2023 report from the Central Electricity Authority (CEA) under the Ministry of Power, Government of India. The report indicates that over 150 MW of rooftop solar capacity has been installed in sewage treatment plants across the country. This substantial increase in solar capacity not only helps reduce electricity costs but also significantly minimizes the carbon footprints of these facilities. By generating clean, renewable energy on-site, WWTPs can achieve greater energy independence and sustainability.

Moreover, this strategy aligns with global efforts to combat climate change and promotes the use of green technologies in essential public infrastructure. The success of these installations serves as a model for other sectors and regions, demonstrating the feasibility and benefits of integrating solar power into existing operations. As more WWTPs adopt this approach, the cumulative positive impact on the environment and energy sector will continue to grow.

Biogas from Wastewater: A Double Win

India is making significant strides in harnessing the power of biogas from wastewater, offering a double win for the environment and wastewater treatment plants (WWTPs). This innovative technology utilizes anaerobic digestion to transform organic matter in wastewater into biogas, a renewable energy source. This not only reduces dependence on fossil fuels but also creates a valuable resource. Furthermore, the biogas produced can be used to generate electricity for the WWTP's internal operations, leading to significant cost savings. The Indian government actively supports this transition. Recognizing the potential of biogas, the Ministry of New and Renewable Energy (MNRE) has set an ambitious target of achieving 50 Gigawatt (GW) of Compressed Bio Gas (CBG) capacity by 2024. While this target year has passed, it highlights the government's commitment to accelerating CBG production. The latest update on the revised target and timeline can be found on the MNRE website.

This initiative, known as the Sustainable Alternative Towards Affordable Transportation (SATAT) program, provides financial and technical assistance for establishing CBG plants. This makes it an attractive option for WWTPs, not just for cost savings but also for environmental benefits. According to a report by the Central Pollution Control Board (CPCB), India generates over 72,000 million liters of wastewater daily. Biogas production from wastewater offers a sustainable solution for managing this vast amount of organic waste while generating renewable energy. For instance, a successful example of this technology in action is the Nagpur Municipal Corporation's sewage treatment plant. This plant utilizes biogas produced from wastewater to meet 80% of its electricity needs. This not only reduces their dependence on the grid but also showcases the real-world implementation and its positive impact on operational costs. By leveraging biogas from wastewater, India is creating a sustainable solution for waste management, energy generation, and cost reduction in WWTPs. This approach aligns with the government's vision for a cleaner environment and a more sustainable future.

Carbon Credits: A Green Incentive

By adopting sustainable practices like solar power and Compressed Biogas (CBG) generation, Wastewater Treatment Plants (WWTPs) in India can significantly reduce their greenhouse gas emissions. This reduction in emissions can translate into carbon credits – tradable certificates representing avoided or captured carbon dioxide emissions. The Ministry of Environment, Forest and Climate Change (MoEFCC) has established a framework for carbon trading in India through the recently launched Pradhan Mantri Pariyojana Karbon Kshetra (PM-PKVY) scheme. This scheme provides a much-needed push for industries to adopt cleaner technologies and processes. Selling carbon credits generated from reduced emissions at WWTPs can create additional revenue streams, further incentivizing sustainable operations. These revenue streams can be used to improve treatment processes, invest in further renewable energy projects, and make WWTPs more financially self-sufficient. The MoEFCC framework ensures proper monitoring, verification, and issuance of carbon credits for transparent carbon trading. This creates a win-win situation for WWTPs, the environment, and the nation's commitment to tackling climate change.

6.4. WASTE TO ENERGY IN INDIA: TURNING TRASH INTO TREASURE

India's rapid urbanization has resulted in a significant challenge – waste management. However, the Indian government is transforming this challenge into an opportunity by promoting innovative solutions that convert waste into a valuable resource: energy. Here's a closer look at some key initiatives driving India's transition towards a more sustainable waste-to-energy future, drawing on official government sources:

6.4.1. SATAT SCHEME: FOSTERING A CIRCULAR ECONOMY THROUGH GOVERNMENT SUPPORT

Launched in 2019 by the Ministry of Housing and Urban Affairs (MoHUA), the **SATAT Scheme (Sustainable Sanitation and Toilet Access in Towns)** plays a critical role in propelling India's waste-to-energy sector. As of March 2022, there are approximately 249 waste-to-energy (waste-to-electricity/biogas/bio-methanation) plants functional in India, with an input capacity of 0.074 lakh tonnes per day, according to the Ministry of Housing and Urban Affairs. This centrally sponsored scheme aims to promote innovation and technological advancements in sanitation, specifically focusing on **source segregation of waste**.

The Satat Scheme empowers local bodies and entrepreneurs by providing financial assistance for setting up bio-gas or composting plants. This financial support fosters a **circular economy**, where waste becomes a source of income and fuel. Local communities benefit from a cleaner environment, while organic waste is transformed into valuable resources like biogas or compost.

6.4.2. NATIONAL POLICY ON BIOFUELS: A POLICY FRAMEWORK FOR CLEAN ENERGY ALTERNATIVES

Recognizing the immense potential of biofuels as a clean and sustainable alternative to fossil fuels, the Ministry of New and Renewable Energy (MNRE) released the **National Policy on Biofuels** in 2018. The total estimated energy generation potential from urban and industrial organic waste in India is approximately 5,690 MW, according to the MNRE. This policy framework provides a crucial push for the adoption of biogas generation technologies across the country.

The National Policy on Biofuels specifically incentivizes the production of biofuels like biogas from various feedstocks, including **municipal solid waste** and **sewage sludge**. This policy framework creates a supportive environment for the development and deployment of biogas technologies, contributing to India's clean energy goals.

6.4.3. WASTE TO ENERGY PROGRAMME: BRIDGING THE GAP FOR GREEN ENERGY GENERATION

The MNRE's **Waste to Energy Programme** offers substantial financial support for establishing waste-to-energy plants. This program bridges the gap between technology adoption and financial feasibility, accelerating the growth of the waste-to-energy sector.

The Waste to Energy Programme provides financial assistance for plants that generate electricity, biogas, or compressed biogas (CBG) from various types of waste. The total installed capacity for waste-to-energy projects in India reached 522.42 MWeq as of July 2023. This includes **municipal solid waste**, **agricultural residues**, and **industrial waste**. The program offers **Central Financial Assistance (CFA)** to project developers, making these clean energy projects more economically viable.

6.4.4. NATIONAL PLAN FOR CONSERVATION OF AQUATIC ECO-SYSTEMS (NPCA):

The **National Plan for Conservation of Aquatic Eco-systems (NPCA)**, under India's **Ministry of Environment, Forest, and Climate Change (MoEF&CC)**, is a strategic initiative aimed at conserving and managing the country's **lakes and wetlands**. Established in 2015 by merging the **National Lake Conservation Plan (NLCP)** and the **National Wetlands Conservation Programme (NWCP)**, the NPCA addresses ecological challenges comprehensively.

The NPCA's primary objective is to maintain and restore the **ecological health** of aquatic ecosystems, focusing on **pollution abatement**, **catchment area treatment**, **biodiversity conservation**, and **sustainable resource use**. This plan adopts an integrated and multidisciplinary approach, recognizing the interdependence of **land, water, and biodiversity**. Key actions include identifying and prioritizing water bodies for conservation, preparing comprehensive management plans, and implementing on-ground interventions such as **desilting**, **weed control**, **bioremediation**, and **community participation initiatives**. The plan emphasizes **water quality maintenance**, **hydrological regime restoration**, and the protection of unique **flora and fauna** associated with these ecosystems.

The NPCA benefits the **water and wastewater industry** significantly by promoting **sustainable water management practices**. By improving the health of aquatic ecosystems, it ensures a consistent and **high-quality water supply**, which is crucial for both domestic and industrial use. The plan's focus on pollution abatement directly impacts **wastewater management**, encouraging the adoption of advanced treatment technologies and practices. This, in turn, drives **innovation** and **efficiency** within the industry, fostering the development of new solutions for **water purification** and **wastewater treatment**.

According to government statistics, as of 2021, the NPCA has undertaken the conservation and management of **115 wetlands** been identified in 24 States and two Union Territories for conservation and management. These efforts have not only helped in preserving biodiversity but also in improving the quality of water available for various uses. Additionally, by involving various stakeholders, including **state governments**, **research institutions**, and **NGOs**, the NPCA fosters a **collaborative environment** that enhances the industry's capacity to address water-related challenges. The plan also stimulates **investment in water infrastructure projects**, generating economic opportunities and contributing to the industry's growth.

6.4.5. UNTAPPED POTENTIAL: BIOGAS GENERATION IN SEWAGE TREATMENT PLANTS (STPS)

India's Sewage Treatment Plants (STPs) hold immense potential for biogas generation. Organic matter present in wastewater can be converted into clean-burning biogas through **anaerobic digestion**, a biological process. Studies by government agencies indicate that India's STPs have the capacity to generate a significant amount of biogas, significantly contributing to the country's clean energy needs and reducing dependence on fossil fuels. Studies by government agencies indicate that India's STPs have the capacity to generate enough biogas to contribute 1,247 MW of energy

Government initiatives like the National Policy on Biofuels and the Waste to Energy Programme can unlock this potential by:

- **Encouraging the adoption of biogas generation technologies** in existing STPs through financial and technical support.
- **Facilitating public-private partnerships (PPPs)** to develop and operate biogas plants at STPs.

- **Creating awareness** among stakeholders about the benefits of biogas generation from wastewater treatment.

6.4.6. HARNESSING THE POWER OF THE SUN: A COMPLEMENTARY APPROACH

While not directly related to waste-to-energy conversion, solar energy offers a significant advantage for WWTPs. The Ministry of New and Renewable Energy (MNRE) promotes the installation of **rooftop solar panels** on wastewater treatment plants. This approach can significantly reduce a plant's electricity consumption, leading to:

- **Lower operational costs**
- **Reduced environmental footprint**

By lowering operational costs, solar energy allows WWTPs to divert more resources towards waste-to-energy initiatives, such as adopting biogas generation technologies. This creates a synergistic approach where renewable energy sources work together to create a more sustainable wastewater treatment process.

6.5. INDIA CURRENT KEY PRACTICES IN WATER AND WASTEWATER MANAGEMENT

India accounts for 2.45% of land area and 4% of water resources of the world but represents 16% of the world population. With the present population growth-rate (1.9% per year), the population is expected to cross the 1.5 billion mark by 2050. The Planning Commission, Government of India has estimated the water demand increase from 710 BCM (Billion Cubic Meters) in 2010 to almost 1180 BCM in 2050 with domestic and industrial water consumption expected to increase almost 2.5 times. The trend of urbanization in India is exerting stress on civic authorities to provide basic requirement such as safe drinking water, sanitation, and infrastructure. The rapid growth of population has exerted the portable water demand, which requires exploration of raw water sources, developing treatment and distribution systems.

With a geographical territory of nearly 3.287 million square kilometers, the vast land of India relies on rivers, oceans, and lakes for its reserves. For instance, rivers like the Ganga, Yamuna, and Brahmaputra among the other major 19 rivers provide water to the northern region. Whereas the rivers, Cauvery, Krishna, and Godavari constitute the prominent water resources of south India. Dam projects like the Tehri Dam of Uttarakhand and the Bhakra Nangal project in Himachal Pradesh are providing a boost to the optimum utilization of this resource for energy generation within the country. Although the country accumulates nearly 4000 billion cubic meters (BCM) annually, as per the Central Water Commission of India, nearly 80-95% of water is accumulated during the monsoon season, ranging from June to September. Hence, being rain dependent is seen to increase the pressure on the limited supply of water. Furthermore, the growing population of the country, increase in urbanization, agricultural demand as well as industrial progress has resulted in a 20% fall in per capita water availability from 2000 to 2020. Additionally, although water consumption per person is nearly 2 liters for survival, with a population of 1.4 billion, the country is facing an acute water crisis. It has also been reported by the National Commission for Integrated Water Resource Development (NCIWRD) in 2020, that the proportion of water used for agriculture has been reducing for the past two decades and is seen to be diverted for industrial uses. For instance, almost 83.30% of total water storage was being used by agriculture, whereas the NCIWRD states that 72.48% would be used by this primary sector till 2025. Hence, there has been a shift of directing water resources towards industrial and chemical developments such as infrastructural projects and fossil fuel extraction. Similarly, the Central Pollution Control Board of India suggests that 500 BCM capacity of water is utilized by various processing and manufacturing industries out of the 4000 BCM acquired per year. Chemical residues, effluents being released in lakes and rivers along with a deterioration of water quality are the negative impacts of this precious resource being heavily used in production sector and being disposed of incorrectly in India.

Such waste water consists of solid waste, toxic waste as well as chemical waste generated by factories and warehouses. Chemicals and reagents like phenols, arsenic, cadmium, and lead among other materials are being detected in India's such waste waters regions. These materials, also known as persistent bio accumulative toxins, are hazardous for aquatic flora, fauna, and for humans. As a result, up to 70% of surface water in the country is contaminated with 40 million liters of such polluted water entering other water bodies, as per the Asian Development Research Institute. Although such contamination might be restricted to industrial areas, their harmful reverberations affect the overall ecosystem, ranging from saline and toxic groundwater and soil for agriculture, up to the excess load on water purification systems in cities. This has also led to the rise in water borne diseases, owing to poor sanitation and water hygiene in rural regions. For example, 37.7 million people are being affected by waterborne diseases like cholera and typhoid in the country, according to a UNICEF report in 2019. There is a pressing need for waste water management in urbanized industrial zones such as the Gurgaon-Delhi-Meerut zone and Mumbai-Pune region. Many governmental programs, incentives and private players are encouraging the growth of the water and wastewater treatment industry in India.

As a result, with the advent of newer technology in purification processes, great involvement of the Indian government in curbing water waste generation and control of industrial effluents through different programs is supporting this sector. Additionally, the growing participation from private companies to produce mechanical parts for treatment plants and a rising awareness about environmental issues is propelling the water and wastewater treatment industry forward. Furthermore, the global influence of sustainable development and funds for research and development in the sector are also some of the important influencing factors for the growth of this sector in the country.

Rainwater Harvesting

Rainwater Harvesting can be defined as the collection and storage of rainwater for future uses--domestic, agricultural, industrial, and so on--as a means to replenish groundwater by allowing the accumulated rainwater to seep back into the earth through assisted means, thereby recharging the water levels below the ground. With increased urbanization, the supply of clean, potable drinking water for the majority is becoming increasingly difficult. Rainwater may be viewed as a valuable renewable resource for all regions. Domestically, it is used to provide potable water, small-scale irrigation, and, most typically, to refill and maintain groundwater levels. It is mostly helpful for agricultural purposes in countries/regions with dry, arid climates with little or no rainfall. It assists farmers in reaping the benefits of nature by catching rainwater and giving a less expensive option for clean water. Farmers in steep and hilly terrains benefit from catching runoffs on sloping terrains to reduce soil erosion loss. In 2001, the government mandated rainwater harvesting for all newly constructed buildings possessing a roof area exceeding 100 square meters.

Tamil Nadu was the first Indian state to make rainwater collecting mandatory for buildings to address groundwater depletion in 2001, and the state has enjoyed huge advantages as a result. Groundwater levels in Chennai surged about 50% in five years, and water quality improved as a result. The effectiveness of this effort was aided by mass awareness campaigns in both rural and urban regions. Following the success of the Tamil Nadu model, several states enacted different laws and regulations, and even the Parliament contributed to the cause by drafting national legislation, The Rainwater (Harvesting and Storage) Bill, in the Lok Sabha in 2016. The Rainwater (Harvesting and Storage Bill) was introduced as a Private Member's Bill in Lok Sabha in 2016 to allow for mandatory rainwater harvesting in all government, residential, commercial, and institutional buildings to save rainfall and maintain groundwater recharge. It suggested building rainwater collecting facilities on properties with an area more than or equal to 1100 square meters to fulfill a portion of its overall water needs. The person in charge of the affairs of the mentioned establishment is responsible for ensuring compliance with the rules and regulations. For example, in the case of a residential society, the Secretary of the society is accountable; in the case of an office, the person responsible is a manager, and so on. The government is required to develop an action plan to educate the public about rainwater harvesting through the internet and other relevant campaigns, as well as to encourage and provide financial assistance to Non-Governmental Organizations and other organizations actively involved in rainwater harvesting. The Bill also recommended a punishment of up to two years in prison and/or a fine of Rs. ten lakhs for failure to comply with the requirements of the Bill.

Himachal Pradesh	Karnataka	Gujarat	Tamil Nadu	New Delhi	Haryana	Rajasthan	Maharashtra
•All buildings- existing and new, residential and commercial spanning over 1000 square meters are to mandatorily have rainwater harvesting systems and storage units, proportional to the size/area of the terrace. All toilet flushes are to be connected to this storage unit.	•In 2009, the government of Karnataka made it mandatory for each and every building/complex in the state spanning over 1500-meter square to adopt rainwater harvesting and management systems, and those over 2400-meter square, to construct a separate facility for the same.	•The Ahmedabad Urban Development Authority made rainwater mandatory for all buildings spanning over 1500-meter squares to construct percolation wells, to store the harvested rainwater, and one well for every additional 4000 m sq. covered in 2002.	•According to the Tamil Nadu Municipal Laws (ordinance) of 2003, the state government made it mandatory for all public and private buildings in the state to build and install rainwater harvesting systems, explicitly stating that in all those occupancies, where no such system is installed, the Municipal Authorities (authorized by the Commissioner) may after due notice to the owner, install a system and recover the costs from the property holder as property tax. Non-compliance with these provisions may lead to disconnection of the main water supply by the authorities.	•The ministry of Urban Affairs and Poverty Alleviation made rainwater harvesting mandatory for new constructions having a roof area greater than 100 meters square in 2001. Rainwater harvesting is mandatory for the regions of South and South-west Delhi, Ghaziabad, Gurgaon, Faridabad, and other notified areas, according to a notification issued by the Central Water Authority and an incentive of 6% rebate on property tax on compounds having fully functioning water harvesting systems is offered for maximum utilization of rainwater, or a 10 percent rebate on the water bills.	•The Haryana Urban Development Authority (HUDA) has made the setting up and installation of rainwater harvesting systems in all new buildings compulsory, irrespective of roof area. All neighboring industrial areas and residential colonies are required to strictly adhere to the notification, especially those having tubewells.	•The state government has made rainwater harvesting mandatory for all public and private compounds in urban areas. Rajasthan is one of those few states having a history of traditionally practicing rainwater harvesting. The local authorities have actively been working towards reviving these old water harvesting systems.	•Rainwater harvesting has been made compulsory for all buildings constructed on plots having an area equal to or greater than 1,000 sq m. in Pune, the existence of a rainwater harvesting system in a housing society is a prerequisite, whereas in Mumbai, although there is no such mandatory rule in existence, the local authorities are planning to make it mandatory for large and expansive housing societies.

Rainwater harvesting has become increasingly prominent in India as a sustainable solution to tackle water scarcity and effectively manage rainfall. Numerous successful examples have emerged across the country, showcasing the effectiveness of this approach. Here are a few noteworthy instances:

- **Alappuzha, Kerala**: In 2002, Alappuzha initiated a comprehensive rainwater harvesting program, which included the construction of rooftop structures, recharge pits, and ponds. This initiative led to a significant rise in groundwater levels, mitigated water scarcity, and enhanced water quality within the town.
- **Ralegan Siddhi, Maharashtra**: With the leadership of social activist Anna Hazare, Ralegan Siddhi transformed from a drought-prone area into a model for sustainable water management. The village implemented various techniques such as rooftop catchment systems, percolation tanks, and check dams, resulting in increased groundwater levels and year-round water availability.
- **Jaisalmer, Rajasthan**: Facing severe water scarcity in its arid environment, Jaisalmer adopted widespread rainwater harvesting practices. The community constructed underground water storage tanks known as 'Tanka,' using locally available materials like stone and mortar. This endeavor successfully replenished groundwater and ensured water availability during dry spells.
- **Noida, Uttar Pradesh**: As a rapidly growing city near Delhi, Noida made rainwater harvesting mandatories for all buildings. This initiative involved the installation of various structures like rooftop systems, recharge wells, and percolation pits, resulting in higher groundwater levels, reduced flooding incidents, and improved water availability.
- **Kalpana Chhaya, Rajasthan**: This village in Rajasthan addressed severe water scarcity caused by erratic rainfall patterns through a rainwater harvesting project. By implementing rooftop systems, check dams, and percolation tanks, the village achieved self-sufficiency in water supply, increased agricultural productivity, and decreased reliance on external water sources.

Reuse and Recycling

Water reuse and recycling have become increasingly important strategies in India due to the growing water scarcity and pollution challenges faced by the country. Several initiatives and practices have been implemented to address these issues and promote sustainable water management. Industries are encouraged to implement water recycling and reuse practices to minimize their impact on freshwater sources. Many industries, such as textile, paper, and chemical, have adopted technologies to treat and reuse their wastewater for production processes. Many cities in India have established wastewater treatment plants to treat and recycle domestic and industrial wastewater. These plants use various treatment processes to remove pollutants and pathogens from wastewater before releasing it into water bodies or reusing it for non-potable purposes such as irrigation and industrial processes.

Water stress has become a recurring worry in India because of the rapid and uncontrolled growth in water demand for household, agricultural, and industrial requirements. More than half of the country's population is expected to be urban by 2050. This would challenge water management since the exponential increase. Furthermore, insufficient, and restricted wastewater treatment facilities endanger water quality and public health. In India, the total installed capacity to treat wastewater (domestic sewage) from urban areas is 44%, or 31,841 million liters per day (MLD), compared to an estimated daily sewage output of 72,368 MLD. The actual treatment rate is only 28%, or 20,236 MLD. Even in class I (populations over 100,000) and class II (populations 50,000-100,000) towns, which account for 72% of the urban population, only 30% of the wastewater gets treated, i.e., 11,787 MLD vs the 38,254 MLD created. The demand would place a large extra pressure on already restricted freshwater supplies. The remaining untreated wastewater is released into natural water bodies such as rivers and lakes, causing contamination and affecting water quality, particularly in downstream settlements. Nonetheless, India has made significant headway in boosting its operational treatment capacity, increasing from 18,883

MLD in 2014 to 26,869 MLD in 2020, a 40% increase. However, much more must be done to manage wastewater and meet the issues created by lack of water.

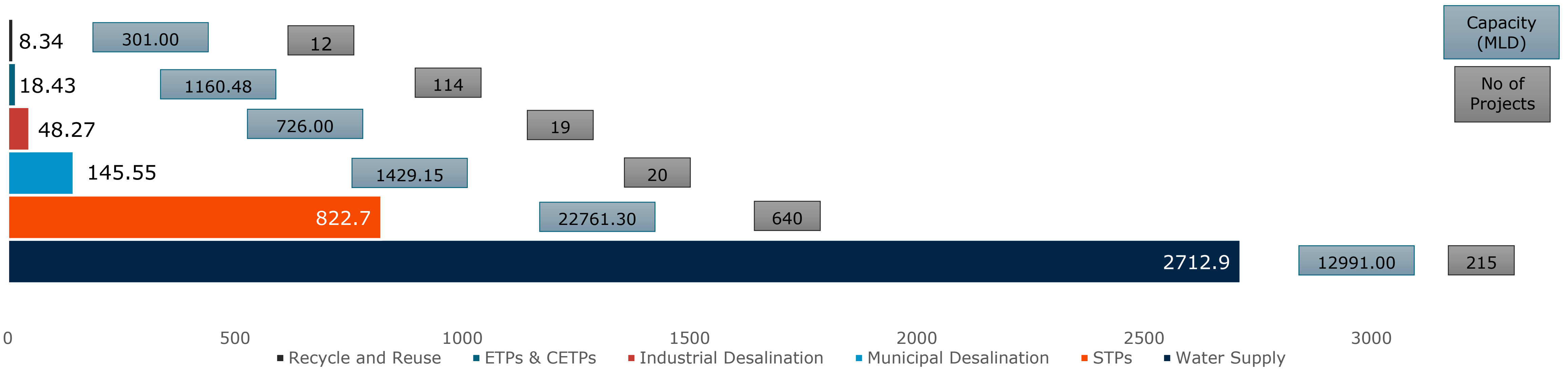
6.5.1. WASTEWATER SCENARIO IN INDIA

With 1.38 billion inhabitants, India is the world's most populous country. According to the United Nations (2021), 67% of the population lives in rural areas, while 33% is connected to metropolitan centers. The country's urban cities are expanding rapidly because of economic development and reforms. This increase in urban population is unsustainable without effective city planning and the supply of utility services, particularly clean and inexpensive water. Water is often allocated in cities from a shared pool with multiple sectoral needs. It is projected that by 2050, around 1450 km3 of water would be required, with approximately 75% being utilized in agriculture, 7% for drinking water, 4% in industry, and 9% for energy generation. However, due to increasing urbanization, the need for drinking water will trump rural water requirements. Many towns are located on river banks, where fresh water is used by the people and waste water is disposed of back into the river, contaminating the water supply and irrigation water. This has created significant difficulties for urban wastewater management, planning, and treatment. According to the Central Pollution Control Board (CPCB), the predicted wastewater generation in rural areas was over 39,600 million liters per day (MLD), while in urban areas it was 72,368 MLD for the year 2020-21. The projected volume in big centers is about double that of rural areas due to the availability of more water for sanitation, which has raised the level of living.

As the country's population grows, so does the need for water and its management. Water scarcity is expected to become a serious issue in the future. Furthermore, pollution's impact on water supplies is a cause of worry. Some of the major causes of water pollution are the release of industrial waste, the discharge of untreated or partially treated municipal wastewater through drains, the discharge of industrial effluent, improper solid waste management, illegal ground water abstraction, encroachments in flood plains/river banks, deforestation, improper water shade management, and the non-maintenance of e-flows and agricultural runoff, among others. The Government of India has devised several initiatives that focus on water conservation and restoration.

As a consequence, the number of contaminated river lengths has decreased from 351 in 2018 to 311 in 2022, and water quality has improved in 180 of the 351 contaminated River lengths (PRS) during 2018. According to research from the Ministry of Jal Shakti, a review of water quality over time reveals that in 2015, 70% of rivers examined were designated as contaminated, however in 2022, just 46% of rivers studied are identified as polluting. The need for water is only expected to rise in the coming years. The government's major priority is to provide safe drinking water. Drinking water quality has been a serious problem in rural regions over the years. The Central Water Commission (CWC) examines the country's total water resources on a regular basis, and it has designated water supply for drinking purposes as the main priority in water distribution.

FIGURE 25. SEGMENT WISE PROJECTS IN THE PIPELINE IN INDIA, 2022



Source: India Infrastructure Research

In India, the urban sewage generation was 72,368 MLD in 2020-21, whereas the existing sewage treatment capacity was 31,841 MLD. The operating capacity is 26,869 MLD, which is much less than the load generation. Only 28% of total sewage generation, or 20,236 MLD, was processed, implying that 72% of waste water is left untreated and is disposed of in various water bodies such as rivers, lakes, or subterranean water. There has been some capacity expansion, such as 4,827 MLD sewage treatment, but there is still a 35,700 MLD gap, or 49%, between waste water generation and treatment. According to a 2018 NITI Aayog assessment, India is one of the world's most water-stressed areas, with 600 million Indians under high water stress. According to the analysis, by 2030, water demand may be twice as high as supply, resulting in acute water scarcity for millions of people and a 6% drop in the country's GDP. As a result, knowing and managing our water demands and resources efficiently is becoming increasingly important. Reusing and recycling our water resources is critical for a sustainable future. According to the UN Waste Water Assessment Program assessment, high-income nations treat around 70% of the wastewater generated. In upper-middle-income nations, the percentage falls to 38%, 28% in lower-middle-income countries, and 8% in low-income countries. This amounts to around 20% of worldwide wastewater treatment. According to a recent Central Pollution Control Board report (March 2021), India's present water treatment capacity is 27.3% and its sewage treatment capacity is 18.6% (with an additional 5.2% capacity being built). Though India's waste and sewage treatment capacity is greater than the global average of roughly 20%, given the magnitude of the problem, it is far from adequate, and without immediate action, major difficulties might arise.

TABLE 5. REGION-WISE SEWAGE GENERATION AND TREATMENT CAPACITY OF URBAN CENTERS-INDIA, 2020 (MLD)

States / UTs	Sewage Generation (MLD)	Installed Capacity (MLD)	Proposed Capacity (MLD)	Operational Treatment Capacity (MLD)
East India	12226	1345	1553	440
West India	19212	13356	3161	11332
South India	20851	6114	23	4869
North India	16894	11026	90	10228

TOTAL	**72368**	**31841**	**4827**	**26869**

Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants, Ministry of Jal Shakti

Currently, there is no centrally mandated policy requirement for wastewater management in India. Water resources are mismanaged because of policy gaps and the lack of a defined regulatory framework. Untreated sewage waste is a major source of surface and groundwater contamination in India. The Water (Prevention and Control of Pollution) Act of 1974 was the country's first legislative legislation addressing the subject of water pollution and conservation. This Act addresses wastewater discharge as a pollution issue. This Act establishes Central and State Pollution Control Boards to oversee water pollution prevention and control. It punishes the act of interfering with water flow by discharging noxious chemicals into streams, wells, sewers, or land. SPCBs' operations on the ground are more thorough and direct, since it inspects sewage and trade effluents, wastewater treatment plants, and examines and establishes standards for the same. SPCBs' operations on the ground are more thorough and direct, since it inspects sewage and trade effluents, wastewater treatment plants, and examines and establishes standards for the same. According to a 2019 study report of Niti Ayog, most of the sewage treatment plants created under the Ganga Action Plan and Yamuna Action Plan are not operational, and only 7000 MLD of waste is collected and processed out of the 33000 MLD generated. According to the report, the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) adopted the National Policy on Faecal Sludge and Septage Management (FSSM) in 2017 because "only 64% of India's 846 municipal sewage treatment plants were operational, resulting in a net capacity to process only 37% of the total human waste generated every day in urban India." According to official figures, 62.5% of metropolitan India's wastewater remains untreated or inadequately treated. Water pollution, conservation, recycling, reuse, and recharging are all exacerbated by the country's limited wastewater treatment infrastructure and inadequate operational maintenance.

TABLE 6. COMPARATIVE STATISTICS ON THE INVENTORY OF SEWAGE TREATMENT PLANT FOR THE YEARS 2014 AND 2020

STP Status	Nos. Of STPs (2014)	Capacity (MLD) in 2014	Nos. Of STPs (2020)	Capacity (MLD) in 2020
Operational	522	18883	1093	26869
Actual Utilization	-	-	1093	20235
Compliance	-	-	578	12197
Non-operational	79	1237	102	1406
Under Construction	145	2528	274	3566
Proposed	70	628	162	4827

Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

The issue of river pollution in India is a matter of great concern and responsibility, governed by the constitutional provisions and environmental regulations of the country. The Constitution of India, under the seventh schedule (Article 246), designates 'Water' as a State subject. Consequently, it is the responsibility of the individual States and Union Territories (UTs) to ensure the cleanliness and development of rivers within their respective jurisdictions. This distribution of authority underscores the federal nature of India's governance, where States play a pivotal role in managing their water resources.

Cleaning rivers is an ongoing and multifaceted process, necessitating collaborative efforts between the Central Government and State/UT Governments. The Government of India, recognizing the gravity of the situation, supplements the endeavors of the State/UT

Governments in addressing the challenges posed by river pollution. This support takes the form of financial and technical assistance. Financial assistance is extended to the State/UT Governments for pollution abatement in identified stretches of various rivers. This initiative falls under the Centrally Sponsored Scheme of the National River Conservation Plan (NRCP). The financing is based on a cost-sharing arrangement between the Central and State/UT Governments. The primary objective is to undertake pollution abatement works comprehensively. These works encompass a range of activities, including:

- **Interception & Diversion of Raw Sewage:** One of the critical components of pollution control is preventing raw sewage from directly entering rivers. Intercepting and diverting sewage away from water bodies is a fundamental step.
- **Construction of Sewerage Systems:** Developing an efficient sewerage system is essential for the proper collection and disposal of sewage.
- **Sewage Treatment Plants (STPs):** The establishment of STPs is crucial for treating sewage before it is released into rivers or water bodies. These plants significantly reduce the pollution load.
- **Low-Cost Sanitation:** Promoting low-cost sanitation facilities is an integral part of pollution abatement efforts.
- **River Front/Bathing Ghat Development:** Enhancing riverfront areas and bathing ghats not only improves the aesthetics but also contributes to the overall cleanliness of the rivers.

TABLE 7. TECHNOLOGICAL DISTRIBUTION WITH RESPECT TO NUMBER AND CAPACITY OF STP'S

Technology	Capacity in MLD	Number of STP's
ASP	9486	321
EA	474	30
SBR	10638	490
MBBR	2032	201
FAB	242	21
UASB	3562	76
WSP	789	67
OP	460	61
Any Other	8497	364

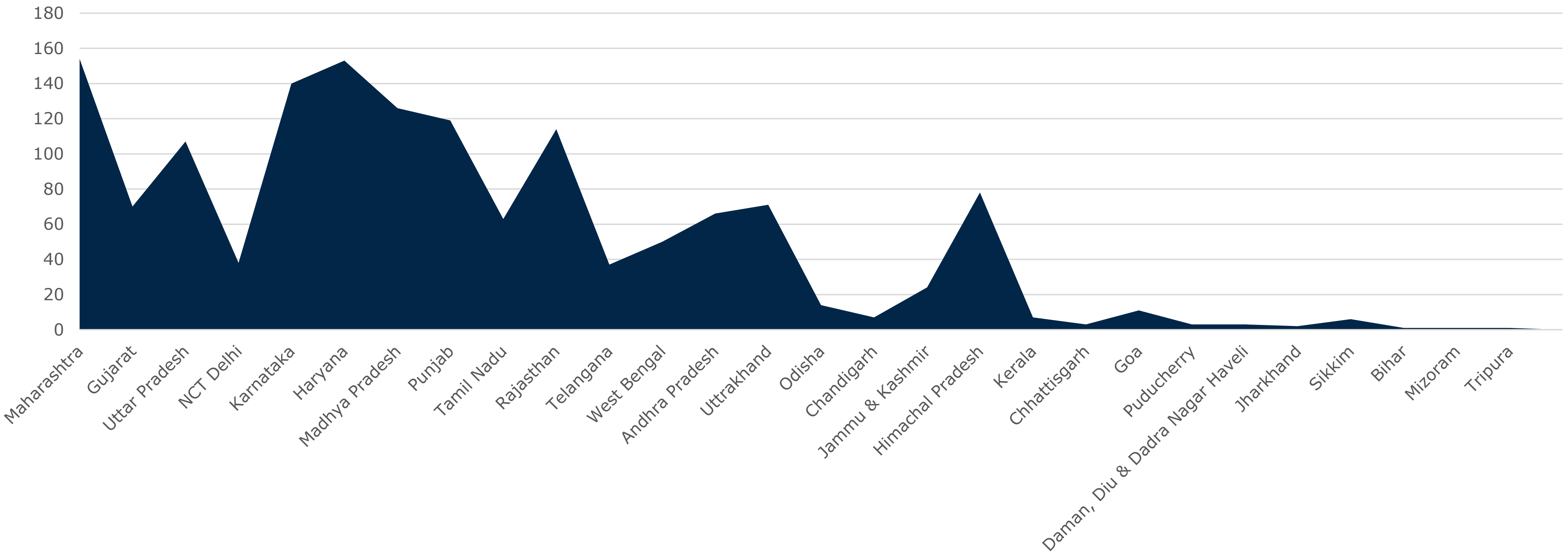
Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

The **National River Conservation Plan** (NRCP) has made significant strides in its mission to clean and conserve rivers. It has covered polluted stretches in 36 rivers across 80 towns in 16 different States. The total project cost sanctioned under NRCP stands at a substantial Rs. 6248.16 crore, with a budget of Rs 56,511 lakhs for FY2024-25. One of the key achievements is the creation of sewage treatment capacity, amounting to 2745.7 million liters per day (MLD). This substantial increase in treatment capacity has led to a considerable reduction in the pollution load discharged into various rivers. While NRCP focuses on multiple rivers, the Namami Gange program is dedicated exclusively to the rejuvenation and conservation of the Ganga River and its tributaries. Under this program, 406 projects have been sanctioned, with 176 of them dedicated to sewage treatment, capable of treating 5270 MLD of sewage. Additionally, a sewer network spanning 5214 km has been approved. These initiatives represent a significant financial commitment, amounting to Rs. 32898 Crores. The impact is evident in the creation of sewage treatment capacity, which now stands at 1858 MLD. Efforts to combat river pollution extend beyond NRCP and Namami Gange. Programs like the Atal Mission for Rejuvenation & Urban Transformation (AMRUT) and the Smart Cities Mission, led by the Ministry of Housing & Urban Affairs, also contribute to sewerage infrastructure development. These programs are designed to transform urban areas and improve the living standards of the populace, which includes addressing sanitation and sewage management.

To ensure that industrial units and local bodies adhere to environmental standards, India has enacted two critical pieces of legislation: the Environment (Protection) Act, 1986, and the Water (Prevention & Control of Pollution) Act, 1974. These acts mandate the installation of effluent treatment plants (ETPs) or common effluent treatment plants (CETPs) by industrial units and local bodies. They must treat their effluent and sewage to comply with stipulated environmental standards before discharge into rivers and water bodies. The Central Pollution Control Board (CPCB), State Pollution Control Boards (SPCBs), and Pollution Control Committees (PCCs) are tasked with enforcing compliance under the provisions of these acts. Punitive actions are taken against those who fail to adhere to the prescribed norms. In addition to regulatory measures, industries are encouraged to adopt sustainable practices to reduce wastewater generation. Technological advancements play a pivotal role in this regard. Reusing and recycling wastewater are promoted as effective strategies to minimize environmental impact. Moreover, the concept of Zero Liquid Discharge (ZLD) is advocated wherever possible. ZLD involves treating wastewater to the extent that no liquid discharge is released into the environment, ensuring minimal ecological harm.

The issue of river pollution in India is a multifaceted challenge that requires concerted efforts from various stakeholders. The constitutional provisions assign the responsibility of managing rivers to State and UT governments, with the central government offering crucial financial and technical support. The **National River Conservation Plan (NRCP) and Namami Gange program** have made substantial progress in cleaning and conserving rivers, with a significant increase in sewage treatment capacity. Additionally, other urban development programs contribute to sewerage infrastructure development. Stringent environmental regulations, backed by punitive actions, ensure compliance with pollution control norms by industrial units and local bodies. Encouraging sustainable practices, such as wastewater reuse and Zero Liquid Discharge, are pivotal in reducing the environmental footprint.

FIGURE 26. STATE-WISE INSTALLED STP'S

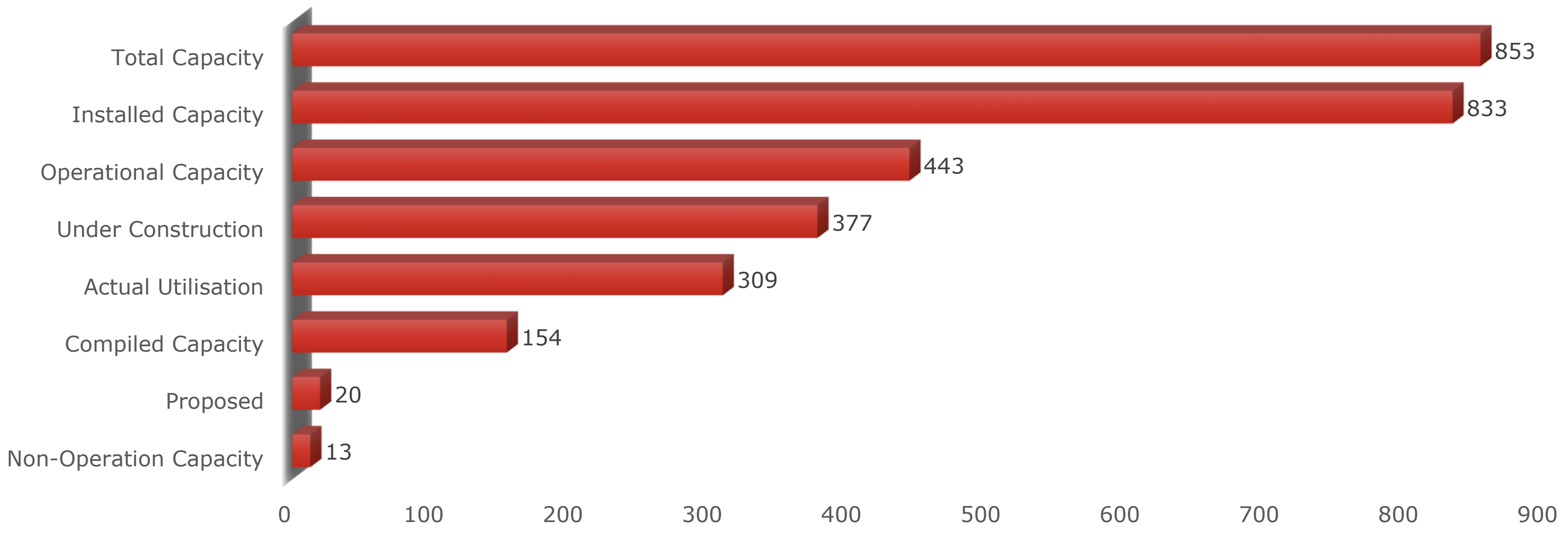


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.1. ANDHRA PRADESH

- The estimated sewage generating capacity for the state of Andhra Pradesh is 2882 MLD, with a total capacity (including projected capacity) of 853.05 MLD (67 STPs).
- The installed capacity is 833 MLD (39.61%) of the sewage generating capacity of 2882 MLD. It reveals a treatment capacity shortfall of 2049 MLD (71.09%).
- The operationalized capacity is 443 MLD (53.18%) of the 833 MLD installed capacity developed. Actual used capacity is 309 MLD, although compliant STP capacity is only 154 MLD.
- In comparison to natural treatment systems, STPs based on ASP and MBBR technologies predominate. STPs based on natural treatment systems, on the other hand, exhibit greater than 50% compliance with stipulated requirements.

FIGURE 27. SEWAGE TREATMENT CAPACITY (MLD) – ANDHRA PRADESH

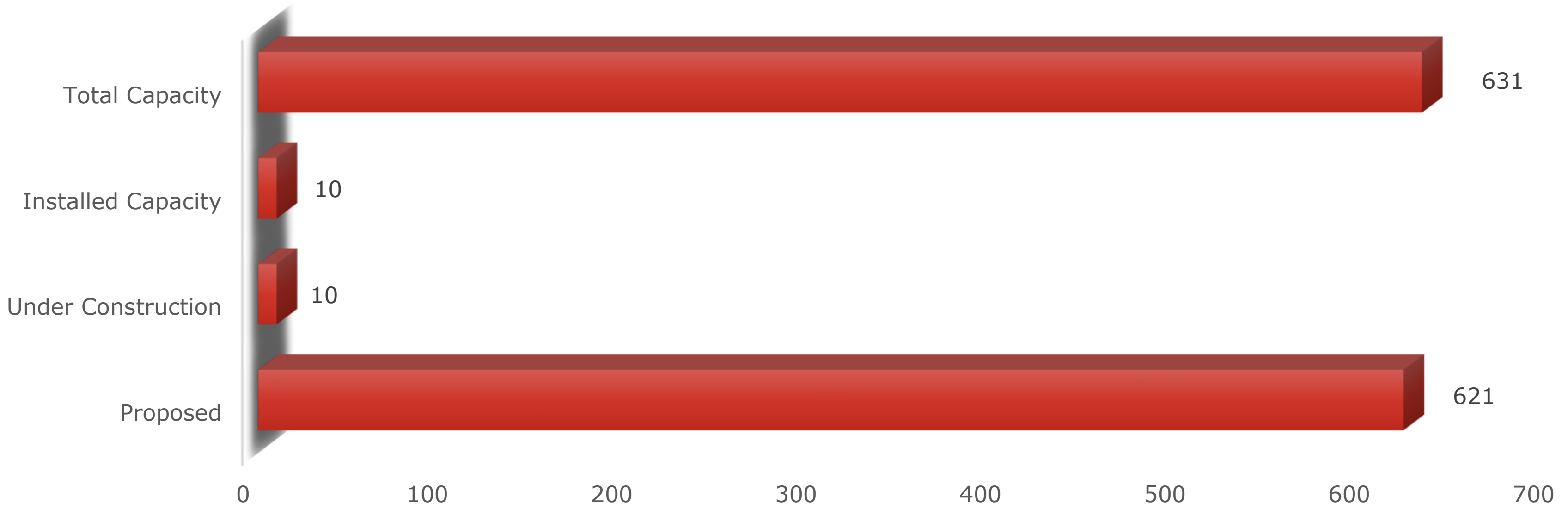


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.2. BIHAR

- The estimated sewage generation in Bihar is 2276 MLD, with a total capacity (including projected) of 631 MLD (25 STPs).
- The installed capacity is just 10 MLD (0.43%), compared to the sewage production of 2276 MLD.
- It reveals a treatment capacity shortfall of 2266 MLD (99.56%). The remaining treatment capacity is either in the planned or building stages.
- The operationalized capacity of the 10 MLD installed capacity is zero.

FIGURE 28. SEWAGE TREATMENT CAPACITY (MLD) – BIHAR

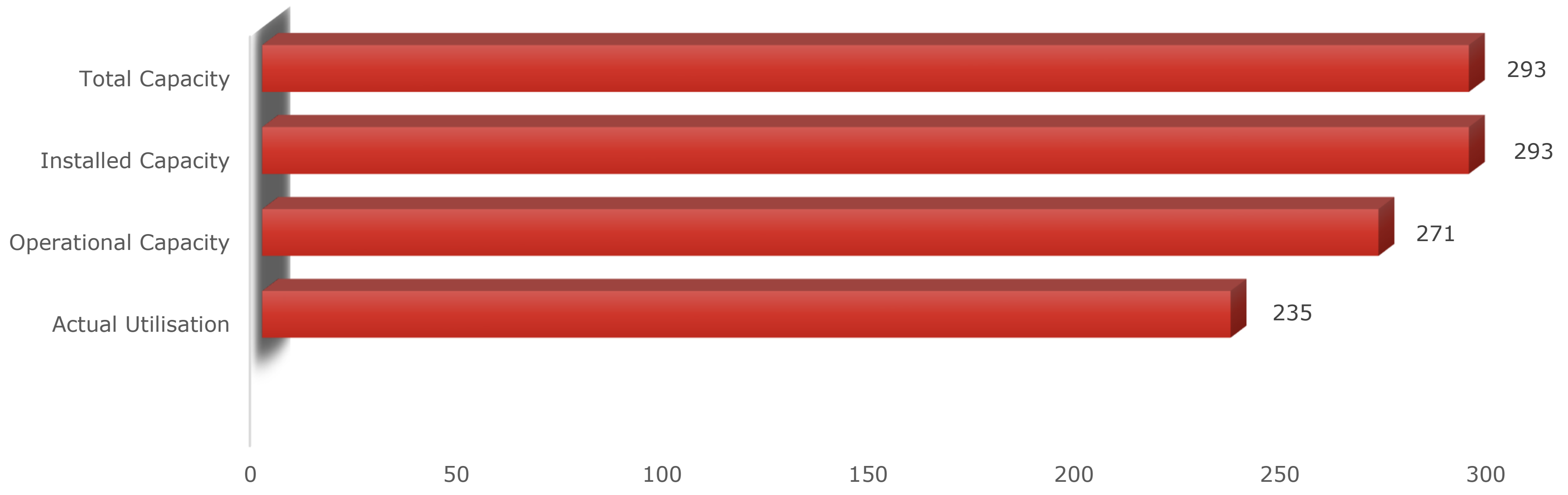


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.3. CHANDIGARH

- The estimated sewage generating capacity for the union territory of Chandigarh is 188 MLD, with a total capacity (including projected capacity) of 293 MLD (07 STPs).
- The installed capacity is 293 MLD, with a sewage generating capacity of 188 MLD. It demonstrates A total of 105 MLD of treatment capacity is available.
- The operationalized capacity is 271 MLD, out of 293 MLD of installed capacity created. (92.49%).
- The actual usable capacity is 235 MLD (86.72%) of the operating capacity of 271 MLD.

FIGURE 29. SEWAGE TREATMENT CAPACITY (MLD) – CHANDIGARH

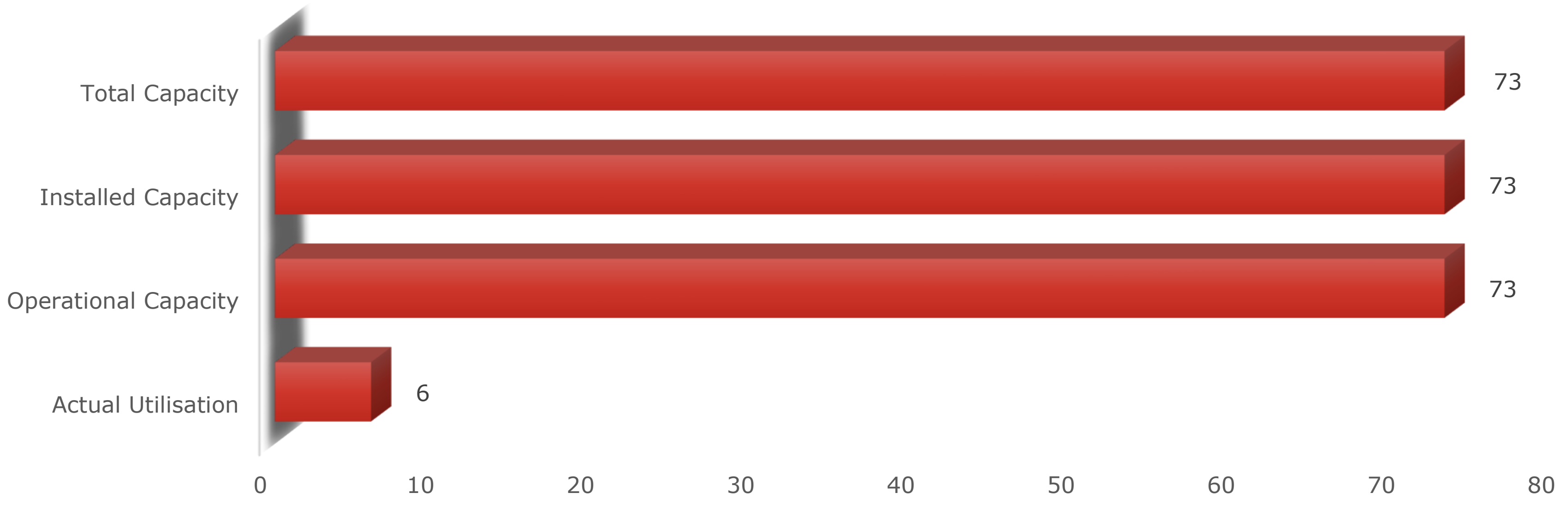


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.4. CHHATTISGARH

- The estimated sewage generation in Chhattisgarh is 1203 MLD, with a total capacity (including projected) of 73 MLD (03 STPs).
- The installed capacity is 73 MLD, with a sewage generating capacity of 1203 MLD. It reveals a treatment capacity shortfall of 1130 MLD (93.93%).
- The operationalized capacity is 73 MLD (100% of the installed capacity of 73 MLD). The actual usable capacity is 06 MLD out of a total operating capacity of 73 MLD.
- throughout comparison to natural treatment systems, STPs based on ASP technology predominate throughout the state.

FIGURE 30. SEWAGE TREATMENT CAPACITY (MLD) – CHHATTISGARH

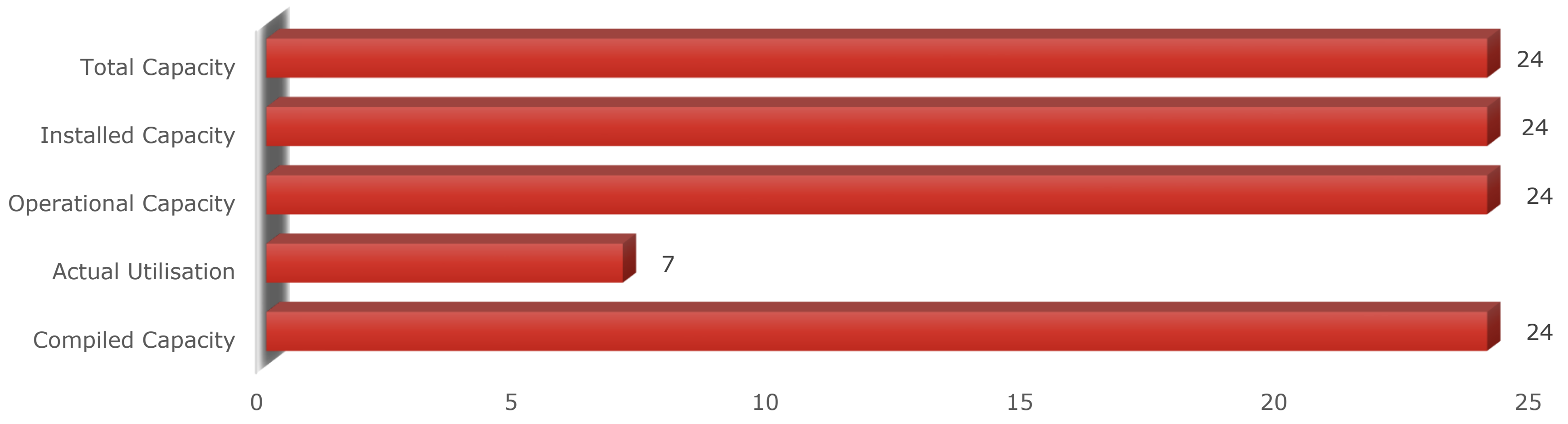


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.5. DAMAN DIU & DADRA NAGAR HAVELI

- Sewage generation in the union territory of Daman Diu and Dadra Nagar Haveli is estimated to be 67 MLD, with a total capacity of 24 MLD (03 STPs).
- The installed capacity is 24 MLD (35.82%), whereas sewage production is 67 MLD. It reveals a treatment capacity shortfall of 43 MLD (64.17%).
- Because all of the STPs are operating, the operational capacity is also 24 MLD. However, actual usable capacity is just 07 MLD of the operating capacity of 24 MLD.

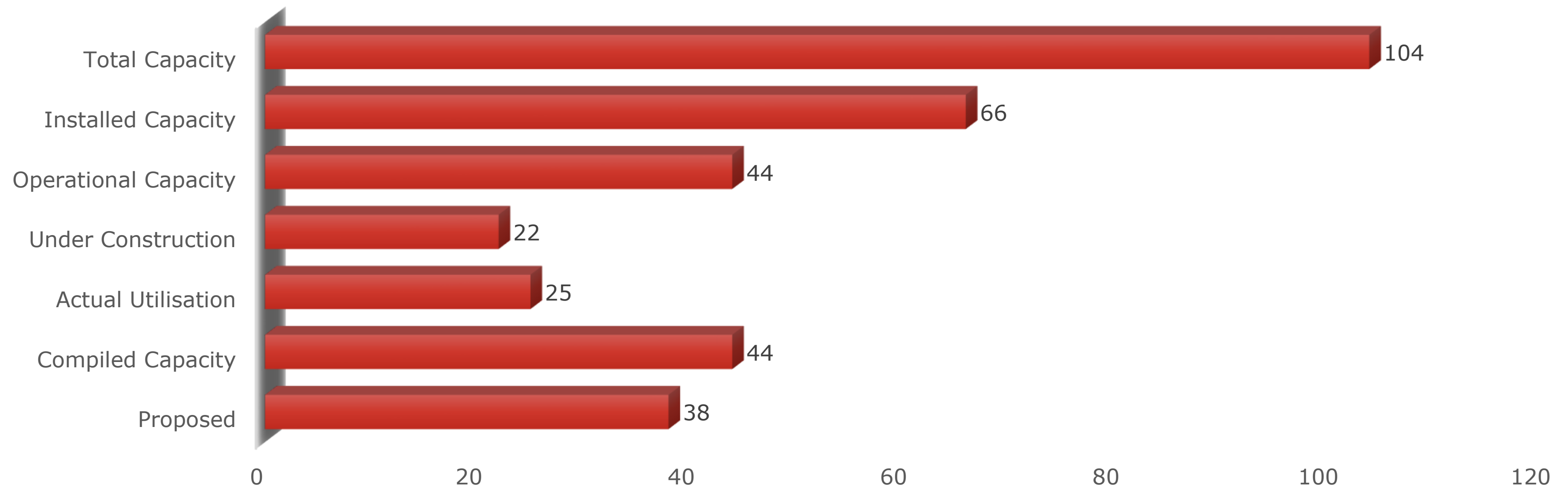
FIGURE 31. SEWAGE TREATMENT CAPACITY (MLD) – DAMAN DIU & DADRA NAGAR HAVELI



6.5.1.6. GOA

- The estimated sewage generating capacity for the state of Goa is 176 MLD, with a total capacity (including projected capacity) of 104 MLD (14 STPs).
- The installed capacity is 66 MLD (25%) of the sewage generating capacity of 176 MLD. It demonstrates a 110 MLD (62.5%) treatment capacity shortfall. The operationalized capacity is 44 MLD (66.67%) of the 66 MLD installed capacity developed.
- The actual used capacity is 25 MLD out of the 44 MLD operational capacity, and all STPs are in compliance with standards.

FIGURE 32. SEWAGE TREATMENT CAPACITY (MLD) – GOA

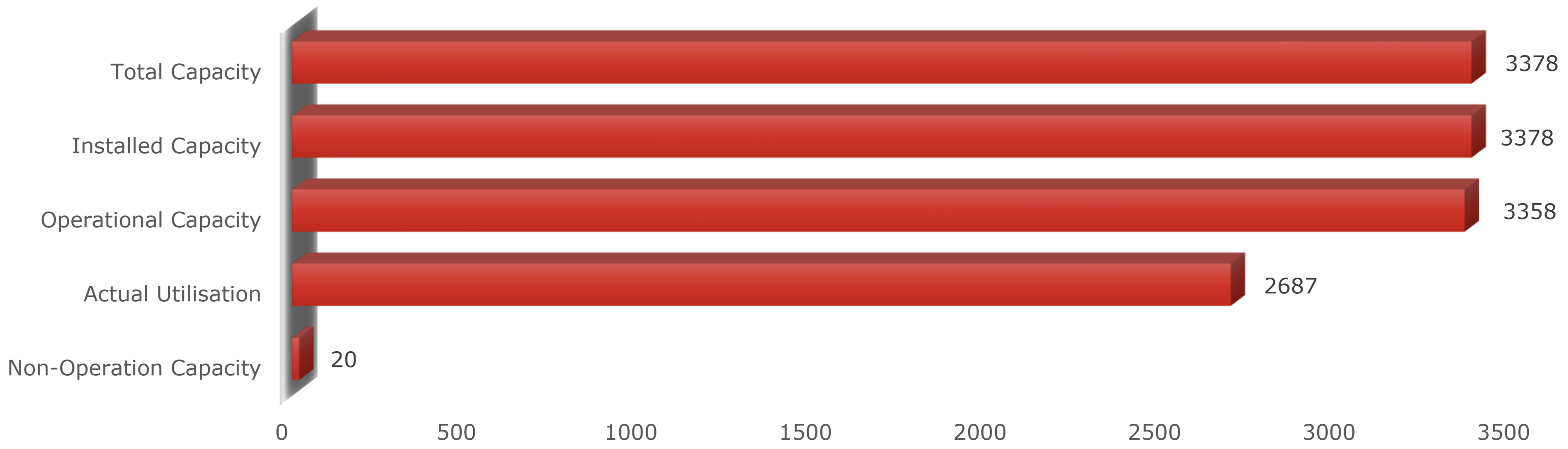


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.7. GUJARAT

- The estimated sewage generation for Gujarat is 5,013 MLD, with a total capacity (including projected) of 3,378 MLD (70 STPs).
- The installed capacity is 3,378 MLD (67.38%) of the sewage generating capacity of 5,013 MLD. It reveals that there is a treatment capacity shortfall of 1635 MLD (32.61%).
- The operational capacity is 3358 MLD (99.40%) of the installed capacity of 3378 MLD. The actual usable capacity is 2,687 MLD out of a total operating capacity of 3,358 MLD.
- In comparison to natural treatment systems, STPs based on SBR and ASP technology predominate.

FIGURE 33. SEWAGE TREATMENT CAPACITY (MLD) – GUJARAT

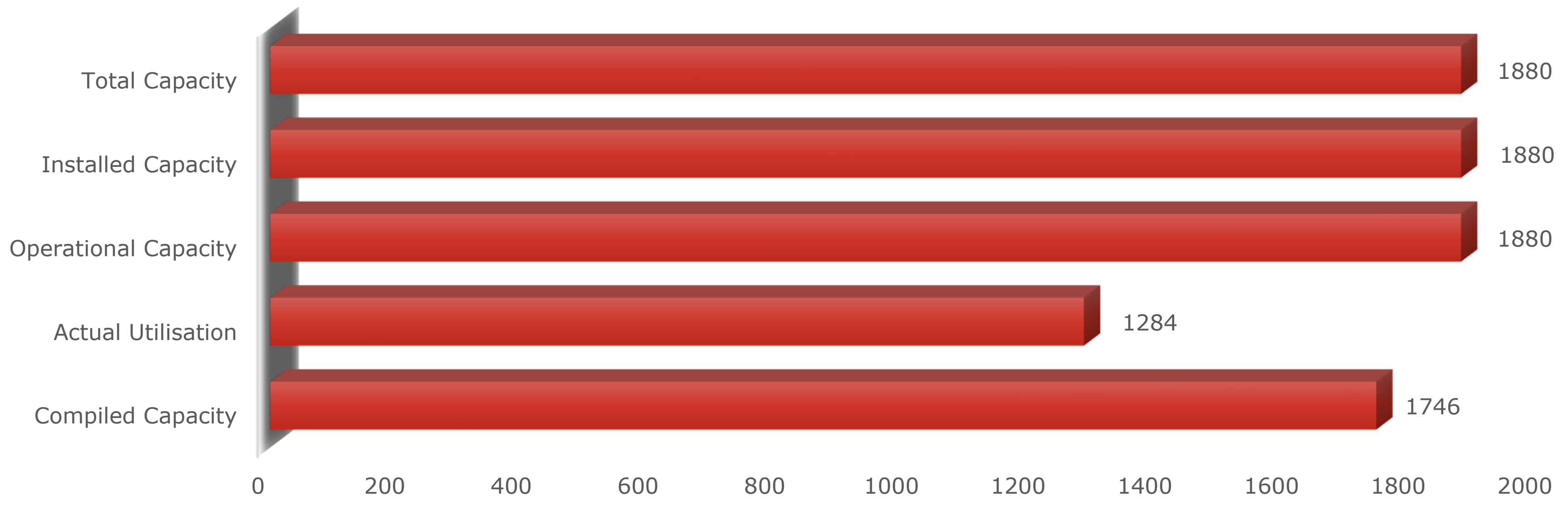


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.8. HARYANA

- Haryana's estimated sewage generation is 1816 MLD, while total treatment capacity (including projected) is 1880 MLD (153 STPs).
- The installed treatment capacity is 1880 MLD, with a sewage generating capacity of 1816 MLD. It demonstrates that the treatment capacity exceeds 64 MLD.
- All STPs are capable of operating at maximum capacity. However, real usable capacity is just 1284 MLD, and compliance STP capacity is only 1746 MLD. Haryana is dominated by STPs based on SBR and MBBR technology.

FIGURE 34. SEWAGE TREATMENT CAPACITY (MLD) – HARYANA

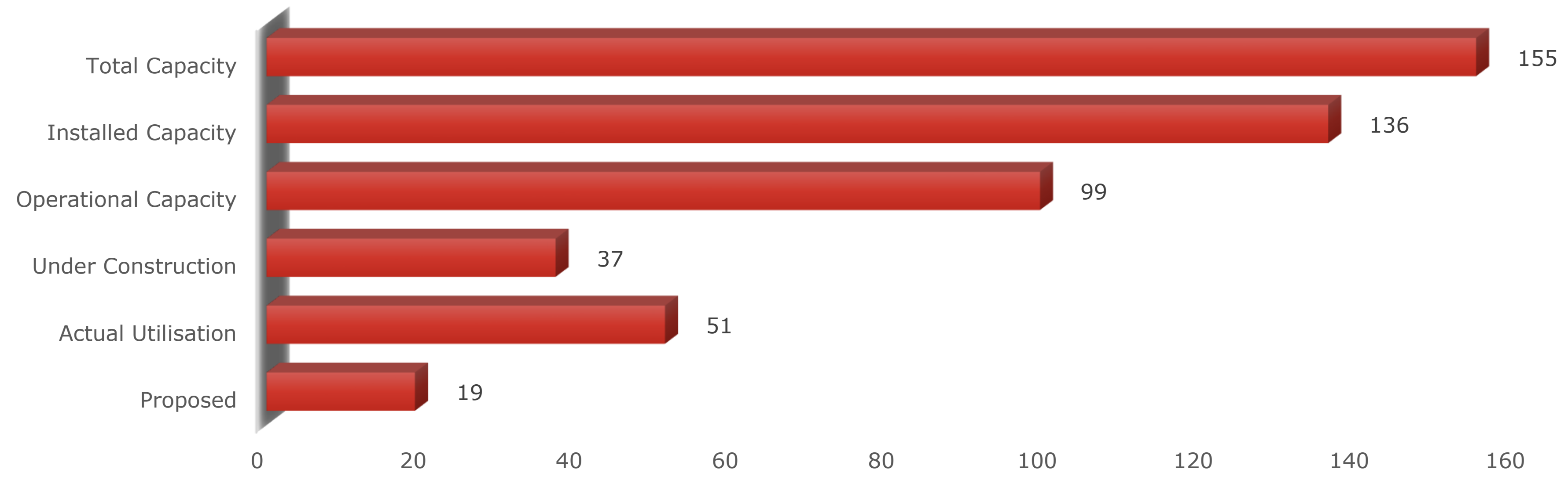


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.9. HIMACHAL PRADESH

- Himachal Pradesh's estimated sewage generation is 116 MLD, with a total capacity (including projected) of 155 MLD (86 STPs).
- The installed capacity is 136 MLD, with a sewage generating capacity of 116 MLD. It demonstrates that the treatment capacity exceeds 20 MLD.
- The operationalized capacity is 99 MLD (72.79%) of the 136 MLD installed capacity created, however the actual used capacity is just 51 MLD.

FIGURE 35. SEWAGE TREATMENT CAPACITY (MLD) – HIMACHAL PRADESH

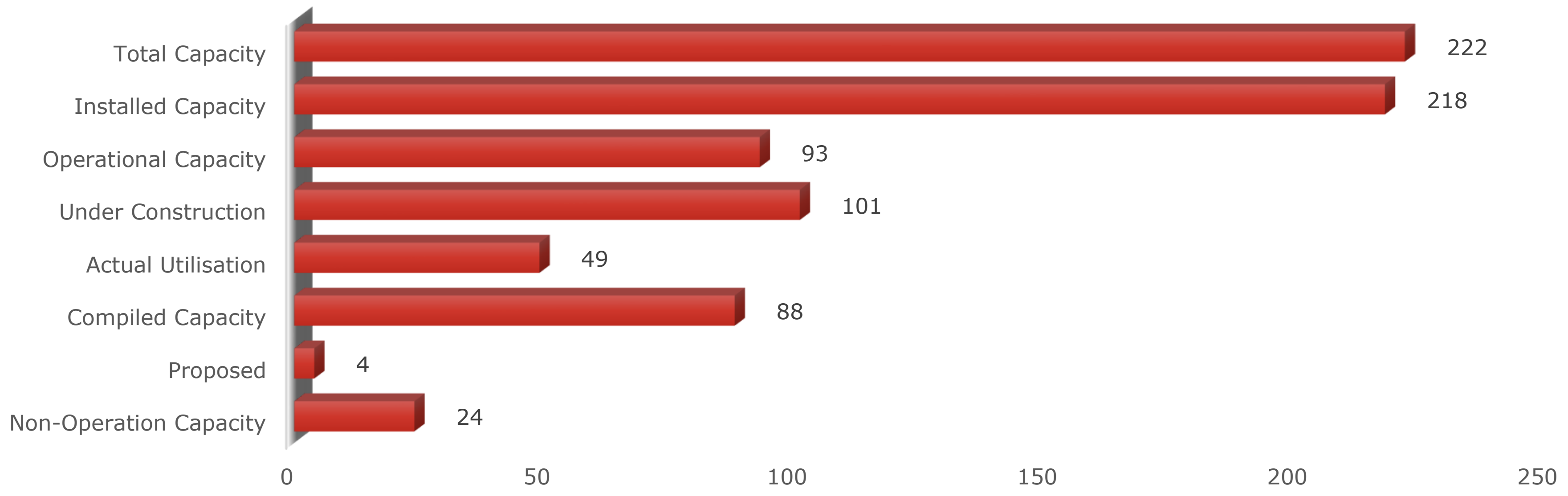


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.10. JAMMU & KASHMIR

- The estimated sewage generating capacity for the state of Jammu and Kashmir is 665 MLD, with a total capacity (including projected capacity) of 222 MLD (26 STPs).
- The installed capacity is 218 MLD (32.78%), with a sewage generating capacity of 665 MLD. It reveals a treatment capacity shortfall of 447 MLD (67.21%).
- The operationalized capacity is 93 MLD (42.66%) of the 218 MLD installed capacity developed. The actual used capacity is 49 MLD, while the capacity of the combined STPs is only 88 MLD.

FIGURE 36. SEWAGE TREATMENT CAPACITY (MLD) – JAMMU & KASHMIR

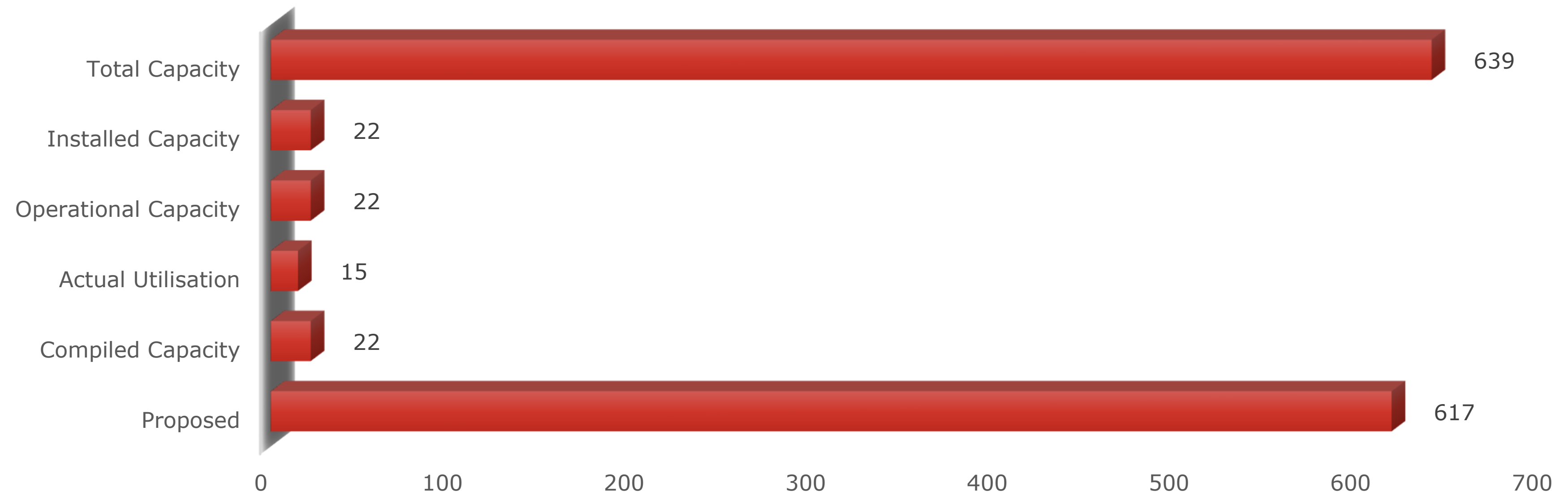


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.11. JHARKHAND

- Jharkhand's estimated sewage generation is 1510 MLD, with a total capacity (including projected) of 639 MLD (12 STPs).
- The installed capacity is 22 MLD (1.45%) of the sewage generating capacity of 1510 MLD. It demonstrates that there is a treatment capacity shortfall of 1488 MLD (98.55%).
- Installed STPs can run at full capacity. However, the actual utilized capacity is just 15 MLD, which meets the agreed-upon standards.

FIGURE 37. SEWAGE TREATMENT CAPACITY (MLD) – JHARKHAND



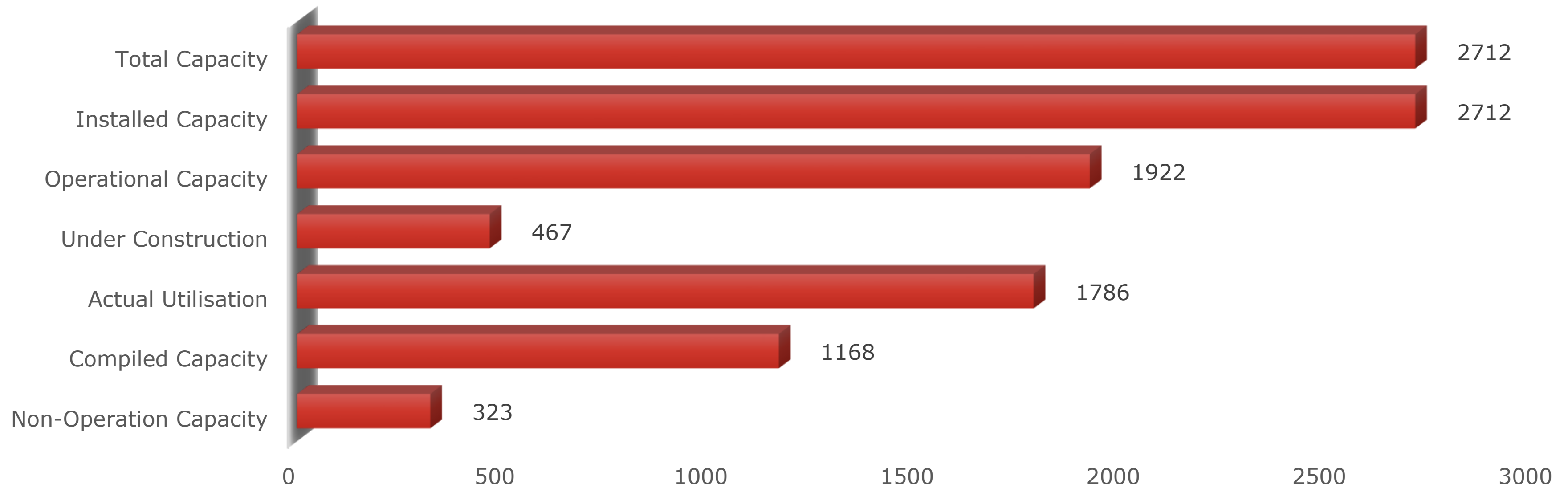
Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.12. KARNATAKA

- The estimated sewage generating capacity for the state of Karnataka is 4,458 MLD, with a total capacity (including projected capacity) of 2,712 MLD (140 STPs).
- In comparison to sewage generation of 4,458 MLD, installed capacity is 2,712 MLD (60.83%). It reveals a treatment capacity shortfall of 1,746 MLD (39.17%). The operational capacity is 1922 MLD (70.87%) of the installed capacity of 2,712 MLD.

- The actual used capacity is 1786 MLD (92.92%), with compliant STPs having a capacity of just 1168 MLD. STPs based on SBR, OP, and ASP technologies are the most common.

FIGURE 38. SEWAGE TREATMENT CAPACITY (MLD) – KARNATAKA

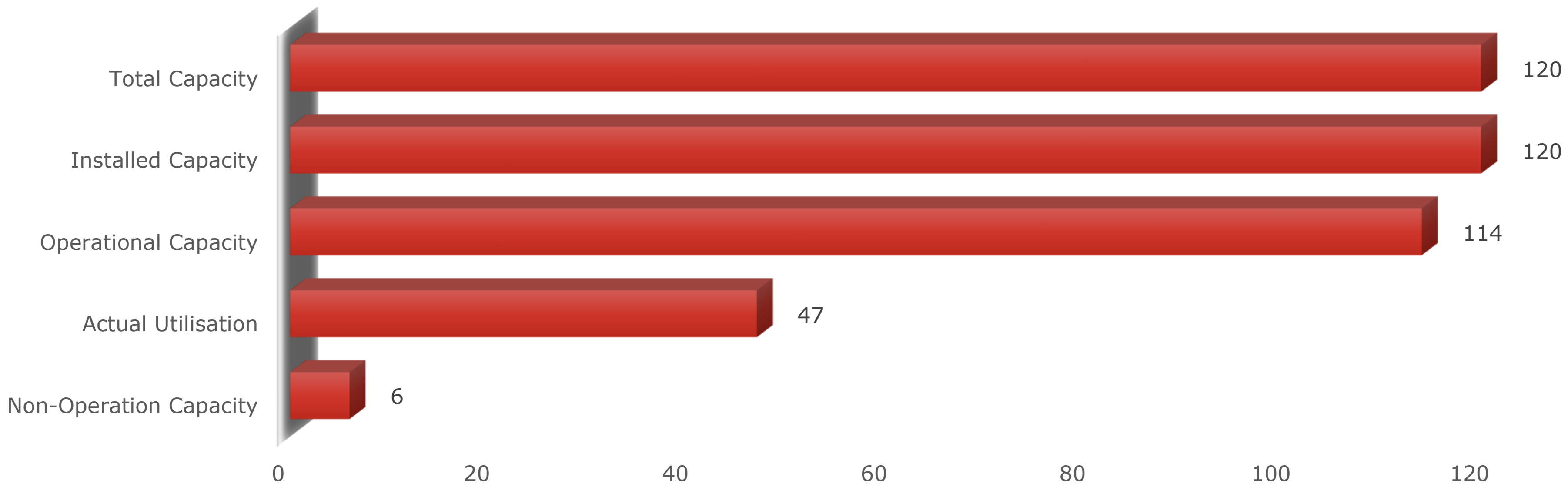


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.13. KERALA

- Kerala's estimated sewage generation is 4,256 MLD, with a total capacity (including projected) of 120 MLD (07 STPs).
- The installed capacity is 120 MLD (2.82%), with a sewage generating capacity of 4,256 MLD. It reveals that there is a treatment capacity shortfall of 4136 MLD (97.18%).
- The operationalized capacity of the 120 MLD installed capacity is 114 MLD (95%) and the actual used capacity is just 47 MLD.

FIGURE 39. SEWAGE TREATMENT CAPACITY (MLD) – KERALA



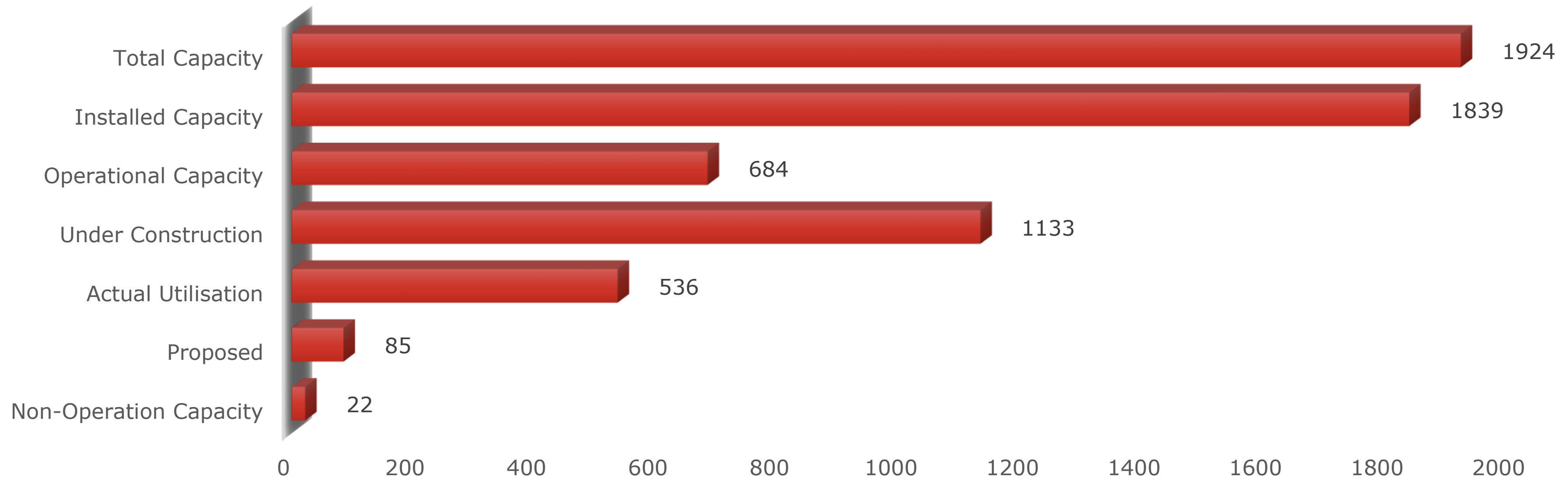
Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.14. MADHYA PRADESH

- Madhya Pradesh's estimated sewage generation is 3,646 MLD, with a total capacity (including projected) of 1,924 MLD (142 STPs).
- The installed capacity is 1,839 MLD (50.44%) of the total sewage generating capacity of 3,646 MLD. It reveals a treatment capacity shortfall of 1,807 MLD (49.56%).
- The operationalized capacity is 684 MLD (37.19%) of the 1839 MLD installed capacity created, while the actual used capacity is 536 MLD.

- MPPCB makes no mention of STP technology in relation to the 123 STPs. The remaining STPs are mostly based on SBR and WSP technology.

FIGURE 40. SEWAGE TREATMENT CAPACITY (MLD) – MADHYA PRADESH

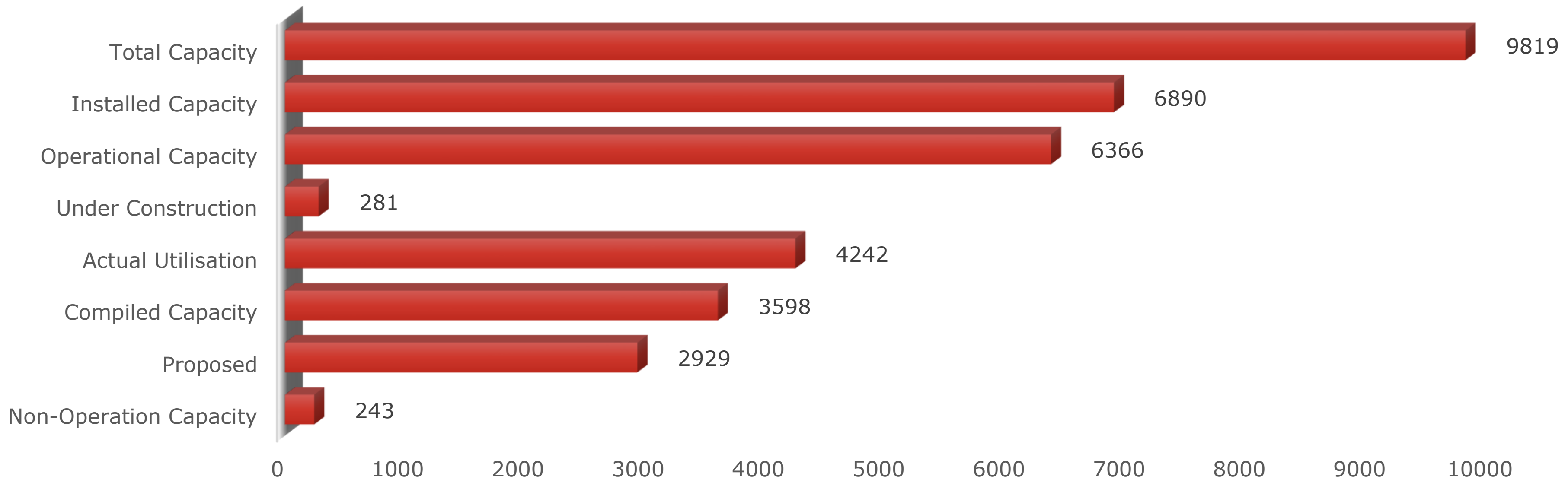


6.5.1.15. MAHARASHTRA

- The estimated sewage generating capacity for Maharashtra is 9,107 MLD, with a total capacity (including projected capacity) of 9,819 MLD (195 STPs).
- The installed capacity is 6,890 MLD (75.65%) of the sewage generating capacity of 9,107 MLD. It reveals a treatment capacity shortfall of 2217 MLD (24.35%).

- The operationalized capacity is 6,366 MLD (92.39%) of the 6,890 MLD of installed capacity created, while the actual used capacity is 4,242 MLD. Furthermore, the combined capacity of STPs is just 3598 MLD.

FIGURE 41. SEWAGE TREATMENT CAPACITY (MLD) – MAHARASHTRA

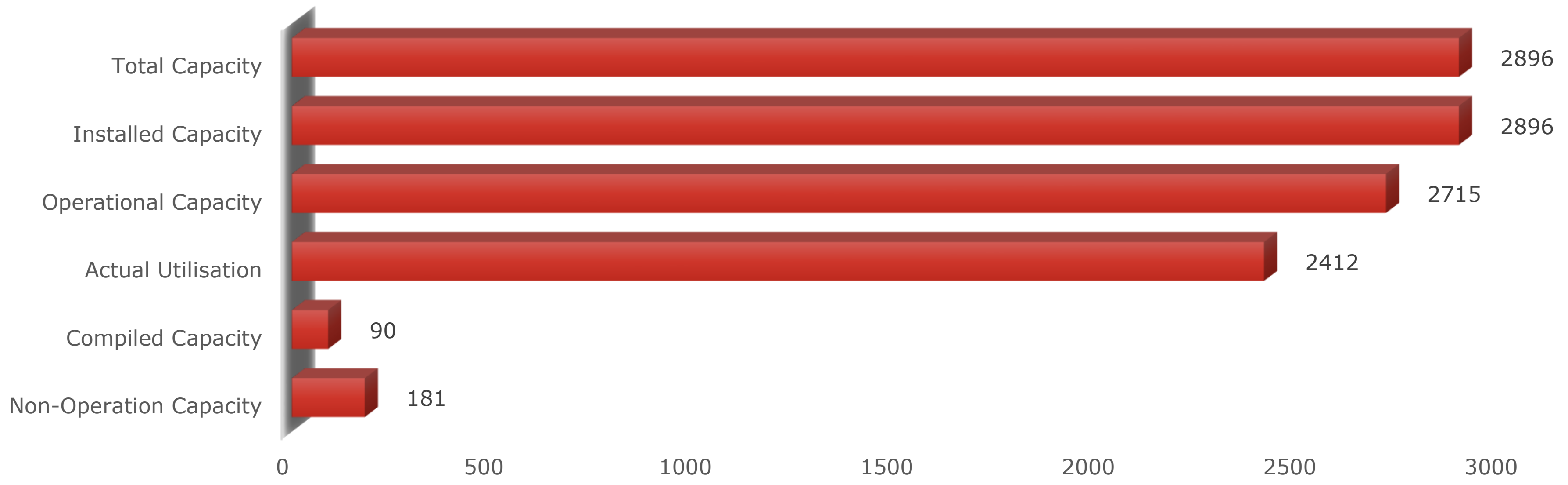


6.5.1.16. NCT DELHI

- The estimated sewage generation for NCT Delhi is 3,330 MLD, with a total treatment capacity of 2,896 MLD (38 STPs).
- The installed capacity is 2,896 MLD (86.96%) of the sewage generating capacity of 3330 MLD. It reveals a 434 MLD (13.04%) shortfall in treatment capacity.

- Out of the total installed capacity of 2,896 MLD, the operationalized capacity is 2715 MLD (35 STPs) (93.75%), the actual utilized capacity is 2412 MLD, and the additional capacity of complied STPs is only 90 MLD.

FIGURE 42. SEWAGE TREATMENT CAPACITY (MLD) – NCT DELHI

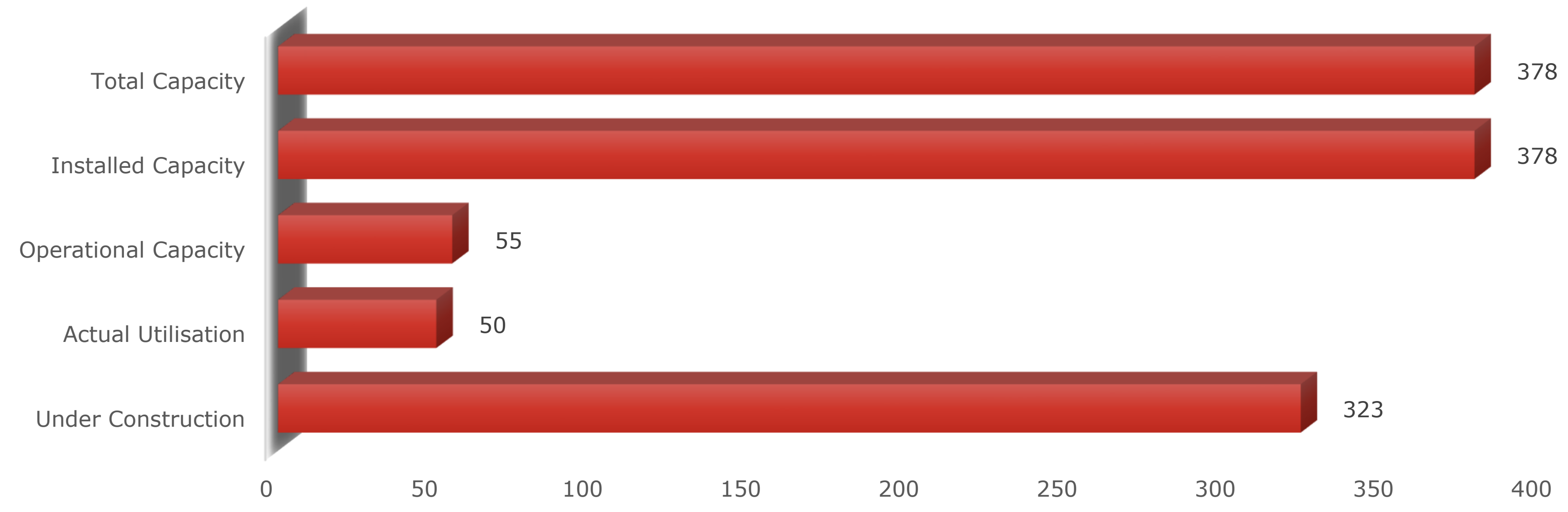


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.17. ODISHA

- Odisha's estimated sewage generation is 1,282 MLD, with a total treatment capacity of 378 MLD (14 STPs).
- The installed capacity is 378 MLD (29.48%), with a sewage generating capacity of 1,282 MLD. It reveals a treatment capacity shortfall of 904 MLD (70.51%).
- The operationalized capacity is 55 MLD (14.55% of the total installed capacity) while the actual used capacity is just 50 MLD.

FIGURE 43. SEWAGE TREATMENT CAPACITY (MLD) – ODISHA

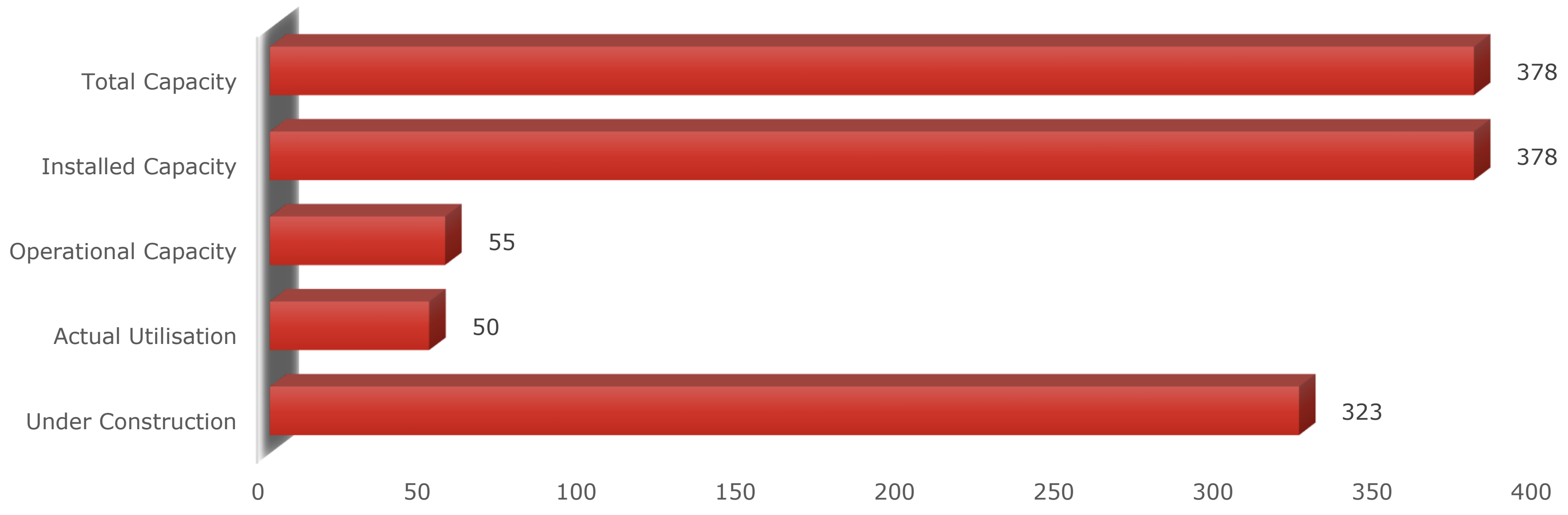


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.18. PUDUCHERRY

- The state of Puducherry's estimated sewage generation is 161 MLD, and total treatment capacity (including projected) is 59 MLD (04 STPs).
- The installed capacity is 56 MLD (34.79%), with a sewage generating capacity of 161 MLD. It reveals a treatment capacity shortfall of 105 MLD (65.21%).
- All of the STPs installed can function at maximum capacity, however the actual utilized capacity is just 30 MLD.

FIGURE 44. SEWAGE TREATMENT CAPACITY (MLD) – PUDUCHERRY

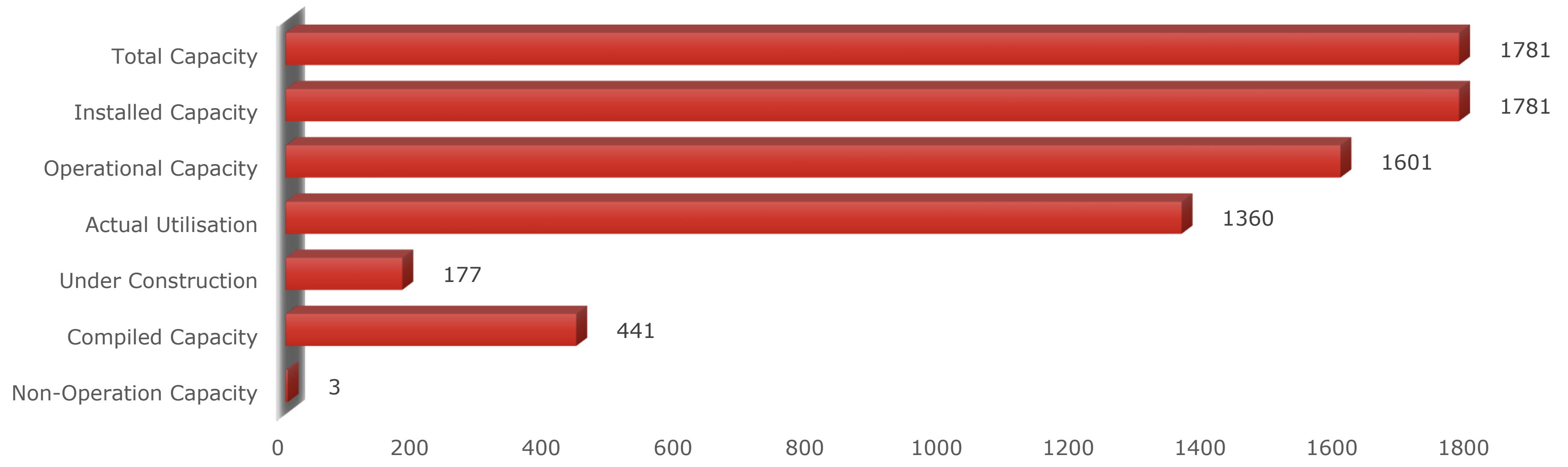


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.19. PUNJAB

- The estimated sewage generation for Punjab is 1,889 MLD, with a total treatment capacity of 1,781 MLD (119 STPs).
- The installed capacity is 1,781 MLD (94.28%), with a sewage generating capacity of 1,889 MLD. It reveals a treatment capacity shortfall of 108 MLD (5.72%).
- The operationalized capacity is 1601 MLD (89.89%) and the actual used capacity is 1,360 MLD (84.94%) of the total installed capacity of 1781 MLD. Furthermore, the combined capacity of the STPs is just 441 MLD.

FIGURE 45. SEWAGE TREATMENT CAPACITY (MLD) – PUNJAB

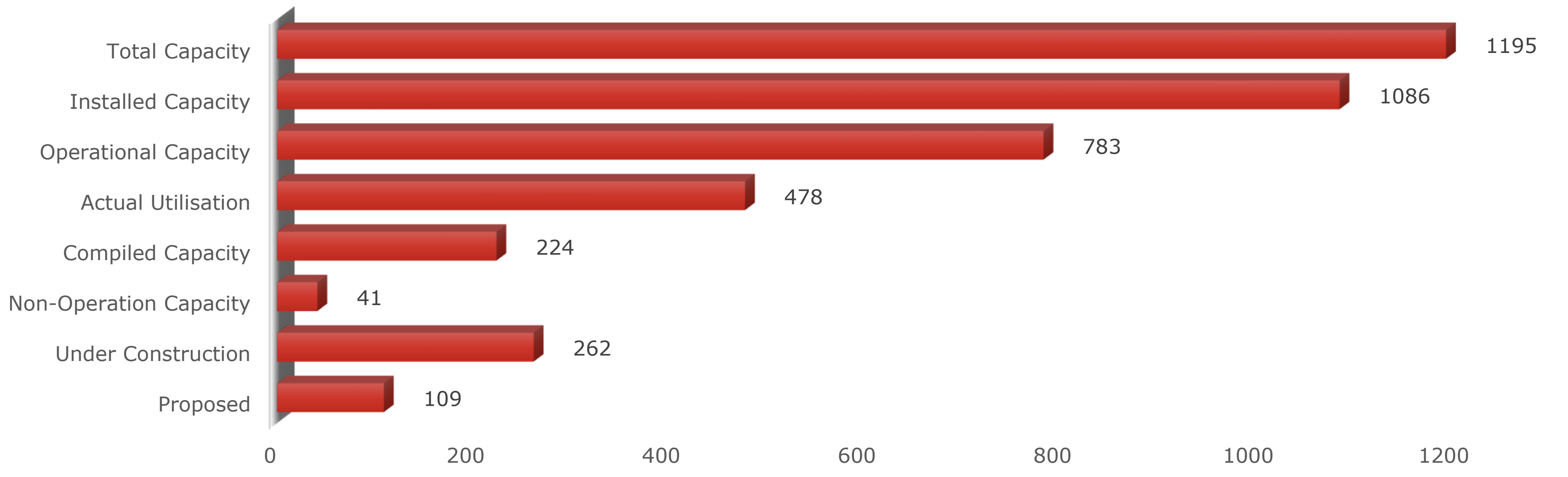


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.20. RAJASTHAN

- Rajasthan's estimated sewage generation is 3,185 MLD, while total treatment capacity (including projected) is 1,195 MLD (140 STPs).
- The installed capacity is 1,086 MLD (34.10%) of the sewage generating capacity of 3,185 MLD. It reveals a treatment capacity shortfall of 2,099 MLD (65.90%).
- The operationalized capacity is 783 MLD (72.09%) of the total installed capacity of 1086 MLD, while the actual used capacity is 478 MLD. Furthermore, the combined capacity of the STPs is just 224 MLD.

FIGURE 46. SEWAGE TREATMENT CAPACITY (MLD) – RAJASTHAN

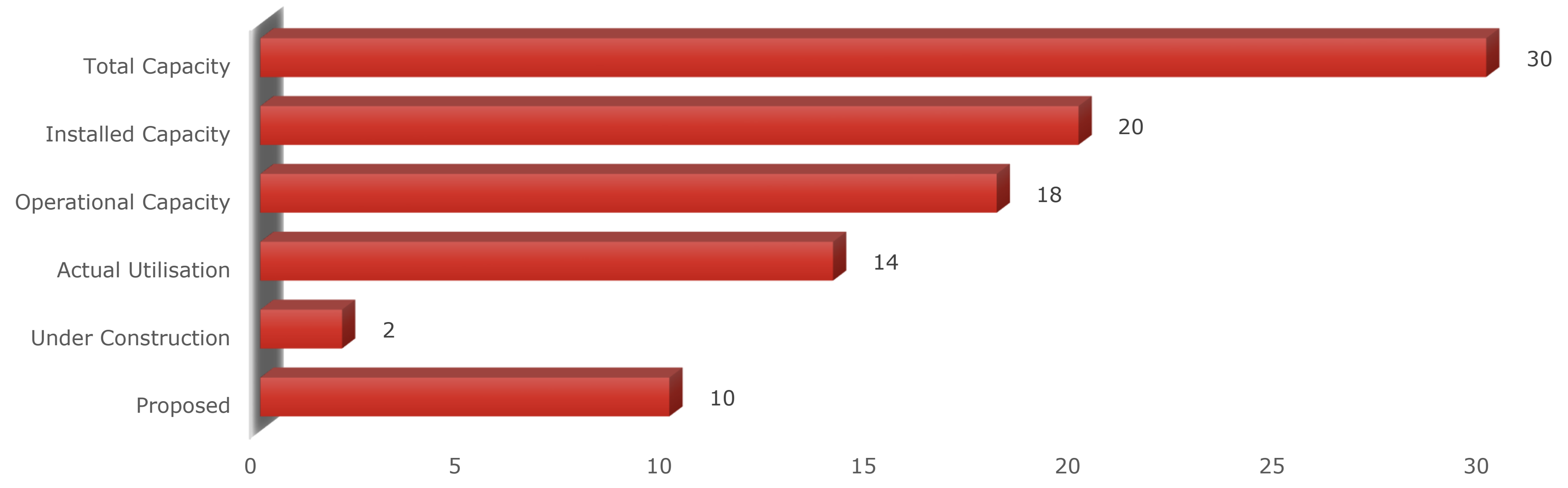


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.21. SIKKIM

- Sikkim's estimated sewage generation is 52 MLD, with a total treatment capacity (including projected) of 30 MLD (11 STPs).
- In comparison to sewage generation of 52 MLD, installed capacity is 20 MLD (38.46%). It reveals a treatment capacity shortfall of 32 MLD (61.54%).
- The operationalized capacity is 18 MLD (90% of the total installed capacity of 20 MLD).
- Similarly, actual used capacity is 14 MLD (77.77%) of operating capacity of 18 MLD.

FIGURE 47. SEWAGE TREATMENT CAPACITY (MLD) – SIKKIM

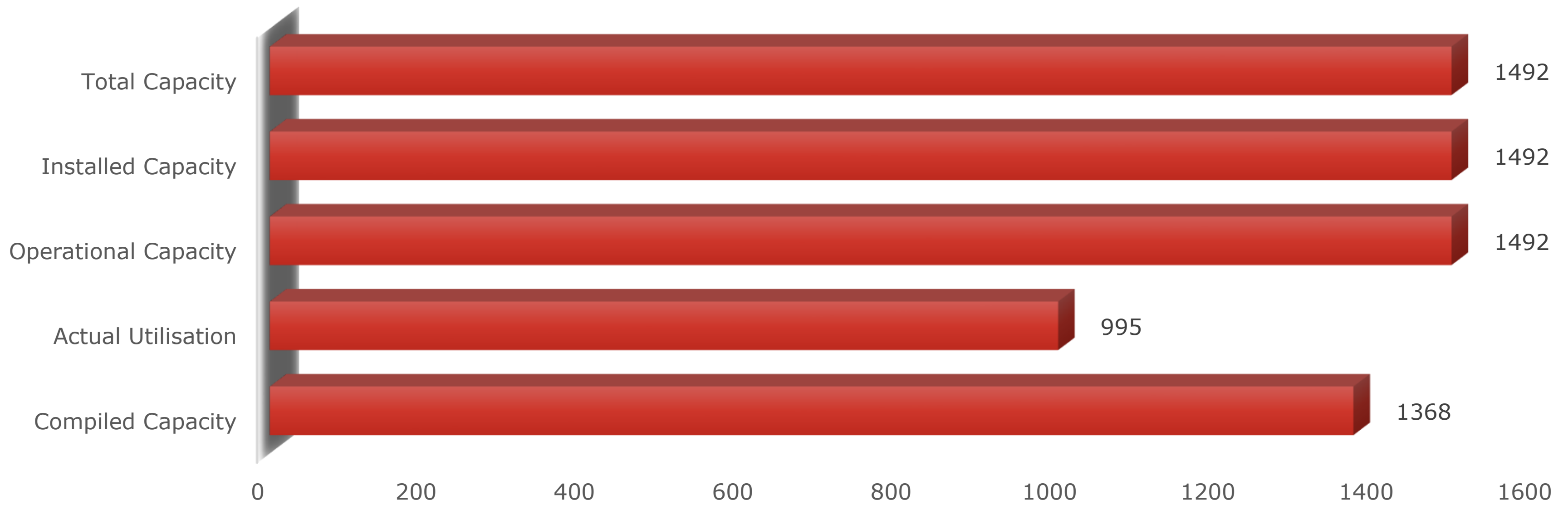


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.22. TAMIL NADU

- The estimated sewage generation for Tamil Nadu is 6,421 MLD, with a total treatment capacity of 1,492 MLD (63 STPs).
- The installed capacity is 1,492 MLD (23.23%), with a sewage generating capacity of 6421 MLD. It reveals a treatment capacity shortfall of 4,929 MLD (76.77%).
- The operationalized capacity is 1,492 MLD (100%) of the installed capacity of 1,492 MLD, while the actual used capacity is 995 MLD. Furthermore, the capacity of STPs that have been approved is just 1,368 MLD.

FIGURE 48. SEWAGE TREATMENT CAPACITY (MLD) – TAMIL NADU

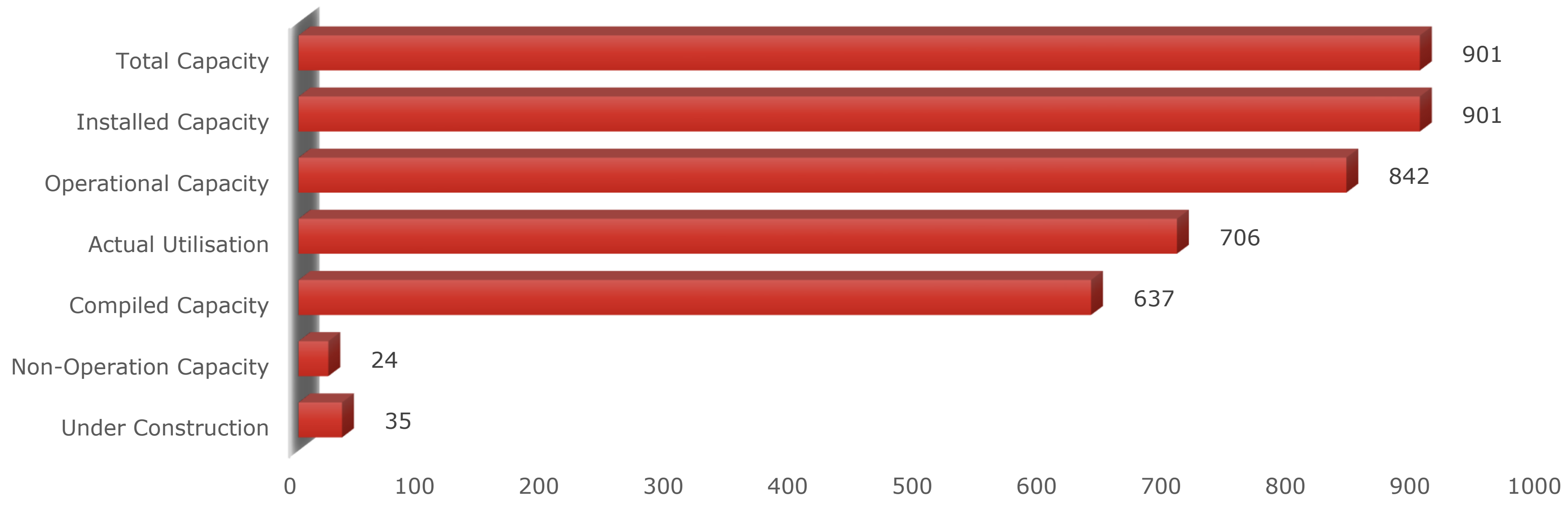


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.23. TELANGANA

- Telangana's estimated sewage generation is 2,660 MLD, while total treatment capacity (including projected) is 901 MLD (37 STPs).
- The installed capacity is 901 MLD (33.87%), with a sewage generating capacity of 2,660 MLD. It reveals a treatment capacity shortfall of 1,759 MLD (66.13%).
- The operationalized capacity is 842 MLD (93.45%) of the installed capacity of 901 MLD, while the actual used capacity is 706 MLD. Furthermore, the combined capacity of STPs is just 637 MLD.

FIGURE 49. SEWAGE TREATMENT CAPACITY (MLD) – TELANGANA

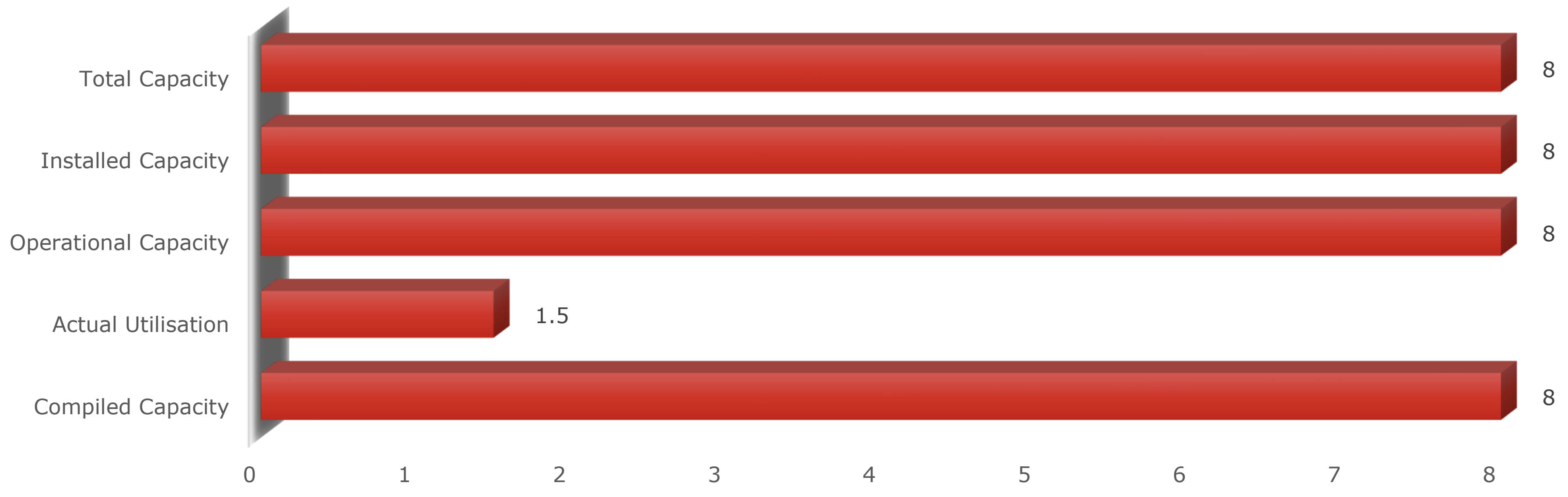


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.24. TRIPURA

- The estimated sewage generating capacity for the state of Tripura is 237 MLD, with a total treatment capacity of just 08 MLD (01 STP).
- According to data analysis, there is only one STP in the state that receives 1.5 MLD of sewage while achieving the agreed-upon standards.

FIGURE 50. SEWAGE TREATMENT CAPACITY (MLD) – TRIPURA

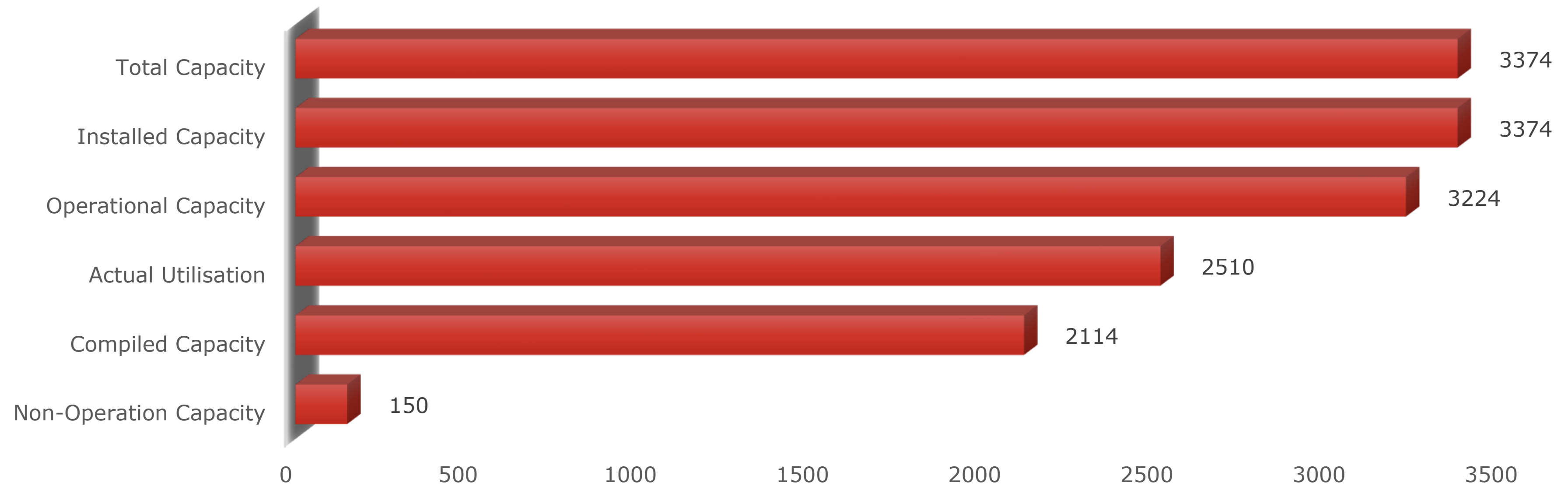


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.25. UTTAR PRADESH

- The estimated sewage generation in Uttar Pradesh is 8,263 MLD, with a total treatment capacity of 3,374 MLD (107 STPs).
- In comparison to sewage generation of 8,263 MLD, installed capacity is 3,374 MLD (40.83%). It reveals a treatment capacity shortfall of 4,889 MLD (59.17%).
- The operationalized capacity is 3,224 MLD (95.55%) and the actual used capacity is 2,510 MLD (77.85%) of the installed capacity of 3,374 MLD. Furthermore, the capacity of STPs that have been approved is just 2,114 MLD.

FIGURE 51. SEWAGE TREATMENT CAPACITY (MLD) – UTTAR PRADESH

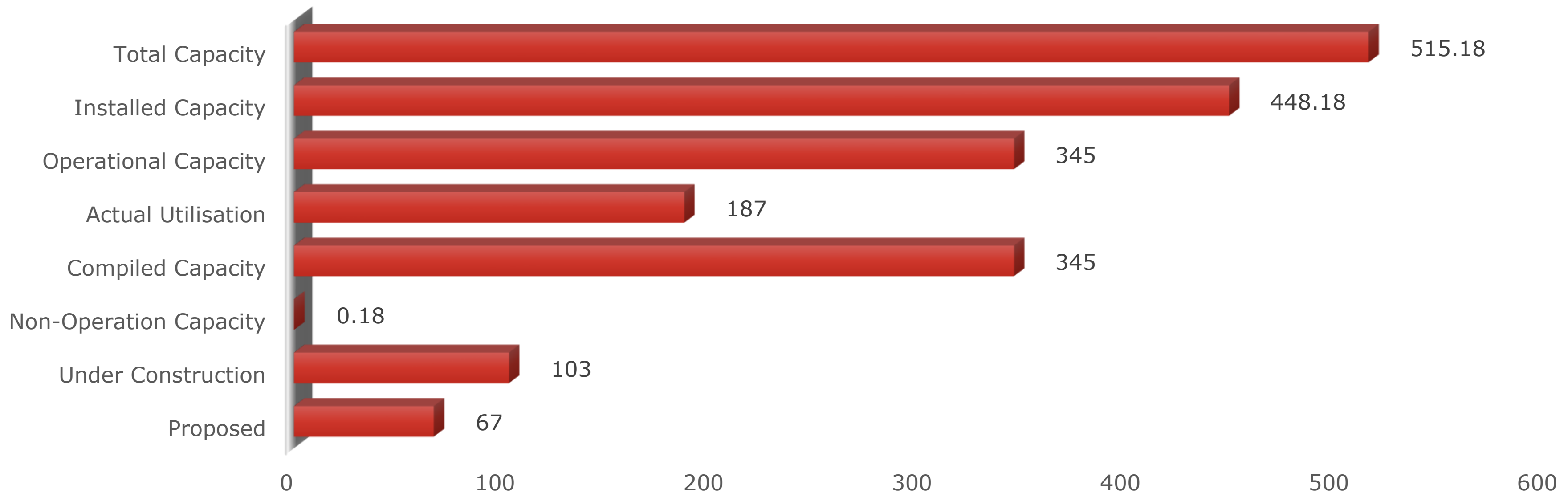


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.26. UTTARAKHAND

- The estimated sewage generation for Uttarakhand is 627 MLD, with a total capacity (including projected) of 515 MLD (81 STPs).
- The installed capacity is 448 MLD (71.45%) of the sewage generating capacity of 627 MLD. It reveals a treatment capacity shortfall of 179 MLD (28.55%).
- The operationalized capacity is 345 MLD (77%) of the 448 MLD of installed capacity created, while the actual used capacity is 187 MLD. Furthermore, the capacity of STPs that have been approved is just 345 MLD.

FIGURE 52. SEWAGE TREATMENT CAPACITY (MLD) – UTTARAKHAND

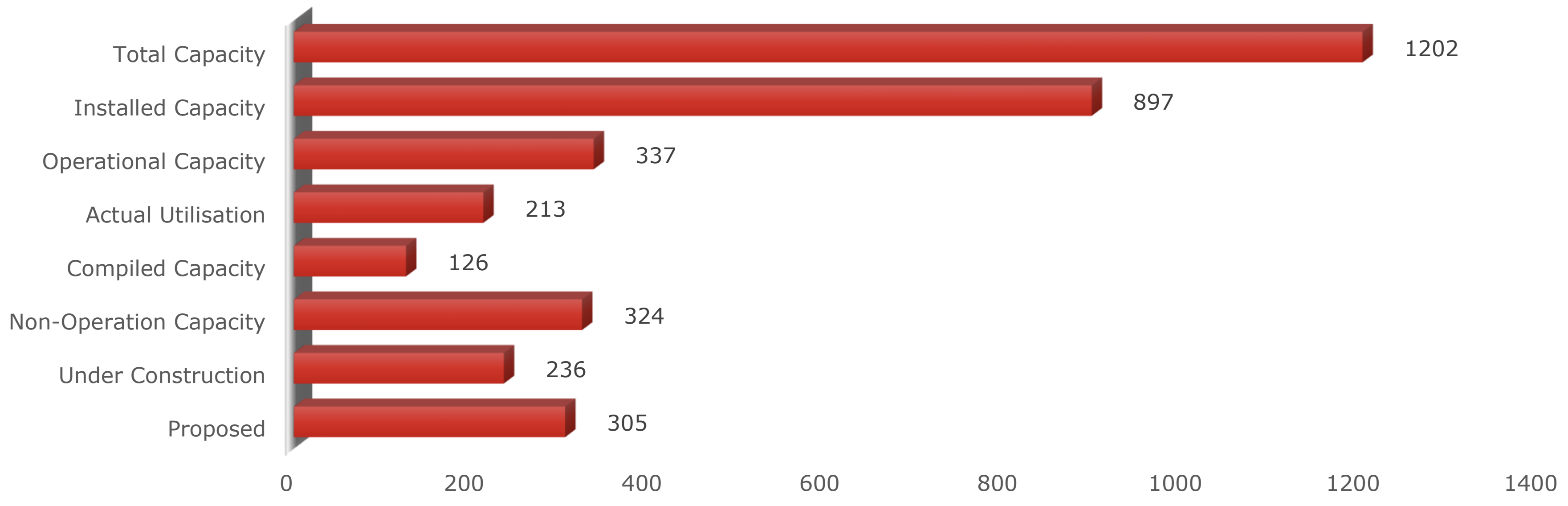


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.5.1.27. WEST BENGAL

- The estimated sewage generating capacity for the state of West Bengal is 5,457 MLD, with a total capacity (including projected capacity) of 1,202 MLD (65 STPs).
- The installed capacity is 897 MLD (16.43%) of the sewage generating capacity of 5,457 MLD. It reveals a treatment capacity shortfall of 4,560 MLD (83.57%).
- The operationalized capacity is 337 MLD (37.56%) and the actual used capacity is 213 MLD (63.20%) of the 897 MLD installed capacity generated. Furthermore, the capacity of STPs that have been approved is just 126 MLD.

FIGURE 53. SEWAGE TREATMENT CAPACITY (MLD) – WEST BENGAL



Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

The expected sewage generation is 72,368 MLD, whereas the existing treatment capacity is 31841 MLD (43.9%). The operationalized capacity is 26,869 MLD (84% of the total installed capacity of 31,841 MLD). Similarly, actual used capacity is 20,235 MLD (75%) of operating capacity is 26,869 MLD. This is due to a lack of conveyance infrastructure (household connection, sewer lines, and sewage pumping stations). States deploy STPs based on various treatment technologies ranging from conventional to sophisticated technology. STPs based on Sequential Batch Reactor (SBR) treatment technology have been erected and dominant in the majority of states and territories. This is followed by STPs based on ASP technology. In all, 490 STPs are planned to use SBR technology, with 321 STPs using the Activated Sludge Process (ASP). Upflow- Anaerobic Sludge Blanket (UASB) technique is used in 76 STPs. STPs based on natural treatment systems are being constructed around the country in addition to conventional treatment technologies.67 STPs are based on the Waste Stabilization Pond technology, whereas 61 STPs are Oxidation Ponds. The top five states with substantial sewage treatment facilities are Maharashtra, Gujarat, Uttar Pradesh, NCT of Delhi, and Karnataka. These five states provide a total of 19,250 MLD, or 60.5% of the country's total installed treatment capacity. In addition to the one mentioned above, the states of Haryana, Madhya Pradesh, Punjab, Tamil Nadu, and Rajasthan, totalling 86% (approx.) of total installed treatment capacity.

There are no sewage treatment plants in Arunachal Pradesh, Andaman and Nicobar Islands, Lakshadweep, Manipur, Meghalaya, or Nagaland. The compliance status of eight states and union territories (Gujarat, Himachal Pradesh, Kerala, Pondicherry, Sikkim, Chandigarh, Chhattisgarh, and Madhya Pradesh) has not been disclosed. Treatment capacity developed per capita is higher in Chandigarh (240 LPCD), Haryana (184 LPCD), NCT of Delhi (151 LPCD), Punjab (141 LPCD), and Maharashtra (115 LPCD). 29 states and territories have treatment capacities of less than 100 LPCD.

The state of Maharashtra has the most installed as well as compliant treatment capacity. However, the per capita installation capacity is highest in the UT of Chandigarh (240 LPCD), whereas Maharashtra has a per capita treatment capacity of 115 LPCD. The state of Haryana has the highest compliant per capita treatment capacity (142 LPCD), whereas Maharashtra has the lowest (58 LPCD). The NCT of Delhi has the fourth greatest treatment capacity of 2896 MLD and the third highest per capita treatment capacity of 151 LPCD, although the complying treatment capacity is only 4 LPCD.

6.5.1.28. OPPORTUNITIES IN SEWAGE TREATMENT

- Given the rising urbanization and sewage creation, there is an urgent need to close the existing sewage treatment gap. Aside from addressing the gap, there is also a need to coordinate future treatment capacity requirements.

- As it has been discovered that existing infrastructure is only being used at 75% of its operationalized treatment capacity, it is suggested that the sewerage conveyance system, which includes the laying of sewer lines and individual household sewer connections, be strengthened to meet current and future demand.
- In terms of compliance, it has been discovered that only 23% of treatment capacity meets the agreed-upon standards for SPCBs / PCCs. Considering this, it is also necessary to focus on the operation and maintenance of treatment facilities in order for STPs to fulfil the desired quality of treatment.
- ULBs must concentrate on the use of treated sewage for non-potable applications such as horticulture, irrigation, firefighting, industrial cooling, toilet flushing, non-contact impoundments, and washing (floors, roads, buses, trains, and so on).

Treated sewage should also be given to industrial clusters / zones for further treatment and utilization as required by the industrial zone.

6.6. MARKET DROC ANALYSIS

FIGURE 54. DROC'S ANALYSIS

D — DRIVERS

- Growth of chemically treated water in various end use industries
- Stringent regulatory and sustainability mandates
- Increasing industrial water consumption and discharge

R — RESTRAINTS

- Lack of water and infrastructure management
- High installation, equipment and operation costs

O — OPPORTUNITIES

- Adoption of more sustainable approach through reduce, recycle and reuse
- New initiatives supporting market growth
- Collaborations between public and private sectors

C — CHALLENGES

- Groundwater depletion and untreated water discharge
- Limited funds may pose challenges in certain regions
- Lack of required techno-commercial awareness

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

6.6.1. MARKET DRIVERS' ANALYSIS

6.6.1.1. INCREASING DEMAND FOR CHEMICALLY TREATED WATER IN VARIOUS END-USE SEGMENTS

The increasing demand for chemically treated water across various end-use segments reflects a fundamental shift in industrial and consumer preferences towards sustainable and safe water solutions. This trend is driven by several key factors, including growing awareness of water quality issues, stricter regulatory standards, and the need for efficient water management practices.

One of the primary drivers of this demand is the rising concern over water pollution and contamination. Industries such as manufacturing, agriculture, and mining are increasingly aware of the detrimental effects of untreated water on the environment and public health. As a result, there is a growing emphasis on implementing water treatment solutions that can effectively remove pollutants and harmful chemicals from water sources. Furthermore, the adoption of chemically treated water is also driven by regulatory requirements aimed at safeguarding water resources. Government agencies and environmental authorities are imposing stricter standards on water quality, mandating industries to treat their wastewater before discharge. This regulatory pressure is compelling businesses to invest in advanced water treatment technologies and services to ensure compliance and mitigate environmental risks.

In addition to regulatory compliance, the demand for chemically treated water is fueled by the need for sustainable water management practices. With water scarcity becoming a global concern, industries are seeking innovative solutions to reduce water consumption, recycle wastewater, and minimize their environmental footprint. Chemically treated water offers a viable option for recycling and reusing water resources, promoting water conservation and sustainability across various sectors. The agriculture sector is a significant contributor to the increasing demand for chemically treated water. With growing population and food demand, farmers are facing challenges related to water availability and quality. Adopting water treatment solutions enables farmers to improve crop yields, reduce water usage, and mitigate soil contamination, ensuring sustainable agricultural practices for long-term productivity.

Moreover, the industrial sector, including manufacturing, energy production, and processing industries, relies heavily on chemically treated water for various processes. Water treatment plays a crucial role in ensuring the quality and safety of industrial processes, protecting equipment from corrosion and scaling, and meeting stringent quality standards for products. The commercial and residential segments also contribute to the demand for chemically treated water, driven by concerns over drinking water quality and health. Water treatment systems installed in homes, offices, and public facilities help remove contaminants such as bacteria, viruses, heavy metals, and chemicals, providing clean and safe drinking water for consumption.

6.6.1.2. STRINGENT REGULATORY AND SUSTAINABILITY MANDATES CONCERNING THE ENVIRONMENT

The increasing demand for water and wastewater treatment solutions is driven by a confluence of factors, chief among them being stringent regulatory and sustainability mandates concerning the environment. In recent years, there has been a notable shift in global attitudes towards environmental stewardship, with governments, industries, and communities placing greater emphasis on responsible water management practices. This shift has been spurred by concerns over water scarcity, pollution, and the need to safeguard precious freshwater resources for future generations.

One of the primary drivers behind the surge in demand for water and wastewater treatment solutions is the tightening of regulatory frameworks worldwide. Governments and regulatory bodies are enacting more stringent standards and guidelines aimed at ensuring the quality and safety of water supplies. This includes mandates for wastewater treatment plants to meet higher effluent quality standards, reduce pollutant discharge levels, and implement advanced treatment technologies to address emerging contaminants.

Furthermore, sustainability has emerged as a key focal point for businesses across industries, including the water and wastewater treatment sector. Companies are increasingly recognizing the importance of adopting sustainable practices that minimize their environmental footprint and contribute to a more circular economy. This shift towards sustainability is driven by factors such as resource conservation, energy efficiency, and the adoption of eco-friendly technologies.

The nexus between regulatory compliance and sustainability has further accelerated the demand for innovative water and wastewater treatment solutions. Manufacturers and service providers in this sector are responding by developing cutting-edge technologies and systems that not only meet regulatory requirements but also deliver measurable environmental benefits. These include advanced filtration and purification technologies, energy-efficient treatment processes, and integrated water management systems that optimize resource utilization. Another significant driver of demand is the growing awareness among consumers and businesses about the importance of clean water and environmental sustainability. This heightened awareness has led to increased investment in water infrastructure projects, including the upgrading of existing treatment facilities and the development of new, more efficient systems. Additionally, industries such as agriculture, manufacturing, and healthcare are ramping up their efforts to minimize water usage, recycle wastewater, and implement sustainable water management practices.

The impact of climate change is also driving the need for enhanced water and wastewater treatment solutions. Changing weather patterns, prolonged droughts, and increased frequency of extreme weather events are putting additional strain on water resources. As a result, there is a growing imperative to develop resilient water infrastructure and deploy adaptive technologies that can cope with fluctuating water availability and quality.

6.6.1.3. INCREASE IN INDUSTRIAL WATER CONSUMPTION & DISCHARGE

The increasing demand for water and wastewater treatment is primarily driven by the escalating levels of industrial water consumption and discharge. As industries expand and modernize, their reliance on water grows exponentially, leading to heightened concerns about water scarcity and pollution. This trend is particularly evident in sectors such as manufacturing, chemicals, and energy production, where large volumes of water are essential for various processes but also result in significant wastewater generation.

One of the key factors contributing to this surge in demand is the global economic growth, which has spurred industrial activities across diverse sectors. As industries scale up their operations to meet market demands, their water requirements amplify proportionally. This is further compounded by the increasing emphasis on sustainability and environmental regulations, which necessitate more stringent water management practices, including efficient water usage and thorough wastewater treatment. Moreover, rapid urbanization and population growth have intensified the strain on water resources, prompting industries to adopt advanced water treatment technologies to ensure compliance with regulatory standards and mitigate environmental impact. This includes the implementation of sophisticated filtration systems, membrane technologies, and chemical treatments to treat wastewater before discharge into water bodies or reuse within the industrial processes.

The rise in industrial water consumption is closely linked to the expansion of sectors such as manufacturing, mining, and food processing, where water plays a crucial role in production processes and cooling systems. As these industries expand their capacities, their water demand rises accordingly, necessitating investments in water treatment infrastructure and technologies to manage the resulting wastewater effectively. Furthermore, increasing awareness among industries about the importance of water conservation and sustainable practices has led to a shift towards adopting eco-friendly water treatment solutions. This includes the adoption of technologies like reverse osmosis, ultraviolet disinfection, and advanced oxidation processes to achieve higher levels of water purity and minimize environmental impact.

Additionally, regulatory bodies worldwide are imposing stricter guidelines and standards regarding wastewater discharge and pollution control. Non-compliance with these regulations can result in hefty fines and reputational damage for industries, compelling them to invest in robust water treatment systems to meet regulatory requirements and maintain operational continuity. The growing demand for water and wastewater treatment solutions has also created opportunities for innovative approaches, such as water recycling and resource recovery from wastewater streams. These initiatives not only contribute to water conservation but also offer economic benefits through the recovery of valuable resources like energy and nutrients from wastewater.

6.6.2. MARKET RESTRAINTS ANALYSIS

6.6.2.1. LACK OF WATER AND INFRASTRUCTURE MANAGEMENT

Lack of water and infrastructure management poses significant restraints on the growth of the water and wastewater treatment market. This challenge is particularly acute in regions where water scarcity is a pressing issue, exacerbated by factors such as climate change and rapid urbanization. One of the primary issues is the inefficient use and distribution of water resources, leading to increased pressure on existing treatment facilities and water supply networks. Inadequate infrastructure investment further compounds these problems, as outdated or poorly maintained water treatment plants struggle to meet the escalating demands for clean water.

A key consequence of this lack of management is the strain it places on water treatment systems. Aging infrastructure often leads to leaks, pipe bursts, and water losses, reducing the overall efficiency of water supply networks. This not only results in wasted water but also compromises the quality of water reaching consumers. As a result, there is a growing need for investment in modernizing and upgrading water treatment facilities to ensure reliable and safe water supply.

Moreover, the lack of efficient water management practices contributes to pollution and environmental degradation. Untreated or inadequately treated wastewater is often discharged into water bodies, leading to contamination of freshwater sources and ecosystems. This not only poses risks to human health but also threatens biodiversity and ecosystem services. In regions where industries play a significant role, industrial wastewater discharge without proper treatment further exacerbates water pollution issues. Inadequate water and infrastructure management also hinder the adoption of advanced water treatment technologies and innovations. Without proper planning and investment, it becomes challenging to implement solutions such as membrane filtration, advanced oxidation processes, and decentralized water treatment systems. These technologies are crucial for addressing emerging contaminants, improving water quality, and enhancing the overall efficiency of water treatment processes.

The lack of effective management also impacts water reuse and recycling initiatives. In regions facing water scarcity, recycling and reusing treated wastewater for non-potable purposes such as irrigation, industrial processes, and environmental restoration are essential strategies. However, without proper infrastructure and management practices in place, realizing the full potential of water reuse becomes a formidable challenge. Furthermore, the financial constraints associated with inadequate water and infrastructure management limit the ability of governments and utilities to invest in sustainable water management practices. The high costs of upgrading and maintaining water treatment plants, expanding distribution networks, and implementing water conservation measures often exceed available budgets. This results in a cycle where the lack of investment leads to deteriorating infrastructure, increased operational costs, and ultimately, higher water tariffs for consumers.

6.6.2.2. HIGH INSTALLATION, EQUIPMENT AND OPERATIONS COSTS

High installation, equipment, and operations costs significantly restrain the growth of the water and wastewater treatment market. The water and wastewater treatment industry plays a critical role in ensuring environmental sustainability and public health by treating water for various purposes, including drinking, industrial processes, and agricultural use. However, the barriers posed by high costs hinder the widespread adoption and expansion of these essential services.

One of the primary challenges faced by stakeholders in the water and wastewater treatment sector is the substantial investment required for infrastructure development and installation of treatment facilities. Building and upgrading treatment plants, installing advanced equipment, and implementing cutting-edge technologies demand significant capital expenditure. This financial burden can deter both public and private entities from investing in new projects or expanding existing facilities, especially in regions with limited financial resources or competing priorities for infrastructure development.

Moreover, the complexity of water treatment processes adds to the overall cost of operations. Treating water to meet regulatory standards involves multiple stages, such as pre-treatment, filtration, disinfection, and sludge management, each requiring specialized equipment and skilled personnel. The operational costs include energy consumption for pumping and treatment processes, chemicals for disinfection and purification, maintenance of equipment, and labor costs for skilled technicians and operators. These ongoing expenses can escalate rapidly, especially for large-scale treatment facilities or systems serving densely populated areas.

In addition to the direct costs of installation and operations, regulatory compliance adds another layer of financial challenge for water and wastewater treatment providers. Stringent environmental regulations, quality standards, and monitoring requirements necessitate continuous investments in technology upgrades, process optimization, and regulatory compliance measures. Meeting these regulatory obligations often requires substantial investments in equipment upgrades, monitoring systems, and staff training to ensure adherence to evolving standards and guidelines.

6.6.3. MARKET OPPORTUNITIES ANALYSIS

6.6.3.1. ADOPTING MORE SUSTAINABLE APPROACHES THROUGH REDUCE-RECYCLE-REUSE

The adoption of more sustainable approaches through reduce-recycle-reuse presents a significant opportunity for the growth of the water and wastewater treatment market. As global concerns about environmental sustainability and resource conservation intensify, industries and communities are increasingly turning to innovative solutions to address water management challenges. This shift towards sustainable practices not only aligns with regulatory requirements but also offers economic and environmental benefits, driving the demand for advanced water and wastewater treatment technologies and services.

One of the key drivers behind the growing demand for sustainable water treatment solutions is the recognition of water as a finite and valuable resource. With the rise in industrial activities and urbanization, there has been a substantial increase in water consumption and wastewater generation. This has led to heightened concerns about water scarcity, pollution, and the impact on ecosystems. By adopting a reduce-recycle-reuse approach, industries and municipalities can minimize water wastage, reduce pollution, and optimize resource utilization, thereby contributing to water conservation efforts.

The reduce component of sustainable water management involves implementing measures to minimize water usage and waste generation. Industries are increasingly investing in water-efficient technologies, such as closed-loop systems, water recycling, and process optimization, to reduce their water footprint. This not only helps in conserving water resources but also leads to cost savings through reduced water consumption and lower wastewater treatment expenses.

Recycling water is another crucial aspect of sustainable water management. Advanced water treatment technologies, such as membrane filtration, reverse osmosis, and advanced oxidation processes, enable the purification and reuse of wastewater for non-potable applications such as irrigation, cooling water, and industrial processes. By recycling wastewater, industries can reduce their reliance on freshwater sources, alleviate pressure on water supplies, and mitigate environmental pollution from untreated discharges.

Furthermore, the reuse of treated wastewater presents opportunities for creating a circular economy in water management. Treated wastewater can be utilized for various beneficial purposes, including agricultural irrigation, groundwater recharge, and non-potable urban uses. This not only conserves freshwater resources but also reduces the need for costly infrastructure development for water supply. The adoption of sustainable water management practices is also driven by regulatory frameworks and sustainability mandates. Governments and regulatory bodies worldwide are imposing stricter regulations on water quality, discharge standards, and resource management. This regulatory environment incentivizes industries to invest in sustainable water treatment solutions to comply with standards and avoid penalties, thereby fueling market growth.

Moreover, the growing awareness among consumers, investors, and stakeholders about environmental stewardship and corporate responsibility is pushing businesses to prioritize sustainability in their operations. Companies that demonstrate a commitment to sustainable practices, including water conservation and pollution prevention, often enjoy reputational benefits, market differentiation, and access to green financing opportunities.

6.6.3.2. NEW INITIATIVES SUPPORTING MARKET GROWTH

In recent years, India has been witnessing a significant emergence of new initiatives aimed at bolstering the growth of the water and wastewater treatment market. With increasing urbanization, industrialization, and population growth, the demand for clean and accessible water has become a pressing concern. Consequently, both governmental and non-governmental entities have stepped up their efforts to address these challenges, leading to a surge in innovative initiatives that are reshaping the water and wastewater treatment landscape. One of the primary drivers of this transformation is the government's commitment to promoting sustainable water management practices. The Swachh Bharat Abhiyan (Clean India Mission) and the Namami Gange project are two noteworthy examples. The Namami Gange project, launched in 2014, focuses on cleaning and conserving the Ganges River, a lifeline for millions. The government's allocation of substantial funds towards these initiatives has not only enhanced wastewater treatment infrastructure but has also spurred investments in research and development of advanced technologies.

Moreover, the private sector has actively engaged in this domain, fostering innovation and competition. Startups and established companies alike are developing cutting-edge solutions for water and wastewater treatment. These range from decentralized and modular treatment systems to IoT-driven monitoring and management platforms. These initiatives are not only catering to the needs of urban areas but are also making inroads into rural communities that often lack access to clean water. Such diversification has broadened the market's scope and accelerated its growth.

The role of technology in transforming the water and wastewater treatment sector cannot be overstated. Advanced treatment methods such as membrane filtration, reverse osmosis, and ultraviolet disinfection are gaining prominence. These technologies are contributing to improved efficiency, reduced operational costs, and enhanced water quality. Partnerships and collaborations are also playing a pivotal role in this sector's evolution. Government bodies are partnering with international organizations and experts to leverage global best practices. Multilateral initiatives like the India-EU Water Partnership and joint ventures with international companies are fostering knowledge exchange and cross-border investments. These collaborations are instrumental in addressing complex challenges and facilitating the transfer of innovative solutions.

Furthermore, the growing awareness of water scarcity and pollution issues has mobilized civil society and non-governmental organizations to take proactive steps. Community-driven initiatives are empowering local communities to actively participate in water management, conservation, and treatment efforts. These initiatives have not only improved water quality but have also generated employment opportunities and enhanced socio-economic conditions in many regions.

6.6.3.3. COLLABORATIONS BETWEEN PUBLIC AND PRIVATE SECTORS

PPPs are increasingly being used to finance and implement water and wastewater treatment projects in India. This is because PPPs can help to bring in the expertise and resources of the private sector to address the country's water challenges. Private sector involvement brings in much-needed investment for developing and upgrading water and wastewater treatment facilities. The public sector often faces budget constraints, and private companies can contribute capital to build and maintain treatment plants, distribution systems, and infrastructure. Private companies often possess advanced technological know-how and expertise in water and wastewater treatment processes. Collaborations allow the public sector to leverage these advancements, leading to more efficient and effective treatment methods. Private sector collaboration fosters innovation through research and development initiatives. This can lead to the discovery of new treatment methods, improved equipment, and more sustainable solutions, enhancing the overall efficiency of water management. Private sector companies bring operational efficiency to water treatment processes. Their experience in project management, procurement, and operations can lead to streamlined processes, reduced costs, and optimized resource utilization.

Developing nations, confronted with the constraints of sustainability and financial viability as a result of the unavoidable reality of poor water supply and sanitation services and tight budgets, are exploring PPPs as a viable alternative to improve performance or create new sources. Water PPPs are increasingly being used by public utilities in a more focused manner, to manage a specific subset of activities or challenges, such as increasing energy efficiency and water availability through non-revenue water management, or development of a new water source, using lessons learned in the past and a better understanding of what PPPs in water can and cannot bring. The emphasis is on performance-based contracting, with payments made depending on outcomes.

Furthermore, the supply-demand imbalance for water and sanitation services is likely to grow in the near future: India's urban population is expected to exceed 600 million by 2031, more than double that of 2001 (HPEC, 2011). In light of lofty national goals, public and media pressure is increasing. The Indian Ministry of Urban Development has set a national service benchmark objective of continuous, around-the-clock water delivery services for all cities in India by 2031, demanding 100% coverage and a daily supply of 135 litres per capita for all households (Ministry of Urban Development 2008).

All cities will be equipped with underground sewerage systems, and 100% of wastewater will be collected and treated. Massive expenditures will be needed over the next 20 years to meet these lofty targets. Between 2012 and 2031, the total investment required in water supply and sewerage is anticipated to be over INR 563,598 crores (USD 90 billion) (HPEC, 2011). Expecting the public sector to fund such development wholly is patently unfeasible, and private-sector engagement will be one of the few viable alternatives open to Indian municipalities if service-level requirements are to be met. However, the growth of public-private partnerships (PPPs) for water and sanitation has been restricted and much slower than in other sectors such as transportation and energy. According to the World Bank's Public-Private Infrastructure (PPI) Database, between 1990 and 2012, India has just 13 PPP projects in the water and sanitation sector, accounting for less than 2% of all PPP projects (PPI Database, 2014). Water and sanitation received even less investment, accounting for 0.2% of overall PPP investments in India. However, the government has been launching various initiative such as Atal Mission for Rejuvenation and Urban Transformation (AMRUT), National Mission for Clean Ganga (Namami Gange) and among others are projected to improve the PPP investment in India in water and wastewater treatment market.

6.6.4. MARKET CHALLENGES ANALYSIS

6.6.4.1. GROUNDWATER DEPLETION AND UNTREATED WATER DISCHARGE

Groundwater depletion and untreated water discharge present significant challenges for the growth of the water and wastewater treatment market, reflecting critical environmental and economic concerns. The depletion of groundwater reserves, driven by excessive extraction and insufficient replenishment, has emerged as a pressing issue globally. This depletion not only threatens the availability of freshwater for various sectors such as agriculture, industry, and domestic use but also exacerbates water quality issues.

One of the primary challenges posed by groundwater depletion is the increased concentration of contaminants in remaining groundwater sources. As water levels decline, contaminants like heavy metals, pesticides, and nitrates become more concentrated, rendering untreated water unsuitable for consumption or use in industrial processes. This heightened contamination underscores the urgent need for robust water treatment solutions capable of effectively removing these pollutants to meet quality standards and ensure public health and safety.

Moreover, groundwater depletion contributes to land subsidence, where the land surface sinks as aquifers are depleted. This phenomenon not only damages infrastructure such as buildings, roads, and pipelines but also alters the natural flow of water, leading to disruptions in ecosystems and water availability. These consequences further underscore the critical importance of sustainable water management practices and advanced wastewater treatment technologies to mitigate environmental impacts and ensure long-term water security.

In parallel, untreated water discharge poses significant challenges to water quality and ecosystem health. Industrial, agricultural, and domestic activities generate vast quantities of wastewater containing pollutants such as chemicals, pathogens, nutrients, and organic matter. Without proper treatment, this untreated wastewater is often discharged directly into water bodies, leading to pollution, eutrophication, and degradation of aquatic ecosystems. The discharge of untreated water not only harms aquatic life but also poses risks to human health and limits the usability of water resources for recreational and agricultural purposes. Additionally, the accumulation of pollutants in water bodies can have far-reaching consequences, including the spread of waterborne diseases, loss of biodiversity, and compromised water quality for downstream users.

6.6.4.2. LIMITED FUNDS MAY POSE CHALLENGES IN CERTAIN REGIONS

India is a country with 28 states and 8 union territories and as India is developing nation some of the states in the country are still underdeveloped. Even by developing-country standards, India's regional growth has been notably unequal. Since the 1960s, India's regional growth has been polarized, with a high-income club and a low-income club. Maharashtra, Punjab, and Haryana are among the wealthy states, with Tamil Nadu, Uttar Pradesh and Karnataka joining recently. Orissa, Bihar, Rajasthan, Jharkhand, Assam, Arunachal Pradesh and Madhya Pradesh are among the states in the low-income club. Worryingly, the makeup of these clubs has essentially stayed consistent over the previous four decades. The central government allocates limited funds to low-income club states. There are a number of reasons for allocation of limited funds in these states which include geographical location, geopolitical scenario, availability of natural resources and among others. Therefore, the rate of industrial development in these states is very low. In addition, the abovementioned low-income states have low population compared to high income states therefore, while allocating funds to these states the central government consider the population of each state.

Water and wastewater treatment facilities require substantial investment for the construction, operation, and maintenance of treatment plants, pipelines, and distribution networks. Limited funds can hamper the development of new infrastructure and upgrades to existing facilities, leading to inadequate treatment capacity and inefficient operations. Advanced water and wastewater treatment technologies often come with higher costs. Limited funds can hinder the adoption of innovative technologies that could improve treatment efficiency and reduce environmental impacts. Without access to cutting-edge solutions, regions may struggle to address water quality and scarcity issues effectively. These states use allocate funds to fulfill basic needs of people and to provide adequate infrastructure. Therefore, the water and wastewater treatment market face significant challenge in the low-income states. Due to lack funds pose a significant challenge for water and wastewater treatment market as the initial investment for the water and wastewater treatment is very high.

6.6.4.3. LACK OF REQUIRED TECHNO-COMMERCIAL AWARENESS

The water and wastewater treatment market plays a pivotal role in safeguarding the environment and public health by managing water resources effectively. However, one of the significant challenges hindering its growth is the lack of required techno-commercial awareness among stakeholders. This challenge stems from several interconnected factors that need to be addressed comprehensively to unlock the full potential of the water and wastewater treatment industry.

Firstly, the complexity of water treatment technologies and processes demands a deep understanding of both technical aspects and commercial viability. Many stakeholders, including policymakers, investors, and even some industry professionals, may lack the necessary expertise to evaluate the efficiency, cost-effectiveness, and sustainability of different treatment solutions. This lack of awareness often leads to suboptimal investment decisions, where short-term cost considerations overshadow long-term benefits and environmental impacts.

Moreover, the rapid evolution of water treatment technologies and the emergence of innovative solutions further exacerbate the challenge. Keeping pace with these advancements requires continuous learning and adaptation, which can be daunting for stakeholders without a strong techno-commercial background. As a result, they may overlook or underestimate the potential of newer, more efficient treatment methods, thereby impeding the industry's overall progress. Another critical aspect linked to techno-commercial awareness is regulatory compliance. The water and wastewater treatment sector operates within a highly regulated environment, with stringent standards and guidelines governing water quality, discharge limits, and environmental impact assessments. Failure to grasp the nuances of these regulations can lead to non-compliance issues, legal complications, and reputational damage for companies operating in this space. Additionally, navigating complex permitting processes and securing approvals often requires a deep understanding of both technical specifications and financial implications, highlighting the interconnectedness of technical and commercial knowledge in this industry.

Furthermore, the lack of techno-commercial awareness can hinder innovation and market competitiveness. In a rapidly evolving landscape where sustainability, efficiency, and cost-effectiveness are paramount, companies that embrace technological advancements and align them with market demands are better positioned for growth. However, without a thorough understanding of market trends, consumer preferences, and competitive dynamics, businesses may struggle to develop and market innovative solutions that resonate with stakeholders and drive market adoption.

6.7. KEY MARKET TRENDS

6.7.1. DIGITAL TRANSFORMATION AND AUTOMATION OF DRINKING WATER TREATMENT PLANTS (DWTPS)

Water treatment plants are currently undergoing a significant digital transformation, a trend that is expected to continue into 2024. This transformation involves substantial investments in automated technology-based plant management, aiming to streamline operations effectively. One key advantage of this digital shift is the centralization and control of data management across different processes within Drinking Water Treatment Plants (DWTPs), bringing them together under a unified umbrella. Through advanced predictive control mechanisms driven by algorithmic models capable of learning and problem-solving, DWTP processes can be optimized continuously. This optimization ensures that operating variables consistently perform at their best levels, enhancing overall process efficiency.

Centralized management offers numerous benefits. It enables the prediction of water quality, automates the dosing of coagulant reagents, simulates chemical properties stored within the plant, monitors decanter performance, and intelligently sequences filter backwashing. Moreover, this centralized approach contributes to improved energy efficiency by optimizing storage and pumping activities. It takes into account factors like electricity tariffs and even integrates considerations for photovoltaic generation, further enhancing sustainability and cost-effectiveness in plant operations. Overall, this digital transformation represents a pivotal shift towards more efficient, data-driven, and environmentally conscious water treatment processes.

The ongoing digital transformation is set to advance significantly in its ability to detect events within water supply networks, thereby improving water quality. This encompasses incidents occurring from the point water leaves the treatment plant or tank to its consumption, which could potentially pose risks to public safety. By automating and monitoring key water quality variables, such as cleanliness and health parameters, optimal drinking water standards can be ensured. Furthermore, the adoption of new cutting-edge sensors has revolutionized the accuracy of measuring crucial variables, making it easier to implement sophisticated quality control algorithms. To achieve these objectives effectively, it is crucial to integrate various technologies and operations within DWTPs. This integration helps prevent source and data fragmentation, breaking down information silos that may exist in water treatment plants. Essentially, digital transformation should not be reactive to isolated needs but should be part of a comprehensive strategic plan. This involves deploying platforms capable of integrating and analyzing data from diverse sources, providing centralized automatic plant control, and facilitating informed decision-making processes.

6.7.2. EFFICIENCY AND SUSTAINABILITY IN DRINKING WATER NETWORK MANAGEMENT

In 2024, drinking water networks are undergoing digital transformation processes aimed at enhancing management efficiency and sustainability. These trends encompass the implementation of digital twins, offering holistic overviews and advanced simulation capabilities for enhanced decision-making. Additionally, the adoption of Advanced Metering Infrastructure (AMI) enables accurate monitoring of water consumption, contributing to better resource management.

For instance, Advanced Metering Infrastructure (AMI) stands out as a crucial technology trend shaping drinking water distribution systems in 2024, marking a milestone in the 4.0 revolution of the urban water cycle with its people-centric approach. Unlike its predecessor, Automatic Meter Reading (AMR), AMI goes beyond remote reading by integrating and processing data using big data technologies, leveraging digital platforms extensively. This disruptive technology brings direct benefits by offering value-added services such as leak detection and demand prediction through advanced algorithms. Such enhancements translate into more efficient and sustainable water management practices. To achieve this, AMI ideally operates on an hourly basis, providing high-quality consumption data. This requirement underscores the importance of new communication protocols like NB-IoT and 5G, which not only facilitate efficient data acquisition but also aid in managing meter batteries effectively, crucial for frequent data transmission in smart metering.

The efficiency brought by AMI translates into reduced operational incidents, ultimately benefiting end customers. Its ability to generate vast amounts of information has led water utilities to recognize the value of measuring consumption beyond billing. Integrating this data with other information sources such as SCADA, CMMS, ERP, GIS, and IoT sensors optimizes operational processes and boosts overall efficiency.

Moreover, AMI deployment not only enables remote reading, reducing energy consumption and environmental impact associated with travel but also contributes significantly to sustainability. It achieves this by performing hourly water balances, curbing non-revenue water, and detecting fraud and leaks effectively. As digital transformation gains momentum in the water sector, the implementation of agnostic solutions becomes imperative to integrate information seamlessly from various sources, making utilities more competitive and efficient. In this landscape, 5G emerges as a crucial player capable of connecting millions of devices in small areas (MIoT), addressing the challenge of smart metering coexisting with other smart devices seamlessly.

6.7.3. DIGITAL TRANSFORMATION OF WASTEWATER TREATMENT PLANTS (WWTPS)

In the current era of digital transformation, various industries, including the wastewater treatment sector, are experiencing a revolution driven by the adoption of new technologies. This transformation is crucial as environmental concerns escalate, leading to changes in wastewater management to address emerging challenges more efficiently and sustainably. The decisions made and actions taken today regarding water, a scarce commodity, will significantly impact its availability for years to come, highlighting the importance of implementing new technologies in 2024 as a catalyst for change. These technologies are poised to enhance the efficiency and quality of treated water significantly.

Automation and control play pivotal roles in industrial safety and optimization within the realms of science and technology. This revolution is marked by the convergence of operational technology (OT) and information technology (IT), creating an ideal synergy between technological innovation and efficiency specifically in the wastewater treatment sector.

The integration of OT and IT facilitates real-time process supervision and regulation through advanced control and monitoring systems, elevating operational productivity to new heights. The availability of a wide array of high-quality sensors in the market is generating substantial volumes of data concerning water quality and the efficiency of treatment processes. This data encompasses detailed measurements of contaminant concentrations as well as physical, chemical, and biological parameters. However, the true value of this wealth of information lies in effectively processing and harnessing it. The proliferation of monitored variables and the expansion of processing capacities in onsite, cloud, and edge-computing environments have given rise to robust, cutting-edge solutions driven by sophisticated algorithms. This ongoing revolution is expected to gain momentum in the coming years, further transforming and optimizing wastewater treatment processes.

Similarly, The Internet of Things (IoT) is a pivotal driver in the digital transformation of wastewater treatment plants (WWTPs), and its adoption is anticipated to surge in 2024 and beyond. IoT devices like smart meters are strategically positioned at critical points within the plant system, continuously collecting relevant data in real-time. This data is then transmitted to centralized platforms, where it undergoes processing to generate high-value insights, offering a detailed and up-to-date snapshot of the system's status.

IoT utilizes wireless technology for monitoring signals transmission, extending control and supervision beyond the plant's premises. One notable application is in monitoring the discharge receiving stream, ensuring its quality and promptly identifying any unauthorized dumping. However, one of the most significant advancements lies in real-time monitoring of the downstream basin of WWTPs, enabling early detection of illegal discharges into the sanitation network and preemptive measures to minimize their impact within the WWTP. This capability also facilitates more effective investigations into identifying pollutant sources within the network.

6.7.4. ADVANCED TREATMENT AND INNOVATIVE TECHNOLOGIES

In the urban wastewater treatment sector, several technologies are gaining prominence and are expected to trend in 2024. One such technology is advanced oxidation, which employs chemical reagents or free radicals to break down persistent organic pollutants in wastewater, particularly effective for compounds resistant to conventional treatment methods. Similarly, ultrafiltration and reverse osmosis utilize high pressure to push water through membranes, leaving contaminants behind and yielding purified water suitable for various reuse applications.

Another technology gaining traction is photocatalytic oxidation which relies on a catalyst like titanium dioxide activated by ultraviolet (UV) light to degrade organic pollutants and microorganisms in wastewater through the generation of free radicals. The ultrasonic reactors have also witnessed a significant increase. They utilize high-frequency waves to create microbubbles that collapse violently, producing high temperatures and pressures to decompose contaminants and microorganisms, effectively decontaminating water. Similarly, naturally and genetically enhanced microorganisms technology has also been growing. It focuses on using improved variants of microorganisms to treat wastewater with refractory TOC/COD or specific pollutants, selecting and feeding them into the treatment process.

6.7.5. DRIVING ENERGY EFFICIENCY IN WASTEWATER TREATMENT

Renewable energies have emerged as a pivotal trend within the water and wastewater industry, driven by the dual imperatives of reducing carbon footprints and trimming operational expenses in wastewater treatment plants (WWTPs). In 2024, enhancing energy efficiency stands out as a primary goal for WWTPs, underscored by four interlinked strategies poised for increased adoption in the foreseeable future. First, real-time monitoring and control of consumption empower the development of novel energy-saving approaches while swiftly identifying and addressing faults as they arise. Second, optimizing the aeration system of biological reactors entails finely tuning the air quantity and distribution, thereby maximizing treatment process efficacy. Third, optimizing biogas production encompasses augmenting the volume of biogas yielded during anaerobic digestion and formulating strategies for its efficient utilization and storage. Lastly, the integration of photovoltaic panels harnesses solar energy to generate electricity, contributing substantially to meeting the energy demands of WWTPs. This multifaceted approach not only aligns with sustainability objectives but also promises substantial cost savings and operational enhancements for WWTPs in the digital era.

6.8. GOVERNMENT POLICIES AND REGULATORY FRAMWORK IN INDIA

According to Provisions of Environment (Protection) Act, 1986 and Water (Prevention & Control of Pollution), Act 1974, the industries must implement Effluent Treatment Plants (ETPs) and should treat respective effluents as per environmental standards before releasing it into rivers and water bodies. Thus, State Pollution Control Boards/Pollution Control Committees usually inspect the industries with respect to effluent discharge standards and also takes action for non-compliance under provisions of these Acts.

The IS 10500: 2012 DRINKING WATER — SPECIFICATION by Bureau of Indian Standards, aims to prescribes the requirements and the methods of sampling and test for drinking water.

The guidelines by WHO for drinking water specifications is prepared through a vast global consultative process involving WHO member states (India is the member state), national authorities and international agencies, in consultation with the WHO Expert Advisory Panel.

Primary Water Quality Criteria for Bathing Waters by the Ministry of Environment and Forests (MoEF): In a water body or its part, water has several types of uses. Relying on water applications and activities, thus the water quality criteria have been specified to determine its suitability for a particular purpose. Among the various types of uses there is one use that demands the highest level of water quality or purity and that is termed as "Designated Best Use" in that stretch of water body. Based on this, water quality requirements have been specified for different uses in terms of primary water quality criteria.

According to Central Pollution Control Board of India the standard such as, WATER QUALITY STANDARDS FOR COASTAL WATERS MARINE OUTFALLS, in a coastal segment marine water is subjected to several types of uses. Depending on the types of uses and activities, water quality criteria have been specified to determine its suitability for a particular purpose. Among the various types of uses there is one use that demands the highest level of water quality/purity and that is termed a "designed best use" in that stretch of the coastal segment. Based on this, primary water quality criteria have been specified into five designated best uses.

As per Central Pollution Control Board of India the standard Designated Best Use Water Quality Criteria includes certain criteria for drinking water source without conventional treatment but after disinfection, outdoor bathing (organized), drinking water source after conventional treatment and disinfection, propagation of wild life and fisheries and irrigation, industrial cooling, controlled waste disposal.

6.8.1. MINISTRY OF JAL SHAKTI

Historical Overview

The Ministry of Jal Shakti was established in May 2019 under the Government of India. Two ministries namely the Ministry of Water Resources, River Development & Ganga Rejuvenation, as well as the Ministry of Drinking Water and Sanitation, were merged together to form the Ministry of Jal Shakti.

The organizational history of the Department of Water Resources, River Development, and Ganga Rejuvenation:

- The origin of "Irrigation & Power" dates to 1855, when it was given to the Department of Public Works, which had just been established at the time.

- In 1923, the Public Works Department and the Department of Industry amalgamated, becoming the Department of Industries and Labor, which was responsible for irrigation and power. In 1927, the Central Board of Irrigation was also established.

- In 1937, the Department of Industry and Labour was bifurcated into the Department of Communication and Department of Labour.

- The Ministry of Works, Mines, and Power relinquished control of the topic of "Irrigation and Power" to the newly established Ministry of National Resources and Scientific Research in 1951.

- To handle the issue of irrigation, a separate Ministry of Irrigation and Power was established in 1952. A Flood Control Board was established during severe floods to evaluate flood control initiatives at the highest level.

- In 1969, an Irrigation Commission was set up to go into the matter of future irrigation development programs in the country in a comprehensive manner.

- In January 1980, the new Ministry of Energy and Irrigation included the Department of Irrigation. In order to have a coordinated and complete perspective of the whole irrigation sector, the then Ministry of Energy and Irrigation was split into two on June 9, 1980, and the former Department of Irrigation was elevated to the rank of Ministry. In addition to major and medium irrigation, the Ministry of Irrigation was given control over the large irrigation sector, including both surface and ground irrigation as well as Command Area Development Programme.

- The following items of work were transferred from the Ministry of Agriculture (Department of Agriculture & Cooperation) to the Ministry of Irrigation with effect from in July 1980: -
    a. Irrigation for agricultural purposes
    b. Minor and emergency irrigation; and
    c. Ground water exploration

- In January 1985, the Ministry of Irrigation was once again combined under the Ministry of Irrigation and Power. However, in the re-organization of the Ministries of the Central Government in September 1985, the then Ministry of Irrigation and Power was bifurcated, and the Department of Irrigation was re-constituted as the Ministry of Water Resources.

- Considering this new viewpoint, which mandated comprehensive planning and coordination of all areas of the country's water resource development, it was deemed necessary to create a National Water Policy, outlining, among other things, priority for different uses of water.

- Under the leadership of the Honorable Prime Minister, the National Water Resources Council was established to investigate this issue. The National Water Resources Council (NWRC) adopted the National Water Policy in September 1987. The National Water Board was established in September 1990 with the Secretary of the Ministry of Water Resources as its Chairman, the Chief

Secretaries of all the States and UTs, the Secretaries of the relevant Union Ministries, and the Chairman of the Central Water Commission serving as its members. Its duties include reviewing the status of the National Water Policy's implementation for the purpose of reporting to the NWRC and launching effective initiatives for the systematic development of the nation's water resources.

- Accelerated Irrigation Benefits Programme (AIBP): The AIBP was established by the Central Government in 1996–1997 to provide Central Assistance to major/medium irrigation projects across the nation with the goal of accelerating the implementation of those projects that were either beyond the States' capacity for resources or at an advanced stage of completion. Priority was given to initiatives that were launched during the Pre-Fifth and Fifth Plans, as well as those that benefited tribal groups and areas vulnerable to drought. The program provided benefits for the twenty-five States. 99 projects with a combined potential of 76.03 lakh hectares have been prioritized under PMKSY (AIBP) for completion by December 2019. The entire amount of money needed to finish these 99 projects, including CAD&WM work, is expected to be INR. 77,595 Crore. For AIBP works estimated cost is INR. 48,546 Crore with Central Assistance (CA) of INR. 16,818 Crore.

- The National Water Resources Council adopted the revised **'National Water Policy2002'** and passed a resolution to this effect in its 5th meeting held on 1st April 2002 at New Delhi under the Chairmanship of Hon'ble Prime Minister. Thereafter, the National Water Board considered the further revised Draft National Water Policy 2012.

- **The Centrally Sponsored Scheme - Rationalization of Minor Irrigation Statistics (RMIS)** was launched in 1987-88 and is being implemented by Minor Irrigation (Stat.) Wing of the Department through State Governments. It is now renamed as

"Irrigation Census" which is a Centrally Sponsored Scheme with 100% Central funding. The major activities under the Scheme are: (i) conduct of 6th Minor Irrigation Census with reference year 2017-18 and (ii) conduct of a Census of Water Bodies which is taken up for the first time.

- For comprehensive improvement of water bodies, two schemes - **Repair, Renovation and Restoration (RRR) of Water Bodies**, one with external assistance and the other with domestic support for implementation during XI Plan Period was approved by the Government. The scheme of RRR of water bodies includes the catchment area treatment, command area development, capacity building of stakeholders and increased availability of drinking water.

- The R & D activities undertaken in the **R&D Programme in Water Sector** Scheme are essential for the management and development of water resources of the country. The activities taken up under this Scheme are:
  a. R&D activities through Apex Research Organizations at National level: Central Water and Power Research Station (CWPRS), Pune; Central Soil and Material Research Station (CSMRS); National Institute of Hydrology (NIH), Roorkee; and Central Water Commission (CWC), New Delhi.
  b. Sponsoring and Coordinating Research in water sector through Educational Institutions, Indian Research Institutes, NGOs and Indian Private Institutes in collaboration with Government Institutes.
  c. Dissemination of research findings and technology transfer and International Collaborations
  d. Evaluation of R&D Activities and Consultancies

i. **National Action Plan on Climate Change**: The Government of India launched National Action Plan on Climate Change (NAPCC) on 30th June 2008, Ministry of Water Resources has set up National Water Mission with the main objective of "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management" Comprehensive Mission Document" of the NWM on 6.4.2011 with following five goals:

   a. Comprehensive Water Data Base in Public Domain and Assessment of Impact of Climate Change on Water Resources.
   b. Promotion of Citizen and State Action for Water Conservation, Augmentation and Preservation.
   c. Focused Attention on Vulnerable Areas including Over-Exploited Areas.
   d. Increasing Water Use Efficiency by 20%.
   e. Promotion of Basin Level and Integrated Water Resources Management

- **Flood Management and Border Areas Programme (FMBAP):** The Flood Management Programme (FMP) and River Management Activities and Works related to Border Areas (RMBA) under operation during XII Five Year Plan by Department of Water Resources, RD & GR merged as Flood Management and Border Areas Programme (FMBAP) for the period 2017-18 to 2019-20 and later extended up to March, 2021. The outlay of FMBAP is INR 3342 Crore comprising of FM component of INR 2642 Crore and RMBA component of INR 700 Crore for the period 2017-18 to 2019-20 under the Scheme. There were 83 ongoing Schemes under FMBAP out of which 39 Schemes have been physically completed / foreclosed by the State Governments.

- **Dam Rehabilitation and Improvement Project (DRIP):** to address comprehensively various dam safety challenges in India, the Ministry of Jal Shakti initiated the World Bank assisted Dam Rehabilitation and Improvement Project (DRIP), in 2012, The initial project cost was INR 2,100 Cr. (Loan share: USD 279.3 M), which was revised to INR 3,466 Cr (Loan Share: USD 416 M) in 2018. Now revised budget outlay is INR 2,642 Cr after surrendering of loan amounting to USD101 during COVID19. In the year 2018, the Project was also extended by Govt of India and World Bank from June 2018 to June 2020. This timeline was further extended by nine months i.e., up to 31 March 2021, to compensate the loss of time due to COVID pandemic and also facilitate the partner agencies to complete the balanced rehabilitation activities. The cumulative expenditure as of 31 March 2021, is INR 2,525 Cr. The loan disbursed by World Bank (up to December 2020) is USD 293.42 M (93%) out of USD 315.3 Million.

- **Under Dam Safety Institutional Strengthening, achievements include the following:**
  a. Preparation of Tier-I Inundation mapping and Dam Break Analysis (197 dams).
  b. Preparation of two dam-specific important protocols viz Operation and Maintenance Manuals (194 dams) as well as Emergency Action Plan (182 dams).
  c. Stakeholder Consultation program (101 Nos).
  d. Publication of 14 Guidelines and Manuals in various areas of dam safety.
  e. 186 nos. customized training benefitting 5442 officials, along with capacity building of 8 Academic Institution and 2 Central Agencies.
  f. Implementation of Dam Health and Rehabilitation Monitoring Application (DHARMA)-a web-based asset management tool in 18 States with 1100 users containing preliminary information of about 5,000 dams wherein health data in respect of about 1,500 dams have been entered: and
  g. Organization of three (3) National and two (2) International Dam Safety Conferences with 2469 participants and 471 technical papers.

- **DRIP Phase II and Phase III** Based on the success of DRIP, the Ministry of Jal Shakti initiated another externally funded Scheme DRIP Phase II and Phase III. This new Scheme has nineteen (19) States, and three Central Agencies on board. The budget outlay is INR 10,211 Cr (Phase II: INR 5,107 Cr; Phase III: INR 5,104 Cr) with rehabilitation provision of 736 dams. The Scheme is of 10 years' duration, proposed to be implemented in two Phases, each of six years' duration with two years overlapping. Each Phase has external assistance of USD 500 M. The Union Cabinet has approved the Scheme on October 29, 2020.

- In July 2014, the Ministry was renamed as "Ministry of Water Resources, River Development & Ganga Rejuvenation". The following additional items of work have been assigned to the Ministry: -
  a. National Ganga River Basin Authority including the Mission Directorate, National Mission for Clean Ganga, and other related matters of Ganga Rejuvenation.
  b. Conservation, development, management, and abatement of pollution in river Ganga and its tributaries.

OBJECTIVE

This ministry has been formed with the primary objective of tackling India's persistent battle against mounting water challenges and water resource-related issues that the country has been facing over the past few decades. Initially, the ministry was created with the intention of cleaning up the Ganges River. It is now operating to include any regional or national conflicts between inter-state water sources and rivers that India and other neighboring countries share with each other. A special project called "Namami Gange" was initiated to clean up Ganga and its tributaries to provide safe drinking water for the region's citizens. The ministry has also initiated unique social media programs to raise awareness of water conservation among the citizens of the country. WAPCOS is an Indian multinational government undertaking and consultancy firm wholly owned by the Ministry of Jal Shakti, Government of India.

TABLE 8. BUDGETARY ALLOCATION FOR MINISTRY OF JAL SHAKTI

MINISTRY OF JAL SHAKTI	
Established in	May, 2019
Revised Budget allocated for 2023-2024	INR 96,550 crore
Estimated Budget allocated for 2024-2025	INR 98,419 crore

Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), National Mission for Clean Ganga, Press Information Bureau (PIB), Union Budget of India

ROLE OF MINISTRY OF JAL SHAKTI:

The Ministry of Water Resources is responsible for laying down policy guidelines and programs for the development and regulation of the country's water resources.

The Ministry has been allocated the following function: -

- Overall planning, policy formulation, coordination, and guidance in the water resources sector.
- Technical guidance, scrutiny, clearance, and monitoring of the irrigation, flood control, and multi-purpose projects (major/medium).
- General infrastructural, technical, and research support for development.
- Providing special Central Financial Assistance for specific projects and assistance in obtaining External Finance from the World Bank and other agencies.

- Overall policy formulation, planning, and guidance in respect of Minor Irrigation and Command Area Development, administration and monitoring of the Centrally Sponsored Schemes, and promotion of Participatory Irrigation Management.
- Overall planning for the development of Ground Water Resources, the establishment of utilizable resources and formulation of policies for exploitation, overseeing of and support to State level activities in groundwater development.
- Formulation of national water development perspective and the determination of the water balance of different basins/sub-basins for consideration of possibilities of inter-basin transfers.
- Coordination, mediation, and facilitation regarding the resolution of differences or disputes relating to Inter-State Rivers and in some instances overseeing of implementation of inter-state projects.
- Operation of the central network for flood forecasting and warning on inter-state rivers, provision of central assistance for some State Schemes in special cases, and preparation of flood control master plans for rivers Ganga and Brahmaputra.
- Talks and negotiations with neighboring countries, regarding river waters, water resources development projects, and the operation of the Indus Water Treaty.
- Ensure effective abatement of pollution and rejuvenation of the river Ganga by adopting a river basin approach to promote inter-sectoral coordination for comprehensive planning and management.

BUDGETARY ALLOCATION

The Ministry of Jal Shakti is responsible for the development, maintenance, and efficient use of water resources in the country and for the coordination of drinking water and sanitation programs in rural areas. The Ministry was created in 2019 by integrating the Ministries of:

a) Water Resources, River Development, and Ganga Rejuvenation, and

b) Drinking Water and Sanitation

TABLE 9. ALLOCATION UNDER THE OBJECT HEAD GRANTS FOR THE CREATION OF CAPITAL ASSETS

(In INR Crores)

MINISTRY/ DEPARTMENT	2023-2024 BUDGET REVISED	2024-2025 BUDGET ESTIMATES
Ministry of Jal Shakti	***96,550***	***98,419***
a) Department of Water Resources, River Development, and Ganga Rejuvenation	**19,517**	**21,028**
b) Department of Drinking Water and Sanitation	**77,033**	**77,391**
c) National River Conservation Plan	**40,975**	**56,511**

Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), National Mission for Clean Ganga, Press Information Bureau (PIB), Union Budget of India

TABLE 10. FURTHER ALLOCATION TO THE DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT, AND GANGA REJUVENATION

(In INR Crores)

PROJECTS/SCHEMES	2023-2024 BUDGET REVISED	2024-2025 BUDGET ESTIMATES
a) Major Irrigation Projects	**124.97**	**126.98**
b) Namami Gange Mission-II	**2,400.00**	**3,500.00**
c) River Basin Management	**94.00**	**154.79**
d) Water Resources Management	**2,705.00**	**2,946.26**
e) Pradhan Mantri Krishi Sinchai Yojna	**7,031.10**	**8,890.07**
f) Others	**84,194.50**	**82,800.69**
TOTAL	***96,550***	***98,419***

Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), National Mission for Clean Ganga, Press Information Bureau (PIB), Union Budget of India

TABLE 11. FURTHER ALLOCATION TO THE DEPARTMENT OF DRINKING WATER AND SANITATION

(In INR Crores)

SCHEMES	2023-2024 BUDGET REVISED	2024-2025 BUDGET ESTIMATES
Jal Jeevan Mission (JJM) / National Rural Drinking Water Mission	**70,000.00**	**70,162.90**
Swachh Bharat Mission (Gramin)	**7,000.00**	**7,192.00**
Others	**32.65**	**35.78**
Total	***77,032.65***	***77,390.68***

Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), National Mission for Clean Ganga, Press Information Bureau (PIB), Union Budget of India

The work assigned to the Department of Water Resources, River Development, and Ganga Rejuvenation:

A. GENERAL

a) Development, conservation, and management of water as a national resource; overall national perspective of water planning and coordination in relation to diverse uses of water and interlinking of rivers.
b) National Water Resources Council.
c) General Policy, technical assistance, research and development training, and all matters relating to irrigation, including multi-purpose, major, medium, minor, and emergency irrigation works; hydraulic structures for navigation and hydro-power; tube wells and groundwater exploration and exploitation; protection and preservation of groundwater resources; conjunctive use of surface and groundwater, irrigation for agricultural purposes, water management, command area development; management of reservoirs and reservoir sedimentation; flood (control) management, drainage, drought proofing, water logging, and sea erosion problems; dam safety;
d) Regulation and development of Inter-State rivers and river valleys. Implementation of Awards of Tribunals through Schemes, River Boards.
e) Water laws, legislation.
f) Water quality assessment.
g) Cadre control and management of the Central Water Engineering Services (Group A).
h) Conservation, development, management, and abatement of pollution of rivers.

B. INTERNATIONAL ASPECTS

a) International organizations, commissions, and conferences relating to water resources development and management, drainage, and flood control.
b) International Water Law.
c) Matters relating to rivers common to India and neighboring countries; the Joint Rivers Commission with Bangladesh, the Indus Waters Treaty 1960; the Permanent Indus Commission.
d) Bilateral and external assistance and cooperation programs in the field of water resources development.

Presently, the following Attached & Subordinate Offices, Statutory Bodies, Registered Societies, and Public Sector Undertakings are working under the control of the Department of Water Resources, RD & GR: -

Attached Offices

1. Central Water Commission (CWC)
2. Central Soil & Materials Research Station (CSMRS)

Subordinate Offices

3. Central Ground Water Board (CGWB)
4. Central Ground Water Authority (CGWA)
5. Central Water & Power Research Station (CWPRS)
6. Bansagar Control Board (BCB)
7. Ganga Flood Control Commission (GFCC)

8. Farakka Barrage Project (FBP)
9. Farakka Barrage Project Control Board
10. Sardar Sarovar Construction Advisory Committee
11. Upper Yamuna River Board (UYRB)
12. National Water Information Centre (NWIC)

Statutory Bodies

13. Tungabhadra Board (TB)
14. Betwa River Board (BRB)
15. Brahmaputra Board (BB)
16. Godavari River Management Board (GRMB)
17. Krishna River Management Board (KRMB)

Corporate Bodies

18. Narmada Control Authority (NCA)
19. Cauvery Water Management Authority

Registered Societies/ Autonomous Bodies

20. National Water Development Agency (NWDA)
21. National Institute of Hydrology (NIH)
22. North Eastern Regional Institute of Water and Land Management (NERIWALM)

23. National Mission for Clean Ganga (NMCG)
24. National River Conservation Directorate
25. National Water Informatics Centre (NWIC).
26. Polavaram Project Authority (PPA)

Public Sector Undertakings

27. National Projects Construction Corporation Limited (NPCC Ltd.)
28. Water & Power Consultancy Services Limited (WAPCOS Ltd.)

Various Programs and Schemes under the Ministry of Jal Shakti

- Ganga Rejuvenation
- Interlinking of Rivers
- CADWM program
- Flood Management Wing Program
- R and D Programme in Water Sector
- Dam Rehabilitation and Improvement Programme
- PMKSY - Pradhan Mantri Krishi Sinchayee Yojna
- HRD / Capacity Building
- Atal Bhujal Yojana
- National Hydrology Project
- Farakka Barrage Project

- Namami Gange
- National River Conservation Plan - Other Basins
- River Basin Management
- Flood Forecasting
- Development of Water Resources Information System
- Ground Water Management and Regulation
- Infrastructure Development
- Assistance for Sutlej Yamuna Link Canal Project
- Flood Management Programme
- River Management Activities and Works Related to Border Areas
- Minor Irrigation Census
- National Ground Water Management Improvement Scheme
- Pancheshwar Multipurpose Project
- Polavaram Project Authority
- National Water Framework Bill
- Policy on Sediment Management

6.8.2. KEY GOVERNMENT PLANS

TABLE 12. BUDGETARY ALLOCATION FOR KEY GOVERNMENT PLANS

SR.NO	SCHEME	LAUNCHED IN	BUDGET ALLOCATION
1	The Atal Mission for Rejuvenation And Urban Transformation 2.0 (AMRUT 2.0)	October, 2021	INR 2,99,000 crore (Budget allocation for five years)
2	Jal Jeevan Mission (JJM)- Har Ghar Jal	August, 2019	INR 3.60 lakh crore (Allocation over five years (2019-24))
3	Namami Gange Programme	June, 2014	INR 4,000 crore (Estimated Budget allocated in 2023-2024)
	Namami Gange Mission-II		INR 22,500 crore till 2026
4	Swajal	February, 2018	INR 700 crore

Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Ministry of Jal Shakti, Jal Jeevan Mission (JJM), National Mission for Clean Ganga, Press Information Bureau (PIB), Union Budget of India

TABLE 13. ABBREVIATIONS FOR KEY GOVERNMENT PLANS

Parameters	Description
A&OE	Administrative and Other Expenses
ACA	Admissible Central Assistance
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AMRUT 2.0	Atal Mission for Rejuvenation and Urban Transformation 2.0
ATR	Action Taken Report
CA	Central Assistance
CMMUs	City Mission Management Units
CPSU	Central Public Sector Undertaking
CSR	Corporate Social Responsibility
CWAP	City Water Action Plan

CWBP	City Water Balance Plans
DDP	Desert Development Programme
DPAP	Drought Prone Area Programme
DPR	Detailed Project Report
JE-AES	Japanese Encephalitis-Acute Encephalitis Syndrome
FHTC	Functional Household Tap Connection
GP	Gram Panchayat
HADP	Hill Area Development Programme
HRD	Human Resource Development
IEC	Information, Education and Communication
IMIS	Integrated Management Information System
INR	Indian rupee

IRMA	Independent Review and Monitoring Agency
IWMP	Watershed Management Programme
JJM	Jal Jeevan Mission
lpcd	liters per capita per day
M&E	Monitoring and Evaluation
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MIS	Management Information System
MLD	Million Liters per Day
MoF	Ministry of Finance
MoHUA	Ministry of Housing and Urban Affairs
MRTS	Mass Rapid Transit System
NCDWSQ	National Center for Drinking Water, Sanitation and Quality

NMCG	National Mission for Clean Ganga
NRDWP	National Rural Drinking Water Programme
NRDWP	National Rural Drinking Water Programme
PDMC	Project Development and Management Consultant
PFMS	Public Financial Management System
PIB	Press Information Bureau
PIU	Project Implementation Units
PMAY	Pradhan Mantri Awas Yojna
PMU	Project Management Unit
PPP	Public Private Partnership
R&D	Research and Development
RLB	Rural Local Bodies

SAGY	Sansad Aadarsh Gram Yojana
SBM	Swachh Bharat Mission
SC	Scheduled Caste
SHPSC	State High Powered Steering Committee
SMMU	State Mission Management Unit
SNA	Single Nodal Agency
ST	Scheduled Tribes
STP	Sewage Treatment Plant
SWAP	State Water Action Plan
UC	Utilization Certificate
ULB	Urban Local Body
UT	Union Territory

WQMS	Water Quality Monitoring System

Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Ministry of Jal Shakti, Jal Jeevan Mission (JJM), National Mission for Clean Ganga, Press Information Bureau (PIB), Union Budget of India

6.8.3. THE ATAL MISSION FOR REJUVENATION AND URBAN TRANSFORMATION 2.0 (AMRUT 2.0)

On October 1, 2021, the Government of India launched the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 2.0, as a continuation of the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) launched in 2015 by the Ministry of Housing and Urban Affairs, with additional incorporation of the circular economy of water, through influencing water source conservation, rejuvenation of bodies of water and wells, recycling and reuse of treated used water, and rainwater harvesting, to make cities water secure and self-sustainable. It has introduced Pey Jal Survekshan as a challenge process under AMRUT 2.0 to assess the compliance of service level benchmarks with respect to the quality, quantity, and coverage of water supply in a city, with the first phase covering 500 cities. This will also evaluate the steps taken to reduce non-revenue water through water clusters, water body rejuvenation, and skill development. The extension of the project will include a robust technology-based portal that will be used to monitor the mission through geo-tags which have been installed at the project sites. Moreover, through the technology sub-mission, it will also bring in the world's leading technologies in the water sector since entrepreneurs and new businesses will be encouraged to participate and bring in reforms in the water ecosystem. The mission involves cities to monitor their assessment of water sources, consumption, future needs, and water losses using a city water balance plan. A public information, education, and communication (IEC) campaign will also be launched to raise public awareness about the importance of water and the need for conservation. The results of the projects would be translated into effective city water action plans which will be compiled into the State Water Action Plan and approved by the Ministry of Housing and Urban Affairs.

The mission puts key emphasis on water demand management, water quality testing, and water infrastructure operations which will be handled by women Self-Help Groups (SHGs) to ensure recruitment of women and youth into the program to obtain crucial feedback on the progress. These women would be trained through a programme led by the Public Health Engineering Department (PHED) or water and sewerage boards, with oversight from the State's urban development department, to test water quality and develop detailed City Water Balance Plans (CWBPs) and City Water Action Plans (CWAPs) based on the prevailing situation. It proposes some key function outcomes which would be put special focus on during implementation. Providing universal piped water supply with household water tap connection is one component which is being worked on by ensuring freshwater treatment, proper water distribution systems in uncovered areas, augmentation of existing water distribution system, sustainability of quality and quantity of water supply, and reuse of treated used water, amongst other measures. Another crucial objective is providing universal sewerage and septage management coverage in the cities and promoting the circular economy of water which requires construction of necessary interception and diversion (I&D) infrastructure and sewage treatment plants (STPs), management of faecal sludge and septage, sewerage system provision and rehabilitation with end-to-end treatment and reuse, and identification of the bulk users of recycled used water to facilitating the sale of used water to potential users. Furthermore, rejuvenation of water bodies for supplementing water and increasing amenity value along with the development of green spaces is another fundamental intent the mission aims to achieve through desilting, embankment strengthening, and stone packing for revitalization of wetlands and water bodies, diversion of polluting drains to treatment plants, strengthening of aquifers and community wells, and creation and better facilitation of storm water drains around water bodies.

The operation also includes an Urban Aquifer Management Plan (UAMP) which prioritizes the preservation of positive groundwater balance in urban aquifer systems. The development of this roadmap will ensure that cities strategize groundwater recharge augmentation for improving rainwater harvesting within city limits. Moreover, it encourages cities to map aquifers to identify recharge and discharge zones and integrate aquifer management into urban planning to further create an annual groundwater balance report to determine current and future groundwater availability. UAMP also aligns with the aim to make every city achieve universal coverage and become water secure. Another crucial objective is reduction of non-revenue water, which is the water lost before reaching the end user, to less than 20%. This can be accomplished by regularizing illegal connections and reducing pipe damage leakage in the distribution system through timely detection and resolution of complaints. Furthermore, measuring stations at the source, storage, and distribution have evaluation criteria which must be adhered to for every metered connection. A proactive approach is being undertaken to train plumbers and infrastructure managers to ensure minimal disruptions and a functional and easy to use mobile application for pipe reporting is being developed. These proceedings will boost the operation of supply projects oriented towards 24x7 supply in the regions. The project puts emphasis on recycling of used treated water to meet at least 20% of total city water demand by following institutionalization mechanisms for checking the quality, treatment capacity of sewage treatment plants (STP), treated recycled water used, and sector specific percentage of recycled water usage. These steps propose a remarkable reduction in sewage and septage. It also targets water availability 24x7, with sufficient improvement in the quality to provide the option of drinking from the tap in designated wards. The continual supply will further be evaluated specifically for quality, accessibility, and availability of water to the citizens. The incentive-based reforms implemented for achieving the desired targets of restoration of urban water bodies, reduction of non-revenue water, installation of rainwater harvesting systems in all institutional buildings, and reuse of treated wastewater are expected to bolster the program’s progress by making the alternatives look more lucrative, encouraging wide adoption.

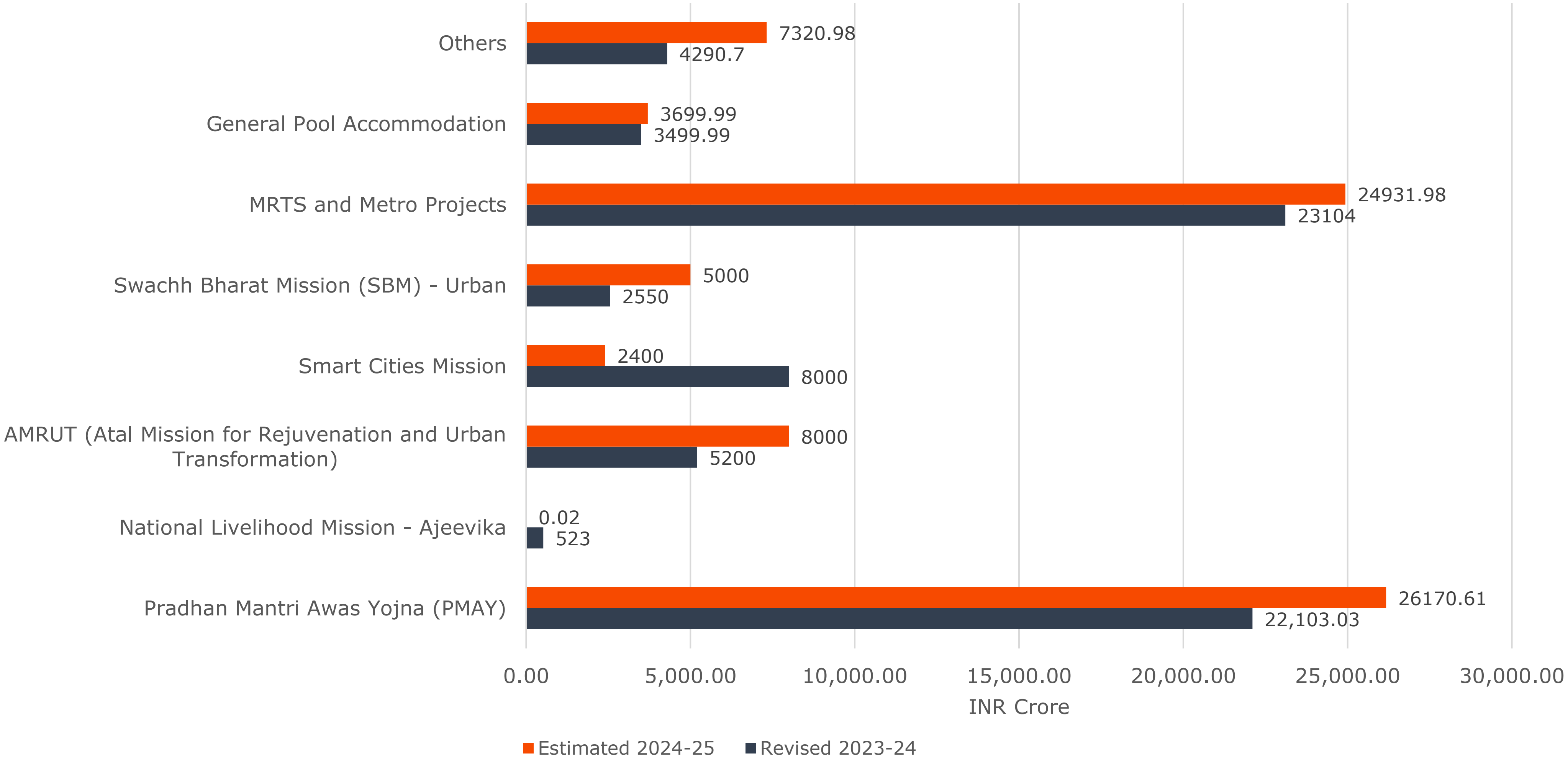
Governance reforms are an elementary part of the whole proceeding. They work towards easing the procedure of obtaining water and sewer connections simple for households by reducing the documents required and dropping the incurred costs. The Pey Jal Survekshan initiative will incentivise cities to keep improving and updating the existing system by fostering healthy competition between cities on the parameters of water supply management, innovative practices, compliance of water supply service level benchmarks, reduction in non-revenue water, operational efficiency of sewage and water treatment plants, rejuvenation of water bodies and wells, and evaluation of collection, treatment, and reuse of treated used water. Frequent feedback collection from citizens and municipal officials, and laboratory testing of water samples will ensure effectiveness of the initiative. Furthermore, it supports developing synergies between the rural and urban regions for better project facilitation. The co-treatment of sewage from villages close to each other in excess capacity would be investigated for installation of STPs to improve water security in rural regions and speed up the reutilization of treated water. It further extends to establish urban-urban synergies to make the procedure viable for the urban local bodies (ULBs) which have populations of less than 10,000 people. Water supply projects for such ULBs are made techno economically sustainable by forming clusters of adjacent ULBs, which share a common intake line from a distant water source, which makes accomplishing the sustained water supply initiative more feasible and financially practical. A capacity building convergence between urban and rural areas is also widely encouraged in the mission.

AMRUT 2.0 recognises the importance of wells and aquifers, owing to the heavy reliance of the urban population on these systems. It intends to prioritize urban aquifer system management in its pursuit of water-secure cities by developing sound groundwater resource management strategies, with a particular emphasis on groundwater dependence, key characteristics of the city's aquifer systems and the availability of recharge potential within city limits. Moreover, it promotes and encourages citizen participation in groundwater management in cities. The urban local bodies would be required to enhance their technical capacities to facilitate a scientific approach to groundwater aquifer system management and would be responsible for monitoring groundwater usage, identifying aquifer potential, and identifying recharge opportunities. The mission essentially plans to develop protocols for running a scientific routine around data collection on groundwater resources to aid in the development and refinement of an aquifer management plan. It intends to start a behavioural change communication (BCC) through information dissipation, education, and persuasion of people to raise awareness about water conservation practises, municipal services such as the new water connection, optimal water usage and waste reduction, and established markets for treated used water in rural and peri-urban areas. Additionally, it will instil a sense of ownership of water supply infrastructure in citizens to encourage proper conduction of the proposed measures. It is an effective approach applied to improve water quality, ensure a constant water supply, provide sewerage facilities and septage management, install effective drainage systems to reduce flooding, and enhancing city amenity value by creating and upgrading green spaces to enhance the living conditions and extend basic requirements to households in the AMRUT cities which will show progress in terms of water security and improve the quality of life for all urban dwellers, especially the poor and the disadvantaged.

6.8.3.1. BUDGETARY ALLOCATION FOR AMRUT 2.0

The Ministry of Housing and Urban Affairs is engaged in policy developments, manages the operations of numerous organisations at the state and municipal level, and oversees programmes for urban development. Additionally, it offers financial support to states and urban local bodies (ULBs) through several centrally backed programmes. The total expenditure of Ministry of Housing and Urban Affairs' projected budget for 2024–2025 is estimated to be **INR 77,523.58 crore**. Various centrally sponsored schemes, and a few central sector schemes are being carried out by the Ministry. Some of these include Pradhan Mantri Awas Yojna (PMAY), National Livelihood Mission – Ajeevika, AMRUT (Atal Mission for Rejuvenation and Urban Transformation), Smart Cities Mission, Swachh Bharat Mission (SBM) – Urban, Mass Rapid Transit System (MRTS), and Metro Projects, General Pool Accommodation, and others.

FIGURE 55. BUDGETARY ALLOCATION FOR MINISTRY OF HOUSING AND URBAN AFFAIRS



Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

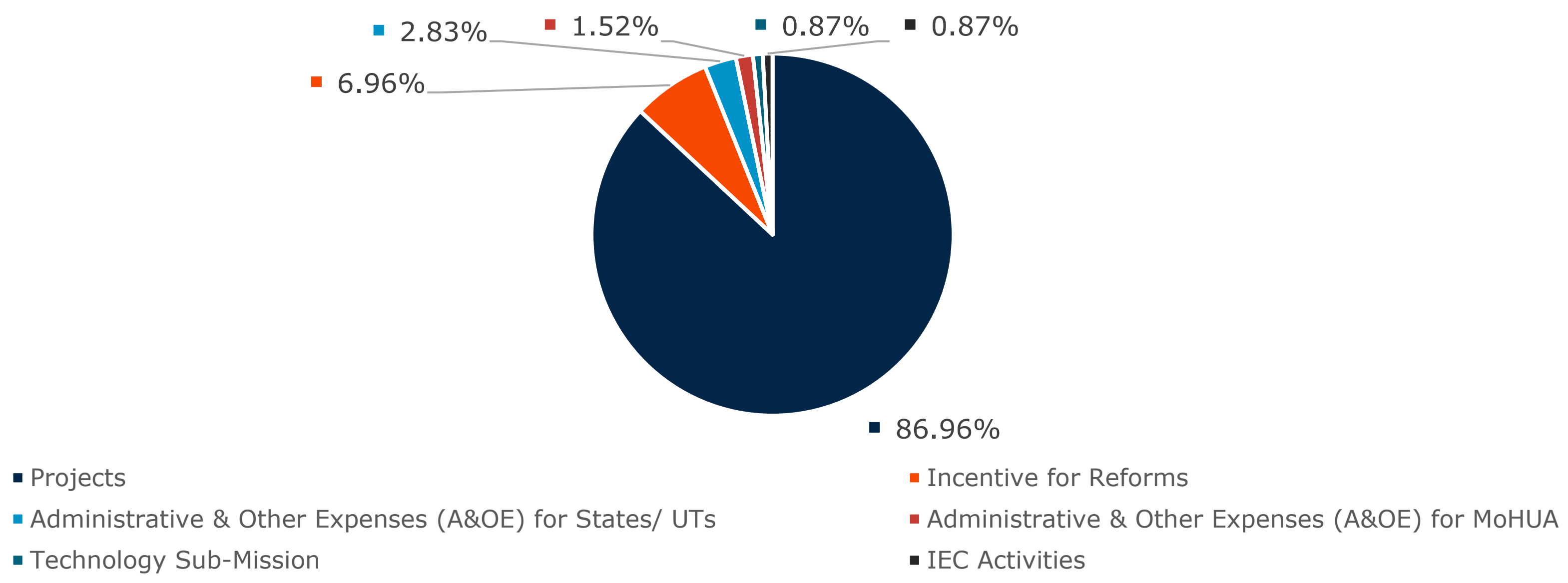
TABLE 14. BUDGETARY ALLOCATION FOR MINISTRY OF HOUSING AND URBAN AFFAIRS

SR.NO	SCHEMES	REVISED BUDGET 2023-2024 (INR CRORE)	ESTIMATED BUDGET 2024-2025 (INR CRORE)
1	Pradhan Mantri Awas Yojna (PMAY)	22,103.03	26,170.61
2	National Livelihood Mission - Ajeevika	523.00	0.02
3	AMRUT (Atal Mission for Rejuvenation and Urban Transformation)	5,200.00	8,000.00
4	Smart Cities Mission	8,000.00	2,400.00
5	Swachh Bharat Mission (SBM) - Urban	2,550.00	5,000.00
6	MRTS and Metro Projects	23,104.00	24,931.98
7	PM-SVANIDHI	3,499.99	3,699.99
8	Others	4,290.70	7,320.98
	Total	**69,270.72**	**77,523.58**

Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

The Ministry's total budget allocation has surged by 12% from INR 69,270.72 crore in 2023-2024 to INR 77,523.58 crore in 2024-2025. Notably, Pradhan Mantri Awas Yojna (PMAY) has experienced a substantial boost of INR 4,067.58 crore. Similarly, AMRUT has witnessed an increase of INR 2,800 crore, underscoring the government's persistent focus on urban renewal. The allocation for Swachh Bharat Mission (SBM) - Urban has doubled, signaling a renewed commitment to urban sanitation. However, there's a noteworthy decline in the allocation for the National Livelihood Mission - Ajeevika, prompting further investigation into the underlying reasons for this shift. AMRUT 2.0 boasts a total outlay of INR 2,99,000 crore, spanning seven years. Existing projects under AMRUT will continue to be centrally funded until March 31st, 2023.

FIGURE 56. THE CENTRAL BUDGETARY ALLOCATION FOR VARIOUS MISSION COMPONENTS



Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

TABLE 15. THE CENTRAL BUDGETARY ALLOCATION FOR VARIOUS MISSION COMPONENTS

SR.NO	MISSION COMPONENT	CENTRAL ALLOCATION (INR CRORE)	SHARE IN %
1	Projects	66,750	86.96%
2	Incentive for Reforms (8% of project CA allocation)	5,340	6.96%
3	Administrative & Other Expenses (A&OE) for States/ UTs (3.25% of project CA allocation)	2,169	2.83%
4	Administrative & Other Expenses (A&OE) for MoHUA (1.75% of project CA allocation)	1,168	1.52%
5	Technology Sub-Mission (1% of project CA allocation	667	0.87%
6	IEC Activities (1% of project CA allocation)	667	0.87%

Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

Under the AMRUT the approved plan size for Union Territory (UT) of Puducherry is **INR 64.91 crore** that is entirely funded by the Central share through the entire mission period. Through the AMRUT scheme a total three cities of UT of Puducherry are being covered. Thus, for the project implementation **INR 44.09 crore** have been released, over which Utilization Certificates (UCs) being received is of **INR 32.68 crore**. For the UT of Puducherry 24 project of worth **INR 60.52 crore** have been assigned through the AMRUT initiative in which 15 projects of **INR 19.41 crore** had been completed, 6 projects are under implementation of **INR 25.03 crore** and 3 projects are being under tendering that worth of **INR 16.08 crore**. Hereby, the work of **INR 36.65 crore** is physically completed for this UT of Puducherry.

TABLE 16. STATE-WISE CENTRAL FUND ALLOCATION UNDER AMRUT - 2.0 (INR CRORE)

STATE/UT	CENTRAL FUND ALLOCATION FOR PROJECTS	CENTRAL FUND ALLOCATION FOR A&OE (ADMINISTRATIVE & OTHER EXPENSES)
Andaman and Nicobar Islands	35	1.14
Andhra Pradesh	3,158	102.62
Arunachal Pradesh	225	7.31
Assam	770	25.02
Bihar	2,620	85.14
Chandigarh	170	5.52
Chhattisgarh	1,294	42.05
Dadra - Nagar Haveli & Daman – Diu	30	0.97

Delhi	2,880	93.58
Goa	85	2.76
Gujarat	4,500	146.22
Haryana	1,494	48.55
Himachal Pradesh	252	8.19
Jammu and Kashmir	856	27.82
Jharkhand	1,178	38.28
Karnataka	4,615	149.96
Kerala	1,372	44.58
Ladakh	124	4.03
Lakshadweep	2	0.06
Madhya Pradesh	4,045	131.44

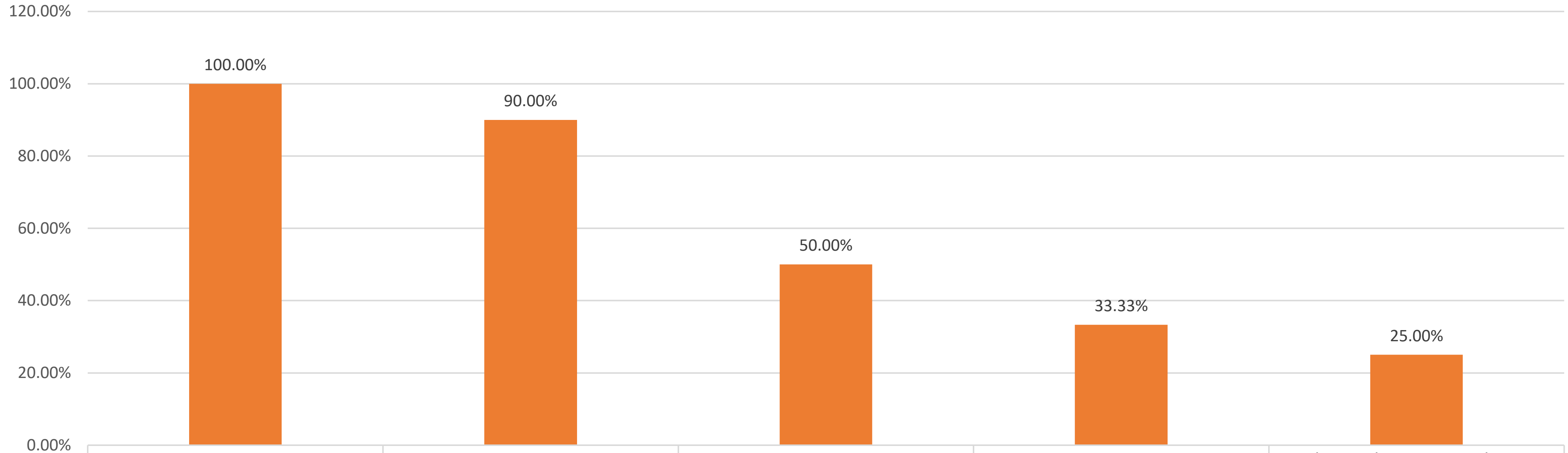
Maharashtra	9,285	301.71
Manipur	169	5.49
Meghalaya	110	3.57
Mizoram	142	4.61
Nagaland	175	5.69
Odisha	1,363	44.29
Puducherry	150	4.87
Punjab	1,833	59.56
Rajasthan	3,530	114.71
Sikkim	40	1.30
Tamil Nadu	4,935	160.36
Telangana	2,780	90.33

Tripura	156	5.07
Uttar Pradesh	8,145	264.67
Uttarakhand	582	18.91
West Bengal	3,650	118.6
Grand Total	**66,750**	**2,169.00**

Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

The Centre, States/ UTs and ULBs will share the funding for the projects.

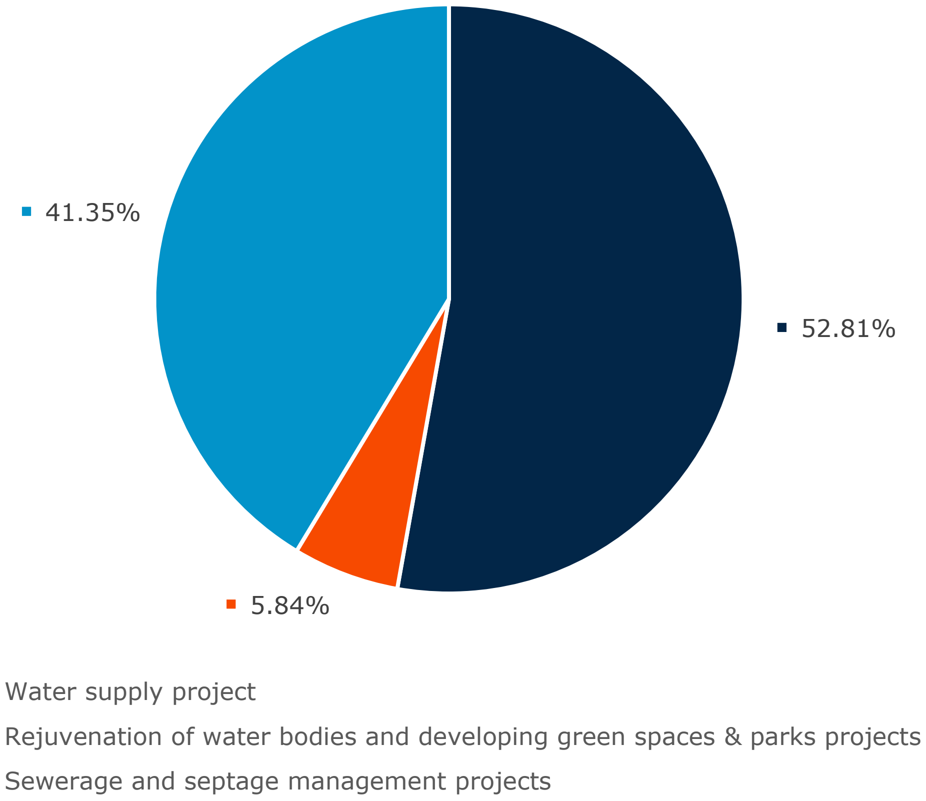
FIGURE 57. CENTRAL SHARE FOR VARIOUS CLASSES OF ULBS (URBAN LOCAL BODIES)



	Union Territories	North eastern States and Himalayan States	With less than one lakh population	With population one lakh to ten lakh (both included)	With population more than ten lakh (except for projects taken up under PPP mode)
Central share	100.00%	90.00%	50.00%	33.33%	25.00%

Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

FIGURE 58. TENTATIVE DISTRIBUTION OF CENTRAL FUND ALLOCATION AMONG PROJECT COMPONENTS OF MISSION



Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

TABLE 17. TENTATIVE DISTRIBUTION OF CENTRAL FUND ALLOCATION AMONG PROJECT COMPONENTS OF MISSION

SR.NO	DESCRIPTION	CENTRAL SHARE (INR CRORE)	SHARE IN %
1	Water supply projects	35,250	52.81%
2	Rejuvenation of water bodies and developing green spaces & parks projects	3,900	5.84%
3	Sewerage and septage management projects	27,600	41.35%

Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

If universal water supply is attained at the city level, then other components that are acceptable can be utilized to accomplish mission goals. As top priority, the State Mission Directorate needs to ensure that all cities have access to universal water supply and sewage/sewage treatment.

- **Release of Funds**

1. General conditions for release of project funds

- The central assistance would be conducted through online claims and settlement system that would be developed from the actual progress, which is updated on portal through various parameters including, physical/ financial data, videos and photos that can be collected through third-party assessment and citizen feedback.

- In this mission the fund flow would be followed by the instructions provided by the Ministry of Finance OM No. F. No. 1(13) PFMS |FCD/2020, dated 23 March 2021.
- The central fund that is being allocated to the States/UTs for project would be performed by distributing entire central project funds which is of **INR 66,750 crore** among these States/UTs in which weightage will be given to the urban population and area of States/ UTs in ratio 90:10.
- Through the AMRUT 2.0 states need to ensure that the further allocation to the cities must be in-line with accomplishing for all ULBs with universal coverage of water supply and universal coverage of sewerage/ septage management in 500 AMRUT cities. In the case where if city has already obtained universal coverage of water and sewerage then it will be considered into City Water Balance Plans (CWBP) and through AMRUT 2.0 further initiatives can be taken for enhancing the city water secure. Whereas the city in which the supposed outcomes are fulfilled by any other funding sources rather than AMRUT 2.0, that must be distinctly stated in the format offered for the same purpose in City Water Action Plan (CWAP).
- The functional outcomes that are being obtained above the baselines such as, 1st of November 2021 that are being funded by the other sources rather AMRUT/AMRUT 2.0 would also get grant of funding. These other sources may include State Funds, XV Finance Commission grants, ULB funds and funds offered by the external agencies.
- Based on total amount of State Water Action Plan (SWAPs) submitted and the application proportion for the category of the State/City the Admissible Central Assistance (ACA) will be determined.
- The total project fund release through all the instalments to a State/ UT would not surpass the central fund allocation.
- For specific tranche of State Water Action Plan (SWAP), the Central Assistance (CA) released would be used for the employment of the permitted projects of another tranche. As per physical/ financial progress of the projects States/ UTs may use CA for projects in any of the ULBs.

2. Release of project funds (other than PPP)

The Central Assistance (CA) for the States/ UTs can be categorized into two components such as, Component-1 and Component-2.

- **Component-1**

Component-1 consists of CA for projects that are granted through the State Water Action Plan (SWAPs) that can be offered in three instalments of 20:40:40.

- **First instalment under component 1**

This would count for 20 percent of CA admissible over the SWAP provided by the State/ UT and which is also approved the Apex Committee.

This can be claimed into three almost equal tranches over the submission and approval of individual tranches of SWAP.

- **Second Instalment under component 1**

It would count for 40 percent of total CA for the State/UT.

The projects under the AMRUT 2.0 that are being awarded contracts would be authorized for the consideration for release of second instalment.

For the working out instalment, the approved cost of projects is considered as basis. This cost may be lesser than appraised cost and contract award cost.

The following factors need to be gained before claiming second instalment:

- The projects that have gained 15 percent physical and financial progress would be applicable for the second instalment. And the work for the project needs to be initiated on site.
- For the submission of City Aquifer Management Plan, the criteria for the states would be minimum 20 percent AMRUT cities of that state with first tranche of SWAP, 30 percent AMRUT cities with second tranche and rest 50 percent AMRUT cities with third tranche of SWAP. The states that have less than ten AMRUT cities need to provide City Aquifer Management Plan with third tranche.
- Need to submit Utilization Certificate (UC) of Administrative and Other Expenses (A&OE) grants and reform incentive.
- Need to submit IRMA's (Independent Review and Monitoring Agency) evaluation of AMRUT 2.0 that need to be appointed by Ministry of Housing and Urban Affairs (MoHUA) and State/ UT need to submit Action Taken Report (ATR) and IRMA's compliance report.
- Consideration of citizen feedback.

- **Third instalment under component 1**

Third instalment under component-1 would count for 40 percent of admissible central assistance (ACA) to the State/UT which can be completely released after the expected functional outcomes achieved through AMRUT 2.0 projects.

TABLE 18. THIRD INSTALMENT UNDER COMPONENT-1

SR.NO	OUTCOME	FORMULA FOR WORKING OUT 3RD INSTALMENT
1	Tap connections (both new and serviced through augmentation)	(0.4) X (ACA for water supply projects) X (WA/ WT)
2	Sewer/ septage connection (both new and serviced through augmentation)	(0.4) X (ACA for sewerage/ septage projects) X (SA/ ST)
3	Water body rejuvenation projects	(0.4) X (ACA for Water body rejuvenation projects) X (WBA/ WBT)
4	Parks & green spaces	(0.4) X (ACA for Parks & green spaces projects) X (PA/ PT)

Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

TABLE 19. DESCRIPTION OF TERMS IN THE ABOVE TABLE

SR.NO	OUTCOMES	ACHIEVEMENT THROUGH AMRUT 2.0	CUMULATIVE TARGET UNDER AMRUT 2.0
1	Number of new household water tap connections provided + number of tap connections serviced through augmentation + tap connections provided with 24x7 water supply as per real outcomes.	WA	WT

2	Number of new household sewer connections provided + sewer connections serviced through new sewerage network + households covered with septage management + households covered with tertiary treatment	SA	ST
3	Number of water body rejuvenation projects completed under AMRUT 2.0	WBA	WBT
4	Number of parks projects completed under AMRUT 2.0	PA	PT

Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

Sum of all above will be the admissible amount of third instalment. This is an illustration. Actual apportionment of third instalment for projects will be based on achievement of actual outcomes pertaining to those projects.

The admissible amount of third instalment would be sum of all above. This is only for illustration purposes, on the basis of actual results related to those initiatives, the third instalment's actual distribution will be determined.

Three authorized tranches of SWAPs may be used to claim the third instalment.

- **Component-2**

Each additional household water tap connection installed in ULBs above the baseline as of 1st November 2021 will get funding at a rate of **INR 3,000 (three thousand)**.

Also, financing will be paid at a rate of **INR 3,000 (three thousand)** for each new household sewer connection installed in all 500 AMRUT ULBs over the baseline as of 1st November 2021.

For the aforesaid funding, only new connections that are not supported by AMRUT and AMRUT 2.0 will be taken into consideration.

After the baseline is established, funds for these outcomes may be claimed once every three months in tranches.

After careful verification using citizen feedback and third-party sources, funds will be disbursed.

The State/ UT/ ULB need to utilize the funds that are being offered through component-2 on components of AMRUT 2.0 only.

3. **Funds for projects implemented in PPP (Public Private Partnership) mode.**

The State/ULB would create an adequate financial model and determine the viability gap for projects that are slated for implementation under the PPP model in cities having a population of more than ten lakhs. A project's overall viability gap cannot be greater than 60 percent of the total cost. The viability gap of 50 percent, which does not exceed over 30 percent of project cost would be allowed to be funded as CA.

As with non-PPP projects, the CA developed for such projects will be made available in three instalments. Following the completion of the PPP project's financial model and DPR (Detailed Project Report) approval, the first instalment, of 20 percent of the allowable CA, will be released.

On reaching 15% of the project's physical and financial progress, a second instalment of 40 percent of the allowable CA for PPP projects will be released. When functional results are reached, the third instalment will be made available. The State/ULB will pay the annuity over the specified time in accordance with the financial model. States may enable ULBs to establish escrow accounts for assuring smooth fund flow to boost confidence in PPP contracts.

4. Administrative and Other Expenses (A&OE) for States & MoHUA

The States/UTs will receive 3.25 percent of the annual budget allotment. As per urban population and area in the ratio 90:10 of States/ UTs/ ULBs, the State A&OE funds will be distributed accordingly.

At the initial stage of the mission, the state will receive A&OE funds. The state will also receive some fundings for the set-up State Mission Management Units such as Project Development and Management Consultant (PDMC). The state will receive INR 20 lakhs for each AMRUT City to enable ULBs for the preparation of City Water Balance Plans (CWBPs), which will be distributed to each AMRUT ULB based on their claim in SNA account, and INR 10 lakhs to the remaining ULBs. This further can also be utilized to create separate units for the management of missions in ULBs. For initializing mission states need to take immediate initiatives to bring resources on board to aid the cities and parastatals.

The states and UTs need to submit A&OE action plan along with SWAPs. here will be two instalments of the annual A&OE allocation given to a State or ULB. Following receipt of the A&OE action plan, the first instalment for the first year will be released. Upon receipt of online claims and UC worth at least 75 percent of the central aid already issued, the second instalment will be made available. In the following years, the first instalment will be issued on receipt of action plan and UC count of 75 percent for the previous yearly A&OE fund issued. The amount of eligible A&OE funding will be limited based on the proportion of actual spending.

The state A&OE funds can be spent for several factors as mentioned below:

- Capacity building, preparation of CWBPs, Programme Management/ Implementation Unit (PMU/ PIU)
- Project Development and Management Consultant (PDMC), State Mission Management Unit (SMMU)
- City or City cluster Mission Management Unit (CMMU)
- Preparation of Detailed Project Reports (DPRs)
- Publications like e-Newsletter, guidelines, brochures etc., promotional activities for Mission
- Display of the logo and tagline of AMRUT 2.0 prominently on all projects
- Reform implementation

The North-Eastern and Himalayan States would require additional handholding for effective project execution owing to smaller size and lower number of ULBs. MoHUA may send out extra support/ experts/ institutions upon written request to enhance capabilities. In the PDMCs/PMUs, representatives from local technical institutions, universities and colleges may be employed.

Hydrogeologists and data analysts can also be part of Mission management units at the State, regional, and city levels along with water sector experts. If there is need for model guidance document for hiring of these members, then that will be provided by the MoHUA.

At the National Mission Directorate level, the A&OE funds for MoHUA will be used for the following:

- Capacity building
- Convening national & regional workshops,
- Conferring awards and recognition, up-scaling, and replication of best practices & smart solutions

- Commissioning of research and applied studies through Center of Excellence and other institutions
- Independent Review and Monitoring Agency (IRMA) to be positioned at State/ Substate/ regional level.
- Feedback using gig economy model.
- International cooperation for capacity building and technology development, among others.
- Pey Jal Survekshan components

The indicative list of inadmissible components under A&OE includes:

- Purchase of land for projects or project related works
- Regular staff salaries of State Governments/ULBs
- Any other purpose not oriented towards achieving Mission objectives

5. Reform incentives

For reform incentive the total fund of **INR 5,340 crore** has been set aside. The States/UTs will receive reform incentive of 8 percent of the annual budget each year for accomplishment of Reforms from second year of mission onwards. Incentives for reforms carried out in a year are given in the next fiscal year. Along with SWAPs, States/UTs need to submit a reform roadmap.

A marking system toolkit will be released prior to the start of the fiscal year. This toolkit will comprise of a description of the process for evaluating reforms and creating incentives for the States and UTs.

In-line with accomplishing mission objectives as an untied fund, the incentive may be utilized in mission cities on AMRUT 2.0 components that are admissible. The utilization of incentive amount will be determined by the State High Power Steering Committee (SHPSC).

As per Ministry of Finance requirements (MoF), UCs against disbursed incentives need to be submitted on time. The funds which were not utilized will be transferred to the project fund each year.

6. Fund flow

For the submission of CWBPs there would be need of adopting Public Financial Management System recommended by the Ministry of Finance. According to the revised procedure for fund release outlined in Department of Expenditure (GoI)’s OM No. F. No. 1(13) PFMS |FCD/2020, dated 23rd March 2021, as updated from time to time all transactions to receive funds under AMRUT 2.0 must be made through Single Nodal Agency (SNA) by using EAT as applicable.

6.8.4. JAL JEEVAN MISSION- HAR GHAR JAL

The Jal Jeevan Mission (JJM) was initiated on August 15, 2019, by the Government of India with the intention to provide Functional Household Tap Connections (FHTC), which have access to safe and adequate drinking water, to every rural household in the country by 2024. The programme also includes mandatory source sustainability measures such as recharge and reuse through gray water management, water conservation, and rainwater harvesting to incorporate a community-based approach to water, accounting for expansive knowledge, education, and communication as vital components. JJM hopes to establish water as a priority for everyone. The vision of the program is bringing in improvement in rural communities' living standards by assuring every rural household to receive adequate quantities of drinking water of prescribed quality daily for an extended time period at affordable service delivery charges. It is focused on assisting, empowering, and facilitating states and union territories to develop a participatory rural water supply strategy to ensure long-term potable drinking water security for every rural household and public institution, such as gram panchayat buildings, government schools in villages, Anganwadi centres, health centres, wellness centres, and other government establishments. Moreover, it will assist in the construction of the necessary water supply infrastructure required for development of functional tap connections for sufficient water supply to households on a regular basis to fulfil the plan's objectives. The gram panchayats and the local rural communities will be responsible for planning, implementing, managing, owning, operating, and maintaining the in-village water supply systems for their corresponding villages. It also empowers states and union territories to plan for drinking water security for a sustained usage for a longer time and promotes for the development of strong institutions focused on service delivery and financial sustainability in the sector. Furthermore, it plans on building stakeholder capacity and raising community awareness about the importance of water in improving quality of life to ensure a smooth operation.

The mission has put forth broad objectives as the foundation to ensure implementation of tap water connections, and a regular and long-term access to adequate and good quality drinking water. Its implementation was followed the National Rural Drinking Water Programme reported, on March 31, 2019, only 18.33% households having tap water connections, signalling the dire need of an initiative to expand provisioning of tap water connections. It follows a holistic and integrative approach of involving the gram panchayat and its sub-committees along with the local community and stakeholders in the critical steps of planning, implementation, management, operation, and maintenance of water supply within villages by effectively recognising the lack of reach of the state government department to the bottommost level for management of water supply to every household, making it more inclusive of the community with better recognition of problems are potential solutions existing on ground. Moreover, it allows for the formation of a separate technical cadre for planning and implementation to ensure necessary involvement of the local community and the gram panchayat in operations and maintenance (O&M), cost recovery, and good governance to see the desired results. It plans on a community-led collaboration with states to be an effective strategy for achieving JJM objectives as communities can take up the onus of ensuring every rural household has FHTC delivering water at least 55 litres per capita per day, which has been set as the adequate minimum quantity required. Local action and inclusion of the state government as true facilitators will make the approach viable in the long-term.

Rural women and adolescent girls spend a significant amount of time and energy in obtaining water for daily use which results in their lesser participation in income-generating activities, gender discriminated school enrolment ratios, and poor health. The plan identifies these issues and targets to have a multitude of impacts which will play an important role in bringing ease of living to the rural community, particularly women. It promotes women to lead with the initiative in their villages to better incorporate their problems and ensure equitable benefits are obtained. It has designed FHTC to be provided in every household with three delivery points through taps, including kitchen, washing, and bathing area, and toilet, with only one tap funded, to keep water clean and prevent misuse. It has structured the rural water supply infrastructure built over the years to be dovetailed, retrofitted, and renovated to provide functional FHTCs. It has provisioned for the same local water source to be used in villages with sufficient groundwater availability of prescribed quality within the village boundary owing to the availability of technologies for providing safe water from contaminated groundwater sources with the government department. In villages with functional hand pumps, it allows for a depth deepening to meet the service delivery level and safeguard the basic water needs. Because of the development and increased application of new technologies, the mission stimulates exploration and prioritization of gravity and solar power-based water supply schemes with low O&M expenditure in tribal regions, and hilly and forested areas. Moreover, spring water is another reliable source of drinking water widely present in hills and mountains which will be optimally utilized with technological advancement for requirement fulfilment. The utilization of solar energy for water procurement in hot regions and deserts will also be surveyed with a possibility of technology intervention.

The plan also emphasizes on the specifics pertaining to each region, increasing outreach to more rural areas. It proposes the use of in-situ suitable treatment technology in villages with sufficient groundwater availability but quality issues. In villages which have water quality issues and a lack of suitable surface water sources in the nearby area, it recommends conjunctive use of multiple sources of water. Similarly, for villages in drought-prone areas, a combined implementation of multiple sources of water such as ponds, lakes, rivers, groundwater, supply from a long distance, rainwater harvesting, and artificial recharge will be considered. In water-scarce states with insufficient rainfall, it is developing regional water supply schemes covering both urban and rural areas by sourcing water from a single perennial source. Furthermore, it is working on planning a new water supply scheme in peri-urban sectors and large villages in water-scarce areas with a dual-piped water supply system, covering fresh water in one and treated wastewater in the other pipe to save precious fresh water. The wastewater pipe would contain treated water which will be suitable for non-potable needs, such as gardening, and use for toilet flushing and cleaning. The households will be prompted to use faucet aerators to save significant amounts of water within their homes, lessening the burden. It also mentions provisioning of potable water, on priority, in water quality-affected habitations, specifically with arsenic and fluoride contaminants to avoid poisoning. It accounts to the gradual and time-taking procedure of planning and implementation of a piped water supply scheme based on a safe water source and recommends establishing Community Water Purification Plants (CWPPs) as an interim measure to provide 8-10 LPCD potable water to meet the drinking and cooking needs of every household residing in such villages and habitations, keeping in mind the safety of the residents.

For source recharging it indents to adopt dedicated bore well recharge structures, and rainwater recharging systems, while focusing on rejuvenation of existing water bodies using watershed and spring shed principles, in collaboration with other schemes such as MGNREGS, IWMP, Finance Commission grants, State schemes, MPLAD, and MLALAD, amongst others. To enhance recharging of aquifers, especially in arid and semi-arid areas, the state government will be required to strengthen and further extend existing canal networks to transfer surplus flood waters from dams and reservoirs to ponds, lakes, rivers and other water bodies which will refill groundwater and also prevent waterlogging during the monsoon season. Program arrangements will be made at all levels, with links and convergence with other organizations, such as the State Water and Sanitation Mission (SWSM), and the District Water and Sanitation Mission (DWSM) for superior outcomes. The collaborative approach will be included in the State Action Plan (SAP) and District Action Plan (DAP) to target long-term water security. These policies include an appropriate incentive and disincentive mechanism to discourage water waste while also meeting recurring expenditures on bulk water transfer, treatment, distribution network, and household level supply. Furthermore, the state government and UT Administration will assist the village level committee in making decisions on user charges for providing household connection as well as water supply by contemplating to achieve the lowest possible cost of water supply systems. The department monitors water quality through laboratory tests, while the community monitors water quality through Field Test Kits (FTKs) and sanitary inspection, ensuring proper sanitation guidelines are being followed. Provisioning of 24 X 7 water supply is the preference, but the mission provides states the ability to consult with Gram Panchayats for any requirement of individual household storage tanks. All efforts are anticipated to increase community ownership and trust and raise awareness about responsible use. The vision and impetus to this mission is assured availability of potable water, establishment of a functional household tap connection, increased participation by local communities especially women, in water ownership and resource management, improved water transfer and treatment, enhanced water distribution systems and a bottom-up approach to accomplish the desired objectives.

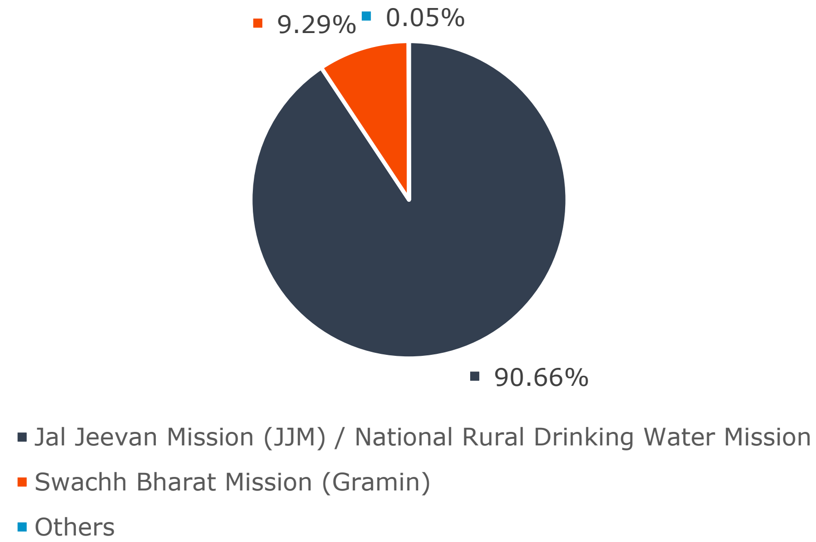
6.8.4.1. BUDGETARY ALLOCATION FOR JAL JEEVAN MISSION (JJM)-HAR GHAR JAL

The Department of Drinking Water and Sanitation was allocated **INR 77,391 crore** in the 2024-2025 estimated budget. This department mainly consists of Jal Jeevan Mission (JJM) / National Rural Drinking Water Mission and Swachh Bharat Mission (Gramin).

Since August 2019, the Indian government is engaged with States to implement Jal Jeevan Mission (JJM). The mission aims to offer regular and long-term access to potable water to every rural household through a tap water connection at a service level of 55 liters per capita per day (lpcd), of the required quality (BIS:10500), by 2024. The anticipated outlay of the mission is of **INR 3.60 lakh crore** in which **INR 2.08 lakh crore** is of Central share.

More than **INR 61,459 crore** in grants have been given to States/ UTs for fiscal year 2023-2024 depending upon performance for offering of household tap water connections and using the available Central grant with a corresponding State share. The Central government has increased the budget for Jal Jeevan Mission to **INR 60,000 crore** for the fiscal year 2022-2023, highlighting the significance of the Har Ghar Jal' Programme.

FIGURE 59. ESTIMATED BUDGETARY ALLOCATION FOR DEPARTMENT OF DRINKING WATER AND SANITATION FOR 2024-2025



Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), Press Information Bureau (PIB), Union Budget of India

TABLE 20. ESTIMATED BUDGETARY ALLOCATION FOR DEPARTMENT OF DRINKING WATER AND SANITATION FOR 2024-2025

SCHEMES	ESTIMATED BUDGET 2024-2025 (INR CRORE)	SHARE IN %
Jal Jeevan Mission (JJM) / National Rural Drinking Water Mission	70,162.9	90.66%
Swachh Bharat Mission (Gramin)	7192	9.29%
Others	35.78	0.05%
Total	**77,390.68**	**100.00%**

Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), Press Information Bureau (PIB), Union Budget of India

TABLE 21. THE FUND DISTRIBUTION UNDER JAL JEEVAN MISSION (JJM) BETWEEN CENTRE AND STATES/ UTS

SR.NO	AREAS	FUND DISTRIBUTION
1	Union Territories without legislature	100%
2	North Eastern & Himalayan States and UTs with legislature	90:10
3	Rest of the States	50:50

Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), Press Information Bureau (PIB), Union Budget of India

TABLE 22. THE FUND DISTRIBUTION FOR SUPPORT AND WATER QUALITY MONITORING SYSTEM (WQMS) OPERATIONS

SR.NO	AREAS	FUND DISTRIBUTION
1	Union Territories	100%
2	Himalayan & North Eastern States	90%
3	Other States	60%

Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), Press Information Bureau (PIB), Union Budget of India

Based on balance households to be offered Functional Household Tap Connection (FHTCs) as per 'per household cost' for various scheme types, the fund requirement for capital expenditure for JJM would be determined. The balance households to be offered with FHTCs were chosen as per data provided by States on Integrated Management Information System (IMIS). For each household the average number of people is considered as five. This was done solely to arrive at total outlay for the Jal Jeevan Mission and would not be utilized to approve schemes.

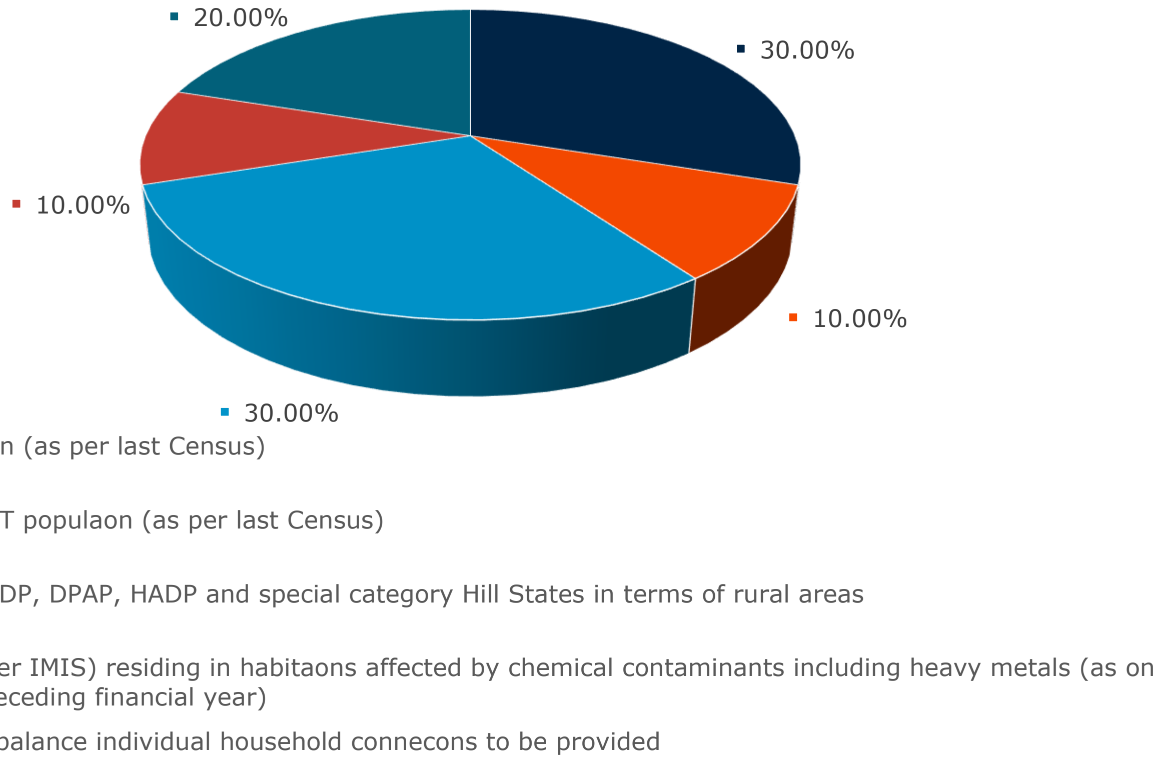
Through this mission, difficult terrains such as those covered by the Desert Development Programme (DDP) and the Drought Prone Area Programme (DPAP) are provided with 30 percentage of weightage, while population living in SC/ST dominated areas are offered with 10 percentage of weightage, aiding on prioritize coverage in these areas. Additionally, villages in drought-prone and desert areas, villages with a SC/ST majority, villages in Aspirational and JE-AES impacted districts, and Sansad Aadarsh Gram Yojana (SAGY) villages have been prioritized for tap water supply connections.

Furthermore, provisions have been made under JJM for pursing the augmentation and strengthening of local & ancient drinking water sources in convergence with other village-level schemes including, Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), 15th Finance Commission tied grants to Rural Local Bodies (RLBs), District Mineral Development Fund, community contribution, Integrated Watershed Management Programme (IWMP) and CSR funds, among others.

Criteria for allocation of fund

For fund distribution under the Jal Jeevan Mission (JJM) there must need to follow certain criteria and weightage for both budgetary and extrabudgetary resources.

FIGURE 60. CRITERIA FOR ALLOCATION OF FUND



Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), Press Information Bureau (PIB), Union Budget of India

Various sub-missions and sub-components which were part of the erstwhile National Rural Drinking Water Programme (NRDWP) would also get funding. This projects also get up to 2 percent of Annual Allocation that would be set aside for the various activities at the Department/ National Mission level including, administrative and capital expenditure related to National Center for Drinking Water, Sanitation and Quality (NCDWSQ) and Department/ National Mission activities including, third party functionality assessment, program management unit (PMU), information, education and communication (IEC) & capacity building, research and development (R&D), workshops, conferences, centre of excellence, action research, professional services, human resource development (HRD), seminars, monitoring and evaluation (M&E), exhibitions and computerizing & management information system (MIS), among others.

TABLE 23. STATE-WISE DETAILS OF FUNDS ALLOCATED, RELEASED AND UTILIZED UNDER JJM IN FY 2023-24 IN INR CRORE

States	Opening Balance (Central Share)	Central Allocation	Central Share Release Upto Month December	State Share Release	Expenditure Release Upto Month December				Unspent Amount (Central Share)
					Total	Central	Expenditure in % age	State	
Andaman & Nicobar Islands	3.09	7.52	3.76	0	0	0	0	0	6.85
Andhra Pradesh	397.87	6530.49	793.57	1068.72	1601.19	760.59	63.84	840.6	430.85
Arunachal Pradesh	288.93	1057.11	771.21	118.04	772.03	687.6	64.86	84.43	372.54
Assam	2447.47	10351.68	5804	795.75	5387.05	4847.35	58.75	539.7	3404.12
Bihar	54.95	0	0	0	0	0	0	0	54.95

Chhattisgarh	273.99	4485.6	2585.56	2772.1	3500.12	1753.9	61.33	1746.22	1105.65
Dadra & Nagar Haveli And Daman & Diu	0	0	0	0	0	0	0	0	0
Goa	0.92	11.25	11.25	16.97	22.03	7.21	59.26	14.82	4.96
Gujarat	1088.66	2982.85	2237.14	2469.75	3013.91	1450.93	43.63	1562.98	1874.87
Haryana	100.7	1053.44	526.72	627.48	841.94	410.61	65.44	431.33	216.81
Himachal Pradesh	547.56	379.67	379.67	104.94	692.46	620.26	66.89	72.2	306.97
Jammu & Kashmir	902.56	9611.31	2867.12	318.1	2464.73	2287.77	60.69	176.96	1481.91
Jharkhand	529.13	4722.76	2675.35	3400.43	3635.1	1657.34	51.72	1977.76	1547.14
Karnataka	1270.33	12623.37	3724.97	8710.43	4145.54	2103.57	42.11	2041.97	2891.73
Kerala	900.69	1342.36	671.18	1446.45	2600.6	1306.83	83.14	1293.77	265.04

Ladakh	280.68	477.11	119.28	0	209.41	209.41	52.36	0	190.55
Lakshadweep	9.25	39.63	19.82	0	0	0	0	0	29.07
Madhya Pradesh	1060.06	10297.86	5294.9	5946.4	9007.36	4508.83	70.95	4498.53	1846.13
Maharashtra	2363.58	21465.88	5583.2	7935.14	10408.27	5072.95	63.84	5335.32	2873.83
Manipur	164.42	110.54	0	17.04	53.13	47.04	28.61	6.09	117.38
Meghalaya	369.49	3567.25	1013.85	142.35	1124.57	1012.03	73.16	112.54	371.31
Mizoram	121.27	425.46	303.1	44.5	278.88	251.51	59.27	27.37	172.86
Nagaland	19.57	366.86	275.15	44.02	235.83	202	68.54	33.83	92.72
Odisha	799.56	2108.54	1581.41	2298.72	2560.83	1284.56	53.95	1276.27	1096.41
Puducherry	5.4	15.39	1	0.57	5.85	5.28	82.55	0.57	1.12

Punjab	0	479.02	119.76	315.19	115.56	46.64	38.95	68.92	73.12
Rajasthan	3431.69	3019.94	0	2838.95	4861.67	2404.38	70.06	2457.29	1027.31
Sikkim	79.29	634.55	251.61	27.3	225.87	204.74	61.87	21.13	126.16
Tamil Nadu	812.6	3615.56	1744.73	2522.02	3067.36	1532.7	59.93	1534.66	1024.63
Telangana	26.06	0	0	0	0	0	0	0	26.06
Tripura	227.01	1773.4	594.18	106.85	618.84	558.82	68.05	60.02	262.37
Uttar Pradesh	2478.12	20884.45	15808.05	18757.05	29225.64	14150.96	77.39	15074.68	4135.21
Uttarakhand	297.46	4689.69	1890.66	600.33	1686.46	1515.97	69.28	170.49	672.15
West Bengal	1751.06	3806.29	3806.29	4623.56	5986.37	2915.72	52.47	3070.65	2641.63
Total	**23103.42**	**132936.83**	**61458.49**	**68069.15**	**98348.6**	**53817.5**	**63.64**	**44531.1**	**30744.41**

Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), Press Information Bureau (PIB), Union Budget of India

6.8.5. NAMAMI GANGE PROGRAMME

The **Namami Gange Programme** is an **integrated preservation program** approved as a flagship programme in June 2014, by the Union Cabinet chaired by the Prime Minister to achieve the twin goals of **conservation** and **restoration** of the **National River Ganga** along with **effective pollution abatement**. It makes a transition to an integrated basin-based approach while continuing work on the principles set forth for cleaning of the river previously, including the **GAP-I (Ganga Action Plan)** of 1985, **GAP-II** of 1993, **NRCP (National River Conservation Plan)** from 1995, and **NGRBA (National Ganga River Basin Authority)** formed in 2009. It is being implemented in a phased manner with divisions of **entry-level activities** for immediate visible impact, **medium-term activities** to be implemented within five years, and **long-term activities** to be implemented within 10 years. The initiative was implemented on account of the significant **economic, environmental**, and **cultural value** associated with the river Ganga, in India. Moreover, the river flows more than 2,500 kilometres through the plains of north and eastern India, and the Ganga basin accounts for 26% of India's landmass, making it a consequential component of the nation and a source of water for many citizens. The project covers **8 states**, **47 towns**, and **12 rivers**, comprising the main river and its tributaries. Its elementary objectives include **improving the quality of life** of the people settled on the rivers' banks, setting up a **river-centric urban planning process** to improve citizen connections through interventions at Ghats and riverfronts, expansion of **sewerage infrastructure coverage** in 118 urban habitations along the Ganga's banks, creation of the **Ganga Knowledge Center** for increasing awareness of the people, development of **efficient irrigation methods** and **rational agricultural practices**, and making rural regions **free of open defecation**. The project was launched by the Water Resources Ministry in collaboration with several ministries, working on sustainable environments, urban development, shipping, tourism, and rural development.

It has identified **municipal wastewater** containing sewage, industrial pollution, solid waste, and non-point sources, such as agricultural run-off, open defecation, pious refuse, partially cremated bodies, and associated materials, as the main contaminants of the river which are being effectively handled to achieve the desired results. The project has undertaken **industrial sector development** for pollution control. **Common Effluent Treatment Plants (CETPs)** have been provided to the tannery industries along the riverbank to transition to cleaner processes and reduce water consumption. The paper and pulp sector have achieved advancements in process technology which has resulted in lower freshwater consumption and overall wastewater discharge and a remarkable zero black liquor discharge. Additionally, in molasses-based distilleries, zero liquid discharge is obtained, making the industry cleaner. The switch to charter implementation in sugar production and process technology upgrades have resulted in lower freshwater consumption, effluent generation, and BOD load in sugar industries. Furthermore, the upgradation of the CETP system and the installation of flow meters at various unit processes has resulted in a reduction in the pollution load of textiles. **Hybrid Annuity Models (HAM)** have been introduced to incentivise quick construction of the required infrastructure for satisfactory performance of sewage infrastructure for longer time periods. To combat the problem of solid waste, the project is supporting **Ghat Cleaning** activities in cities along the bank of Ganga, including Haridwar, Bithoor, Kanpur, Prayagraj, Mathura, Vrindavan, and Varanasi. Furthermore, increased emphasis is being put on **river surface cleaning** with trash skimmers being deployed to clean the surface of Yamuna Stretch in Delhi. To accomplish **rural sanitation**, the initiative management is assisting the Department of Drinking Water and Sanitation in ensuring sanitation in Ganga villages. Growing awareness and stringent implementation has resulted in all 4465 Ganga bank villages being given the open defecation free (ODF) status.

The program plans to restore the wholesomeness of the river defined in terms of ensuring **continuous flow** termed as '**Aviral Dhara**', **unpolluted flow** termed as '**Nirmal Dhara**', **geologic** and **ecological integrity** termed as '**Jan Ganga**' and **climatic** and **spatial**

understanding termed as '**Gyan Ganga**'. As a part of its Nirmal Dhara, it is working on building and improving **sewerage infrastructure**, inhibiting **industrial pollution**, **wastewater reuse**, **rural sanitation recycling**, and **solid waste management** for availability of good quality water. Under the Aviral Dhara it is focused on **wetland mapping and conservation**, **floodplain protection**, **sustainable agriculture**, **afforestation**, **biodiversity conservation**, and **small river rejuvenation** for achieving an uninterrupted flow in water bodies. As a part of Jan Ganga, it is developing **riverfront, ghat**, and **crematoriums**, enhancing community engagement, organizing activities such as **Ganga Run, Ganga Amantran** (rafting expedition), and **Ganga Utsav**, and encouraging participation in the **Ganga Quest quiz** to increase awareness. Similarly, Gyan Ganga includes frequent **water quality monitoring**, **high-resolution mapping** of Ganga using **light detection and ranging (LiDAR)**, **microbial diversity aquifer development**, mapping and spring rejuvenation, cultural and climate scenario mapping, and urban river management planning. Continuous and sufficient presence of sediments, nutrients, and other natural constituents throughout the river network improves the natural flow cycle of rivers. **Sustainable agriculture** is critical for Ganga rejuvenation to achieve improved soil health and water efficiency. Moreover, it assists in lowering pollution, balancing ecological services, mitigating climate change, and increasing crop productivity. This has led to the development of sustainable agri-scapes in the basin which promote **organic** and **natural farming** in the **gram panchayats** in the region. Wetland mapping and conservation is another significant step taken as a component of the mission to improve groundwater recharging for sustained water utilization. It includes use of wetlands for recharging, establishment of a **State Wetland Authority**, and detailed conservation plans for states. For rejuvenation of small rivers, the program incorporates activities, in coordination with MNREGA, involving the revitalization of small rivers that are Ganga tributaries. A **GIS-based inventory** of all rivers and districts has been developed to gather relevant data and model the correct approach. The activities introduced include desilting of small kunds, ponds, and lakes, embankment construction, water harvesting system construction, preparation of storage structures, and afforestation, which will restore the natural river flow.

The **community inclusive approach** requires raising public awareness, promoting **people-river connectivity**, and large-scale participation and involvement of the community and common masses. **State Mission for Clean Ganga** has been initiated at the state level along with involvement of district specific committees, such as **Ganga Vichar Manch, Ganga Task Force, National Cadet Corps, Ganga Mitras**, and **Ganga Bal Praharis**, amongst many others, for effective execution of targeted knowledge dissemination. Moreover, the **Clean Ganga Initiative** has been introduced as a component to provide a unique platform for the public to participate in the cause. **Ganga Utsav**, a diverse activity program engaging students and youth through cinemas, quiz, storytelling, games on ecological learnings, and group discussions is also organized each year in the month of November to celebrate declaration of Ganga as the national river and expand its outreach. **Ganga Amantran** is a 34-day river rafting expedition over the Ganga River from Devprayag to Gangasagar. It is one of the largest social outreach programmes through adventure sports, with the goal of connecting lakhs of people to the initiative.

Since its implementation it has achieved some key achievements such as an increase in **sewage treatment capacity** through the implementation of **54 sewage management projects** in the states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Delhi, Himachal Pradesh, Haryana, and Rajasthan, and successful competition of **92 sewage projects**. Under the river-front development program, it has initiated **67 Ghats and Crematoria projects** along with the construction, modernization, and renovation of **265 existing kunds and ponds**. Efforts have been undertaken for collection and disposal of floating solid waste from the surface of the ghats and rivers at **11 different locations** in the country to accomplish the set goal for river surface cleaning. It has worked hard on its vision of restoration of viable populations of all endemic and endangered biodiversity of the river by maintaining the integrity of Ganga River ecosystems. Holistic conservation of the river also included **afforestation** as an important aspect owing to its utility in increasing the productivity and diversity of forests in headwater areas and all along the river and its tributaries. The program has also made a strong case for public outreach and community participation in the programme attributable to a series of activities conducted, such as events, workshops, seminars, and conferences, along with numerous information, education & communication (IEC) activities. Various awareness activities such as rallies, campaigns, exhibitions, shram daan, cleanliness drives, competitions, plantation drives, and the development and distribution of resource materials were organized alongside the mass media outreach goals involving TV advertisements, radio messages, print media advertisements, advertorials, and featured articles, published for wider publicity. Moreover, the Gange Theme Song was widely distributed and played on digital media to increase the program's visibility and the team ensured a presence on social media platforms such as Facebook, Twitter, and YouTube to effectively dissipate relevant information about the program which can be beneficial to the citizens. Effectual monitoring of industrial effluents was attained through regulation and enforcement which were carried out through regular and surprise inspections of Grossly Polluting Industries (GPIs) to ensure compliance with specified environmental norms and lower the degradation in the quality of water bodies. The Ministry of Drinking Water and Sanitation (MoDWS) identified 1674 Gram Panchayats on the Ganga's banks across five states and has completed more than half the targeted toilet unit constructions for obtaining the necessary sanitation levels. These measures are fulfilling the desired objectives and ameliorating the water quality of the river Ganga.

6.8.6. NAMAMI GANGE PROGRAMME PHASE II: REJUVENATING THE RIVER GANGA

Namami Gange Mission-II and its Budget:

- **Budgetary Outlay:** Rs. 22,500 crore (US$2.7 billion) allocated until 2026.
  - This includes Rs. 11,225 crore for existing projects and liabilities.

  - An additional Rs. 11,275 crore is dedicated to new projects and interventions.

Key Areas of Focus:

The program addresses various aspects of Ganga's rejuvenation through a comprehensive approach. Some of the key areas include:

- **Pollution Abatement:** This tackles sewage and industrial waste management to minimize pollution entering the river.
- **Waste Management:** Solid waste management initiatives aim to reduce waste ending up in the river.
- **Riverfront Management:** This involves developing ghats (bathing places) and crematoria along the river while ensuring their cleanliness.
- **Environmental Flow (E-Flow):** Maintaining adequate water flow in the river is crucial for its health.
- **Afforestation and Biodiversity Conservation:** Planting trees along the riverbank and protecting Ganga's unique flora and fauna are important aspects of the program.
- **Public Participation:** The program actively seeks public involvement in its initiatives to create a sense of ownership and ensure long-term sustainability.

Progress and Challenges: As of December 2022, a total of 409 projects have been undertaken with an estimated cost of Rs. 32,912.40 crore (including Phase I). While 232 projects have been completed, ongoing efforts are required to achieve the program's ambitious goals. The Namami Gange Programme is a significant undertaking and faces challenges like rapid urbanization, industrial pollution, and public behavior changes. Continued government commitment, technological advancements, and community engagement will be crucial for the program's success in restoring the Ganges to its pristine glory.

6.8.6.1. BUDGETARY ALLOCATION FOR NAMAMI GANGE PROGRAMME

In June 2014, the Government of India has initiated with Namami Gange Programme for the achieving dual objectives of effective pollution abatement, and conservation and rejuvenation of the National River Ganga and its tributaries. The Programme was subsequently extended up to 31st March 2026. A total sum of **INR 16,011.65 crore** was released by the Government of India to the National Mission for Clean Ganga (NMCG), from Financial Year 2014-15 till 31st October 2023. NMCG have released/disbursed **INR 15,015.26 crore** to various agencies during the said period, for implementation of projects under the Programme. From the Financial Year 2022–23, the release of fund was **INR 2,220 crore** to the National Mission for Clean Ganga (NMCG). In which Releases/Disbursements by NMCG was of **INR 2,215.85 crore**. In the fiscal year 2023-2024 (till 31st October 2023) the Indian government released budget of **INR 1,681.93 crore** to NMCG. In which Releases/Disbursements by NMCG was of **INR 1,279.87 crore**. The State-wise and year-wise fund released/expended by NMCG to State Governments /State Programme Management Groups/Central Public Sector Undertakings (CPSUs)/ Other Executing Agencies from the financial year 2020-21 up to 31 January 2022 is as below in **INR crore.**

TABLE 24. THE STATE-WISE AND YEAR-WISE FUND RELEASED/EXPENDED BY NMCG

SR.NO	STATE	FY 2020-21	FY 2021-22*	TOTAL
1	Uttarakhand	124.82	143.42	268.24

2	Uttar Pradesh	472.46	331.98	804.44
3	Bihar	194.43	47.97	242.40
4	Jharkhand	28.03	2.59	30.62
5	West Bengal	105.06	72.87	177.93
6	Delhi	235.00	240.00	475.00
7	Urban Improvement Trust, Kota, Rajasthan	-	20.00	20.00
8	Irrigation & Public Health Department, Himachal Pradesh	1.25	2.50	3.75
9	NMCG's Expenditure including other Basin wide interventions	178.92	154.66	333.58
	Total	**1,339.97**	**1,015.99**	**2,355.96**

Sources: National Mission for Clean Ganga, Ministry of Jal Shakti, Press Information Bureau (PIB), Union Budget of India ***Note: (* till 31 January 2022)***

Under the Namami Gange Programme, a comprehensive range of measures including wastewater treatment, solid waste management, riverfront management (such as ghats and crematoria development), maintaining environmental flow (e-flow), afforestation, biodiversity conservation, and encouraging public participation have been initiated to revive the River Ganga and its tributaries. Thus far, a total of 450 projects have been undertaken, with an estimated cost of **INR 38,022.37 Crore**. Out of these, 270 projects have been successfully completed and put into operation. Most of these projects focus on establishing sewage infrastructure, as untreated domestic and industrial wastewater is the primary cause of pollution in the river. Specifically, 195 sewerage infrastructure projects have been implemented at a cost of **INR 31,344.13 crore**. These projects include the creation and rehabilitation of 6,173.12 Million Liters per Day (MLD) of Sewage Treatment Plant (STP) capacity and the installation of approximately 5,253.64 km of sewerage network. Among these, 109 sewerage projects have been concluded, resulting in the creation and rehabilitation of 2,664.05 MLD of STP capacity and the laying of 4,465.54 km of sewerage network.

TABLE 25. SANCTIONED PROJECTS, COSTS AND COMPLETION STATUS

S.NO.	TYPE OF PROJECT		NO. OF PROJECTS SANCTIONED	TOTAL SANCTIONED COST (INR CRORE)	NO. OF PROJECTS COMPLETED
1	Sewerage Projects	Uttarakhand	41	1,581.59	36
		Uttar Pradesh	69	14,097.18	37
		Bihar	37	6,160.15	13
		Jharkhand	5	1,310.30	2
		West Bengal	27	4,742.02	11
		Haryana	2	217.87	2
		Delhi	9	1,951.03	7
		Himachal Pradesh	1	11.57	1
		Rajasthan	1	258.48	0

		Madhya Pradesh	2	603.94	0
		Modular STP Decentralized	1	410	0
		Total	**195**	**31,344.13**	**109**
2	Entry Level Activities		104	1,733.88	79
3	Solid-Waste Management		12	295.26	9
4	Institutional Development (Non -Infrastructure)		29	1,764.3	9
5	Project Implementation Support/Research & Study Projects/Public Relations and Public Outreach		37	260.29	12
6	Biodiversity		14	238.93	8
7	Afforestation		37	525.18	32
8	Composite Ecological Task Force & Ganga Mitra		6	200.18	5
9	Bioremediation		15	238.96	7
10	Construction of IHHL across Gram Panchayats near Ganga River		1	1,421.26	0
	Grand Total		**450**	**38,022.37**	**270**

Sources: National Mission for Clean Ganga, Ministry of Jal Shakti, Press Information Bureau (PIB), Union Budget of India

6.8.7. SWAJAL

Swajal is a demand-driven and community-centred pilot programme which has been launched with the aim to provide people in rural areas with sustainable access to drinking water with at least minimum quality standards, on a long-term basis to fulfil fundamental requirements of drinking, cooking, and other basic domestic necessities. Under the National Rural Drinking Water Programme (NRDWP), it was proposed in the first phase to select pilot project districts in six states, which are Uttar Pradesh, Maharashtra, Uttarakhand, Madhya Pradesh, Rajasthan, and Bihar. The state government, in collaboration with rural communities, is intended to plan, design, build, operate, and maintain the water supply and sanitation systems of their jurisdictions, ensuring that each rural household has safe drinking water. Moreover, the state government and its sector institutions serve as supporters, facilitators, and co-financiers of the project along with providing technical assistance, training and larger construction projects as needed. Its impact is anticipated to expand into a multitude of advantages in terms of health and hygiene. The demonstrated success of demand-driven reform in rural water supply and sanitation has contributed significantly to the replication of such models in other states. The formulation of the swajal project intends to amalgamate these models by presenting a central government level programme for mainstreaming the key principles countrywide. Observations from previous models and policy formulation based on demand-driven and community-centred principles have been incorporated into the initiative to ensure an effective result.

The approach involves a collaboration between village communities, local committees and NGOs, and the role of the government is as a facilitator and co-financer. Stakeholders are tasked with the responsibility to monitor transparency at each stage by adhering to the proposed guidelines to minimize the possibility of misappropriating and misusing funds. Panchayati Raj Institutions (PRIs) have been empowered to scale up the decentralized service delivery models for a viable and long-term output. The approach also marks a transition from a supply-based model to a demand-based model which demonstrates the need for a new mind-set and investment at various levels for the problems to be tackled through the new model. Furthermore, it ensures the implementation of a good facilitation model and appropriate techniques in the community management model, with external support for communities for long-term sustainability. The State Water and Sanitation Mission (SWSM) is the highest policy-making body for the Swajal Pilot Project with the Department of Drinking Water & Sanitation (DDWS) being responsible for implementing rural drinking water supply in the State and for collaborating effectively with sector stakeholders such as Health, Education, PRI, Rural Development, Panchayati Raj Institutions, and Watershed management. At the lower levels, District Water and Sanitation Mission (DWSMs) have been established in the pilot districts which facilitate the program and report to the SWSM. Their tasks involve reviewing the Swajal Pilot Project's implementation, guiding the DWSC in planning, designing, and implementing operations and maintenance of water supply schemes, approving the scheme's annual budget, channelling funds to gram panchayats and assisting them in scheme procurement and construction. At the lowest levels gram panchayats are responsible for ensuring a participatory approach and mobilizing and supporting the formation of Village Water and Sanitation Sub-Committees (VWSSC). The work involved will be mostly administrative such as raising awareness among the villagers about sanitation and hygiene through deliberation on technical construction alternatives and adoption of these measures to meet the expectations of the villagers. Furthermore, they will plan, design, implement, operate, and maintain water supply and sanitation schemes through collection of suitable user charges from drinking water scheme users.

Single-sector rural water supply and sanitation approach is adopted in the project attributable to those areas being the most water-scarce for each of the states, with the greatest demand for improved water supply. Moreover, the single-sector approach becomes especially relevant on account of appropriate sector policies and institutional rules supportive of a community-based, demand-responsive approach to water supply that were initially not in place. The Project Management Units (PMUs) have been established by certain state governments as a legally registered body under the Indian Societies Registration Act of 1860, for facilitation, coordination, and monitoring with a complete operational autonomy and flexibility. PMUs have a core multidisciplinary and gender-balanced team of experienced professionals and NGOs which has resulted in a cross-pollination of ideas, experiences, and attitudes for better results. The NGOs serve as a link between the PMU and the project village communities, assisting in policy planning to achieve the main outcomes of community mobilization through the use a specialized PRA-type tool for water and sanitation, SARAR (Self Esteem, Associative Strengths, Resourcefulness, Action Planning, Responsibility), initiatives for women's development, design of water supply and sanitation systems, and community's capital cost share collection. Furthermore, the incentive system at all levels, ensures effective functioning and reduces chances of corruption. The incentive structure includes a unique compensation package, contributing to the high level of motivation for PMU employees, and a secured source of funding for a water supply scheme for the community individuals.

The key objective of the project is to provide 117 aspirational districts, covered under Swajal, with decentralized and sustainable, preferably solar energy-based, piped water supply through a community-designed single village water supply scheme. It includes some mandatory schemes based on groundwater, the most used source in rural areas, which must be compiled by every district. It includes formulation of crucial infrastructure, including bore-well or tube well construction or improvement of a similar existing structure of required yield with proper casing, installation of a pump with the required capacity and a dry run sensor which controls the pump's operation, availability, and installation of pipes of the necessary size and length, and delivery and distribution of standard quality water. Furthermore, a recharge structure is prepared alongside to ensure the sustainability of the source. Enough stand-posts are required to be installed along with a soak pit for each to ensure safe disposal of wastewater. The gram panchayats are encouraged to provide piped water supply to schools, anganwadis, hospitals, and other government establishments and establish the necessary infrastructure, such as multiple hand wash units. Owing to the wide utilization of groundwater, the program further mentions some optional elements such as a community water treatment unit which will address the issue of water quality through frequent testing of water sources, an online chlorination unit with the ability to disinfect water, an LED light powered by a battery charged by a solar panel for water drawl at night, and sensors with data logging capabilities to measure groundwater levels, discharge, and leakage. Surface water or springs are another commonly used water source with compulsory schemes of community consultation to identify a sustainable surface water source, certification of the source's sustainability by the Water Resources Department, infrastructure construction of intake structure and filtering arrangement, and installation of a pump with the required capacity and a dry run sensor, amongst others.

Information, education, and communication are the three pillars being used to propel growth in the schemes. Artistic and creative mediums of workshops at each level, road shows, wall writings, slogans, and other activities, are being employed for an extensive campaign to raise awareness about the project's principles, objectives, scope, implementation, approach, roles, and responsibilities of all stakeholders. The campaign also emphasizes community involvement, social auditing, credit requirements for household connection, and meeting operational and maintenance costs to ensure transparency and knowledge of the progress by the locals. Moreover, it will collaborate with reputed institutions in various states, along with NGOs and key resource centres to undertake capacity building of stakeholders at various levels. The Ministry of Drinking Water and Sanitation (MoDWS) will also organize twinning training programmes for interstate cross learning to ensure an equitable growth across regions. Documents prepared by MoDWS on capacity building and training will be shared with states for them to build adequate capacity and align with the goals to achieve the set targets. Effective monitoring is essential for smoothly running the program. Dedicated dashboards linked to the MoDWS’s Integrated Management Information System (IMIS) would be set up for monitoring at the state level, with data loggers feeding the dashboard. Information delivery via mobile phone apps and SMS will enable community empowerment and wider accessibility. MoDWS also reviews the progress made at regular intervals using the monthly progress data feed into the system by the state authorities. Physical monitoring is also carried out through field visits, and third-party monitoring using national monitors.

Because of the Swajal villages having their own water supply schemes, they are now embarking on other development projects which denote the expansive cycle of reforms it can bring. The program is building the pathway to achieve the objectives of water sustainability in rural regions by following a demand-driven approach with increasing community participation, women empowerment, and involvement, setting up of Support Organizations (SOs) to provide single window assistance, integrated approach for holistic solutions and a continuous training and capacity building program. It is also playing a crucial role in making women and socially disadvantaged groups more assertive of their rights and taking an active role in both project and village activities to develop cost recovery development programmes for a sustainable future.

6.8.7.1. BUDGETARY ALLOCATION FOR SWAJAL

The Swajal scheme was launched by the Union Minister for Drinking Water and Sanitation with outlay of worth **INR 750 crore** in 115 aspirational districts of the country through flexi-funds under the National Rural Drinking Water Programme (NRDWP) budget. The main aim of the scheme is to offer villages with piped water supply which is powered by solar energy. To offer piped water to villages with minimal operation and maintenance cost that would aid in minimizing the tariff burden on community, each Swajal scheme may cost up to **INR 50 lakhs**. The ongoing Swajal programs will continue in accordance with the current Swajal guidelines and should be ensured of completion of scheme within the allotted time frame. Additional new projects in these aspirational districts will be undertaken under Jal Jeevan Mission (JJM). The Swajal schemes that have already been finished but do not contain the Functional Household Tap Connection (FHTC) provision must be retrofitted under Jal Jeevan Mission (JJM).

TABLE 26. FUNDING PATTERN

SR.NO	AREAS	FUNDING PATTERN OF CENTRE: STATE: GRAM PANCHAYAT (GP)
1	North Eastern States & Himalayan States	81:09:10
2	Other States	45:45:10

Sources: Ministry of Jal Shakti, Jal Jeevan Mission (JJM), Press Information Bureau (PIB), Union Budget of India

6.9. BUDGET ALLOCATIONS FOR WATER AND WASTEWATER INDUSTRY (2023-2024)

In the union budget for 2023-2024, roughly 1,12,478 crore INR is projected for the water domain, which is distributed between the Ministries of Jal Shakti, Agriculture and Farmers' Welfare, Rural Development, and Housing and Urban Affairs. This allocation is over 15% greater than the projected budget for the previous fiscal year. The 70,000-crore allocation to **Jal Jeevan Mission** (JJM) for installing functional household tap connections (FHTC) in rural India deserves most of the credit. The goal for fiscal year 2023-24 is to obtain an extra 4 crore FHTCs.

TABLE 27. BUDGET ALLOCATIONS (2024-2025)

Department / Budget Head	Budget Estimated: 24-25	Revised Estimated: 23-24	Budget Estimated: 23-24	Revised Estimated: 22-23	Budget Estimated: 22-23	Actual: 21-22
Ministry of Jal Shakti						
Total – MoJS	98,419.00	96,550.00	97,278.00	74,029.00	86,189.00	83,467.00
Department of Water Resources, River Development and Ganga Rejuvenation						
Total - DoWR, RD, GR	98,418.79	96,549.57	20,054.67	14,000.00	18,967.88	17,215.16

Namami Gange	3,500.00	2,400.00	4,000.00	2,500.00	2,800.00	1,394.00
Pradhan Mantri Krishi Sinchai Yojna	8,890.07	7,031.10	8,587.00	7,084.00	10,954.00	8,541.00
Servicing of loans from NABARD under PMKSY	3,749.80	3,774.41	3,875.00	3,875.00	4,585.00	3,736.00
Har Khet Ko Pani	600.00	600.00	300.00	550.00	785.00	1,264.00
Command Area Development and Water Management	1400.00	236.69	400.00	140.00	1,044.00	108.00
Atal Bhujal Yojana	1,778.00	1,778.00	1,000.00	700.00	700.00	327.00
Water Resources Management	2,946.26	2,705.00	2,042.00	1,703.00	2,112.00	753.00
Department of Drinking Water and Sanitation (DDWS)						
Total - DDWS	77,223.00	77,032.65	77,223.00	60,029.00	67,221.00	66,252.00

Jal Jeevan Mission (JJM)	70,162.90	70,000.00	70,000.00	55,000.00	60,000.00	63,125.00
Swachh Bharat Mission (Gramin)	7,192.00	7,000.00	7,192.00	5,000.00	7,192.00	3,099.00
Department of Land Resources, Ministry of Rural Development						
Integrated Watershed Development Program	-	-	2,200.00	1,100.00	2,000.00	941.00
Ministry of Housing and Urban Affairs						
Swachh Bharat Mission Urban	5,000.00	2,550.00	5,000.00	2,000.00	2,300.00	1,952.00
Atal Mission for Rejuvenation and Urban Transformation	8,000.00	5,200.00	8,000.00	6,500.00	7,300.00	7,280.00

Source: Ministry of Finance, Government of India

The Ministry of Jal Shakti, which includes the **Departments of Drinking Water and Sanitation as well as Water Resources, River Development, and Ganga Rejuvenation**, has been allocated a planned budget of INT 86,189 crore, which is 12% more than the previous fiscal year's budget. The JJM program receives nearly all the new funding. The budget of the **Pradhan Mantri Krishi Sinchai Yojana (PMKSY)** at the **Department of Water Resources, River Development, and Ganga Rejuvenation** has been reduced by about 20% compared to previous year's 10,954 Cr. Within PMKSY, both the budget heads for command area development, i.e. **'Har Khet Ko Pani**,' as well as the budget head for 'Command Area Development and Water Management,' have suffered a fall in allocation. Continuing the pattern, nearly 50% of the allocation under **PMKSY** this year is going to service **NABARD** loans under PMKSY, which includes payment of interest to NABARD. The budget for the **Namami Gange and Atal Bhujal Yojana** component has been significantly increased. The Namami Gange budget has been boosted to 4,000 crores, up from 2,800 crores last year. The Atal Bhujal Yojana has also seen almost 40% growth from the previous year's 700 cr.

The entire allocation for the Department of Drinking Water and Sanitation is 77,223 cr INR, up from 67,221 cr INR the previous year. The **Jal Jeevan Mission** hopes to have the Functional Household Tap Connection (FHTC) in place by 2024. The yearly allocation of JJM has been enhanced as the deadline approaches and a big objective of additional 8 cr FHTCs remains. The budget has been boosted from 60,000 cr to 70,000 cr this year, up from 60,000 cr last year.

The Department of Land Resources has allocated a total of 2,200 crores for the **Watershed Development Component-Pradhan Mantri Krishi Sinchai Yojana** (WDC PMKSY 2.0). Moreover, the **Swarnim Jayanti Mukhya Mantri Shaheri Vikas Yojana** (SJMMSVY) is an initiative by the Gujarat state government aimed at enhancing urban infrastructure and improving the quality of life in urban areas. In the fiscal year 2024-25, the Gujarat government allocated ₹8,864 crore to this scheme, highlighting its importance in the state's urban development strategy. Also, the Nirmal Gujarat Abhiyan 2.0 Allocated ₹1,200 crore, with an objective: to improve sanitation and waste management across urban and rural areas. This scheme focuses on constructing new sewage treatment plants, upgrading existing ones, and promoting better waste management practices to achieve a cleaner Gujarat.

The PMKSY's Integrated Watershed Development Program oversaw a large chunk of the watershed until March 31, 2022. The MGNREGA funding supports a significant amount of watershed and water conservation activities. The MGNREGA budget in the Department of Rural Development has been reduced by over 20% this year compared to previous year's 73,000 crores. The **Rural Water Supply Scheme** in Gujarat Allocated ₹1,500 crore to provide reliable and clean drinking water to rural areas, ensuring that even the most remote villages have access to safe water.

The Per Drop More Crop (Micro Irrigation) component has been combined with the **Rashtriya Krishi Vikas Yojana** (RKVY) from the previous fiscal year budget. The paper makes no mention of a separate financial allocation. However, the entire RKVY budget has fallen by about 25% as compared to last year's allocation of 10,433 cr INR. The allocation for the **Swachh Bharat Mission Urban** has been enhanced to 5,000 cr INR, up from 2,300 cr INR previous year. In addition, the **Atal Mission for Rejuvenation and Urban Transformation** (AMRUT) would get 8,000 crore INR. The major activities in this budget, according to the Output Outcome Framework, include functional water tap connections to urban homes, sewage treatment, and water body rejuvenation, among others.

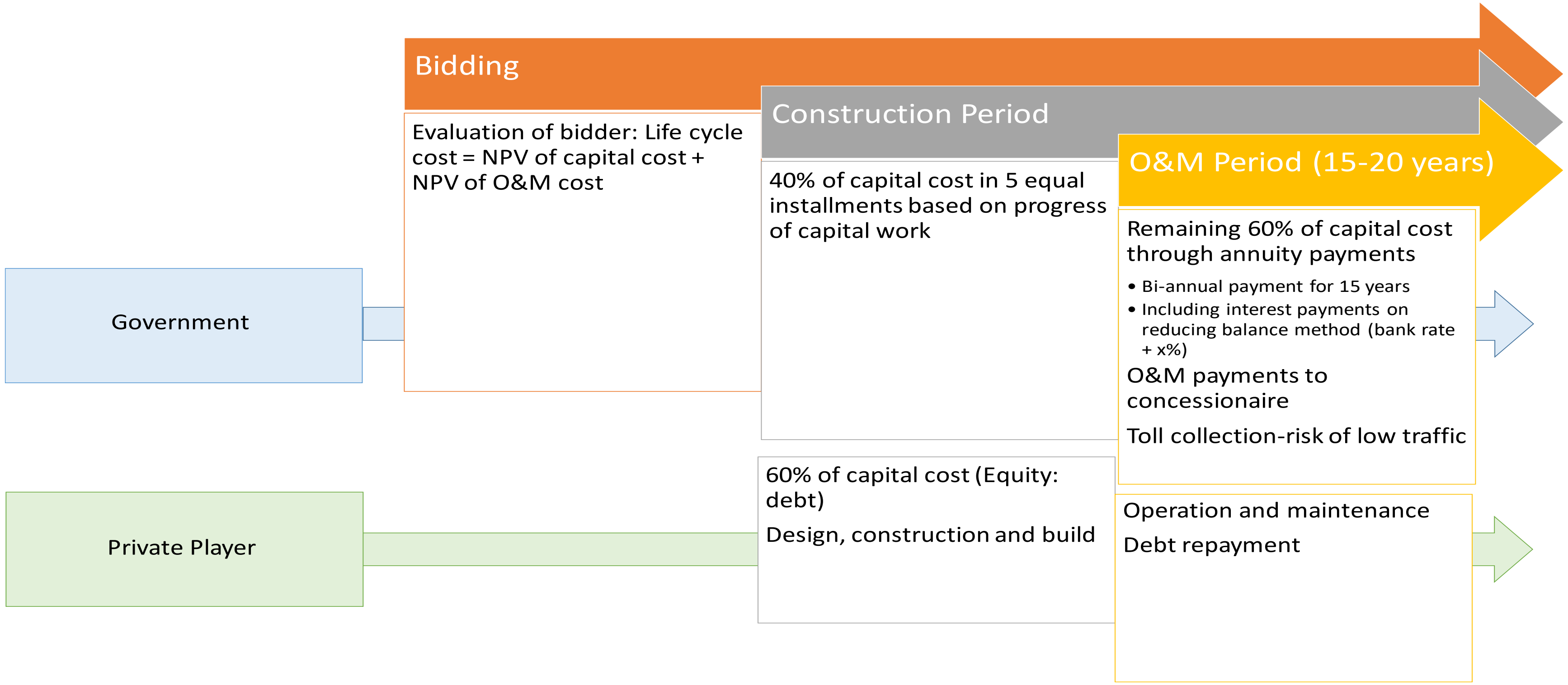
6.10. HAM AND EPC CONTRIBUTION

6.10.1. HAM CONTRIBUTION TO WATER AND WASTEWATER TREATMENT MARKET

Hybrid Annuity Model (HAM) is a combination of EPC Model and BOT Annuity. In this model, 40% of the capital cost of the project during the construction period is paid by the government and 60% of the payment is paid as annuities along with interest over the operation period. During the construction phase, the first payment of 40% is made in equal payments; the remaining 60% is paid as an annuity sum over a 15-year period for operation and maintenance. The shift to HAM would ease initial cash flow pressure on the government. Furthermore, it should be noted that while the wastewater treatment sector is still in the early stages of implementation, in comparison to the roads sector, which has acquired a decent level of maturity in project execution, with several projects being constructed under HAM method.

The hybrid annuity model has been adopted by the Indian Government’s National Mission for Clean Ganga (NMCG) to create sewerage treatment projects. To ensure both the long-term financial feasibility of the projects and the long-term operation and maintenance of STPs, this financial model was developed as part of a PPP project. This strategy calls for a Special Purpose Vehicle (SPV) to oversee creating, running, and maintaining the Sewage Treatment Plant (STP). In terms of financing, 40 percent of the estimated capital cost would be paid upon completion of construction, and the other 60 percent would be paid over the course of the project as annuities together with expenses for Operation and Maintenance (O&M).

FIGURE 61. FINANCIAL ARRANGEMENT UNDER HAM



Source: Center for Water and Sanitation (C-WAS)

The first hybrid annuity STPs in India was being inaugurated in 2019 in Varanasi (Uttar Pradesh) and Haridwar (Uttarakhand). Total awarded cost for STP in Haridwar was **INR 171.53 Crores** and for STP in Varanasi was **INR 153.16 Crore**. The National Mission for Clean Ganga (NMCG), state-level implementing organizations Uttar Pradesh Jal Nigam and Uttarakhand Pey Jal Nigam, and the concessionaires signed a tripartite agreement.

TABLE 28. EXISTING STP CAPACITY AND PROPOSED STP CAPACITY

TOWN, STATE	EXISTING STP CAPACITY	PROPOSED STP CAPACITY	REMARKS
Haridwar, Uttarakhand	Jagjitpur – 27 and 18 MLD Sarai – 18 MLD CETP 4.5 MLD	Jagjitpur enhanced to 62 MLD and 6 MLD Sarai, refurbishment of 18 MLD & additional 8 MLD by 2028. Concession agreement to enhance 9.0 MLD	Rehabilitation & Brownfield, O&M of existing STP, New STP, I&D
Farrukhabad-Fatehgarh, Uttar Pradesh	Existing STP of 2.7 MLD oxidation pond	STPs with the capacity of • 28 MLD • 5 MLD • 2 MLD	6 I&D works proposed, effective date of completion is June, 2024.
Meerut, Uttar Pradesh	All New Assets	STP with the capacity of 200 MLD; decentralized STPs with a cumulative capacity of 14 MLD No existing Rehabilitation Brownfield, O&M of existing STP, New STP, I&D	It is at tendering stage and the largest capacity of a single STP amongst NMCG projects.
Agra, Uttar Pradesh	Existing STPs of 220 MLD and 75 MLD	3 STPs with the capacity of 166 MLD, 10 MLD decentralized STPs and 9.38 MLD	Large single STP with a sizeable number of brownfield assets.

			22 I&D works proposed. Work to be started after issuance of effective date of start by NMCG.
Rishikesh, Uttarakhand	18 MLD at Sarai. Swarg Ashram - 3.0 MLD Lakharghat 6.0 MLD	14 MLD at Sarai.	Rehabilitation & Brownfield, O&M of existing STP, New STP, I&D

6.10.1.1. ADVANTAGES OF HAM

- Less money up front is needed by government agencies. Only 40% of the initial funds must be mobilized by them up front. The remaining 60% of the project's cost is arranged by the private participant.
- During the O&M phase, the government entirely assumes the financial risk. Any O&M cost shortages must be covered by the government. Mechanisms for escrow accounts can be used to guarantee timely payments to independent contractors.
- Since the government is in charge of handling all environmental and land clearances, projects start more quickly, which lowers the risk of a delayed construction phase for the private sector.
- Guaranteed annuity payments provide prospective lenders and financing institutions confidence to lend money to independent contractors.
- For projects with an implementation period of more than a year as well as for O&M costs, the model takes inflation into account over time. This lessens the risks of inflation.
- The right incentives are also created for the private sector providers via performance-linked annuity payments.

6.10.1.2. CHALLENGES IN USING HAM

- It is anticipated that the final project cost will be greater since it reflects both the private concessionaire's high returns on equity and their higher interest rates on debt compared to the government. The private concessionaire is required to mobilize 60% of costs. This will probably raise the price of the entire project.
- Small bidders' ability to raise enough finance to cover 60% of the costs of the initial Capex investment required by this strategy may be limited by the HAM approach. Institutions of finance could be hesitant to offer loans to small developers with fragile/weak balance sheets.
- The use of the HAM model in the water and sanitation sector is significantly hampered by the need for a lengthy commitment of public finances over a period of 10 to 15 years. Local governments, who are the main stakeholders in such initiatives, can probably afford to pay the O&M expenses over time. The capital costs, which are normally paid by capital grants from the federal and state governments, are difficult for them to raise. Most importantly, it might be difficult for local and state governments to honor their commitments to long-term funds for annuity payments. This risk may affect bid pricing and increase total project costs.

6.10.1.3. RISKS UNDER HAM

A variety of risks have been found because of the building and operation of sewage treatment plants as a concessionaire under performance-based benchmarks, and these risks have been grouped under the Hybrid Annuity Model (HAM). Due to public health concerns and externalities related to the waste recycling industry, it is crucial to reduce the inherent risks of wastewater treatment plants. Under risk mitigation measures, it is important to review the following strategy points.

- **Contractually Allocated Risk**
    - Site Risk

  - Land Acquisition Risk
  - Statutory Clearance Risk
  - Environmental Risk
- **Residual Risk**
  - Design and Engineering Risk
  - Contractor Risk
  - O&M Risk
  - Financial Risk
  - Concessionaire Management Risk
  - Take back Risk
- **Contract Variation Risk**
  - Change in Scope Risk
  - Change in Law or Policy Risk
- **Unidentified or Unresolved Risk**
  - Social Risk
  - Force Measure Risk

The HAM model has shown to be an appropriate model in the Public-Private Partnership (PPP) segment for domestic wastewater treatment plants since it provides guaranteed funding from the government and indexed O&M payments while reducing the risk of cash flow for plant maintenance during the concession period. As a result, it makes sense to use the HAM model to leverage cash flow quarterly to secure financing from commercial and development banks. Long term wastewater business development in India is less hazardous and more attractive despite the little return.

A large, integrated sewage plant operator has replaced small and medium-sized operators in the wastewater recycling industry. There is a growing need for a stable market for wastewater treatment facilities in communities all over the Ganga states of north and east India. The HAM's intuitive approach also ensures, on a case-by-case basis, that resources will be available over the long term for investments in networks, interception & diversion, and waste recycling facilities using CAPEX and OPEX cash flow models. This will undoubtedly result in the establishment of a new, green, sustainable wastewater industry in the future.

6.10.2. EPC CONTRIBUTION TO WATER AND WASTEWATER TREATMENT MARKET

Engineering, Procurement and Construction (EPC) represent the most popular project management approach. It is a contractual model, and the general contractor is responsible for taking on most the project's execution risks. All project-related duties, such as engineering design, acquiring tools and supplies, and timely completion of construction work, are delegated by the client to the contractor. Regardless of whether the work necessitates additional expenses, the contractor establishes a fixed fee that will not alter. Customers value a plant's commissioning date being set in stone. Due to the obvious advantages for consumers, building waste water treatment plants under an EPC contract is becoming more and more popular.

The cost of a project is a primary concern for the customers to build or expand the existing wastewater treatment plant. Depending upon the technology and equipment used, the cost varies. Furthermore, the wastewater flow rate is the primary factor influencing the project's cost. The investor should also consider the regulatory requirements and the wastewater's composition, as breaking the law can result in fines while the WWTP is in operation. Thus, being aware of these elements will make it easier to pinpoint company requirements and make the project budget clear.

TABLE 29. FACTORS AFFECTING THE COST OF WASTEWATER TREATMENT PLANTS

FACTORS	DETAILED DESCRIPTION
Pre-project engineering designs and studies	Engineering design costs around 10% of total investment. Also, the local market and regulatory requirements are needed to be researched by the customer before the beginning of project.
Purchase or lease of land	The WWTP construction site and adjoining sanitary zone are large, which requires to obtain official permits for land use and purchasing of land plot. These factors have a significant effect on the final project cost.
Equipment & material purchase and delivery	For the purchasing of equipment and building materials or the rental of construction equipment, significant funds are allocated. Further costs are added for delivery to hard to reach areas.
Construction works	Civil engineering, land clearing & leveling and equipment installation are expensive.

Plant automation	In terms of reliability and safety the treatment plants need to meet strict requirements. Thus, automation and control is considered which also increases the cost of project.
Additional expenses	Local fees and taxes, environmental permits, electricity costs and others are also added.

6.10.2.1. BENEFITS OF EPC

- The price is fixed and there are no unexpected costs.
- It outlines the exact deadline for the commissioning of the wastewater treatment plants as well as the extent of the work and technical specifications for the facility. In the event of a work delay, the EPC contractor pays compensation, ensuring that the customer will fulfil their own responsibilities.
- The customer is not required to supervise intricate, staged work done by subcontractors. Since project management is left to experts, a small business does not need to establish additional technical divisions or hire staff.
- A sizable engineering firm with international expertise offers clients the greatest technologies, staff, resources, and equipment required for the project's effective implementation, as well as resolving any issues that may crop up along the way.

6.10.2.2. CHALLENGES OF EPC

- The client is required to express all his requirements and expectations to the general contractor in writing. Conflicts could occur while building the wastewater treatment plant if this is not done.
- As the contractor assumes additional obligations and risks, EPC contracts are more expensive than EPCM contracts.

- This legal structure is thought to work best for large-scale, technically challenging projects where the general contractor's experience is crucial to the project's success.

According to the Invest India (National Investment Promotion & Facilitation Agency), the Waste and Water sector of India currently has 2,413 opportunities which are worth USD 93.02 billion. Out of the total opportunities, 2,135 EPC projects are available across the country.

FIGURE 62. MODE OF IMPLEMENTATION OF PROJECTS IN WASTE AND WATER SECTOR

Source: Invest India (National Investment Promotion & Facilitation Agency)

In the EPC contracting model for wastewater treatment plants, steps include research, design, procurement, construction, testing, and commissioning. With government funding, this approach is feasible for private players. EPC contractors offer benefits such as providing all resources, being accountable for project success, and often handling maintenance. Their expertise ensures swift and cost-effective resolution of technical issues.

6.11. PORTER'S FIVE FORCE ANALYSIS

FIGURE 63. PORTERS FIVE FORCE ANALYSIS

Bargaining Power of Buyers: Moderate to High

- Availability of alternative solutions
- Increasing demand for environmentally friendly solutions
- Large buyers can negotiate volume discounts or customized solutions

Threat of Substitution: Low to Moderate

- Moderate threat of substitutes from alternative water sources
- Growing focus on water conservation and reuse

Degree of Competition: Moderate to High

- Intense competition among major players
- Market consolidation through mergers and acquisitions
- Innovation and technological advancements

Bargaining Power of Suppliers: Moderate to High

- Limited number of large suppliers of water treatment technologies and chemicals
- High switching costs
- Ability to dictate prices and terms, especially for proprietary technologies
- Supplier consolidation

Threat of New Entrants: High

- High barriers to entry due to the need for substantial capital investment in technology, R&D, and infrastructure
- Strict regulatory requirements and certifications for water treatment technologies
- Established companies have economies of scale and brand recognition

Source: Water and Wastewater Treatment Association, Indian Society of Water and Wastewater Treatment, American Society for Nutrition, The Nutrition Society, International & American Associations of Water and Wastewater Treatmentists, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

6.11.1. BARGAINING POWER OF BUYERS: MODERATE TO HIGH

The ability of the customers to drive prices lower or up to their level of power is one of the five forces. It is generally affected by how many customers or buyers a company has, and how much it would cost a company to find markets for its output or new customers. A company that has many, smaller but independent customers will have an easier time charging higher prices to increase their profitability.

Buyers in the water and wastewater treatment market wield moderate to high bargaining power. This is attributed to the availability of alternative solutions in the market, giving buyers options and leverage in negotiations. The increasing demand for environmentally friendly solutions also empowers buyers, as they seek solutions that align with sustainability goals. Large buyers, such as industries and municipalities, can negotiate volume discounts or request customized solutions, further enhancing their bargaining power. However, regulatory requirements and industry standards also play a role in shaping buyer power, particularly in segments with strict compliance mandates.

6.11.2. BARGAINING POWER OF SUPPLIERS: MODERATE TO HIGH

The bargaining power of suppliers refers to the pressure that suppliers can put on companies by raising their prices, offering different products, or reducing the availability of their products. The supplier power in the water and wastewater treatment market can be considered moderate to high. This is due to several factors, including a limited number of large suppliers offering specialized water treatment technologies and chemicals. Buyers often face high switching costs when considering alternative suppliers due to the specialized nature of equipment and chemicals used in water treatment processes. Additionally, suppliers, especially those with proprietary technologies, can dictate prices and terms, further enhancing their power in negotiations. The market also sees supplier consolidation, which contributes to increased supplier power, particularly in segments where a few dominant players exist.

6.11.3. THREAT OF NEW ENTRY: HIGH

A company's power is affected by the power of new entrants into the market. The threat of new entrants into the water and wastewater treatment market is high, primarily due to significant barriers to entry. New entrants face substantial capital investment requirements in technology development, research and development, and infrastructure setup. Moreover, the industry is highly regulated, with stringent requirements and certifications for water treatment technologies, which act as deterrents for new players. Established companies in the market benefit from economies of scale, brand recognition, and established customer relationships, making it challenging for newcomers to gain a foothold.

6.11.4. THREAT OF SUBSTITUTES: LOW TO MODERATE

Substitute products that can be used in place of a product or service poses a threat. When close substitutes are available in a market, the customers will have the option to forgo buying a company's product, and thus, the company's power can be weakened. The threat of substitutes in the water and wastewater treatment market is generally low to moderate. While alternative water sources such as desalination present a moderate threat as substitutes, factors like costs and environmental impacts limit their widespread adoption as primary solutions. Non-chemical treatment methods, such as membrane filtration and UV disinfection, also serve as substitutes for traditional chemical-based treatments, albeit with varying degrees of threat depending on the specific application and market segment. The increasing focus on water conservation and reuse may elevate the threat level of substitutes over time, particularly in regions facing water scarcity challenges.

6.11.5. INTENSITY OF COMPETITIVE RIVALRY: MODERATE TO HIGH

The intensity of rivalry among competitors in an industry refers to the extent to which firms within an industry put pressure on one another and limit each other's profit potential. Competitive rivalry within the water and wastewater treatment market can be characterized as moderate to high. The market is characterized by intense competition among major players, driving innovation and technological advancements to offer more efficient and sustainable solutions. Market consolidation through mergers and acquisitions has further intensified competition, with companies vying for market share and differentiation. Pricing pressure is also a factor, especially for commoditized components of water treatment systems. Overall, the competitive landscape is dynamic, with companies focusing on differentiation, value-added services, and market expansion strategies to stay ahead in the market.

6.12. PESTEL ANALYSIS

Politics

- Government regulations and policies regarding water quality standards and wastewater discharge.
- Political stability and government support for infrastructure development in the water sector.
- International agreements and treaties affecting water resource management and cross-border wastewater issues.

Economy

- Economic growth and investment opportunities in the water and wastewater treatment industry.
- Cost of water treatment technologies and infrastructure development.
- Funding availability for water projects, including public-private partnerships (PPPs) and government grants.

Social

- Public awareness and concern for water quality and environmental sustainability.
- Demographic trends influencing water demand, such as urbanization and population growth.
- Community attitudes towards water conservation and wastewater recycling initiatives.

Technology

- Advancements in water treatment technologies, such as membrane filtration, UV disinfection, and advanced oxidation processes.
- Integration of digital technologies for real-time monitoring and control of treatment processes (e.g., IoT, AI, data analytics).
- Development of innovative solutions for water reuse and resource recovery from wastewater.

Environment

- Impact of climate change on water availability, quality, and extreme weather events affecting infrastructure resilience.
- Adoption of sustainable practices in water treatment, including energy-efficient technologies and carbon footprint reduction.
- Conservation of natural resources and ecosystems impacted by water extraction and discharge.

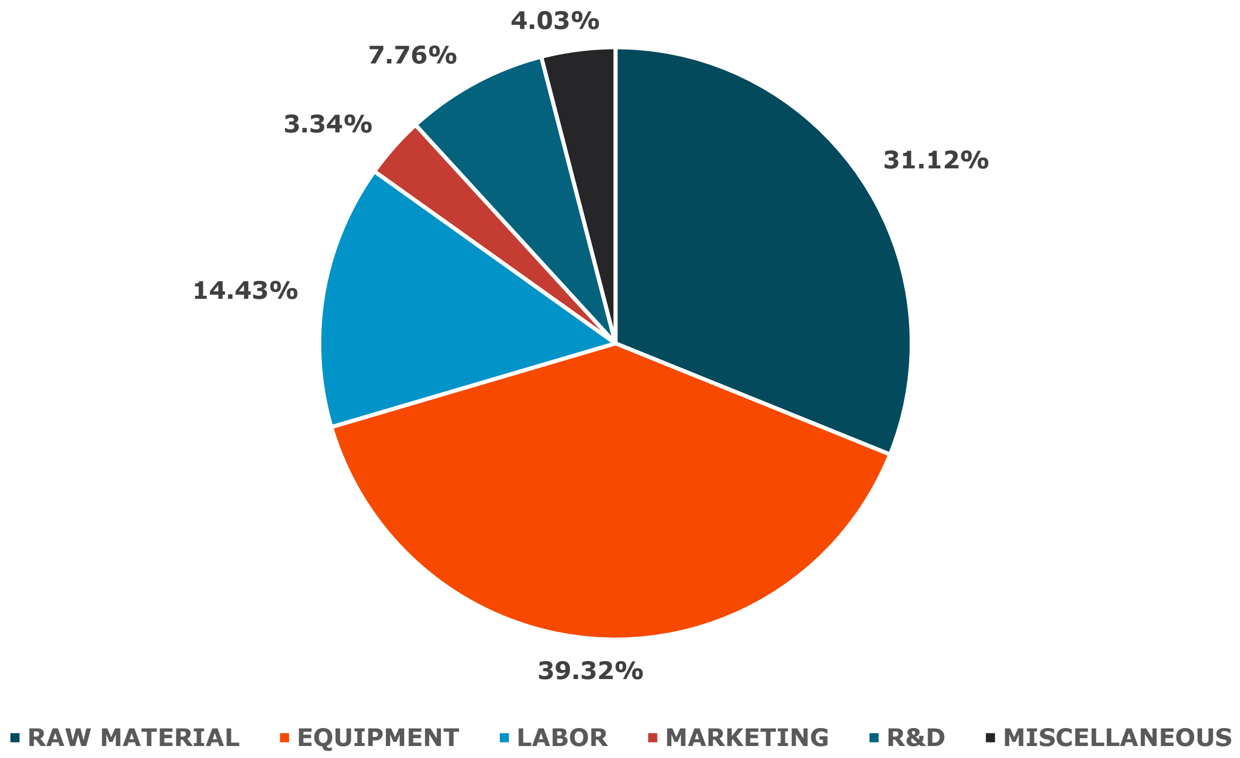
Legal

- Compliance with environmental regulations and water quality standards (e.g., EPA regulations in the United States, EU directives in Europe).
- Intellectual property rights related to water treatment technologies and patents.
- Legal frameworks governing water rights, access, and distribution.

Source: Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

6.13. COST STRUCTURE ANALYSIS

FIGURE 64. WATER AND WASTEWATER TREATMENT MARKET COST STRUCTURE ANALYSIS



Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

The cost structure of the water and wastewater treatment market encompasses various elements that contribute to the overall expenses incurred by businesses in this sector. These elements include the cost of raw materials, labor, maintenance, infrastructure fixed capital, and miscellaneous costs. Each component plays a crucial role in shaping the financial dynamics of water and wastewater treatment operations.

- Raw materials constitute a significant portion of the cost structure, accounting for over 40.21% of the total cost. The cost of raw materials is pivotal as it directly impacts the overall cost of water and wastewater treatment processes. Fluctuations in raw material prices can significantly influence the profitability and competitiveness of companies operating in this market segment.
- Fixed capital costs encompass a range of expenses such as rent, utilities, security, software, and hardware. For manufacturing businesses in the water and wastewater treatment sector, fixed costs are typically high due to investments in facility rentals and equipment procurement. Over the long term, these fixed costs can be justified and covered through operational efficiencies and economies of scale.
- In recent years, there has been a notable trend towards the adoption of automated machines and equipment in water and wastewater treatment facilities. These technologies, developed by various equipment manufacturers, have contributed to reducing labor costs and improving operational efficiency. However, the initial investment in modern and high-end equipment can result in substantial capital expenditure, making equipment the most capital-consuming factor after raw materials.
- Labor costs, although impacted by automation, remain a significant component of the cost structure. Other expenses such as marketing, research, and development (R&D), and miscellaneous costs also contribute to the overall financial outlay of water and wastewater treatment operations. Efficient cost management strategies, coupled with technological advancements and strategic investments, are essential for businesses to optimize their cost structures and enhance competitiveness in the market.

7. GLOBAL WATER AND WASTEWATER TREATMENT MARKET BY TYPE INSIGHTS & TREND

KEY TRENDS & HIGHLIGHTS

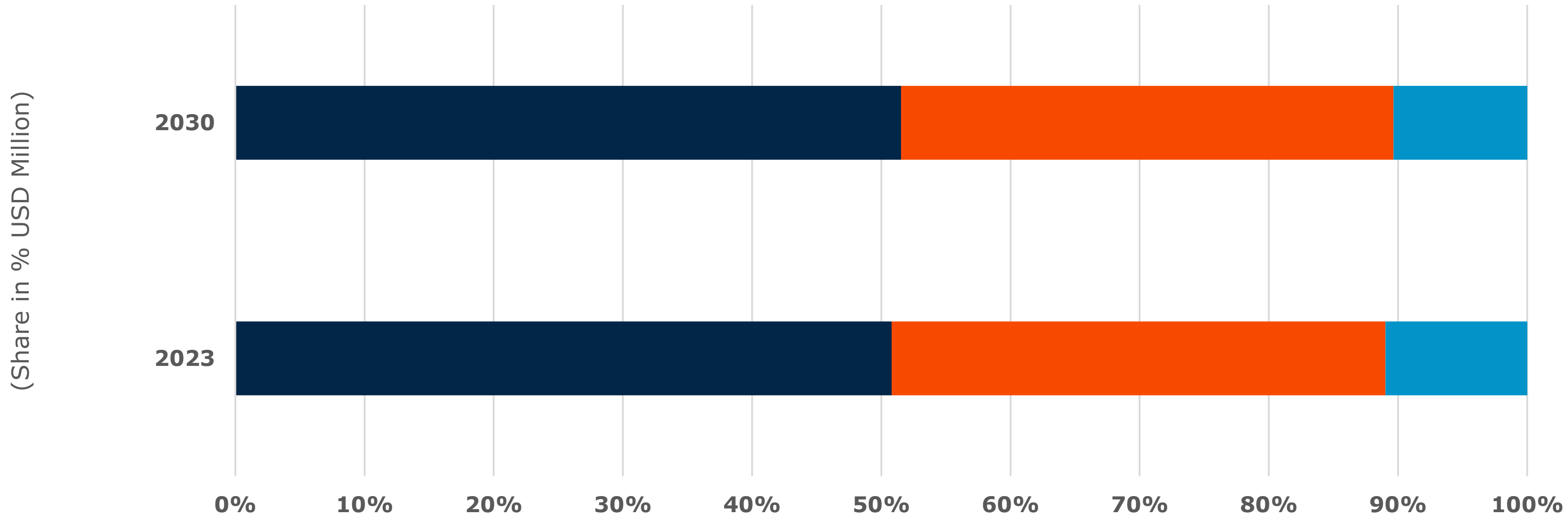
- The demand for Water Treatment accounted for over USD 6,276.633 Million in 2023 and is expected to grow at a CAGR of 6.29% in the forecast period.

7.1. TYPE DYNAMICS & MARKET SHARE, 2023 & 2033

By Type, the market is segmented into:

- Water Treatment
- Wastewater Treatment

FIGURE 65. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: TYPE DYNAMICS (SHARE IN % USD BILLION)



	2023	2030
Water Treatment	50.80%	51.52%
Sewage Treatment	38.23%	38.13%
Effluent Treatment	10.98%	10.35%

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

7.2. GLOBAL WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY TYPE, 2019-2033, (USD BILLION)

TABLE 30. GLOBAL WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY TYPE, 2019-2033, (USD BILLION)

Type	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Water Treatment	116.429	137.699	146.602	156.208	189.632	231.724	284.633	**6.89%**
Wastewater Treatment	119.541	136.175	142.940	150.123	174.266	203.094	237.337	**5.22%**
Total	**235.970**	**273.874**	**289.542**	**306.332**	**363.897**	**434.818**	**521.970**	**6.10%**

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

7.3. WATER TREATMENT

Water treatment, an essential process in safeguarding access to clean water, has seen significant growth and development in response to escalating challenges posed by water scarcity, pollution, and increasing demand. As the Earth's population continues to surge and industrial activities expand, the need for reliable and efficient water treatment methods becomes ever more pronounced. The escalating demand for water treatment stems from the finite nature of freshwater resources. Despite covering about 71% of the Earth's surface, only a minuscule fraction—approximately 3%—is fresh and suitable for human consumption. The bulk of freshwater remains locked in ice caps and glaciers, with surface water sources like lakes and rivers serving as vital reservoirs for human use. However, rapid urbanization, industrialization, and agricultural practices have led to the contamination of these surface water bodies, further exacerbating the scarcity of clean water.

Water treatment processes play a pivotal role in mitigating the effects of pollution and ensuring that water is safe for various applications, including drinking, agriculture, and industrial processes. These treatment methods encompass a spectrum of physical, chemical, and biological techniques aimed at removing contaminants and undesirable substances from water. From the initial stages of collection and screening to final steps of disinfection and distribution, each phase of the treatment process is meticulously designed to purify water and make it fit for consumption. Moreover, advancements in water treatment technologies have propelled the industry forward, enabling more efficient and sustainable methods of purification. Innovations such as membrane filtration, ultraviolet (UV) disinfection, and advanced oxidation processes have revolutionized the way water is treated, offering higher efficacy and lower environmental impact compared to conventional methods. Additionally, the integration of smart sensors, automation, and data analytics has enhanced the monitoring and control of water treatment processes, ensuring optimal performance and resource utilization.

Moreover, recent trends in water treatment highlight the growing importance of technology-driven approaches to address water scarcity and quality challenges. Innovations such as IoT-enabled water quality monitoring and cloud-based purification management offer real-time insights and optimization opportunities, enhancing efficiency and sustainability across the water treatment lifecycle. Furthermore, advancements in membrane technology, carbon-based purification, and desalination are revolutionizing water treatment processes, making them more efficient, cost-effective, and environmentally friendly. From polymer membranes to biomimetic filtration systems, these innovations hold immense potential to meet the rising demand for clean water while minimizing waste and environmental impact.

The growth of the water treatment industry is further fueled by increasing awareness of water-related issues and the implementation of stringent regulations governing water quality and sanitation. Governments, environmental agencies, and international organizations have placed greater emphasis on promoting sustainable water management practices and investing in infrastructure for water treatment and distribution. This heightened focus on water sustainability has spurred investments in research and development, fostering innovation and the adoption of eco-friendly treatment solutions. Furthermore, the water treatment sector is witnessing a shift towards decentralized and modular treatment systems, catering to diverse needs and localized challenges. These decentralized systems offer flexibility, scalability, and resilience, particularly in remote or underserved areas where centralized infrastructure may be lacking. Moreover, decentralized treatment solutions contribute to resource conservation and climate resilience by minimizing water losses and reducing energy consumption associated with long-distance water transport. Thus, as the world strives to achieve the United Nations Sustainable Development Goal of ensuring access to clean water and sanitation for all, the convergence of technological innovation and collaborative research will play a pivotal role in shaping the future of water treatment. By leveraging cutting-edge technologies and interdisciplinary approaches, the water treatment industry is poised to address the complex challenges posed by water scarcity and pollution, safeguarding this precious resource for generations to come.

7.3.1. WATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 31. WATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	28.662	33.949	36.163	38.554	46.883	57.389	70.619	**6.96%**
Europe	34.556	40.816	43.433	46.256	56.069	68.407	83.892	**6.84%**
North America	44.492	52.646	56.060	59.745	72.569	88.729	109.054	**6.91%**
Middle East & Africa	3.514	4.122	4.376	4.648	5.590	6.764	8.226	**6.55%**
Latin America	5.204	6.167	6.570	7.005	8.521	10.434	12.842	**6.97%**
Total	**116.429**	**137.699**	**146.602**	**156.208**	**189.632**	**231.724**	**284.633**	**6.89%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

7.4. WASTEWATER TREATMENT

The wastewater treatment industry is experiencing significant growth and evolution driven by a convergence of factors ranging from urbanization and industrialization to regulatory imperatives and heightened environmental awareness. At its core, wastewater treatment is vital for maintaining water quality, safeguarding public health, and preserving aquatic ecosystems. As urban populations expand and industrial activities intensify globally, the volume of wastewater generated continues to rise, necessitating more advanced treatment solutions to mitigate its environmental impact. One of the primary drivers of growth in the wastewater treatment sector is the increasing demand for efficient purification technologies capable of addressing diverse sources of contamination. From residential sewage to industrial effluents, wastewater contains a myriad of pollutants, including organic matter, chemicals, and pathogens, which must be effectively removed before discharge. This demand for comprehensive treatment solutions is propelling innovation in the industry, fostering the development of advanced processes and technologies aimed at achieving higher levels of treatment efficiency.

Moreover, stringent regulatory standards and environmental mandates play a pivotal role in shaping the trajectory of the wastewater treatment market. Governments worldwide are enacting stricter regulations to control water pollution and ensure compliance with effluent quality standards. Legislation such as the Environment (Protection) Act of 1986 and the Water (Prevention & Control of Pollution) Act of 1974 require industrial units to install effluent treatment plants (ETPs) and treat their effluents to meet environmental standards before discharging into water bodies. This regulatory framework not only compels industries to invest in wastewater treatment infrastructure but also incentivizes innovation and the adoption of cleaner technologies to meet evolving compliance requirements. Consequently, wastewater treatment companies are under increasing pressure to enhance treatment efficacy, reduce energy consumption, and minimize the environmental footprint of their operations.

Furthermore, growing awareness of the interdependence between water quality, human health, and ecological well-being is driving the demand for sustainable wastewater treatment solutions. Stakeholders across sectors, including governments, municipalities, industries, and communities, recognize the importance of investing in wastewater infrastructure that aligns with broader sustainability objectives. This includes promoting water reuse and recycling initiatives, implementing circular economy principles, and adopting eco-friendly treatment practices to minimize environmental degradation and resource depletion. The wastewater treatment market is characterized by a dynamic landscape of innovation and adaptation, with key players continuously investing in research and development to address emerging challenges and opportunities. Technologies such as membrane filtration, biological treatment, and advanced oxidation processes are becoming increasingly prevalent, offering more efficient and cost-effective solutions for pollutant removal and resource recovery. Moreover, digitalization and data analytics are revolutionizing wastewater management, enabling real-time monitoring, predictive maintenance, and optimized operations for improved performance and resilience. Thus, the wastewater treatment industry is poised for sustained growth and innovation as it continues to play a critical role in addressing the global water crisis. By embracing technological advancements, regulatory compliance, and sustainability principles, wastewater treatment companies can drive positive environmental outcomes, protect public health, and contribute to the preservation of water resources for future generations.

7.4.1. WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 32. WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	29.500	33.645	35.332	37.124	43.153	50.361	58.934	**5.27%**
Europe	35.583	40.495	42.492	44.612	51.731	60.224	70.302	**5.18%**
North America	45.516	51.865	54.448	57.191	66.410	77.423	90.506	**5.23%**
Middle East & Africa	3.622	4.100	4.294	4.499	5.186	6.000	6.961	**4.97%**
Latin America	5.320	6.069	6.374	6.697	7.786	9.087	10.634	**5.27%**
Total	**119.541**	**136.175**	**142.940**	**150.123**	**174.266**	**203.094**	**237.337**	**5.22%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8. GLOBAL WATER AND WASTEWATER TREATMENT MARKET BY OFFERING INSIGHTS & TREND

KEY TRENDS & HIGHLIGHTS

- The demand for Process Control and Automation accounted for over USD 4,008.099 Million in 2022 and is expected to grow at a CAGR of 6.05% in the forecast period.

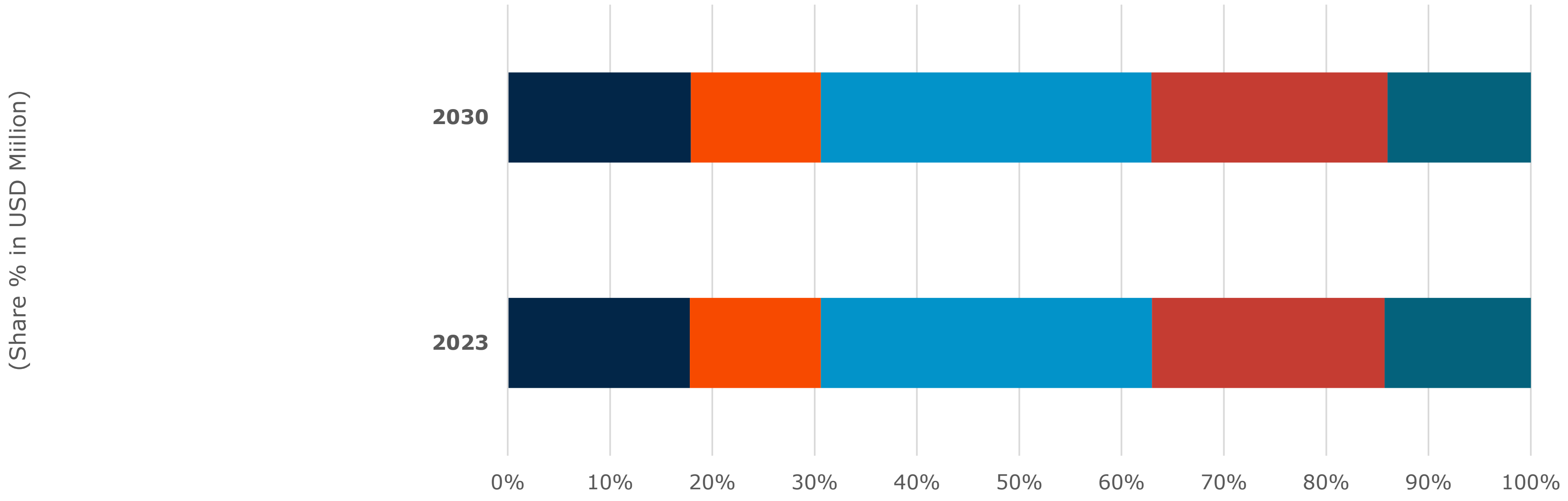
8.1. OFFERING DYNAMICS & MARKET SHARE, 2023 & 2033

By Offering, the market is segmented into:

- Treatment Technologies
  - Activated Sludge Process
  - Membrane Bio Reactor
  - Moving Bed Bio Reactor
  - Sequencing Batch Reactor
  - Upflow Anaerobic Sludge Blanket Reactor
  - Submerged Aerated Fixed Film Reactor
  - Other Treatment Technologies
- Treatment Chemicals
  - Corrosion Inhibitors
  - Scale Inhibitors
  - Biocides & Disinfectants
  - Coagulants & Flocculants

  - Chelating Agents
  - Anti-Foaming Agents
  - Ph Adjusters and Stabilizers
  - Others
- Process Control and Automation
- Design, Engineering, and Construction Services
- Operation and Maintenance Services

FIGURE 66. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: OFFERING DYNAMICS (SHARE IN % USD BILLION)



	2023	2030
Treatment Technologies	17.79%	17.90%
Treatment Chemicals	12.81%	12.71%
Process Control and Automation	32.36%	32.30%
Design, Engineering, and Construction Services	22.74%	23.10%
Operation and Maintenance Services	14.30%	13.99%

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.2. GLOBAL WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD BILLION)

TABLE 33. GLOBAL WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD BILLION)

Offering	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Treatment Technologies	45.735	53.190	56.275	59.584	70.948	84.982	102.270	**6.19%**
Activated Sludge Process	17.680	20.486	21.645	22.886	27.135	32.360	38.768	**6.03%**
Membrane Bio Reactor	9.068	10.517	11.115	11.756	13.953	16.657	19.977	**6.07%**
Moving Bed Bio Reactor	6.251	7.307	7.746	8.217	9.843	11.862	14.366	**6.40%**
Sequencing Batch Reactor	4.795	5.627	5.974	6.347	7.638	9.249	11.255	**6.57%**
Upflow Anaerobic Sludge Blanket Reactor	3.156	3.650	3.854	4.072	4.819	5.735	6.856	**5.96%**
Submerged Aerated Fixed Film Reactor	2.747	3.206	3.397	3.601	4.305	5.179	6.260	**6.34%**
Other Treatment Technologies	2.039	2.397	2.545	2.705	3.256	3.941	4.790	**6.55%**
Treatment Chemicals	26.625	30.826	32.560	34.416	40.767	48.570	58.130	**6.00%**
Corrosion Inhibitors	6.769	7.822	8.256	8.720	10.305	12.248	14.623	**5.91%**
Scale Inhibitors	0.600	0.689	0.726	0.765	0.899	1.061	1.259	**5.69%**
Biocides & Disinfectants	6.586	7.616	8.040	8.495	10.047	11.952	14.283	**5.94%**

Coagulants & Flocculants	2.103	2.451	2.596	2.750	3.283	3.942	4.756	**6.27%**
Chelating Agents	4.199	4.889	5.175	5.481	6.535	7.837	9.444	**6.23%**
Anti-Foaming Agents	4.473	5.162	5.446	5.749	6.784	8.051	9.598	**5.86%**
Ph Adjusters and Stabilizers	1.095	1.279	1.355	1.436	1.717	2.066	2.497	**6.34%**
Others	0.798	0.918	0.967	1.020	1.197	1.412	1.672	**5.64%**
Process Control and Automation	76.336	88.534	93.573	98.972	117.473	140.247	168.209	**6.07%**
Design, Engineering, and Construction Services	51.786	60.436	64.025	67.878	81.147	97.599	117.950	**6.33%**
Operation and Maintenance Services	35.489	40.889	43.109	45.481	53.562	63.420	75.410	**5.78%**
Total	**235.970**	**273.874**	**289.542**	**306.332**	**363.897**	**434.818**	**521.970**	**6.10%**

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.3. TREATMENT TECHNOLOGIES

Treatment technologies encompass a diverse array of methods and processes designed to purify water and treat wastewater, ensuring its safety for consumption, industrial use, and environmental sustainability. These technologies form an essential component of modern infrastructure, safeguarding public health and the environment by mitigating the risks associated with waterborne contaminants. From municipal water treatment plants to industrial facilities and decentralized systems, treatment technologies play a crucial role in addressing the challenges posed by pollution, population growth, and urbanization. Various types of treatment technologies are employed to address specific contaminants and tailor solutions to diverse water sources and wastewater streams. Among the most utilized treatment methods are biological, physical, and chemical processes. Biological treatment technologies harness the metabolic activity of microorganisms to break down organic pollutants, such as activated sludge processes, membrane bioreactors (MBRs), and sequencing batch reactors (SBRs). These methods are highly effective in removing organic matter, nutrients, and pathogens from wastewater, promoting natural purification mechanisms.

Physical treatment technologies rely on physical processes to separate contaminants from water, typically through filtration, sedimentation, or flotation. Membrane filtration, including microfiltration, ultrafiltration, nanofiltration, and reverse osmosis, is particularly effective in removing suspended solids, bacteria, viruses, and dissolved substances from water. Meanwhile, sedimentation and flotation processes facilitate the removal of solids through gravitational or buoyancy-driven separation, respectively. Chemical treatment technologies involve the addition of chemicals to water or wastewater to precipitate, neutralize, or oxidize contaminants. Coagulation and flocculation, for instance, are employed to aggregate suspended particles and enhance their removal during subsequent filtration or sedimentation processes. Advanced oxidation processes (AOPs), such as ozonation and ultraviolet (UV) irradiation, utilize powerful oxidants to degrade persistent organic pollutants and disinfect water.

The growth of treatment technologies is propelled by various factors, including population growth, urbanization, industrialization, and environmental regulations. With expanding urban populations and increasing water demand, there is a growing imperative to invest in water and wastewater infrastructure, driving innovation and adoption of advanced treatment solutions. Furthermore, emerging contaminants, such as pharmaceuticals, microplastics, and industrial chemicals, present new challenges that necessitate the development of specialized treatment technologies. The adoption of decentralized treatment systems, including onsite wastewater treatment and water reuse schemes, is also gaining traction as a means to enhance water resilience and resource efficiency. These systems leverage compact, modular technologies to treat water at the point of use, reducing reliance on centralized infrastructure and minimizing transmission losses. Additionally, advancements in sensor technology, automation, and data analytics are facilitating the optimization and monitoring of treatment processes, enhancing operational efficiency and reliability. Thus, treatment technologies play a critical role in ensuring the availability of safe, clean water for human consumption, industrial processes, and environmental protection. As the global population continues to grow and environmental pressures mount, the evolution and expansion of treatment technologies are paramount to addressing emerging challenges and achieving sustainable water management goals.

8.3.1. WATER & WASTEWATER TREATMENT TECHNOLOGIES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 34. WATER & WASTEWATER TREATMENT TECHNOLOGIES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	11.255	13.107	13.874	14.697	17.527	21.027	25.345	**6.24%**
Europe	13.568	15.761	16.668	17.640	20.976	25.089	30.149	**6.14%**
North America	17.487	20.346	21.530	22.800	27.163	32.553	39.196	**6.20%**
Middle East & Africa	1.380	1.593	1.680	1.774	2.095	2.487	2.966	**5.88%**
Latin America	2.046	2.383	2.523	2.673	3.189	3.826	4.613	**6.25%**
Total	**45.735**	**53.190**	**56.275**	**59.584**	**70.948**	**84.982**	**102.270**	**6.19%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.3.2. ACTIVATED SLUDGE PROCESS

The activated sludge process stands as a cornerstone in the domain of water and wastewater treatment, serving as a pivotal method in the removal of organic pollutants and suspended particles. Its significance is poised to witness a substantial surge in demand over the forecast period, driven by escalating needs for efficient treatment solutions across various sectors. Originating from the early 20th century, the activated sludge method represents a sophisticated biological treatment approach, wherein suspended growth organisms, predominantly aerobic bacteria, play a pivotal role in degrading organic matter and contaminants present in wastewater. Through the infusion of air or oxygen into raw sewage, a dynamic biological environment known as 'activated sludge' is fostered, facilitating the breakdown of organic components within the sewage. This process, characterized by its reliance on aeration tanks and settling chambers, epitomizes a meticulously orchestrated interplay of microbial activity and hydraulic dynamics.

Operators of activated sludge facilities shoulder a weighty responsibility in maintaining the delicate balance of food, organisms, and oxygen within the treatment system. This necessitates meticulous control over aeration, return rates, waste rates, and a keen eye on various operational parameters such as mixing patterns, foam formation, color variations, and odors. Process control hinges heavily upon regular sampling and testing, encompassing a gamut of parameters including settled sludge volume, suspended solids concentrations, dissolved oxygen levels, and biochemical oxygen demand (BOD) or chemical oxygen demand (COD). Such rigorous monitoring underscores the criticality of ensuring optimal performance and compliance with regulatory standards. The activated sludge itself constitutes a complex matrix teeming with diverse microorganisms, predominantly bacteria along with fungi, protozoa, and invertebrates. This flocculent culture, typically brown in color, thrives within aeration tanks under controlled conditions, driving the biodegradation of organic pollutants. Mechanisms such as mechanical or diffused aeration systems facilitate the vital process of oxygenation, ensuring the sustenance of aerobic conditions conducive to microbial activity. Settling tanks provide the necessary hydraulic detention time for the separation of activated sludge solids from treated wastewater, thereby enabling the recovery and recirculation of active biomass to the aeration tank, a crucial aspect in maintaining treatment efficiency.

Despite its efficacy, the activated sludge process is not without its challenges. Vulnerability to shock loads, particularly in conventional setups with low mixed liquor suspended solids (MLSS) concentrations, underscores the need for prudent design and operational strategies. Moreover, the process demands substantial initial capital investment and ongoing operational expenditures, necessitating a skilled workforce for system management. Energy-intensive aeration requirements further compound operational costs, while logistical constraints pertaining to parts availability and regulatory compliance pose additional complexities. Thus, the activated sludge process emerges as a cornerstone of modern water and wastewater treatment, offering unparalleled efficacy in organic pollutant removal and treatment. Its continued evolution and adoption signify a pivotal milestone in the quest for sustainable and environmentally responsible wastewater management solutions. As demands for efficient treatment escalate, propelled by environmental imperatives and regulatory mandates, the activated sludge process is poised to remain a linchpin in the global water treatment landscape, embodying the epitome of innovation and resilience in the face of evolving challenges.

8.3.2.1. ACTIVATED SLUDGE PROCESS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 35. ACTIVATED SLUDGE PROCESS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	4.355	5.053	5.341	5.650	6.709	8.013	9.615	**6.09%**
Europe	5.251	6.077	6.418	6.783	8.032	9.566	11.444	**5.98%**
North America	6.750	7.825	8.269	8.745	10.373	12.377	14.836	**6.05%**
Middle East & Africa	0.534	0.614	0.647	0.683	0.803	0.949	1.127	**5.73%**
Latin America	0.789	0.916	0.969	1.025	1.217	1.454	1.745	**6.09%**
Total	**17.680**	**20.486**	**21.645**	**22.886**	**27.135**	**32.360**	**38.768**	**6.03%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.3.3. MEMBRANE BIO REACTOR

Membrane bioreactors (MBRs) represent a cutting-edge innovation in the field of water and wastewater treatment, offering a comprehensive solution to the challenges posed by increasingly stringent environmental regulations and the growing demand for high-quality treated water. MBR technology seamlessly integrates a bioreactor with advanced membrane filtration units, revolutionizing the traditional approach to wastewater treatment. This amalgamation of biological processes with membrane-based solid-liquid separation techniques has garnered significant attention and appreciation across municipal and industrial sectors worldwide. The demand for MBR systems is experiencing an unprecedented surge, driven by their unparalleled efficacy in producing effluent of unparalleled quality. Municipalities and industries alike are embracing MBR technology as a reliable and efficient means to address diverse wastewater treatment needs. From municipal wastewater reclamation to the treatment of industrial effluents laden with complex contaminants, MBRs offer a versatile solution that can be tailored to suit various applications. This versatility is further enhanced by the adaptability of MBRs to handle fluctuating organic loads, making them particularly well-suited for industrial wastewater treatment scenarios.

One of the most striking advantages of MBRs lies in their ability to produce effluent of drinking water quality, thereby facilitating water reuse and recycling initiatives. The treated effluent from MBR systems is devoid of suspended solids and pathogens, eliminating the need for extensive disinfection processes. This renders MBR-treated water suitable for a myriad of purposes, ranging from industrial operations to urban irrigation and even direct potable use in some cases. Consequently, MBR technology is emerging as a cornerstone in the quest for sustainable water management practices, mitigating the strain on local water supplies and safeguarding precious water resources for future generations. The compact footprint of MBR systems further enhances their appeal, especially in space-constrained urban environments or remote locations where traditional treatment facilities may be impractical. By eliminating the need for large clarifiers and reducing the overall space requirements, MBRs offer a pragmatic solution for optimizing land utilization while maintaining superior treatment efficiency. Moreover, the modular design and scalability of MBR units facilitate seamless integration into existing infrastructure, providing a cost-effective upgrade path for conventional treatment plants seeking to enhance their performance and compliance with regulatory standards.

However, the efficacy and longevity of MBR systems hinge crucially on diligent maintenance practices and proactive fouling mitigation strategies. Fouling, a persistent challenge in membrane-based filtration processes, can impair the performance and longevity of MBR membranes if left unchecked. Routine cleaning and maintenance regimes, encompassing both physical and chemical interventions, are imperative to mitigate fouling and maximize the operational efficiency of MBR systems. Furthermore, skilled personnel trained in the intricacies of MBR operation and maintenance play a pivotal role in ensuring the smooth functioning and longevity of these advanced treatment facilities. As the global demand for clean water continues to escalate, MBR technology emerges as a linchpin in the quest for resilient and resource-efficient water management solutions. With proper maintenance and prudent deployment, MBR systems hold the promise of revolutionizing wastewater treatment practices and ushering in a new era of sustainable water stewardship.

8.3.3.1. MEMBRANE BIO REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 36. MEMBRANE BIO REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	2.236	2.597	2.746	2.906	3.454	4.129	4.960	**6.12%**
Europe	2.697	3.124	3.300	3.489	4.136	4.930	5.905	**6.02%**
North America	3.457	4.011	4.239	4.485	5.325	6.361	7.633	**6.09%**
Middle East & Africa	0.274	0.316	0.333	0.351	0.413	0.489	0.582	**5.76%**
Latin America	0.404	0.469	0.496	0.525	0.625	0.747	0.898	**6.13%**
Total	**9.068**	**10.517**	**11.115**	**11.756**	**13.953**	**16.657**	**19.977**	**6.07%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.3.4. MOVING BED BIO REACTOR

Moving Bed Bio Reactor (MBBR) technology has emerged as a pivotal innovation in the water and wastewater treatment industry, offering a versatile and efficient solution for addressing the increasing demand for effective purification processes. Developed by Norwegian researchers in the late 1980s and early 1990s, MBBR has rapidly gained traction due to its ability to mitigate the challenges associated with traditional biological treatment methods. This technology represents a significant advancement in the field, combining the strengths of activated sludge processes and biofilm media, while effectively mitigating the limitations typically encountered in biological wastewater treatment. The demand for MBBR systems has seen a notable surge, driven by several factors. Firstly, the economic feasibility of MBBR makes it an attractive choice for industries where cost reduction is a primary concern or where discharge regulations are not as stringent. By efficiently removing the bulk of the pollution load, MBBR offers a cost-effective alternative for wastewater treatment, minimizing the financial burden associated with discharge costs. Additionally, the compact nature of MBBR systems allows for significant space savings, making them particularly appealing for facilities with limited real estate.

One of the key advantages of MBBR technology lies in its ability to enhance the capacity and efficiency of existing wastewater treatment plants, while simultaneously reducing the footprint of new plant deployments. The system achieves this by utilizing plastic carriers coated with biofilm, which provide an extensive surface area for optimal contact with water, air, and bacteria. This design maximizes the efficiency of organic substance removal, nitrification, and denitrification processes, ensuring thorough purification of wastewater. The operational simplicity and low maintenance requirements of MBBR further contribute to its growing demand in the industry. Unlike traditional treatment methods that necessitate extensive manual intervention and maintenance tasks, MBBR systems operate largely autonomously, minimizing the need for constant oversight by operators. This inherent simplicity not only streamlines the treatment process but also reduces operational costs associated with manpower and maintenance.

Furthermore, the flexibility of MBBR systems enables them to adapt seamlessly to fluctuations in influent characteristics and load variations. The presence of microorganisms on the carriers allows the system to respond effectively to changes in wastewater composition, ensuring consistent performance even under challenging conditions. This resilience makes MBBR particularly well-suited for industries that experience fluctuating wastewater volumes or compositions. With its economic viability, compact design, operational simplicity, and flexibility, MBBR represents a paradigm shift in wastewater treatment, offering an efficient and sustainable solution for addressing the evolving needs of modern industrial processes. As industries increasingly prioritize environmental sustainability and regulatory compliance, MBBR emerges as a cornerstone technology in the quest for effective wastewater management.

8.3.4.1. MOVING BED BIO REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 37. MOVING BED BIO REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	1.535	1.797	1.906	2.023	2.427	2.930	3.554	**6.46%**
Europe	1.850	2.160	2.289	2.427	2.903	3.493	4.224	**6.35%**
North America	2.397	2.803	2.972	3.154	3.780	4.558	5.522	**6.42%**
Middle East & Africa	0.188	0.218	0.230	0.244	0.290	0.346	0.415	**6.08%**
Latin America	0.281	0.329	0.348	0.370	0.444	0.536	0.650	**6.47%**
Total	**6.251**	**7.307**	**7.746**	**8.217**	**9.843**	**11.862**	**14.366**	**6.40%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.3.5. SEQUENCING BATCH REACTOR

Sequencing Batch Reactors (SBRs) have emerged as indispensable tools within the realm of water and wastewater treatment, representing a sophisticated approach to managing the complexities of purification processes. Characterized by their ability to execute numerous treatment procedures within a single tank, SBRs have garnered substantial attention and demand in the industry owing to their efficacy and versatility. Fundamentally, SBRs function as industrial processing tanks dedicated to treating wastewater in discrete batches. This process involves subjecting the wastewater, be it sewage or output from anaerobic digesters or other treatment facilities to a series of meticulously orchestrated stages. The pivotal aspect of SBRs lies in their capacity to facilitate various treatment mechanisms, including the reduction of biochemical oxygen demand (BOD) and chemical oxygen demand (COD), thereby rendering the water fit for discharge or reuse.

Operating on a fill-and-draw basis, SBRs adhere to a structured cycle encompassing distinct phases: Fill, React, Settle, Draw, and Idle. During the Fill phase, the tank is replenished with wastewater, which undergoes subsequent treatment. The React phase witnesses the culmination of biological reactions initiated during Fill, often characterized by alternating conditions of low and high dissolved oxygen concentrations. This phase is critical for fostering microbial activity essential for organic matter degradation. Following React, the Settle phase allows for solids separation under quiescent conditions, leveraging the entire tank as a clarifier. Effluent removal transpires during the Draw phase, facilitated by various mechanisms ensuring uniform withdrawal from within the tank. Finally, the Idle phase intercedes between Draw and Fill, providing opportunities for efficient sludge management.

The demand for SBRs in water and wastewater treatment is burgeoning, driven by their efficacy in delivering superior effluent quality while navigating stringent regulatory frameworks. These reactors offer unparalleled flexibility, capable of accommodating diverse treatment requirements and adapting to fluctuating operational demands. Moreover, their compact footprint and modular expandability render them well-suited for a spectrum of applications, from small-scale facilities to large municipalities. Despite their sophistication, SBRs necessitate meticulous design and operation to harness their full potential. Factors such as aeration system selection, cycle duration, and effluent removal mechanisms require careful consideration to optimize performance and efficiency. Nonetheless, the benefits they confer—ranging from reduced footprint to compliance with regulatory standards—position SBRs as indispensable assets within the water and wastewater treatment landscape. In essence, the escalating demand for SBRs underscores their pivotal role in advancing the efficacy and sustainability of water and wastewater treatment processes. As industries and municipalities increasingly prioritize environmental stewardship and regulatory compliance, the adoption of SBR technology is poised to continue its upward trajectory, shaping the future of water management worldwide.

8.3.5.1. SEQUENCING BATCH REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 38. SEQUENCING BATCH REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	1.176	1.382	1.468	1.560	1.880	2.281	2.780	**6.63%**
Europe	1.416	1.660	1.761	1.870	2.247	2.717	3.301	**6.52%**
North America	1.843	2.165	2.298	2.442	2.941	3.563	4.338	**6.59%**
Middle East & Africa	0.144	0.167	0.177	0.188	0.224	0.269	0.324	**6.24%**
Latin America	0.216	0.254	0.270	0.287	0.346	0.419	0.511	**6.64%**
Total	**4.795**	**5.627**	**5.974**	**6.347**	**7.638**	**9.249**	**11.255**	**6.57%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.3.6. UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR

The demand for Upflow Anaerobic Sludge Blanket (UASB) reactors in the water and wastewater treatment industry is poised for significant growth during the forecast period. Widely recognized as a highly effective anaerobic treatment technology, UASB reactors have garnered substantial attention, particularly in tropical regions such as Latin America and India. These reactors play a pivotal role in mitigating organic pollution in wastewater through anaerobic digestion processes, converting organic contaminants into methane and carbon dioxide. Notably, Brazil stands as a prominent example, boasting over 650 full-scale UASB installations, indicative of its widespread adoption and efficacy in addressing wastewater treatment challenges. At the core of UASB reactor functionality lies its innovative design, featuring a three-phase separator that enables the efficient separation of gas, water, and sludge mixtures even under high turbulence conditions. This design not only enhances operational efficiency but also allows for more compact and cost-effective reactor configurations. With multiple gas hoods facilitating biogas separation, UASB reactors can accommodate relatively high loading rates, further enhancing their appeal for industrial wastewater treatment applications.

The operational process within a UASB reactor is orchestrated through careful management of biomass distribution within the reactor. Initially, influent wastewater is introduced at the bottom of the reactor, gradually ascending through an expanded sludge bed characterized by a high concentration of biomass. Subsequently, the remaining substrate passes through a less dense biomass layer, termed the sludge blanket, ensuring thorough treatment and maintaining stable effluent quality. The volume of the sludge blanket serves a dual purpose, providing both additional treatment capacity and facilitating the separation of solid particles from the treated mixture through a three-phase separator situated above. Critical to the success of UASB reactors is their optimal height and area configuration, aimed at maximizing treatment efficiency while minimizing operational complexities. Striking a balance between reactor height and sludge bed characteristics is essential to mitigate issues such as channeling and ensure adherence to permissible liquid upflow velocities. Moreover, the design considerations extend to the Gas-Liquid-Solid (GLS) separator, which is meticulously engineered to facilitate sludge return without external energy requirements or control devices, underscoring the reactor's self-sustaining operational framework.

Despite the manifold advantages offered by UASB reactors, including energy production, minimal biosolids waste generation, and robust performance under organic shock loads, certain limitations warrant consideration. Notably, UASB treatment alone may not suffice to achieve surface water discharge quality without supplementary post-treatment measures. Moreover, the production of reduced sulfur compounds necessitates careful management to address concerns related to corrosion, odour, and safety. Additionally, longer start-up periods and specific temperature requirements pose operational challenges, highlighting the importance of meticulous monitoring and management protocols. Thus, the Upflow Anaerobic Sludge Blanket (UASB) reactor stands as a cornerstone technology in the water and wastewater treatment industry, offering a compelling solution for organic pollution mitigation. As demand for sustainable and efficient wastewater treatment solutions continues to escalate globally, UASB reactors are poised to emerge as indispensable assets, driving advancements in environmental stewardship and resource conservation.

8.3.6.1. UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 39. UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.774	0.896	0.947	1.001	1.186	1.413	1.692	**6.01%**
Europe	0.932	1.077	1.136	1.200	1.418	1.685	2.012	**5.91%**
North America	1.213	1.404	1.483	1.567	1.855	2.209	2.642	**5.98%**
Middle East & Africa	0.095	0.109	0.114	0.121	0.142	0.167	0.198	**5.66%**
Latin America	0.142	0.165	0.174	0.184	0.218	0.260	0.311	**6.02%**
Total	**3.156**	**3.650**	**3.854**	**4.072**	**4.819**	**5.735**	**6.856**	**5.96%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.3.7. SUBMERGED AERATED FIXED FILM REACTOR

The Submerged Aerated Fixed Film (SAFF) Reactor represents a cornerstone in contemporary water and wastewater treatment methodologies, owing to its efficiency, cost-effectiveness, and adaptability. SAFF technology has garnered substantial attention in the industry due to its remarkable ability to mitigate organic load, Biochemical Oxygen Demand (BOD), and Suspended Solids (SS) within sewage effluents. This versatile approach finds widespread application in diverse settings, including commercial complexes, residential areas, and sewage sanitation industries. Notably, SAFF technology emerges as an indispensable solution in scenarios where land constraints and cost considerations render traditional treatment methods impractical. In essence, SAFF reactors operate through an aerobic biological process, facilitated by the utilization of corrugated inert UV stabilized PVC media. This specialized media design offers an expansive surface area that facilitates the rapid digestion of biomass by microbial organisms. The process is further augmented by a mechanical aeration system comprising blowers and diffusers, which supply the necessary air to support microbial activity within the reactor. The structured arrangement of SAFF media, supported by bottom support infrastructure, ensures optimal performance and longevity of the treatment system.

Recent trends underscore a significant surge in demand for SAFF technology within the water and wastewater treatment industry, propelled by evolving regulatory standards and burgeoning population needs. Notably, water utilities worldwide are increasingly turning to SAFF-based solutions to address the challenges posed by population growth and stringent effluent quality requirements. Furthermore, prominent players in the water utilities sector, such as those in the UK, have recognized the potential of SAFF technology to meet their evolving needs and objectives. Through recent initiatives, these utilities are actively investing in the deployment of SAFF-based solutions to upgrade and expand their wastewater treatment infrastructure. By leveraging the inherent benefits of SAFF technology, including its proven efficacy in reducing organic pollutants and improving effluent quality, these initiatives aim to enhance the resilience and sustainability of water treatment operations.

In particular, the adoption of Hybrid-SAF modular biological treatment units signifies a paradigm shift in wastewater treatment practices. These innovative solutions, exemplified by WCSEE's patented Hybrid-SAF technology, offer enhanced efficiency and adaptability compared to conventional SAF systems. By integrating submerged moving-bed and fixed-film reactor designs, Hybrid-SAF units boast superior energy efficiency and operational flexibility, making them ideally suited for addressing variable flow rates and dynamic environmental conditions. Furthermore, the modular design and compact footprint of Hybrid-SAF units confer unparalleled versatility, enabling their deployment in a wide range of settings, including rural areas, and densely populated urban centers. The offsite construction and rapid installation capabilities of these units minimize onsite disruption, reduce waste, and optimize overall operational efficiency.

Thus, the burgeoning demand for SAFF technology underscores its pivotal role in shaping the future of water and wastewater treatment practices. By leveraging the inherent advantages of SAFF reactors, coupled with advancements in Hybrid-SAF technology, water utilities can effectively address the evolving challenges posed by population growth, regulatory compliance, and sustainability objectives. As the industry continues to embrace innovative solutions, SAFF technology stands poised to remain at the forefront of transformative change, driving towards a more efficient, resilient, and environmentally sustainable future.

8.3.7.1. SUBMERGED AERATED FIXED FILM REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 40. SUBMERGED AERATED FIXED FILM REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.674	0.787	0.835	0.885	1.060	1.277	1.546	**6.39%**
Europe	0.812	0.946	1.002	1.062	1.268	1.523	1.838	**6.28%**
North America	1.055	1.232	1.306	1.385	1.657	1.994	2.411	**6.36%**
Middle East & Africa	0.082	0.095	0.101	0.107	0.126	0.151	0.180	**6.02%**
Latin America	0.124	0.144	0.153	0.162	0.195	0.235	0.284	**6.40%**
Total	**2.747**	**3.206**	**3.397**	**3.601**	**4.305**	**5.179**	**6.260**	**6.34%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.3.8. OTHER TREATMENT TECHNOLOGIES

The water and wastewater treatment industry are witnessing a growing demand for alternative treatment technologies, driven by the need for effective solutions to address water scarcity and quality concerns. Among these technologies, desalination and LED-based treatment systems are gaining significant traction. LED technology is emerging as a promising approach for water purification. These systems utilize light emitting diodes to facilitate the removal of chemicals, debris, and biological impurities from water. By trapping contaminants in filters equipped with nanotechnology coatings, LEDs initiate a chemical reaction that breaks down molecules, thereby purifying the water. This innovative method not only enhances the efficiency of water treatment but also offers potential cost savings and environmental benefits.

Desalination, despite its historical reputation for being costly and energy-intensive, is undergoing transformative advancements. The adoption of reverse osmosis technology has significantly improved the efficiency of salt removal from ocean water, expanding access to clean freshwater for drinking and industrial use. Moreover, ongoing developments in membrane technology are further enhancing the economic viability of desalination processes, making them more sustainable and accessible on a global scale. In addition to these advancements, the integration of renewable energy sources such as solar power holds immense potential for revolutionizing water treatment practices. By harnessing solar electricity to power desalination facilities, researchers and engineers are exploring avenues to reduce operational costs and environmental impact. This shift towards sustainable energy solutions not only aligns with global efforts to combat climate change but also addresses the affordability challenges faced by underdeveloped regions in accessing clean water resources.

Furthermore, the utilization of modern nanotechnology alongside renewable energy sources underscores a holistic approach towards water treatment. By leveraging the synergies between innovative technologies, the industry is poised to overcome existing limitations and achieve greater efficiency, reliability, and sustainability in water and wastewater treatment processes. Thus, the growing demand for alternative treatment technologies underscores the urgent need for innovation in the water and wastewater treatment industry. Through advancements in desalination, LED technology, and the integration of renewable energy sources, stakeholders are driving transformative changes that promise to enhance access to clean water resources while mitigating environmental impacts. As these technologies continue to evolve, they hold the potential to address some of the most pressing challenges facing water management and sustainability globally.

8.3.8.1. OTHER WATER & WASTEWATER TREATMENT TECHNOLOGIES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 41. OTHER WATER & WASTEWATER TREATMENT TECHNOLOGIES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.506	0.595	0.632	0.672	0.811	0.983	1.197	**6.62%**
Europe	0.611	0.717	0.761	0.808	0.972	1.175	1.426	**6.51%**
North America	0.771	0.906	0.962	1.023	1.232	1.492	1.814	**6.57%**
Middle East & Africa	0.062	0.073	0.077	0.081	0.097	0.117	0.140	**6.24%**
Latin America	0.090	0.106	0.113	0.120	0.144	0.175	0.213	**6.62%**
Total	**2.039**	**2.397**	**2.545**	**2.705**	**3.256**	**3.941**	**4.790**	**6.55%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.4. TREATMENT CHEMICALS

The water treatment chemicals market has experienced substantial growth in recent years, driven by a convergence of factors that underscore the critical importance of efficient water management practices. This growth trajectory is underpinned by the escalating demand for chemically treated water across a myriad of end-use sectors worldwide. The proliferation of industrial activities, coupled with the exponential rise in urbanization and population growth, has placed unprecedented pressure on global freshwater resources. As freshwater reserves dwindle, the need for effective water treatment solutions becomes increasingly imperative. Water treatment chemicals encompass a diverse array of compounds meticulously formulated to address specific contaminants and impurities present in water sources. Among the prominent types of water treatment chemicals are corrosion inhibitors, scale inhibitors, biocides and disinfectants, coagulants and flocculants, chelating agents, anti-foaming agents, pH adjusters and stabilizers, among others. Each category serves a unique function, ranging from preventing corrosion in infrastructure and equipment to facilitating the removal of suspended particles and organic matter.

The applications of water treatment chemicals span across a broad spectrum of industries, each with distinct requirements and challenges. In the oil and gas sector, for instance, these chemicals play a pivotal role in treating produced water and mitigating the deleterious effects of contaminants on equipment integrity and operational efficiency. Similarly, in power generation facilities, water treatment chemicals are indispensable for maintaining the performance and longevity of cooling systems, boilers, and turbines. In the mining industry, where water-intensive processes are prevalent, these chemicals are employed to optimize water usage and manage wastewater discharge responsibly. Moreover, the burgeoning demand for clean water across residential, commercial, and agricultural sectors has propelled the adoption of water treatment chemicals on a global scale. Rapid industrialization and urbanization in emerging economies have further accentuated this trend, as governments and industries prioritize water quality and environmental sustainability.

Additionally, stringent regulatory standards and heightened awareness of the adverse impacts of water pollution have compelled businesses to invest in advanced water treatment technologies and chemicals to ensure compliance and mitigate risks.

The water and wastewater treatment industry stands at the forefront of addressing the multifaceted challenges posed by water scarcity, pollution, and escalating demand. As such, the demand for water treatment chemicals is expected to continue its upward trajectory, driven by the imperative to optimize water resources, enhance operational efficiency, and safeguard public health and environmental integrity. In this dynamic landscape, innovative formulations, sustainable practices, and strategic partnerships will be pivotal in shaping the future of water treatment chemical solutions, fostering resilience and sustainability in water management practices worldwide.

8.4.1. WATER & WASTEWATER TREATMENT CHEMICALS MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 42. WATER & WASTEWATER TREATMENT CHEMICALS MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	6.551	7.594	8.025	8.487	10.068	12.014	14.401	**6.05%**
Europe	7.897	9.133	9.642	10.187	12.051	14.338	17.136	**5.95%**
North America	10.183	11.795	12.460	13.173	15.611	18.609	22.284	**6.02%**
Middle East & Africa	0.803	0.923	0.972	1.025	1.204	1.422	1.688	**5.70%**
Latin America	1.191	1.382	1.460	1.544	1.833	2.187	2.622	**6.06%**
Total	**26.625**	**30.826**	**32.560**	**34.416**	**40.767**	**48.570**	**58.130**	**6.00%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.4.2. CORROSION INHIBITORS

Corrosion inhibitors serve as indispensable tools in the arsenal of measures employed to combat the deleterious effects of corrosion within industrial sectors, particularly in water and wastewater treatment. The incessant demand for corrosion inhibitors underscores their pivotal role in safeguarding critical infrastructure and optimizing operational efficiency. Corrosion, an electrochemical process that leads to the degradation of metallic surfaces, poses significant challenges across various industries, resulting in equipment failure, decreased efficiency, and substantial financial losses. As such, the proactive utilization of corrosion inhibitors emerges as a primary strategy for mitigating these adverse outcomes and ensuring the longevity of infrastructure components.

Within the water and wastewater treatment industry, corrosion inhibitors assume a multifaceted role, offering protection to a wide array of equipment and structures subjected to corrosive environments. These inhibitors function by impeding the electrochemical reactions that facilitate corrosion, thereby forming protective layers or altering the corrosion potential of metal surfaces. An array of corrosion inhibitors is deployed in water treatment processes, each tailored to address specific corrosion mechanisms and environmental conditions. The demand for corrosion inhibitors within the water and wastewater treatment industry is poised for significant growth, driven by several factors. Firstly, the escalating emphasis on infrastructure modernization and expansion initiatives necessitates robust corrosion mitigation strategies to safeguard investments and enhance operational reliability. Additionally, stringent regulatory frameworks mandating the maintenance of water quality standards propel the adoption of corrosion inhibitors as integral components of comprehensive water treatment protocols. Furthermore, the increasing prevalence of corrosive elements in water sources, exacerbated by factors such as industrial effluents and environmental pollutants, amplifies the imperative for proactive corrosion management measures.

Technological advancements and innovations in corrosion inhibitor formulations further augment their appeal within the water and wastewater treatment sector. Manufacturers continually refine inhibitor compositions to enhance efficacy, compatibility, and environmental sustainability, thereby catering to the evolving needs of end-users. Customized corrosion inhibition solutions tailored to specific applications and environmental conditions are increasingly sought after, reflecting a growing recognition of the importance of targeted corrosion management strategies. Corrosion inhibitors represent a cost-effective and efficient means of preserving infrastructure integrity and prolonging equipment lifespan within the water and wastewater treatment industry. By mitigating corrosion-induced damage and minimizing operational disruptions, these inhibitors contribute to the optimization of asset performance and the attainment of operational excellence. As industries confront the pervasive challenge of corrosion, the sustained demand for corrosion inhibitors underscores their indispensable role in safeguarding critical infrastructure and sustaining industrial operations amidst evolving environmental and regulatory landscapes.

8.4.2.1. CORROSION INHIBITORS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 43. CORROSION INHIBITORS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	1.668	1.930	2.038	2.153	2.548	3.034	3.627	**5.97%**
Europe	2.011	2.321	2.449	2.586	3.052	3.622	4.319	**5.87%**
North America	2.584	2.986	3.153	3.330	3.938	4.682	5.593	**5.93%**
Middle East & Africa	0.205	0.235	0.247	0.260	0.305	0.360	0.426	**5.62%**
Latin America	0.302	0.350	0.369	0.390	0.462	0.550	0.658	**5.97%**
Total	**6.769**	**7.822**	**8.256**	**8.720**	**10.305**	**12.248**	**14.623**	**5.91%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.4.3. SCALE INHIBITORS

Scale inhibitors are indispensable components in the water and wastewater treatment industry, playing a crucial role in mitigating the adverse effects of scale formation. Scale, a common precipitate that emerges on surfaces in contact with water, poses significant challenges in industrial settings, particularly in systems where temperature fluctuations occur. This scaling phenomenon arises from the precipitation of typically soluble particles, such as calcium carbonate, calcium sulfate, and calcium silicate, which become insoluble as temperatures rise. Scale inhibitors serve as highly effective solutions to this problem, functioning as negatively charged, surface-active polymers. The mechanism by which scale inhibitors operate involves disrupting the crystalline structure of scale-forming minerals, thereby inhibiting their deposition onto surfaces. These inhibitors effectively bind to minerals when they reach a state of solubility beyond their natural capacity, preventing them from combining and forming scale. Moreover, the particles of scale and inhibitor remain suspended in the water, preventing their adherence to surfaces. This process not only inhibits scale formation but also contributes to the prevention of corrosion by increasing flow velocity and hindering the attachment of corrosive compounds to equipment walls and tubes.

In the selection of scale inhibitors, several key criteria are considered to ensure optimal performance and compatibility within treatment systems. Factors such as efficiency, stability, and compatibility with other treatment chemicals are paramount. Scale inhibitors must demonstrate effectiveness in inhibiting scale formation, maintain stability over time, and not interfere with the function of other treatment chemicals. Additionally, considerations such as the type and severity of scaling, cost-effectiveness, temperature, pH levels, and chemical compatibility influence the selection process. The demand for scale inhibitors in the water and wastewater treatment industry is poised for significant growth during the forecast period. This anticipated surge in demand can be attributed to the increasing awareness of the detrimental effects of scale formation on system efficiency and longevity. As industries continue to prioritize operational efficiency and environmental sustainability, the adoption of scale inhibitors becomes imperative. Furthermore, advancements in inhibitor technology, such as dendrimer-based inhibitors, offer enhanced performance and compatibility, further driving market growth.

In practical applications, scale inhibitors find widespread use across various sectors, including tap water treatment, heating systems, solar water heaters, and industrial circulating water systems. By preventing scale formation and corrosion, these inhibitors contribute to the efficient operation and prolonged lifespan of water treatment equipment. Moreover, they play a crucial role in maintaining the integrity and performance of critical components such as reverse osmosis membranes, thereby ensuring the production of high-quality water. Thus, scale inhibitors represent an indispensable aspect of water and wastewater treatment processes, offering effective solutions to mitigate scale formation and corrosion. With their ability to improve system efficiency, reduce maintenance costs, and prolong equipment lifespan, scale inhibitors are poised to witness increased demand and adoption across diverse industrial sectors in the coming years.

8.4.3.1. SCALE INHIBITORS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 44. SCALE INHIBITORS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.150	0.172	0.181	0.191	0.225	0.266	0.316	**5.74%**
Europe	0.181	0.208	0.218	0.230	0.270	0.319	0.377	**5.65%**
North America	0.225	0.258	0.272	0.287	0.337	0.398	0.473	**5.70%**
Middle East & Africa	0.018	0.021	0.022	0.023	0.027	0.032	0.037	**5.41%**
Latin America	0.026	0.030	0.032	0.034	0.039	0.047	0.055	**5.75%**
Total	**0.600**	**0.689**	**0.726**	**0.765**	**0.899**	**1.061**	**1.259**	**5.69%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.4.4. BIOCIDES & DISINFECTANTS

The demand for biocides and disinfectants in water and wastewater treatment is projected to experience significant growth in the foreseeable future. Laboratory experiments establish maximum tolerated microbial population limits within systems, prompting the need for substantial reduction of bacteria and other microbes under certain circumstances. Biocides, chemical substances toxic to existing microorganisms, are introduced into the mix to achieve this objective efficiently and swiftly. Often, biocides are slug-fed into systems to ensure rapid and effective population reductions from which microbes struggle to recover. These biocides encompass a diverse array of types, each exerting varied effects on different bacterial species, and can be categorized into oxidizing and non-oxidizing agents.

In tandem with biocides, disinfectants serve to eradicate any undesired bacteria already present in water. Chlorine, chlorine dioxide, ozone, hypochlorite, and chlorine dioxide disinfection represent only a selection of the wide range of disinfectants available. Chlorine dioxide, for instance, stands out as a primary disinfectant for surface waters afflicted with odor and taste issues, demonstrating efficacy across a broad pH spectrum and at low doses as minimal as 0.1 ppm. Unlike chlorine, chlorine dioxide disinfection poses no adverse health effects on humans while effectively combating microbial presence. Similarly, hypochlorite, although once commonly employed, has seen diminished use due to environmental concerns regarding its role in bromate consistency within water.

Ozone emerges as a disinfectant with remarkable attributes, boasting a remarkably short lifespan and serving as a potent oxidation medium. Composed of oxygen molecules with an additional O-atom, ozone promptly oxidizes germs, viruses, and odors upon contact, subsequently reverting to pure oxygen. Various sectors harness disinfectants for diverse applications; in the pharmaceutical industry, for instance, ozone finds utility in water purification, process water treatment, production of ultra-pure water, and surface disinfection, while chlorine dioxide is commonly utilized for pipeline disinfection and potable water preparation.

8.4.4.1. BIOCIDES & DISINFECTANTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 45. BIOCIDES & DISINFECTANTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	1.619	1.874	1.980	2.092	2.479	2.953	3.534	**6.00%**
Europe	1.951	2.253	2.378	2.511	2.966	3.524	4.205	**5.90%**
North America	2.523	2.919	3.082	3.257	3.854	4.587	5.484	**5.96%**
Middle East & Africa	0.198	0.228	0.240	0.253	0.296	0.350	0.414	**5.65%**
Latin America	0.295	0.342	0.361	0.382	0.452	0.539	0.645	**6.01%**
Total	**6.586**	**7.616**	**8.040**	**8.495**	**10.047**	**11.952**	**14.283**	**5.94%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.4.5. COAGULANTS & FLOCCULANTS

Coagulants and flocculants serve as indispensable agents in the water and wastewater treatment industry, playing pivotal roles in the purification of both drinking water and industrial wastewater. As global concerns regarding water quality and environmental sustainability continue to escalate, the demand for these essential chemicals is expected to experience significant growth in the foreseeable future. In the realm of water treatment, coagulants and flocculants operate in tandem to tackle the myriad of impurities present in raw water sources. Coagulants, whether organic or inorganic, initiate the destabilization of suspended particles by neutralizing their charges. This crucial process paves the way for the formation of larger aggregates, known as flocs, which can be more effectively removed from the water through subsequent filtration or sedimentation processes. Inorganic coagulants such as aluminum sulphate and ferric chloride are commonly favored for their efficiency in particle removal, while organic alternatives like polyamines and polydiallyldimethylammonium chloride offer advantages such as lower environmental impact and enhanced microfloc formation.

Following coagulation, flocculants come into play, facilitating the aggregation of fine particles into larger, settleable flocs. Typically, in the form of polymers, flocculants act as binding agents, promoting the gentle mixing necessary for floc formation. This crucial step not only aids in the removal of suspended solids and organic compounds but also contributes to the clarification of water, rendering it suitable for various end uses ranging from drinking to industrial processes. The demand for coagulants and flocculants in water and wastewater treatment is underpinned by their unparalleled efficacy in addressing a spectrum of water quality challenges. From the removal of turbidity and suspended solids to the mitigation of organic contaminants, these chemicals play a fundamental role in safeguarding public health and protecting the environment. Furthermore, their versatility extends beyond conventional municipal water treatment to encompass specialized applications such as slurry pond management, mining wastewater treatment, and recycled plastics wash water treatment, underscoring their indispensable nature across diverse industrial sectors.

As regulatory frameworks governing water quality become increasingly stringent, the water and wastewater treatment industry faces mounting pressure to adopt advanced treatment methodologies capable of meeting stringent effluent standards. Coagulants and flocculants, with their proven track record of efficacy and reliability, emerge as cornerstone solutions in this endeavor, offering wastewater treatment facilities the means to achieve desired levels of purification while minimizing environmental impact and operational costs. Thus, coagulants and flocculants represent indispensable tools in the arsenal of water and wastewater treatment technologies, driving advancements in water quality management and environmental stewardship. As global demand for clean water continues to surge, the critical role of these chemicals in facilitating the purification of water resources cannot be overstated, positioning them as indispensable assets in the pursuit of a sustainable water future.

8.4.5.1. COAGULANTS & FLOCCULANTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 46. COAGULANTS & FLOCCULANTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.516	0.602	0.638	0.676	0.809	0.973	1.175	**6.33%**
Europe	0.622	0.724	0.766	0.811	0.967	1.159	1.397	**6.22%**
North America	0.808	0.942	0.997	1.057	1.262	1.517	1.831	**6.29%**
Middle East & Africa	0.063	0.073	0.077	0.082	0.096	0.115	0.137	**5.96%**
Latin America	0.095	0.110	0.117	0.124	0.148	0.178	0.216	**6.34%**
Total	**2.103**	**2.451**	**2.596**	**2.750**	**3.283**	**3.942**	**4.756**	**6.27%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.4.6. CHELATING AGENTS

Chelating agents play a pivotal role in the water and wastewater treatment industry, offering effective solutions for complex challenges associated with metal ion contamination and scale formation. These chemical compounds, also known as chelants or sequestrants, are adept at forming stable complexes with metal ions, thereby preventing them from reacting with other substances in water systems. The ability of chelating agents to bind with metal ions through multiple coordination sites makes them invaluable in various applications, including metal cleaning, scale inhibition, and corrosion control. In recent years, the demand for chelating agents in the water and wastewater treatment sector has witnessed significant growth. This growth can be attributed to several factors, including the increasing awareness of environmental issues, stricter regulatory standards governing water quality, and the continuous expansion of industrial activities requiring efficient water management practices. As industries strive to optimize their processes and minimize environmental impacts, the role of chelating agents becomes even more critical in achieving these objectives.

One of the primary drivers of the growth in chelating agent usage is their effectiveness in mitigating the adverse effects of metal ion contamination in water systems. Metal ions, such as iron, calcium, and magnesium, can lead to scale deposition, corrosion, and reduced system efficiency if left untreated. Chelating agents offer a proactive approach to addressing these challenges by forming stable complexes with metal ions, thereby preventing scale formation and corrosion. Furthermore, advancements in chelating agent technology have led to the development of more sustainable and environmentally friendly alternatives. Manufacturers are increasingly focused on producing chelants derived from renewable resources or bio-inspired molecules that exhibit biodegradability and reduced ecological impact. These innovations align with the industry's growing emphasis on sustainability and responsible chemical management practices.

In addition to their role in traditional water treatment applications, chelating agents are also finding new avenues of use in emerging technologies and treatment processes. For instance, chelating agents are being explored for their potential in advanced oxidation processes (AOPs) for the removal of recalcitrant pollutants and emerging contaminants from wastewater streams. Their ability to complex with metal ions and organic pollutants enhances the efficiency of AOPs, leading to improved treatment outcomes. Moreover, the versatility of chelating agents makes them suitable for a wide range of water treatment applications, from industrial processes to municipal water supply systems. Whether it's preventing scale deposition in cooling towers, reducing heavy metal concentrations in industrial wastewater, or enhancing the effectiveness of disinfection processes, chelating agents offer tailored solutions to meet diverse treatment needs. Overall, the growth of chelating agents in the water and wastewater treatment industry reflects their indispensable role in addressing complex water quality challenges and advancing sustainable water management practices. As industries continue to prioritize environmental stewardship and regulatory compliance, the demand for effective chelating agents is expected to continue its upward trajectory, driving further innovation and development in the field.

8.4.6.1. CHELATING AGENTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 47. CHELATING AGENTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	1.031	1.202	1.273	1.349	1.611	1.935	2.335	**6.29%**
Europe	1.242	1.445	1.528	1.618	1.926	2.307	2.776	**6.18%**
North America	1.611	1.877	1.987	2.105	2.511	3.013	3.632	**6.25%**
Middle East & Africa	0.126	0.146	0.154	0.163	0.192	0.228	0.273	**5.92%**
Latin America	0.189	0.220	0.233	0.247	0.295	0.354	0.428	**6.30%**
Total	**4.199**	**4.889**	**5.175**	**5.481**	**6.535**	**7.837**	**9.444**	**6.23%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.4.7. ANTI-FOAMING AGENTS

Anti-foaming agents represent a critical component within the water and wastewater treatment industry, where the management of foam is paramount to maintaining operational efficiency and product quality. With an increasing demand projected for anti-foaming agents in this sector, the necessity for effective foam control solutions is underscored. Foam, characterized by a mass of bubbles within a liquid, poses significant challenges across various industrial processes due to its disruptive nature. Whether it arises from mechanical agitation or chemically induced mechanisms, foam can impede the performance of equipment, reduce throughput, and lead to overspills, potentially endangering personnel and necessitating costly cleanup operations.

The growth in demand for anti-foaming agents can be attributed to the escalating awareness of their indispensable role in mitigating foam-related issues within water and wastewater treatment facilities. As industries strive for heightened efficiency and productivity, the detrimental impacts of uncontrolled foam formation become increasingly apparent. Consequently, there is a burgeoning interest in anti-foaming agents as indispensable additives capable of averting foam-related disruptions and enhancing operational stability. This surge in demand underscores the pivotal role played by anti-foaming agents in safeguarding the seamless functioning of water and wastewater treatment processes.

The efficacy of anti-foaming agents lies in their ability to disrupt the formation and persistence of foam through various mechanisms. By introducing insoluble agents that swiftly spread across foamy surfaces, these additives destabilize and rupture the bubbles, thus preventing the escalation of foam formation. Whether in the form of hydrocarbon-based agents tailored for resilient foams or organic defoamers ideal for biologically generated foam, anti-foaming agents offer versatile solutions adaptable to diverse foam types and industrial applications. Moreover, silicone-based antifoams stand out for their economical nature and universal applicability, catering to a wide array of scenarios within water and wastewater treatment processes. Regulatory frameworks governing anti-foaming products underscore the importance of compliance with stringent standards to ensure their safe and effective utilization. From regulations governing adhesives to those pertaining to paper manufacturing and animal glue production, adherence to prescribed limitations and guidelines is imperative to mitigate potential risks to human health, environmental integrity, and industrial operations. By adhering to established regulations, stakeholders can instill confidence in the reliability and safety of anti-foaming agents, fostering their widespread adoption across the water and wastewater treatment industry.

Thus, the escalating demand for anti-foaming agents within the water and wastewater treatment industry underscores their indispensable role in ensuring operational efficiency and product quality. As industries grapple with the challenges posed by foam-related disruptions, the adoption of effective foam control solutions becomes increasingly imperative. By leveraging a diverse array of anti-foaming agents tailored to specific applications and regulatory requirements, stakeholders can navigate the complexities of foam management with confidence, fostering a robust and sustainable approach to water and wastewater treatment processes.

8.4.7.1. ANTI-FOAMING AGENTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 48. ANTI-FOAMING AGENTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	1.099	1.269	1.340	1.415	1.672	1.988	2.373	**5.91%**
Europe	1.324	1.526	1.609	1.698	2.001	2.372	2.824	**5.81%**
North America	1.715	1.980	2.089	2.206	2.605	3.093	3.688	**5.88%**
Middle East & Africa	0.135	0.154	0.162	0.171	0.200	0.235	0.278	**5.57%**
Latin America	0.201	0.232	0.245	0.259	0.306	0.364	0.434	**5.92%**
Total	**4.473**	**5.162**	**5.446**	**5.749**	**6.784**	**8.051**	**9.598**	**5.86%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.4.8. PH ADJUSTERS AND STABILIZERS

The demand for pH adjusters and stabilizers within the water and wastewater treatment industry has witnessed a notable surge, with projections indicating sustained growth throughout the forecast period. This heightened demand can be attributed to the critical role these chemicals play in ensuring the efficient management and treatment of water supplies. Municipal water systems, in particular, rely heavily on pH adjustment to combat issues such as pipe corrosion and the dissolution of harmful substances like lead into water sources. pH modification is also integral to various stages of water treatment processes, where precise pH levels are crucial for optimizing treatment efficiency and ensuring water quality compliance. In essence, a pH adjuster serves as a chemical agent employed to manipulate the pH, or Potential Hydrogen, level of water. The pH scale, ranging from 0 to 14, delineates the acidity or alkalinity of a solution, with a neutral pH set at 7. By introducing pH-relevant chemicals such as acids or bases, water treatment facilities can effectively raise or lower pH levels as necessary. For instance, the addition of sulfuric acid facilitates pH reduction, while sodium hydroxide serves to elevate pH levels. However, it is imperative to exercise caution during pH adjustment processes, as the chemical reactions involved can generate heat, with the intensity of this reaction escalating in proportion to the severity of the application.

Moreover, the stabilization of sludge solids represents another crucial aspect of water and wastewater treatment, necessitating a range of chemical interventions. Lime stabilization and chlorine application emerge as two widely adopted techniques for this purpose, each offering distinct advantages in terms of efficacy and operational feasibility. Lime stabilization, for instance, entails the incorporation of lime into the sludge matrix to elevate pH levels to 12 or higher. This process not only mitigates bacterial risks and odors but also enhances vacuum filter performance, thereby facilitating efficient sludge management and disposal practices. Furthermore, the significance of pH adjustment extends beyond mere water treatment, encompassing the broader domain of environmental sustainability and public health protection. Acidic or alkaline water conditions not only pose immediate risks to infrastructure integrity but also harbor potential health hazards through the leaching of heavy metals into water supplies. Consequently, the meticulous regulation of pH levels assumes paramount importance in safeguarding both environmental integrity and human well-being.

Thus, the escalating demand for pH adjusters and stabilizers underscores their indispensable role in contemporary water and wastewater treatment practices. As regulatory scrutiny intensifies and environmental concerns heighten, the adoption of effective pH management strategies assumes heightened significance for stakeholders across the water treatment spectrum. By leveraging innovative chemical solutions and adhering to best practices in treatment protocols, the industry is poised to navigate evolving challenges and realize sustainable water management outcomes in the years ahead.

8.4.8.1. PH ADJUSTERS AND STABILIZERS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 49. PH ADJUSTERS AND STABILIZERS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.269	0.314	0.333	0.353	0.423	0.510	0.617	**6.40%**
Europe	0.324	0.378	0.400	0.424	0.506	0.608	0.734	**6.29%**
North America	0.421	0.491	0.520	0.552	0.660	0.795	0.961	**6.36%**
Middle East & Africa	0.033	0.038	0.040	0.043	0.050	0.060	0.072	**6.02%**
Latin America	0.049	0.058	0.061	0.065	0.078	0.093	0.113	**6.41%**
Total	**1.095**	**1.279**	**1.355**	**1.436**	**1.717**	**2.066**	**2.497**	**6.34%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.4.9. OTHERS

In the realm of water and wastewater treatment, the efficacy of processes heavily relies on the judicious application of treatment chemicals. Among these, resin cleaners and oxygen scavengers occupy pivotal roles in maintaining system integrity and efficiency. Resin cleaners play an indispensable role in ensuring the optimal performance of ion exchange resins, which serve as linchpins in various treatment methodologies. Following their application, these resins necessitate regeneration to sustain their functionality. However, persistent usage leads to fouling, where impurities accrue within the resin matrix. To mitigate this, specialized chemicals such as sodium chloride, potassium chloride, citric acid, and chlorine dioxide are employed in cleaning protocols. Of these, chlorine dioxide emerges as a particularly potent agent in purging organic impurities from ion exchange resins, thereby rejuvenating their efficacy. Prior to each cleaning endeavor, resins are replenished to ensure maximal impact. During the cleaning process, a carefully calibrated solution of 500 ppm chlorine dioxide is systematically applied over the resin bed, facilitating the oxidation and subsequent removal of impurities.

Simultaneously, the imperative to counteract oxidation processes underscores the significance of oxygen scavengers in water and wastewater treatment regimes. Oxygen, when left unchecked, can catalyze a cascade of deleterious oxidation events, compromising the integrity of treated water. Oxygen scavengers thus function as frontline defenders, intercepting and neutralizing oxygen molecules before they can instigate oxidation reactions. This is particularly pertinent given the prevalence of naturally occurring organics within water matrices, which, owing to their slight positive charge, can readily absorb oxygen molecules. The arsenal of oxygen scavengers encompasses a diverse array of volatile molecules and organic compounds, including hydrazine, carbohydrazine, hydroquinone, diethylhydroxyethanol, and methylethylketoxime. Moreover, non-volatile salts such as sodium sulphite and other inorganic derivatives play integral roles in oxygen scavenging protocols, offering robust protection against oxidative degradation. To expedite the scavenging process, catalyzing chemicals like cobalt chloride are often judiciously integrated into salt formulations, augmenting the rate of reaction with dissolved oxygen.

In essence, the utilization of treatment chemicals such as resin cleaners and oxygen scavengers exemplify a proactive stance towards optimizing water and wastewater treatment endeavors. By leveraging the potency of these specialized agents, treatment facilities can safeguard against fouling, preserve the efficacy of ion exchange resins, and forestall the insidious onset of oxidation reactions. As the demand for comprehensive water and wastewater treatment solutions continues to burgeon, the indispensability of these treatment chemicals is poised to ascend commensurately, underscoring their status as cornerstone components in the pursuit of water purity and environmental stewardship.

8.4.9.1. OTHER CHEMICALS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 50. OTHER CHEMICALS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.200	0.231	0.243	0.256	0.301	0.356	0.422	**5.71%**
Europe	0.242	0.278	0.293	0.309	0.363	0.427	0.506	**5.62%**
North America	0.297	0.341	0.360	0.379	0.445	0.525	0.621	**5.63%**
Middle East & Africa	0.025	0.028	0.030	0.031	0.037	0.043	0.050	**5.39%**
Latin America	0.035	0.040	0.042	0.044	0.052	0.061	0.073	**5.68%**
Total	**0.798**	**0.918**	**0.967**	**1.020**	**1.197**	**1.412**	**1.672**	**5.64%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.5. PROCESS CONTROL AND AUTOMATION

The demand for process control and automation within the water and wastewater industry is experiencing a significant surge, poised to grow exponentially in the foreseeable future. This surge can be attributed to the indispensable role played by instrumentation, control, and automation (ICA) in ensuring the seamless operation and optimization of modern water and wastewater treatment systems. These systems, characterized by their inherent susceptibility to disruptions, necessitate the automatic mitigation of adverse impacts to uphold operational efficiency and environmental standards. In the intricate ecosystem of water and wastewater management, two distinct but interrelated sectors stand out: wastewater treatment and water distribution systems. Wastewater treatment systems, inherently driven by varying load dynamics, demand adaptive measures to maintain consistent performance levels. Conversely, water distribution systems are propelled by fluctuating demand patterns, necessitating real-time adjustments to ensure uninterrupted supply. Irrespective of these inherent differences, both sectors require process control and automation solutions to guarantee reliable outputs amidst changing operational conditions.

The adoption of process control and automation is further fueled by economic imperatives, compelling stakeholders to maximize plant capacity while minimizing operational costs. In the context of contemporary nutrient removal plants, characterized by escalating process complexities, the need for sophisticated management solutions becomes paramount. ICA emerges as the linchpin in this quest for operational excellence, enabling efficient utilization of resources and adherence to stringent regulatory standards. Beyond operational considerations, the imperative of safeguarding natural resources underscores the necessity for an integrated approach encompassing various facets of water and wastewater management. From collection and transport to treatment procedures, the seamless orchestration of interdependent systems hinges on the efficacy of process control and automation technologies. By facilitating holistic resource management and environmental stewardship, ICA emerges as a cornerstone in achieving sustainable water management practices.

However, the efficacy of process control and automation hinges not only on technological prowess but also on the availability of knowledgeable personnel for maintenance and operational contingencies. While automation mitigates the significance of routine operator interventions, the indispensable role of qualified staff in ensuring system integrity and resilience cannot be overstated. Moreover, the execution of microprocessor control projects necessitates the engagement of private consulting firms, endowed with the requisite expertise to manage treatment plants effectively. The burgeoning demand for process control and automation has catalyzed the evolution of intelligent, decentralized networks tailored to the unique requirements of automation systems. Concurrently, it has spurred the development of integrated information systems, serving as nerve centers for control and administration within water and wastewater management entities. This convergence of technological innovation and operational exigencies underscores the transformative potential of ICA in reshaping the water and wastewater industry landscape, propelling it towards greater efficiency, resilience, and sustainability.

8.5.1. WATER & WASTEWATER TREATMENT PROCESS CONTROL AND AUTOMATION MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 51. WATER & WASTEWATER TREATMENT PROCESS CONTROL AND AUTOMATION MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	18.801	21.834	23.088	24.433	29.043	34.727	41.718	**6.12%**
Europe	22.670	26.262	27.745	29.333	34.769	41.453	49.647	**6.02%**
North America	29.150	33.822	35.753	37.822	44.915	53.650	64.381	**6.09%**
Middle East & Africa	2.306	2.655	2.799	2.952	3.475	4.113	4.889	**5.77%**
Latin America	3.409	3.960	4.188	4.433	5.271	6.304	7.575	**6.13%**
Total	**76.336**	**88.534**	**93.573**	**98.972**	**117.473**	**140.247**	**168.209**	**6.07%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.6. DESIGN, ENGINEERING, AND CONSTRUCTION SERVICES

The demand for design, engineering, and construction services in the water and wastewater industry is experiencing a notable surge, driven by a confluence of factors that underscore the critical importance of effective water management strategies. As populations grow and urbanization intensifies, the strain on existing water infrastructure becomes more pronounced, necessitating comprehensive solutions to ensure sustainable access to clean water and efficient wastewater treatment. In today's regulatory landscape, compliance with stringent environmental standards has become paramount. Owners and operators of water and wastewater facilities are tasked with navigating a complex web of regulations aimed at safeguarding water quality and minimizing environmental impact. This heightened regulatory scrutiny underscores the need for sophisticated design, engineering, and construction services that can deliver solutions tailored to meet both current requirements and future challenges.

One of the key drivers of demand in this sector is the increasing awareness of the interconnectedness between water management practices and broader sustainability goals. As stakeholders across industries recognize the importance of responsible water stewardship, there is a growing appetite for innovative solutions that prioritize resource efficiency, pollution prevention, and ecosystem protection. Design, engineering, and construction firms play a pivotal role in meeting this demand by developing cutting-edge technologies and implementing best practices to optimize water and wastewater systems. Moreover, the water and wastewater industry is witnessing a paradigm shift towards holistic, integrated approaches to water management. Gone are the days of siloed solutions that address water supply and wastewater treatment as separate challenges. Instead, there is a growing recognition of the need for integrated systems that consider the entire water cycle, from source to treatment to reuse. This shift towards integrated water management presents a myriad of opportunities for design, engineering, and construction professionals to innovate and collaborate across disciplines to deliver comprehensive solutions that maximize efficiency and resilience.

In addition to regulatory compliance and sustainability imperatives, demographic trends and urbanization patterns are also driving demand for design, engineering, and construction services in the water and wastewater industry. Rapid population growth, particularly in urban areas, places significant pressure on aging water infrastructure, necessitating upgrades, expansions, and retrofits to meet growing demand and ensure reliable service delivery. Design and engineering firms are increasingly called upon to develop creative solutions that optimize existing infrastructure while accommodating future growth and evolving environmental challenges. Thus, the demand for design, engineering, and construction services in the water and wastewater industry is experiencing robust growth driven by a combination of factors, including regulatory compliance, sustainability goals, integrated water management approaches, and demographic trends. As the need for efficient water management solutions continues to escalate, design, engineering, and construction professionals play a pivotal role in shaping the future of water infrastructure, ensuring access to clean water, protecting the environment, and supporting sustainable development.

8.6.1. WATER & WASTEWATER TREATMENT DESIGN, ENGINEERING, AND CONSTRUCTION SERVICES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 52. WATER & WASTEWATER TREATMENT DESIGN, ENGINEERING, AND CONSTRUCTION SERVICES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	12.787	14.943	15.838	16.800	20.115	24.232	29.334	**6.39%**
Europe	15.425	17.980	19.039	20.176	24.087	28.929	34.910	**6.28%**
North America	19.701	23.002	24.372	25.844	30.911	37.198	44.980	**6.35%**
Middle East & Africa	1.570	1.819	1.922	2.032	2.408	2.870	3.437	**6.02%**
Latin America	2.302	2.692	2.853	3.027	3.626	4.369	5.290	**6.40%**
Total	**51.786**	**60.436**	**64.025**	**67.878**	**81.147**	**97.599**	**117.950**	**6.33%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

8.7. OPERATION AND MAINTENANCE SERVICES

The demand for operation and maintenance (O&M) services in the water and wastewater industry is experiencing a significant upsurge, driven by a confluence of factors that underscore the critical importance of effective management and upkeep of treatment facilities. As societies grapple with escalating environmental challenges and increasing urbanization, the complexity of water treatment processes has intensified. This complexity is compounded by the emergence of new technologies designed to address evolving water quality issues and regulatory requirements. Within this landscape, O&M services play a pivotal role in ensuring the optimal performance of water and wastewater treatment plants. Operations within these facilities involve a meticulous balancing act, aimed at consistently producing the requisite quantity of high-quality treated water while navigating a myriad of regulatory standards and environmental considerations. Maintenance, on the other hand, is indispensable for preserving the functionality and longevity of plant equipment, thus safeguarding operational efficiency and mitigating risks of breakdowns or malfunctions.

Technological advancements have been a key catalyst in shaping the demand for O&M services. As treatment processes become increasingly sophisticated, specialized expertise is required to operate and maintain these systems effectively. From advanced filtration methods to cutting-edge monitoring and control systems, the modern water treatment landscape demands a skilled workforce capable of navigating and leveraging these technologies to optimize plant performance. Moreover, the challenges associated with raw water treatment have become more pronounced in recent years. Factors such as pollution, climate change, and population growth have placed unprecedented strain on water resources, necessitating innovative solutions to address emerging contaminants and ensure the provision of safe drinking water. In this context, O&M services play a crucial role in deploying and managing these innovative solutions, whether through the implementation of advanced treatment processes or the integration of decentralized water treatment systems.

In addition to technological complexities, the water and wastewater industry faces mounting pressure to meet evolving customer expectations. Consumers are increasingly concerned about water quality, reliability, and sustainability, driving the need for enhanced service levels and transparent communication from water utilities. O&M services are instrumental in meeting these demands, as they enable utilities to optimize plant performance, minimize downtime, and deliver consistent, high-quality water services to their customers. Furthermore, regulatory compliance remains a top priority for water treatment facilities, with regulatory bodies imposing stringent standards to safeguard public health and the environment. O&M services are indispensable for ensuring compliance with these regulations, as they provide the expertise and resources needed to monitor, assess, and adapt treatment processes in response to changing regulatory requirements. As treatment processes become more complex, and regulatory requirements become more stringent, the role of O&M services will only become more critical in ensuring the efficient, reliable, and sustainable operation of water treatment facilities. By investing in skilled personnel, advanced technologies, and proactive maintenance strategies, water utilities can navigate these challenges effectively and meet the evolving needs of their customers and communities.

8.7.1. WATER & WASTEWATER TREATMENT OPERATION AND MAINTENANCE SERVICES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 53. WATER & WASTEWATER TREATMENT OPERATION AND MAINTENANCE SERVICES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	8.769	10.116	10.670	11.262	13.282	15.750	18.756	**5.83%**
Europe	10.580	12.176	12.832	13.533	15.917	18.822	22.351	**5.73%**
North America	13.487	15.546	16.392	17.297	20.379	24.142	28.720	**5.80%**
Middle East & Africa	1.077	1.233	1.296	1.364	1.594	1.872	2.207	**5.49%**
Latin America	1.576	1.819	1.919	2.025	2.389	2.834	3.375	**5.84%**
Total	**35.489**	**40.889**	**43.109**	**45.481**	**53.562**	**63.420**	**75.410**	**5.78%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

9. GLOBAL WATER AND WASTEWATER TREATMENT MARKET BY EQUIPMENT INSIGHTS & TREND

KEY TRENDS & HIGHLIGHTS

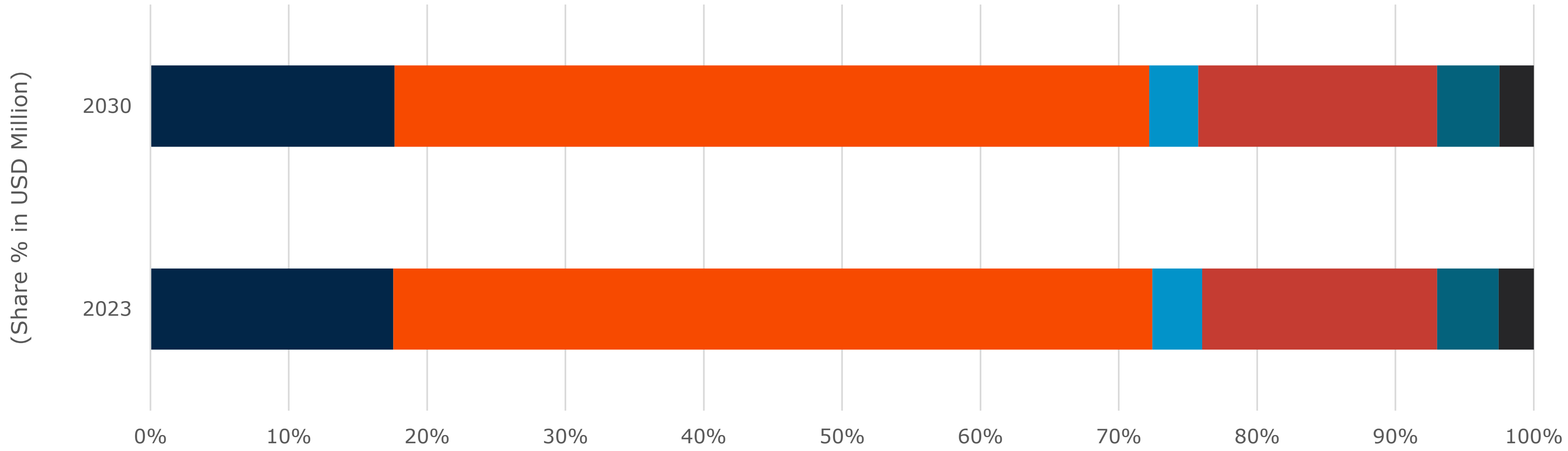
- The demand for Disinfection equipment accounted for over USD 6,798.517 Million in 2023 and is expected to grow at a CAGR of 5.99% in the forecast period.

9.1. EQUIPMENT DYNAMICS & MARKET SHARE, 2023 & 2033

By Equipment, the market is segmented into:

- Filtration
    - Ultra-Filtration
    - Micro-Filtration
- Disinfection
- Adsorption
- Desalination
- Testing
- Others

FIGURE 67. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: EQUIPMENT DYNAMICS (SHARE IN % USD BILLION)



	2023	2030
Filtration	17.56%	17.64%
Disinfection	54.87%	54.57%
Adsorption	3.60%	3.54%
Desalination	16.98%	17.27%
Testing	4.45%	4.49%
Others	2.53%	2.49%

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

9.2. GLOBAL WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY EQUIPMENT, 2019-2033, (USD BILLION)

TABLE 54. GLOBAL WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY EQUIPMENT, 2019-2033, (USD BILLION)

Equipment	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Filtration	43.390	50.499	53.443	56.602	67.453	80.865	97.402	**6.22%**
Ultra-Filtration	27.189	31.901	33.863	35.973	43.271	52.376	63.711	**6.56%**
Micro-Filtration	16.201	18.598	19.581	20.629	24.182	28.489	33.690	**5.60%**
Disinfection	141.479	163.764	172.959	182.802	216.482	257.844	308.510	**5.99%**
Adsorption	1.421	1.644	1.735	1.834	2.170	2.582	3.087	**5.96%**
Desalination	44.451	51.840	54.904	58.193	69.511	83.534	100.866	**6.30%**
Testing	2.966	3.439	3.635	3.845	4.563	5.447	6.533	**6.07%**
Others	2.263	2.689	2.866	3.057	3.719	4.545	5.573	**6.90%**
Total	**235.970**	**273.874**	**289.542**	**306.332**	**363.897**	**434.818**	**521.970**	**6.10%**

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

9.3. FILTRATION

Filtration equipment plays a critical role in ensuring access to clean and safe drinking water, addressing concerns related to water contamination and scarcity. Over the years, the demand for filtration equipment has witnessed significant growth, driven by various factors such as increasing population, rising environmental concerns, and advancements in technology. This surge in demand is expected to continue in the forecast period as industries and communities seek effective solutions for water purification. Innovations in filtration technology have paved the way for more efficient and precise water purification methods. Nanotechnology, for instance, has revolutionized filtration by enabling the development of ultrafine filters capable of capturing contaminants at the molecular level. These advanced filters, exemplified by the nanofiber-based ion exchange filters, offer heightened precision and effectiveness in removing impurities from water, catering to industries such as pharmaceutical processing, biotechnology, and semiconductor manufacturing.

Moreover, the integration of intelligent technologies and artificial intelligence (AI) has transformed traditional water purification processes. AI-driven systems optimize filtration system efficiency by analyzing real-time data, predicting potential issues, and automating certain processes. This not only enhances the overall performance of water treatment facilities but also contributes to resource efficiency and cost-effectiveness. Examples of such intelligent technologies include AI-driven optimization systems deployed in water treatment plants. Electrochemical filtration represents another innovative approach to water purification. This method utilizes electrochemical reactions to target specific pollutants, offering a customized and environmentally friendly solution to water treatment. By operating with minimal chemical usage and energy consumption, electrochemical filtration aligns with sustainability goals while effectively removing contaminants from water sources.

Nature-based solutions have also gained prominence in the realm of water filtration. Green infrastructure, such as constructed wetlands and vegetated buffer strips, mimics natural processes to filter and treat water using plants, soil, and microbial communities. These systems promote sustainability and reduce reliance on energy-intensive conventional treatment methods, showcasing a holistic approach to water purification. An example of nature-based filtration is the utilization of fog catchers, which collect water from fog droplets using polypropylene mesh nets, particularly beneficial in areas facing water scarcity. In addition to technological advancements, innovative filtration systems have emerged to address specific challenges in water purification. Examples include the Drinkable Book, which features pages that serve as water filters and provide educational information on hygiene and sanitation, and LifeStraw, a membrane microfilter designed to remove bacteria, parasites, and microplastics from water. These solutions exemplify the diverse range of approaches towards ensuring access to clean and safe drinking water, aligning with global initiatives such as the United Nations Sustainable Development Goal 6 (Clean water and sanitation). Overall, the growth and innovation in filtration equipment underscore the importance of continuous advancements in water purification technology to address evolving challenges related to water quality and scarcity. By leveraging cutting-edge materials, intelligent technologies, and nature-inspired solutions, filtration equipment plays a pivotal role in safeguarding public health and promoting environmental sustainability.

9.3.1. FILTRATION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 55. FILTRATION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	10.677	12.443	13.175	13.961	16.663	20.007	24.138	**6.27%**
Europe	12.872	14.963	15.828	16.756	19.941	23.872	28.711	**6.17%**
North America	16.592	19.319	20.449	21.661	25.827	30.978	37.334	**6.24%**
Middle East & Africa	1.309	1.512	1.596	1.685	1.991	2.366	2.824	**5.91%**
Latin America	1.941	2.263	2.396	2.539	3.032	3.641	4.394	**6.28%**
Total	**43.390**	**50.499**	**53.443**	**56.602**	**67.453**	**80.865**	**97.402**	**6.22%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

9.3.2. ULTRA-FILTRATION

Ultrafiltration (UF) has emerged as a vital technology in the water and wastewater treatment industry, providing efficient filtration solutions for a wide range of applications. UF operates by utilizing semi-permeable membranes to selectively remove suspended solids, bacteria, viruses, and other contaminants from water, while allowing clean water to pass through. Its ability to produce high-purity water with low silt density makes it indispensable in municipal drinking water treatment, industrial water purification, and various other sectors. In recent years, the demand for UF equipment has witnessed significant growth, driven by several key factors. One of the primary drivers is the increasing need for reliable and sustainable water treatment solutions in response to escalating water scarcity and pollution concerns globally. UF systems offer a sustainable approach to water purification by effectively removing contaminants without the need for extensive chemical treatments, thereby reducing environmental impact.

Advancements in membrane technology and manufacturing processes have been instrumental in driving significant improvements in the performance and cost-effectiveness of ultrafiltration (UF) systems. These innovations encompass a range of developments, including the design of new membrane materials, module configurations, and system enhancements. One area of innovation lies in the development of novel membrane materials with improved properties such as increased permeability, selectivity, and mechanical strength. These advanced materials enable UF membranes to achieve higher filtration efficiencies while maintaining robustness and durability under various operating conditions. For example, DuPont's Multibore PRO membranes utilize a unique polymeric material and 19-capillary geometry, allowing for greater membrane filtration surface area per module. This increased surface area enhances productivity and reduces the number of modules required, resulting in cost savings and improved system performance. In addition to membrane materials, companies have also focused on optimizing module designs and configurations to maximize filtration efficiency and minimize footprint. By leveraging innovative module geometries and rack configurations, UF systems can achieve higher throughput with reduced space requirements, making them suitable for installations where space is limited or costly. H2O Innovation, for instance, has developed ceramic ultrafiltration (UF) systems with high-water recovery rates and compact designs, making them ideal for applications where space constraints are a concern.

Another significant trend shaping the demand for UF equipment is the increasing adoption of water reuse and recycling initiatives across various industries. With growing concerns over freshwater availability and stricter regulations on wastewater discharge, industries are increasingly turning to UF technology to treat and recycle water for non-potable purposes. UF systems play a crucial role in removing contaminants from wastewater streams, allowing treated water to be reused for industrial processes, irrigation, and other applications, thus conserving precious freshwater resources. Furthermore, the expansion of urban populations and industrial activities in emerging economies has fueled the demand for reliable and scalable water treatment solutions. UF technology offers versatility and adaptability to diverse water sources and treatment challenges, making it well-suited for deployment in both centralized and decentralized water treatment facilities. Its modular design allows for easy integration into existing infrastructure and enables scalable capacity expansion to meet growing water demands.

Additionally, stringent regulations governing water quality and environmental protection have propelled the adoption of UF equipment across various sectors. Regulatory mandates aimed at reducing contaminants in drinking water and wastewater effluents have prompted utilities, municipalities, and industries to invest in advanced UF systems to ensure compliance with regulatory standards and safeguard public health and the environment. Thus, ultrafiltration technology continues to play a crucial role in addressing water treatment challenges and meeting the increasing demand for clean and safe water worldwide. With ongoing technological advancements, expanding applications, and evolving regulatory landscapes, the demand for UF equipment is expected to continue growing, driving further innovation and investment in the water and wastewater treatment industry.

9.3.2.1. ULTRA-FILTRATION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 56. ULTRA-FILTRATION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	6.688	7.857	8.345	8.870	10.686	12.957	15.788	**6.62%**
Europe	8.061	9.447	10.023	10.642	12.783	15.449	18.764	**6.50%**
North America	10.404	12.212	12.965	13.776	16.580	20.079	24.439	**6.58%**
Middle East & Africa	0.820	0.954	1.010	1.070	1.275	1.529	1.842	**6.23%**
Latin America	1.217	1.431	1.520	1.615	1.947	2.361	2.878	**6.63%**
Total	**27.189**	**31.901**	**33.863**	**35.973**	**43.271**	**52.376**	**63.711**	**6.56%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

9.3.3. MICRO-FILTRATION

Microfiltration, a widely employed filtration process, utilizes microporous membranes to separate suspended solids, bacteria, and other contaminants from fluids. With pore sizes typically ranging from 0.1 to 1 micron, these membranes allow the passage of water and smaller molecules while capturing larger particles. The process operates under low pressure conditions, making it energy-efficient and cost-effective for various applications across industries. In recent years, the demand for microfiltration has surged across numerous sectors owing to its versatility and efficacy. One of the primary drivers of this growth is its pivotal role in water and wastewater treatment. With increasing concerns about water quality and scarcity, industries and municipalities are turning to advanced filtration technologies like microfiltration to meet stringent regulatory standards and ensure the supply of clean water.

In the water treatment industry, microfiltration serves as a crucial pretreatment step, effectively removing suspended solids, bacteria, and pathogens from raw water sources. This pretreated water can then undergo further purification processes like reverse osmosis or ultraviolet (UV) disinfection to meet specific quality requirements. Additionally, microfiltration finds applications in industrial water reuse and recycling, helping businesses minimize water consumption and reduce environmental impact. Moreover, the wastewater treatment sector has witnessed a significant uptick in the adoption of microfiltration technology. As industries strive to comply with wastewater discharge regulations and minimize their ecological footprint, microfiltration offers an efficient solution for removing contaminants from effluent streams. By producing treated water that meets regulatory standards, microfiltration enables industries to mitigate environmental risks and achieve sustainable wastewater management practices.

The growing demand for microfiltration equipment in the water and wastewater treatment industry is driven by several factors. Firstly, the increasing global population and industrialization have intensified the strain on water resources, necessitating investments in water treatment infrastructure. Furthermore, tightening environmental regulations and public awareness of water quality issues have spurred the adoption of advanced filtration technologies like microfiltration. Additionally, advancements in membrane materials and manufacturing techniques have enhanced the performance and efficiency of microfiltration systems, making them more attractive to end-users. Innovations such as enhanced membrane durability, higher flux rates, and improved fouling resistance have contributed to the widespread adoption of microfiltration across diverse applications. Thus, microfiltration has emerged as a vital technology in the water and wastewater treatment industry, driven by the need for effective contaminant removal and regulatory compliance. The growing demand for microfiltration equipment underscores its pivotal role in ensuring access to clean water and sustainable wastewater management practices across various sectors. As industries continue to prioritize environmental stewardship and resource conservation, the demand for microfiltration is expected to remain robust, driving further innovation and investment in filtration technologies.

9.3.3.1. MICRO-FILTRATION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 57. MICRO-FILTRATION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	3.989	4.586	4.830	5.091	5.976	7.051	8.350	**5.65%**
Europe	4.810	5.516	5.805	6.113	7.158	8.422	9.947	**5.56%**
North America	6.188	7.107	7.483	7.885	9.247	10.899	12.894	**5.62%**
Middle East & Africa	0.489	0.558	0.586	0.616	0.716	0.837	0.982	**5.32%**
Latin America	0.724	0.832	0.877	0.924	1.085	1.280	1.516	**5.66%**
Total	**16.201**	**18.598**	**19.581**	**20.629**	**24.182**	**28.489**	**33.690**	**5.60%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

9.4. DISINFECTION

Disinfection is a critical process in water and wastewater treatment, involving the removal, deactivation, or killing of pathogenic microorganisms present in water. This essential step ensures that water intended for consumption, or other uses is safe and free from harmful bacteria, viruses, fungi, and other microorganisms that can pose health risks to humans and the environment. There are various methods of disinfection, classified into two main types: physical and chemical. Physical disinfection methods include ultraviolet (UV) light, electronic radiation, gamma rays, sounds, and heat. These methods work by physically damaging the cell walls or membranes of microorganisms, altering their permeability, or disrupting essential cellular functions, ultimately leading to their inactivation or death. Chemical disinfection, on the other hand, involves the use of disinfectants such as chlorine, chlorine dioxide, ozone, bromine, iodine, metals like copper and silver, potassium permanganate, phenols, alcohols, and hydrogen peroxide. These chemical agents work by reacting with microorganisms to disrupt their cellular structures or metabolic processes, rendering them harmless.

The demand for disinfection equipment in the water and wastewater treatment industry is influenced by several factors. Firstly, increasing awareness of waterborne diseases and the importance of clean water for public health drives the demand for effective disinfection solutions. With growing urbanization and industrialization, the risk of water contamination also rises, leading to higher demand for disinfection equipment to ensure water safety. Moreover, stringent regulations and standards imposed by regulatory authorities regarding water quality and treatment processes further fuel the demand for disinfection equipment. Water treatment plants and facilities are required to comply with these regulations to ensure that treated water meets specified safety standards before distribution to consumers. Furthermore, technological advancements and innovations in disinfection equipment, such as UV disinfection systems and advanced chemical disinfectants, contribute to the growth of the market. These advanced technologies offer more efficient, cost-effective, and environmentally friendly solutions for water disinfection, attracting investment from water treatment facilities and industries.

Additionally, increasing investment in infrastructure development, particularly in emerging economies, to improve water and sanitation systems drives the demand for disinfection equipment. As governments and municipalities prioritize investments in water and wastewater infrastructure to meet the growing demand for clean water, the market for disinfection equipment experiences significant growth. Overall, the demand for disinfection equipment in the water and wastewater treatment industry is expected to continue growing due to factors such as increasing awareness of waterborne diseases, stringent regulatory standards, technological advancements, and infrastructure development initiatives. As the importance of clean water for public health and environmental sustainability becomes increasingly recognized, the market for disinfection equipment is poised for further expansion in the coming years.

9.4.1. DISINFECTION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 58. DISINFECTION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	34.894	40.442	42.733	45.187	53.591	63.928	76.610	**6.04%**
Europe	42.084	48.657	51.367	54.267	64.181	76.341	91.214	**5.94%**
North America	53.916	62.435	65.951	69.716	82.601	98.433	117.836	**6.01%**
Middle East & Africa	4.283	4.922	5.185	5.465	6.419	7.580	8.991	**5.69%**
Latin America	6.303	7.308	7.723	8.168	9.690	11.562	13.858	**6.05%**
Total	**141.479**	**163.764**	**172.959**	**182.802**	**216.482**	**257.844**	**308.510**	**5.99%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

9.5. ADSORPTION

The global demand for adsorption equipment is on a trajectory of significant expansion, fueled primarily by its pivotal role in water and wastewater treatment industries. Adsorption, a method crucial for purifying water sources contaminated by an array of compounds, stands as a cornerstone in the quest for cleaner and safer environments. This purification process, whether employed in drinking water preparation, groundwater treatment, or industrial wastewater management, relies on adsorption equipment to effectively eliminate non-degradable organic compounds from diverse water streams. The allure of adsorption lies in its versatility, adept at tackling a spectrum of contaminants, ranging from volatile solvents like benzene and ethanol to recalcitrant organic pollutants. Moreover, the simplicity in design and comparatively lower initial investment render adsorption equipment a compelling choice for industries grappling with water quality challenges.

At the heart of adsorption equipment lie various adsorbents, each tailored to target specific contaminants with precision. From the ubiquitous activated carbon, revered for its efficacy in removing apolar compounds, to the molecular sieves and zeolites celebrated for their selective retention properties, the arsenal of adsorbents offers a multifaceted approach to water treatment. These adsorbents, characterized by their substantial internal surface area, facilitate the adhesion of contaminants, ensuring efficient purification of water and wastewater streams. The demand for such equipment spans a myriad of industrial applications, ranging from odor control and solvent recovery to the remediation of contaminated water and air streams. As industries grapple with mounting regulatory pressures and heightened environmental concerns, the indispensability of adsorption equipment becomes increasingly pronounced, driving sustained growth in its adoption across diverse sectors.

Within the realm of adsorption systems, two distinct design implementations emerge as frontrunners: fixed-bed adsorbers and fluidized-bed adsorbers. Fixed-bed adsorbers, characterized by their stationary adsorbents, find utility across a broad spectrum of applications, from small-scale consumer uses to large industrial operations. These systems, boasting predictable properties such as pressure drop and adsorbent life expectancy, offer a reliable means of combating waterborne contaminants. Conversely, fluidized-bed adsorbers, employing a dynamic, fluidized adsorbent, present a more complex yet dynamic solution. While offering advantages such as continuous regeneration and uniform temperature gradients, these systems entail higher energy costs and necessitate larger chambers, primarily suited for high-volume industrial endeavors. Despite their disparities, both fixed-bed and fluidized-bed adsorption systems play pivotal roles in addressing the evolving needs of water and wastewater treatment industries.

In the pursuit of effective adsorption equipment, the selection of appropriate media assumes paramount importance. Activated alumina, renowned for its desiccant properties and fluoride filtration capabilities, emerges as a stalwart in water treatment. Similarly, activated carbon, hailed for its versatility and cost-effectiveness, finds ubiquitous application across gas purification, water treatment, and air filtration domains. Complemented by molecular sieves, zeolites, and silica gel, the array of adsorption media underscores the versatility and adaptability of adsorption equipment across diverse industrial settings. As industries navigate the intricate landscape of water treatment, considerations such as selectivity, capacity, and regeneration emerge as pivotal determinants in the selection of adsorption equipment, ensuring optimal performance and efficiency.

In tandem with the burgeoning demand for adsorption equipment, suppliers are poised to play a pivotal role in catering to the evolving needs of industries. Beyond offering a gamut of adsorption products, suppliers extend a suite of services encompassing media reactivation and system assembly, augmenting the operational efficiency and longevity of adsorption equipment. By facilitating media reactivation and offering turnkey solutions, suppliers enable industries to minimize operational costs and adhere to stringent regulatory frameworks, thereby bolstering their environmental stewardship endeavors. As industries strive to navigate the complexities of water and wastewater treatment, the symbiotic relationship between suppliers and end-users emerges as a linchpin in driving innovation and sustainability across the adsorption landscape.

9.5.1. ADSORPTION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 59. ADSORPTION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.345	0.399	0.422	0.446	0.528	0.630	0.754	**6.01%**
Europe	0.414	0.478	0.505	0.533	0.630	0.748	0.893	**5.91%**
North America	0.555	0.643	0.679	0.717	0.849	1.011	1.209	**5.98%**
Middle East & Africa	0.042	0.048	0.051	0.053	0.063	0.074	0.088	**5.66%**
Latin America	0.065	0.076	0.080	0.084	0.100	0.119	0.143	**6.02%**
Total	**1.421**	**1.644**	**1.735**	**1.834**	**2.170**	**2.582**	**3.087**	**5.96%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

9.6. DESALINATION

The demand for desalination equipment is projected to experience significant growth in the coming years, driven by the escalating need for efficient water and wastewater treatment solutions across diverse industries. Desalination technology plays a pivotal role in removing salts and other minerals from water sources, particularly seawater, thereby rendering it suitable for a myriad of applications spanning from potable water provision to industrial processes and oil field operations. This technology encompasses three primary methodologies: thermal desalination, separation desalination, and chemical desalination. In thermal desalination systems, water is subjected to vaporization followed by physical separation to eliminate salts, ultimately resulting in the reversion of vapor to liquid form. Separation desalination systems, on the other hand, leverage physical separation mechanisms like membranes to segregate components based on externally-applied gradients. Chemical desalination systems entail chemical processes coupled with membranes or distillation methods.

The applications of desalination equipment are wide-ranging, extending across residential, commercial, and industrial sectors. In residential settings, desalination equipment finds utility in households, hotels, resorts, and maritime vessels, providing access to clean drinking water where traditional sources may be scarce. Moreover, the industrial sector relies heavily on desalination for various operations, including oil field activities where treated water is indispensable for diverse production processes. Additionally, desalination equipment plays a crucial role in wastewater treatment, offering solutions for the purification and reuse of wastewater in industrial and municipal contexts. As the global demand for clean water continues to mount, the adoption of desalination technology is anticipated to witness substantial growth across these diverse applications.

Within the water and wastewater treatment industry, desalination equipment holds profound significance, serving as a cornerstone in addressing water scarcity challenges and promoting sustainable water management practices. The adoption of desalination technology in water treatment processes is driven by its efficacy in producing high-quality water suitable for consumption and industrial use. Distillation and membrane processes represent the two major commercial approaches to desalination equipment. Distillation processes, such as multi-stage flash and multi-effect evaporation, harness thermal energy to facilitate water evaporation and condensation, while membrane processes like reverse osmosis and electrodialysis employ semipermeable membranes to selectively separate salts and impurities from water.

The ongoing research and development endeavors in the desalination field are instrumental in propelling innovations in desalination equipment. Advancements in membrane technology, energy recovery systems, and materials science are paving the way for enhanced efficiency, reduced energy consumption, and lower production costs. Furthermore, research initiatives focusing on chemical-free desalination and the beneficial reuse of concentrate are poised to revolutionize desalination into a more environmentally sustainable and economically viable water treatment solution. As these research efforts continue to evolve, desalination equipment is poised to play an indispensable role in meeting the escalating global demand for clean water and addressing the pressing challenges of water scarcity and wastewater management.

9.6.1. DESALINATION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 60. DESALINATION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	10.939	12.774	13.536	14.354	17.173	20.671	25.001	**6.36%**
Europe	13.187	15.361	16.261	17.228	20.550	24.660	29.733	**6.25%**
North America	16.996	19.830	21.005	22.267	26.612	31.998	38.659	**6.32%**
Middle East & Africa	1.341	1.552	1.639	1.733	2.052	2.444	2.924	**5.99%**
Latin America	1.988	2.323	2.461	2.611	3.124	3.762	4.550	**6.37%**
Total	**44.451**	**51.840**	**54.904**	**58.193**	**69.511**	**83.534**	**100.866**	**6.30%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

9.7. TESTING

The demand for testing equipment, particularly in the water and wastewater treatment industry, is experiencing significant growth as industries and municipalities alike prioritize water quality management. This surge in demand is driven by the pressing need to ensure the safety of public drinking water supplies, preserve natural water sources, and meet regulatory standards. Water testing plays a crucial role in identifying contaminants, assessing water quality parameters, and guiding treatment processes to mitigate risks and protect human health and the environment. Various types of testing equipment have emerged to address the diverse needs of water and wastewater treatment facilities. Handheld meters offer portability and convenience, allowing for on-site testing of parameters such as pH, turbidity, and conductivity. These meters are essential for quick assessments in the field, enabling rapid decision-making and immediate response to water quality concerns. Additionally, benchtop instruments provide higher precision and accuracy, making them suitable for detailed laboratory analysis of complex samples. These instruments are often utilized for in-depth research, quality control, and compliance testing in industrial and research settings.

Multiparameter meters and sondes have gained prominence due to their ability to simultaneously measure multiple parameters, offering efficiency and versatility in water quality monitoring applications. These advanced instruments provide comprehensive data collection capabilities, facilitating comprehensive assessments of water quality dynamics and trends over time. Furthermore, automatic water samplers streamline the sampling process by autonomously collecting representative water samples at predetermined intervals. These samplers are invaluable for long-term monitoring initiatives and regulatory compliance assessments, ensuring consistent and reliable data collection. The adoption of online/process monitors is on the rise, driven by the need for continuous, real-time monitoring of water quality parameters in industrial processes and treatment systems. These sophisticated instruments enable proactive management of water treatment processes, allowing operators to promptly detect deviations from desired water quality standards and implement corrective measures. Moreover, colorimeters offer a cost-effective solution for instantaneous measurement of various water quality parameters, providing rapid insights into water quality characteristics without the need for complex laboratory analyses.

In the context of the water and wastewater treatment industry, the applications of testing equipment are diverse and far-reaching. These instruments are extensively utilized in drinking water treatment plants, wastewater treatment facilities, industrial manufacturing processes, agricultural operations, and environmental monitoring programs. They play a critical role in identifying sources of contamination, optimizing treatment processes, assessing the effectiveness of remediation efforts, and ensuring compliance with regulatory requirements. As water scarcity and pollution continue to pose significant challenges globally, the demand for testing equipment is expected to escalate further in the coming years. Governments, industries, and communities are increasingly recognizing the importance of proactive water quality management and investing in advanced testing technologies to safeguard precious water resources and promote sustainable development. The continuous innovation and expansion of testing equipment capabilities will undoubtedly contribute to enhanced water quality monitoring and management practices, ultimately benefiting public health, environmental sustainability, and economic prosperity.

9.7.1. TESTING EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 61. TESTING EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.739	0.858	0.907	0.960	1.141	1.364	1.638	**6.12%**
Europe	0.892	1.034	1.092	1.155	1.369	1.632	1.954	**6.02%**
North America	1.113	1.292	1.366	1.445	1.715	2.049	2.458	**6.08%**
Middle East & Africa	0.091	0.105	0.111	0.117	0.137	0.163	0.193	**5.77%**
Latin America	0.130	0.151	0.159	0.169	0.201	0.240	0.288	**6.13%**
Total	**2.966**	**3.439**	**3.635**	**3.845**	**4.563**	**5.447**	**6.533**	**6.07%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

9.8. OTHERS

The others segment within the water and wastewater treatment industry is poised for significant growth during the forecast period. This growth is primarily driven by innovative technologies such as biological wastewater treatment and solar photocatalytic wastewater treatment, among others. These emerging solutions offer promising avenues for addressing water pollution and scarcity challenges while aligning with sustainability goals. Biological wastewater treatment systems utilize a variety of microorganisms, including bacteria, protozoa, and specialty microbes, to degrade organic pollutants present in wastewater. These microorganisms facilitate the breakdown of organic matter, promoting flocculation and settling, which results in the production of more manageable sludge. Through this process, organic pollutants are effectively removed from water sources, contributing to improved water quality and environmental sustainability. Moreover, the production of sludge can be further optimized, reducing the need for extensive dewatering and disposal processes.

In parallel, solar photocatalytic wastewater treatment represents a cutting-edge approach to wastewater remediation. This technology harnesses solar irradiation and photocatalytic reactions to degrade organic pollutants present in wastewater. By leveraging the synergistic effects of solar energy and hydrogen peroxide, this process can significantly reduce the amount of carbon in sludge, thereby minimizing sludge production by up to 80% compared to conventional treatment methods. Additionally, solar photocatalytic systems offer versatility, with applications ranging from water disinfection to water splitting and advanced wastewater treatment. The adoption of these innovative wastewater treatment technologies is expected to drive demand for associated equipment and services in the coming years. As industries and municipalities seek more sustainable and cost-effective solutions for managing wastewater, the market for biological and solar photocatalytic treatment systems is projected to expand rapidly. Moreover, advancements in research and development are likely to further enhance the efficiency and scalability of these technologies, opening new opportunities for growth and innovation within the water and wastewater treatment industry. Thus, biological, and solar photocatalytic wastewater treatment technologies are poised to experience substantial growth in the forecast period. These innovative solutions offer environmentally friendly alternatives to conventional treatment methods, addressing water pollution challenges while promoting sustainability. As demand for more efficient and sustainable wastewater treatment solutions continues to rise, the market for these emerging technologies is expected to flourish, driving revenue growth and technological innovation in the water and wastewater treatment industry.

9.8.1. OTHER EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 62. OTHER EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.570	0.678	0.723	0.771	0.939	1.150	1.412	**6.95%**
Europe	0.690	0.819	0.872	0.930	1.130	1.378	1.688	**6.84%**
North America	0.835	0.993	1.059	1.130	1.376	1.682	2.064	**6.92%**
Middle East & Africa	0.071	0.083	0.089	0.094	0.113	0.137	0.167	**6.56%**
Latin America	0.097	0.116	0.123	0.132	0.161	0.197	0.242	**6.98%**
Total	**2.263**	**2.689**	**2.866**	**3.057**	**3.719**	**4.545**	**5.573**	**6.90%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

10. GLOBAL WATER AND WASTEWATER TREATMENT MARKET BY APPLICATION INSIGHTS & TREND

KEY TRENDS & HIGHLIGHTS

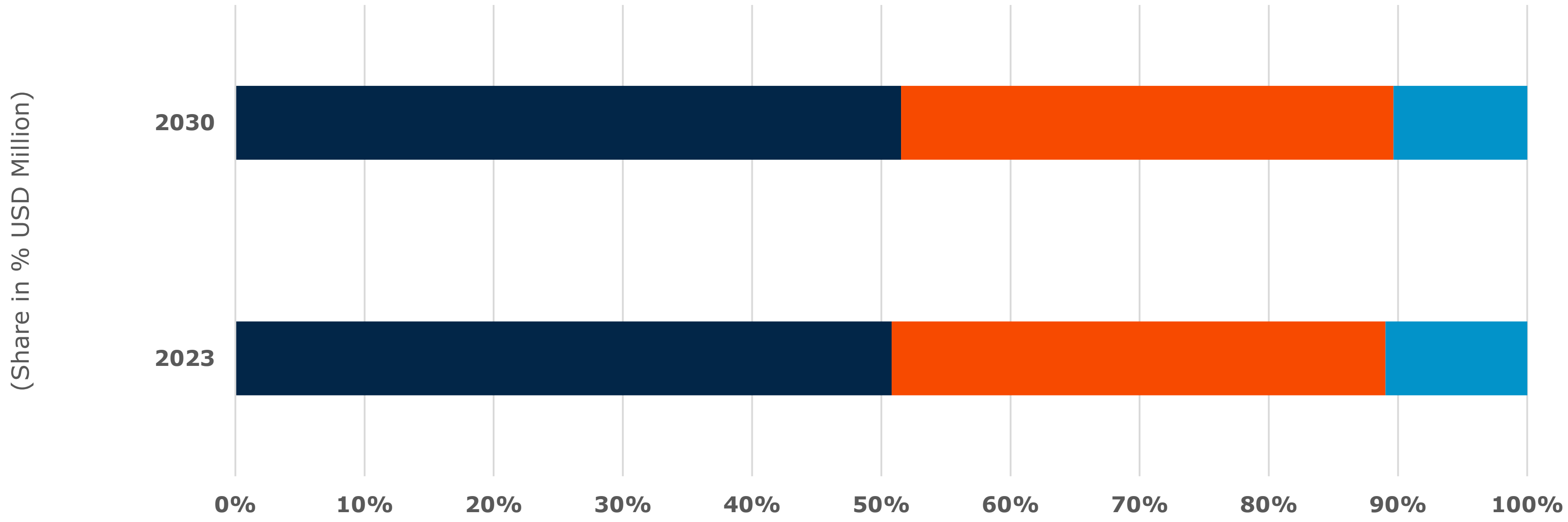
- The demand for Water Treatment accounted for over USD 6,276.633 Million in 2023 and is expected to grow at a CAGR of 6.29% in the forecast period.

10.1. APPLICATION DYNAMICS & MARKET SHARE, 2023 & 2033

By Application, the market is segmented into:

- Sewage Water Treatment Plant
- Common Effluent Treatment Plant
- Water Treatment Plant

FIGURE 68. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: APPLICATION DYNAMICS (SHARE IN % USD BILLION)



	2023	2030
Water Treatment	50.80%	51.52%
Sewage Treatment	38.23%	38.13%
Effluent Treatment	10.98%	10.35%

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

10.2. GLOBAL WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY APPLICATION, 2019-2033, (USD BILLION)

TABLE 63. GLOBAL WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY APPLICATION, 2019-2033, (USD BILLION)

Application	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Sewage Water Treatment Plant	91.017	105.439	111.393	117.769	139.596	166.429	199.329	**6.02%**
Common Effluent Treatment Plant	31.686	36.568	38.579	40.729	48.069	57.052	68.016	**5.86%**
Water Treatment Plant	113.267	131.867	139.570	147.834	176.232	211.337	254.626	**6.23%**
Total	**235.970**	**273.874**	**289.542**	**306.332**	**363.897**	**434.818**	**521.970**	**6.10%**

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

10.3. SEWAGE WATER TREATMENT PLANT

Sewage treatment plants represent the backbone of modern wastewater management systems, crucial for maintaining environmental sustainability and public health standards. As populations expand and urban areas grow, the demand for effective sewage treatment has escalated, prompting significant advancements in treatment technologies and infrastructure development. At its core, sewage treatment plants are tasked with the vital responsibility of collecting, treating, and ultimately disposing or reusing wastewater generated from various sources, including households, industries, and commercial establishments. The treatment process undergoes several stages, each designed to progressively remove contaminants and pollutants from the wastewater, rendering it safe for discharge into the environment or reuse in various applications.

The initial stage of sewage treatment typically involves preliminary filtration, where large solids and debris are removed from the wastewater through screens and grit chambers. This process helps prevent clogging and damage to downstream equipment, ensuring smooth operation of the treatment plant. Following preliminary filtration, the wastewater undergoes primary treatment, aimed at separating solids from liquids. In this stage, gravity sedimentation tanks allow suspended solids to settle at the bottom, forming sludge, while the clarified water is separated and advanced for further treatment. Secondary treatment represents a critical phase in sewage treatment, often involving biological processes to degrade organic contaminants present in the wastewater. Technologies such as activated sludge and trickling filters facilitate the growth of beneficial microorganisms that metabolize organic matter, significantly reducing pollutant levels in the water. Secondary treatment plays a pivotal role in improving water quality and minimizing environmental pollution by enhancing the removal of pathogens and harmful substances.

As sewage treatment standards become increasingly stringent, tertiary treatment has emerged as an essential component in many modern treatment plants. Tertiary treatment focuses on achieving the highest possible water quality standards by employing advanced processes such as microfiltration, ion exchange, and disinfection. These methods effectively remove remaining contaminants, pathogens, and nutrients from wastewater, ensuring compliance with regulatory requirements and safeguarding public health. The growth of sewage treatment plants has paralleled the rapid urbanization and industrialization witnessed globally. As cities expand and populations soar, the demand for reliable and efficient sewage treatment infrastructure has intensified. Consequently, significant investments have been made in the construction, upgrading, and expansion of sewage treatment plants worldwide, aiming to meet the escalating demand for wastewater treatment services while mitigating environmental impacts. Moreover, technological innovations have revolutionized sewage treatment processes, enabling greater efficiency, reliability, and sustainability. Advanced treatment technologies such as membrane bioreactors (MBRs), sequencing batch reactors (SBRs), and ultraviolet (UV) disinfection systems have become increasingly prevalent, offering enhanced performance and treatment outcomes. Furthermore, some of the top sewage treatment plants across the world includes Stickney Water Reclamation Plant in the USA, Deer Island Waste Water Treatment Plant in the USA, Detroit Wastewater Treatment Plant in the USA, Hyperion Sewage Treatment Plant in the USA, Bailonggang Wastewater Treatment Plant in China, Stonecutters Island Sewage Treatment Plant in Hong Kong, Gabal El Asfar Wastewater Treatment Plant in Egypt, Seine Aval Wastewater Treatment Plant in France, Morigasaki Water Reclamation Center in Japan, and Blue Plains Advanced Wastewater Treatment Plant in the USA.

Thus, sewage treatment plants play a pivotal role in safeguarding public health, protecting the environment, and promoting sustainable water management practices. The continuous growth and evolution of sewage treatment infrastructure underscore its critical importance in addressing the challenges posed by urbanization, industrialization, and environmental degradation. Through ongoing investments in technology, infrastructure, and regulatory frameworks, sewage treatment plants will continue to evolve, ensuring the safe and responsible management of wastewater for generations to come.

10.3.1. SEWAGE WATER TREATMENT PLANT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 64. SEWAGE WATER TREATMENT PLANT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	22.408	25.992	27.473	29.060	34.497	41.192	49.412	**6.08%**
Europe	27.016	31.261	33.012	34.886	41.297	49.168	58.804	**5.97%**
North America	34.778	40.306	42.588	45.033	53.407	63.705	76.339	**6.04%**
Middle East & Africa	2.747	3.160	3.330	3.511	4.127	4.878	5.792	**5.72%**
Latin America	4.068	4.720	4.990	5.279	6.268	7.486	8.982	**6.08%**
Total	**91.017**	**105.439**	**111.393**	**117.769**	**139.596**	**166.429**	**199.329**	**6.02%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

10.4. COMMON EFFLUENT TREATMENT PLANT

The Common Effluent Treatment Plant (CETP) represents a pivotal advancement in water and wastewater treatment methodologies, particularly within industrial settings. CETPs operate as centralized facilities designed to collect, treat, and manage effluents from multiple industrial sources within a designated area or industrial estate. This innovative approach offers a collaborative solution to the complex challenge of industrial pollution, providing a cost-effective and efficient means of addressing environmental concerns while meeting regulatory requirements. The growth of CETPs in the water and wastewater treatment market has been substantial, driven by several key factors. Firstly, the rising awareness of environmental sustainability and the need for stringent pollution control measures have propelled industries to seek comprehensive solutions for effluent management. CETPs offer a centralized approach that not only streamlines the treatment process but also ensures consistency in treatment standards across diverse industrial sectors. This aspect is particularly crucial in regions with high industrial activity, where individual treatment facilities may be impractical or economically unviable.

Furthermore, the economic benefits associated with CETPs have contributed significantly to their proliferation in the market. By sharing infrastructure and resources, industries can significantly reduce the capital and operational costs associated with establishing and maintaining individual treatment plants. This cost-efficiency factor makes CETPs an attractive option for small and medium-scale industries, which may lack the resources to invest in standalone treatment facilities. Additionally, the collective treatment approach of CETPs enables industries to leverage shared expertise and technical capabilities, leading to enhanced treatment efficiency and reliability. Moreover, the regulatory landscape governing industrial wastewater discharge has played a pivotal role in driving the adoption of CETPs. Stringent environmental regulations and discharge standards imposed by regulatory authorities compel industries to invest in advanced treatment solutions to ensure compliance. CETPs offer a centralized platform for industries to meet these regulatory requirements effectively, thereby minimizing the risk of non-compliance penalties and environmental damage.

The evolution of CETPs has also been characterized by advancements in treatment technologies and process optimization strategies. With ongoing research and development efforts, CETPs are continually improving their treatment efficiency, reliability, and environmental performance. Advanced treatment technologies such as membrane filtration, biological reactors, and chemical precipitation are increasingly integrated into CETP infrastructure to enhance treatment efficacy and address emerging contaminants. Thus, the growth of Common Effluent Treatment Plants in the water and wastewater treatment market underscores their significant role in mitigating industrial pollution and promoting environmental sustainability. By providing a centralized, cost-effective, and regulatory-compliant solution for effluent management, CETPs have emerged as indispensable assets in industrial ecosystems worldwide. Continued innovation and collaboration within the industry are expected to drive further advancements in CETP technology, facilitating greater environmental stewardship and sustainable industrial development.

10.4.1. COMMON EFFLUENT TREATMENT PLANT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 65. COMMON EFFLUENT TREATMENT PLANT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	7.787	8.999	9.498	10.032	11.857	14.094	16.829	**5.92%**
Europe	9.386	10.819	11.409	12.040	14.191	16.821	20.025	**5.82%**
North America	12.139	14.015	14.788	15.615	18.438	21.894	26.115	**5.88%**
Middle East & Africa	0.954	1.093	1.150	1.211	1.418	1.669	1.973	**5.57%**
Latin America	1.420	1.642	1.733	1.831	2.165	2.574	3.074	**5.92%**
Total	**31.686**	**36.568**	**38.579**	**40.729**	**48.069**	**57.052**	**68.016**	**5.86%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

10.5. WATER TREATMENT PLANT

Water treatment plants play a pivotal role in ensuring access to clean and safe drinking water, a fundamental necessity for sustaining life and fostering socio-economic development. As the global population continues to grow and urbanize, the demand for clean water has surged, prompting the establishment and expansion of water treatment infrastructure worldwide. These facilities employ a range of sophisticated technologies and processes to purify water from diverse sources, including groundwater, surface water, and rainwater, making it suitable for human consumption and various industrial applications. Among the notable examples of large-scale water treatment plants is the James W. Jardine Water Purification Plant in Chicago, recognized as the world's largest such facility. Serving over 2.8 million people in north Chicago and adjacent suburban areas, the Jardine Plant epitomizes the scale and complexity of modern water treatment operations. Its comprehensive treatment process involves multiple stages, including chemical treatment, flocculation, sedimentation, filtration, and disinfection, ensuring the removal of contaminants and pathogens from raw water sourced from Lake Michigan.

Similarly, the Guandu Water Treatment Plant in Rio de Janeiro stands as one of the world's largest water treatment facilities, processing over 981 million gallons per day to supply 90% of Rio's water demand. Employing conventional treatment methods such as coagulation, flocculation, sedimentation, and disinfection, the Guandu Plant plays a crucial role in safeguarding public health and supporting urban development in one of Brazil's largest cities. In Buenos Aires, Argentina, the Water Treatment Plant General San Martín exemplifies the significance of large-scale treatment infrastructure in meeting the water needs of densely populated urban areas. With a capacity exceeding 894 million gallons per day, the San Martín Plant serves a substantial portion of Buenos Aires' population, highlighting its pivotal role in ensuring water security and public health.

Across the Pacific, in Sydney, Australia, the Prospect Water Filtration Plant represents a testament to the collaborative efforts between the public and private sectors in delivering safe drinking water to millions of residents. Through a 23-year partnership between SUEZ and Sydney's water authorities, the Prospect Plant has demonstrated operational excellence and innovation, utilizing advanced filtration technologies and process management systems to maintain water quality standards and meet the needs of a rapidly growing urban population. In São Paulo, Brazil, the Guarau Water Treatment Plant underscores the vital role of public utilities in providing essential services to metropolitan regions facing water challenges. Expanded several times since its inception in 1973, the Guarau Plant now processes over 750 million gallons per day, supplying clean water to millions of residents in São Paulo's metropolitan area. With its reliance on the Cantareira reservoir system and advanced treatment methods, the Guarau Plant plays a critical role in ensuring water availability and resilience in the face of changing environmental conditions.

In California, the Joseph Jensen Treatment Plant in Granada Hills stands as a testament to ongoing efforts to enhance water treatment capacity and resilience in the face of growing demand and environmental pressures. Expanded over the years to accommodate the needs of the metropolitan area, the Jensen Plant exemplifies the adoption of innovative technologies such as ozone disinfection and fluoride containment systems to ensure water quality and public health protection. In Mumbai, India, the Bhandup Water Treatment Plant represents a critical component of the city's water supply infrastructure, processing approximately 739 million gallons per day to meet the needs of millions of residents. Situated amidst the scenic backdrop of Sanjay Gandhi National Park, the Bhandup Plant exemplifies the integration of natural and engineered systems in water treatment, with ongoing efforts to enhance energy efficiency and sustainability through the deployment of solar energy solutions.

Moreover, beyond individual plant capacities and operational processes, the global evolution of water treatment reflects broader trends in urbanization, industrialization, and environmental management. As cities expand and populations grow, the demand for clean water continues to rise, necessitating continuous investment in water infrastructure, technology innovation, and policy reform to ensure equitable access to this vital resource. In this context, collaborative initiatives and knowledge-sharing platforms play a crucial role in advancing best practices, fostering innovation, and addressing emerging challenges such as water scarcity, pollution, and climate change. By leveraging insights and experiences from diverse regions and stakeholders, the global community can work towards building resilient and sustainable water systems that meet the needs of present and future generations. Thus, water treatment plants represent critical infrastructure assets that underpin public health, economic prosperity, and environmental sustainability across the globe. Through ongoing investment, innovation, and collaboration, these facilities play a central role in safeguarding water resources, enhancing resilience to emerging threats, and ensuring equitable access to clean and safe drinking water for all.

10.5.1. WATER TREATMENT PLANT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 66. WATER TREATMENT PLANT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	27.967	32.603	34.524	36.587	43.681	52.464	63.312	**6.28%**
Europe	33.737	39.231	41.504	43.942	52.311	62.643	75.364	**6.18%**
North America	43.091	50.191	53.132	56.287	67.135	80.552	97.106	**6.25%**
Middle East & Africa	3.435	3.969	4.190	4.425	5.230	6.217	7.423	**5.92%**
Latin America	5.036	5.873	6.220	6.593	7.874	9.461	11.420	**6.29%**
Total	**113.267**	**131.867**	**139.570**	**147.834**	**176.232**	**211.337**	**254.626**	**6.23%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11. GLOBAL WATER AND WASTEWATER TREATMENT MARKET BY END-USE INSIGHTS & TREND

KEY TRENDS & HIGHLIGHTS

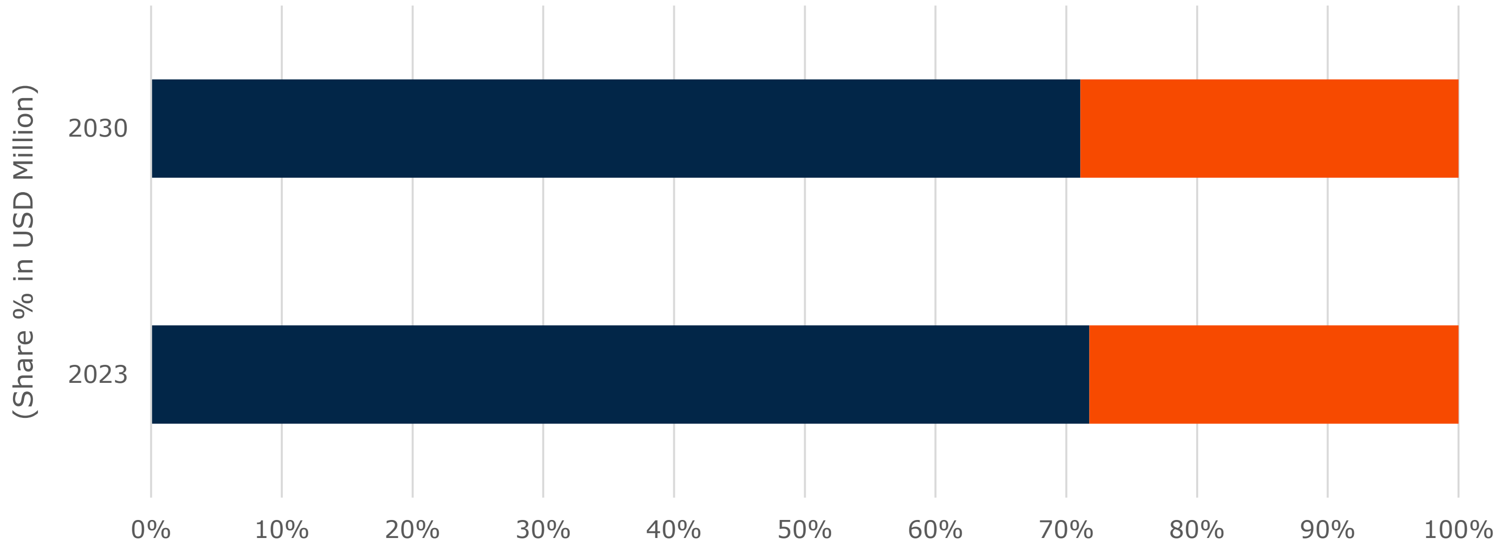
- The demand form Industrial sector accounted for over USD 3,484.882 Million in 2022 and is expected to grow at a CAGR of 6.44% in the forecast period.

11.1. END-USE DYNAMICS & MARKET SHARE, 2023 & 2033

By end-Use, the market is segmented into:

- Municipal
- Residential
- Industrial
  - Food & Beverages
  - Pharmaceuticals and Chemicals
  - Power Generation
  - Pulp and Paper
  - Oil & Gas
  - Mining
  - Petrochemical
  - Semiconductors
  - Others

FIGURE 69. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: END-USE DYNAMICS (SHARE IN % USD BILLION)



	2023	2030
Municipal	71.76%	71.08%
Industrial	28.24%	28.92%

Source: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.2. GLOBAL WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY END-USE, 2019-2033, (USD BILLION)

TABLE 67. GLOBAL WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY END-USE, 2019-2033, (USD BILLION)

End-Use	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Municipal	153.304	177.654	187.709	198.478	235.355	280.705	336.331	**6.04%**
Residential	35.642	41.106	43.355	45.759	53.962	63.994	76.228	**5.83%**
Industrial	47.024	55.114	58.478	62.095	74.580	90.119	109.410	**6.50%**
Food & Beverages	0.563	0.665	0.707	0.753	0.911	1.109	1.358	**6.78%**
Pharmaceuticals and Chemicals	9.740	11.507	12.245	13.042	15.808	19.283	23.638	**6.83%**
Power Generation	7.833	9.204	9.775	10.389	12.514	15.167	18.470	**6.60%**
Pulp and Paper	8.096	9.477	10.051	10.667	12.794	15.436	18.712	**6.44%**
Oil & Gas	4.546	5.315	5.635	5.978	7.161	8.630	10.448	**6.40%**
Mining	8.285	9.675	10.251	10.870	13.000	15.640	18.903	**6.34%**
Petrochemical	2.749	3.204	3.393	3.595	4.290	5.150	6.211	**6.26%**
Semiconductors	3.008	3.546	3.771	4.013	4.852	5.904	7.219	**6.74%**
Others Industrial Applications	2.204	2.521	2.650	2.788	3.249	3.799	4.452	**5.34%**

Total	**235.970**	**273.874**	**289.542**	**306.332**	**363.897**	**434.818**	**521.970**	**6.10%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.3. MUNICIPAL

The municipal sector's expansion is markedly impacting the water and wastewater treatment industry, precipitating a significant surge in demand for comprehensive water management solutions. This growth is propelled by burgeoning urbanization, escalating population densities, and the concurrent rise in municipal infrastructure requirements worldwide. As municipalities strive to accommodate swelling populations and meet burgeoning urban demands, the imperative for effective water and wastewater management becomes increasingly pronounced. Central to this paradigm is the meticulous treatment of municipal water and wastewater, a process vital for safeguarding public health, preserving environmental integrity, and fostering sustainable development. In essence, municipal water and wastewater treatment constitutes an intricate system designed to purify water resources while mitigating the adverse impacts of anthropogenic contaminants. Wastewater originating from residential, commercial, and industrial sources is subject to rigorous treatment protocols spanning multiple stages, each meticulously engineered to eliminate pollutants through a combination of physical, chemical, and biological processes.

The treatment journey commences with preliminary procedures encompassing screening and grit removal, aimed at separating coarse solids and inorganic materials from the wastewater stream. Subsequently, primary treatment facilitates the gravitational settling of organic matter, oils, and grease, further refining the wastewater's composition. Following primary treatment, secondary processes are enacted to target biodegradable pollutants through aerobic or anaerobic biological treatment methods, thereby enhancing the water's quality. Invariably, tertiary treatment serves as the final purification stage, entailing advanced filtration and disinfection measures to eradicate residual contaminants and pathogens. This culminates in the production of treated effluent deemed safe for various applications, including agricultural irrigation, industrial processes, and municipal consumption, thereby exemplifying the inherent versatility of treated wastewater. Moreover, the proliferation of water reuse initiatives underscores the evolving dynamics of municipal water management, accentuating the industry's progressive trajectory. Amidst this burgeoning landscape, the water and wastewater treatment industry is poised for substantial expansion, underpinned by the imperative for innovative technologies, robust infrastructure investments, and heightened regulatory compliance. Consequently, stakeholders across the water value chain are compelled to embrace cutting-edge solutions and best practices to meet the escalating demands of municipal water and wastewater treatment effectively.

11.3.1. WATER & WASTEWATER TREATMENT FOR MUNICIPAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 68. WATER & WASTEWATER TREATMENT FOR MUNICIPAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	37.816	43.879	46.385	49.070	58.274	69.609	83.535	**6.09%**
Europe	45.609	52.793	55.757	58.930	69.787	83.121	99.453	**5.99%**
North America	58.409	67.716	71.560	75.678	89.783	107.138	128.436	**6.05%**
Middle East & Africa	4.642	5.340	5.628	5.934	6.979	8.253	9.802	**5.73%**
Latin America	6.828	7.926	8.380	8.866	10.532	12.584	15.105	**6.10%**
Total	**153.304**	**177.654**	**187.709**	**198.478**	**235.355**	**280.705**	**336.331**	**6.04%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.4. RESIDENTIAL

The exponential growth of residential areas has become a defining feature of modern urbanization, significantly impacting the water and wastewater treatment industry. As urban populations swell and cities expand outward, the demand for housing in residential areas has surged, prompting rapid development to accommodate burgeoning populations. This proliferation of residential spaces presents a dual challenge to the water and wastewater treatment sector, both in terms of quantity and quality management. Firstly, the sheer volume of wastewater generated by expanding residential communities strains existing treatment infrastructure. Traditional treatment plants are often overwhelmed by the influx of sewage, leading to inefficiencies and potential environmental hazards as untreated or inadequately treated wastewater is discharged into natural water bodies. The magnitude of this challenge is amplified in densely populated urban areas where space constraints limit the expansion or construction of new treatment facilities.

Secondly, the composition of wastewater from residential areas has evolved due to changing lifestyle patterns and demographic shifts. Increased usage of household chemicals, detergents, and personal care products introduces a diverse array of contaminants into the wastewater stream. Additionally, the prevalence of pharmaceuticals, microplastics, and other emerging pollutants further complicates the treatment process, necessitating advanced treatment technologies to ensure adequate removal. The impact of residential growth on water resources extends beyond wastewater generation to encompass water supply and distribution systems. As residential areas expand, the demand for potable water escalates, placing stress on existing water supply infrastructure and diminishing finite water resources. This strain is particularly pronounced in regions grappling with water scarcity or erratic precipitation patterns, exacerbating concerns about water availability and sustainability.

In response to these challenges, the water and wastewater treatment industry is undergoing a paradigm shift, characterized by innovation, adaptation, and technological advancement. Efforts are underway to develop decentralized treatment solutions tailored to the needs of expanding residential communities. These modular, scalable systems offer flexibility and resilience, enabling efficient treatment of wastewater closer to the point of generation. Furthermore, advancements in membrane filtration, biological treatment, and disinfection technologies are enhancing the efficacy of treatment processes, enabling the removal of a broader range of contaminants from wastewater. Moreover, there is a growing emphasis on integrated water management strategies that prioritize water reuse, resource recovery, and ecosystem protection. From decentralized greywater recycling systems to nutrient recovery from wastewater streams, innovative approaches are emerging to optimize water use efficiency and minimize environmental impact. Collaborative initiatives between government agencies, private sector entities, and research institutions are driving these efforts forward, fostering interdisciplinary collaboration and knowledge exchange.

11.4.1. WATER & WASTEWATER TREATMENT FOR RESIDENTIAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 69. WATER & WASTEWATER TREATMENT FOR RESIDENTIAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	8.766	10.122	10.681	11.279	13.320	15.820	18.873	**5.89%**
Europe	10.566	12.172	12.833	13.539	15.945	18.885	22.464	**5.79%**
North America	13.640	15.737	16.601	17.524	20.676	24.532	29.237	**5.85%**
Middle East & Africa	1.074	1.230	1.294	1.362	1.594	1.874	2.214	**5.54%**
Latin America	1.596	1.843	1.945	2.055	2.427	2.883	3.440	**5.90%**
Total	**35.642**	**41.106**	**43.355**	**45.759**	**53.962**	**63.994**	**76.228**	**5.83%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.5. INDUSTRIAL

The growth trajectory of various industrial sectors, including but not limited to food & beverages, pharmaceuticals, chemicals, power generation, pulp and paper, oil & gas, mining, petrochemicals, and semiconductors, has significantly impacted the water and wastewater treatment industry. With the expansion of these sectors globally, there has been a proportional increase in the generation of wastewater containing diverse contaminants and pollutants. This surge in industrial activity has underscored the critical importance of effective water and wastewater treatment processes. Industries such as food & beverages and pharmaceuticals, which rely heavily on water as a raw material and for various processing steps, have witnessed substantial growth driven by changing consumer preferences and technological advancements. However, this increased production has resulted in higher volumes of wastewater containing organic compounds, suspended solids, and potentially harmful substances. Consequently, there is a heightened demand for advanced treatment technologies to ensure compliance with stringent environmental regulations and to safeguard public health.

Similarly, the chemical and petrochemical industries, integral to manufacturing processes across numerous sectors, have experienced robust growth due to rising global demand for chemicals and petroleum products. The production processes in these industries often involve the use of hazardous chemicals, leading to the generation of wastewater with complex compositions. Effective treatment of such wastewater is essential not only for environmental protection but also for preserving the integrity of water resources and ecosystems. Furthermore, the power generation sector, including conventional fossil fuel-based power plants and renewable energy facilities, has witnessed rapid expansion to meet the growing global energy demand and transition towards cleaner sources of power. However, power generation activities, particularly in thermal power plants, require significant quantities of water for cooling purposes, leading to the discharge of thermal effluents into water bodies. Adequate treatment of these effluents is vital to mitigate the adverse impacts on aquatic ecosystems and ensure compliance with regulatory standards.

In addition to these sectors, the mining and metals industry, essential for supplying raw materials for various manufacturing processes, has seen substantial growth driven by urbanization and industrialization. However, mining operations often generate wastewater contaminated with heavy metals, suspended solids, and other pollutants, posing significant environmental challenges. Effective wastewater treatment solutions are crucial to minimize the environmental footprint of mining activities and mitigate the risks associated with water pollution. Moreover, the pulp and paper industry, a cornerstone of the global economy, has experienced steady growth fueled by increasing demand for paper-based products and packaging materials. However, the production processes in pulp and paper mills result in the discharge of wastewater containing chlorinated organic compounds, suspended solids, and high levels of biochemical oxygen demand (BOD). Robust wastewater treatment measures are essential to prevent contamination of water bodies and protect aquatic ecosystems.

11.5.1. WATER & WASTEWATER TREATMENT FOR INDUSTRIAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 70. WATER & WASTEWATER TREATMENT FOR INDUSTRIAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	11.581	13.592	14.429	15.330	18.442	22.321	27.145	**6.55%**
Europe	13.964	16.346	17.335	18.399	22.067	26.625	32.277	**6.44%**
North America	17.959	21.058	22.347	23.734	28.521	34.482	41.887	**6.52%**
Middle East & Africa	1.420	1.652	1.748	1.850	2.203	2.637	3.172	**6.17%**
Latin America	2.100	2.466	2.618	2.782	3.348	4.053	4.930	**6.56%**
Total	**47.024**	**55.114**	**58.478**	**62.095**	**74.580**	**90.119**	**109.410**	**6.50%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.5.2. FOOD AND BEVERAGE

The food and beverage industry stands as a cornerstone of global economic activity, continuously evolving to meet the demands of a growing population and shifting consumer preferences. Characterized by its diverse array of products and processes, this industry spans from fruit and vegetable processing to meat production, from soft drinks to spirits. As consumption patterns shift and demand rises, the industry experiences a parallel surge in water consumption. Water serves as a vital ingredient, a utility for cleaning and processing, and a key component in the final product. However, this increased water usage inevitably leads to the generation of wastewater, presenting a significant challenge for sustainability and environmental stewardship. In response to these challenges, the water and wastewater treatment industry has emerged as an indispensable partner for the food and beverage sector. Recognizing the imperative to manage water resources responsibly, food and beverage manufacturers are increasingly investing in advanced treatment technologies. These technologies play a crucial role in ensuring regulatory compliance, maintaining product quality, and mitigating environmental impact.

One of the primary drivers behind the adoption of water and wastewater treatment solutions in the food and beverage industry is the growing awareness of water scarcity. With freshwater supplies dwindling and regulatory pressures mounting, companies are compelled to implement strategies for water conservation and reuse. By treating and recycling wastewater, food and beverage manufacturers not only reduce their environmental footprint but also enhance operational efficiency and resource recovery. Moreover, the pursuit of operational excellence and product quality further fuels the demand for advanced treatment technologies. Microbiologically contaminated water poses a significant risk to food safety and shelf life, underscoring the importance of stringent water quality standards. Treatment processes such as UV disinfection play a critical role in eliminating pathogens and ensuring the integrity of the final product.

Furthermore, the water and wastewater treatment industry is propelled by broader trends in corporate sustainability and responsible business practices. Leading food and beverage companies recognize the importance of aligning their operations with environmental goals and societal expectations. By investing in water management solutions, these companies demonstrate their commitment to sustainability, while also unlocking potential cost savings and operational efficiencies. Innovations in membrane-based technologies, such as tubular ultrafiltration membranes, have emerged as game-changers in the food and beverage wastewater treatment landscape. These technologies offer superior treated water quality, enabling compliance with stringent discharge regulations. Additionally, membrane-based solutions facilitate water reuse, supporting initiatives for closed-loop systems and minimum liquid discharge strategies. Overall, the growth of the food and beverage industry presents both opportunities and challenges for the water and wastewater treatment sector. As demand for food and beverages continues to rise, so too does the need for sustainable water management solutions. By partnering with innovative technology providers and embracing a holistic approach to water stewardship, food and beverage manufacturers can navigate the complexities of water management while driving growth, resilience, and environmental sustainability.

11.5.2.1. WATER & WASTEWATER TREATMENT FOR FOOD AND BEVERAGE REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 71. WATER & WASTEWATER TREATMENT FOR FOOD AND BEVERAGE REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.138	0.163	0.173	0.184	0.224	0.273	0.334	**6.84%**
Europe	0.166	0.195	0.208	0.221	0.267	0.325	0.397	**6.72%**
North America	0.218	0.257	0.273	0.291	0.352	0.429	0.526	**6.80%**
Middle East & Africa	0.017	0.020	0.021	0.022	0.027	0.032	0.039	**6.44%**
Latin America	0.026	0.030	0.032	0.034	0.041	0.051	0.062	**6.84%**
Total	**0.563**	**0.665**	**0.707**	**0.753**	**0.911**	**1.109**	**1.358**	**6.78%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.5.3. PHARMACEUTICALS AND CHEMICALS

The pharmaceuticals and chemicals industries are witnessing significant growth globally, driven by emerging economies such as India, Brazil, and China. From 2016 to 2021, these markets experienced remarkable expansion, outpacing traditional hubs like Europe and the United States. For instance, during this period, the Brazilian, Chinese, and Indian markets recorded growth rates of 11.7%, 6.7%, and 11.8% respectively, surpassing the average market growth rates of 5.8% for the top 5 European Union markets and 5.6% for the US market. This surge in demand for pharmaceutical and chemical products reflects a dynamic shift in economic and research activities toward these fast-growing regions. However, amidst this growth, global chemical production, excluding pharmaceuticals, is expected to grow modestly by 2.0% in 2023, slightly slower than the previous year's rate of 2.2%. Advanced economies are anticipated to witness a decline in production, with forecasts indicating a decrease of 3.0% in 2023 compared to 2.9% in 2022. Similarly, in China, the world's largest chemical market, slightly weaker growth in chemical production is anticipated at 5.9% in 2023 compared to 6.6% in 2022. While the opening of the Chinese economy may drive higher growth in domestic demand, challenges such as high energy costs may temper this expansion.

This growth trajectory in the pharmaceuticals and chemicals industries has profound implications for the water and wastewater treatment sector. As production increases, so does the demand for water, which serves as a critical component in various manufacturing processes within these industries. Consequently, the generation of complex wastewater streams containing organic compounds, solvents, heavy metals, and other contaminants escalates, necessitating robust treatment methods to ensure compliance with environmental regulations and sustainably manage water resources. In regions such as India, where the pharmaceutical industry holds significant global market share, the impact on the water and wastewater treatment industry is particularly pronounced. Government statistics underscore the importance of responsible water management, with regulatory bodies like the Central Pollution Control Board

(CPCB) highlighting the pharmaceutical sector's contribution to water pollution. Effluent discharge from pharmaceutical facilities poses risks to aquatic ecosystems and public health, necessitating stringent regulations and investment in advanced treatment technologies.

To address these concerns, governments are implementing regulatory frameworks mandating adherence to environmental norms, periodic reporting of effluent quality, and the adoption of advanced treatment methods by pharmaceutical and chemical industries. Initiatives like the Zero Liquid Discharge (ZLD) program encourage industries to minimize wastewater discharge, promoting water recovery and reuse to sustainably manage water resources amidst this dynamic growth landscape. Thus, while the growth of the pharmaceuticals and chemicals industries presents significant economic opportunities, it also underscores the critical importance of sustainable water management practices and advanced treatment technologies. By addressing the challenges posed by increased water demand and wastewater generation, stakeholders can mitigate environmental risks and ensure the long-term viability of these industries while safeguarding water resources for future generations.

11.5.3.1. WATER & WASTEWATER TREATMENT FOR PHARMACEUTICALS AND CHEMICALS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 72. WATER & WASTEWATER TREATMENT FOR PHARMACEUTICALS AND CHEMICALS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	2.396	2.834	3.018	3.216	3.905	4.771	5.859	**6.89%**
Europe	2.888	3.407	3.624	3.858	4.669	5.687	6.960	**6.78%**
North America	3.727	4.405	4.689	4.994	6.057	7.393	9.068	**6.85%**
Middle East & Africa	0.294	0.344	0.365	0.388	0.465	0.562	0.683	**6.49%**
Latin America	0.436	0.516	0.550	0.586	0.711	0.869	1.068	**6.90%**
Total	**9.740**	**11.507**	**12.245**	**13.042**	**15.808**	**19.283**	**23.638**	**6.83%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.5.4. POWER GENERATION

The power generation industry is witnessing robust global growth, driven by escalating energy demand, technological advancements, and environmental concerns. Reports indicate that global electricity demand is projected to surge by approximately 44% by 2040 compared to 2018 levels. This surge in demand presents significant opportunities for the power generation sector but also brings challenges, particularly regarding water usage and wastewater management. Water is a fundamental resource in power generation, with thermal power plants alone accounting for about 41% of daily water withdrawals in the United States. As industry expands to meet escalating energy needs, the demand for water-intensive processes such as cooling, steam production, and pollution control escalates. Consequently, the power generation sector is becoming a major driver of growth for the water and wastewater treatment industry.

In response to escalating water consumption and tightening environmental regulations, power plants are increasingly investing in advanced water treatment technologies. These technologies are crucial for ensuring the efficient and sustainable operation of power generation facilities while minimizing their environmental footprint. Key trends in the power generation industry driving the growth of water and wastewater treatment include rising demand for clean water, stringent environmental regulations, focus on sustainability, integration of renewable energy sources, and technological advancements. Rising concerns over water scarcity and quality are prompting power plants to prioritize the use of purified water to enhance equipment performance and minimize the risk of corrosion and scaling. This trend is fueling the adoption of advanced water treatment processes such as reverse osmosis, ion exchange, and filtration. Additionally, regulatory bodies worldwide are imposing stricter effluent discharge standards on power plants, necessitating the implementation of comprehensive wastewater treatment solutions. Power plants must comply with regulations set forth by agencies like the USA EPA, driving the demand for innovative water treatment technologies to meet compliance requirements.

As the importance of environmental sustainability grows, power generation companies are seeking to minimize their water footprint and maximize water reuse. This trend is driving the adoption of water recycling and reuse systems, as well as technologies for zero liquid discharge (ZLD) to minimize wastewater generation. Furthermore, the increasing adoption of renewable energy sources such as hydroelectric power underscores the importance of water treatment in power generation. Hydroelectric plants rely on clean water reserves for efficient operation, necessitating effective water treatment processes to maintain equipment integrity and environmental compliance. Ongoing advancements in water treatment technologies, such as membrane filtration, advanced oxidation, and electrochemical processes, are enabling power plants to achieve higher levels of water purity and efficiency. These innovations are driving the development of more cost-effective and sustainable water treatment solutions tailored to the needs of the power generation industry. Thus, the power generation industry's growing demand for energy is fueling significant growth in the water and wastewater treatment sector. By investing in advanced water treatment technologies and embracing sustainable practices, power plants can enhance operational efficiency, mitigate environmental impact, and ensure long-term viability in an increasingly water-constrained world.

11.5.4.1. WATER & WASTEWATER TREATMENT FOR POWER GENERATION REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 73. WATER & WASTEWATER TREATMENT FOR POWER GENERATION MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	1.932	2.274	2.416	2.569	3.100	3.763	4.591	**6.66%**
Europe	2.331	2.735	2.904	3.085	3.710	4.490	5.459	**6.55%**
North America	2.984	3.508	3.726	3.961	4.774	5.789	7.053	**6.62%**
Middle East & Africa	0.237	0.277	0.293	0.310	0.370	0.445	0.537	**6.27%**
Latin America	0.349	0.411	0.436	0.464	0.560	0.680	0.830	**6.67%**
Total	**7.833**	**9.204**	**9.775**	**10.389**	**12.514**	**15.167**	**18.470**	**6.60%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.5.5. PULP AND PAPER

The pulp and paper industry has historically played a crucial role in global economic development, providing essential products such as office paper, packaging materials, and tissue products. Over the years, the industry has experienced steady growth, driven by increasing demand for paper products worldwide. As of recent data, the global pulp and paper market size was valued at over $400 billion USD, with projections indicating further expansion in the coming years. However, this growth has come with significant environmental implications, particularly concerning water usage and wastewater generation. The pulp and paper manufacturing process is water-intensive, with large quantities of water required for various stages, including pulp production, papermaking, and wastewater treatment. As a result, industry has become a major consumer of freshwater resources and a significant contributor to wastewater pollution.

The impact of the pulp and paper industry on the water and wastewater sector is multifaceted. On one hand, the industry's growth has driven demand for advanced water and wastewater treatment technologies. With increasing awareness of environmental sustainability and regulatory pressures, pulp and paper companies are investing in state-of-the-art treatment systems to minimize their environmental footprint. This has led to a surge in the development and adoption of innovative treatment processes, such as membrane filtration, advanced oxidation, and biological treatment methods. Moreover, the growth of the pulp and paper industry has spurred innovation and investment in water recycling and reuse technologies. Efforts to optimize water usage and minimize wastewater discharge have led to the implementation of closed-loop systems and water recovery strategies within pulp and paper mills. These initiatives not only reduce freshwater consumption but also mitigate the environmental impact of wastewater discharge, contributing to overall sustainability goals.

However, alongside these positive developments, challenges persist in managing the water and wastewater impacts of the pulp and paper industry. Despite advancements in treatment technologies, concerns remain about the quality of discharged effluents and their potential effects on aquatic ecosystems and public health. Additionally, the sheer scale of water usage by pulp and paper mills poses challenges in regions already facing water scarcity or competing demands for freshwater resources. In response to these challenges, stakeholders across the pulp and paper, water, and wastewater sectors are increasingly collaborating to develop integrated solutions. Partnerships between industry players, research institutions, and government agencies are fostering innovation and knowledge-sharing to address water-related challenges effectively. Furthermore, initiatives aimed at promoting sustainable water management practices, such as water stewardship certification programs, are gaining traction within the pulp and paper industry. Looking ahead, the growth of the pulp and paper industry is likely to continue, driven by evolving consumer demands and global economic trends. However, ensuring sustainable water management practices will be paramount for the industry's long-term viability. By embracing innovation, collaboration, and responsible stewardship of water resources, the pulp and paper industry can minimize its environmental footprint and contribute to a more sustainable future for all.

11.5.5.1. WATER & WASTEWATER TREATMENT FOR PULP AND PAPER REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 74. WATER & WASTEWATER TREATMENT FOR PULP AND PAPER MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	1.998	2.342	2.485	2.638	3.169	3.830	4.651	**6.50%**
Europe	2.410	2.817	2.986	3.168	3.794	4.571	5.533	**6.39%**
North America	3.083	3.610	3.830	4.065	4.878	5.889	7.143	**6.46%**
Middle East & Africa	0.245	0.285	0.301	0.319	0.379	0.453	0.544	**6.12%**
Latin America	0.360	0.423	0.448	0.476	0.572	0.692	0.840	**6.51%**
Total	**8.096**	**9.477**	**10.051**	**10.667**	**12.794**	**15.436**	**18.712**	**6.44%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.5.6. OIL AND GAS

The Oil & Gas industry has long been a cornerstone of global energy production, with its growth and evolution profoundly impacting various sectors, including water and wastewater treatment. As demand for energy continues to surge worldwide, the oil and gas sector is poised for significant expansion, driven by factors such as geopolitical dynamics, macroeconomic conditions, regulatory frameworks, and technological advancements. Despite facing disruptions and challenges, the industry has demonstrated resilience, with robust financial performance and high oil prices bolstering its growth trajectory. According to industry forecasts, global oil demand is projected to continue its upward trend, crossing the historic milestone of 100 million barrels per day (mbpd) for the first time. This surge in demand is accompanied by a parallel rise in natural gas consumption, fueled by increasing industrialization, urbanization, and economic development across regions. As a result, investments in upstream activities, including exploration, extraction, and production, are expected to remain substantial, driving the expansion of the oil and gas industry.

However, alongside this growth comes a heightened focus on sustainability and environmental responsibility, particularly concerning water and wastewater management. The oil and gas extraction process entails significant water usage and generates substantial volumes of wastewater, laden with contaminants such as hydrocarbons, suspended solids, dissolved organic matter, and heavy metals. Recognizing the environmental impact of these activities, stakeholders within the industry are increasingly prioritizing efficient and sustainable water treatment solutions. In response to these challenges, the water and wastewater treatment industry is experiencing a parallel surge in demand, driven by the need for effective solutions to mitigate environmental risks and ensure regulatory compliance. Technologies such as coagulation, flocculation, sedimentation, multimedia filtration, reverse osmosis, and ion exchange are being deployed to treat oil and gas wastewater, removing contaminants, and facilitating reuse or safe discharge.

Moreover, there is a growing emphasis on circular economy principles, promoting the reuse and recycling of wastewater within oil and gas operations. By implementing innovative treatment technologies and adopting water reuse strategies, companies can minimize their reliance on freshwater sources, reduce environmental footprint, and enhance operational efficiency. The integration of advanced wastewater treatment systems, such as Dissolved Air Flotation (DAF) and membrane filtration, is becoming increasingly prevalent across oilfields, refineries, and petrochemical plants. These technologies enable the efficient separation and removal of oils, greases, hydrocarbons, and other contaminants from wastewater streams, ensuring compliance with stringent environmental standards.

Furthermore, the adoption of alternative wastewater management approaches, such as decentralized treatment systems and zero liquid discharge (ZLD) solutions, is gaining traction within the oil and gas industry. These strategies aim to minimize the discharge of untreated or inadequately treated wastewater into the environment, mitigating pollution risks and preserving water resources. Thus, the growth of the Oil & Gas industry is intricately linked to the expansion of the water and wastewater treatment sector, driven by the imperative to address environmental concerns and ensure sustainable resource management. As both industries continue to evolve, collaborative efforts between stakeholders, technological innovation, and regulatory frameworks will play a crucial role in shaping their future trajectory, fostering a more sustainable and resilient energy ecosystem.

11.5.6.1. WATER & WASTEWATER TREATMENT FOR OIL AND GAS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 75. WATER & WASTEWATER TREATMENT FOR OIL AND GAS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	1.117	1.308	1.387	1.472	1.766	2.132	2.585	**6.46%**
Europe	1.346	1.572	1.665	1.766	2.113	2.542	3.073	**6.35%**
North America	1.742	2.038	2.161	2.293	2.749	3.314	4.015	**6.42%**
Middle East & Africa	0.137	0.159	0.168	0.177	0.211	0.252	0.302	**6.08%**
Latin America	0.204	0.239	0.253	0.269	0.323	0.390	0.473	**6.47%**
Total	**4.546**	**5.315**	**5.635**	**5.978**	**7.161**	**8.630**	**10.448**	**6.40%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.5.7. MINING

The mining industry has witnessed significant growth over the years, driven by increasing global demand for metals and minerals essential for various industrial processes and infrastructural development. According to industry reports, the global mining market size was valued at over USD 800 billion in 2021 and is projected to continue expanding at a steady pace. This growth is attributed to rising industrialization, urbanization, and infrastructure projects, particularly in emerging economies. As the mining industry expands, so does its impact on water and wastewater management. Mining operations require substantial amounts of water for various purposes, including mineral processing, dust suppression, and cooling. Consequently, the industry generates large volumes of wastewater containing contaminants such as heavy metals, suspended solids, and chemicals. This wastewater poses significant environmental and health risks if not properly managed and treated.

The increasing demand for metals and minerals, coupled with stringent environmental regulations, has fueled the growth of the water and wastewater treatment industry. This growth is driven by the need for sustainable water management solutions, including efficient wastewater treatment technologies. In response to regulatory pressures and environmental concerns, mining companies are increasingly investing in advanced water and wastewater treatment technologies to mitigate the impact of their operations. These technologies include pH adjustment, coagulation, flocculation, sedimentation, filtration, and advanced oxidation processes. Additionally, there is a growing trend towards the adoption of decentralized wastewater treatment systems to minimize the discharge of pollutants into water bodies and enhance water reuse and recycling.

Furthermore, the mining industry's focus on sustainability and corporate social responsibility (CSR) initiatives has led to collaborations with water and wastewater treatment companies to develop innovative solutions for water conservation and pollution prevention. For instance, some mining companies are implementing zero liquid discharge (ZLD) systems to eliminate wastewater discharge and maximize water reuse within their operations. Despite the growing adoption of advanced water and wastewater treatment technologies in the mining sector, challenges persist, including the high cost of implementation, limited access to freshwater resources in remote mining regions, and regulatory complexities. However, advancements in technology, coupled with increasing awareness of the importance of water stewardship, are driving continued innovation in the water and wastewater treatment industry to support sustainable mining practices. Thus, the growth of the mining industry has a significant impact on the water and wastewater treatment sector, driving demand for advanced technologies and solutions to address the environmental challenges associated with mining operations. As both industries continue to evolve, collaboration and innovation will play a crucial role in ensuring sustainable water management practices and mitigating the environmental footprint of mining activities.

11.5.7.1. WATER & WASTEWATER TREATMENT FOR MINING REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 76. WATER & WASTEWATER TREATMENT FOR MINING MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	2.036	2.381	2.524	2.678	3.207	3.865	4.679	**6.40%**
Europe	2.454	2.862	3.031	3.212	3.837	4.609	5.562	**6.29%**
North America	3.175	3.709	3.931	4.168	4.988	6.004	7.261	**6.36%**
Middle East & Africa	0.249	0.289	0.305	0.323	0.383	0.456	0.547	**6.02%**
Latin America	0.372	0.435	0.461	0.489	0.586	0.706	0.855	**6.41%**
Total	**8.285**	**9.675**	**10.251**	**10.870**	**13.000**	**15.640**	**18.903**	**6.34%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.5.8. PETROCHEMICAL

The petrochemical industry has witnessed substantial growth in recent years, driven by increasing demand for its products across various sectors of the global economy. From plastics and fertilizers to textiles and electronics, petrochemicals serve as essential raw materials for countless everyday items. This surge in demand is reflected in statistics showing that the global consumption of plastics, a prominent petrochemical product, has nearly doubled since 2000. Moreover, advanced economies such as the United States and Europe currently utilize significantly more plastic and fertilizers per capita compared to developing economies, indicating the vast potential for further growth worldwide. As the petrochemical industry expands, its impact on the water and wastewater industry becomes increasingly significant. Petrochemical plants are known to consume substantial quantities of water in their operations, utilizing it for processes such as cooling, cleaning, and steam generation. This high demand for water places pressure on existing water resources, both surface and groundwater, leading to concerns about water scarcity and quality.

Furthermore, the production processes within petrochemical facilities result in the generation of industrial wastewater, which often contains various pollutants and contaminants. The treatment and disposal of this wastewater presents significant challenges, as it must meet stringent environmental regulations to minimize its impact on ecosystems and human health. Consequently, there is a growing need for advanced wastewater treatment technologies capable of effectively removing pollutants from petrochemical effluents. In response to these challenges, the water and wastewater industry is experiencing its own period of growth and innovation. Companies specializing in water treatment technologies are developing advanced solutions tailored to the specific needs of the petrochemical sector. These technologies range from biological treatment systems to advanced filtration and membrane processes, designed to remove contaminants and produce effluent suitable for reuse or safe discharge.

Moreover, there is a growing emphasis on the concept of water reuse within the petrochemical industry. Instead of viewing wastewater as a liability, companies are increasingly recognizing it as a valuable resource that can be reclaimed and reused in various industrial processes. This shift towards water reuse not only helps to alleviate pressure on freshwater sources but also reduces the volume of wastewater requiring treatment and disposal. Thus, the growth of the petrochemical industry is closely intertwined with the expansion of the water and wastewater sector. As petrochemical production continues to rise, the demand for water and wastewater treatment technologies will similarly increase. By embracing innovation and sustainable practices, both industries can work together to ensure responsible resource management and environmental stewardship in the years to come.

11.5.8.1. WATER & WASTEWATER TREATMENT FOR PETROCHEMICAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 77. WATER & WASTEWATER TREATMENT FOR PETROCHEMICAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.675	0.788	0.834	0.884	1.057	1.271	1.535	**6.32%**
Europe	0.813	0.946	1.002	1.061	1.264	1.516	1.825	**6.21%**
North America	1.055	1.230	1.303	1.381	1.649	1.981	2.390	**6.28%**
Middle East & Africa	0.083	0.096	0.101	0.107	0.126	0.150	0.179	**5.95%**
Latin America	0.124	0.144	0.153	0.162	0.194	0.233	0.281	**6.33%**
Total	**2.749**	**3.204**	**3.393**	**3.595**	**4.290**	**5.150**	**6.211**	**6.26%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.5.9. SEMICONDUCTORS

The semiconductor industry has experienced remarkable growth in recent years, driven by the increasing demand for chips across various sectors. With sales surpassing USD 600 billion in 2021 and projected to reach USD 1 trillion by the end of the decade, the industry's expansion is undeniable. This growth can be attributed to several key factors, including the surge in demand for electronic devices, the proliferation of AI and machine learning technologies, and the rapid adoption of electric vehicles. As the world becomes increasingly digitized, semiconductors have become the backbone of modern technology, underpinning everything from smartphones and computers to automotive and industrial applications. However, this exponential growth in semiconductor manufacturing comes with its set of challenges, particularly concerning water usage and wastewater management. The production of semiconductors requires vast amounts of ultra-pure water at various stages of the manufacturing process. Even minute contaminants in the water can result in defects in the chips, compromising their functionality and reliability. As a result, semiconductor manufacturers must adhere to strict standards for water quality to ensure the integrity of their products.

Consequently, the semiconductor industry has a significant impact on the water and wastewater industry, driving demand for advanced water treatment solutions. The manufacturing processes generate substantial volumes of contaminated wastewater that cannot be discharged into the environment without proper treatment. Regulatory bodies impose stringent regulations on industrial wastewater discharge to safeguard public health and the environment. Violations of these regulations can result in hefty fines and legal consequences, prompting semiconductor companies to invest in cutting-edge water treatment technologies. Moreover, the semiconductor industry's reliance on ultra-pure water has led to a growing need for innovative water recovery and recycling solutions. With access to external water resources becoming increasingly limited and costly, semiconductor manufacturers are exploring ways to maximize water reuse within their processes. Advanced water treatment technologies, such as reverse osmosis, deionization, and advanced oxidation processes, play a crucial role in producing clean water for ongoing operations and minimizing environmental impact.

Additionally, emerging contaminants like per- and polyfluoroalkyl substances (PFAS) pose new challenges for the semiconductor industry and water treatment providers. PFAS, commonly used in semiconductor manufacturing processes, can find their way into wastewater streams, and pose risks to human health and the environment if not properly managed and treated. This has led to a heightened focus on zero liquid discharge (ZLD) and advanced water treatment solutions capable of removing PFAS contaminants effectively. Thus, while the semiconductor industry's growth presents immense opportunities, it also underscores the importance of sustainable water management practices. The industry's increasing demand for ultra-pure water drives innovation and investment in the water and wastewater industry, leading to the development of advanced treatment technologies and sustainable solutions. By addressing water-related challenges proactively, semiconductor manufacturers can ensure the continued growth and success of their operations while minimizing their environmental footprint.

11.5.9.1. WATER & WASTEWATER TREATMENT FOR SEMICONDUCTORS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 78. WATER & WASTEWATER TREATMENT FOR SEMICONDUCTORS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.739	0.872	0.928	0.988	1.197	1.459	1.787	**6.80%**
Europe	0.891	1.049	1.114	1.185	1.431	1.739	2.123	**6.69%**
North America	1.153	1.360	1.446	1.539	1.863	2.268	2.774	**6.76%**
Middle East & Africa	0.090	0.106	0.112	0.119	0.143	0.172	0.208	**6.41%**
Latin America	0.135	0.159	0.170	0.181	0.219	0.267	0.327	**6.81%**
Total	**3.008**	**3.546**	**3.771**	**4.013**	**4.852**	**5.904**	**7.219**	**6.74%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.5.10. OTHERS

The textiles, paints and coatings, and personal care industries are integral components of the global economy, each experiencing distinct patterns of growth and development. These sectors play critical roles in fulfilling consumer needs and driving economic activity worldwide. However, their expansion also brings significant implications for water and wastewater treatment industries, as the production processes within these sectors inherently generate substantial volumes of wastewater and require considerable water resources. The paints and coatings industry, essential for both decorative and protective applications, has experienced steady growth fueled by construction activities, automotive production, and industrial development. However, the manufacturing of paints and coatings involves the use of solvents, pigments, and other chemicals that can contaminate water sources if not properly managed. Additionally, wastewater generated during the cleaning of equipment and facilities further contributes to environmental challenges. Consequently, stringent regulations and heightened environmental awareness have prompted the paint and coatings industry to invest in water treatment solutions to minimize pollution and enhance sustainability. The textiles industry, characterized by its diverse range of products including clothing, home textiles, and industrial fabrics, has witnessed significant growth driven by factors such as population growth, urbanization, and evolving fashion trends. As demand for textiles continues to rise globally, so does the need for water-intensive manufacturing processes such as dyeing, finishing, and washing. Consequently, the textiles industry remains a major contributor to water pollution, with wastewater containing various pollutants such as dyes, chemicals, and heavy metals. This necessitates the implementation of efficient water treatment technologies to mitigate environmental impact and ensure compliance with regulatory standards.

Meanwhile, the personal care industry, encompassing products such as cosmetics, toiletries, and skincare items, has seen remarkable expansion driven by changing consumer lifestyles, increasing disposable incomes, and growing awareness of personal hygiene. The production of personal care products often involves water-intensive processes such as mixing, blending, and emulsification, leading to significant wastewater generation containing organic compounds, surfactants, and other contaminants. As consumer preferences shift towards eco-friendly and natural products, there is a growing emphasis on sustainable manufacturing practices, including the efficient use of water resources and the adoption of wastewater treatment technologies to reduce environmental footprint. The collective growth of these industries underscores the increasing demand for water and wastewater treatment solutions to address the challenges posed by industrial activities. Advanced treatment technologies such as membrane filtration, biological treatment, and chemical oxidation are increasingly being adopted to treat complex wastewater streams effectively. Additionally, there is a growing trend towards water recycling and reuse within industrial processes to optimize resource utilization and minimize environmental impact.

11.5.10.1. WATER & WASTEWATER TREATMENT FOR OTHER END-USES REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 79. WATER & WASTEWATER TREATMENT FOR OTHER END-USES REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	0.551	0.631	0.664	0.699	0.816	0.956	1.122	**5.40%**
Europe	0.667	0.762	0.801	0.842	0.981	1.147	1.344	**5.33%**
North America	0.822	0.940	0.988	1.040	1.211	1.416	1.658	**5.32%**
Middle East & Africa	0.068	0.078	0.081	0.085	0.099	0.115	0.134	**5.11%**
Latin America	0.096	0.110	0.115	0.121	0.141	0.166	0.194	**5.36%**
Total	**2.204**	**2.521**	**2.650**	**2.788**	**3.249**	**3.799**	**4.452**	**5.34%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

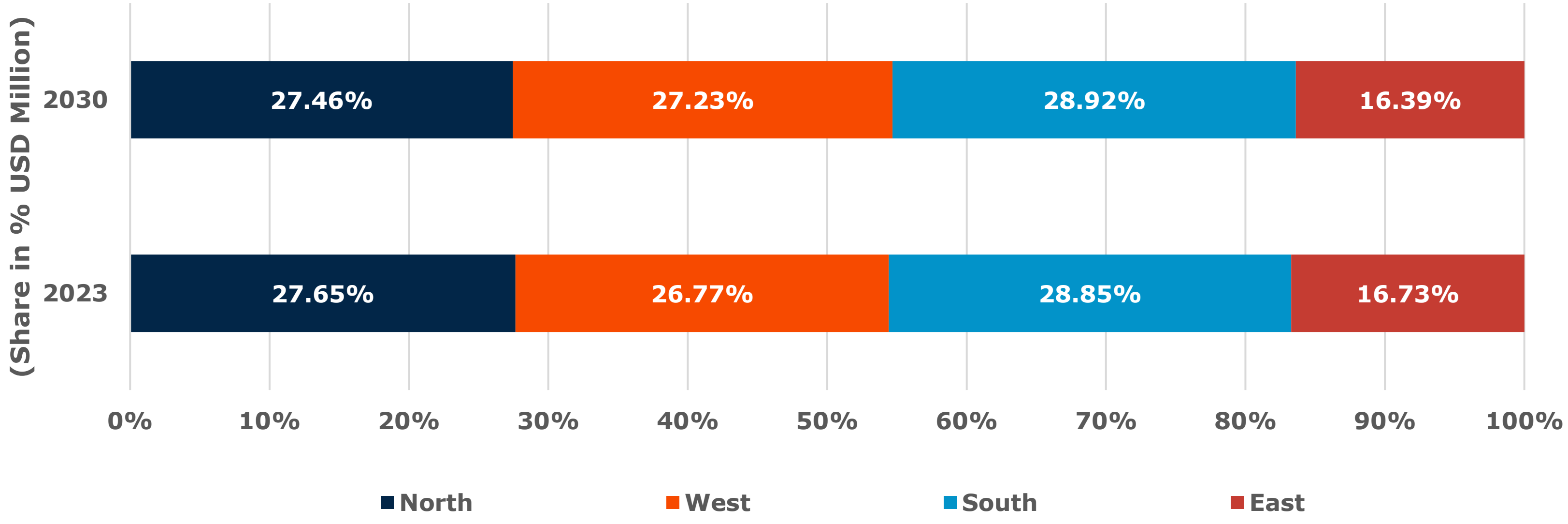
12. GLOBAL WATER AND WASTEWATER TREATMENT MARKET BY REGION INSIGHTS & TRENDS

KEY REGIONAL TRENDS & HIGHLIGHTS

- Asia Pacific is expected to account for a share of 28.85% in the Water & Wastewater Treatment Market in 2033.

12.1. REGION DYNAMICS & MARKET SHARE, 2023 & 2033

FIGURE 70. GLOBAL WATER & WASTEWATER TREATMENT MARKET: REGION DYNAMICS (SHARE IN % USD BILLION)



Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

12.2. GLOBAL WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

TABLE 80. GLOBAL WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD BILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Asia Pacific	58.163	67.594	71.495	75.679	90.035	107.750	129.553	**6.16%**
Europe	70.139	81.311	85.926	90.868	107.800	128.631	154.194	**6.05%**
North America	90.008	104.511	110.508	116.936	138.980	166.152	199.560	**6.12%**
Middle East & Africa	7.136	8.222	8.669	9.147	10.775	12.764	15.187	**5.80%**
Latin America	10.524	12.236	12.944	13.703	16.307	19.521	23.475	**6.16%**
Total	**235.970**	**273.874**	**289.542**	**306.332**	**363.897**	**434.818**	**521.970**	**6.10%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

12.3. INDIA

According to a 2018 assessment by NITI Aayog, India ranks among the most water-stressed countries globally, with approximately 600 million people experiencing high water stress. Projections indicate that by 2030, water demand in India could double compared to current supplies, exacerbating water scarcity issues for millions. Understanding and effectively managing water needs and resources are thus becoming increasingly vital for the nation's sustainable future. Given the finite nature of freshwater resources, the reuse and recycling of water resources are imperative. Wastewater treatment emerges as a critical strategy, offering a potential backup water source. Depending on the treatment level, reclaimed water can be suitable for direct consumption or may be partially treated for purposes such as irrigation and industrial use. Technological advancements have significantly enhanced the recovery of nitrate and phosphorus from sewage waste, with treated wastewater yielding high-quality manure as a valuable by-product.

The water and wastewater treatment market in India is poised for significant growth, driven by escalating demand for clean water and ongoing technological advancements in water treatment methods. The country's increasing investments in wastewater networks and facilities, particularly aimed at addressing the remaining 50% of sewage generated in urban areas, further fuel market expansion. With persistent and rapid urbanization, coupled with the imperative to treat sewage from semi-urban and rural areas, projections suggest a need for 4500 or more sewage treatment plants (STPs) across India. To finance such projects, the Indian government has introduced innovative financial mechanisms, including the Hybrid Annuity Model (HAM) under the National Mission for Clean Ganga (NMCG), overseen by the water resources department. Under this model, developers are tasked with covering operation and maintenance (O&M) costs, along with 60% of the capital costs, while the government funds the remaining 40%. Over a predetermined period, typically 15 years, the government reimburses the developer, including interest, incentivizing private investment and attracting financial institutions to the market.

Recent statistics sourced from the Ministry of Jal Shakti, Government of India, highlight the significant water consumption in Western India. Maharashtra, for instance, recorded a surge in water demand, reaching approximately 18.6 billion cubic meters in 2021, emphasizing the urgent need for sustainable water management practices in the region. Similarly, Gujarat experienced heightened industrial activity, leading to increased discharge of industrial effluents. This underscores the importance of implementing stringent wastewater treatment measures to safeguard water resources and mitigate environmental impacts.

12.3.1. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033 (USD BILLION)

TABLE 81. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033(USD BILLION)

Type	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Water Treatment	5.228	6.201	6.608	7.049	8.584	10.524	12.971	**7.01%**
Wastewater Treatment	5.413	6.180	6.493	6.825	7.944	9.283	10.879	**5.32%**
Total	**10.641**	**12.381**	**13.101**	**13.874**	**16.528**	**19.808**	**23.850**	**6.20%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

12.3.2. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD BILLION)

TABLE 82. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD BILLION)

Offering	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Treatment Technologies	2.051	2.391	2.532	2.684	3.205	3.850	4.648	**6.29%**
Activated Sludge Process	0.795	0.924	0.977	1.034	1.230	1.471	1.767	**6.13%**
Membrane Bio Reactor	0.410	0.476	0.504	0.533	0.635	0.760	0.914	**6.17%**
Moving Bed Bio Reactor	0.278	0.326	0.346	0.368	0.442	0.534	0.649	**6.51%**
Sequencing Batch Reactor	0.212	0.250	0.265	0.282	0.341	0.414	0.505	**6.68%**
Upflow Anaerobic Sludge Blanket Reactor	0.140	0.162	0.171	0.181	0.215	0.256	0.307	**6.06%**
Submerged Aerated Fixed Film Reactor	0.122	0.143	0.151	0.160	0.192	0.232	0.281	**6.44%**
Other Treatment Technologies	0.094	0.111	0.118	0.125	0.151	0.184	0.224	**6.68%**
Treatment Chemicals	1.193	1.385	1.464	1.549	1.840	2.199	2.639	**6.10%**
Corrosion Inhibitors	0.305	0.353	0.373	0.394	0.467	0.557	0.667	**6.01%**
Scale Inhibitors	0.028	0.032	0.034	0.036	0.042	0.050	0.060	**5.79%**
Biocides & Disinfectants	0.294	0.341	0.360	0.381	0.452	0.539	0.646	**6.04%**

Coagulants & Flocculants	0.093	0.109	0.116	0.123	0.147	0.177	0.214	**6.38%**
Chelating Agents	0.187	0.218	0.231	0.245	0.293	0.352	0.426	**6.34%**
Anti-Foaming Agents	0.199	0.231	0.243	0.257	0.304	0.362	0.433	**5.96%**
Ph Adjusters and Stabilizers	0.049	0.057	0.060	0.064	0.077	0.093	0.112	**6.45%**
Others	0.038	0.044	0.046	0.049	0.058	0.068	0.081	**5.79%**
Process Control and Automation	3.434	3.992	4.223	4.471	5.322	6.372	7.666	**6.17%**
Design, Engineering, and Construction Services	2.349	2.749	2.915	3.093	3.709	4.474	5.424	**6.44%**
Operation and Maintenance Services	1.614	1.864	1.967	2.077	2.452	2.912	3.473	**5.88%**
Total	**10.641**	**12.381**	**13.101**	**13.874**	**16.528**	**19.808**	**23.850**	**6.20%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

12.3.3. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033 (USD BILLION)

TABLE 83. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033(USD BILLION)

Equipment	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Filtration	1.946	2.270	2.405	2.549	3.047	3.663	4.426	**6.32%**
Ultra-Filtration	1.217	1.432	1.522	1.618	1.952	2.370	2.893	**6.67%**
Micro-Filtration	0.728	0.838	0.883	0.931	1.094	1.293	1.533	**5.70%**
Disinfection	6.393	7.418	7.842	8.296	9.852	11.769	14.123	**6.09%**
Adsorption	0.061	0.070	0.074	0.078	0.093	0.111	0.133	**6.06%**
Desalination	1.994	2.331	2.471	2.622	3.141	3.786	4.585	**6.41%**
Testing	0.139	0.161	0.170	0.180	0.215	0.257	0.309	**6.17%**
Others	0.109	0.130	0.139	0.149	0.181	0.222	0.273	**7.01%**
Total	**10.641**	**12.381**	**13.101**	**13.874**	**16.528**	**19.808**	**23.850**	**6.20%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

12.3.4. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY APPLICATION, 2019-2033 (USD BILLION)

TABLE 84. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY APPLICATION, 2019-2033(USD BILLION)

Application	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Sewage Water Treatment Plant	4.088	4.747	5.020	5.312	6.315	7.550	9.070	**6.12%**
Common Effluent Treatment Plant	1.415	1.637	1.728	1.826	2.161	2.572	3.075	**5.96%**
Water Treatment Plant	5.138	5.997	6.353	6.736	8.052	9.685	11.705	**6.33%**
Total	**10.641**	**12.381**	**13.101**	**13.874**	**16.528**	**19.808**	**23.850**	**6.20%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

12.3.5. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033 (USD BILLION)

TABLE 85. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033(USD BILLION)

End-Use	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Municipal	6.931	8.052	8.515	9.012	10.717	12.819	15.406	**6.14%**

Residential	1.595	1.844	1.947	2.057	2.432	2.892	3.455	**5.93%**
Industrial	2.115	2.485	2.639	2.805	3.379	4.096	4.989	**6.61%**
Food & Beverages	0.025	0.029	0.031	0.033	0.040	0.049	0.060	**6.89%**
Pharmaceuticals and Chemicals	0.436	0.517	0.550	0.587	0.713	0.873	1.074	**6.95%**
Power Generation	0.354	0.417	0.444	0.472	0.570	0.694	0.847	**6.71%**
Pulp and Paper	0.366	0.430	0.457	0.485	0.584	0.706	0.859	**6.55%**
Oil & Gas	0.203	0.238	0.252	0.268	0.322	0.389	0.472	**6.51%**
Mining	0.370	0.433	0.459	0.487	0.584	0.705	0.855	**6.45%**
Petrochemical	0.122	0.143	0.151	0.161	0.192	0.231	0.280	**6.37%**
Semiconductors	0.134	0.159	0.169	0.180	0.218	0.266	0.327	**6.86%**
Others	0.104	0.120	0.126	0.133	0.155	0.183	0.215	**5.50%**
Total	**10.641**	**12.381**	**13.101**	**13.874**	**16.528**	**19.808**	**23.850**	**6.20%**

Sources: International Water Association, Association of Water Technologies, National Ground Water Association, Water Environment Federation, Water Quality Association, Water & Sewer Industry Organizations, Ministry of Jal Shakti (MoJS),Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, Central Pollution Control Board , Department of Water Resources, River Development, Department of Drinking Water and Sanitation, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

13. SWOT ANALYSIS FOR ENVIRO INFRA ENGINEERS LIMITED (EIEL)

13.1. COMPANY PROFILE

Enviro Infra Engineers Limited (EIEL) is a listed public company incorporated in 2009, and located in North West, Delhi, India. The company primarily engages in Engineering, Procurement, and Construction (EPC) projects and is dynamic in Sewage Treatment Plants (STPs), Common Effluent Treatment Plants (CETPs), and Sewerage Networks, Water Treatment Plants (WTPs), and Water Supply Scheme Projects (WSSPs). The treatment process installed at most of the STPs and CETPs is Zero Liquid Discharge (ZLD) compliant and the treated water can be used for horticulture, washing, refrigeration, and other industrial processes. The company offers its products and services in Water and Wastewater Treatment Plants (WWTPs) for government authorities/bodies.

The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and National Mission of Clean Ganga (NMCG) are two programs among others that the Central Government uses to partially fund projects in urban areas that include WWTPs and WSSPs. Additionally, WSSPs are partially sponsored by Central Government programs such as the Jal Jeevan Mission (JJM) for rural India. Under their separate programs, the states or Urban Local Bodies (ULBs) contribute to the costs of both WSSPs and WWTPs. EIEL engages in the bidding of these WSSPs and WWTPs tenders issued by the governments for developing, filtration, water, and wastewater treatment systems for water purification, wastewater treatment, as well as, water recycling, and reuse.

In addition to the execution of projects independently, EIEL also engages and invests in various strategic initiatives such as partnerships & agreements, and enters into joint ventures, with other infrastructure and construction companies to jointly bid and execute projects. These strategies provide the company leverage to achieve pre-qualification, both technical and financial, with the partners at the time of the bid, and where the bid is successful, also execute the project with these partners – considering the technical skill and qualification of the joint venture partner required to execute a particular project.

13.2. COMPANY OPERATIONS

Range of Solutions for WWTPs

1. ***Sewage treatment plants and Sewage Schemes***

   The objective of the sewerage scheme is to aid in the collection of sewage or domestically produced wastewater from each household through pipelines, and intermediate pumping stations, to take it to a common facility called a sewage treatment plant, where the water is treated up to the current stringent norms prescribed by the NGT or up to the standards to reuse in horticulture, refrigeration, and processing industries. The sewage wastewater is rich in nitrogen and phosphorous, besides organic matter, which acts as a carbon source and aids in the formation of organic cells. A number of technologies are available for the biological treatment of sewage wastewater in the combination of technologies for biological nutrient removal. Sewage treatment plants employ a combination of all or any one of the following systems for the treatment of water to usable standards:

- ***Primary Treatment Units*** - For removal of large particles/ solids from sewage.
- ***Aeration*** – for the removal of BOD and COD in sewage. There are two types of biological systems: aerobic which acts in presence of air and anaerobic systems which operate in absence of oxygen. There are various technologies available for the removal of BOD and COD.

The aerobic systems include:

- *Activated Sludge Process*

- *Extended Aeration System*
- *Diffused Aeration System*
- *MBBR (Mixed Bed Biological Reactor)*
- *SAFF (Submerged Aerated Fixed Film Reactor)*
- *IFAS*
- *SBR (Sequential Batch Reactor)*
- *MBR (Membrane Bio Reactor)*

The anaerobic systems include:

- UASB (Upflow Anaerobic Sludge Blanket Reactor)
- High Rate Anaerobic Digestor

Technologies employed by the company include:

- ***Sedimentation*** – removal of suspended particles present in water. For sedimentation, EIEL employs conventional clariflocculator technology, advanced space saving technologies such as inclined plate settler technology and tube settler technology.
- ***Filtration*** –wherein the water will be filtered through a media of sand for removal of fine suspended particles present in water. For filtration, superior nozzle based under drain system for collecting filtered water which ensures superior quality compared with conventional header and lateral systems. Depending upon the requirement of quality, the company offers space-saving dual media gravity filtration where anthracite or carbon is used in addition to sand as a filtration media.

- ***Disinfection*** – for controlling microbial substances such as bacteria and viruses present in water. Depending upon the requirements, EIEL uses chlorine, ozone or ultra violet rays as disinfectants.
- ***Sludge Dewatering*** – The sludge generated from the facilities is dewatered using equipment such as centrifuge vacuum filter, filter press or dried on sludge drying beds.

Sewerage Schemes– The sewerage schemes in India are of two types. The first where the sewerage flowing into river(s) or any water body is diverted to an STP in certain cities where sewer lines have not been laid. The second one is in which the sewer line is already laid connecting to the STP before disposal into water body or its reuse. For these projects the company begins with the survey of the entire area where sewer is to be laid, design of the sewerage system, design of STP, providing and laying of sewerage pipes, civil construction, supply, erection, testing and commissioning of STP, followed by operation and maintenance for the designated period as per the work order.

2. *Common Effluent Treatment Plants (CETPs)*

The company is also specialized in offering tailor-made solutions for recycling and reuse of contaminated wastewater produced by manufacturing facilities. These solutions include:

1. Physico Chemical Treatment – Oil removal system using DAF / API / CPI separators;
2. Neutralization and primary sedimentation and grit removal;

3. Biological anaerobic treatment – UASB;

4. Tertiary treatment – activated carbon/sand filtration, disinfection;

5. Biological aerobic treatment – activated sludge process using surface and diffused aeration system, extended aeration system, trickling filter using stone or plastic media and fixed film reactors; and

6. Advanced treatment for recycling and reuse – ultra / micro-filtration and reverse osmosis.

3. ***Water Treatment Plants and Water Supply Schemes***

The company's capabilities in this segment include:

i. Raw water pre-treatment which includes cascade aeration and pre-chlorination;
ii. Clarification which provides sedimentation time so that the solids get settles at the floor and clarified water flows through launders at the top of clarifiers;
iii. Filtration plants which include rapid sand gravity filters and pressure sand filters (for smaller plants);
iv. Disinfection, which is generally done through chlorination; and
v. The other available technologies include UV treatment.

A water supply scheme is a complete scheme where water is drawn from a river or water body through an intake well. Pumps are installed in the intake well which pumps raw water from the intake well to a water treatment plant through DI pipelines, which are called raw water rising mains. This water is treated in a WTP as per the process explained above and then is pumped through the clear water rising mains to the overhead reservoirs/ underground reservoirs. The distribution pipelines are laid to carry the water from these reservoirs to individual households. The housing connections are provided to individual consumers from these distribution lines. The distribution lines are laid in DI, HDPE, or PVC. For WSSPs projects EIEL initiates the project by surveying the entire area and considers where the intake WWTP is to be installed and where the elevated/ underground reservoirs are to be constructed, the entire route of pipelines, complete design of all components, providing and laying of water pipes, civil construction, supply, erection testing and commissioning of the WWTP, elevated/ underground reservoirs, followed by operation and maintenance for the designated period as per the work order.

Various other tertiary treatment technologies include:

- Pressure sand filtration and activated carbon filtration: The treated water is pumped through a pressure vessel containing either filtration sand in pressure sand filter to remove suspended solids or activated carbon to remove color, odor, or traces of BOD.
- Disc Filters: The treated water flows through a battery of discs having cloth as filtration. This battery of discs rotates inside a tank, wherein clear water flows through the cloth and is collected, the solid sticks to the surface which is cleaned through back wash of filters at periodic intervals.
- Ultra-filtration: which is a membrane separation process for reduction of solids in the water.
- Reverse Osmosis for sea water / brackish water treatment: Dissolved solid quantity is high whether treating sea water or industrial effluent like textile effluent, to make water suitable for reuse, and reverse osmosis process is used for this. It entails a membrane separation process, in which the usable water flows through the RO membranes, is collected, has low TDS and is usable. The

remaining water is a highly concentrated stream, which is disposed of if it is separated from sea water. In case of RO process used in industrial effluent, the concentrated stream is required to be evaporated by installing multiple effect evaporators.

Zero Liquid Discharge: Zero liquid discharge or reuse of treated water from a STP, CETP. In case of CETPs, NGT has mandated to install plants with Zero Liquid Discharge, to prevent any pollution from industries. Zero liquid discharge scheme depends upon the quality of water required where it is to be used. It can be horticulture, refrigeration, process industries etc. The quality requirements are different for various type of uses. The treatment process at most of the STPs and CETPs installed by the company are ZLD-compliant and the treated water can be used for horticulture, washing, refrigeration, or processes in other industries.

4. **Operations & Maintenance**:

Bids for almost all turnkey projects in the field of WWTPs are being invited along with O&M for a period of 5-15 years. O&M contracts generally include operations, maintenance, and supply of consumables and spares providing continuous revenue. It also provides a dedicated team to monitor O&M activities for all the plants. The O&M team at the site consists of a chemist, fitter, electrician, operators, and supporting staff. The company conducts routine drills to take up the preventive maintenance of different equipment, as per recommendations of OEMs. In the event of a breakdown, the O&M team undertakes breakdown maintenance to ensure the use of the equipment. Major breakdowns are handled by the OEMs within the warranty period of the equipment, wherein the company ensures that the equipment is either repaired or replaced by the OEM on behalf of the clients.

5. Utilities & Infrastructure Facilities

As wastewater and water treatment become more significant, demand for more advanced and innovative procedures and solutions and approaches to offer the requisite pollutant removal efficiency. Enviro Infra Engineers Limited plays an important role in developments and technological advancements in the water and wastewater treatment industry by providing innovative and eco-friendly solutions to treat wastewater as well as drinking water. The company engages to speed up the natural process of purifying water. With billions of people consuming or using water for various purposes and needs and even more wastewater being generated and accumulated each day, the natural process starts to get overloaded. Without wastewater treatment, the volume of wastewater would cause major environmental impact. Globally, over 80 percent of all wastewater is discharged without treatment.

The company offers various methods to treat water with one common goal: purify water as much as possible and send it back into the environment to keep humans and the Earth safe and thriving. The services and products offered to treat water is not only to ensure recovery of uncontaminated water for reuse to industries, but also to alleviate rising environmental concerns, reduce impacts wastewater is having on the ecosystem, and to address concerns regarding water conservation. Treated water can significantly reduce need to utilize fresh or pure water for industrial applications. In addition, the company also offers modifications to the conventional water treatment scheme as well as engages in exploring the best feasible mechanism to ensure proper drinking water production with the least possible rejections and effective management. The company offers technologies and treatments including biological treatment, metals removals, and filtration/recycling technologies, from which a low-cost, high-performance treatment solution can be created.

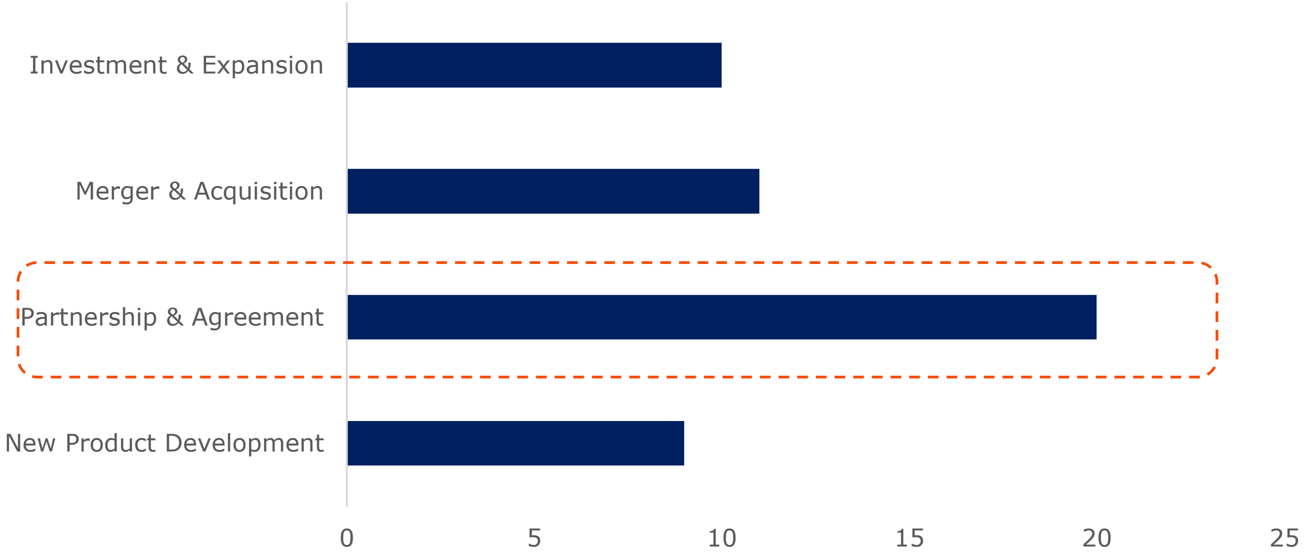
14. COMPETITIVE LANDSCAPE

14.1. GLOBAL WATER AND WASTEWATER TREATMENT MARKET: COMPANY SNAPSHOT

Key participants in the water and water treatment market include leading entities such as VA tech wabag, ION exchange, Vishnu Prakash and EMS, among others.

Currently, the market is witnessing heightened activity from these players, particularly in the realm of new product development, as they strive to establish a competitive edge by fostering collaboration and resource-sharing within the industry. Moreover, market participants are actively engaging in strategic maneuvers such as mergers and acquisitions, agreements and partnerships, as well as investments and expansions. These strategic initiatives are geared towards forging alliances with pivotal end-users and organizations, both within the public and private sectors. By doing so, market players aim to bolster their competitive positions and enhance sales performance in the dynamically evolving landscape of the Indian water and water treatment market.

14.2. STRATEGY BENCHMARKING



In the water and wastewater treatment market, various strategic approaches have been employed by industry players to fortify their market positions and capitalize on emerging opportunities. Notably, the strategies of New Product Development, Partnership & Agreement, Merger & Acquisition, and Investment & Expansion have been instrumental in shaping the competitive landscape and fostering growth within the sector. Notable companies such as Ecolab, Veolia, Thermax Group, DuPont, and VA TECH WABAG LIMITED have demonstrated exemplary execution of these strategies, contributing to their market leadership and sustained success. Moving forward, continued emphasis on innovation, collaboration, and strategic investments will remain critical for navigating evolving market dynamics and capitalizing on emerging opportunities in the water and wastewater treatment industry.

New Product Development (NPD): New Product Development emerges as a pivotal strategy in the water and wastewater treatment market, reflecting the commitment of companies to innovate and address evolving consumer needs. This strategy involves the conceptualization, design, and launch of novel solutions tailored to meet specific market demands. Companies have prioritized NPD to enhance their product portfolios, improve efficiency, and differentiate themselves from competitors. Notable initiatives in this realm include the introduction of advanced filtration systems, sustainable treatment technologies, and IoT-enabled monitoring solutions. ***For instance, In Mar-24, Nalco Water, an Ecolab Company launched an advanced filtration technologies project at Lindström Group's laundry plant in Chennai, India, in 2022. In just over a year, Lindström recovered 74% of water at the plant and reduced its total freshwater usage in Chennai by 56%.***

Partnership & Agreement: Collaboration and strategic alliances play a significant role in driving growth and expanding market reach within the water and wastewater treatment sector. ***For instance, In Dec-23, South West Water has teamed up with Veolia Water Technologies & Solutions to introduce desalination to Cornwall, addressing water scarcity exacerbated by record droughts in the region.*** The desalination process involves initial treatment of seawater from St Austell Bay, followed by secondary treatment at Restormel, benefiting around 300,000 residents. The plant's capacity of 20 million litres per day is set to fulfill 40% of Cornwall's current water demand, providing a crucial long-term solution. Partnerships and agreements enable companies to leverage complementary strengths, access new markets, and enhance operational capabilities. Through collaborative efforts with technology providers, research institutions, and governmental bodies, companies have accelerated innovation, streamlined distribution channels, and strengthened their competitive positioning. Key partnerships include joint ventures for infrastructure development, licensing agreements for proprietary technologies, and strategic alliances for market expansion initiatives.

Merger & Acquisition: Merger & Acquisition activities have been instrumental in reshaping the competitive landscape and fostering consolidation within the water and wastewater treatment market. Companies have pursued strategic acquisitions, mergers, and divestitures to gain access to new technologies, expand market presence, and achieve economies of scale. M&A transactions have facilitated portfolio diversification, geographic expansion, and synergistic integration of capabilities. Notable examples include the acquisition of specialized treatment firms, consolidation of regional players, and strategic partnerships with engineering firms to enhance project execution capabilities. ***For instance, In Feb-24, Thermax Group signed an agreement to acquire a 51% stake in TSA Process Equipment, a strategic addition to Thermax's portfolio that will enable the company to offer a one-stop solution for high-purity water requirements of its customers in sectors such as pharma, biopharma, personal care, and food & beverages.***

Investment & Expansion: Investment and expansion initiatives underscore companies' commitment to capitalizing on growth opportunities and strengthening their foothold in the water and wastewater treatment market. Capital expenditure programs, infrastructure investments, and facility expansions enable companies to enhance production capacities, improve supply chain efficiency, and meet evolving customer demands. Moreover, strategic investments in R&D, technology upgrades, and market development initiatives have positioned companies for sustainable growth and competitive advantage. ***For instance, In Mar-23, DuPont MemPulse Membrane Bioreactor System (MBR) and FilmTec Reverse Osmosis (RO) technologies have been selected as part of a multi-technology solution for implementation in Singapore's Tuas Water Reclamation Plant (WRP), this new facility is planned to commence initial operations in 2026 and is poised to become one of the world's largest membrane bioreactor (MBR) facilities when fully completed.*** Expansion efforts include market entry into emerging regions, establishment of manufacturing facilities, and strategic investments in water infrastructure projects.

TABLE 86. PARTNERSHIP & AGREEMENT IN WATER AND WASTEWATER TREATMENT MARKET, 2019-2024

DATE	COMPANY NAME	DESCRIPTION
Sep-23	**VA TECH WABAG LIMITED**	In a strategic move aimed at addressing water challenges in the Middle East, WABAG has partnered with Al Jomaih Energy and Water (AEW), a prominent developer of energy and water projects in the region. The Memorandum of Understanding (MoU), signed during the India-Saudi Investment Forum, signifies a collaborative effort to explore opportunities in large-scale PPP projects across Saudi Arabia and the broader Middle East.
Nov-22	**VA TECH WABAG LIMITED**	VA TECH WABAG LIMITED secured a significant agreement with the Asian Development Bank (ADB), marking a key milestone in the water sector in India. The agreement involved raising Rs. 200 crores through unlisted Non-Convertible Debentures (NCD) with a 5 years and 3 months tenor, subscribed by ADB over a 12-month period. This marked ADB's first investment in a water sector company in India and reinforces WABAG's leadership in the industry.
Jun-22	**VA TECH WABAG LIMITED**	WABAG won an Engineering and Procurement ('EP') order from DL E&C CO., LTD., Korea for a water treatment package for the EuroChem methanol production facility in Kingisepp, Russia.
May-22	**VA TECH WABAG LIMITED**	WABAG through its subsidiary company Ghaziabad Nagar Nigam (GNN) has signed an agreement to design and operate a new 40 MLD Tertiary Treatment Reverse Osmosis (TTRO) plant and related infrastructure using a hybrid annuity model.
Dec-19	**VA TECH WABAG LIMITED**	VA TECH WABAG LIMITED signed an agreement with the government of Bihar to build sustainable wastewater infrastructure in Patna under Namami Gange Program.

Source: Company Annual report, Reports and Data, Primary Interview

TABLE 87. INVESTMENT & EXPANSION IN WATER AND WASTEWATER TREATMENT MARKET, 2019-2024

DATE	COMPANY NAME	DESCRIPTION
Jun-22	**VA TECH WABAG LIMITED**	WABAG has announced plans to broaden its global reach with a new JICA-funded consortium order for a 50 MLD desalination project in Senegal, West Africa, estimated to be worth approximately 146 Million Euro.
Aug-19	**Ion Exchange (India) Limited**	Ion Exchange (India) Limited announced the launch of its new R&D Center at Patancheru in Telangana. The company invested around INR 300 million for the center to develop new resins, membranes, polymers and specialty chemical technologies related to water, wastewater treatment, process separation and purification, specialty process application and catalysis. This state-of-the-art R&D center is spread over 24,000 sq ft and certified by the Department of Scientific and Industrial Research (DSIR).

Source: Company Annual report, Reports and Data, Primary Interview

14.3. WATER & WASTEWATER TREATMENT MARKET: GLOBAL MAJOR PLAYERS

TABLE 88. COMPARATIVE ANALYSIS

	LARGE SCALE	MEDIUM SCALE	SMALL SCALE
Approx. no. of company	Top 10	10-100	More than 150+
Revenue share in USD	Above 750 Million	100- 750 Million	Less than 100 Million
Standard of comparison	✓ Access to all types of Technologies ✓ Strong personal and market grip ✓ Vast experience and diversified product & service portfolio ✓ Global presence and excellent track record	✓ Comparatively smaller projects ✓ Higher expertise in specific products or services. ✓ High dependence on Joint ventures and partnership	✓ Deals in limited technology and for small-scale projects ✓ Offers modular and residential treatment products
Major Players	• Veolia • ECOLAB INC. • XYLEM INC • PENTAIR PLC • Veralto • DuPont de Nemours, Inc. • SCHLUMBERGER LIMITED • Wog Technologies • Voltas limited • Toshiba Water Solutions Private Limited	• Voltas limited • ion exchange India ltd. • Chembond Chemicals Ltd. • Vasu Chemicals • Thermax India • Wipro water • GE Water • Siemens India-Water technology • Concord Enviro • Arvind Evisol • Larsen & Toubro Limited • Hindustan Dorr-Oliver Limited	• Paramount Limited • Praj Industries • Aquaguard • Pure it • Aquatech Asia • Murugappa Organo • Netsol Water Solutions • Triveni Engineering & Industries Ltd.

Type of Projects	• STP • CETP • O&M • TTRO • WWTPs • WSSTs • Government projects • Others	• STP • CETPS • Zero Liquid Discharge (ZLD) • O&M • Small Government projects • Others	• RO Treatment • UV Treatment • Chemical Treatment • Zero Liquid Discharge (ZLD) • Residential water treatment products • Other filtration methods
Target Industry	➢ Oil & Gas ➢ Energy & Power ➢ Municipal ➢ Mining ➢ Others large scale end-use sectors	➢ Paper & Pulp ➢ Pharmaceuticals and Chemicals ➢ Industrial ➢ Others	➢ Food & Beverages ➢ Electrical & Electronics ➢ Residential ➢ Other small scale industries

Source: Company Annual report, Reports and Data, Primary Interview

Key participants in the Global water and wastewater treatment market are Suez S.A., Ecolab Inc., Xylem Inc., Pentair plc, Danaher Corporation, DuPont de Nemours, Inc., Schlumberger Limited, Wog Technologies

SUEZ is a French utility firm that provides water management, recycling and waste recovery, water treatment, and consulting services. The company operates in four business segments Water Europe, Recycling and Recovery Europe, International, and other segments. The company provides water distribution and treatment services to individuals, industrial clients, and local authorities; waste collection and treatment services which include sorting, collection, composting, recycling, energy recovery, and landfilling for hazardous and non-hazardous waste to local authorities and industrial clients and waste, water, and engineering services.

ITT Corporation (ITT) produces specialty components for the transportation, aerospace, energy, and industrial markets. The water technology business of this company is named Xylem Inc. Xylem is engaged in the manufacture, design, and service of engineered solutions for water and wastewater applications. Water Infrastructure, Applied Water, and Sensus are the three business segments through which ITT operates. The company focuses on growth in treatment, transport, dewatering, and analytics. It also serves industries such as food and beverage, agriculture, and residential. Xylem has a selection of biological treatment technology, membrane filtration systems, and desalination solutions, among others. Besides, they also offer UV and ozone disinfection systems for oxidizing contaminants present in wastewater such as bacteria, viruses, and odor-causing compounds.

A subdivision of General Electric and GE Power, the company aims to provide water management solutions to its clients and utilizes a comprehensive set of advanced technologies to solve water quality challenges, scarcity, and productivity challenges. The company also resolves water-related issues for the energy and environment and serves both municipal and industrial companies. UF membranes, clarifiers, chemicals, evaporation, conventional gravity filters, and an assortment of post-treatment technologies are the series of innovative, integrated products offered by GE.

Key players in Indian Water & Wastewater Treatment Market include VA Tech Wabag, Thermax India, Voltas limited, ion exchange India ltd., Toshiba Water Solutions Private Limited, Khilari Infrastructure Private Limited, Vishvaraj Enviornment Private Limited, Aquatech System (Asia) Private Limited, Triveni Engineering & Industries Limited, Driplex Water Engineering Private Limited and others.

Khilari Infrastructure Pvt. Ltd. is an India-based company, founded in 2005, engages in infrastructure construction services. The company offers land filling, hazardous waste management, environmental protection, and sewage treatment plant construction services.

It also provides a wide range of services which include operation and maintenance of compost plants, sewage treatment plant, jointing sewer line network service and compost plant operation service. Khilari Infrastructure serves customers in India.

Vishvaraj Environment Pvt. Ltd., the flagship company of the Vishvaraj Group, is an ESG-focused water utility. The company engages in water sustainability and wastewater treatment and reuse, leading to water security. The company focuses on the Public-Private Partnership (PPP) route to come up with sustainable solutions along with the support of the Indian Government. It executed the first PPP project in India that provides tertiary treated water to thermal power stations, freeing up 190 MLD of fresh water that can take care of population growth for the next 25 years of the city of Nagpur. The company have a combined operating capacity of over 3,057 MLD across 42 water and wastewater treatment & reuse plants, and recently expanded their footprint overseas by winning a project in Maldives.

Other treatment companies include major players, one of which is Voltas Water, and treatment is a subdivision of the TATA enterprise, specializing in wastewater and industrial sewage treatment. The company is over four decades old and aims to build a healthier nation. It focuses mainly on effluent treatment plants, sewage treatment plants, zero liquid discharge plant, and water treatment plant. The company encompasses a wide range of products to fulfill this, including Sequence Batch Reactors (SBR), Moving Bed Biofilm Reactors (MBBR), along with technologies such as ultrafiltration and reverse osmosis.

TABLE 89. WATER & WASTEWATER MARKET: RECYCLING AND REUSE SOLUTION

COMPANY	ZERO LIQUID DISCHARGE	CONVENTIONAL SOLUTIONS	RECYCLE & REUSE SOLUTIONS
VA Tech Wabag	•	•	•
Ion Exchange	•	•	•
Vishnu Prakash R Punglia Ltd.		•	
EMS Limited.		•	

Source: Company Annual report, Reports and Data, Primary Interview

TABLE 90. WATER & WASTEWATER MARKET: GLOBAL COMPANY PROJECT

COMPANY	DESIGN & DEVELOPMENT	COMPONENT MANUFACTURING	CONSTRUCTION & INSTALLATION	O&M	IOT
VA Tech Wabag	•		•	•	•
Ion Exchange	•	•	•	•	•
Vishnu Prakash R Punglia Ltd.	•		•	•	
EMS Limited.	•		•	•	•

Source: Company Annual report, Reports and Data, Primary Interview

14.4. REPORTS AND DATA ANALYSIS

14.4.1. VA TECH WABAG LTD.

VA Tech WABAG Ltd. focuses on providing clean drinking water along with securing of environmentally-compatible disposal of municipal and industrial wastewater. The company has completed various projects under Indian government schemes and initiatives, and is considered to be one of the major players that provide cleaner and healthier ecosystems. The trust built by the company through its projects is expected to ensure receipt and offer of more significant opportunities in the future.

- The company currently holds the highest record of **INR 11,050 crore**, which includes mega projects under the Atal Mission for Rejuvenation and Urban Transformation scheme to establish a 178-MLD drinking water treatment plant in Coimbatore and the National Mission for Clean Ganga Scheme to develop sewage treatment plants of 150 MLD capacity, along with a sewerage network of over 450 km.
- In 2019, the company secured a project worth **INR 575 crore** under the National Mission for Clean Ganga Scheme in West Bengal. The projec scope includes developing, constructing, renovating, and operating sewage treatment facilities in Kolkata, West Bengal, as well as related infrastructure.
- The company was also awarded a project worth **INR 1,187 crore** to build sustainable wastewater infrastructure in Patna under the Namami Gange mission in 2019. The agreement was signed among the National Mission for Clean Ganga (NMCG), Bihar Urban Infrastructure Development Corporation Ltd. (BUIDCO), and DK Sewage Project Private Ltd. (A special arm of VA Tech WABAG Ltd.).

- In 2019, the company secured **INR 1,477 crore** worth order from State Mission for Clean Ganga, Uttar Pradesh, towards operation, maintenance, and management of the sewage treatment and network infrastructure in the cities of Agra and Ghaziabad for a period of 10 years, expandable for an additional period of 5 years.

14.4.2. ION EXCHANGE INDIA LIMITED

Ion Exchange India Limited aims to achieve water management through waste water recycle and source reduction; and waste management through product recovery and waste minimization. The company is aiming to work on water and waste infrastructure projects under various government schemes and initiatives.

- The State Water Supply and Sanitation Mission, Namami Gange, and the Rural Water Supply Department under the Jal Jeevan Mission in Uttar Pradesh awarded the company a contract worth **INR 1,000 crore** in 2021. The Letter of Award (LoA) is for two EPC projects that include surveying, designing, creating a Detailed Project Report (DPR), providing, building, and commissioning a water treatment plant, as well as operating and maintaining it for 10 years to supply rural drinking water to 1,000 villages in two districts of Uttar Pradesh, Varanasi, and Aligarh.
- The company, in partnership with the Welspun Group designed, established, and commissioned a sewage treatment and recycling plant along with undertaking its O&M. The 30 million liters per day (MLD) STP is treating sewage generated from two cities, Anjar and Adipur, supplied by their respective local municipalities.

14.4.3. VISHNU PRAKASH R PUNGLIA LIMITED

Vishnu Prakash R Punglia Limited is a distinguished company specializing in integrated engineering, procurement, and construction services. The company has garnered a reputable position in the industry through its commitment to quality, innovation, and sustainable development. Below is an overview of some key projects undertaken by Vishnu Prakash R Punglia Limited, including both completed and ongoing endeavors:

Completed Projects

1. **Water Supply Projects**
    - **Churu Water Supply Project**: This project involved the design and construction of a comprehensive water supply system for the Churu district, ensuring reliable access to potable water for thousands of residents.
    - **Rural Water Supply and Sanitation Project**: Successfully executed in various rural areas, this project aimed to provide clean drinking water and improved sanitation facilities, significantly enhancing the quality of life for the local population.
2. **Irrigation Infrastructure**
    - **Lift Irrigation Schemes**: Vishnu Prakash R Punglia Limited has completed several lift irrigation schemes, facilitating the efficient use of water resources for agricultural purposes in water-scarce regions.
    - **Canal Construction**: The company has constructed numerous irrigation canals, improving water distribution and supporting agricultural productivity across multiple states.
3. **Road and Highway Development**
    - **National Highway Projects**: The company has successfully completed the construction and upgradation of several national highways, contributing to improved connectivity and transportation infrastructure.

Ongoing Projects

1. **Urban Infrastructure Development**
   - **Smart City Projects**: Engaged in the development of smart city infrastructure, Vishnu Prakash R Punglia Limited is working on projects that integrate advanced technology and sustainable practices to enhance urban living conditions.
   - **Metro Rail Projects**: The company is involved in the construction of metro rail systems, which aim to provide efficient and eco-friendly public transportation solutions in major cities.
2. **Large-Scale Water Supply Systems**
   - **Multi-Village Water Supply Schemes**: Ongoing projects include the implementation of water supply systems designed to serve multiple villages, ensuring consistent and safe water access to rural communities.
   - **Urban Water Supply Projects**: Currently, the company is working on expanding and upgrading urban water supply networks to meet the growing demand in metropolitan areas.
3. **Environmental and Renewable Energy Projects**
   - **Wastewater Treatment Plants**: Vishnu Prakash R Punglia Limited is actively engaged in constructing wastewater treatment facilities aimed at promoting sustainable water management and environmental protection.
   - **Solar Power Projects**: The company is involved in developing solar power plants, contributing to the renewable energy sector and supporting the transition to greener energy sources.

Commitment to Excellence

Vishnu Prakash R Punglia Limited is dedicated to delivering high-quality infrastructure projects that meet international standards. Their ongoing commitment to innovation, sustainability, and community development underscores their role as a leading player in the construction and engineering sector. The company's portfolio reflects a diverse range of projects that not only address current infrastructural needs but also pave the way for future advancements.

14.4.4. EMS

EMS Limited, formerly EMS Infracon, established in 2012, specializes in water and wastewater management services. The company's comprehensive offerings include solutions for water supply, sewerage, treatment plants, electrical transmission, road construction, and maintenance projects for government bodies. With a dedicated team of over 57 engineers, supported by third-party consultants, the company operates and maintains 13 projects totaling Rs. 13890.90 Crore, along with 5 O&M projects valued at Rs. 992.80 Crore, spread across five states as of March 24, 2023. In-house capabilities in design, engineering, and execution empower EMS Limited to handle complex projects efficiently. With a team of 61 engineers skilled in various aspects of project design, reliance on third-party consultants is minimized, ensuring timely and cost-effective delivery while adhering to quality standards. Additionally, quality control managers conduct regular inspections to maintain high-quality standards across all project sites.

Over the years, EMS Limited has completed 67 projects, demonstrating strong execution capabilities and project management expertise. By leveraging traditional construction technologies and constantly upgrading technical prowess, the company ensures optimal service delivery without compromising quality. The focus remains on investing in the latest technologies to enhance value for clients and secure substantial orders. Operating primarily on World Bank-funded projects through local state bodies, EMS Limited maintains robust cash flows and timely payments, enabling the undertaking of more projects without accumulating bad debts. The net proceeds from operations are directed towards working capital requirements and general corporate purposes, ensuring sustained financial stability.

An asset-light business model, coupled with a strong financial position, allows EMS Limited to efficiently utilize capital, resulting in lower debt and higher returns. With total borrowings of Rs. 45 crore and net cash equivalents of Rs. 121.22 crore as of March 31, 2023, the company remains poised to seek further debt financing for larger projects while minimizing initial costs. To further strengthen its position in the industry, EMS Limited aims to increase the size of projects and expand its footprint across different regions of the country. By capitalizing on government initiatives in water and wastewater management sectors, such as Namami Gange, AMRUT, and Jal Jeevan Mission, the company aligns its strategies with national development goals.

15. INDIA WATER & WATEWATER TREATMENT COMPANY PROFILES

15.1. ION EXCHANGE INDIA LTD

Ion Exchange India Ltd	**Type:** Public
	Industry: Environmental Service
	Founded: 1964
	Headquarters: Maharashtra, India
	Website: www.ionexchangeglobal.com

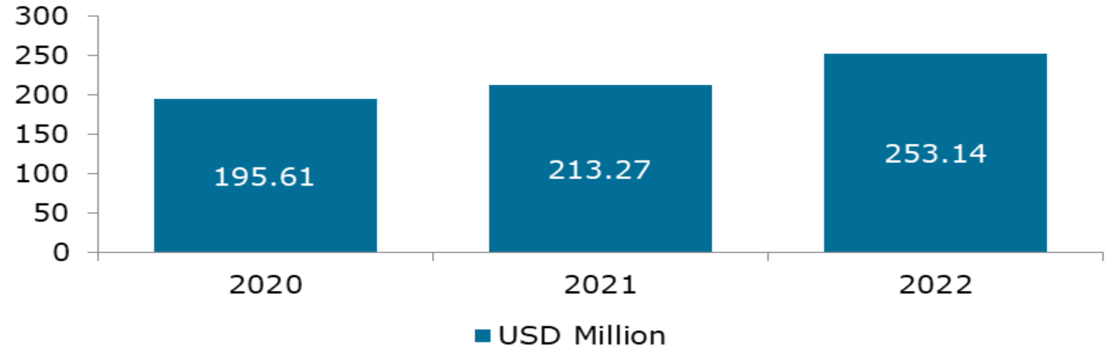
15.1.1. COMPANY SUMMARY

Ion Exchange India Ltd is a company environmental service provider company, specializes in water and environment management solutions. The company provides a range of products and services related to water treatment, wastewater treatment, and other environmental solutions. This includes technologies such as ion exchange, membrane separation, and other advanced processes used to purify water and treat industrial effluents. The company is a prominent player in the field of water treatment and has been involved in various projects across industries such as power, chemicals, pharmaceuticals, municipal water supply, and more. The company's solutions are aimed at addressing water scarcity, pollution, and sustainable water management. It offers total water solutions for industry, homes and communities. Integrating process technology, design engineering and project management capability.

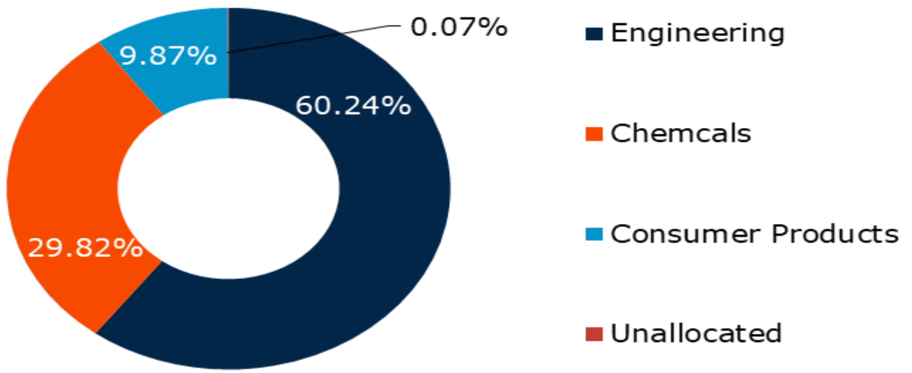
15.1.2. FINANCIAL INSIGHTS

Founded in 1964 and headquartered in Maharashtra, India. Ion Exchange India Ltd is a public company. As of 2022, the company employed around 2,160 people across the globe.

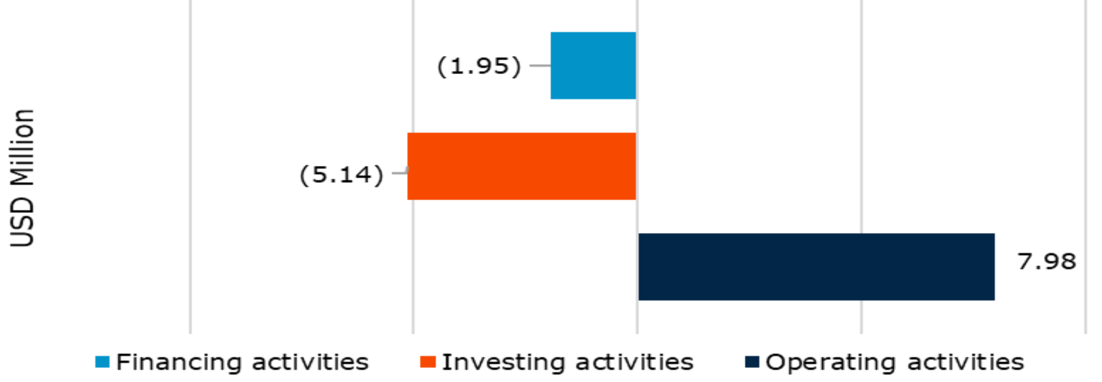
Net Sales



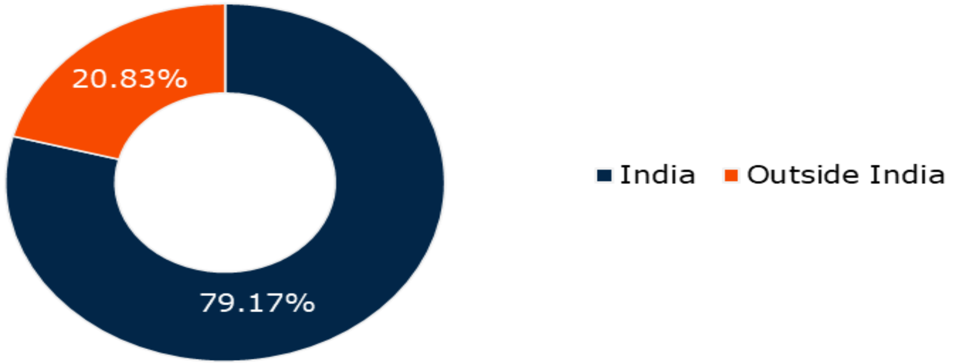
Business Mix



Cash Flow



Geographic Mix



Source: Company Website, Annual Report, News & Press Releases
Note: Exchange rate, for 2022 1 USD = INR 78.598, 2021 1 USD = INR 73.936, for 2020 1 USD = INR 74.102

15.1.3. PRODUCT INSIGHTS

CATEGORY	TYPE	DESCRIPTION
Raw Water Treatment	Aeration	• Aeration is the first step in pretreatment of surface water. • This process raw water cascades down a stepped fountain resulting in large contact area between air and water. • Helps in oxidation of heavy metals, if any, with simultaneous release of carbon dioxide and other odors.
Raw Water Treatment	Coagulation & Flocculation	• Coagulation and flocculation are the unit processes employed for the removal of colloidal particles • Suitable for clarification and filtration, heavy metal and colour removal from most water, waste water and process fluids
Filtration	INDION Auto Valveless Gravity Filter (AVGF)	• Ideal for side stream filtration. It is widely used to reduce suspended solids in cooling tower water to improve the efficiency of the cooling system as a whole and reduce maintenance and cleaning costs. • Pretreatment of process water for the paper and pulp, metallurgical, refinery, food processing, automobile, fertilizer & petrochemical industries
DISINFECTION	Ozonation	• Ozonation is a chemical water treatment which involves onsite ozone generation for disinfection & degradation of organics, inorganic pollutants, color removal, BOD/ COD reduction from water and waste water. • Ozone is considered as a strong oxidant and virucide.

Waste Water System	INDION UHRSCC	• INDION Ultra High Rate Solid Contact Clarifier is a compact, efficient and low cost clarifier for clarification of surface water and waste water • Removal of iron & manganese for potable water
Waste Water System	INDION Membrane Bio-Reactor (MBR)	• It is among the latest technologies in biological treatment, designed to produce high quality treated water from waste water with highest possible contaminant reduction without using any chemicals. • A membrane treatment that produces high quality permeate from domestic sewage and industrial waste water.
Waste Water System	INDION External Circulation Sludge Bed Reactor (ECSB)	• Unique Two phased separator design • Completely sealed reactor • Simplest gas handling
Waste Water System	INDION CHLOGEN	• INDION CHLOGEN is a reliable and cost-effective solution in disinfection technology combining high performance, simplicity of use and low maintenance. • Finds application in almost every industry such as dairy, beverage, pulp and paper, food and vegetable processing, poultry, chemical, power, textile, hotels, hospitals and among others.

Waste Water System	Advanced Oxidation Processes (AOPS)	• AOPs refers to a set of chemical treatment procedures designed to remove organic (and sometimes inorganic) materials in water and wastewater by oxidation through reactions with hydroxyl radicals (OH) • Useful for treating biologically toxic or non-degradable materials such as aromatics, pesticides, petroleum constituents present in waste water.

Source: Annual Reports, Primary Interviews, and Reports and Data (We have profile major products)

15.1.1. STRATEGIC INITIATIVES

DATE	STRATEGY	DESCRIPTION
Aug-19	Investments & Expansions	Ion Exchange (India) Limited announced the launch of its new R&D Center at Patancheru in Telangana. The company invested around INR 300 million for the center to develop new resins, membranes, polymers and specialty chemical technologies related to water, wastewater treatment, process separation and purification, specialty process application and catalysis. This state-of-the-art R&D center is spread over 24,000 sq. ft. and certified by the Department of Scientific and Industrial Research (DSIR).

Source: Company Website, News & Press Releases port, Primary Interviews, Reports and Data

15.2. VA TECH WABAG LTD

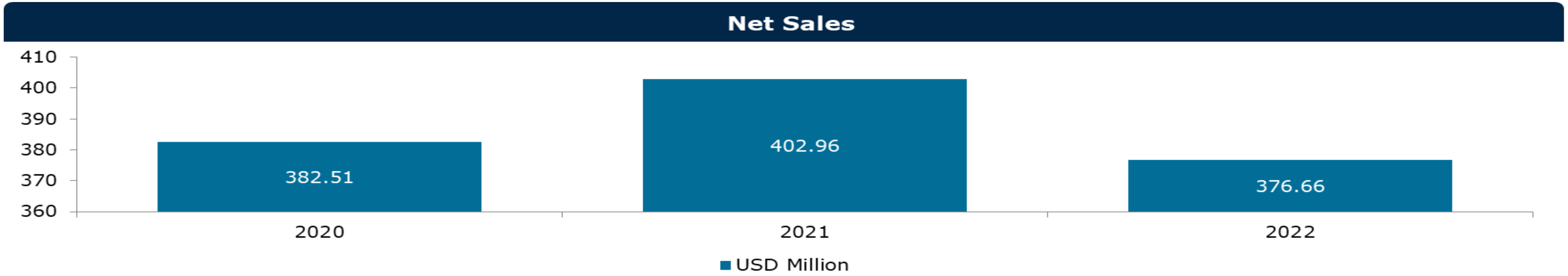
VA TECH WABAG LTD	
	Type: Public
	Industry: Water and Wastewater Treatment
	Founded: 1924
	Headquarters: Chennai, India
	Website: www.wabag.com

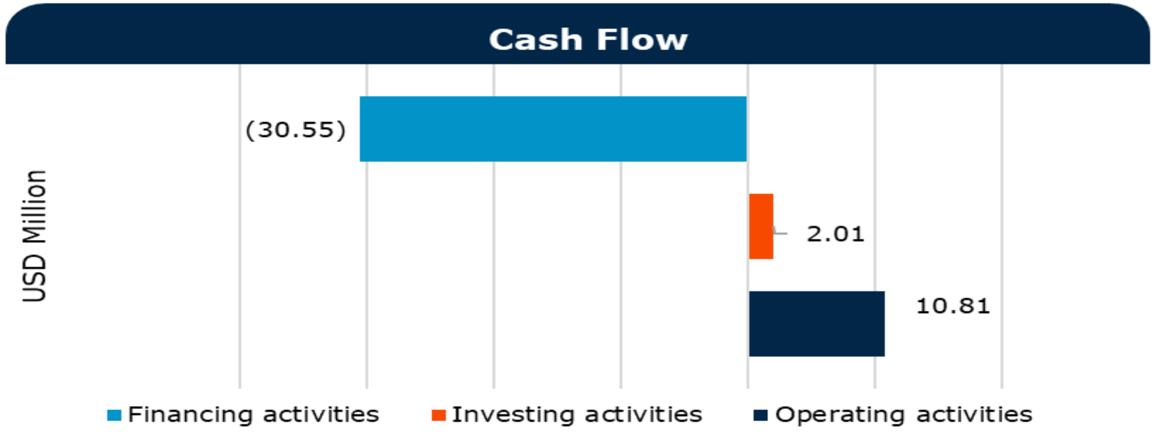
15.2.1. COMPANY SUMMARY

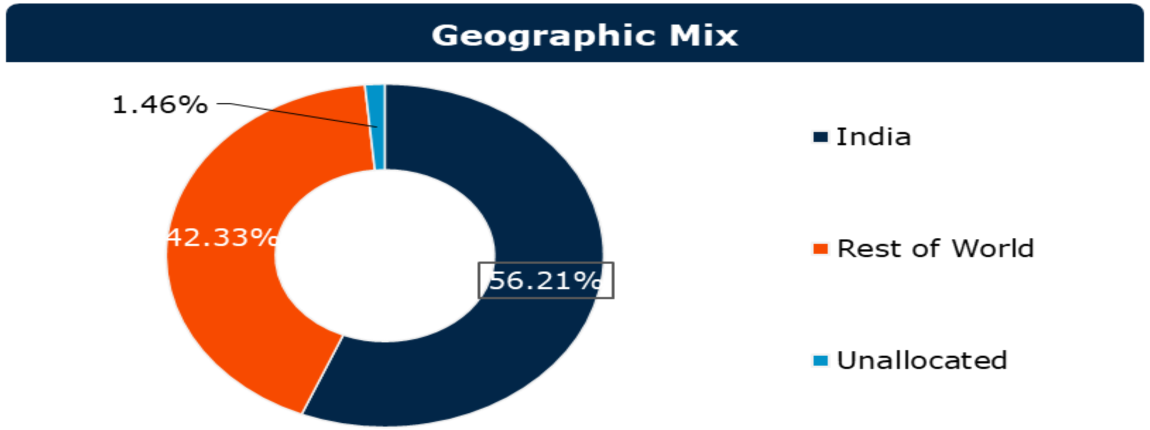
VA TECH WABAG LTD provides comprehensive solutions for water and wastewater treatment, including design, engineering, construction, operation, and maintenance of water treatment plants, sewage treatment plants, and recycling systems. Their solutions cover a range of technologies, such as filtration, desalination, membrane separation, ion exchange, and more. The company serves various sectors, including municipal water supply, industrial water treatment, desalination, and water reuse. Their clients include government bodies, corporations, industries, and municipalities. It has a global presence with operations in multiple countries. They have executed projects in various parts of the world, contributing to water scarcity management, pollution control, and sustainable water solutions.

15.2.2. FINANCIAL INSIGHTS

Founded in 1924 and headquartered in Chennai, India. VA TECH WABAG LTD is a public company. As of 2022, the company employed about 1,054 people across the globe.







Source: Company Website, Annual Report, News & Press Releases
Note: Exchange rate, for 2022 1 USD = INR 78.598, 2021 1 USD = INR 73.936, for 2020 1 USD = INR 74.102

15.2.3. PRODUCT INSIGHTS

CATEGORY	PRODUCT	DESCRIPTION	APPLICATION
Wastewater Treatment	• Single and Dual-Stage (Hybrid) Activated Sludge Processes • Granular Activated Sludge Process Using Nereda Technology • SBR (CYCLOPUR) • Membrane Bioreactor Technology (MARAPUR) • Biofiltration (BIOPUR) • Moving Bed Biological Reactor And IFAS (FLUOPUR)	• Provides a range of optimal solutions extending from highly effective pre-treatment (MICROPUR) to complete nutrient-removal.	• Plants like Adana West & East in Turkey, treating 250,000 m3 & 210,000 m3 of influent every day, and Kodungaiyur in Chennai (110,000 m3/d) or Kondli in Delhi (204,500 m3/d).
Water Treatment	• BIODEN for selective nitrate removal, • Lamella Clarifier technology OPUR-SK • Membrane Filtration processes (PACOPUR, CERAMOPUR, CERAMOZONE)	• Efficient extraction of potable water from all the available sources of fresh water as well as used water for direct or indirect potable reuse. • The company's water treatment facilities are highly scalable and can be established to suit any business model, be it EPC, DBO or BOOT.	• Cases in point include such large scale projects as Panjrapur (455 MLD) in India, Izmir (360 MLD) in Turkey, Upper Ruvu WTP (200 MLD) in Tanzania or Putatan (150 MLD) at the Philippines. • Also solutions are provided for industrial water solutions for different sectors namely Oil and Gas, Power, Semiconductors, Fertilizers, Steel, Food and Beverage and Pharmaceuticals and many more. Some projects executed are Paradip (Odisha, India), Indorama (Nigeria), Petrobrazi (Romania), and Prerov (Czech Republic).

Desalination	• Reverse Osmosis • Thermal Desalination	• Delivers end-to-end desalination solutions from deep seawater intake and outflow structures to the post-treatment of the product-water. • The company provides customized desalination solutions on every major business model — EPC, DBO, BOT and BOOT.	• Landmark projects at Nemmeli at Chennai, India, and Al- Ghubra at Oman. • Industrial applications include Power, Petrochemicals, Pharmaceuticals and Semiconductors. Some of the projects are the 50,000 m3/day desalination plant for Reliance Industries in Gujarat and the 20,000 m3/day Desalination Plant in Sohar, Oman, that caters to the industries in the Sohar Port.
Sludge Treatment	BIOZONE-AD	• The technology uses ozone with pre-digested sludge for an accelerated and more comprehensive oxidative decomposition of the incoming sludge enables ultra-efficient sludge digestion. • The treatment solutions can be customized for any business model, like EPC, DBO, BOT or BOOT.	• Some of the plants are based at Kodungaiyur in Chennai, India, and at Adana, Turkey.
Water Reclamation	• Multi Barrier systems • Micro- Filtration • Tertiary Ultra-Filtration • Reverse Osmosis • Advanced Oxidation Processes • Disinfection for Reservoir Augmentation	• The company provides state-of-the-art water reuse and reclamation systems meant for agricultural, domestic, and industrial applications. • The solutions can be customized with business modules such as EPC, BOOT and DBO.	• The company has designed and built the Koyambedu Tertiary Treatment Reverse Osmosis (TTRO) plant at Chennai, India. • Other projects include water recycling plant for IOCL at Paradip Refinery.
Effluent Treatment	• Aerobic • Anaerobic • Chemical-physical processes	• The company's solutions enable resource recovery from effluents in terms of reuse as	• The company provide treatment solutions for different industries like Oil and Gas, Fertilizers,

		process water and production of green energy from sludge. • The company employ highly-effective membrane processes (UF, RO) for water recovery systems reducing burden on freshwater sources and ensuring high-quality treatment of wastewater, thus conforming to international discharge norms. • The treatment solutions can be customized for any business model, like EPC, DBOT, BOT or BOOT.	Power-Plants, Steel, Paper and Pulp, Food and Beverage. • Plants like Petronas RAPID in Johor, Malaysia, for Oil and Gas, and Dangote, Nigeria, for Fertilizers, are some examples of WABAG's technological expertise.

Source: Annual Reports, Primary Interviews, and Reports and Data

15.2.4. STRATEGIC INITIATIVES

DATE	STRATEGY	DESCRIPTION
Sep-23	Partnerships & Agreements	In a strategic move aimed at addressing water challenges in the Middle East, WABAG has partnered with Al Jomaih Energy and Water (AEW), a prominent developer of energy and water projects in the region. The Memorandum of Understanding (MoU), signed during the India-Saudi Investment Forum, signifies a collaborative effort to explore opportunities in large-scale PPP projects across Saudi Arabia and the broader Middle East.
Nov-22	Partnerships & Agreements	VA TECH WABAG LIMITED secured a significant agreement with the Asian Development Bank (ADB), marking a key milestone in the water sector in India. The agreement involved raising Rs. 200 crores through unlisted Non-Convertible Debentures (NCD)

		with a 5 years and 3 months tenor, subscribed by ADB over a 12-month period. This marked ADB's first investment in a water sector company in India and reinforces WABAG's leadership in the industry.
Jun-22	Investments & Expansions	WABAG has announced plans to broaden its global reach with a new JICA-funded consortium order for a 50 MLD desalination project in Senegal, West Africa, estimated to be worth approximately 146 Million Euro.
Jun-22	Partnerships & Agreements	WABAG won an Engineering and Procurement ('EP') order from DL E&C CO., LTD., Korea for a water treatment package for the EuroChem methanol production facility in Kingisepp, Russia.
May-22	Partnerships & Agreements	WABAG through its subsidiary company Ghaziabad Nagar Nigam (GNN) has signed an agreement to design and operate a new 40 MLD Tertiary Treatment Reverse Osmosis (TTRO) plant and related infrastructure using a hybrid annuity model.
Dec-19	Partnerships & Agreements	VA TECH WABAG LIMITED signed an agreement with the government of Bihar to build sustainable wastewater infrastructure in Patna under Namami Gange Program.

Source: Company Website, News & Press Releases port, Primary Interviews, Reports and Data

15.3. VISHNU PRAKASH R PUNGLIA LIMITED

Vishnu Prakash R Punglia Limited	**Type:** Private
	Industry: Environmental Services
	Founded: 1986
	Headquarters : Maharashtra, India
	Website: www.vprp.com

15.3.1. COMPANY SUMMARY

VPRPL is a leading Indian infrastructure development company established in 1986. They specialize in design, construction, and operation & maintenance of infrastructure projects across various sectors like water, railways, roads, and irrigation. With a strong commitment to client satisfaction and a legacy of innovation, VPRPL boasts a successful track record of over 75 completed projects. As of December 2022, they hold a robust order book of INR 3799.53 Cr., showcasing their expertise recognized by governments and public bodies across India. VPRPL prioritizes professionalism, high ethical standards, and sustainable practices throughout its operations. Their commitment to excellence and technological advancements allows them to deliver complex projects efficiently and cost-effectively. Looking ahead, VPRPL aims to expand geographically, diversify into new sectors, and solidify its position as a technology-driven leader in India's infrastructure development.

15.3.2. PRODUCTS OFFERED

SERVICE	DESCRIPTION
WATER SUPPLY	• VPRPL has executed numerous water supply projects in several cities and rural areas of India. We promote sustainable water management which is an important step toward managing scarce resources. • They provide solutions for water supply-related problems. With smart infrastructure and management, and have contributed towards conserving depleted resources through a reduction in wastage, leakage, and pilferage. • The project design maintains the performance of the drinking water network, and the quality of distributed water, and effectively manages, protects, and preserves the water assets.
SEWERAGE	• ewerage projects are conducted keeping all the challenges and results in sustainable, cost-effective, and low-maintenance sewerage projects in mind. Our sewerage projects are focused on sustainability and safety. Our team's skills and expertise lead to reduced risk of failures, for example, sewer leakages, overflow, and odour. We provide end-to-end wastewater management solutions. Furthermore, the framework supports the decision-making process throughout the life cycle of assets ensuring the long-term sustainability of the projects.

Source: Company Website, News & Press Releases port, Primary Interviews, Reports and Data (Note: we have profiled company's major products)

15.4. EMS LIMITED

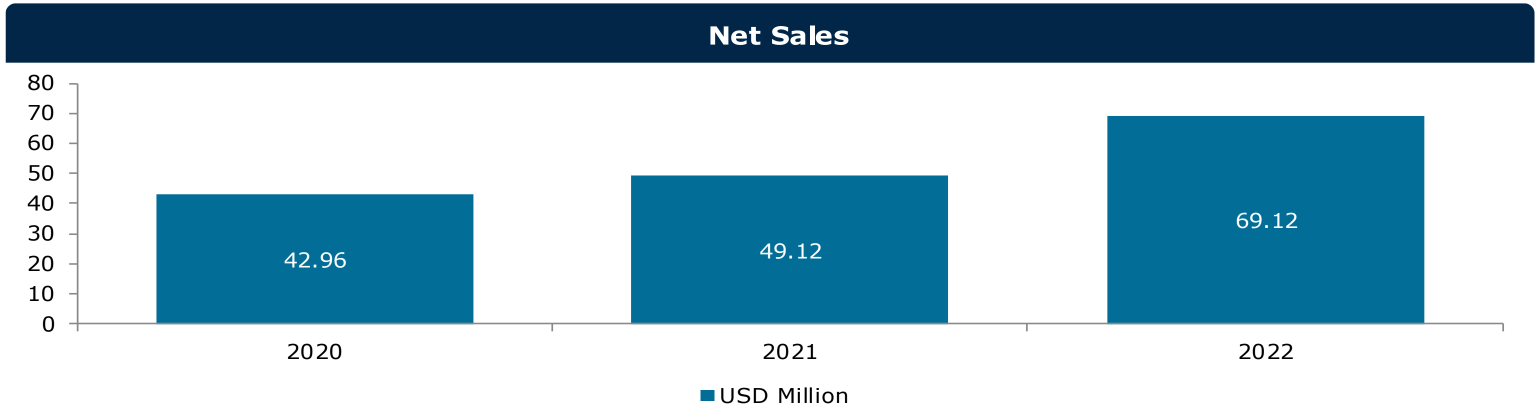
EMS Limited	
	Type: Public
	Industry: Environmental Service & Construction
	Founded: 1998
	Headquarters: Uttar Pradesh, India
	Website: www.ems.com

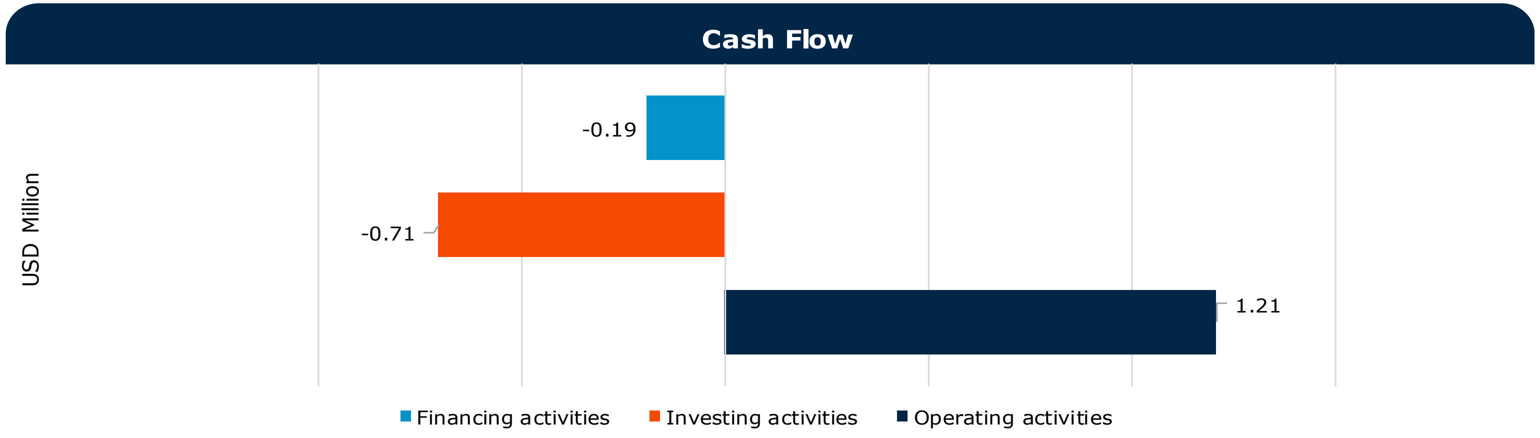
15.4.1. COMPANY SUMMARY

EMS Limited, based in India, was established in 1998, is a dynamic company that offers a comprehensive range of services in the field of environmental management and sustainability. With a strong commitment to environmental responsibility, EMS Limited has established itself as a leader in providing sustainable solutions for businesses and organizations across various sectors. The core services offered by EMS Limited encompass environmental impact assessments, waste management, renewable energy solutions, and sustainability consulting. Their team of experts leverages cutting-edge technology and in-depth industry knowledge to help clients reduce their environmental footprint and comply with regulatory requirements. EMS Limited's services are tailored to meet the unique needs of each client, ensuring effective and sustainable solutions. One of the standout features of EMS Limited is its dedication to innovation and research. Furthermore, EMS Limited has a proven track record of successfully executing projects for a wide range of clients, including multinational corporations, government bodies, and non-governmental organizations.

15.4.2. FINANCIAL INSIGHTS

Founded in 1998 and headquartered in Uttar Pradesh, India. EMS Limited is a public company. The company specializes in Sewerage Infrastructure, Water Supply System, Water And Waste Treatment Plants, Electrical Transmission And Distribution, Buildings And Allied Works.





Source: Company Website, Annual Report, News & Press Releases, and Reports and Data
Note: Exchange rate, for 2022 1 USD = INR 78.598, 2021 1 USD = INR 73.936, for 2020 1 USD = INR 74.102

15.4.3. PRODUCTS OFFERED

Service	Description
Sewerage Management	• This service includes design, procurement, laying, jointing, testing, commissioning, operation and maintenance of new sewerage network as well as refurbishment of old/existing sewerage network.
Design and construction	• Design and construction of pipeline by trenchless technology. • Design, construction, operation and maintenance of Sewage Treatment Plants. • Design, construction, operation and maintenance of Sewage Pumping Stations. • Design, construction, operation and maintenance of Water Treatment Plants.
Water supply	• Water supply works including design, procurement, laying, jointing, testing, commissioning, operation and maintenance of new water supply and distribution networks as well as construction of reservoir and refurbishment of old/existing water supply infrastructures.
Road & Allied works	• This service includes construction of new road networks as well as repair/renovation of existing road networks. • Design and construction of power transmission and distribution infrastructure. • Design and construction of buildings and allied works. • Design, construction, operation and maintenance of public infrastructure facilities & utilities.

Source: Company Website, News & Press Releases port, Primary Interviews, Reports and Data (Note: we have profiled company's major products)

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