INDIA WATER AND WASTEWATER TREATMENT MARKET

FORECAST TO 2033

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

13th December 2024

ABOUT US

Reports and Data is a market research and consulting company that provides syndicated research reports, customized research reports, and consulting services. Our solutions purely focus on your purpose to locate, target, analyze consumer behavior shifts across demographics, across industries, and help client's make a smarter business decision. We offer market intelligence studies ensuring relevant and fact-based research across multiple industries including Healthcare, Material, Chemicals, Power, and Energy. We consistently update our research offerings to ensure our clients are aware about the latest trends existent in the market. Reports and Data has a strong base of experienced analysts from varied areas of expertise. Our industry experience and ability to develop a concrete solution to any research problems provides our clients the ability to secure an edge over their respective competitors.

Reports and Data reaffirms the independence of its team members, including Pawan Gusain, Assistant Manager; Surbhi Jalan, Team Lead; Kallol Ghosh, Senior Research Analyst; Shubhangi Verma, Research Analyst; and Ritika Patel, Senior Research Associate, engaged in crafting industry reports. Committed to the highest standards of professionalism, the firm ensures no conflicts of interest, mandates ethical conduct, and employs rigorous internal controls. The team is dedicated to delivering accurate, reliable, and impartial assessments, inviting further inquiry if needed. Reports and Data as an independent consulting firm, does not hold any direct or indirect interest in the proposed IPO of Denta Water and Infra Solutions Limited or any client company. Our role is strictly that of external consultants, providing professional services to assist companies like yours in various aspects of business development, market analysis, and strategic planning. We are committed to maintaining the highest standards of professional integrity and adheres to a strict code of ethics. Our engagement with clients is based on delivering objective and unbiased analysis, recommendations, and support, free from any conflicts of interest that could compromise the integrity of our services.

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.

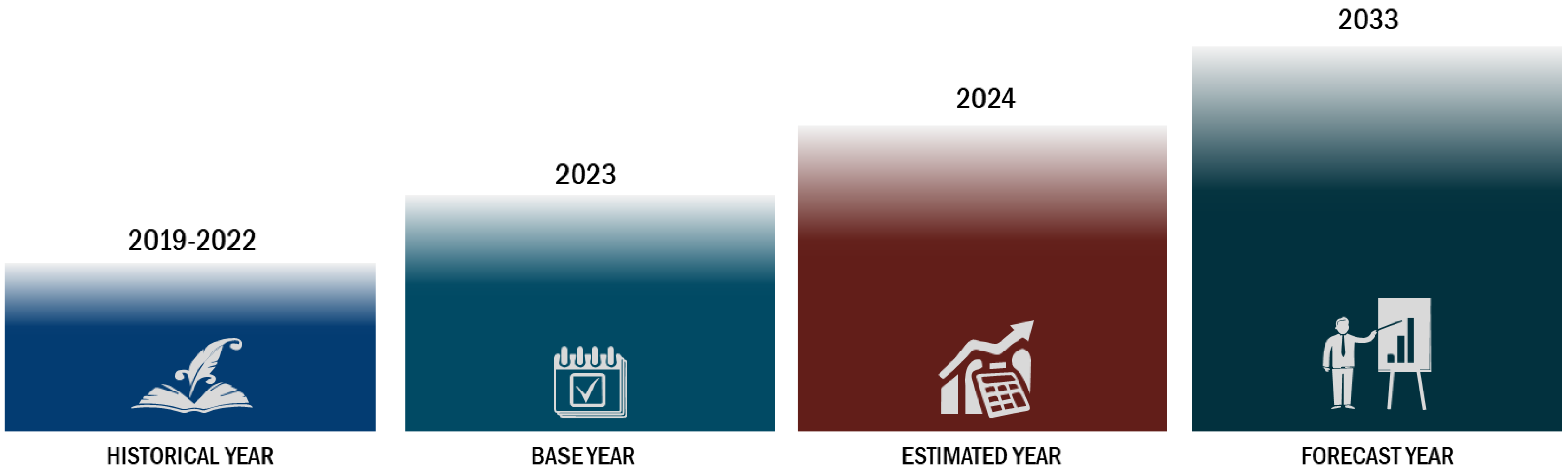
Wastewater treatment involves eliminating pollutants from used or polluted water, ensuring its safe return to the environment or potential reuse. The process includes primary, secondary, and tertiary treatment stages, effectively purifying the water for release into rivers, lakes, oceans, or non-drinking 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.

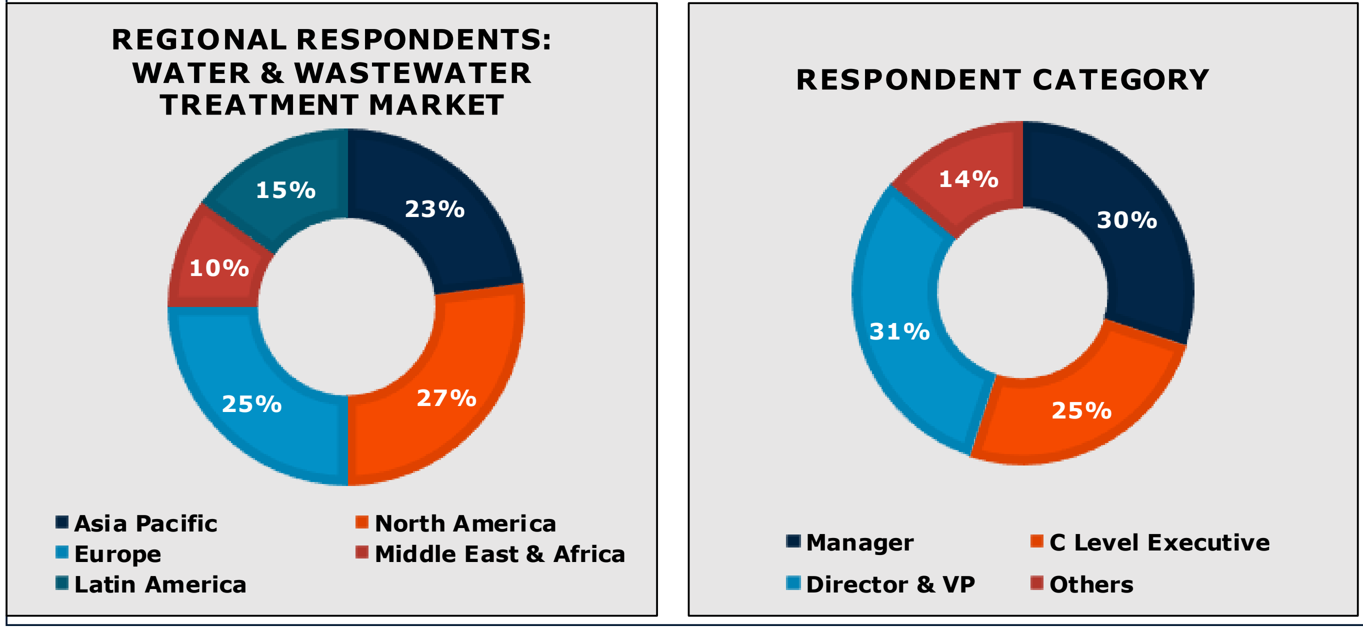
1.3.2. PRIMARY RESEARCH MODEL

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

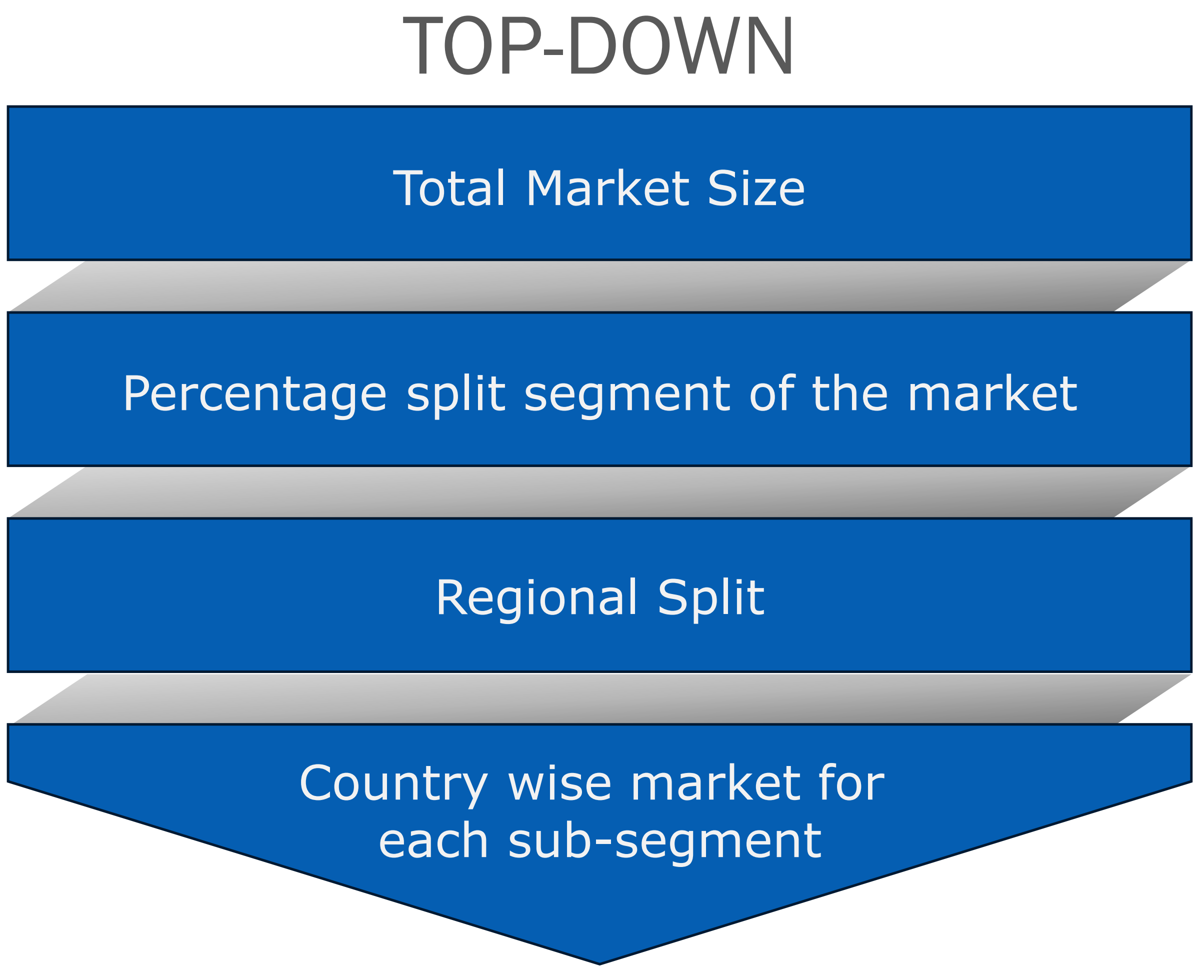
The market estimation is conducted by analyzing the data collected through both secondary and primary research. This process involves market breakdown, bottom-up and top-down approach.

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.

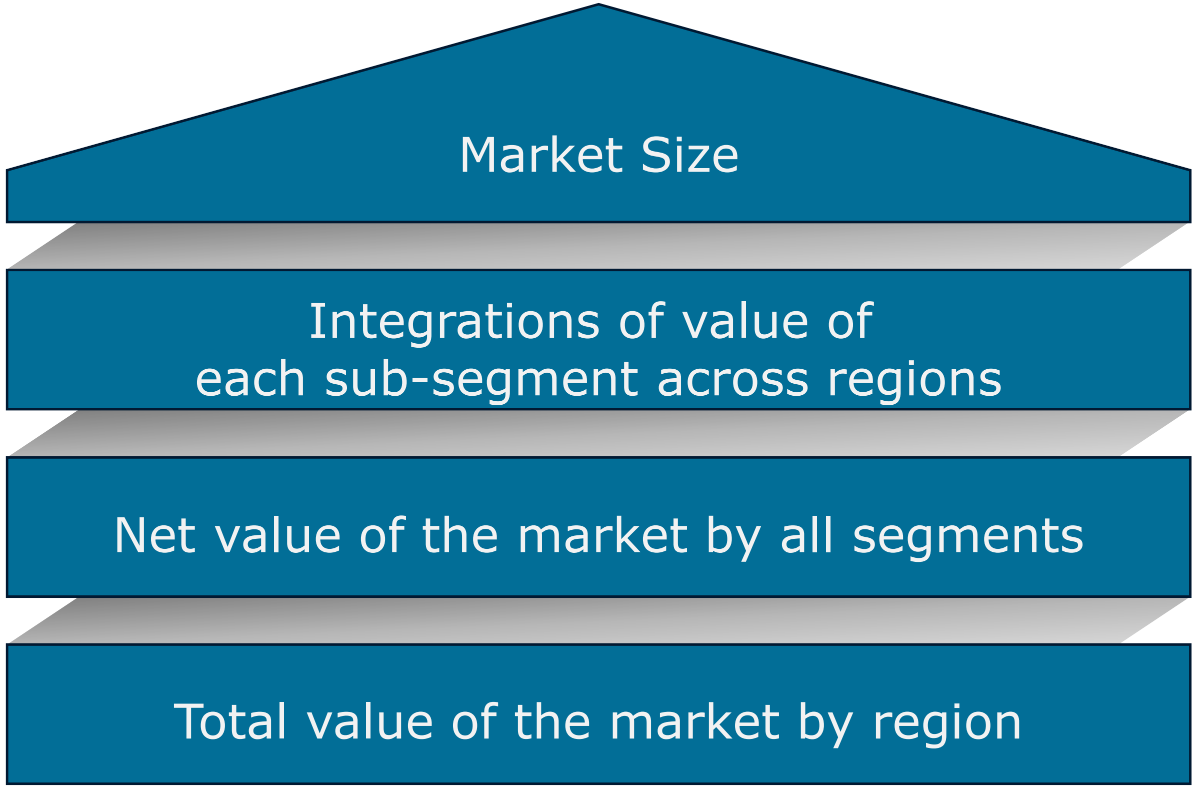
1.4.2. END-USE BASED APPROACH

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



BOTTOM-UP

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

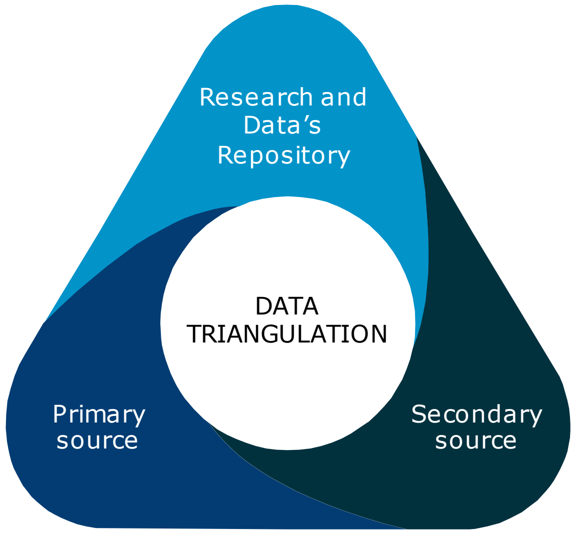
PRIMARY SOURCES

DEMAND SIDE

- Top Executives of end-use industries
- Intermediaries

SUPPLY SIDE

- C-level executives in the leading products of **Water & Wastewater Treatment Market**
- Product Managers
- Sales Managers
- Suppliers and Distributors



SECONDARY SOURCES

GLOBAL PUBLICATION

- Industry Publications
- Government Agencies Publications
- Industry News
- Data Sources

COMPANY PUBLICATION

- Annual Report
- Presentation
- Company Websites
- Press Releases
- News Articles
- Journals
- Paid Databases

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 Million
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

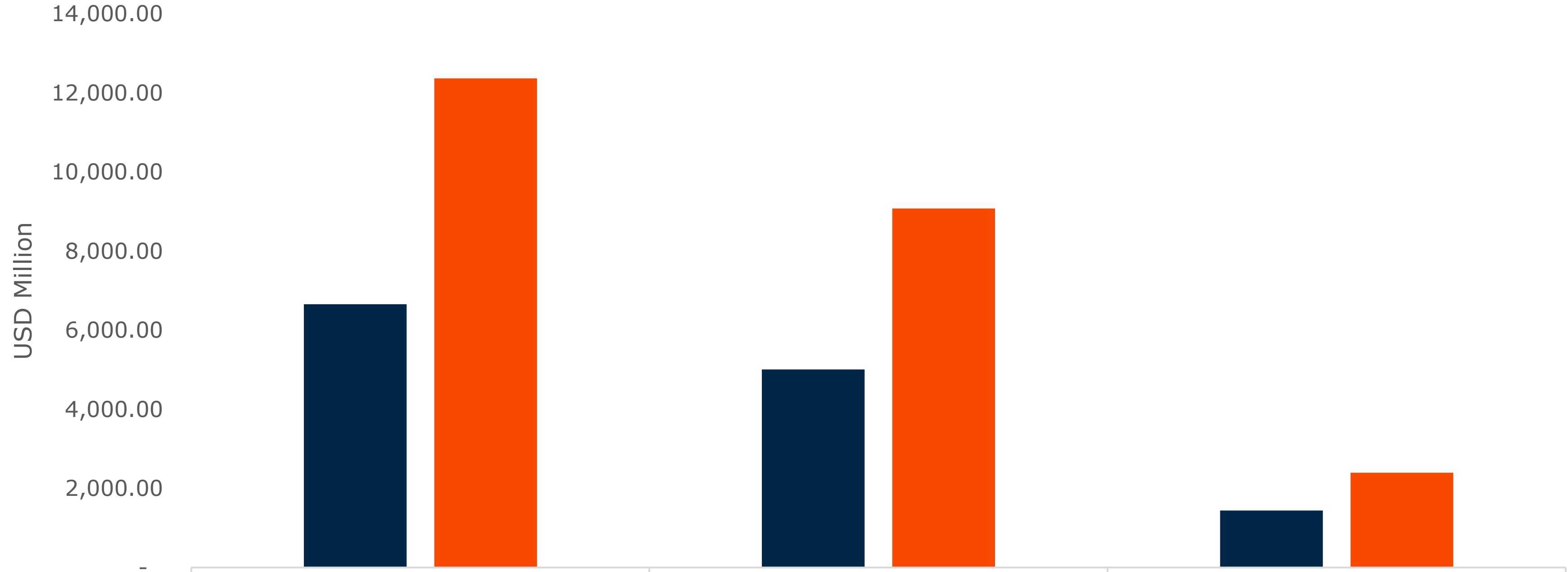
The India Water and Wastewater Treatment market is expected to grow at a CAGR of 6.20% in terms of value to reach USD 23,849.806 Million in 2033 from USD 13,101.158 Million in 2023.

In India, the demand for drinking water and the production of wastewater have surged exponentially due to the country's robust economic growth and rapid urbanization. The premier cities and towns, constituting over 70% of the urban population, are responsible for a significant portion of wastewater generated per person. Alarmingly, untreated urban wastewater accounts for a substantial 70% of all discharges into rivers and oceans. Growing concerns about environmental degradation drive the market's growth prospects in India. The susceptibility of India's population to water supply changes and wastewater issues is pronounced. With more than 70% of households relying on agriculture and a significant portion of cultivated land being rain-fed, climate change impacts on the monsoon have severe ramifications for agriculture and vulnerability. To address these challenges, the Indian government has launched ambitious initiatives like the Jal Jeevan Mission-Har Ghar Jal, AMRUT, NAMAMI Gange Programme, and SWAJAL, aimed at expanding water and wastewater treatment infrastructure.

The business of water and industrial water treatment is advancing at twice the rate of industrial GDP growth, as companies recognize the essentiality of water preservation for their operations. Thermal power plants are the major consumers of industrial water, accounting for 87.8% of total usage. Industries like power, textile, pulp and paper, and FMCG are the primary clients for water solution providers, suggesting that the growth of India's industrial sector will significantly impact market expansion. Water and wastewater management represent a promising niche within India's environmental technology sector. The projected water demand in India is expected to double the available supply by 2030. Responding to this challenge, both public and private sectors are actively planning comprehensive water treatment and distribution systems. The demand for advanced treatment technologies is rising, supported by government initiatives such as the Atal Mission for Rejuvenation and Urban Transformation, National Mission for Clean Ganga, Jal Jeevan Mission, and Community Drinking Water Schemes.

In May 2019, the establishment of the Jal Shakti Ministry unified various water-related agencies to ensure safe drinking water for India's population. Subsequently, the Jal Jeevan Mission was launched to provide piped drinking water to 146 million households across 700,000 villages by 2024, with a significant budget allocation. This ambitious initiative has created opportunities for water meter suppliers, water quality monitoring systems, IT systems for water management, tertiary treatment technologies, and water-focused Engineering, Procurement, and Construction firms. In various sectors like power, food and beverage, chemicals, pharmaceuticals, refineries, and textiles, the private industry is gravitating toward advanced treatment technologies, particularly reverse osmosis membranes, for wastewater treatment. The shift from chemical treatment to membrane-based technologies is underway, and concepts like wastewater recycling and zero discharge systems are gaining traction, supported by innovative technologies like sequencing batch reactors (SBR) and membrane bioreactors (MBR). Leading the way, Tamil Nadu and Gujarat are pioneering the establishment of desalination plants to bolster drinking water supply, while several industries are adopting desalination facilities for process water needs. Industries are increasingly embracing principles like Reuse, Recycle, and Zero Liquid Discharge to enhance water management and reduce environmental impact.

FIGURE 6. INDIA WATER AND WASTEWATER TREATMENT MARKET: TYPE (IN USD MILLION)

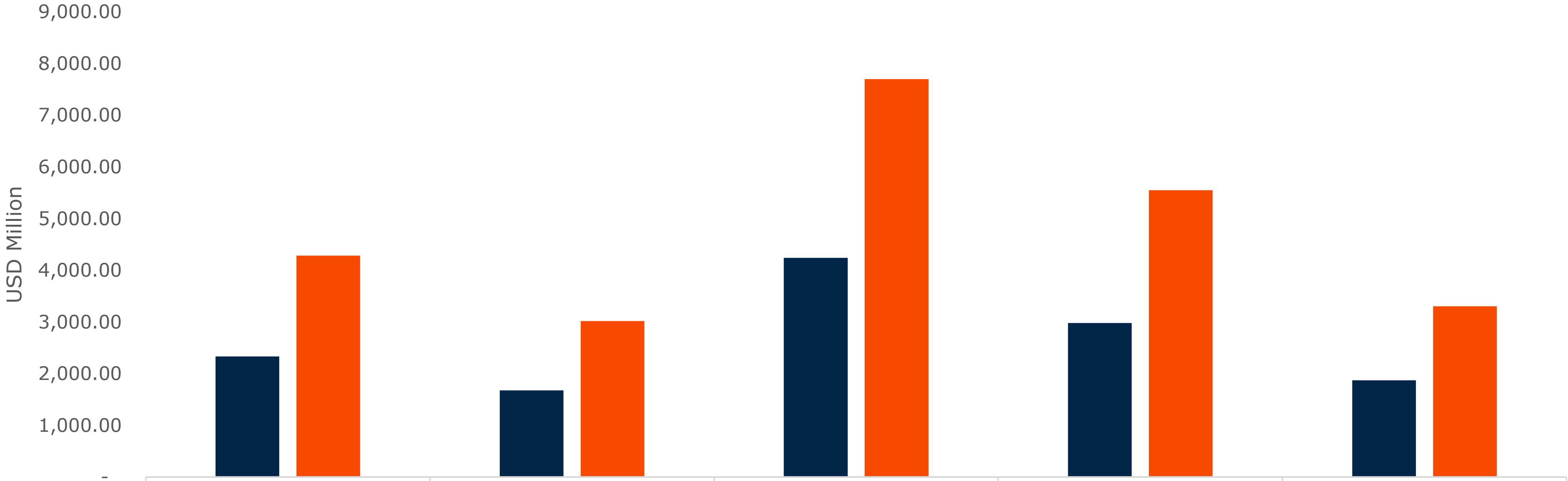


	Water Treatment	Sewage Treatment	Effluent Treatment
2023	6,654.80	5,008.40	1,437.96
2033	12,366.88	9,082.59	2,400.33

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 6.42% in terms of value. The water treatment sector plays a critical role in addressing India's mounting water challenges, driven by factors such as population expansion, urbanization, and industrialization. As the country grapples with issues of water scarcity and pollution, the demand for effective water treatment solutions is burgeoning. Stringent environmental regulations and a growing awareness of the importance of sustainable water management are further propelling the adoption of advanced treatment technologies. This shift is particularly evident in industries such as manufacturing, power generation, and pharmaceuticals, which require substantial water resources while striving to reduce their ecological footprint. The government's initiatives, like the Swachh Bharat Abhiyan and the National Mission for Clean Ganga, also emphasize the need for comprehensive water and wastewater treatment solutions. These factors collectively create a favorable landscape for the water treatment segment to dominate the Indian water and wastewater treatment market. As the nation strives for holistic water management, the sector's consistent growth promises to address the pressing challenges of water scarcity and contamination, contributing to a sustainable and healthier future for India.

FIGURE 7. INDIA WATER AND WASTEWATER TREATMENT MARKET: OFFERING (IN USD MILLION)

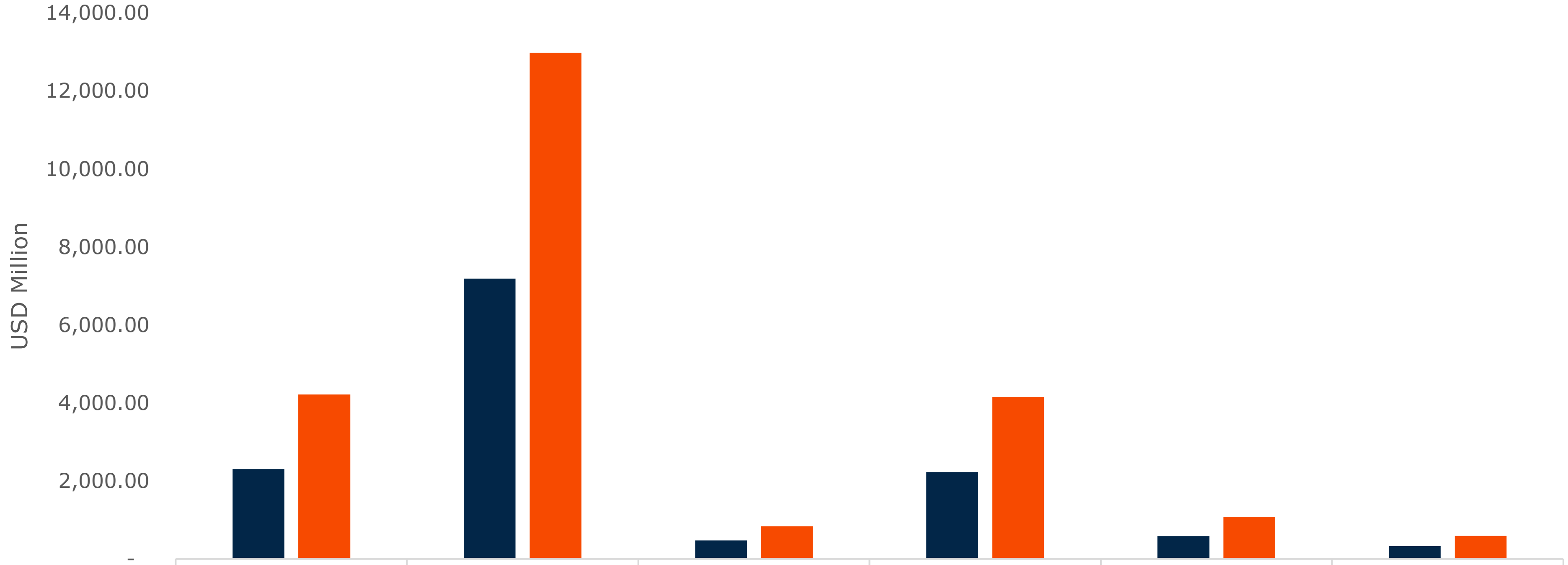


	Treatment Technologies	Treatment Chemicals	Process Control and Automation	Design, Engineering, and Construction Services	Operation and Maintenance Services
2023	2,331.02	1,677.74	4,240.17	2,979.42	1,872.82
2033	4,282.43	3,020.09	7,697.04	5,546.86	3,303.39

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 process control and automation segment is expected to have major share in the water and wastewater treatment market with a CAGR of 6.17% in terms of value. Process control and automation technologies are revolutionizing the water and wastewater treatment landscape in India. These advanced systems offer real-time monitoring, data analytics, and remote operation capabilities, enhancing operational efficiency, minimizing human intervention, and optimizing resource utilization. As industries and municipalities grapple with escalating water scarcity and stricter environmental regulations, these technologies prove indispensable in ensuring sustainable water management practices. The driving force behind this projected growth is multifaceted. Rising population, urbanization, and industrialization are straining water resources, necessitating more efficient and effective treatment processes. Moreover, increasing awareness of the need for environmental preservation is prompting investments in modern water treatment solutions. The Indian government's initiatives towards cleaner water bodies and the 'Make in India' campaign further stimulate the demand for innovative, homegrown technologies. These initiatives not only encourage the development of advanced treatment solutions but also support the creation of a robust ecosystem for sustainable water management. As a result, India is witnessing a significant transformation in its approach to water and wastewater treatment, driven by a combination of technological advancements, regulatory pressures, and a growing commitment to environmental sustainability.

FIGURE 8. INDIA WATER AND WASTEWATER TREATMENT MARKET: EQUIPMENT (IN USD MILLION)

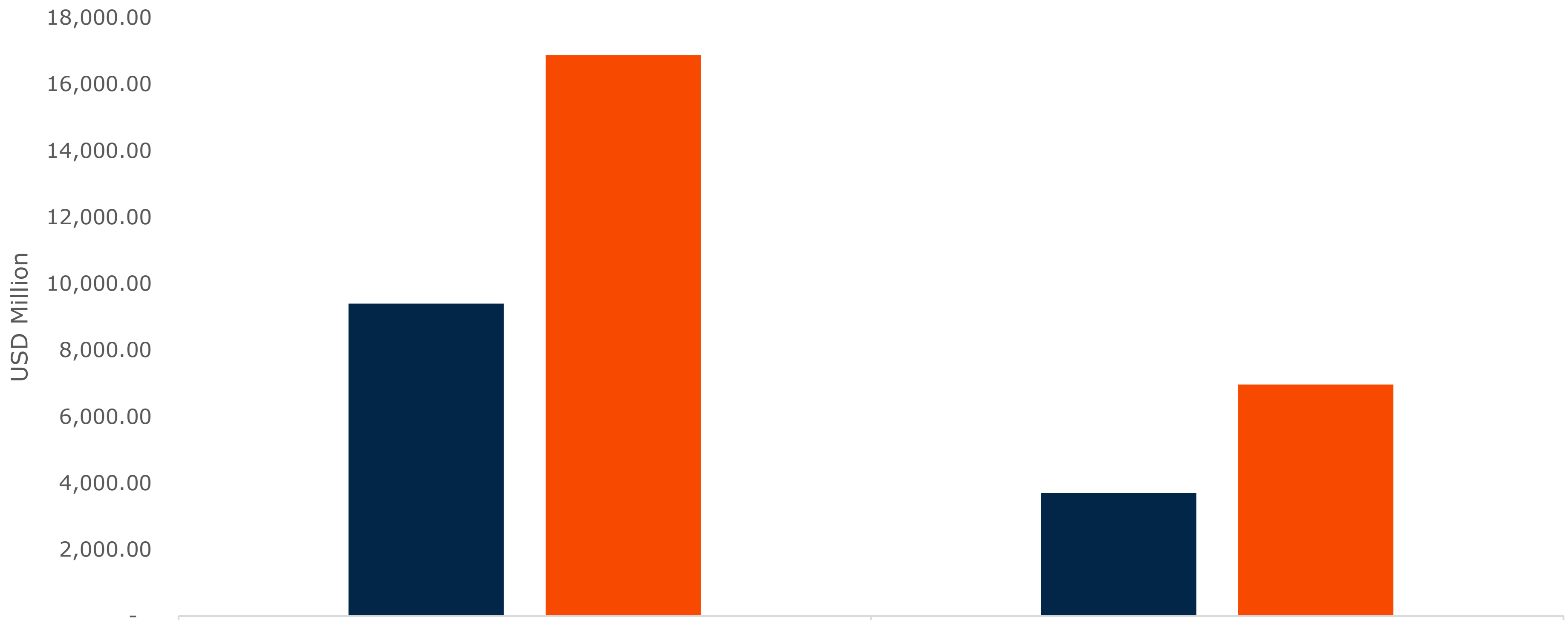


	Filtration	Disinfection	Adsorption	Desalination	Testing	Others
2023	2,300.10	7,188.64	472.16	2,224.84	583.47	331.94
2033	4,215.52	12,982.11	837.31	4,151.07	1,076.14	587.66

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 6.12% in terms of value. As environmental concerns and health awareness gain prominence, the need for effective disinfection processes in water and wastewater treatment has become paramount. This sector's anticipated growth is further reinforced by advancements in disinfection technologies, which ensure the mitigation of harmful pathogens and contaminants from water sources, safeguarding public health and ecosystem integrity. In India, the burgeoning population, rapid urbanization, and industrial expansion accentuate the significance of reliable water treatment practices. Consequently, the growth of the disinfection segment is closely tied to these demographic and economic trends. From traditional chemical disinfectants to cutting-edge UV and ozone treatment solutions, the sector is experiencing a dynamic fusion of innovation and application, driving forward the effectiveness and efficiency of water treatment processes.

FIGURE 9. INDIA WATER AND WASTEWATER TREATMENT MARKET: END-USE (IN USD MILLION)

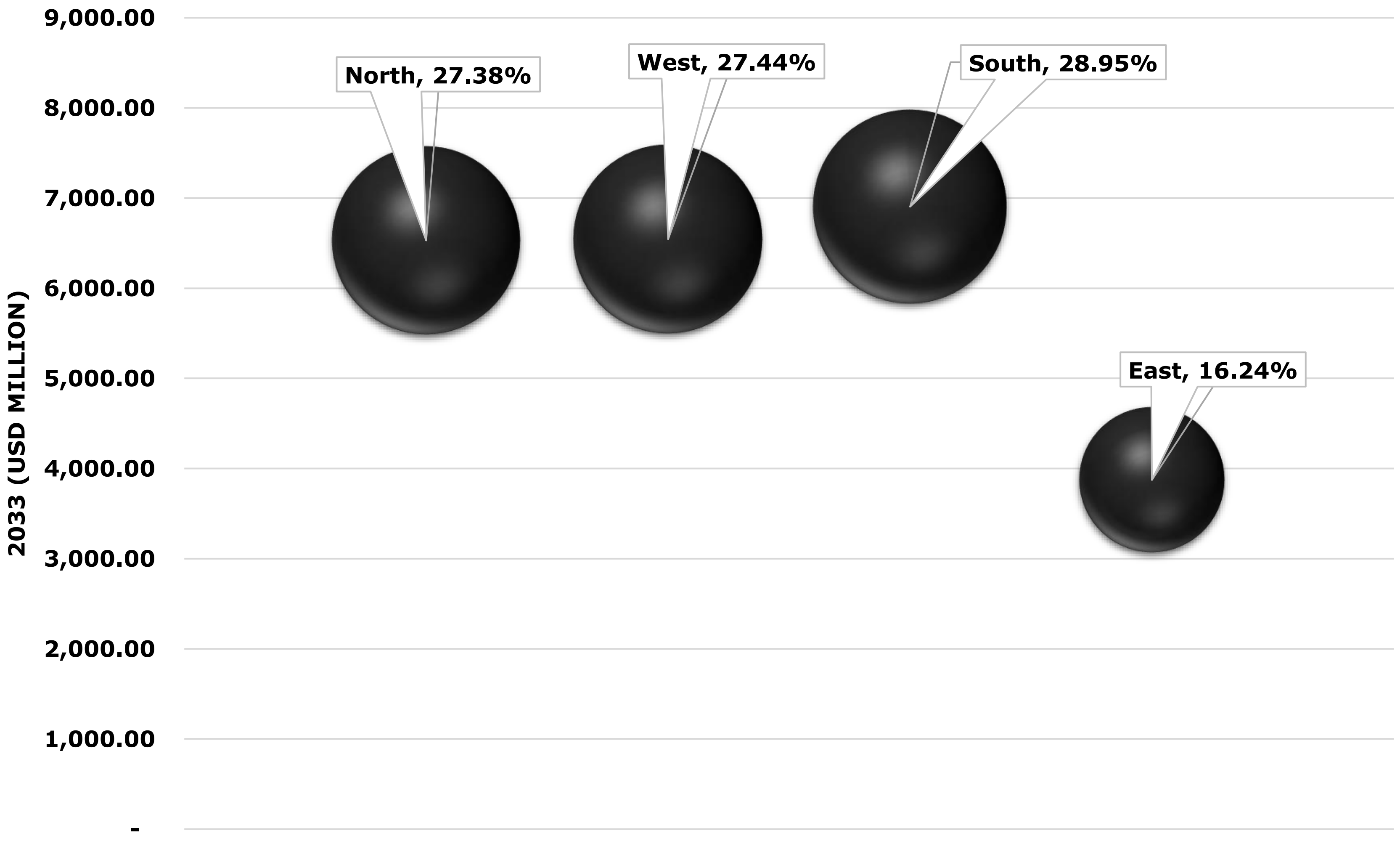


	Municipal	Industrial
2023	9,401.31	3,699.85
2033	16,881.27	6,968.54

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 a major share in the Water and Wastewater Treatment market with a CAGR of 6.06% in terms of value. The municipal sector's prominence can be attributed to the ever-growing urban population and the imperative of ensuring clean and potable water for cities and towns across the nation. As urbanization accelerates, so does the demand for efficient water and wastewater management solutions. The municipal segment encompasses a wide array of applications, including water purification, sewage treatment, and recycling, which collectively contribute to sustainable urban development. In a country where access to clean water remains a critical concern, the municipal segment's projected growth reflects a commitment to address this challenge head-on. Government initiatives, regulatory frameworks, and public-private partnerships further amplify the sector's significance, fostering investments and technological advancements in wastewater treatment, distribution, and reuse. As India strives to strike a balance between rapid urbanization and environmental stewardship, the pivotal role of the municipal segment becomes unmistakable. With an anticipated CAGR of 6.06% in value, this segment not only drives economic growth but also underscores the nation's commitment to equitable access to clean water resources, thus setting a sustainable trajectory for India's water and wastewater treatment endeavors.

FIGURE 10. INDIA WATER AND WASTEWATER TREATMENT MARKET: REGION (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, South India is expected to have major share in the Water and Wastewater Treatment market with a CAGR of 6.24% in terms of value. South India is poised to lead the water and wastewater treatment sector, driven by several compelling factors. According to Government of India Census, 2022, the region's expanding population, rapid urbanization rate exceeding 33% annually, and robust industrial growth are creating an unprecedented demand for advanced water management solutions. With growing environmental consciousness and stringent regulatory frameworks, the imperative for sustainable resource management has never been more critical. This scenario underscores the urgent need for innovative treatment technologies.

South India's geographical diversity, encompassing dense urban areas and scattered rural communities, presents a multifaceted water treatment challenge. This diversity necessitates flexible and scalable solutions capable of catering to diverse needs and infrastructural setups. As a result, the market is witnessing a surge in cutting-edge technologies designed to address these complexities. According to recent Ministry of Jal Shakti, Government of India, 2023, water scarcity affects over 40% of India's population, highlighting the pressing need for effective water management solutions in regions like South India. This statistic underscores the region's pivotal role in driving innovation and investment in water treatment technologies. In response to these challenges, stakeholders are increasingly investing in state-of-the-art treatment facilities and sustainable practices. The convergence of technology and regulatory momentum is shaping South India's water treatment landscape into a dynamic arena for innovation and growth.

TABLE 1. SOME OF THE MAJOR GLOBAL WATER AND WASTWATER TREATMENT COMPANIES:

COMPANY	HEADQUARTERS
Ion Exchange India Ltd	Maharashtra, India
VA TECH WABAG LTD.	Chennai, India
Larsen & Toubro Limited	Maharashtra, India
Thermax Limited	Maharashtra, India
Triveni Engineering & Industries Ltd.	Noida, India
KIRLOSKAR BROTHERS LIMITED (INDIA).	Maharashtra, India
IVRCL Infrastructures and Projects Ltd	Hyderabad, India
NCC Limited	Kolkata, India
Praj Industries	Maharashtra, India
SPML Infra Limited	Kolkata India
Veolia India	Uttar Pradesh, India

SUEZ Group	Paris, France
Evoqua Water Technologies LLC	Pennsylvania, United States
Ecolab	Minnesota, United States
Aquatech International LLC	Pennsylvania, 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

TABLE 2. SOME OF THE MAJOR WATER AND WASTWATER INFRASTRUCTURE COMPANIES:

COMPANY	HEADQUARTERS
Felix Industries Ltd	Gujrat, India
Tata Projects Limited	Maharashtra, India
SHAPOORJI PALLONJI	Maharashtra, India
Hindustan Dorr-Oliver Ltd	Maharashtra, India
AECOM	Haryana, India

Hitachi, Ltd	Tokyo, Japan
Black & Veatch Holding Company	Kansas, United States
HCC	Maharashtra, India
Gammon India Limited	Maharashtra, India
Shivsu Canadian Clear International Ltd	Chennai, India
IDE Technologies India Pvt Ltd	Uttar Pradesh, India
Ionic Engineering Technology Pvt. Ltd	Maharashtra, India
Forbes Marshall	Maharashtra, India
Oryana Ventures	Maharashtra, India
SFC ENVIRONMENTAL TECHNOLOGIES PVT. LTD	Maharashtra, India

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 AND WASTEWATER TREATMENT

The rising demand for water and wastewater treatment is becoming increasingly urgent due to several interconnected factors. The quality of water is paramount for human health, ecosystems, and socio-economic development. As the global population continues to grow rapidly, natural environments are increasingly degraded, presenting significant challenges in maintaining sufficient and safe water supplies. In response, governments, private firms, and various sectors are focusing on minimizing water pollution and promoting the use of advanced water and wastewater treatment processes and techniques. These efforts are not only aimed at protecting ecosystems from untreated effluent discharge but also at enabling the reuse of industrial water and recovering valuable materials such as nutrients and energy.

A crucial aspect of this growing demand is highlighted by the UN's emphasis on proper wastewater treatment during World Water Day. In many developing countries, particularly in low-income urban areas, a large proportion of wastewater is discharged with minimal or no treatment into informal drainage systems and nearby water bodies. This includes waste from urban hospitals, industries, small-scale mining operations, and motor garages, all of which contribute toxic chemicals, oils, and other pollutants to water bodies. Additionally, improper household effluent and human waste management systems further exacerbate water contamination. To address these issues, new approaches for wastewater collection and management are essential. Treated water can then be reused for agricultural and industrial activities, enhancing water sustainability and reducing overall water demand.

Industries and municipalities worldwide are increasingly recognizing the importance of sustainable water management practices. This has led to a greater focus on advanced water and wastewater treatment technologies and water reuse. Emerging contaminants in drinking water, such as endocrine disruptors and naturally occurring pollutants like arsenic, pose significant risks to both environmental and human health. In coastal regions, seawater intrusion into aquifers adds another layer of complexity to water treatment needs. Flexible and robust potable water treatment solutions, such as modular water treatment plants, offer cost-efficient ways to address these diverse challenges by desalinating seawater and treating various water sources to potability standards.

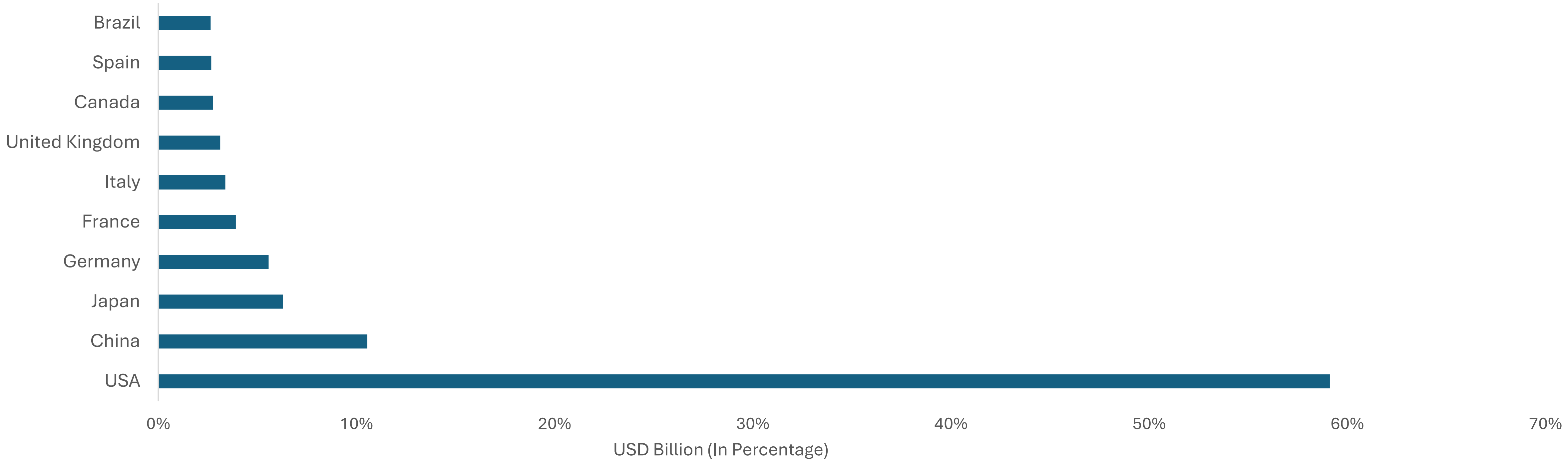
Strict environmental regulations are pushing municipalities and industries to comply with stringent wastewater effluent quality standards. Technologies like the membrane aerated biofilm reactor (MABR) provide energy-efficient and cost-effective solutions for removing a wide range of pollutants from commercial and domestic wastewater. These technologies help eliminate harmful nutrients and pollutants, ensuring compliance with regulatory requirements and protecting the environment. A notable trend in water management is the shift toward decentralized treatment of both water and wastewater. Decentralized systems treat water at the point of need, reducing the burden on aging centralized infrastructure and minimizing the need for extensive pipelines. This approach enhances sustainability by recirculating water for on-site reuse, such as irrigation. Modular wastewater treatment plants and potable desalination units packaged in shipping containers exemplify this trend, offering scalable and flexible solutions for decentralized treatment.

As water resources become scarcer, there is an increasing trend toward recycling wastewater for various uses, including irrigation and industrial processes. High-quality effluent from advanced treatment solutions meets stringent water reuse standards, helping to conserve freshwater resources. The quest for Zero Liquid Discharge (ZLD) systems, particularly in industries like semiconductors, highlights the drive to minimize waste and recover clean water. Despite the costs, ZLD systems mitigate regulatory risks associated with hazardous waste disposal and ensure water availability for critical processes. Emerging technologies in wastewater treatment, such as advanced membranes and AI-driven data analysis, are crucial for enhancing recovery rates and operational efficiency. These innovations address challenges like brine disposal and the treatment of persistent contaminants like PFAS, aligning with the industry's commitment to environmental stewardship and regulatory compliance. Overall, the rising demand for water and wastewater treatment underscores the need for innovative and sustainable solutions to manage and preserve vital water resources. By adopting advanced technologies and sustainable practices, industries and municipalities can ensure a balance between human development and environmental preservation, contributing to a sustainable future.

3.1.2. GROWING PHARMACEUTICAL INDUSTRY

Over recent years, the pharmaceutical sector has established itself as a crucial component of the global healthcare system, significantly enhancing human development by improving the quality of life and reducing hospital stays. The remarkable progress in this sector can be attributed to advancements in science and technology, ushering in a new era of medicine development. These advancements have catalyzed the growth of one of the most research-intensive industries, paving the way for innovative cell and gene therapies. During the COVID-19 pandemic, the industry saw a surge in research initiatives and activities, many of which continue to this day. These ongoing efforts are instrumental in understanding epidemics and pandemics, as well as in seeking cures for chronic diseases. Consequently, the pharmaceutical industry is now recognized as one of the largest and fastest-growing sectors worldwide.

FIGURE 11. TOP GLOBAL PHARMACEUTICAL MARKETS, 2022



Source: India Brand Equity Foundation, 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

This burgeoning growth in the global pharmaceutical sector is projected to drive a substantial increase in demand for water and wastewater treatment technologies in the coming years. High-purity water is an essential ingredient in the production processes of various pharmaceutical and healthcare products. The utilization of advanced treatment technologies ensures the measurement and control of organic molecules and pollutants in water, which is crucial for maintaining the high standards required in pharmaceutical manufacturing. By ensuring the removal of germs and other organic contaminants, these technologies help preserve the quality of the final products.

Furthermore, these water treatment processes provide an assessment of cleaning efficiency for the pharmaceutical industry, ensuring that the equipment used in production is adequately maintained. Various organizations, including the European Pharmacopoeia, United States Pharmacopoeia (USP), and Japanese Pharmacopoeia, have developed standard tests for examining water purity and water for injections, highlighting the critical role of water quality in pharmaceutical manufacturing. Therefore, the continuous growth of the pharmaceutical industry is expected to have a favorable impact on the demand for water and wastewater treatment solutions, reinforcing the sector's commitment to maintaining high standards of quality and safety in its products.

3.1.3. GROWING OIL & GAS INDUSTRY

The oil and gas industry are a cornerstone of both national and global economies, serving as the primary source of fuel worldwide. This industry employs thousands of workers globally and generates billions of dollars each year. Particularly in regions with a significant presence of National Oil Companies (NOCs), oil and gas companies are crucial to the national GDP. The industry is divided into three key segments: upstream, midstream, and downstream. The upstream sector involves the exploration and drilling of natural gas and crude oil fields, the midstream sector focuses on the transportation, storage, and processing of these resources, and the downstream sector involves refining crude oil and purifying natural gas to produce usable products. However, the industry's operations generate large volumes of wastewater, and projections suggest that these volumes will continue to rise. Currently, most wastewater from oilfield processes is managed through disposal or underground injection, making the water inaccessible for future use. This practice has raised significant concerns, especially in water-scarce regions, prompting organizations and stakeholders to focus on implementing more sustainable and eco-friendly wastewater management practices.

The necessity for improved water and wastewater treatment in the oil and gas industry is becoming increasingly evident. Proper treatment technologies can significantly reduce the demand for fresh water and promote the reuse of wastewater, thereby conserving resources and supporting both economic and environmental sustainability. For example, mandatory wastewater reuse could become a standard practice, reducing the industry's environmental footprint, and ensuring a more sustainable approach to water resource management. Furthermore, the oil and gas industry are expected to face increasing pressure to adopt more sustainable practices, including advanced wastewater treatment and recycling technologies. This shift is not only driven by environmental concerns but also by the potential economic benefits of reducing water consumption and improving wastewater management efficiency. Thus, the oil and gas industry's impact on water and wastewater treatment is significant and multifaceted. As the industry continues to grow, the need for sustainable water management practices will become more critical. By adopting advanced treatment technologies and promoting the reuse of wastewater, industry can contribute to the conservation of water resources and enhance its overall sustainability.

3.1.4. GROWING FOOD & BEVERAGE INDUSTRY

The food and beverage industry faces significant challenges concerning water supply and quality. Global manufacturers must navigate periods of drought, extreme weather, and varying water quality, which can disrupt operations and impact the integrity of their products. Even in regions with stable water supplies, legal restrictions often limit the amount of water these companies can use annually. To remain competitive, food and beverage companies increasingly rely on advanced industrial reverse osmosis water purification systems.

These systems offer multiple benefits, including ensuring consumer health, enhancing operational efficiency, and providing more control over water resources.

Consumers expect food and beverages to be free from contamination. Therefore, any water involved in the manufacturing process—whether for ingredients, packaging, bottles, pipes, or equipment—must meet stringent purity standards set by organizations like the World Health Organization (WHO). This includes water used for cleaning packaging equipment, storage, and transportation vehicles, ensuring high cleanliness across the production chain. High-quality water is not only crucial for the product but also for the overall efficiency of the manufacturing process. Impurities in water used for boilers and cooling towers can lead to corrosion, scale buildup, and reduced efficiency, resulting in costly downtime and maintenance. An industrial reverse osmosis water purification system helps mitigate these issues by providing cleaner water, thereby reducing wear and tear on equipment and cutting repair and maintenance costs.

Given the unpredictability of water supplies due to environmental factors, food and beverage manufacturers benefit from systems like Closed Circuit Reverse Osmosis (CCRO). These systems enable the recycling and reuse of water, offering greater control over water supply and costs. By reclaiming water that would otherwise be wasted, companies can significantly reduce their environmental footprint and improve sustainability. Water quality is paramount in the food and beverage industry because microbiologically contaminated water can degrade product quality and shorten shelf life. Compliance with strict water purity standards is essential to avoid legal repercussions and ensure the safety of products. The Food and Drug Administration (FDA) and WHO mandate the use of adequately treated and disinfected water in food manufacturing, cleaning, and processing.

Maintaining high water quality extends beyond the production process to equipment cleaning and sterilization. Using properly treated water for cleaning packaging equipment, transport vehicles, and storage facilities is critical to prevent contamination and ensure compliance with current Good Manufacturing Practices (cGMP). This also enhances product safety and quality. Investing in advanced water treatment systems can lead to a higher return on investment by improving resource efficiency and increasing productivity. Moreover, the quick deployment of prefabricated water treatment systems ensures that companies can meet stringent water quality targets efficiently, conserving both capital and natural resources. The modular design of these systems allows for tailored solutions that address the unique needs of each application, whether it's for boiler and hot water treatment, ingredient blending, beverage and ice filtration, or process water purification.

4. GLOBAL MICRO-ECONOMIC OVERVIEW

4.1. GLOBAL MACROECONOMIC OVERVIEW

The global economy is projected to maintain a growth rate of 3.2 percent in both 2024 and 2025, consistent with 2023 levels. Advanced economies are expected to experience a slight increase in growth, from 1.6 percent in 2023 to 1.7 percent in 2024 and 1.8 percent in 2025. Conversely, emerging market and developing economies are anticipated to see a modest deceleration, with growth slowing from 4.3 percent in 2023 to 4.2 percent in 2024 and 2025. The five-year forecast for global growth, at 3.1 percent, is the lowest in decades. Global inflation is predicted to steadily decrease, from 6.8 percent in 2023 to 5.9 percent in 2024 and 4.5 percent in 2025. Advanced economies are expected to reach their inflation targets sooner than the emerging market and developing economies, with core inflation generally declining at a more gradual pace.

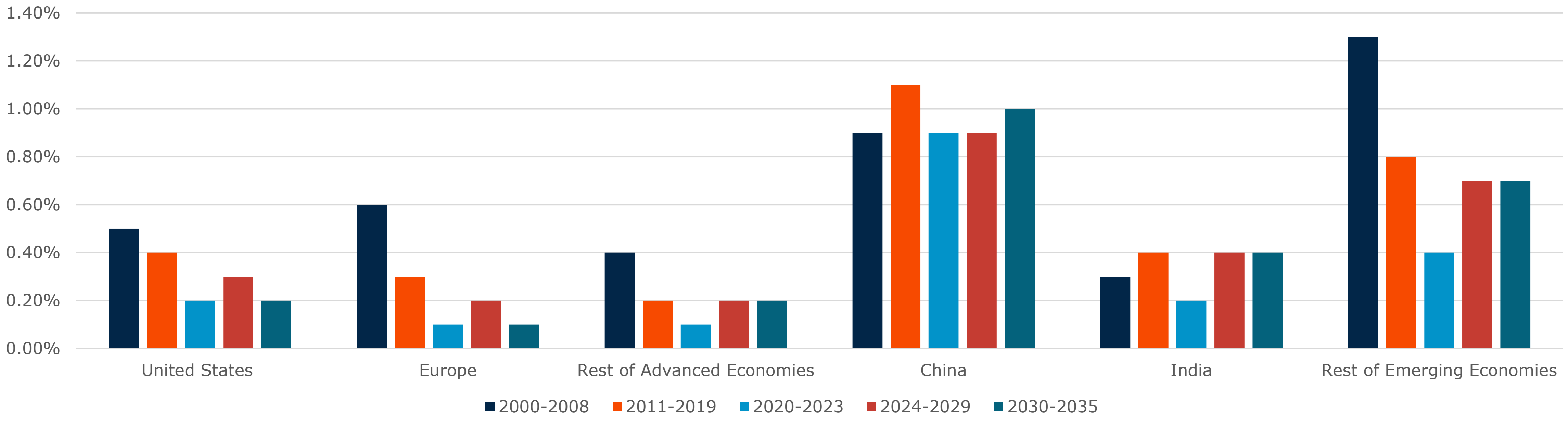
4.1.1. INSIGHT INTO ADVANCED ECONOMIES AND EMERGING MARKETS & DEVELOPING ECONOMIES

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 favourable 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 forecasted to be 5.1% in 2023, 4.8% in 2024, 4.2% in 2025 and 4.1% in 2026.
- **Europe and Central Asia**: The growth rate is projected to be 3.2% in 2023, 3.0% in 2024, 2.9% in 2025 and 2.8% in 2026.
- **Latin America and the Caribbean**: The growth rate is projected to be 2.2% in 2023, 1.8% in 2024, 2.7% in 2025 and 2.6% in 2026.
- **Middle East and North Africa**: Growth is forecasted to be 1.5% in 2023, 2.8% in 2024, 4.2% in 2025 and 3.6% in 2026.

- **South Asia**: The growth rate is projected to be 6.6% in 2023, 6.2% in each of 2024, 2025 and 2026.
- **Sub-Saharan Africa**: Growth is forecasted to be 3.0% in 2023, 3.5% in 2024, 3.9% in 2025 and 4.0% in 2026.

The Global Economic Prospect forecasts economic growth to slow in most regions in 2024-25 compared to the 2010s. Specifically, growth is projected to be slower than the 2010s average in nearly 60 percent of economies, representing more than 80 percent of global output and population.

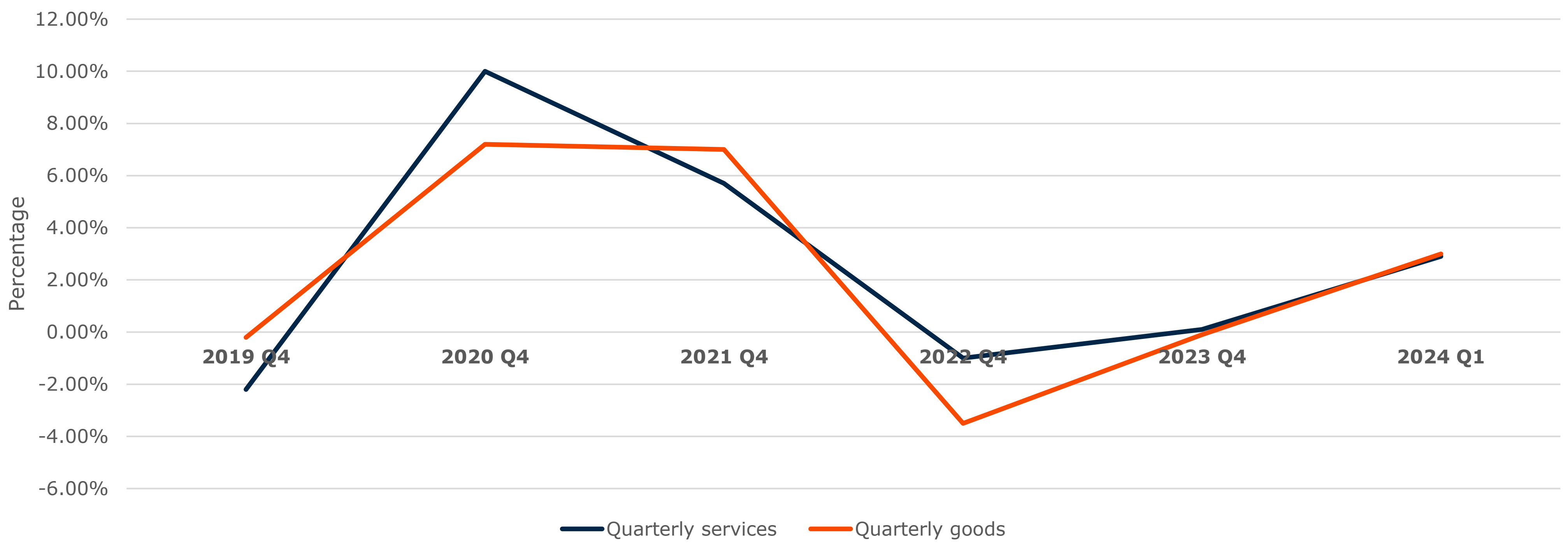
4.1.1.2. GLOBAL GDP AND TRADE ANALYSIS

World merchandise trade volume is projected to increase by 2.6% in 2024 and 3.3% in 2025, following a significant decline of -1.2% in 2023. Import demand in 2023 was notably weak in Europe, North America, and Asia, with the Middle East and the Commonwealth of Independent States (CIS) being exceptions where imports surged. Global real GDP growth at market exchange rates slowed from 3.1% in 2022 to 2.7% in 2023, and it is expected to stabilize at 2.6% in 2024 and 2.7% in 2025. This divergence between steady GDP growth and a slowdown in merchandise trade volume is primarily due to inflationary pressures, which have suppressed consumption of trade-intensive goods in major economies.

The US dollar value of world merchandise trade dropped by 5% in 2023 to USD24.01 trillion, attributed to declining commodity prices like oil and gas. In contrast, commercial services trade experienced a 9% rise to USD7.54 trillion, fueled by recovering international travel and the growth of digitally delivered services. Despite several economic shocks, global trade has demonstrated resilience, with merchandise trade volume up by 6.3% and commercial services trade value up by 21% between 2019 and 2023.

In 2024 and 2025, the gradual abatement of inflation is expected to boost real incomes in advanced economies, enhancing consumption of manufactured goods. A recovery in demand for tradable goods is already visible, linked to improved income prospects. Nevertheless, risks such as geopolitical tensions, policy uncertainty, and rising protectionism pose potential threats to the recovery of trade in the coming years.

FIGURE 13. ANNUAL GROWTH IN THE VALUE OF TRADE IN GOODS AND SERVICES, PER CENT:2024



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 buoyed by a shift in demand towards tradable goods, while services, less trade-intensive, lagged behind. As economies move towards pre-pandemic consumption patterns, trade expansion has moderated. China's recovery, primarily driven by services, may limit positive spill-over effects on global demand for goods and commodities. The rise in restrictive trade measures reflects escalating geopolitical tensions and a shift towards inward-focused policies among major economies, likely reshaping global supply chains and increasing trade costs in the long term.

2023: A Challenging Year for Trade

- Global trade contracted by 3% to USD31 trillion in 2023, following a peak in 2022. This decline was driven by reduced demand in developed economies and weaker trade performance in East Asia and Latin America.
- Trade in goods saw a 5% decline, whereas trade in services bucked the trend with an 8% growth, propelled by a nearly 40% surge in tourism and related services.

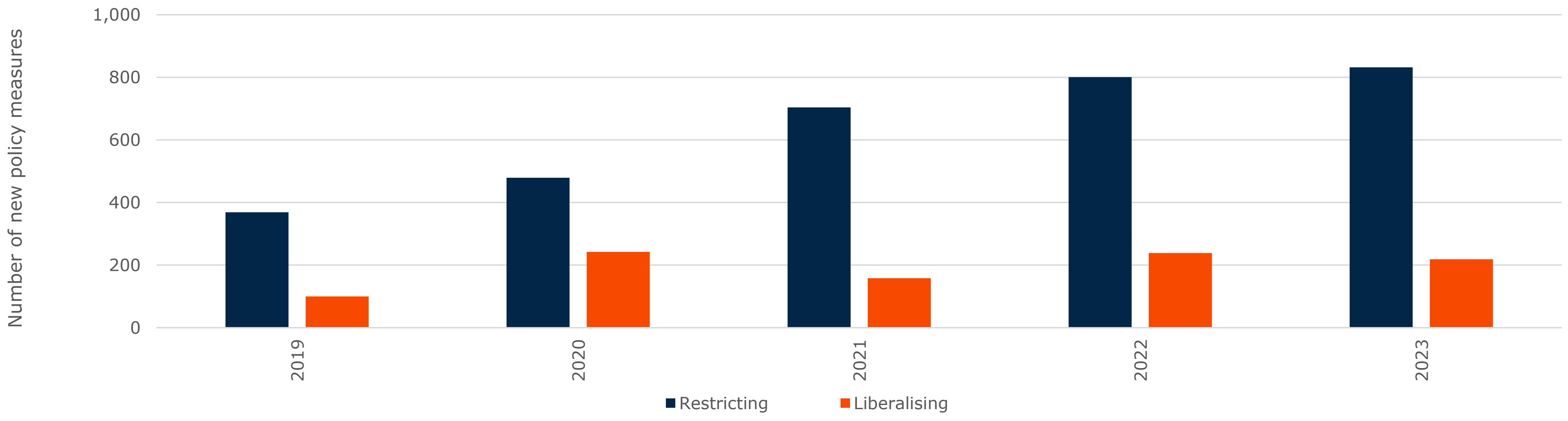
Impact on Developing Countries

- Developing nations faced a sharper downturn, with imports and exports declining by 5% and 7% respectively, compared to a 4% drop in imports and 3% in exports for developed countries.
- Most regions experienced negative trade growth in 2023, except for a notable increase in intra-regional trade in Africa.

Looking Ahead to 2024: Optimistic Outlook Amid Challenges

- GDP growth is forecasted at around 3% for 2024, driven in part by rising demand for environmental goods, particularly electric cars.
- However, logistical challenges such as shipping disruptions in the Red Sea, Black Sea, and Panama Canal pose risks to this optimistic outlook, potentially increasing costs and disrupting supply chains.
- Ongoing geopolitical tensions and regional conflicts could reintroduce volatility in energy and agricultural markets. The need to secure critical minerals for the energy transition may also impact prices, contributing to market volatility in these commodities.

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. In 2023, global trade faced a significant slowdown, marked by a 3% decline according to the United Nations Conference on Trade and Development (UNCTAD). This downturn mirrored broader economic forecasts, with growth projections dropping from 6% in 2022 to a modest 1.7%. Looking ahead to 2024, expectations suggest a cautious recovery. The International Monetary Fund (IMF) anticipates a 3.0% growth rate, aligning closely with the World Trade Organization's (WTO) forecast of 3.3% growth in merchandise trade. However, the Organization for Economic Co-operation and Development (OECD) takes a more reserved stance, predicting 2.7% growth amid lingering uncertainties. These uncertainties include rising trade restrictions, dwindling new trade agreements noted by the World Bank, and persistent geopolitical tensions and supply chain disruptions highlighted by UNCTAD. As global economies navigate these challenges, the path to recovery remains contingent on mitigating these risks to foster sustainable trade expansion.

4.1.1.3. GLOBAL INFLATION IMPACT

Global inflation remains a persistent challenge despite significant reductions achieved over the past year. The steep descent in global commodity prices between mid-2022 and mid-2023 played a crucial role in reducing inflation by approximately 2 percentage points. However, since mid-2023, commodity prices have plateaued, complicating efforts by central banks to lower interest rates quickly. This stagnation in commodity prices suggests that inflation may continue to exceed central bank targets in many countries, necessitating prolonged higher interest rates. Geopolitical tensions, particularly in the Middle East, pose significant risks to global inflation. The price of Brent crude oil, for instance, recently surged to USD 91 per barrel, far above the pre-pandemic average. The World Bank forecasts that Brent prices will average USD84 per barrel in 2024, with potential for further increases if conflicts escalate, potentially surpassing

USD100 per barrel in severe scenarios. Such increases would inevitably push global inflation higher, reversing some of the progress made in recent years.

Gold prices are expected to reach record highs in 2024, driven by strong demand from investors seeking safe-haven assets amidst geopolitical and economic uncertainties. Other commodities, such as natural gas, fertilizers, and food, could also see price hikes if the Middle East conflicts intensify, given the region's critical role in global supply chains. While the baseline forecast predicts a slight decline in food and fertilizer prices in 2024 and 2025, any significant disruption in supply could alter this trajectory, exacerbating inflationary pressures. The drive towards green technologies is another factor influencing commodity prices. Metals crucial for the clean-energy transition, such as copper and aluminum, have seen price increases due to rising demand for electric vehicles and renewable energy infrastructure. Copper prices, for example, are projected to rise by 5% in 2024 before stabilizing, while aluminum prices are expected to increase by 2% in 2024 and 4% in 2025. These trends highlight the complex interplay between technological advancements and commodity markets, which can have broad implications for inflation.

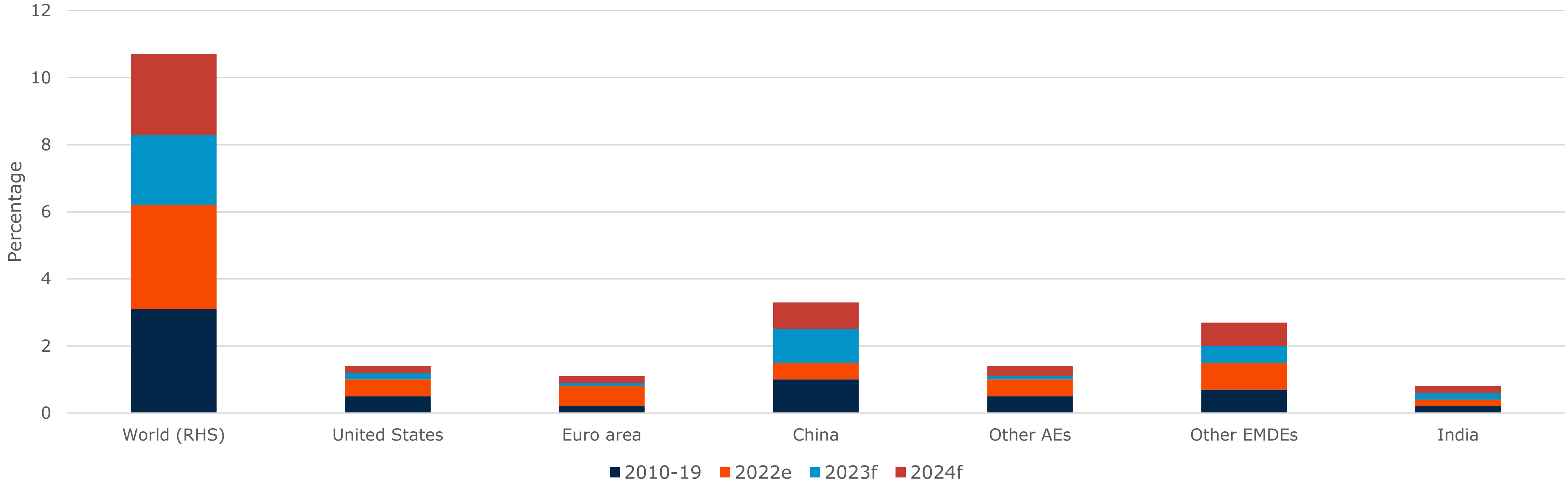
Global economic growth is projected to be slightly below historical averages in 2024 and 2025, with forecasts of 3.1% and 3.2%, respectively. The persistence of high central bank policy rates and low productivity growth are contributing factors. However, the likelihood of a hard landing has diminished, with global headline inflation expected to fall to 5.8% in 2024 and 4.4% in 2025. Despite this, the risks of new commodity price spikes from geopolitical shocks remain, which could prolong tight monetary conditions and impact growth. Policymakers face the challenge of navigating the final stages of disinflation, requiring careful calibration of monetary policy in response to evolving inflation dynamics. As inflation declines and economies better absorb fiscal tightening effects, a renewed focus on fiscal consolidation is essential to rebuild budgetary capacity and curb public debt. Targeted structural reforms aimed at boosting productivity and ensuring debt sustainability are also necessary. Effective multilateral coordination will be crucial for addressing issues such as debt resolution and climate change mitigation, ensuring global economic stability in the face of ongoing challenges.

4.1.1.4. GLOBAL OUTLOOKS AND RISKS

Global growth is anticipated to decelerate this year as credit conditions tighten due to ongoing monetary policies and banking sector stresses in advanced economies. This financial tightening is becoming increasingly evident, expected to reach its peak this year. Inflation, which has been persistently high, should decline as demand slows and commodity prices moderate, assuming longer-term inflation expectations remain stable. However, stress in systemically important banks could precipitate a financial crisis, leading to prolonged economic downturns. Should core inflation persist unexpectedly or further commodity price shocks occur, greater-than-expected monetary tightening may increase the risk of renewed financial stress. Long-term, the fundamental drivers of growth may slow further due to trade fragmentation and intensified climate change.

The year 2023 highlighted many global issues, from lethal conflicts in Sudan, Gaza, and Israel to record-breaking heat, droughts, wildfires, and flooding. Societal discontent was widespread, with violent protests, riots, and strikes becoming common. Although the immediate destabilizing impacts akin to the Russia-Ukraine war or the COVID-19 pandemic were avoided, the long-term outlook suggests potential for further global shocks. Survey results from late 2023 indicate a predominantly negative global outlook for the next two years, expected to worsen over the next decade. A significant portion of respondents anticipate moderate to severe instability and global catastrophes, with nearly two-thirds predicting a turbulent decade ahead.

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

The banking sector's vulnerabilities vary, with some regions facing liquidity risks and others dealing with low profitability or limited capital buffers. Bank balance sheets have suffered from recent economic weaknesses and rapid interest rate rises. Declines in house prices, already occurring in countries accounting for half of global activity, could worsen this situation. Financial stress scenarios envision a sharp tightening of financial conditions in advanced economies, potentially leading to global recession or, alternatively, avoiding recession through central bank policy easing and rapid inflation decline. However, persistent inflation forecasts may necessitate further monetary tightening, impacting emerging market and developing economies (EMDEs) severely, especially with rising U.S. rates driven by a hawkish Federal Reserve. This could make borrowing unaffordable for many EMDEs, further dampening global potential growth.

Environmental risks are becoming increasingly critical, with extreme weather events ranking as the top risk likely to cause a global crisis in 2024. The El Niño-Southern Oscillation (ENSO) cycle is expected to intensify, exacerbating these risks. Disagreements on the urgency of environmental risks like biodiversity loss and critical Earth system changes reveal generational and sectoral divides in prioritizing these threats. Younger respondents and the private sector see these as urgent short-term risks, whereas civil society and government focus on immediate concerns. This misalignment could result in missed intervention opportunities, leading to long-term changes to planetary systems. Societal polarization and economic downturn are deeply interconnected, driving and exacerbating various global risks. Misinformation and disinformation are anticipated to be severe global risks over the next two years, potentially undermining the legitimacy of governments and leading to unrest. This could manifest as violent protests, hate crimes, or terrorism, further polarizing public discourse on issues like public health and social justice. Governments may respond by increasing control over information, risking broader repression of information flows.

Economic strains are set to grow, with the cost-of-living crisis and inflation remaining major concerns. High interest rates could expose small and medium-sized enterprises and indebted countries to debt distress, particularly in climate-vulnerable or conflict-prone regions. Technological advances and geopolitical dynamics will create new disparities, with vulnerable countries falling behind in digital and economic developments. Over the long term, economic, environmental, and technological trends may entrench existing challenges, impacting labor and social mobility and blocking opportunities for economic improvement. Geopolitical tensions combined with technological advancements are likely to drive new security risks. State fragility and interstate conflicts are expected to rise, with technological advances like AI enabling new tools of disruption and conflict. This could lead to more blurred lines between state and non-state actors, fueling cycles of conflict, corruption, and crime. The internationalization of conflicts and the integration of AI in decision-making may significantly raise the risk of accidental or intentional escalations.

Governance will face challenges as ideological and geoeconomic divides deepen, potentially paralyzing international mechanisms and diverting resources from urgent global risks. As dissatisfaction with the Global North's dominance grows, an evolving set of states will seek greater influence, reshaping security dynamics and global risk management. This shifting balance of power will impact access to advanced technologies and economic assets, creating new power dynamics and opportunities for action. Despite these challenges, localized strategies and cross-border collaboration can significantly reduce global risks. Investments in research and development, prioritizing future-oriented policies, and collective actions by citizens, companies, and countries can help address global risks. Even in a fragmented world, international cooperation remains critical for human security and prosperity. The next decade will be marked by significant changes, testing our adaptive capacity, but positive outcomes are possible through proactive risk management and global collaboration.

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.

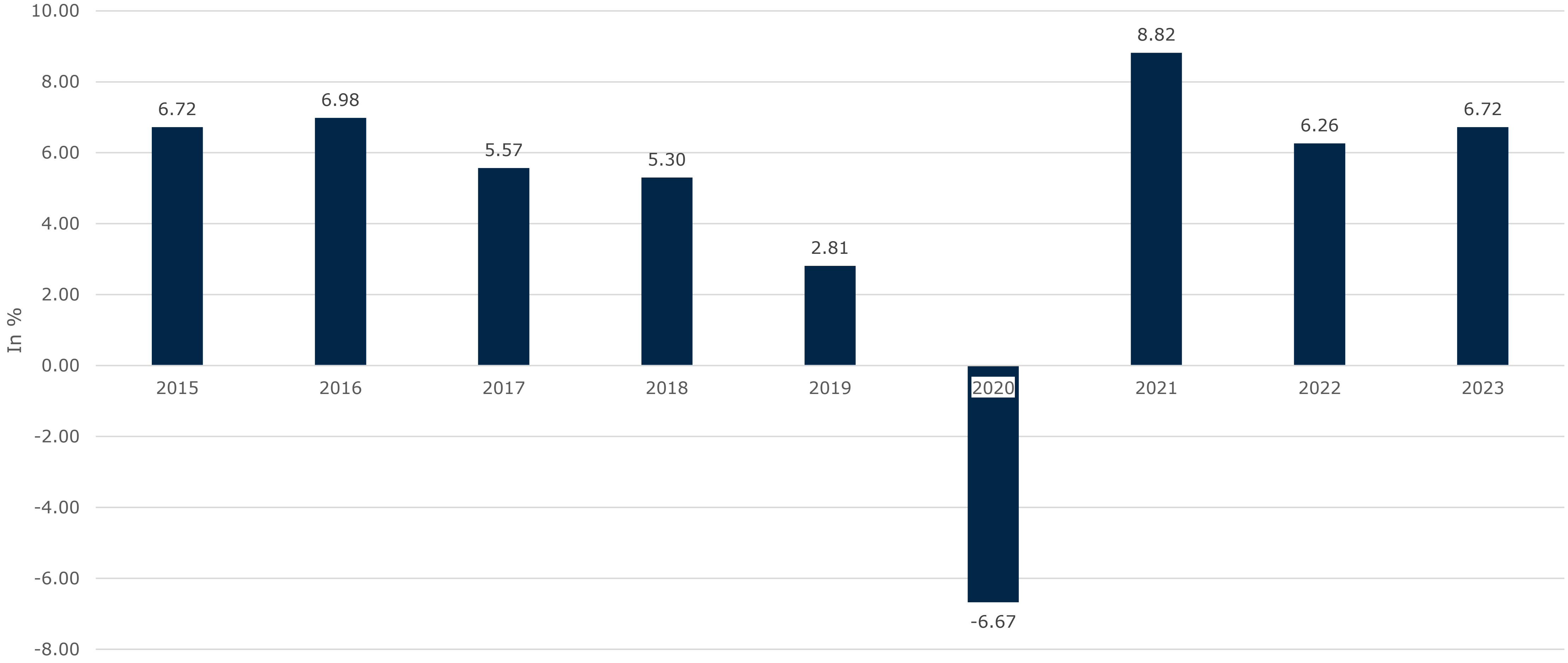
5.1.1. TREND IN GDP AND GVA

TABLE 3. 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

FIGURE 16. GDP PER CAPITA GROWTH (ANNUAL %)



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

TABLE 4. INDIAN GDP, 2022-2026

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

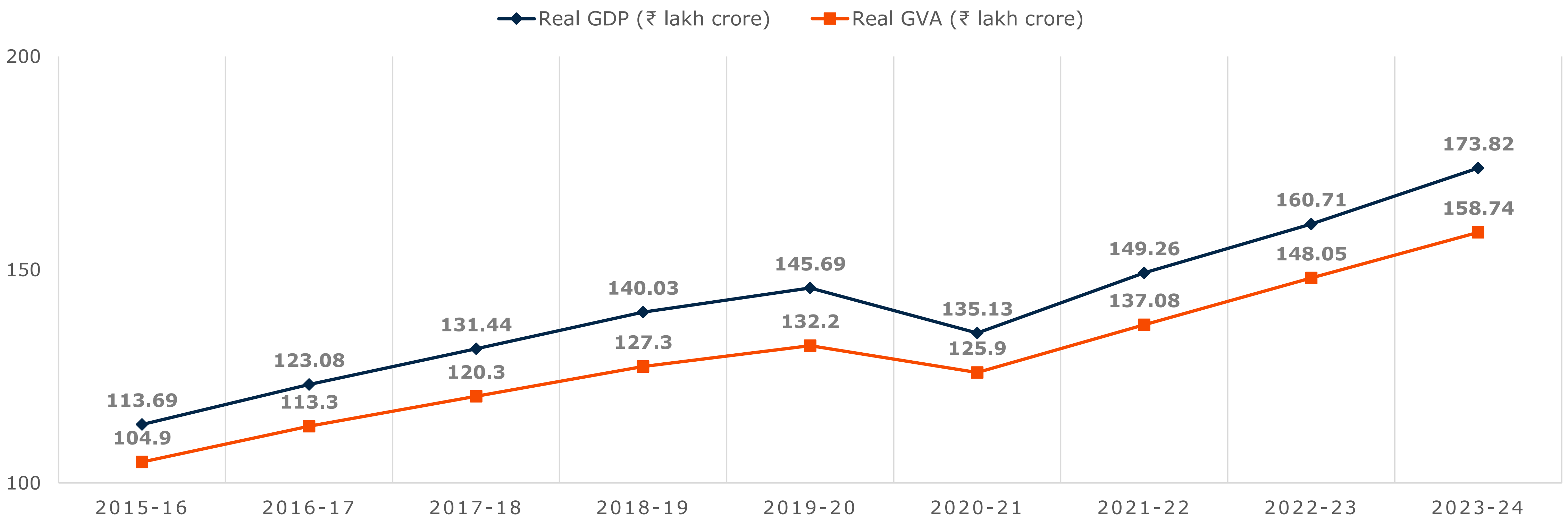
5.1.2. PER CAPITA GDP, INCOME AND PER CAPITA CONSUMPTION (PAST & OUTLOOK)

TABLE 5. GDP PER CAPITA, 2017-2020 (HISTORICAL), 2021-2024E

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
2024-E	228,020.66

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

FIGURE 17. 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. In March 2024, Prime Minister, Mr. Narendra Modi inaugurated multiple connectivity projects in Kolkata, totaling USD 1.8 billion. In March 2024, the Minister of Civil Aviation and Steel announced inaugurating 15 airport projects worth USD 12.1 billion by 2028.

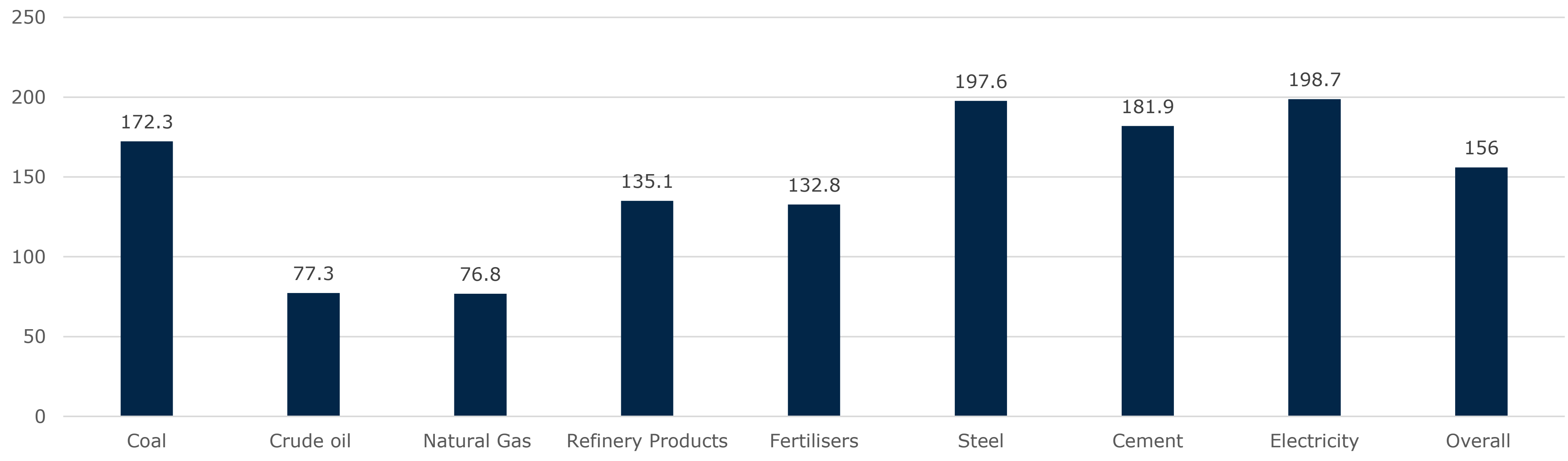
Strategic Initiatives: Notably, the government's strategic initiatives such as "Housing for All" and the "Smart City Mission" underscore its commitment to surmounting bottlenecks within the infrastructure sector. Civil Aviation Ministry’s “Vision 2040” report states that there will be 190-200 functioning airports in India by 2040. Delhi and Mumbai will have three international airports each, while top 31 Indian cities will have two operational airports each. Civil Aviation Ministry’s “Vision 2040” report states that there will be 190-200 functioning airports in India by 2040. Delhi and Mumbai will have three international airports each, while top 31 Indian cities will have two operational airports each. 220 destinations (airports/heliports/water aerodromes) under UDAN are targeted to be completed by

2026 with 1000 routes to provide air connectivity to unconnected destinations in India. 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 18. INFRASTRUCTURE INDEX OF 8 CR. INDUSTRIES FY24 (28TH JUNE 2024)



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. Further, to meet India’s aim of reaching a USD 5 trillion economy by 2025, infrastructure development is the need of the hour. The government has launched the National Infrastructure Pipeline (NIP) combined with other initiatives such as ‘Make in India’ and the production-linked incentives (PLI) scheme to augment the growth of the infrastructure sector. Historically, more than 80% of the country's infrastructure spending has gone toward funding for transportation, electricity and water, and irrigation.

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.

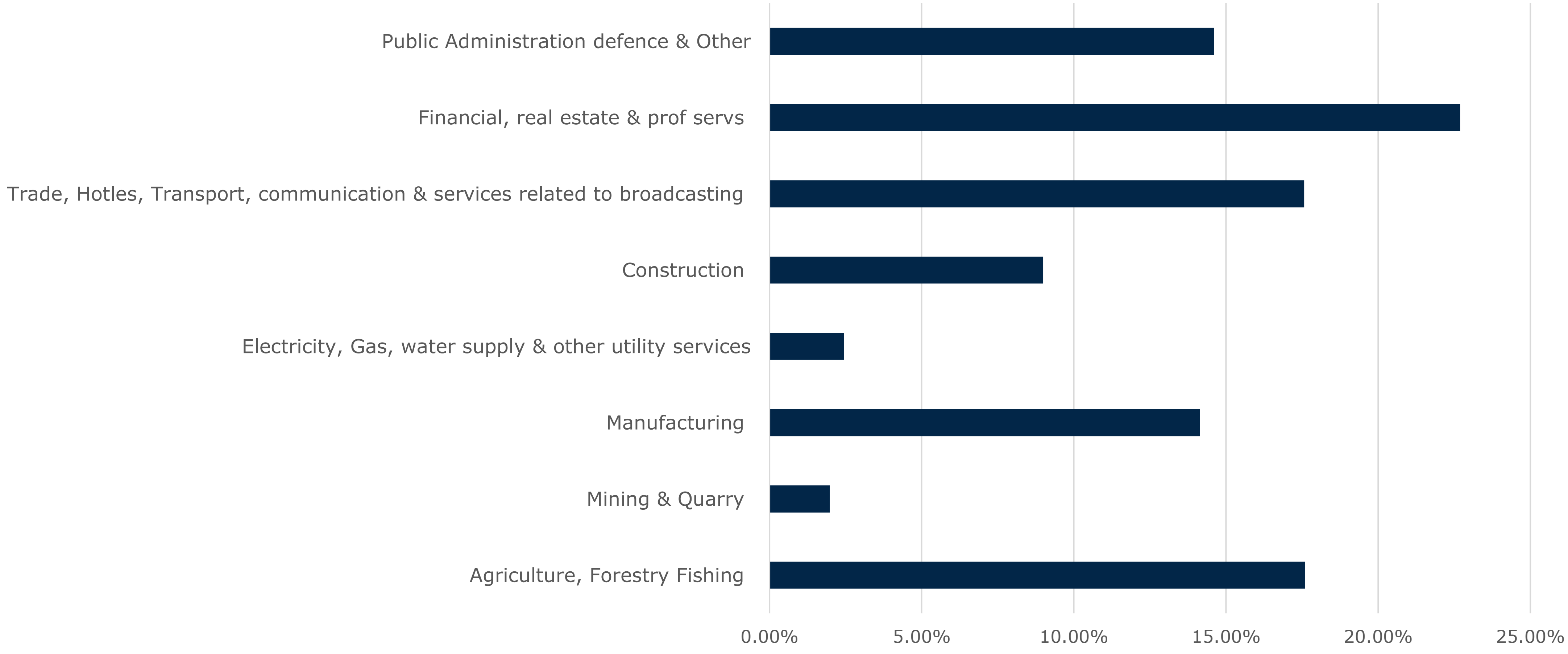
Moreover, On May 17, 2023, the Union Cabinet, led by Prime Minister Shri Narendra Modi, granted approval for the introduction of the Production-Linked Incentive (PLI) Scheme 2.0 for IT Hardware, aimed at enhancing India's manufacturing capabilities and promoting exports under the Atmanirbhar Bharat initiative. 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.

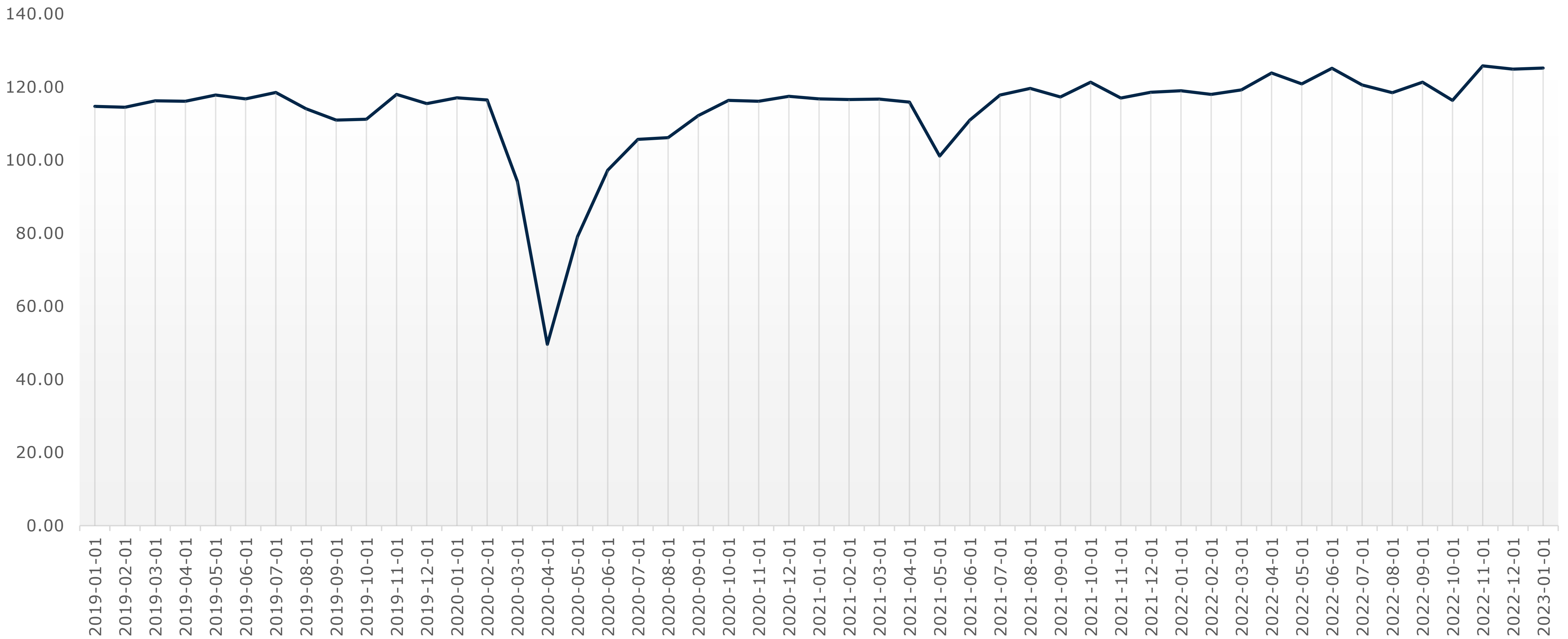
FIGURE 19. SHARE OF INDIAN GDP BY SECTOR: FY:2023-24



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 20. INDIA INDUSTRIAL PRODUCTION (2019-2023)

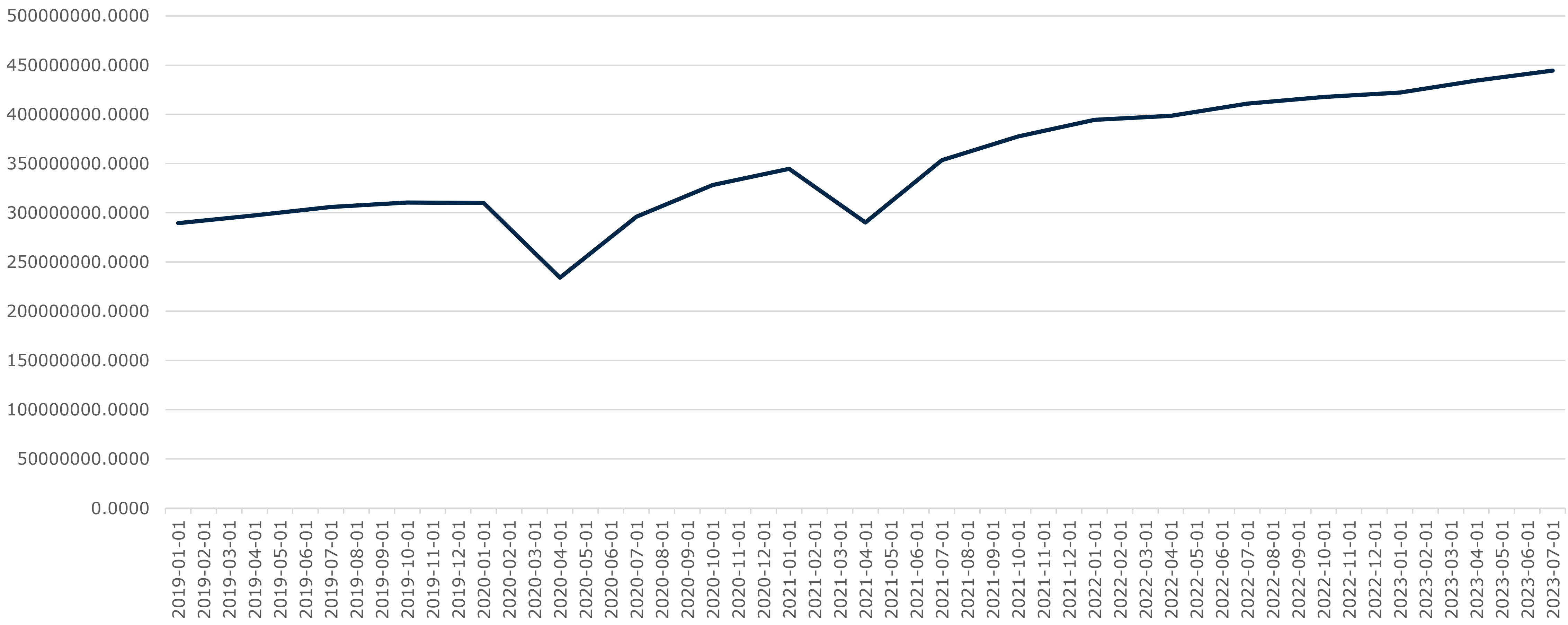


Source: Trading Economies, Central Water Commission (CWC), National Water Development Agency (NWDA), Water Resources Management Organisation, World Bank Company Annual Report, Primary Interviews, Reports and Data

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 21. 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

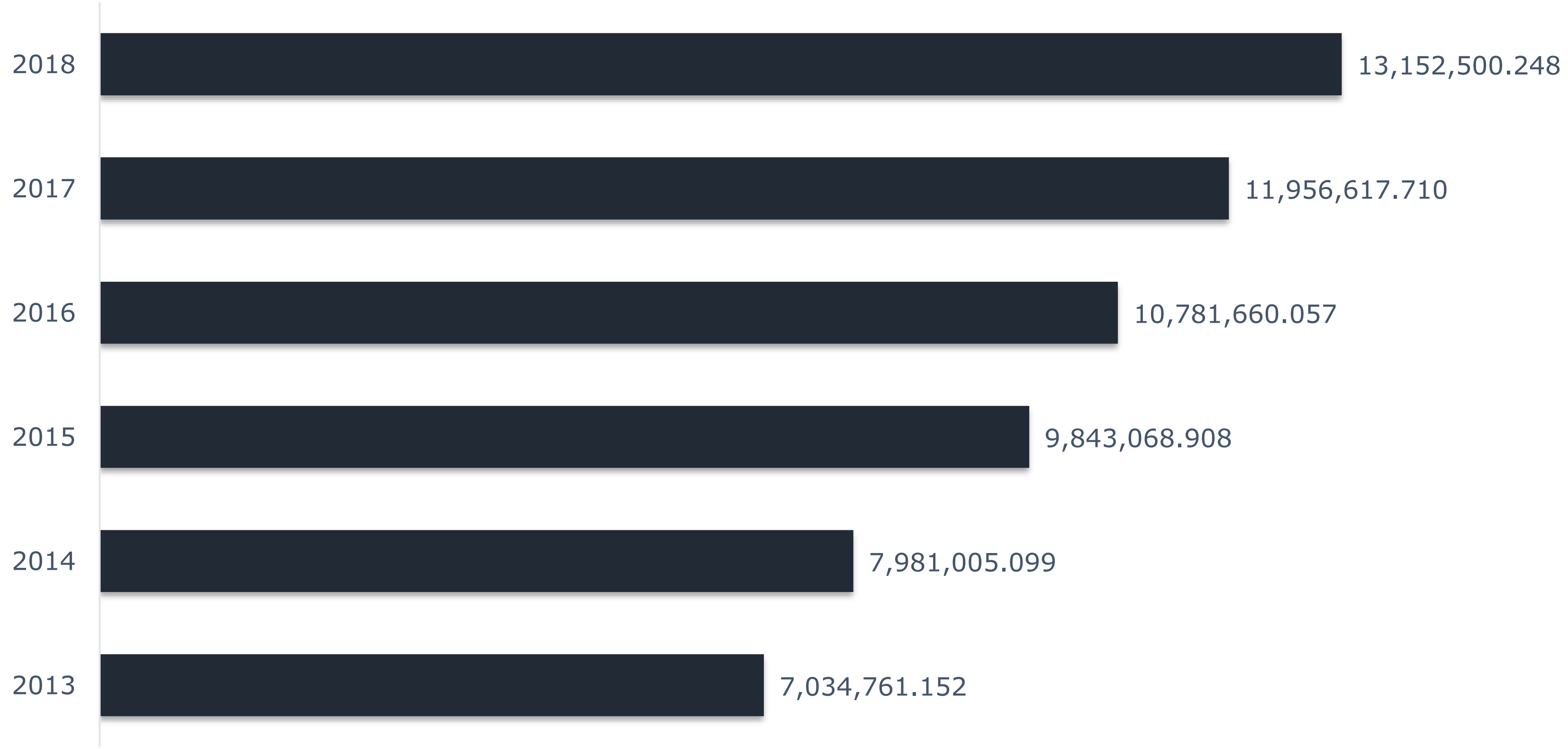
India’s private final consumption expenditure (PFCE) declined by six% in nominal terms to Rs.115.7 lakh crore in 2020-21 from Rs.123.1 lakh crore in 2019-20. Consumption expenditure growth has been slowing through the last decade. Growth in PFCE that averaged at 16.2% per annum during 2010-14, fell to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

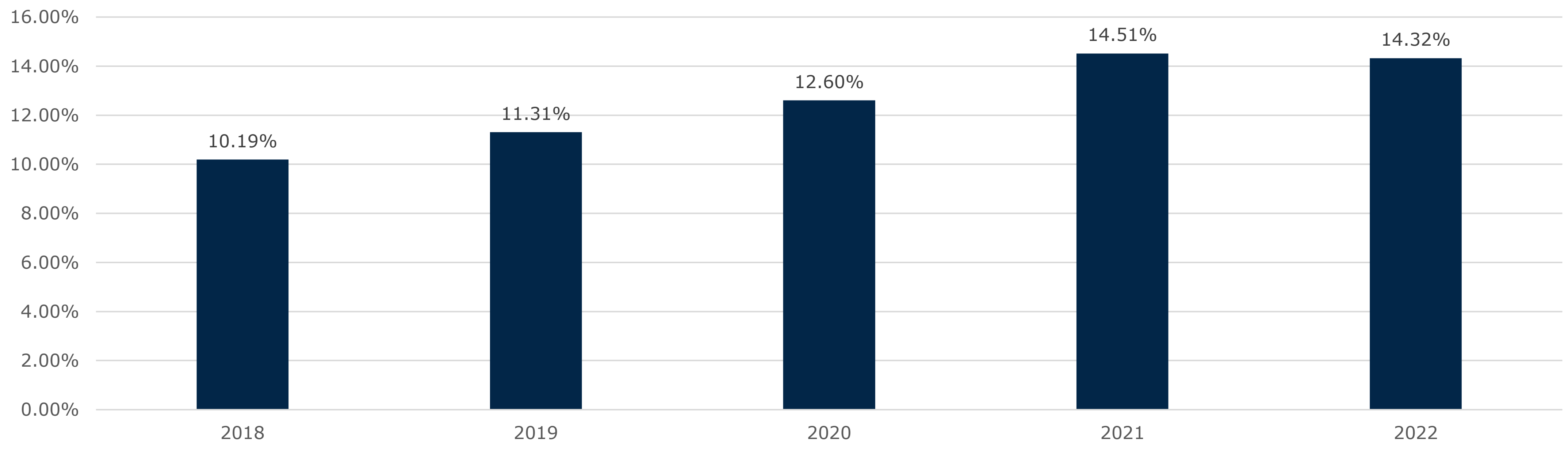
FIGURE 22. GROSS NATIONAL DISPOSABLE INCOME (INR LAKHS)



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.

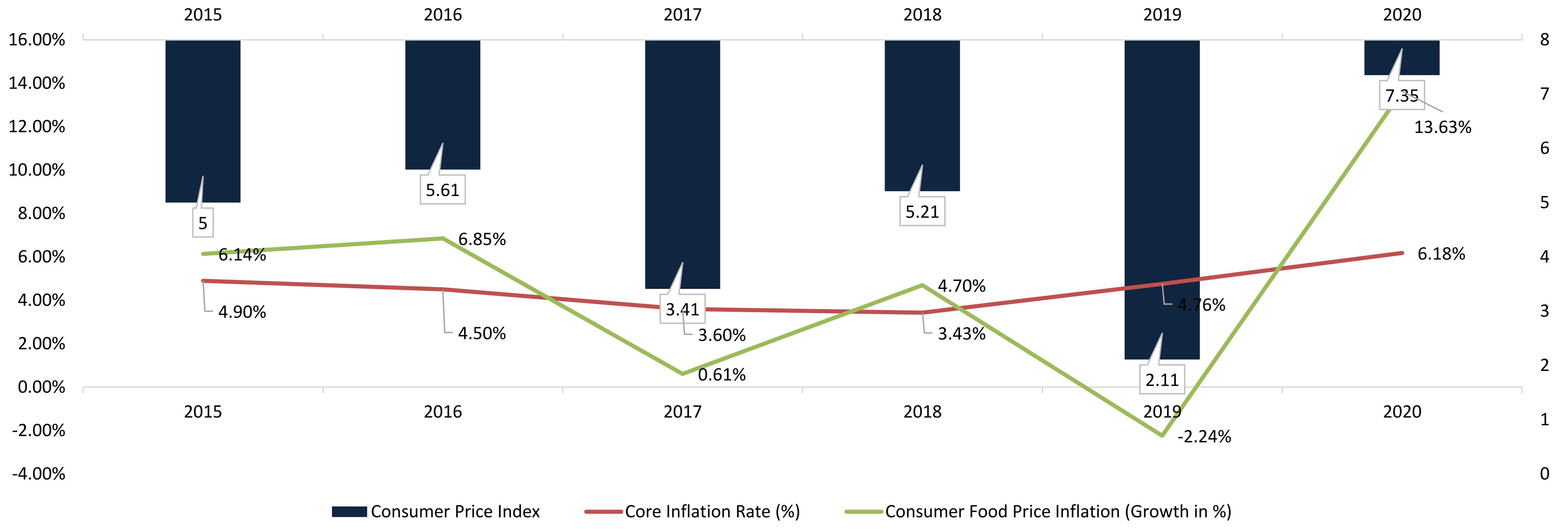
FIGURE 23. INDIA'S HOUSEHOLD DEBT: % OF GDP



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 24. 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

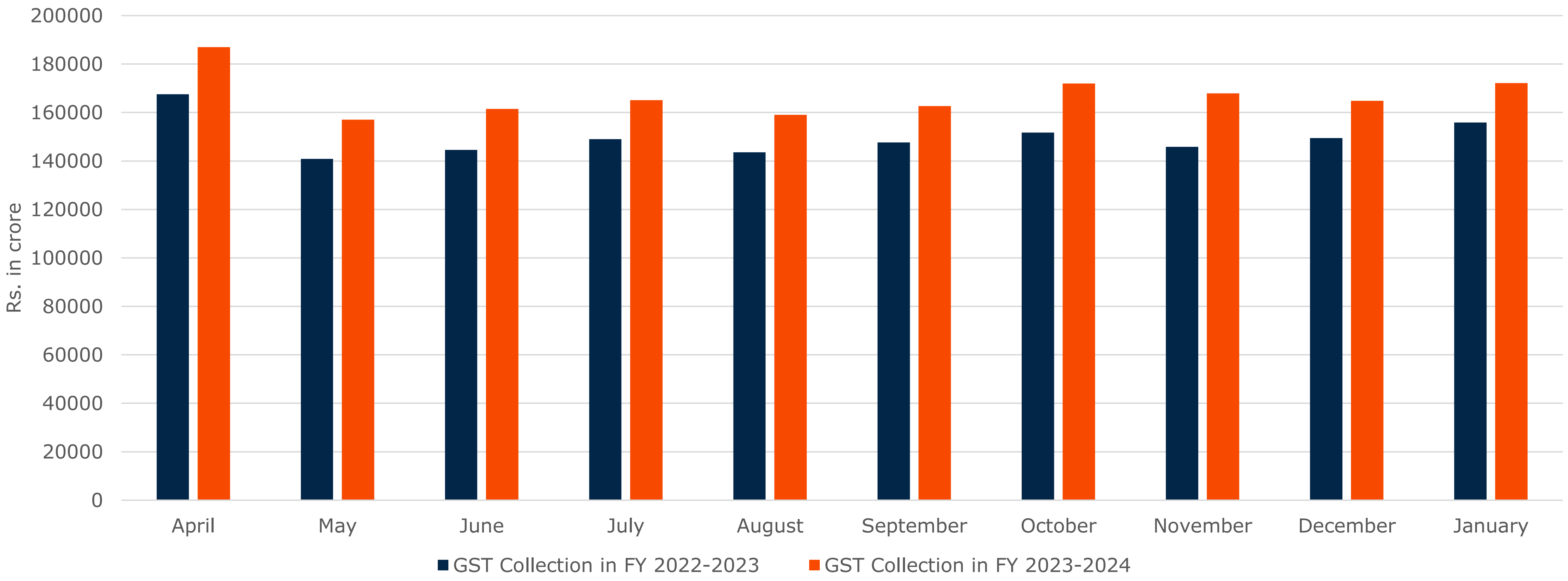
Consumer price inflation in India went through three phases in 2022. A rising phase up to April 2022 when it crested at 7.8 per cent, then a holding pattern at around 7.0 per cent up to August 2022 and then a decline to around 5.7 per cent by December 2022. The rising phase was largely due to the fallout 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 25. 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 Gross Goods and Services Tax (GST) revenue collections in India have demonstrated significant growth, marking a positive trend in the fiscal health of the nation. For September 2023, the gross GST revenue amounted to ₹1,62,712 crore, which includes Central GST (CGST) of ₹29,818 crore, State GST (SGST) of ₹37,657 crore, Integrated GST (IGST) of ₹83,623 crore, and cess of ₹11,613 crore. This substantial figure marks a 10% year-on-year growth compared to September 2022.

Breakdown of GST Collections

In September 2023, the GST components were as follows:

- **CGST**: ₹29,818 crore
- **SGST**: ₹37,657 crore
- **IGST**: ₹83,623 crore (including ₹41,145 crore collected on import of goods)
- **Cess**: ₹11,613 crore (including ₹881 crore collected on import of goods)

The government also settled ₹33,736 crore to CGST and ₹27,578 crore to SGST from IGST. Post-settlement, the total revenue for the Centre and States stood at ₹63,555 crore for CGST and ₹65,235 crore for SGST.

Year-on-Year Growth

The 10% increase in GST revenue for September 2023, compared to the same month in the previous year, is indicative of a robust economic recovery and effective tax collection mechanisms. Specifically, revenues from domestic transactions, including the import of services, rose by 14% year-on-year. This surge reflects improved compliance and a broader tax base.

Half-Yearly Performance

For the first half of the fiscal year 2023-24 (April to September), the gross GST collection was ₹9,92,508 crore, up by 11% from the ₹8,93,334 crore collected during the same period in FY 2022-23. The average monthly gross GST collection for the first half of FY 2023-24 stood at ₹1.65 lakh crore, surpassing the average monthly collection of ₹1.49 lakh crore in the first half of the previous fiscal year by 11%.

State-wise GST Collection

The state-wise GST collection for September 2023 showed varied growth rates, reflecting regional economic activities and compliance levels:

- **Telangana**: 33% growth
- **Jammu and Kashmir**: 32% growth
- **Maharashtra**: 17% growth

- **Tamil Nadu**: 21% growth
- **Karnataka**: 20% growth

On the other hand, some states showed more modest increases or even declines:

- **Bihar**: -5% growth
- **Lakshadweep**: -45% growth
- **Andaman and Nicobar Islands**: -30% growth

Post-Settlement SGST

The settlement of IGST to states and union territories (UTs) further bolstered the revenue figures. The cumulative post-settlement SGST revenue showed healthy growth across most regions, with significant increases in states like Maharashtra, Karnataka, and Uttar Pradesh.

Outlook

The consistent crossing of the ₹1.60 lakh crore mark in monthly GST collections for four months within FY 2023-24 highlights the underlying strength of India's tax system and economy. The government's ongoing efforts to streamline GST processes, enhance compliance, and broaden the tax base are likely to sustain and even accelerate this growth trend.

5.7. INDIAN ECONOMY OUTLOOK & ECONOMIC IMPACT

Despite uncertainties arising from adverse geopolitical developments and the expansionary fiscal measures taken during the COVID-19 pandemic, the Indian economy has shown remarkable resilience and maintained healthy macroeconomic fundamentals. According to the First Advance Estimates of National Income for FY 2023-24, India's Real GDP is projected to grow at an impressive 7.3%, reflecting strong domestic demand for consumption and investment, alongside the government’s continued emphasis on capital expenditure. The industry and services sectors have been the primary growth drivers in the first half of FY 2023-24, positioning India as the fastest-growing major advanced and emerging market economy during this period. The International Monetary Fund (IMF) projects India to become the third-largest economy by 2027 at market exchange rates and estimates that India's contribution to global growth will rise by 200 basis points over the next five years.

A significant factor driving this robust growth has been the tripling of capital expenditure outlay over the past four years, which has had a substantial multiplier effect on economic growth and employment creation. Union Minister for Finance and Corporate Affairs, Smt. Nirmala Sitharaman, announced an 11.1% increase in capital expenditure outlay for the next year, amounting to Rs. 11,11,111 crores, representing 3.4% of GDP. This strategic allocation underscores the government's commitment to strengthening growth momentum. To further support this initiative, the government has allocated Rs. 1.3 lakh crore in the Budget Estimates (BE) for 2023-24 towards fifty-year interest-free loans to states to boost their capital expenditures, a scheme set to continue in the coming year.

Foreign Direct Investment (FDI) has also played a crucial role in sustaining economic growth. Smt. Sitharaman highlighted that the period from 2014 to 2023, termed the golden era for FDI inflows, saw a total inflow of USD 596 billion, which is double the figure recorded during 2005-14. To encourage sustained foreign investment, India is negotiating bilateral investment treaties with foreign partners under the 'First Develop India' initiative.

Macroeconomic stability and improvements in India's external position have been pivotal in maintaining economic resilience. The significant moderation in the current account deficit and the revival of capital flows, supported by a robust foreign exchange reserves buffer, have contributed to the stability of the Indian rupee during FY 2023-24. Additionally, proactive supply-side initiatives by the government have effectively moderated inflationary pressures.

On the fiscal front, the finance minister indicated that the fiscal deficit for 2024-25 is estimated to be 5.1% of GDP, in line with the path of fiscal consolidation announced in the Budget Speech for 2021-22, aiming to reduce the fiscal deficit below 4.5% by 2025-26. The Revised Estimates (RE) for 2023-24 project a fiscal deficit to GDP ratio of 5.8%, lower than the Budget Estimates (BE) of 5.9%, reflecting a disciplined fiscal approach.

The strategic priorities for FY 2024-25 focus on creating a more inclusive, sustainable, and resilient domestic economy capable of absorbing unanticipated shocks. This includes directing increased resources towards capital spending to sustain infrastructure development momentum, supporting states' capital spending through fiscal federalism, and emphasizing integrated and coordinated planning and implementation of infrastructure projects under the PM Gati Shakti principles. The government also prioritizes expenditure towards key developmental sectors such as drinking water, housing, sanitation, green energy, health, education, agriculture, and rural development to ensure long-term sustainable and inclusive betterment of its citizens. Additionally, enhancing the effectiveness of cash management through systems like SNA/TSA is crucial for the just-in-time release of resources.

5.8. CURRENT GEOPOLITICAL SCENARIO

The year 2024 is shaping up to be a pivotal year for global geopolitics, marked by a significant transformation across domestic and international fronts. The world is experiencing the highest number of military conflicts since the Cold War, with major hotspots influencing international relations across continents. Two prominent conflicts are at the forefront: the ongoing war in Ukraine, initiated by Russia, and the Israel-Hamas clash in the Middle East.

Major Conflict Zones and Diplomatic Efforts

In Ukraine, Russia's persistent ambition for complete subjugation poses a continuous threat to European stability. The reduction in Western military and financial support for Kyiv could potentially lead to further territorial expansions by Moscow in the upcoming year. On the other hand, the Israel-Hamas conflict has ignited a significant humanitarian crisis in the Gaza Strip. Although there are emerging signs of potential diplomatic negotiations and ceasefire talks, the road to a two-state solution remains challenging, with the Palestinians facing the enormous task of rebuilding.

The year 2023 witnessed a grim episode of ethnic cleansing in Nagorno-Karabakh, where nearly 120,000 Armenians were displaced due to Azerbaijan's military actions. However, there is a glimmer of hope with the potential normalization of Armenia-Azerbaijan relations in 2024, which could benefit global trade routes, especially the International North-South Transport Corridor (INSTC) via Iran and Central Asia to Russia. This development is particularly significant given the suspension of the India-Middle East-Europe Corridor (IMEC) project due to military tensions in the Gulf region following the Israel-Hamas conflict.

Geopolitical Shifts in the Indo-Pacific and Beyond

The Indo-Pacific region is another critical area of geopolitical tension. The possibility of China and Russia opening a third front to challenge American influence is high, particularly before the US presidential election. Russia's collaboration with North Korea, providing rocket and satellite technology in exchange for ammunition, adds another layer of complexity. Meanwhile, China's increased military activities in the South and East China Seas further complicate the situation. This evolving scenario suggests a Cold War 2.0 involving the US, China, and Russia, with a low likelihood of direct military confrontation but significant geopolitical ramifications.

Amid these global tensions, India emerges as a potential major beneficiary. Strategically positioned between the conflicting interests of the US, China, and Russia, India's focus on domestic and regional stability is likely to intensify following the 2024 elections. The disruption of global supply chains and the US-China mutual decoupling position India as a prime destination for redirected global capital, new technological investments, and enhanced global and regional partnerships. India's predictable political leadership and increased engagement with the West, as well as within frameworks like BRICS and G20, will solidify its position, though risks from terrorism and climate-related events remain.

Europe's Geopolitical Challenges

Europe faces significant geopolitical challenges, being one of the primary casualties in the current transformation of international relations. The continent is experiencing the most tumultuous period in recent history, exacerbated by demographic, structural, and systemic challenges. The 2024 election cycle is expected to heighten political polarization, leading to surges in both right- and left-wing populism and significant reshuffles within European institutions. This period signals the end of the dominance of traditional and centrist parties, which have historically represented a large segment of the middle class. Additionally, Europe's economic situation is deteriorating due to the security challenges and complicated relations with China, further emphasized by the emergence of a new 'Iron Curtain' stretching from Scandinavia through the Baltics, Central and Eastern Europe, to the Black Sea and Turkey.

The Rise of Middle Powers and Geopolitical Realignment

In this shifting landscape, 'middle powers' or 'swing states' are gaining increased geopolitical relevance. Countries like Mexico, Indonesia, Brazil, and Türkiye are poised to elevate their presence on the global stage, buoyed by their strategic locations, technological prowess, or access to critical raw materials and rare earths. These countries' fluid alignments between America and China will continue to erode the coherence of global organizations and networks.

The relationships between major Asian powers, particularly China and India, are becoming more significant. While some tensions may arise in 2024, both nations are expected to manage their relationship to ensure regional stability. Additionally, the strategic coordination between China and Russia, known as the 'DragonBear' modus vivendi, juxtaposed against the US's strategic pivot towards the Indo-Pacific, further diminishes Europe's geopolitical importance.

In 2024, India's geopolitical landscape will be significantly influenced by global tensions and transformations. Positioned strategically between the US, China, and Russia, India stands to benefit amid these rivalries. As global supply chains face disruptions and US-China decoupling intensifies, India is set to attract redirected global capital, new technological investments, and enhanced partnerships. This influx will bolster India's economic growth and technological advancement, positioning it as a key player in global trade. India's political stability post-2024 elections will further enhance its appeal as a reliable partner. Increased engagement with Western countries, alongside its involvement in BRICS and G20, will solidify India's geopolitical standing. However, India must navigate risks such as terrorism and climate-related events, which could impact its progress. The Indo-Pacific region's heightened tensions, with potential

Chinese and Russian challenges to US influence, will require India to maintain a delicate balance in its foreign relations. Strengthening military and strategic partnerships, especially with the US and other Quad members, will be crucial for safeguarding its interests. India's role as a mediator in regional conflicts, such as the normalization of Armenia-Azerbaijan relations, could further enhance its diplomatic influence. Additionally, India's involvement in major global trade routes, like the International North-South Transport Corridor (INSTC), will boost its strategic importance.

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. GLOBAL WATER AND WASTEWATER TREATMENT MARKET

Global trade and industrial production are growing at rates that are significantly higher than average compared to the previous 10 years. However, the pandemic and the Russia-Ukraine conflict have contributed to rising inflation, which is primarily being driven by sharp increases in prices of food and energy. This is making life difficult for those on low incomes and posing serious risks to food security in some of the world's poorest economies. In almost all economies, growth is projected to be noticeably weaker than anticipated. Europe, which is majorly vulnerable to the conflict due to dependency on oil imports and also the steady refugee inflows taking a toll, is home to a number of the worst-hit countries in the region. Commodity price increases is also having a major impact on countries across the globe. This adds to inflationary pressures, reduces real wages and spending, and slows the recovery process.

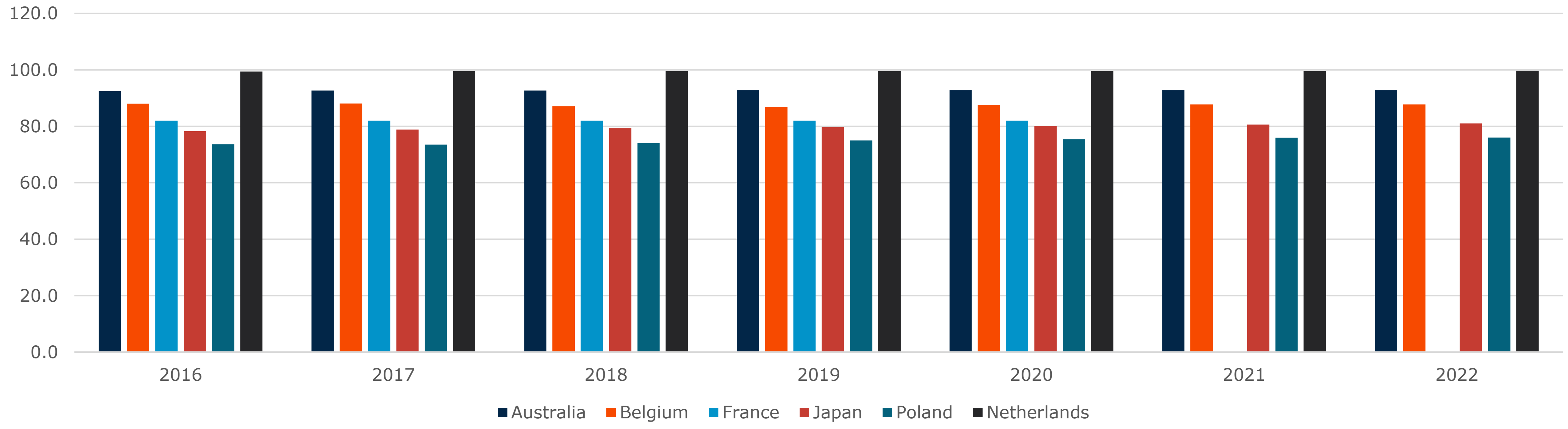
The difference between the world's water supply and demand is predicted to increase to 40% by 2030. Demand already outpaces supply in many areas, and in other areas, water shortage is impeding economic progress. It is to note that demand has been outpaced in recent years for world water demand and supply due to rapid growth in population, expansion in industrial activities and climate change impact. We derived this information from reliable sources that specialize in water resource management and global water challenges. Specifically, the “WATER RESOURCES MANAGEMENT” report published by The World Bank on October 22 and the article titled "Global freshwater demand will exceed supply 40% by 2030, experts warn" published by the World Economic Forum on March 23 serve as key references supporting the projected increase in the water supply-demand gap. While economic development and more unpredictable weather patterns enhance competition for access to water, affecting citizens, farms, industries, and governments, water insecurity raises the possibility of a global food crisis. This indicates that various stakeholders from all spheres of society must be involved in any solutions to the global water dilemma. Improved water supply and sanitation, and better water resource management boost global economic growth and contributes significantly to poverty eradication. Furthermore, investing in water and wastewater treatment solutions is a good business, as new and more advanced solutions, equipment, and enhanced water management solutions can be developed, and deployed, and enhance or increase efficiency of treatment and production and productivity within economic sectors.

The importance of sustainability and the need to mitigate climate change, issues related to water, rapid urbanization along with increasing global population have been gaining significant prominence in recent years. According to the 2015 United Nations World Water Development Report, the world is expected to register a 40% decline in water supply by 2030 unless the management of this resource is dramatically improved. The complexities associated with water treatment including technological, logistical, and regulatory make bundled design, construction and operation service packages highly profitable. In addition, water infrastructure, industrial needs, and uses together with environmental norms and regulations make the global water quality monitoring equipment for highly sensitive and competitive applications. There are numerous measurement methods for identifying the amount of organic and inorganic substances in water and wastewater, including Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Organic Carbon (TOC) to name a few.

A large amount of wastewater treated by municipal and industrial wastewater treatment plants makes the regulation of treated wastewater an effort crucial to the health and safety of humans and the environment. Because there can be striking variations in flow rate and organic content of water coming to a treatment plant which results from surge in rainfall or changes in the chemical usage in industrial plants, it is crucial to have access to reliable, real-time water quality data.

Wastewater treatment refers to the treatment of wastewater done in wastewater treatment plants operated by public departments or by private companies regulated by public authorities. 'Population connected to wastewater treatment' is the share of population with their wastewater being treated at wastewater treatment plants. Developed countries such as Germany have high rate of wastewater treatment of sewage water, prior to its disposal in the large water bodies. Such initiatives are vital for the growth of water treatment assistive technologies such as TOC, BOD, COD, and other parameter-based equipment.

FIGURE 26. WASTEWATER TREATMENT (% POPULATION CONNECTED)



Source: OECD.Stats, 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

Freshwater is considered a finite resource, which is crucial for agriculture, industry, and human existence. If freshwater is unavailable in adequate quantity and appropriate quality, the goals for sustainable development cannot be attained. Water pollution coupled with wasteful use of freshwater threatens the future of development projects globally.

While the degradation of water quality is almost invariably the result of human activities, certain natural phenomena have also resulted in the reduction of water quality below the standard required for different purposes. Natural calamities such as torrential rainfall and hurricanes also lead to excessive erosion, mudflows, and landslides, which increase the content of suspended materials in rivers and lakes. In addition, naturally occurring areas of trace metals, high nutrients, trace metals, salts, and other constituents also limit the use of water. Common examples include salinization of surface waters through evaporation in semi-arid and arid regions. Another example can be the high salt content of some aquifers under some geological conditions. For instance, some aquifers have a high content of carbonates, and thus treatment before use for industrial applications is a necessity.

Almost all human activities can and do have an adverse impact on water quality. Water quality is influenced by Non-Point Source Pollution (NSP) through farming activities as well as Point-Source Pollution (PSP) mainly coming from sewage treatment and industrial discharge. Agricultural pollutants include excessive nutrients such as nitrates and phosphates, pesticides and fertilizers, sediments, and fecal microbes. Release of toxic chemicals and wastewater from factories and industries, over-flows from aquifers, long-range atmospheric transport of pollutants are among some major causes of water quality degradation currently.

6.2.1. OPPORTUNITIES FOR CONTRACTORS OR TECHNOLOGY/EQUIPMENT PROVIDERS

Demand for water for municipal and industrial use has increased in parallel with expanding urbanization and industrialization in countries across the globe. This offers major growth potential for players operating in the water and wastewater treatment market as well as governments to focus on innovation and more advanced solutions, particularly in the areas of infrastructure, technologies, and services. Major replacement or upgrade is required for many current water and wastewater treatment plants to be able to cater to the more demanding standards. At both the federal and state government levels, environmental clearances from pollution control bodies are a required. In addition, there has been a large investment gap in this market, which can be bridged by the private sector by choosing the right technologies, ratcheting up funding sources, and putting plans into action. Municipal wastewater collection, treatment and reuse presents the opportunity for both environmental restoration and for addressing rising water needs of various economic sectors.

For many economies, like India for instance, moving toward a circular economy is essential for guaranteeing social and economic stability. To do this, a framework that makes use of clever legislation, market-based tools, research and innovation, incentives, and information sharing for voluntary initiatives can be created. Also, rather than relying on solutions at the end of the product life, technology or equipment providers should be able to focus on building ways through the value chain. This can be accomplished by lowering the amount of energy used in production, reducing the volume of water needed to deliver services, thereby developing a market for secondary raw materials, encouraging and supporting waste reduction and high-quality waste separation by consumers, and facilitating clustering of activities so as to prevent by-products from becoming waste. In addition, freshwater allotment for drinking in urban and rural areas must be rationalized to account for the specific industry. Adopting micro irrigation techniques should similarly promote efficient water use in agriculture applications. For wastewater to be recycled and reused, each of these uses should be dependent on the others.

India mostly imports water treatment equipment from the U.S., China, and other economies. However, businesses with offices in India of all sizes and specialties will discover exciting market potential in the country, especially if these businesses provide goods and services for gathering, transporting, treating, monitoring, and analysis of water and wastewater for a variety of end-uses and consumers. There are currently well-established water treatment companies in India that offer cutting-edge technologies, but some face difficulties that must be overcome and solutions explored, which in future could open and present major revenue potential and expansion opportunities for market players.

Companies can focus on specializing in the following infrastructure solutions, technologies, and services, which will be well-positioned to cater to needs in the market and can provide great opportunities. Some include:

- Integrated solutions such as performing feasibility studies, designing, technical consulting and providing operation and online maintenance services; and successfully offer such solutions.
- Companies should consider entering into Joint Venture (JV) or other types of partnerships or mergers with strategic depth
- Systems and equipment for water supply, sewerage treatment, as well as efficient use and reuse of water; such offerings should be addressed primarily to industrial sectors which account for a high degree of pollution
- Develop advanced technical designs and equipment for wastewater systems (collection, conveyance, monitoring, and analysis)
- Innovate with equipment for wastewater treatment, including treatment technologies, biogas regeneration through anaerobic treatment of municipal and industrial wastewater
- Technical designs, equipment and maintenance of equipment for disinfecting water by electrolysis
- Explore more solutions for the efficient use of water.
- Instruments to analyse water (including water-saving devices for private households)

- Water purification systems for municipal, community, and household use
- Technical designs and equipment for rainwater harvesting systems
- Equipment for water saving and water recycling
- Systems for rehabilitation of sewage (including septic system rehabilitation)
- Packaged and transportable sewerage and wastewater treatment systems

These requirements can be transformed into growth opportunities by key players such as contractors and technology, or equipment providers in the future.

6.3. 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 waste water 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

Rain Water 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. Due to an exponential increase in urban population, this would be a challenge for water management in the country. 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.

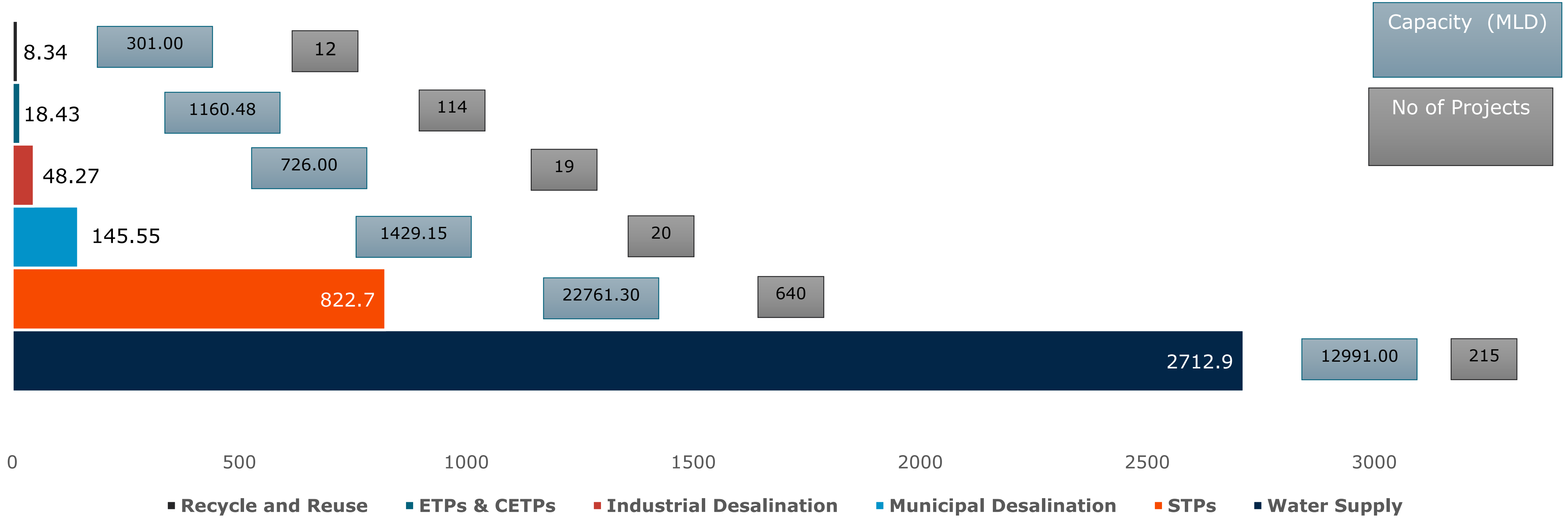
6.3.1. WASTEWATER SCENARIO IN INDIA

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 27. 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 6. 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 7. 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 8. 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

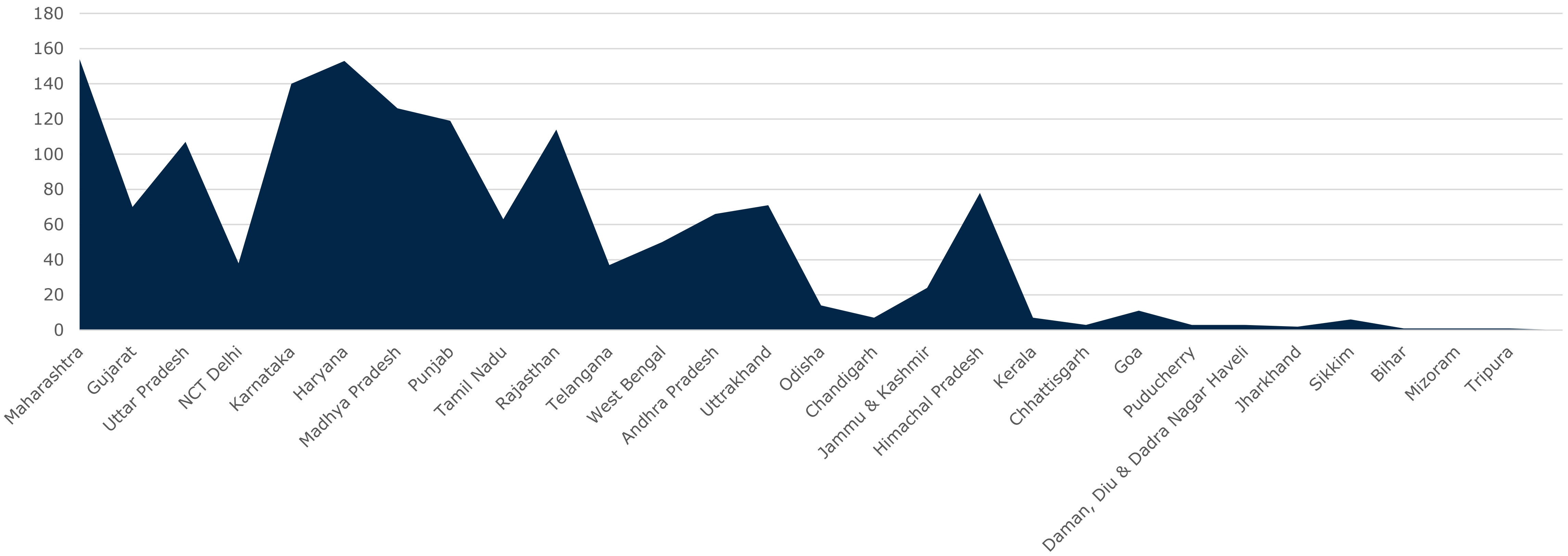
Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

The 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. 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 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 28. STATE-WISE INSTALLED STP'S

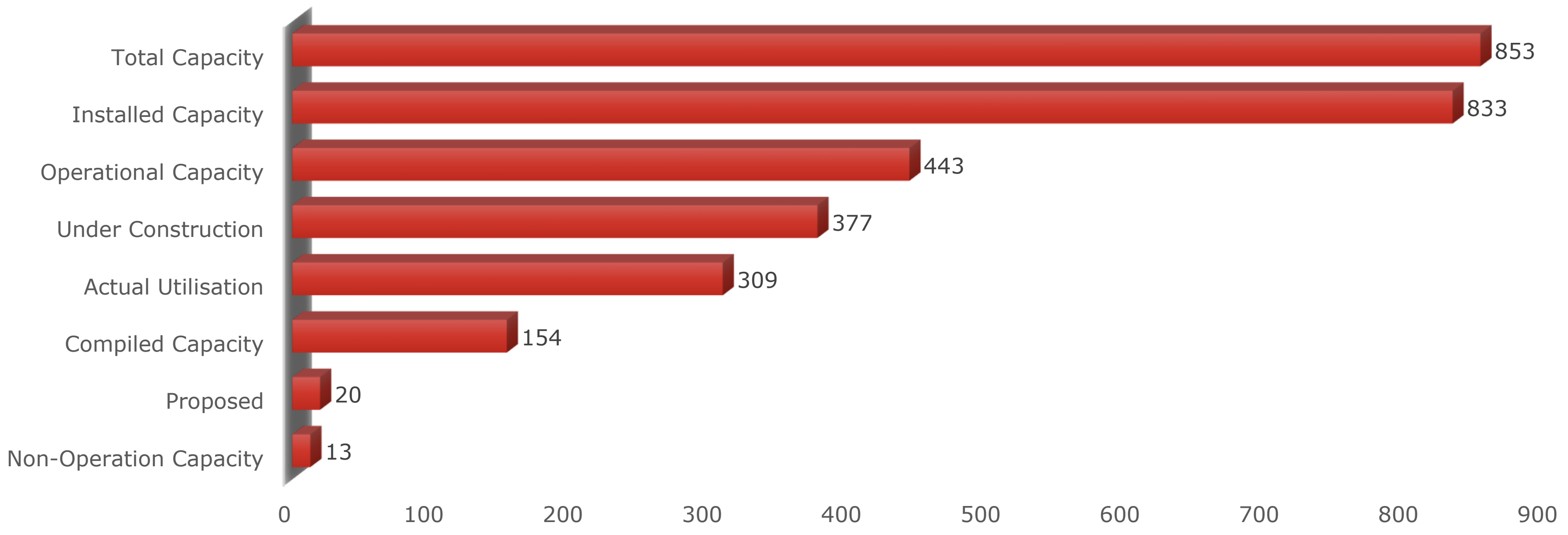


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.1. 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 29. SEWAGE TREATMENT CAPACITY (MLD) – ANDHRA PRADESH

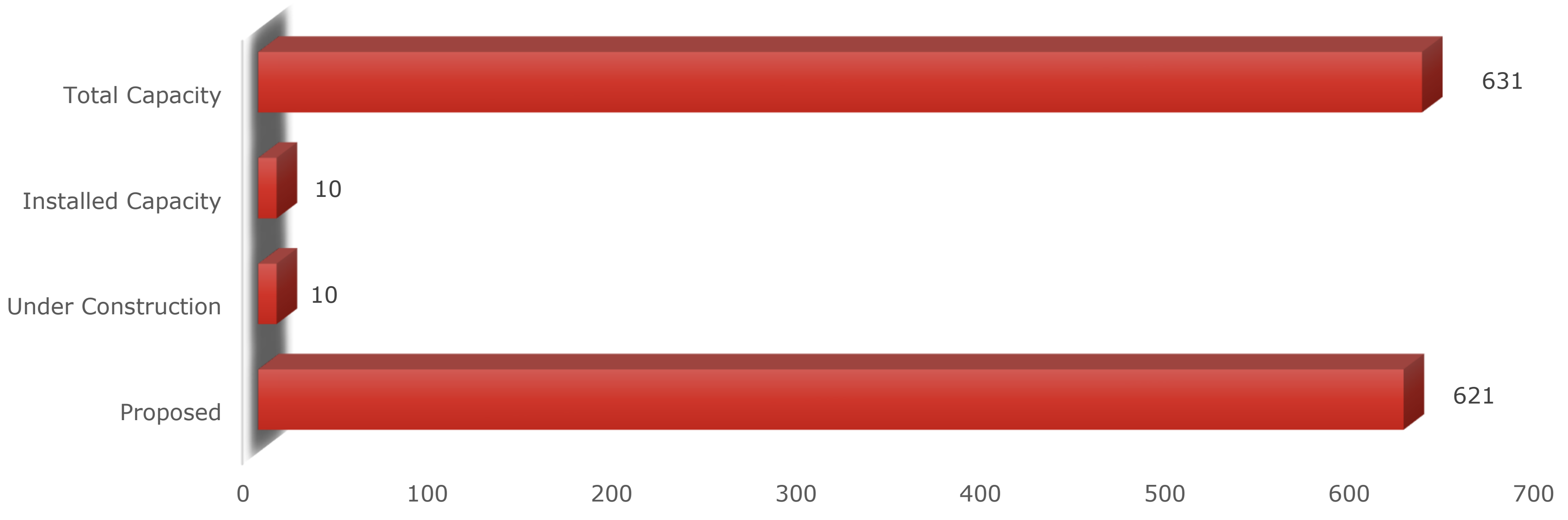


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.2. 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 30. SEWAGE TREATMENT CAPACITY (MLD) – BIHAR

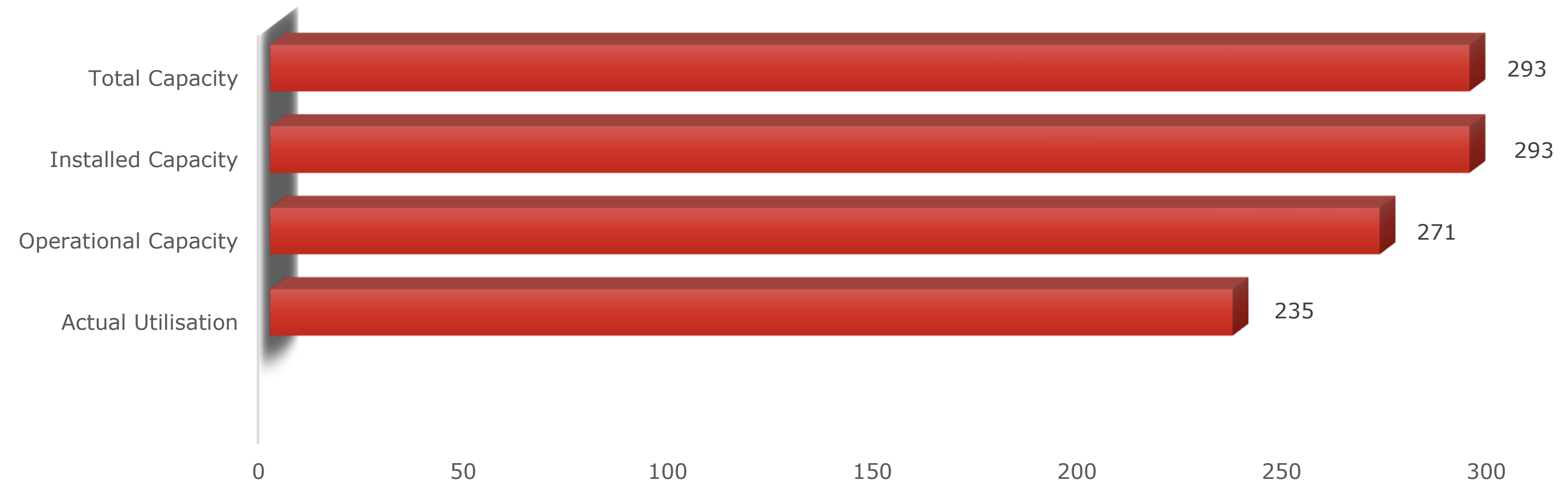


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.3. 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 31. SEWAGE TREATMENT CAPACITY (MLD) – CHANDIGARH

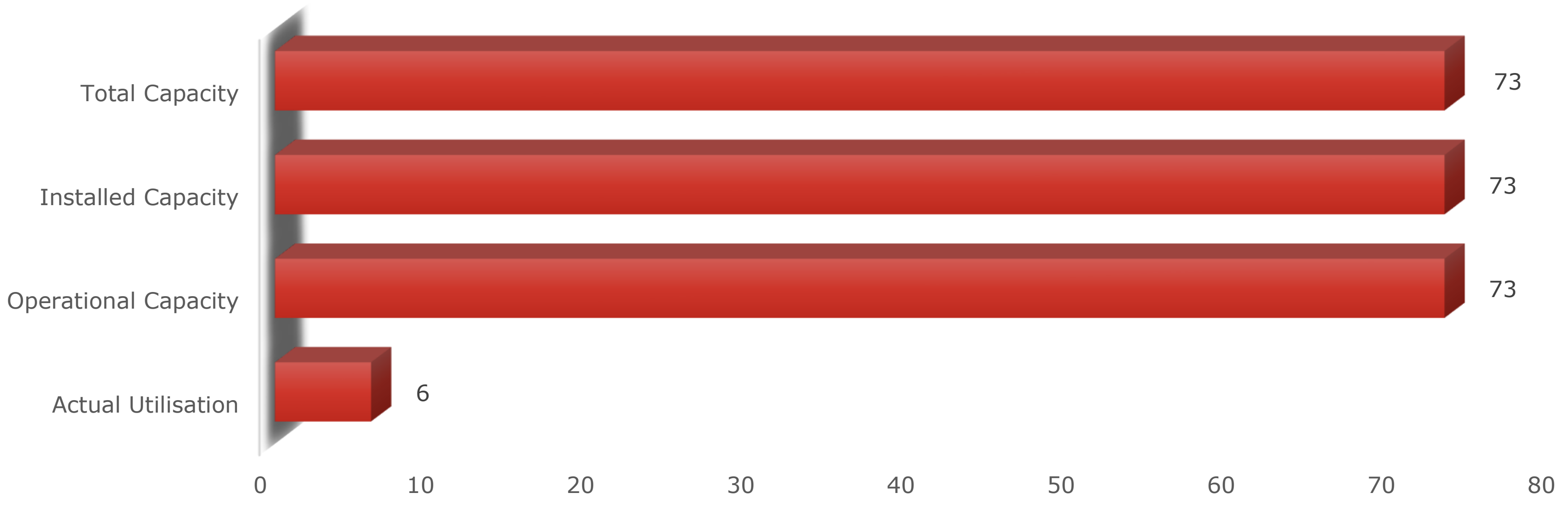


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.4. 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 32. SEWAGE TREATMENT CAPACITY (MLD) – CHHATTISGARH

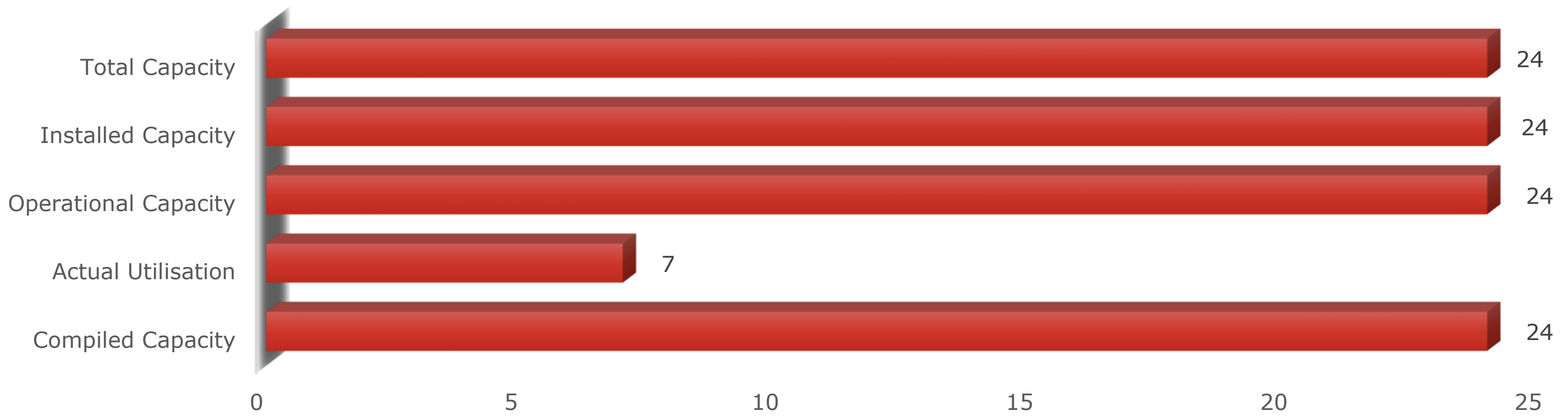


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.5. 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.

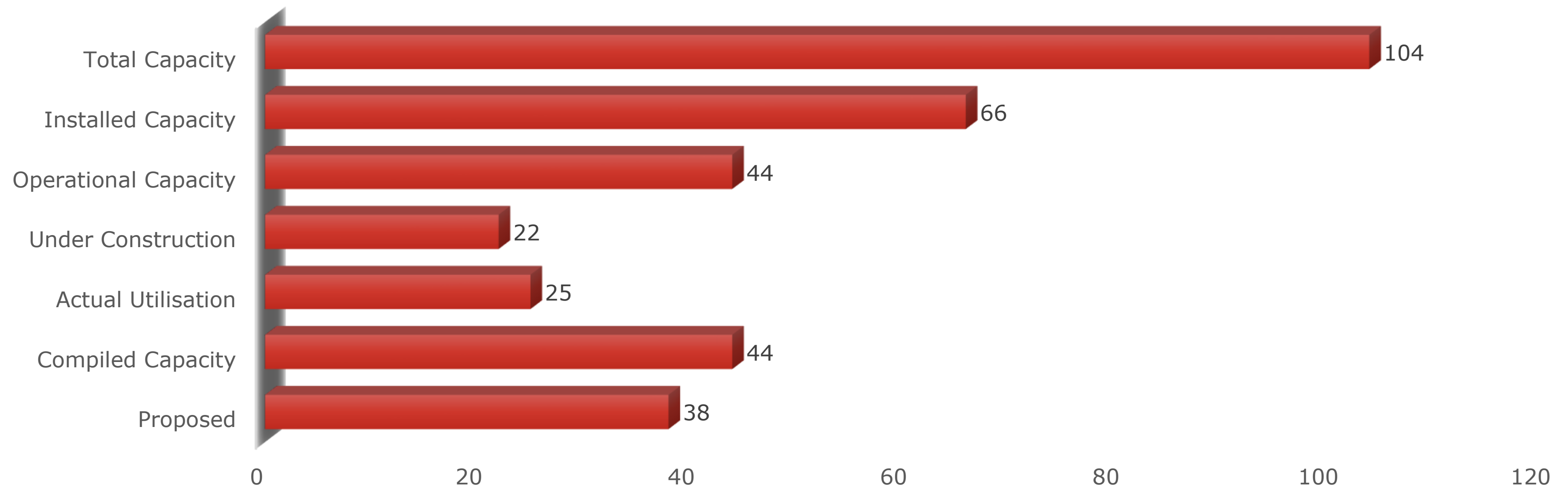
FIGURE 33. SEWAGE TREATMENT CAPACITY (MLD) – DAMAN DIU & DADRA NAGAR HAVELI



6.3.1.6. 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 following standards.

FIGURE 34. SEWAGE TREATMENT CAPACITY (MLD) – GOA

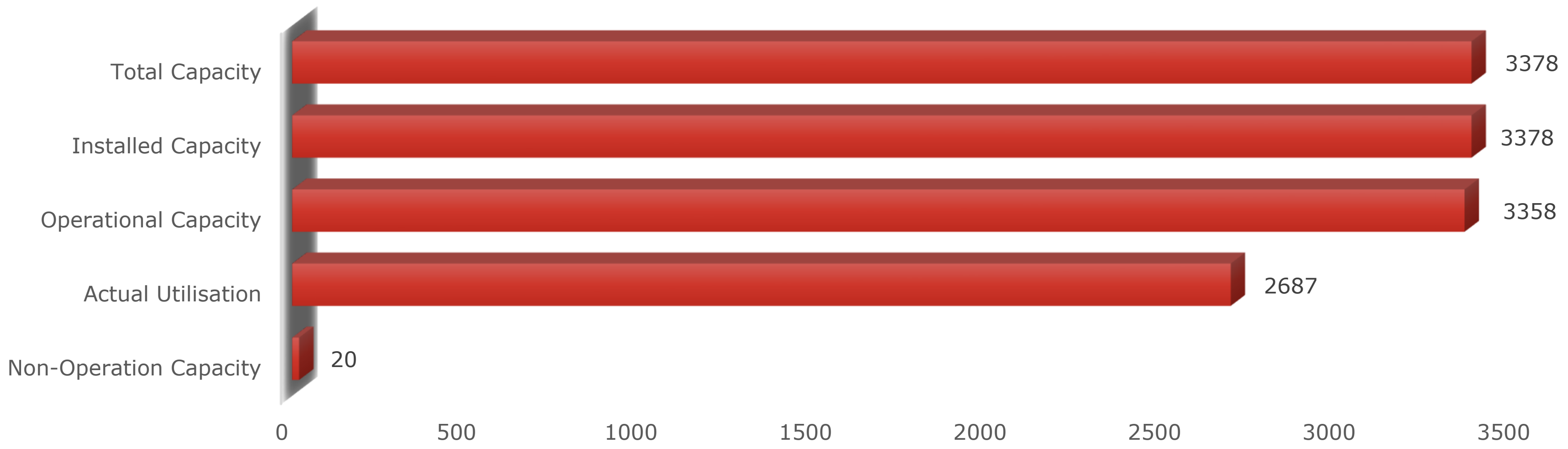


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.7. 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 35. SEWAGE TREATMENT CAPACITY (MLD) – GUJARAT

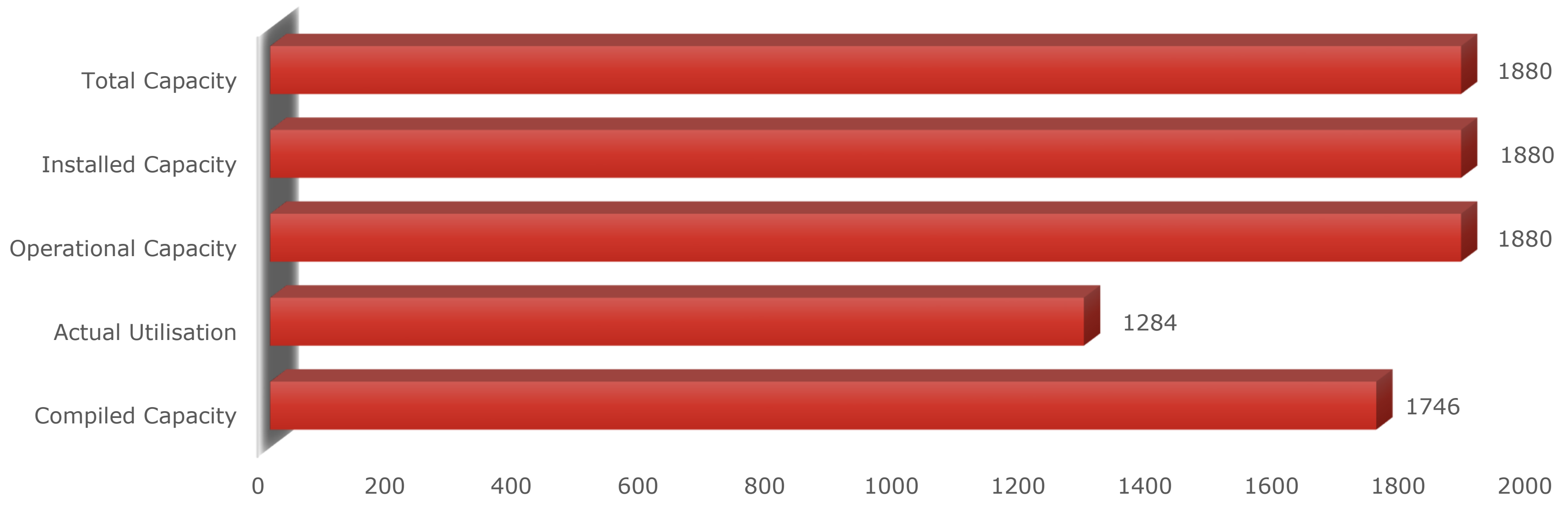


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.8. 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 36. SEWAGE TREATMENT CAPACITY (MLD) – HARYANA

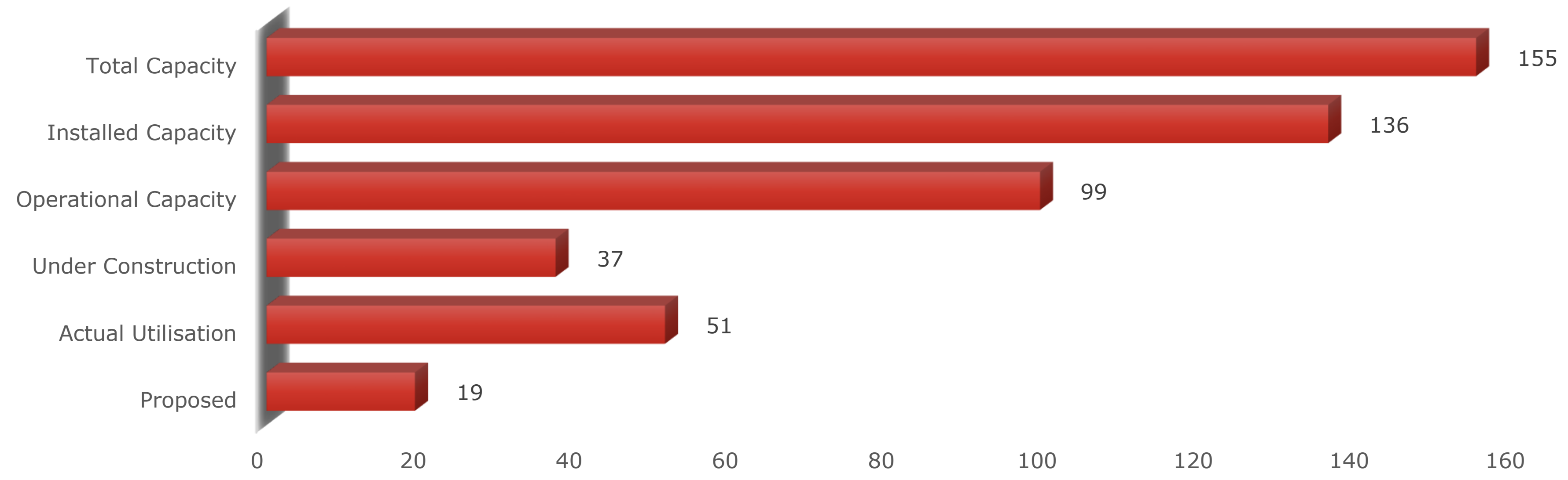


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.9. 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 37. SEWAGE TREATMENT CAPACITY (MLD) – HIMACHAL PRADESH

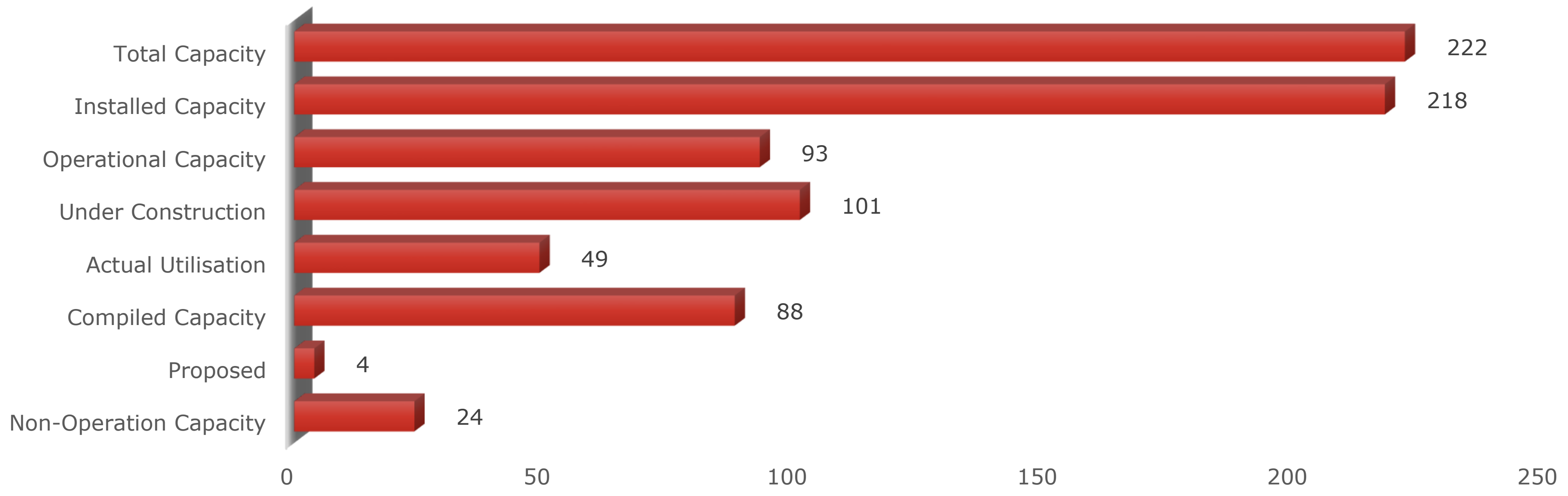


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.10. 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 38. SEWAGE TREATMENT CAPACITY (MLD) – JAMMU & KASHMIR

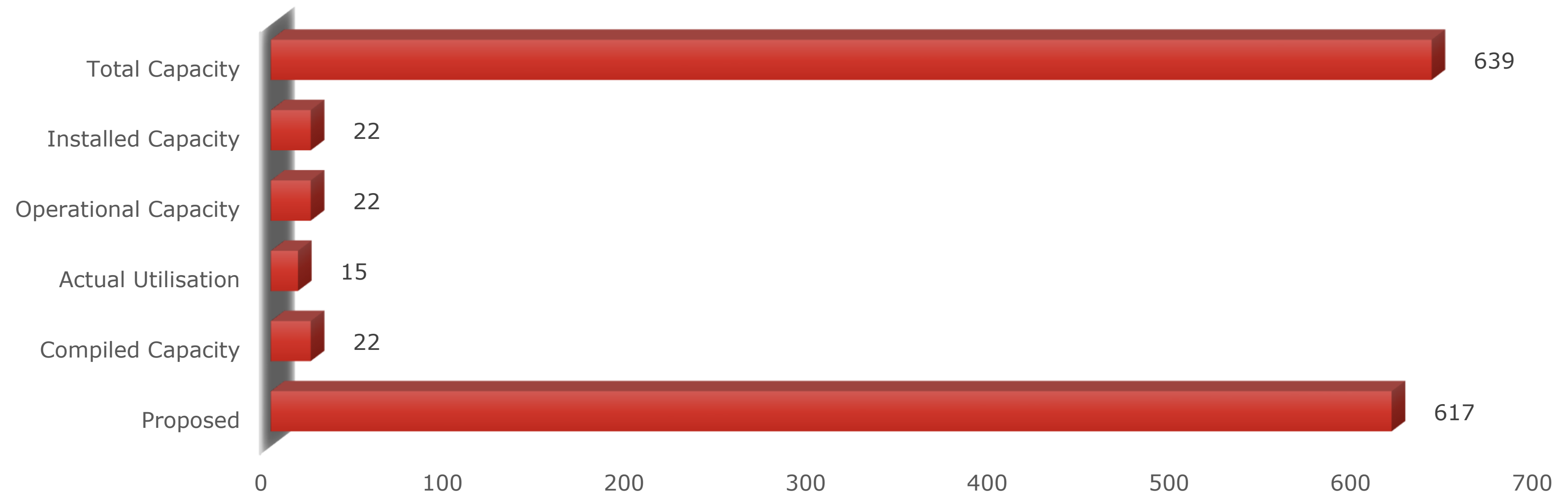


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.11. 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 39. SEWAGE TREATMENT CAPACITY (MLD) – JHARKHAND

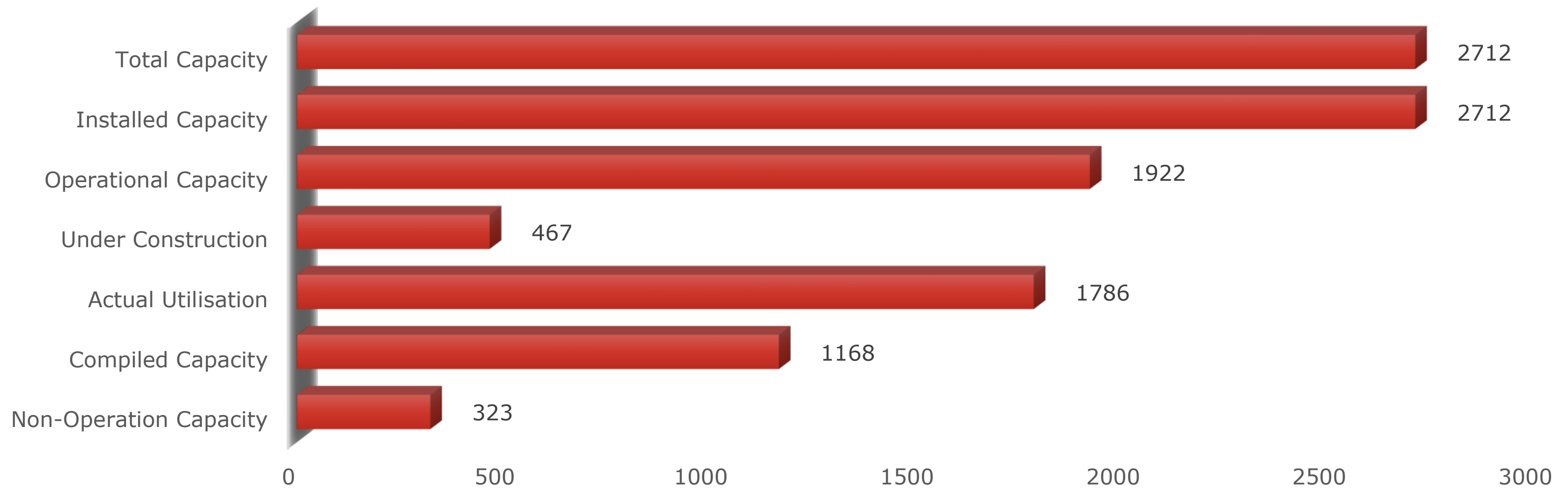


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.12. 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 40. SEWAGE TREATMENT CAPACITY (MLD) – KARNATAKA



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

The state of Karnataka has emerged as a pioneer in sustainable water resource management, taking significant strides to address the challenges posed by water scarcity and pollution. Through a series of innovative initiatives, Karnataka has positioned itself at the forefront of the water and wastewater industry, showcasing a commitment to environmental conservation and long-term water security.

Jaladhare Project: One of the flagship initiatives is the "Jaladhare" project, a comprehensive water conservation and management program. This project focuses on watershed development, rainwater harvesting, and rejuvenation of traditional water bodies. By leveraging technology and community participation, the state aims to recharge groundwater levels and ensure a sustainable supply of water for agricultural and domestic use.

Reuse and Recycle Policies: Karnataka has implemented robust policies to promote the reuse and recycling of wastewater. The state government has incentivized industries and municipalities to adopt advanced wastewater treatment technologies, reducing the burden on freshwater sources. By encouraging the use of treated wastewater for non-potable purposes such as industrial processes and irrigation, Karnataka aims to minimize water wastage and promote a circular water economy.

Smart Water Metering: In a bid to enhance water efficiency and curb unauthorized water usage, Karnataka has introduced smart water metering systems. These meters enable real-time monitoring of water consumption, allowing for accurate billing and early detection of leaks. The deployment of smart meters not only ensures fair distribution of water resources but also encourages consumers to adopt water-saving practices.

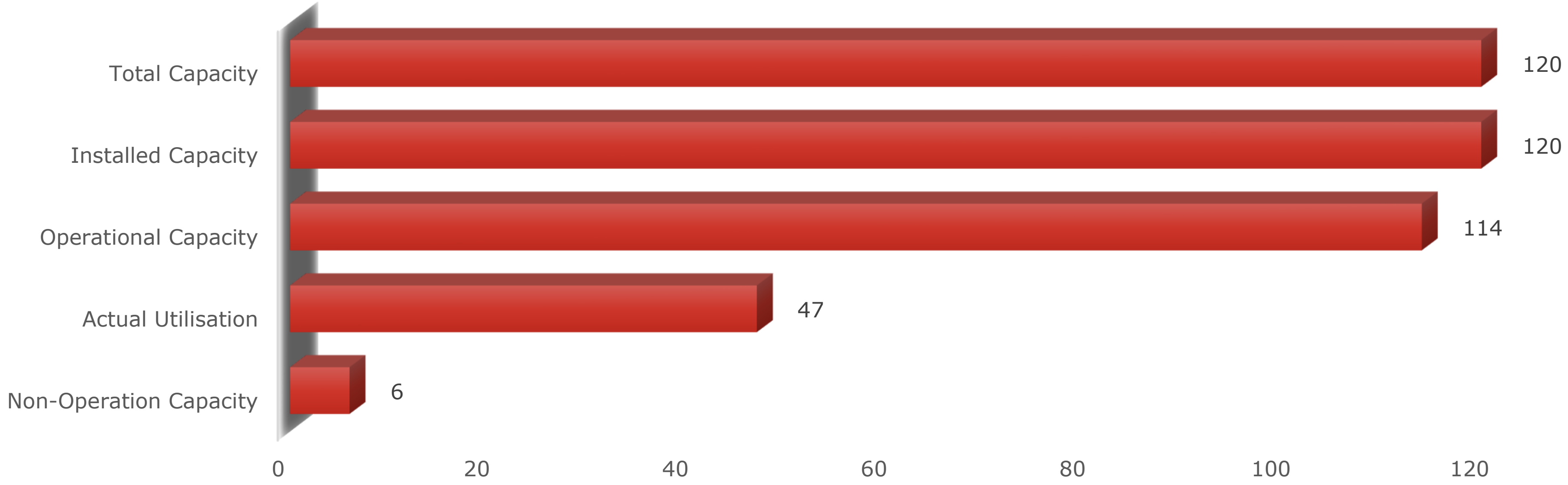
Public-Private Partnerships (PPPs): The state has actively engaged in fostering collaborations between the public and private sectors to augment the water and wastewater infrastructure. Through PPPs, Karnataka seeks to harness the expertise and resources of the private sector to develop and maintain state-of-the-art water treatment plants, distribution networks, and sewage treatment facilities. This approach facilitates the efficient delivery of water services while leveraging private investments.

Capacity Building and Awareness Programs: Recognizing the importance of community involvement, Karnataka has initiated extensive capacity-building programs and awareness campaigns. These efforts aim to educate citizens about the importance of water conservation, proper wastewater disposal, and sustainable water management practices. By fostering a sense of responsibility among the populace, the state aims to create a culture of water consciousness and stewardship.

6.3.1.13. 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 41. SEWAGE TREATMENT CAPACITY (MLD) – KERALA

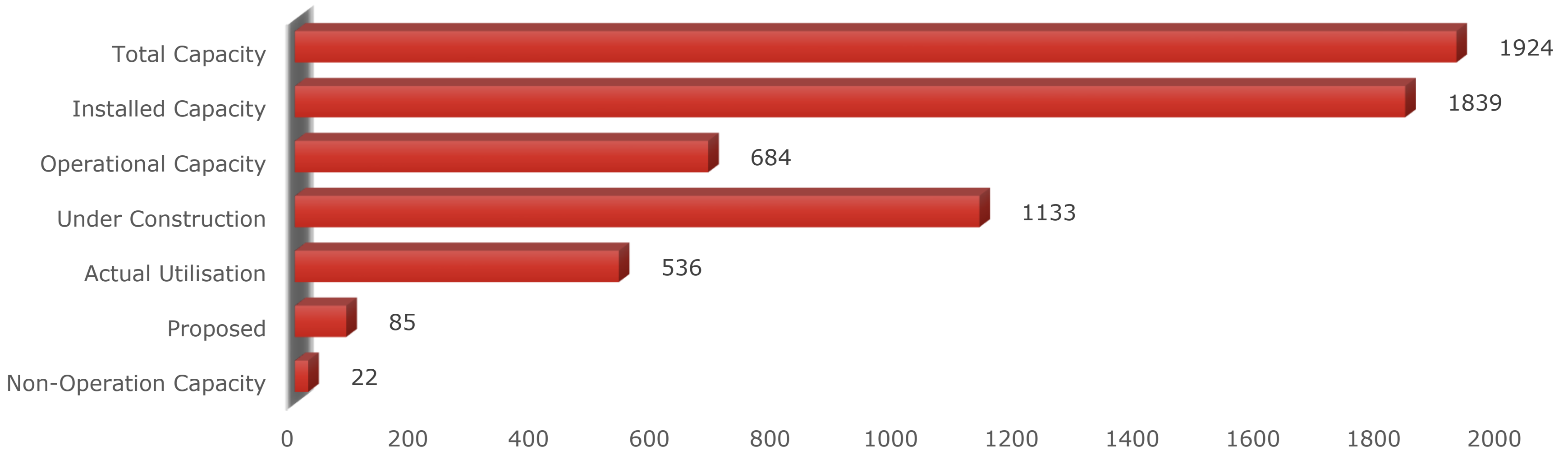


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.14. 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.

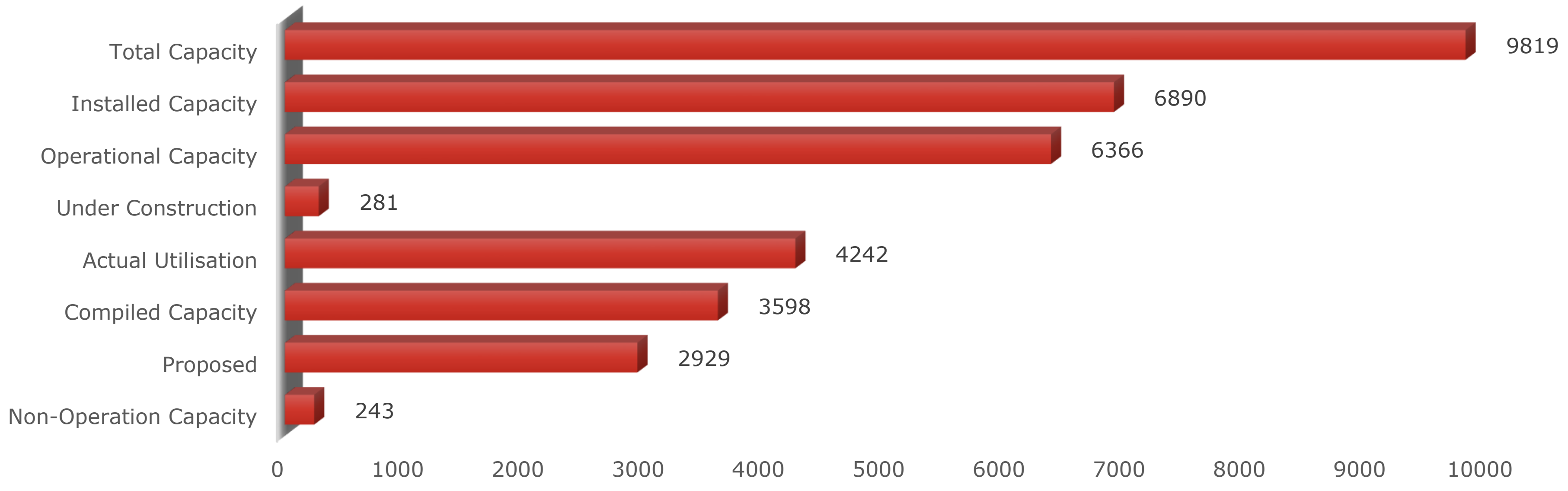
FIGURE 42. SEWAGE TREATMENT CAPACITY (MLD) – MADHYA PRADESH



6.3.1.15. 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.

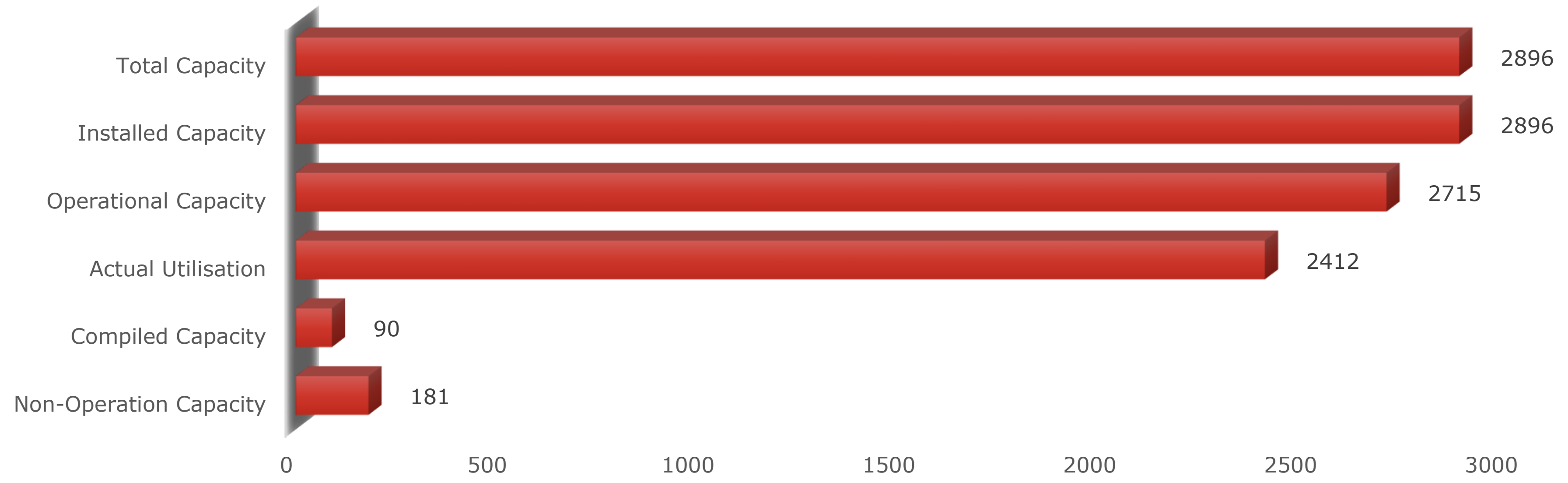
FIGURE 43. SEWAGE TREATMENT CAPACITY (MLD) – MAHARASHTRA



6.3.1.16. 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 44. SEWAGE TREATMENT CAPACITY (MLD) – NCT DELHI

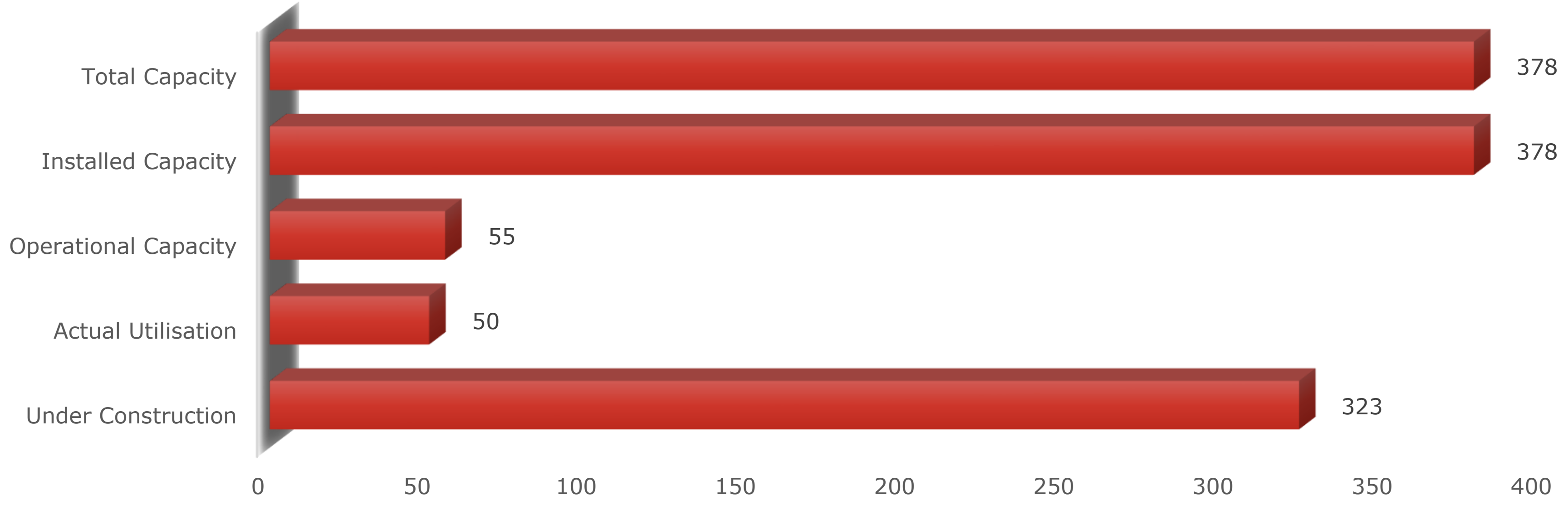


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.17. 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 45. SEWAGE TREATMENT CAPACITY (MLD) – ODISHA

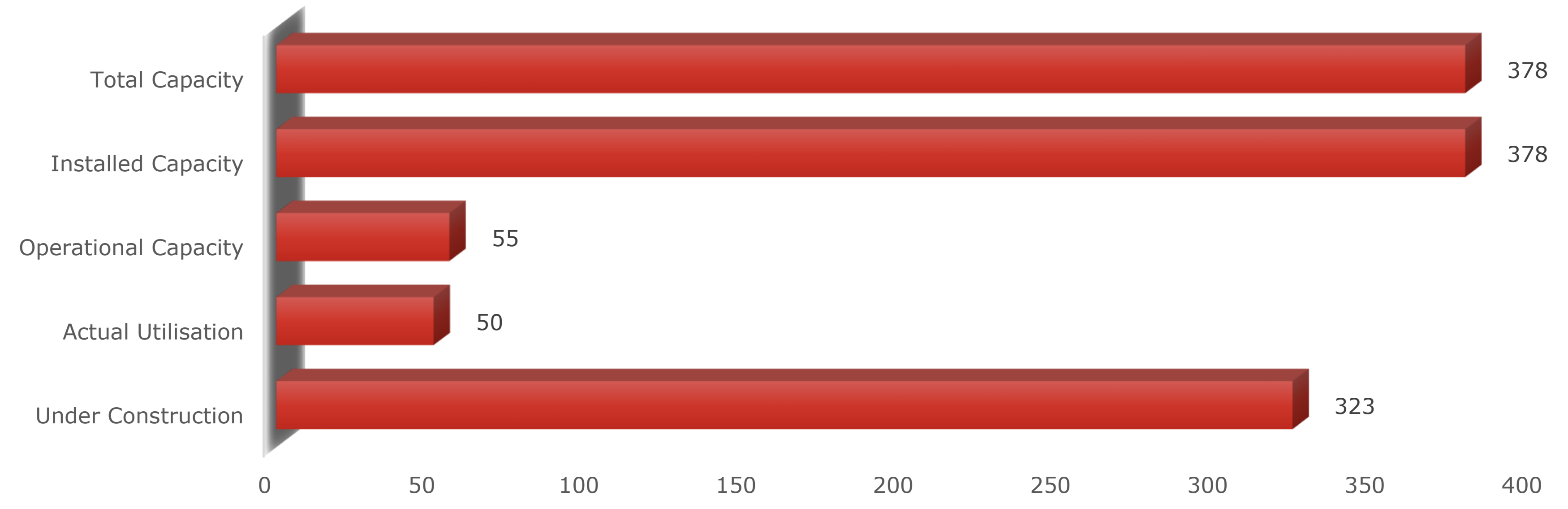


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.18. 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 46. SEWAGE TREATMENT CAPACITY (MLD) – PUDUCHERRY

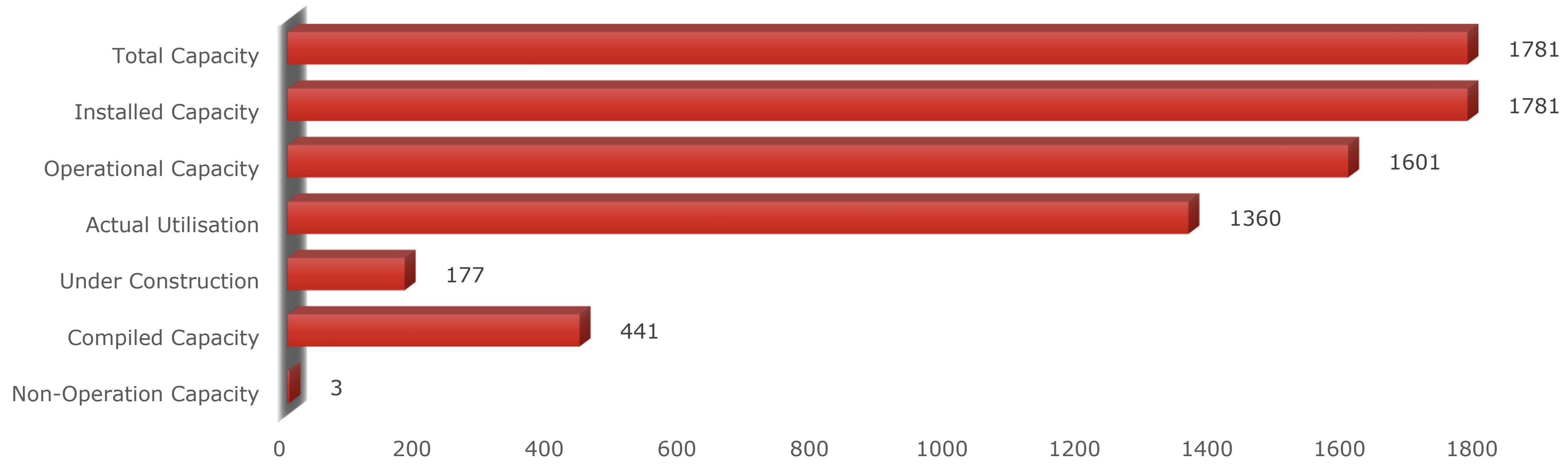


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.19. 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 47. SEWAGE TREATMENT CAPACITY (MLD) – PUNJAB

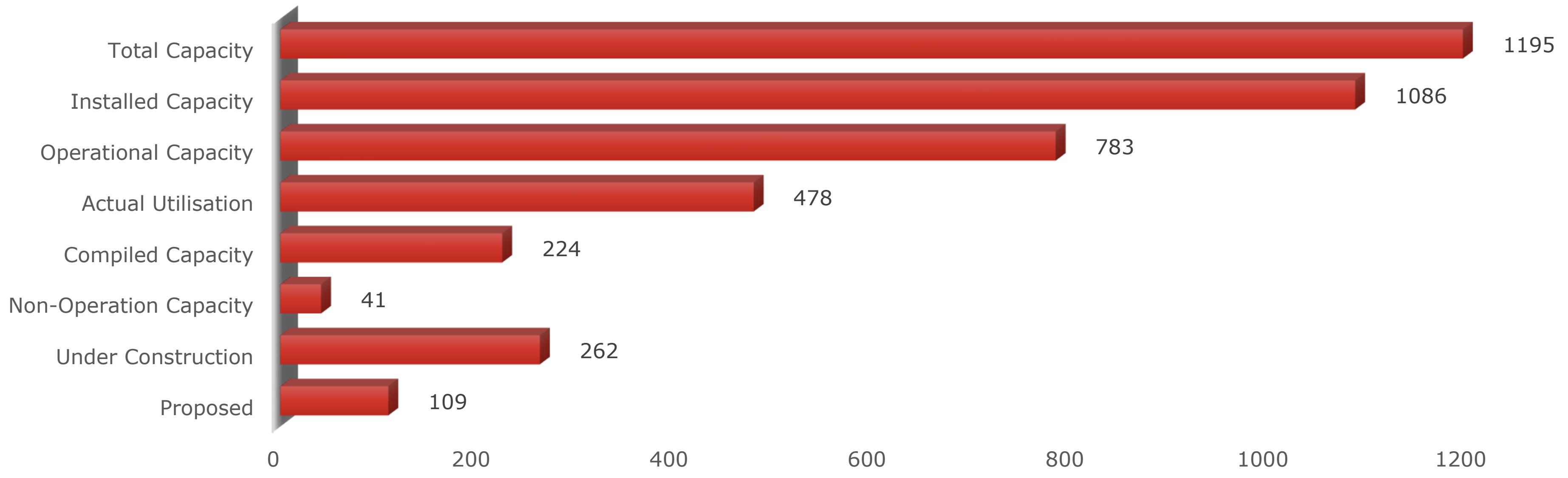


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.20. 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 48. SEWAGE TREATMENT CAPACITY (MLD) – RAJASTHAN

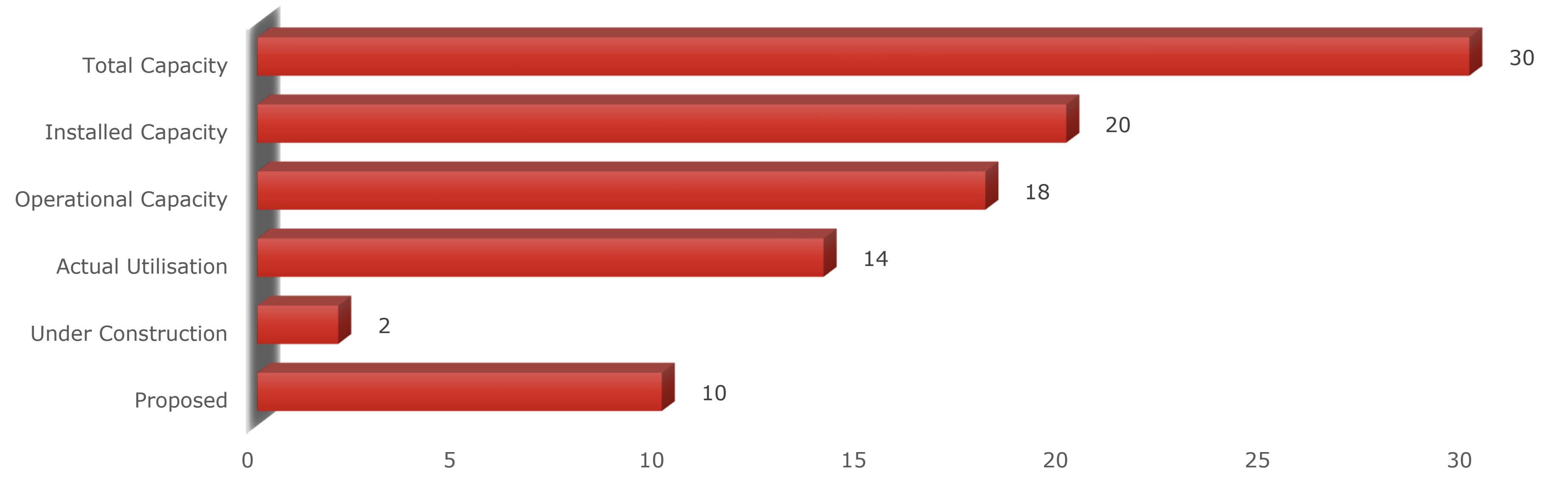


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.21. 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 49. SEWAGE TREATMENT CAPACITY (MLD) – SIKKIM

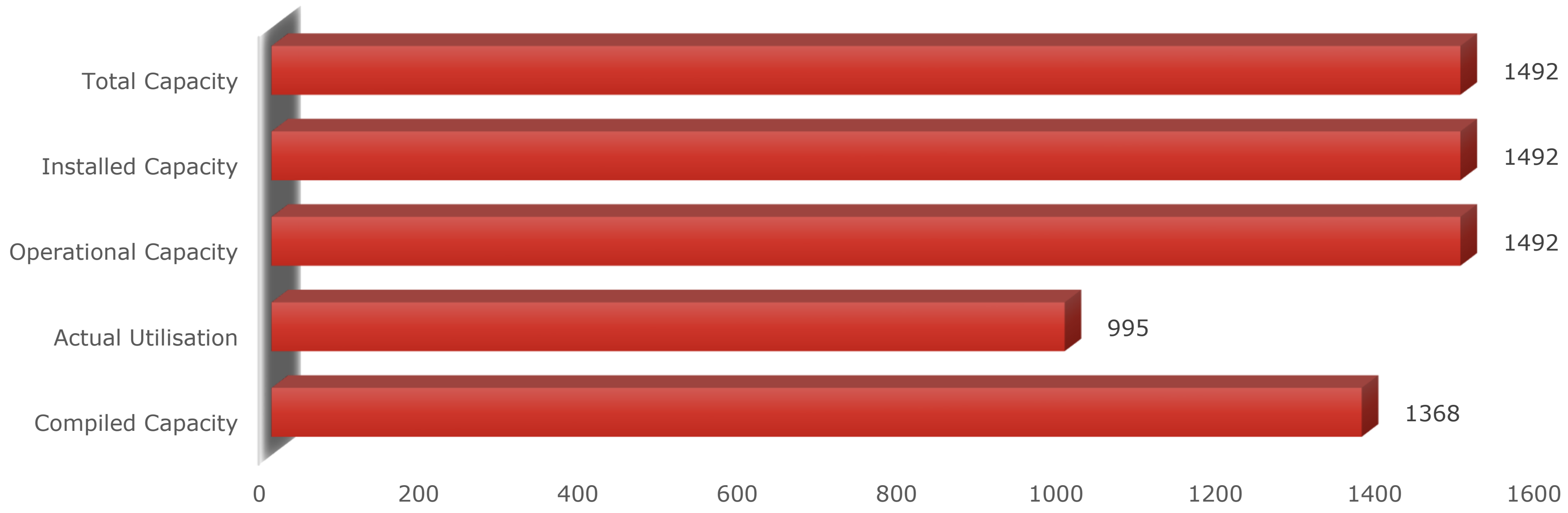


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.22. 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 50. SEWAGE TREATMENT CAPACITY (MLD) – TAMIL NADU

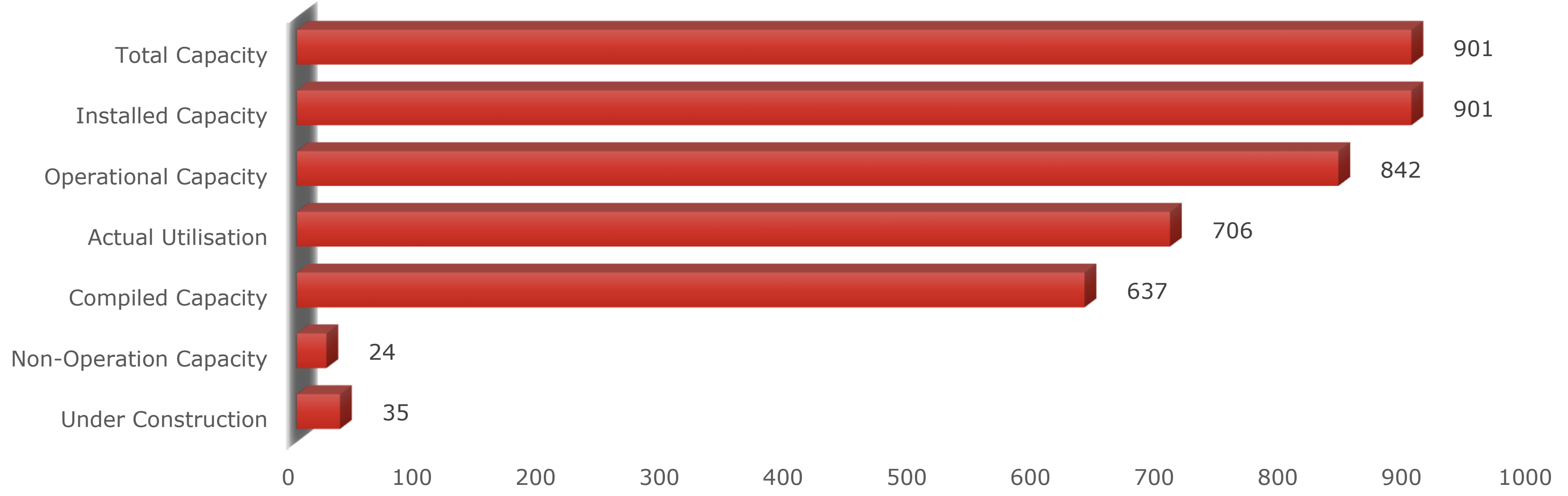


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.23. 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 51. SEWAGE TREATMENT CAPACITY (MLD) – TELANGANA

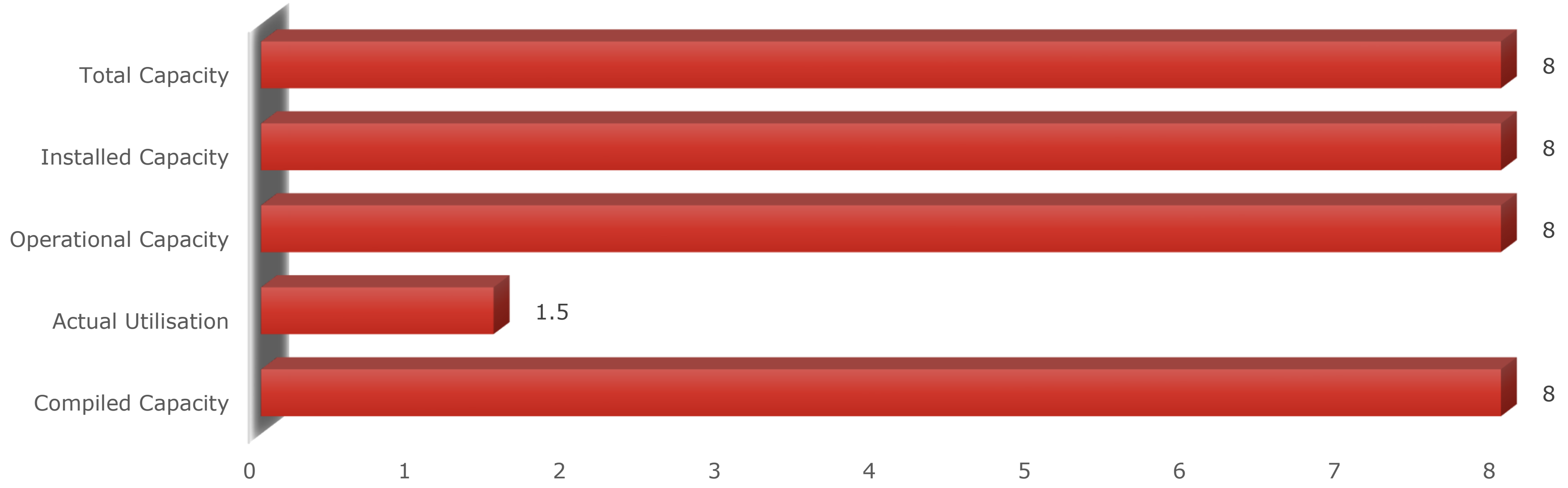


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.24. 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 52. SEWAGE TREATMENT CAPACITY (MLD) – TRIPURA

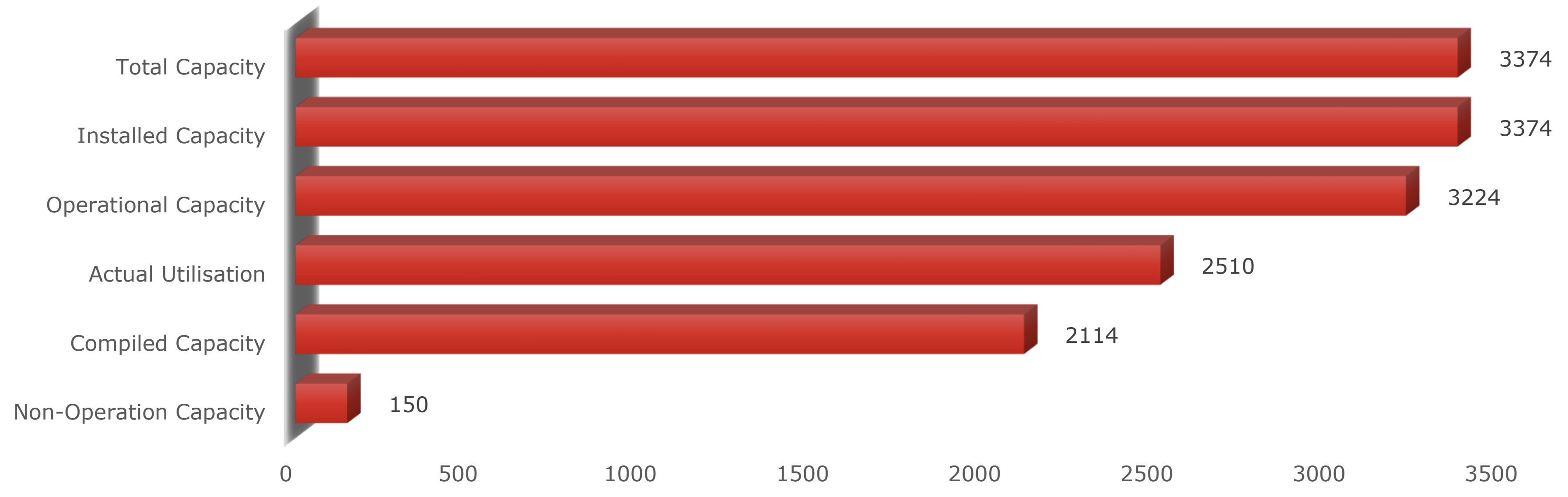


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.25. 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 53. SEWAGE TREATMENT CAPACITY (MLD) – UTTAR PRADESH

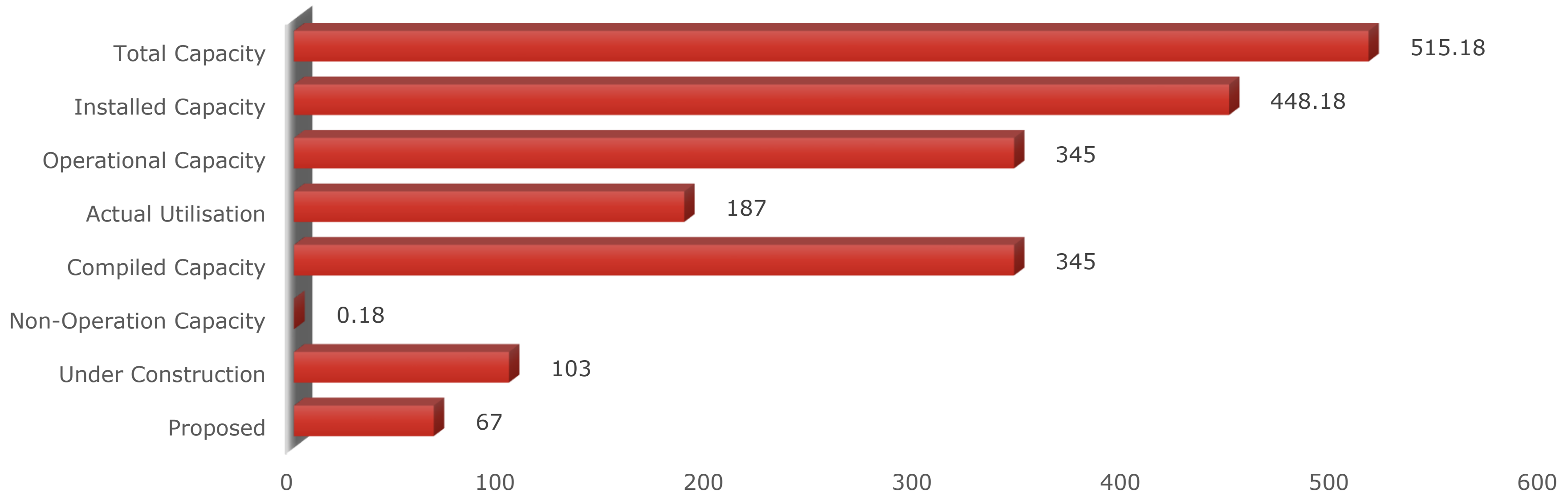


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.26. 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 54. SEWAGE TREATMENT CAPACITY (MLD) – UTTARAKHAND

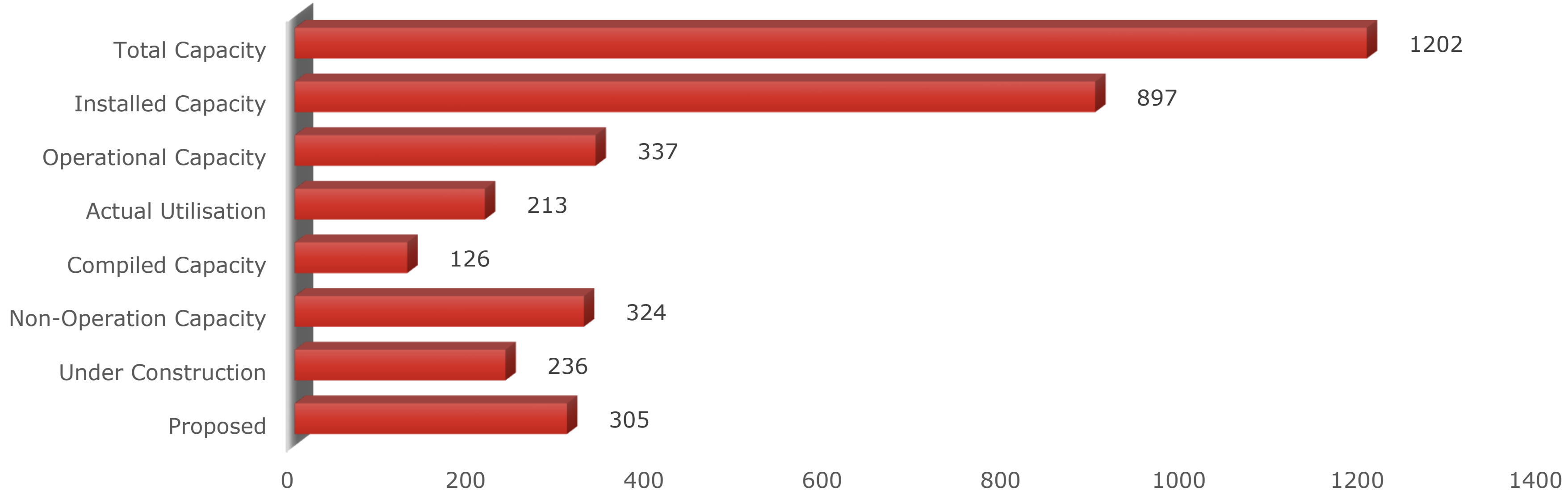


Source: Central Pollution Control Board, National Inventory of Sewage Treatment Plants

6.3.1.27. 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 55. 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.

TABLE 9. STATE-WISE DETAILS OF SEWERAGE GENERATION AND STP CAPACITY AS PER NGT ORDER, DECEMBER 2023

Sn. No.	State / UT	Sewage Generation (in MLD)	Existing STP capacity (in MLD)	Capacity Utilization as shown in data (In MLD)	Gap in Treatment at present (in MLD)
1	Andhra Pradesh	1503.2	535.45	382.81	1120.39
2	Arunachal Pradesh	236.48	Nil	Nil	236.48 (NGT accounted gap for 100 MLD)
3	Assam	435.35	-	-	435.35
4	Bihar	2371 (110 ULBs)	178.73	-	2193

Sn. No.	State / UT	Sewage Generation (in MLD)	Existing STP capacity (in MLD)	Capacity Utilization as shown in data (In MLD)	Gap in Treatment at present (in MLD)
5	Chandigarh	220	242.63	216.75	3.25
6	Chhattisgarh	600	360.5	178.6	421.4
7	Delhi	3482	2865	2403	1079
		(768 MGD)	(632 MGD)		
8	Goa	52.09	80.35	-	4.72
9	Gujarat	4414	4754	3409	1005
10	Haryana	Urban: 1508	1835	1465	43
		Rural: 104.5	56.37	56.37	48.13
11	Himachal Pradesh	91.95	114.8	Not given	22.15
12	J&K	523	242.4	242.4	144.82

Sn. No.	State / UT	Sewage Generation (in MLD)	Existing STP capacity (in MLD)	Capacity Utilization as shown in data (In MLD)	Gap in Treatment at present (in MLD)
13	Karnataka	3356.5	1929.1	1929.1	1427.4
14	Kerala	1192 Sewage	-	-	42.3
		2783 Sullage			(1000 MLD)
15	Lakshadweep	2.83	2.83	2.83	0
16	Madhya Pradesh	Urban: 2183.7	1311.99	696.03	1487.73
17	Maharashtra	9758.53	4338.2	4338.2	5420.33
18	Meghalaya	51	0.115	0.115	51
19	Nagaland	91.2	-	-	91.2
20	Odisha	642.373	128	128	514
21	Puducherry	92.1	56	56	36.1

Sn. No.	State / UT	Sewage Generation (in MLD)	Existing STP capacity (in MLD)	Capacity Utilization as shown in data (In MLD)	Gap in Treatment at present (in MLD)
22	Rajasthan	1551	1085	700	1250
23	Sikkim	Urban: 18.79	18.79	18.79	0
		Rural: 28.89			
		Total: 47.68	22.5	22.5	25.18
24	Tamil Nadu	4001.02	3139.04	2519.54	1031.77
				3139.04	
25	Telangana	2750	925.58	925.58	1824.42
26	Tripura	Urban: 82.4	8.72	-	73.68
		Rural: 145.03	25.83	-	119.2
27	Uttar Pradesh	5500	3860	Not given	1640

Sn. No.	State / UT	Sewage Generation (in MLD)	Existing STP capacity (in MLD)	Capacity Utilization as shown in data (In MLD)	Gap in Treatment at present (in MLD)
					-2500
28	Uttarakhand	484.78	425	Not given	59.78 (in terms to treatment capacity)
29	West Bengal	2758	1505.85	1268	1490
30	Punjab	2128 (166 ULBs)	1786	1429	700
31	Andaman & Nicobar	19.20 (PBMC) 2.55 (GP) 21.75	2.303	2.303	16.897
32	Manipur	-	Urban: 85	21	64

Sn. No.	State / UT	Sewage Generation (in MLD)	Existing STP capacity (in MLD)	Capacity Utilization as shown in data (In MLD)	Gap in Treatment at present (in MLD)
			Rural: 30	Nil	30
33	Mizoram	51.8	27.84	27.84	23.96
34	Ladakh	18.08	3	3	15.8
35	Dadra & Nagar Haveli & Daman & Diu	Urban: 21.63	34.21	4.39	17.24
		Rural: 71.08	(septic tank/ soak pit)	-	-
		Total: 92.71			
36	Jharkhand	452	Not given	123.74	328.26
Total		52,644.00	31,885.14	22,491.02	25,995.26

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

6.3.1.28. OPPORTUNITIES IN SEWAGE TREATMENT

- **Rising Urbanization and Infrastructure Needs**: Given the rapid urbanization and corresponding increase in sewage generation, there is an urgent need to address the existing sewage treatment gap. Additionally, future treatment capacity requirements must be anticipated and planned for.
- **Utilization of Existing Infrastructure**: Current infrastructure is only being utilized at 75% of its operationalized treatment capacity. Strengthening the sewerage conveyance system, which includes the laying of sewer lines and individual household sewer connections, is crucial to meet current and future demand.
- **Compliance and Operational Standards**: Only 23% of treatment capacity currently meets the agreed-upon standards for State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs). There is a need to focus on the operation and maintenance of treatment facilities to ensure that Sewage Treatment Plants (STPs) achieve the desired quality of treatment.
- **Use of Treated Sewage**: Urban Local Bodies (ULBs) should concentrate on using treated sewage for non-potable applications such as horticulture, irrigation, firefighting, industrial cooling, toilet flushing, non-contact impoundments, and washing (floors, roads, buses, trains, etc.).
- **Industrial Use of Treated Sewage**: Treated sewage should be supplied to industrial clusters or zones for further treatment and utilization as required by the industrial zone.
- **Innovative Approaches and Technology Integration**
  - **Decentralized Treatment Systems**: Implementing decentralized treatment systems, such as community-level STPs, can reduce the burden on central treatment plants and ensure more localized and efficient treatment.

- **Smart Water Management Solutions**: Integrating IoT and AI-based smart water management solutions can optimize sewage treatment processes, improve efficiency, and reduce operational costs.
- **Public-Private Partnerships (PPPs)**: Encouraging PPPs can bring in private sector expertise, investment, and innovative technologies to enhance sewage treatment infrastructure and services.
- **Resource Recovery and Reuse**: Focusing on resource recovery from sewage, such as biogas production, nutrient recovery (phosphorus and nitrogen), and water reuse, can provide additional revenue streams and promote sustainability.
- **Awareness and Capacity Building**: Conducting awareness campaigns and capacity-building programs for stakeholders, including government officials, industry players, and the public, can drive better compliance and adoption of best practices in sewage treatment.

Policy and Regulatory Support

- **Incentives for Compliance**: Providing financial incentives and support for facilities that comply with environmental standards can encourage better performance and adherence to regulations.
- **Strengthening Regulations**: Revisiting and strengthening regulations related to sewage treatment, discharge standards, and penalties for non-compliance can drive improvements in the sector.
- **Monitoring and Reporting**: Establishing robust monitoring and reporting mechanisms to track the performance of STPs and ensure transparency and accountability in sewage management.

6.4. MARKET DROC ANALYSIS

FIGURE 56. 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

6.4.1. MARKET DRIVERS' ANALYSIS

6.4.1.1. 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.

6.4.1.2. 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.

6.4.1.3. 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.

6.4.2. MARKET RESTRAINTS ANALYSIS

6.4.2.1. 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.

6.4.2.2. 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.

6.4.3. MARKET OPPORTUNITIES ANALYSIS

6.4.3.1. 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.

6.4.3.2. 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.

6.4.3.3. 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.

6.4.4. MARKET CHALLENGES ANALYSIS

6.4.4.1. 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.

6.4.4.2. 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. Gujarat, 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.

6.4.4.3. 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.

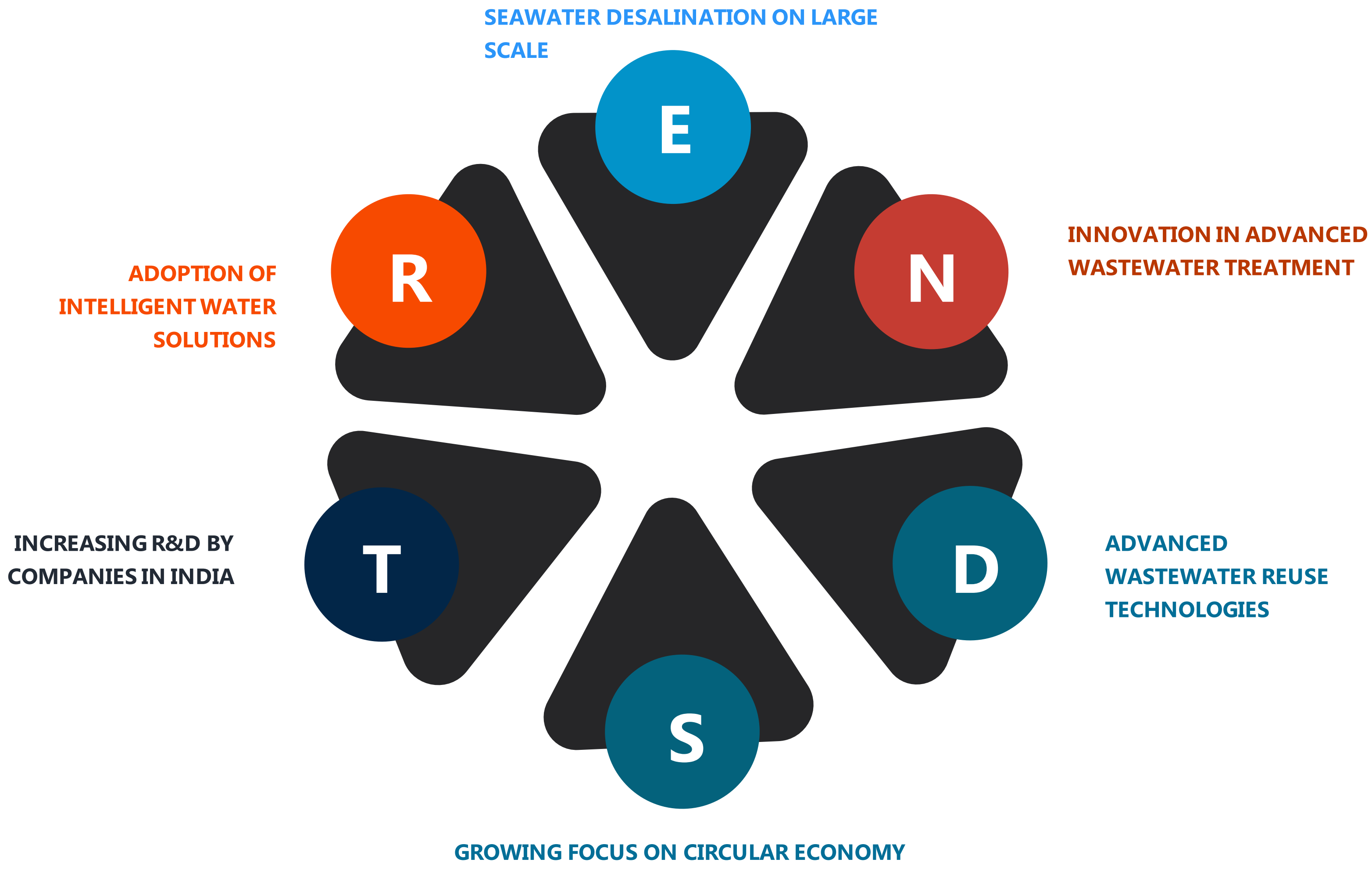
Firstly, the complexity of water treatment technologies and processes demands a deep understanding of both technical aspects and commercial viability. Many stakeholders, including policymakers, investors, and even some industry professionals, may lack the necessary expertise to evaluate the efficiency, 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.

6.5. KEY MARKET TRENDS

FIGURE 57. KEY MARKET TREND ANALYSIS



6.5.1. INCREASING R&D BY COMPANIES IN INDIA

India's water and sewage industries have seen significant development from private players due to available funds and grants for new entrepreneurship. The Startup India program, initiated by the Government in 2016, offers mentors and grants to over 74,750 organizations. Multinational water treatment companies like Evoqua Water Technologies have expanded their presence in India. Evoqua's Indian headquarters in Chennai, established in 2019, includes a Global Engineering and Technology Centre focused on pollution treatment. Major companies like Denta Water & Infrastructure Ltd, Thermax Ltd., Voltas Ltd., GE Water and Process Technologies, and VA Tech WABAG Ltd. offer commercial water filtration solutions. VA Tech WABAG Ltd. partners with the Namami Gange Program to provide clean water solutions. Thermax Ltd. develops resin filtration technologies including products like Tulsion ADS 540 and Tulsion CH 92 for removing radioactive elements and contaminants in sewage and effluent treatment plants.

Nanotechnology research is gaining traction, utilizing nanoparticles to attract pure water and repel impurities. Companies like Voltas Ltd. provide nanofiltration cartridges. Evoqua Water Technologies also offers nanofiltration membranes, useful in desalination projects. Bhabha Atomic Research Center developed an energy-efficient filtration system for water purification in the Punjab region. IIT Madras incubates companies like InnoNano Research Pvt. Ltd., Innodi Water Technologies Pvt. Ltd., Aqueasy Innovations Pvt. Ltd., and VayuJal Technologies Pvt. Ltd. These startups focus on water technology research. InnoNano Research Pvt. Ltd. developed a nanotechnology-based treatment system for anion and metal removal, implemented in multiple Indian villages. Hydromaterials Pvt. Ltd. uses IoT to monitor nanotechnology-enabled arsenic and iron removal. EyeNetAqua Solutions Pvt. Ltd., incubated by the International Centre for Clean Water, employs IoT for smart water sensors that monitor pH levels, nitrate, chlorine, and fluoride. These sensors optimize filtration resources based on water quality. The product aligns with the Jal Jeevan Mission's norms, promoting commercial viability.

Private companies contribute significantly to water treatment technology development in India, partnering with educational institutions and government programs.

Also, Indian startup Peore utilizes nanofiltration technology for water purification. It uses an intelligent semi-permeable membrane with a pore size of 0.001 microns, slightly larger than the pore size of reverse osmosis. This allows the membrane to differentiate between contaminants and essential minerals, ensuring mineral-rich water. Peore’s nanofiltration membranes are configurable based on the type of water supply to produce natural spring-like drinking water. Besides, the startup’s Tru-UV technology features a high reflectivity chamber in which water passes through quartz glass to maximize UV exposure. This deactivates bacteria, viruses, and other microorganisms. This drives advancements in solutions for industries, factories, and municipalities. The expanding role of private enterprises is expected to fuel further progress in the field.

6.5.2. ADOPTION OF INTELLIGENT WATER SOLUTIONS

In India, this global initiative has gained significant importance due to the country's growing water-related challenges. Moreover, the rapid advancements in Artificial Intelligence (AI) and Internet of Things (IoT) technologies are finding applications in various sectors, including manufacturing and production. These technologies, along with the concepts of Industry 3.0 and Industry 4.0, are playing a crucial role in the evolution of the Indian water and wastewater treatment sector. As the demand for efficient water management solutions rises, there is a notable shift towards the adoption of intelligent water systems. These systems prioritize sustainability, energy efficiency, and reduced carbon footprint. For instance, global companies like Hitachi Ltd. have introduced intelligent water systems that integrate smart monitoring controls and data management with water treatment processes. In India, Hitachi has collaborated with the government to implement smart water systems in villages, such as those in the Bhilwara district of Rajasthan, using IoT and Operational Technology (OT) devices.

India faces a pressing need for innovative solutions due to its significant water contamination issues, with around 70% of surface water being contaminated. To address this, companies like Xylem Water Solutions India have developed wastewater management equipment that optimizes energy usage and treatment processes, leading to substantial energy savings. International collaborations are also shaping the Indian water management landscape. Germany's Fraunhofer-Institut für Grenzflächen- und Bioverfahrenstechnik IGB has been working with Indian cities to implement actionable wastewater management plans driven by intelligent integrated networks. In Coimbatore, Tamil Nadu, a smart city project has led to sustainable monitoring and visualization of wastewater management results.

AI-driven solutions are gaining ground in India's water sector. Companies like Greenvironment Innovation & Marketing India are developing AI-based water treatment systems. IoT sensor-based water quality detection is being encouraged, and startups like EyeNetAqua Solutions have emerged, focusing on advanced water quality monitoring. India's abundant sunlight is being harnessed for innovative water purification methods, such as photocatalysis. Gujarat's municipalities are adopting photocatalytic technologies to treat wastewater, with significant budget allocations. Additionally, advanced techniques like automatic variable filtration (AVF) are being embraced by companies like Eureka Forbes Ltd. and Oxive Environment Management Pvt. Ltd., especially for small-scale wastewater management in residential and commercial areas. The Indian water sector is also witnessing the application of biotechnology. Bio-augmentation methods, which involve the introduction of specific microorganisms to chemically transform pollutants, are being employed. Unitech Water Technologies Pvt. Ltd. has developed a product called the Microbial Accelerator, which uses dried microorganisms to treat wastewater. This eco-friendly solution balances oxygen and pH levels and has received support from the India Water Portal, a project by Arghyam.

6.5.3. INNOVATION IN ADVANCED WASTEWATER TREATMENT

37.7 million people are being affected by waterborne diseases such as cholera and typhoid each year in the country, according to a UNICEF report in 2019. The need for more advanced and effective water treatment techniques and approaches are becoming extremely necessary, in order to prevent outbreaks of diseases epidemics, and to secure public health. Advanced waste water treatment can be defined as processes to reduce impurities in water, either through traditional procedures or via biological methods. These methods are focused more on enhancing the efficiency of conventional procedures. Moreover, the effluents of water and waste water treatment plants can be further recycled to conserve water. India's escalating challenges in wastewater management, driven by rapid urbanization, industrialization, and population growth, have necessitated a fundamental shift towards innovation in advanced wastewater treatment. Traditional methods have proven insufficient in tackling the escalating pollution crisis, resulting in dire environmental consequences and health hazards. Acknowledging this urgency, there is a growing momentum towards embracing advanced treatment solutions, signifying a pivotal trend in the country's approach to wastewater management.

Government statistics from the Ministry of Jal Shakti paint a stark reality—over 70% of India's surface water resources are currently contaminated to varying degrees. This alarming scenario has galvanized the Indian government to take proactive measures, prominently represented by flagship initiatives like the "Namami Gange" (Clean Ganga) program and the "Swachh Bharat Mission." These endeavors underscore the pressing need to prioritize wastewater management and pave the way for innovative approaches. The emergence of innovation in advanced wastewater treatment holds immense promise for India. A series of discernible trends has emerged, each poised to address specific challenges in the sector. Firstly, decentralized treatment systems have garnered attention for their ability to effectively manage wastewater at the source. Technologies such as constructed wetlands, biofiltration, and decentralized wastewater treatment plants (DEWATS) offer cost-effective solutions that mitigate pollution before it reaches vulnerable water bodies, thus easing the burden on centralized facilities.

Advanced oxidation processes (AOPs) constitute another influential trend. These processes deploy chemical reactions to degrade organic and inorganic pollutants that often defy conventional treatment methods. Technologies like ozone treatment, ultraviolet (UV) irradiation, and photochemical oxidation are being harnessed to break down persistent pollutants, showcasing their potential to significantly enhance treatment efficacy. Membrane filtration technologies have taken center stage in achieving high-quality wastewater treatment. Employing methods like ultrafiltration, nanofiltration, and reverse osmosis, these approaches excel in eliminating suspended solids, pathogens, and dissolved contaminants. The outcome is treated water that meets stringent quality benchmarks, and in some instances, is even suitable for non-potable reuse, thereby conserving precious water resources.

Biological nutrient removal represents yet another pioneering innovation. By utilizing processes such as sequencing batch reactors (SBRs) and membrane bioreactors (MBRs), this trend simultaneously addresses organic matter and nutrient removal from wastewater. This is particularly crucial in preventing nutrient pollution, which can contribute to harmful algal blooms and oxygen depletion in water bodies.

6.5.4. ADVANCED WASTEWATER REUSE TECHNOLOGIES

As per the United Nations Environment Program (UNEP), reusing water is economically as well as ecologically very important, since it is beneficial in relieving water scarcity and enabling waste water management. In addition, India has a limited supply of this resource, with a total of 4,000 billion Cubic Meter (BCM) of water being acquired per year, of which, up to 500 BCM capacity is used in manufacturing industries and factories. Despite supply being limited, demand for this critical resource continues to rise exponentially, and reusing water is an appropriate solution for industries, sectors, farmers, residents, and citizens. The Jal Jeevan Mission by the government of India has also reported to set a target of 20% of total available water coming from its reused version, as of 2021.

Moreover, the state government of Gujarat had launched the Policy for Reuse of Treated Waste Water in 2018, which aims to complete a full reuse of treated water till the year 2030. According to the Government of India, the country possesses 5% of the world's fresh water sources; however, it hosts 16% of the global population, putting major pressure on limited water available. Thus, advanced waste water reuse technologies are being developed and innovation is being supported due to the aim of water conservation. The technique known as advanced oxidation is being implemented in the country to clean the water of Ganga River. Developed by the Energy and Resources Institute (New Delhi, India), this product has been supported by the Government of India Department of Science and Technology. The product has been reported to achieve a zero liquid discharge, which works on ultraviolet light technology. Compared to tertiary purification systems of Reverse Osmosis (RO) as well as multi effect evaporators, the advanced oxidation technique, also called as TERI Advanced Oxidation Technology (TADOX) has proved to leave a lesser carbon footprint. This technology is viable to be installed in decentralized wastewater treatment systems in large infrastructure and construction projects which require purified water for longer periods of time. In addition, this system has been ready for commercial use since April 2021.
Furthermore, Indirect Potable Reuse (IPR) process involves the usage of a buffer medium such as the soil or a lake before the recycling treatment of waste water, whereas, Direct Potable Reuse (DPR) is characterized by not involving any environmental buffer. The inclusion of these two methods before recycling of used water is crucial in the reuse process. IPR is also being applied in Bangalore, Karnataka, India, and its pilot was conducted in 2006, after which systems have been working to prepare industrial and agricultural grade purified water in the city, as per the Ministry of Urban Development. The second procedure after these two methods is the activated sludge system, which is a biological treatment method to purify water. Protozoa, bacteria, and algae are removed from waste water through

oxidation with the help of microorganisms in the presence of an oxygen environment. A newer modification of this process is the Nereda technology, wherein the sludge is given a granular texture with the help of slow growth of glycogen collecting micro-organisms. Such activated sludge systems have been extensively applied at the Titagarh sewage treatment plant in the vicinity of Kolkata city.
Categorized as a secondary treatment method, Kelvin Water Technologies Pvt. Ltd. (India) is working towards making this procedure affordable across the country. The company is known to provide multiple reactors activated processes along with cyclic sludge processes, which is regarded as highly efficient for water recycling, since it removes suspended particles. Furthermore, this water reuse technique is economical and efficient since the volume of waste water can be controlled easily. Moreover, in 2021, Chennai implemented tertiary treatment reverse osmosis methods by establishing two large plants at Koyambedu and Kodungaiyur, which are utilizing this method to provide recycling at a city level scale while catering to industries in the areas of Oragadam and Sriperumbudur in Tamil Nadu. Since the maximum capacity of the plants is 45 million liters per day, these are proving to be beneficial to make the city self-sufficient in terms of water reuse. This Tertiary Treatment Reverse Osmosis (TTRO) solution applies the membrane-based technique of impurity removal and is also beneficial in agricultural water refining. Being a tertiary treatment level, it is regarded as very advanced, and is prominently used to remove minerals and salts. It can involve flocculation, carbon adsorption, de-chlorination as well as ultra-filtration. Such tertiary treatment plants are also present at the Bamroli sewage treatment plant in Surat, Gujarat, as well as in Kolhapur, in Maharashtra. As a result, recycling has been in the limelight in terms of new innovations taking place along with advanced recycling solutions being made operational in urban cities. Hence, techniques such as IPR, TADOX advanced oxidation, activated sludge systems, and Nereda technology along with biological membrane filtration are being provided as commercial solutions by private companies. Deployment is also being supported by various departments of the Indian government to drive growth of this industry.

6.5.5. SEAWATER DESALINATION ON LARGE SCALE

India, surrounded by the Arabian sea to the west, the Bay of Bengal in the east, and the Indian ocean to the south, has immense water reserve of sea water. However, seawater desalination requires much energy due to the strong bonds salt minerals form with water molecules. As a result, it cannot be utilized for agriculture, for which the resource is required in large quantities. Hence, with the pressing need for increased crop yields in order to provide for the large population of India, desalination is a very viable solution if energy and cost-efficient techniques are developed. Thus, the Department of Science and Technology, Government of India (GoI), has called for desalination project proposals in 2021. The proposals included are based on futuristic technologies pertaining to thermal and membrane-based desalination. The Indian Desalination Association also regards thermal processes viable for the purpose. With the inclusion of vaporization and distillation, multiple boiling containers are involved, wherein gypsum and carbonates are removed via these procedures. These methods are considered inefficient for small scale use, such as in factories.

However, India has been developing economically viable large-scale plants based on the low temperature thermal desalination. For instance, the National Institute of Ocean Technology (NIOT) at Chennai has developed the world’s first low temperature thermal desalination plant established at Lakshadweep islands. Cold water, located at a depth of 400-600m can be desalinated on large scale in the plant. Other such plants are being set up in Amini, Chetlat and Kalpeni islands among other places, with a capacity of 1.5 lakh liter per day. Plans for a 10 million liters per day (MLD) projects are also under consideration. Similarly, the National Institution for Transforming India (NITI) Aayog has been setting up various purification projects along the coastline, especially near Chennai. The Minjur plant is India’s largest desalination project, operational since the past decade. This plant contains up to 8,600 reverse osmosis membranes and 23 pressure exchangers.

In addition, it has the capacity to produce 100 MLD together. IVRCL Infrastructure and Projects Ltd. (India) has also contributed to the construction of this significantly large desalination project. Furthermore, Multi Stage Flash Distillation (MSF) is being utilized in the country to purify sea water of dissolved minerals and salts. The Desalination and Membrane Technology Division of the Bhabha Atomic Research Center (BARC) of India has been working on promoting this technique throughout the nation. The Kalpakkam based Nuclear Desalination Demonstration Plant uses this procedure coupled with the reverse osmosis (RO) method to produce a capacity of 1.8 MLD. This plant supplies pure water to the Madras Atomic Power Station. MSF includes up to 30 stages of methods, in which portions of water are flashed into steam through heat exchangers and condensers. These stages are known to have different atmospheric pressure requirements, which are simulated via vapor compression. MSF plants are even provided by private commercial manufacturers such as Shree Vinayak Jal Pvt. Ltd. (India) and Doosan Power Systems India Pvt. Ltd. (India), among others. Large scale projects have been proposed to be instituted in Kutch, Dawrka, Bhavnagar and other places in Gujarat. Other companies engaged in this sector in India are Genesis Water Technologies Inc. (The U.S.), Landmark Aquatec Pvt. Ltd. (India), and Ionex Engineers (India) along with other firms. Another advanced procedure is the Multiple Effect Desalination (MED), which works on the reuse of energy from the previous stage and is resistant to corrosion. This method can operate at lower concentration of minerals, along with a low temperature, making it easy to maintain and operate efficiently. As a result, this procedure is becoming popular in the water treatment industry.

A plant functional using this technique has been implemented by the Bhabha Atomic Research Center (BARC), combined with a vapor compression process. The plant supplies clean water for nuclear research, by reusing sea water from the Arabian sea shore near Mumbai. IDE Technologies (Israel) has been delivering clean water to the oil refining wing of Reliance Industries Ltd. (India) since the past two decades, in Jamnagar city in Gujarat. Improving awareness regarding eco-friendly technologies, this plant can refine up to 168,000 m3 per day. Also, the Indian subsidiary of Alfa Laval AB (Sweden) also provides multiple effect desalination equipment on a commercial level to be used in power plants. Its products have the ability to generate pure water of up to 10,000 m3 per day, with the plant being lightweight and applicable offshore, land-based, and marine installations. As a result, large scale desalination projects are being implemented in the country for the past decade; however, newer and larger plants have been receiving government funding as of 2021. Furthermore, technologies such as multiple effect desalination, multi stage flash distillation, reverse osmosis, and vapor compression are proving to be the sought-after methods in this field.

6.5.6. GROWING FOCUS ON CIRCULAR ECONOMY

The circular economy model lays emphasis on production and consumption cycles which is more sustainable, including recycling, reusing, refurbishing, as well as optimizing available resources. The United Nations Environment Program regards circular economy as the economic system which aims to minimize pollution, resource wastage as well as to create sustainable jobs and preserve the overall environment. Similarly, the Indian Government has also been promoting this philosophy pertaining to the energy, infrastructure and production sector. For instance, the NITI Aayog has taken multiple initiatives such as the international conference on Sustainable Growth through National Recycling as well as the formation of 11 committees to prepare action plans regarding the country's transition to a circular economy. Construction and Demolition Management rules, Metals recycling policy, as well as plastic waste management rules are the examples of other initiatives taken up by the government. Furthermore, the Ellen McArthur Foundation suggests that circular economy is to bring a benefit of up to USD 624 billion to the Indian economy. Closely linked with the United Nations Sustainable Development Goals, this concept has started to be applied at the local governance level in India. As per the Ministry of Housing and Urban Affairs, recycling of plastic waste along with treatment of waste water for reuse has been at the forefront of this field. Hence, intermediate targets have been set for the recycling of waste water which aim to achieve 25% reuse of by 2026, 35% and 50% by 2050. Moreover, the country has the ability to recycle a total of 20,000 MLD, in which most water treatment plants are observed to not run at full capacity. Hence, since 60% of India's industries are being affected by the lack of water reuse efficiency, circular economy has been gaining importance in the context of water and waste water recycling. According to a research paper published by the American Chemical Society in 2021, carbon and nitrogen removal from waste water are some of the major issues pertaining to the water industry, which need to be addressed. The waste water reuse system adopted by the Surat Municipal Corporation was presented at the United Nations Conference of Parties (COP26) in 2021, which is a conference working towards environment protection through the mandate of Paris Agreement, which legally binds UN member nations to adhere to environment protection laws. The Surat Municipal corporation highlighted their reuse model of waste water, in which the city has been generating USD 6.25 crore by selling 115 MLD recycled water. Being applauded for this circular economy progress, such Indian cities are proving to create an ideal for India in terms of advancing the waste water treatment sector, in order to spread the idea of circular economies. Indian industries located in water scarce regions tend to lose revenue due to hindrances in production due to the lack of pure water. Hence, the focus on financing waste water treatment projects has been the core aim of governmental agencies and ministries. Decentralization of such programs, accurate management strategies along with massive community participation is required in order to make these plans successful in the long term. A study by the Council of Energy, Environment and Water of India regarded large scale interventions, technology access and good public perception about water treatment plants as some of the prominent reasons to drive the circular economic growth of the country pertaining to the water sector. India's trajectory towards circular and sustainable water industry highly revolves around water recycling technologies such as reverse osmosis purification, bio-augmentation, multiple effect desalination, multi stage flash distillation and vapor compression. Additionally, given the rapid urbanization of India, the 6 R rule beneficial to urban water conservation is the rule consisting of reduce, reuse, recycle, reclaim, recovery and restore water. Indian rivers are receiving half treated waste water, which is leading to complex issues in water treatment efficiency and loss of purification time. For instance, the Musi River has been getting partially treated waste water from the city of Hyderabad. Hence, although having the presence of a process of trying to shift to a circular economy, efficacy and management of such procedures needs to be enhanced. As a result, owing to the growing global awareness pertaining to the hazardous effects of a linear economy, government funding for circular economy is increasing. Additionally, many Indian cities are commencing with water recycling plants in order to propel water circular economy and make India sustainable in terms of its water resources. Prevalence of water technology companies in the country such as Thermax Ltd. (India), Evoqua Water Technologies (The U.S.), Voltas Ltd. (India) and GE Water and Process Technologies (The U.S.) are enhancing the working of this industry and aiding in the growth of this sector.

6.6. 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 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, 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 wildlife and fisheries and irrigation, industrial cooling, controlled waste disposal.

6.6.1. 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 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 10.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 11.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**

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

TABLE 12.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 13.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
- Implementation of National Water Mission
- 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

6.6.2. KEY GOVERNMENT PLANS

TABLE 14.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

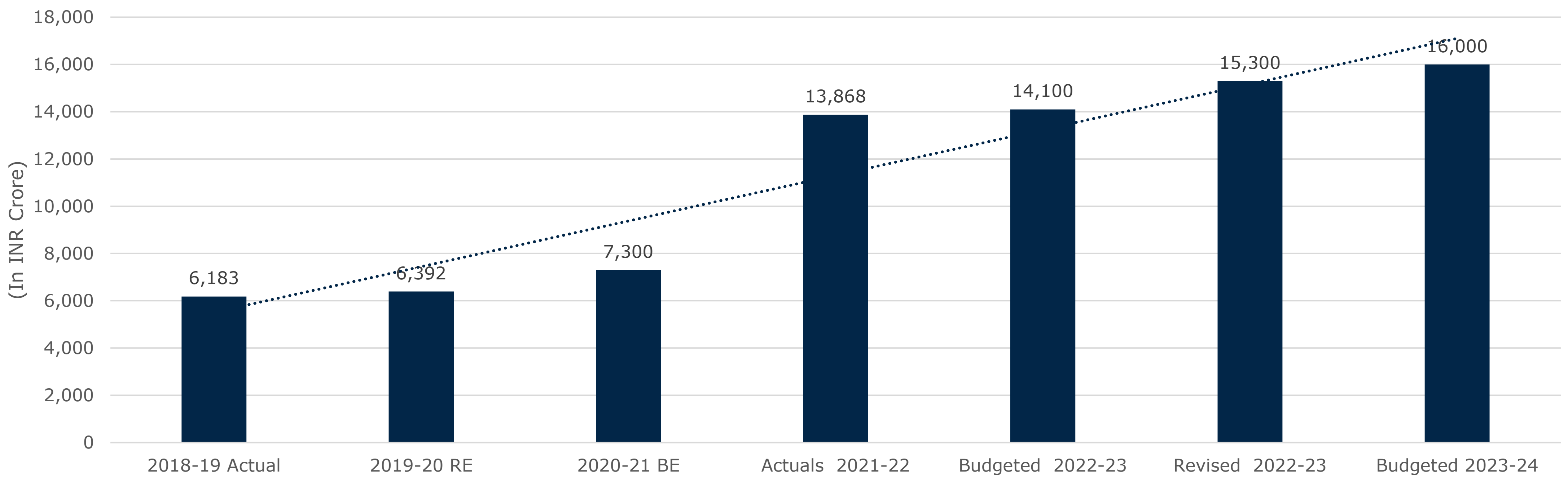
Sources: Ministry of Housing and Urban Affairs (MoHUA), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Ministry of Jal Shakti, Jal Jeevan Mission (JJM), National Mission for Clean Ganga, Press Information Bureau (PIB), Union Budget of India

TABLE 15.BUDGETARY ALLOCATION FOR AMRUT PROGRAMME: FY 2018: 2024

AMRUT (INR Cr.)							
2018-19 Actual	**2019-20 RE**	**2020-21 BE**	**Actuals 2021-22**	**Budgeted 2022-23**	**Revised 2022-23**	**Budgeted 2023-24**	**% change (2022-23 RE to 2023-24 BE)**
6,183	6,392	7,300	13,868	14,100	15,300	16,000	4.6%

Source: Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

FIGURE 58. BUDGETARY ALLOCATION FOR AMRUT PROGRAMME: FY 2018: 2024



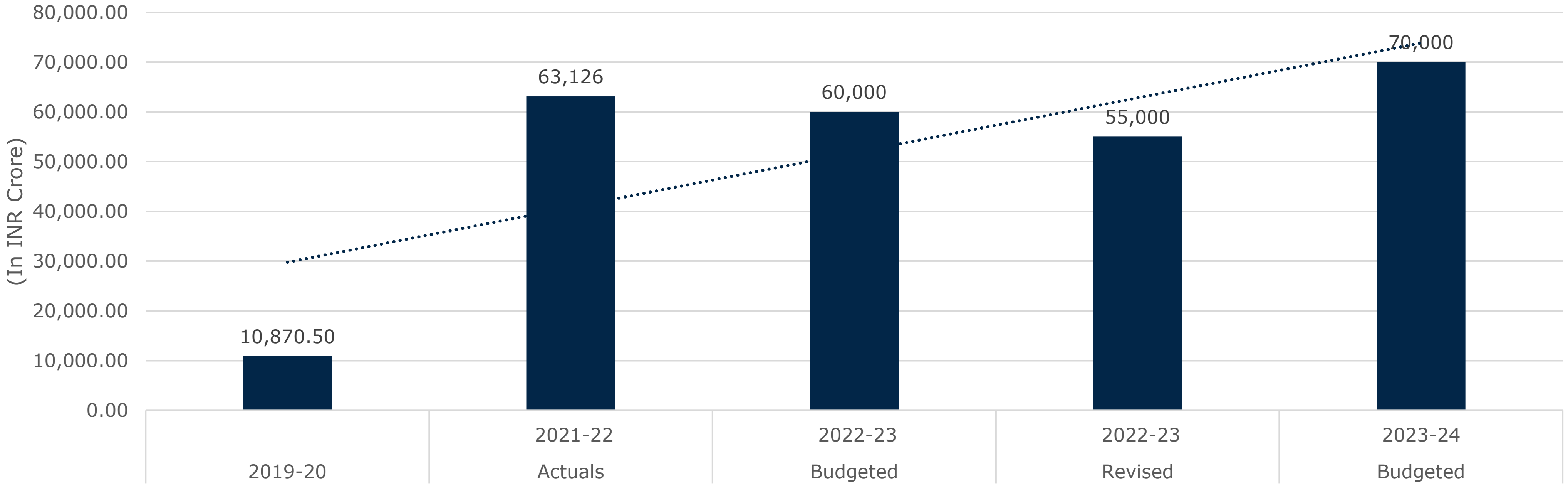
Source: Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Press Information Bureau (PIB), Union Budget of India

TABLE 16. BUDGETARY ALLOCATION FOR JAL JEEVAN MISSION/NATIONAL RURAL DRINKING WATER MISSION (INR CR.): FY 2019: 2024

JAL JEEVAN MISSION/NATIONAL RURAL DRINKING WATER MISSION (INR CR.)					
2019-20	**Actuals 2021-22**	**Budgeted 2022-23**	**Revised 2022-23**	**Budgeted 2023-24**	**% change (2022-23 RE to 2023-24 BE)**
10,870.50	63,126	60,000	55,000	70,000	27.3%

Source: Ministry Of Housing And Urban Affairs Lok Sabha, Ministry of Jal Shakti, Jal Jeevan Mission (JJM), National Mission for Clean Ganga, Press Information Bureau (PIB), Union Budget of India

FIGURE 59. BUDGETARY ALLOCATION FOR JAL JEEVAN MISSION/NATIONAL RURAL DRINKING WATER MISSION (INR CR.): FY 2019: 2024



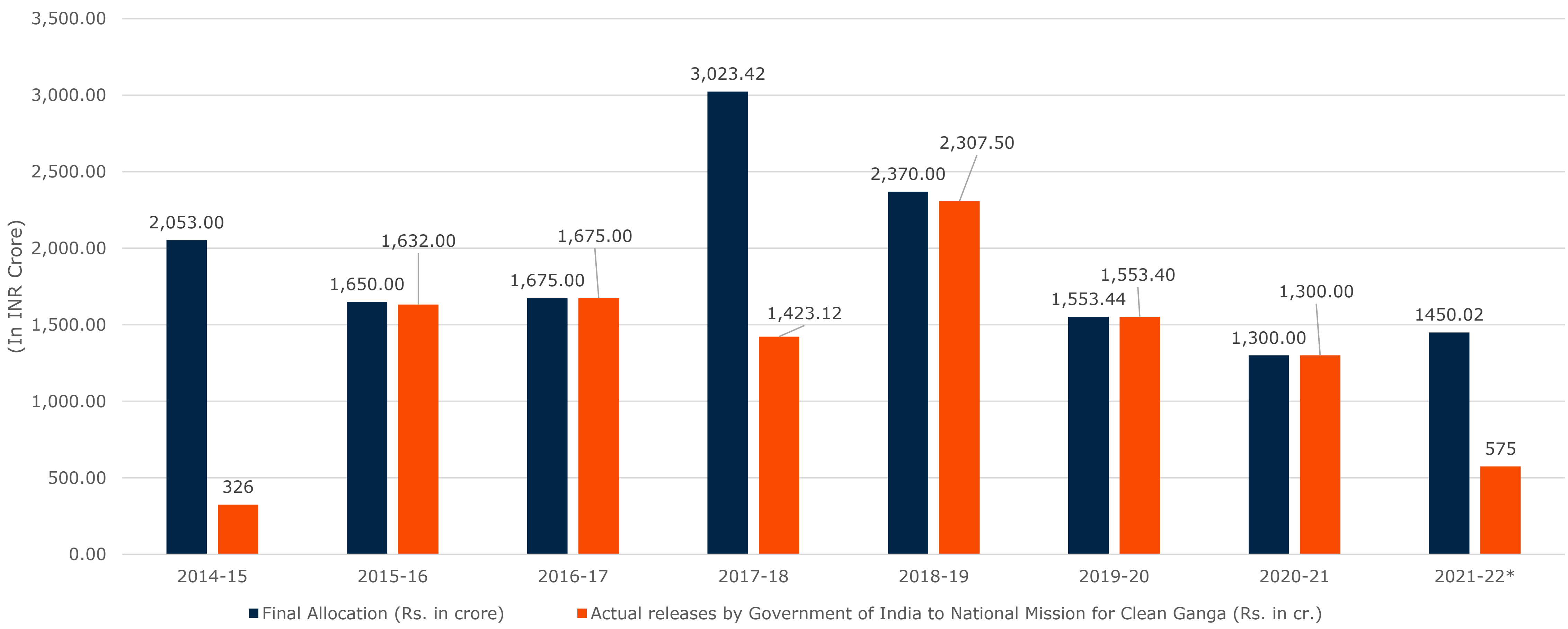
Source: Ministry Of Housing And Urban Affairs Lok Sabha, Ministry of Jal Shakti, Jal Jeevan Mission (JJM), National Mission for Clean Ganga, Press Information Bureau (PIB), Union Budget of India

TABLE 17.BUDGETARY ALLOCATION FOR NATIONAL MISSION FOR CLEAN GANGA (INR CR.): FY 2019: 2024

Financial Year	Final Allocation (INR in crore)	Actual releases by Government of India to National Mission for Clean Ganga (INR. in cr.)
2014-15	2,053.00	326.00
2015-16	1,650.00	1,632.00
2016-17	1,675.00	1,675.00
2017-18	3,023.42	1,423.12
2018-19	2,370.00	2,307.50
2019-20	1,553.44	1,553.40
2020-21	1,300.00	1,300.00
2021-22*	1450.02**	575.00
Total	15,074.88	10,792.02

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

FIGURE 60. BUDGETARY ALLOCATION FOR NATIONAL MISSION FOR CLEAN GANGA (INR CR.): FY 2019: 2024



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

TABLE 18.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

6.6.3. 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.

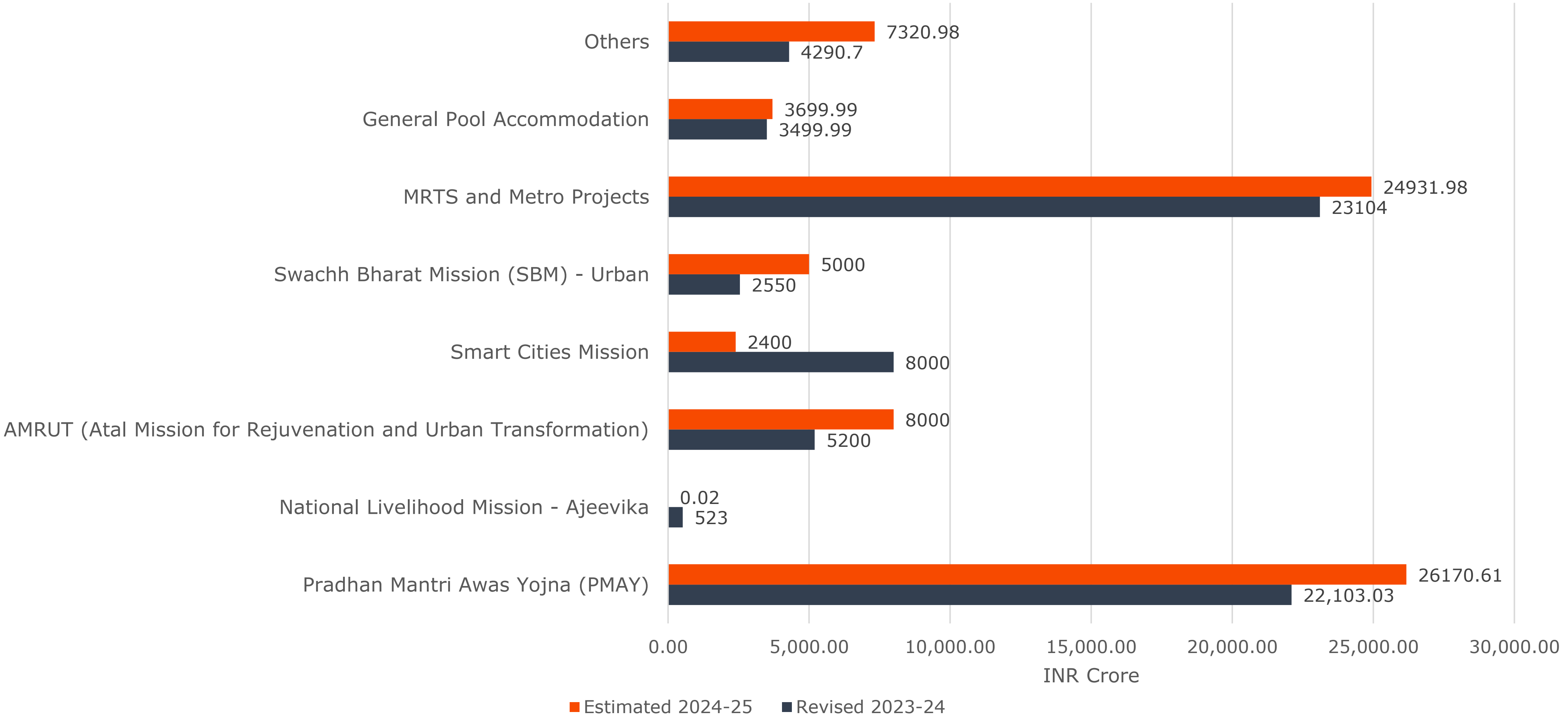
Governance reforms are an elementary part of the whole proceeding. They work towards easing the procedure of obtaining water and sewer connections simple for households by reducing the documents required and dropping the incurred costs. The Pey Jal Survekshan initiative will incentivise cities to keep 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.

6.6.3.1. 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 61. 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

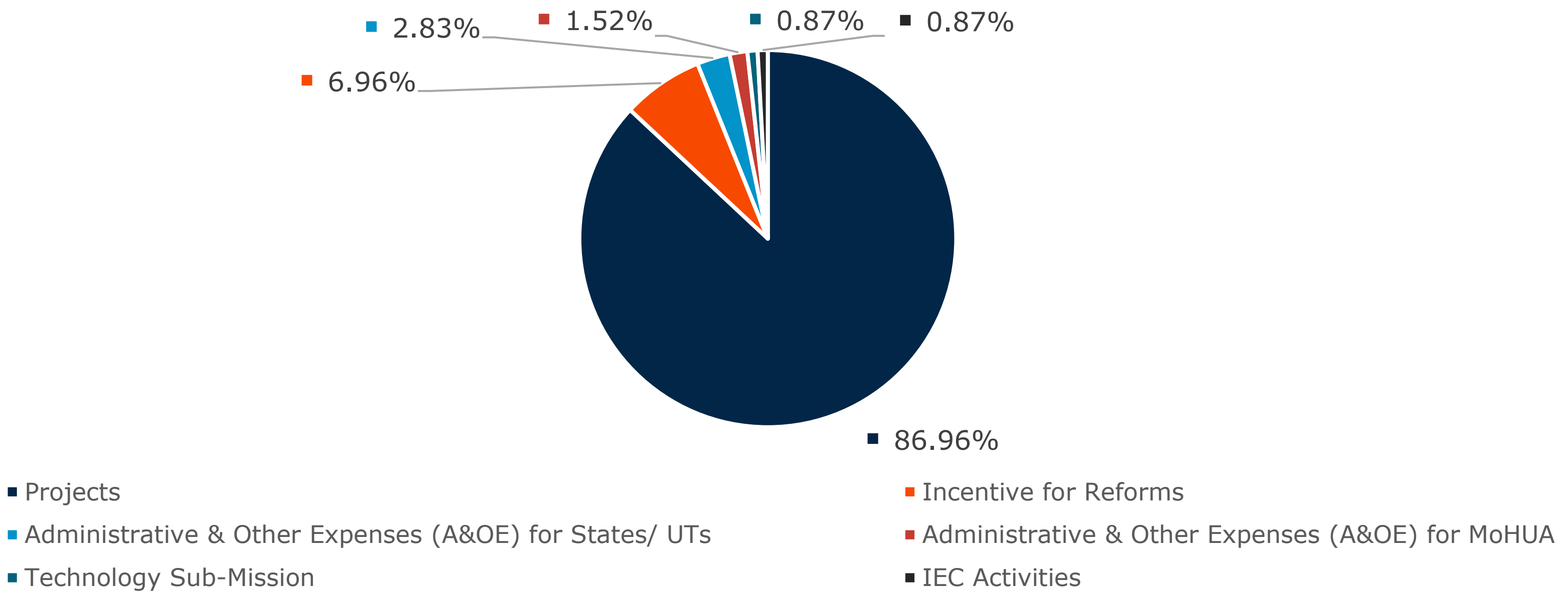
TABLE 19.BUDGETARY ALLOCATION FOR MINISTRY OF HOUSING AND URBAN AFFAIRS

SR.NO	SCHEMES	REVISED BUDGET 2023-2024 (INR CRORE)	ESTIMATED BUDGET 2023-2024 (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 total outlay for the AMRUT 2.0 is **INR 2,99,000 crore**. This budget allocation includes **INR 22,000 crore** for the ongoing AMRUT Mission for two years from FY 2021-22 to FY 2022-23 and the rest of amount would be utilized for five years. In this budget the central share is **INR 86,760 crore** which comprises **INR 10,000 crore** for AMRUT projects. The ongoing projects of AMRUT would be funded up to 31st March 2023 by the central assistance. In 2023-24, AMRUT has been allocated **INR 8,000 crore**, an increase of 23% over 2022-23 revised estimates. Some of the major components of AMRUT 2.0 consists of projects, administrative & other expenses (A&OE), reforms, technology sub-mission, information, education, and communication (IEC), Pey Jal Survekshan, community participation with focus on woman self- help groups, outcome-based funding, evidence based evaluation and public private partnership.

FIGURE 62. 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 20.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 21.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

STATE/UT	CENTRAL FUND ALLOCATION FOR PROJECTS	CENTRAL FUND ALLOCATION FOR A&OE (ADMINISTRATIVE & OTHER EXPENSES)
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

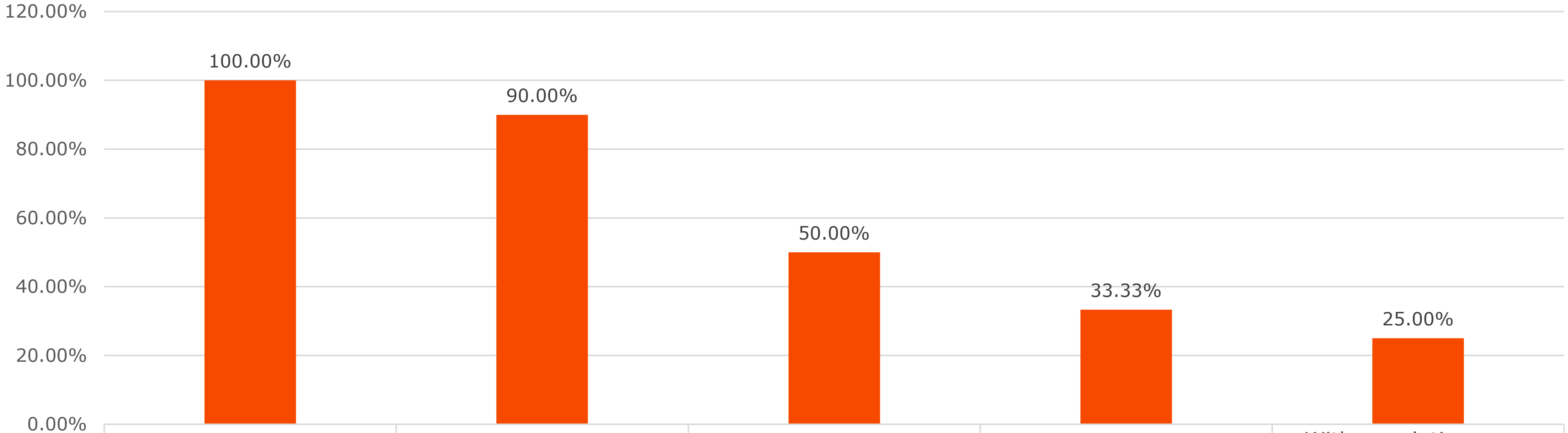
STATE/UT	CENTRAL FUND ALLOCATION FOR PROJECTS	CENTRAL FUND ALLOCATION FOR A&OE (ADMINISTRATIVE & OTHER EXPENSES)
Madhya Pradesh	4,045	131.44
Maharashtra	9,285	301.71
Manipur	169	5.49
Meghalaya	110	3.57
Mizoram	142	4.61
Nagaland	175	5.69
Odisha	1,363	44.29
Puducherry	150	4.87
Punjab	1,833	59.56
Rajasthan	3,530	114.71
Sikkim	40	1.30

STATE/UT	CENTRAL FUND ALLOCATION FOR PROJECTS	CENTRAL FUND ALLOCATION FOR A&OE (ADMINISTRATIVE & OTHER EXPENSES)
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.

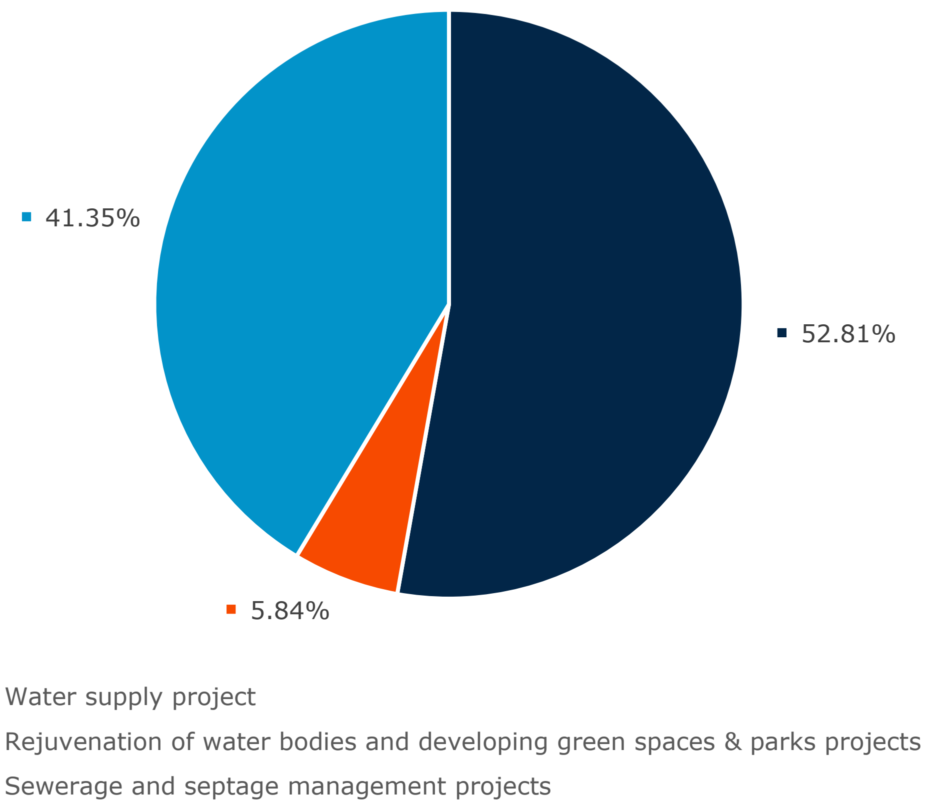
FIGURE 63. CENTRAL SHARE FOR VARIOUS CLASSES OF ULBS (URBAN LOCAL BODIES)



	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 64. 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 22.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 23.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 24.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.

6.6.4. 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.

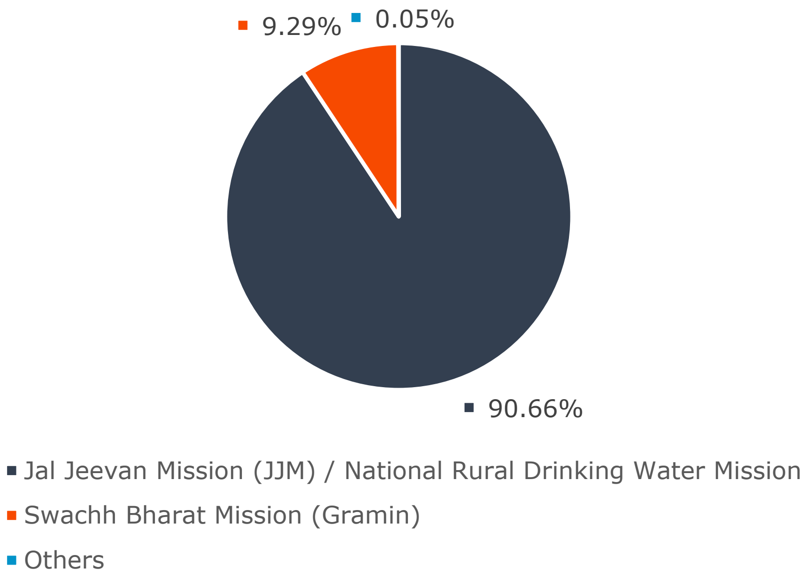
6.6.4.1. BUDGETARY ALLOCATION FOR JAL JEEVAN MISSION (JJM)-HAR GHAR JAL

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 65. 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 25. 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 26. 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 27.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.

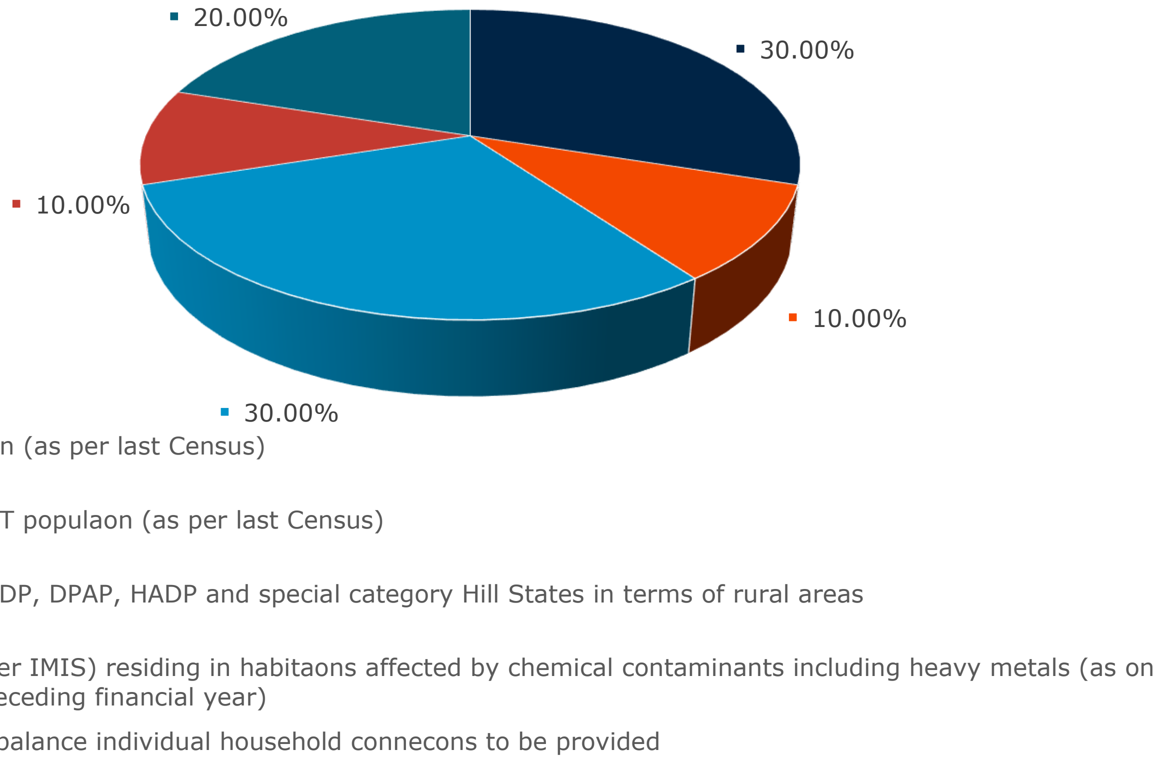
Through this mission, difficult terrains such as those covered by the Desert Development Programme (DDP) and the Drought Prone Area Programme (DPAP) are provided with 30 percentage of weightage, while population living in SC/ST dominated areas are offered with 10 percentage of weightage, aiding on prioritize 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 66. 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 28.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

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	
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

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	
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

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	
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

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	
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

6.6.5. NAMAMI GANGE PROGRAMME

Namami Gange Programme is an integrated preservation program that was 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 (Ganga Action Plan) 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 practises, 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 ground water 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.

6.6.5.1. 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 29.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 Litres 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 30.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

6.6.6. 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.

6.6.6.1. 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 31.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

6.7. 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 32.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 of 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). 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 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.

6.8. GROUNDWATER RECHARGING

6.8.1. NATIONAL SCENARIO OF GROUNDWATER AND AVAILABILITY

India is one of the largest users of groundwater in the world. Groundwater is the only source of water for most of the population in India and the groundwater is being used for farming and domestic purpose. While groundwater fueled the Green Revolution of India, which transformed India into a food-secure nation, extensive exploitation has resulted in its worrisome depletion. Groundwater will become ever more important as climate change makes rainfall patterns more erratic. Already, declining groundwater levels endanger nearly two-thirds of India's districts (63%). This water is frequently becoming polluted. Worryingly, poverty rates are 9-10% higher in places where groundwater levels have dropped below 8 meters, putting small farmers at risk. If current trends continue, at least 25% of India's agriculture would be threatened. Dynamic groundwater is the amount of groundwater accessible in the zone of water level fluctuation that is renewed yearly. Groundwater has increasingly emerged as the foundation of India's agricultural and drinking water security. Groundwater contributes almost 62% of irrigation, 85% of rural water supply, and 45% of urban water supply. It helps to keep rivers and wetlands flowing and promotes terrestrial vegetation. It is sometimes the only source of water in arid and semi-arid regions. As a result, groundwater is critical to the country's socioeconomic growth. However, groundwater supplies in India are under jeopardy. Pumping that is both intensive and uncontrolled has resulted in a quick and widespread drop in groundwater levels. Between 1950 and 2010, the number of tube wells dug surged from 1 million to approximately 30 million, indicating extraordinary growth. This explosive use of groundwater has resulted in decreasing level of water table (level of groundwater).

Ground water in the fluctuating water level zone is replenished annually, with rainfall being the primary contributor. As a result, sustainable ground water resource exploitation necessitates a realistic quantitative evaluation of ground water availability in this zone based on generally reliable scientific concepts. The National Water Policy of 2012 emphasized the scientific evaluation of ground water resources on a regular basis. Water availability changes affected by a variety of reasons, including climate change, must also be examined and accounted for during water resource planning. It supports direct use of rainwater, desalination, and prevention of accidental evapotranspiration to supplement utilizable water supplies to fulfill the rising demand for water. According to the National Water Policy 2012, safe drinking water and sanitation should be prioritized over other domestic needs (including animal needs), achieving food security, supporting sustenance agriculture, and meeting minimum eco-system needs. After addressing the demands, available water should be allocated in a way that promotes conservation and efficient usage.

Pre-Monsoon 2022 Groundwater Levels

The groundwater level data for pre-monsoon 2022 across the country indicates that the general depth to water ranges from 5 to 10 meters below ground level (m bgl). Very shallow water levels of less than 2 m bgl are observed in small patches within states such as Assam, Andhra Pradesh, Bihar, Karnataka, Kerala, Jharkhand, Maharashtra, Meghalaya, and Tamil Nadu. Groundwater levels between 2 to 5 m bgl are seen in Assam, Andhra Pradesh, northern parts of Uttar Pradesh and Bihar, coastal parts of Odisha, and some pockets in Telangana, Karnataka, Kerala, Tamil Nadu, Gujarat, and Maharashtra. The majority of the country, particularly the states of Madhya Pradesh, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Chhattisgarh, Maharashtra, Gujarat, Tamil Nadu, Telangana, and Karnataka, exhibit water levels in the range of 5 to 10 m bgl. In contrast, the north-western and western states, including Delhi, Haryana, Punjab, and Rajasthan, generally have deeper water levels ranging from 20 to over 40 m bgl. In the peninsular region, water levels typically range from 5 to 20 m bgl.

Post-Monsoon 2022 Groundwater Levels

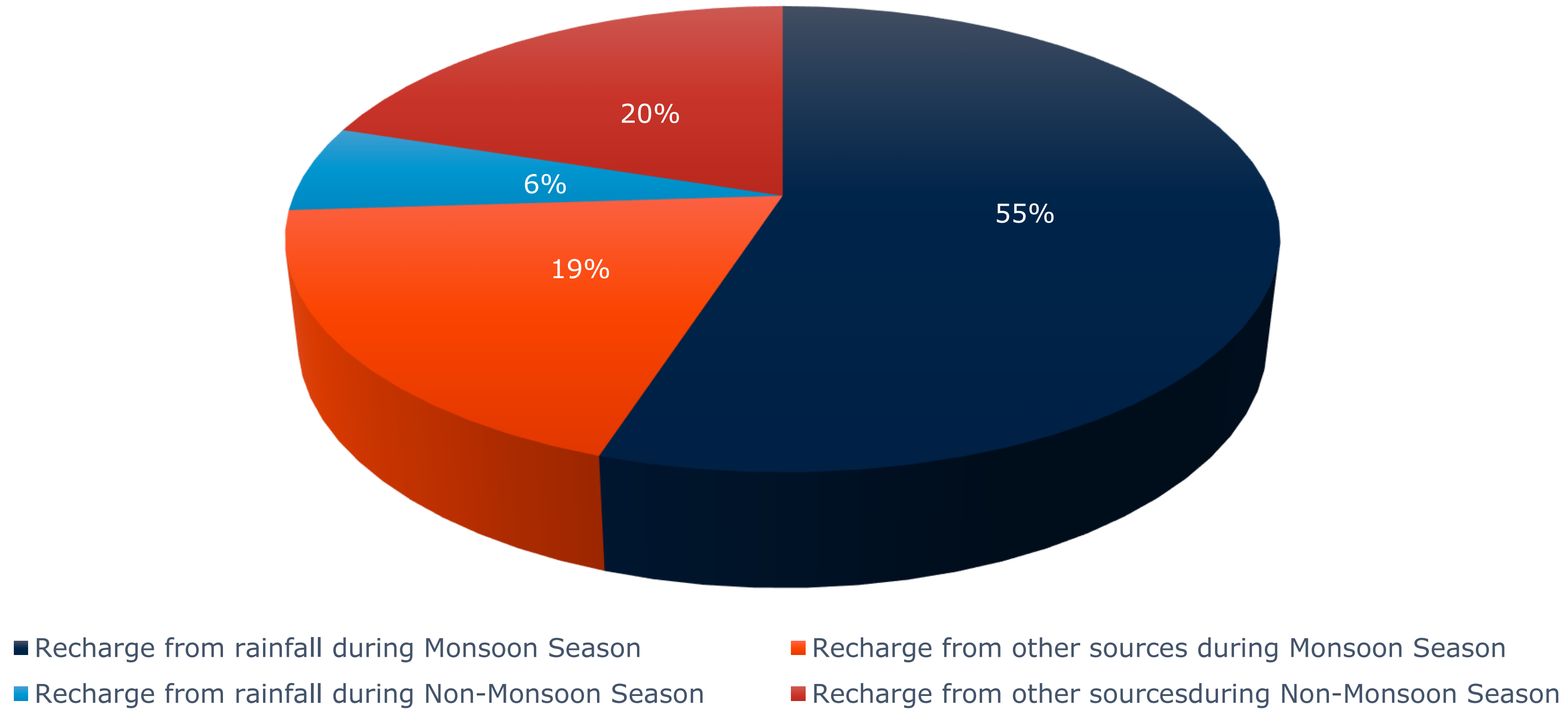
The post-monsoon 2022 groundwater level analysis of 14,577 wells reveals significant changes in water levels. Approximately 25.4% (3,697 wells) show water levels less than 2 m bgl. Around 41.8% (6,095 wells) have water levels ranging from 2 to 5 m bgl, while 21.5% (3,127 wells) range from 5 to 10 m bgl. About 7.1% (1,039 wells) have water levels between 10 to 20 m bgl, 2.8% (414 wells) between 20 to 40 m bgl, and 1.4% (205 wells) have water levels deeper than 40 m bgl. Generally, the country's water levels range from 0 to 5 m bgl, as nearly 70% of the wells fall within this range. Very shallow water levels of less than 2 m bgl are widespread across all states except Chandigarh. Water levels between 2 to 5 m bgl are also predominant throughout the country. However, deeper water levels are observed in parts of the north-western and western states, specifically in Chandigarh, Delhi, Haryana, Punjab, and Rajasthan, with depths ranging from about 10 m bgl to more than 40 m bgl.

6.8.2. OVERVIEW OF GROUNDWATER RECHARGING

The 2023 assessment of India's dynamic ground water resources, conducted jointly by the Central Ground Water Board (CGWB) and State Ground Water Departments, indicates that the Total Annual Ground Water Recharge is 449.08 billion cubic meters (bcm), with natural discharges amounting to 41.89 bcm. Consequently, the Annual Extractable Ground Water Resources are 407.21 bcm. The primary source of this recharge is rainfall, contributing 270.78 bcm or 60% of the total recharge, with 54% occurring during the monsoon and 6% during the non-monsoon seasons. The remaining 40%, equivalent to 178.31 bcm, comes from secondary sources like canal seepage, irrigation return flow, and water conservation structures. Certain states and Union Territories, including Assam, Goa, Gujarat, Jharkhand, Kerala, Madhya Pradesh, and others, see more than 70% of their groundwater recharge from monsoon rainfall. In contrast, areas like the Indus-Ganga-Brahmaputra belt experience significantly high recharge rates due to favorable climatic and geological conditions. The coastal alluvial belt also shows high recharge rates, whereas arid regions like Rajasthan and parts of Gujarat, as well as the hard rock terrains of southern India, exhibit lower recharge rates. Overall, the 2023 assessment reveals an increase of 11.48 bcm in annual ground water recharge and 9.13 bcm in extractable resources compared to previous assessments, with a rise of 2.18 bcm in groundwater extraction for various uses.

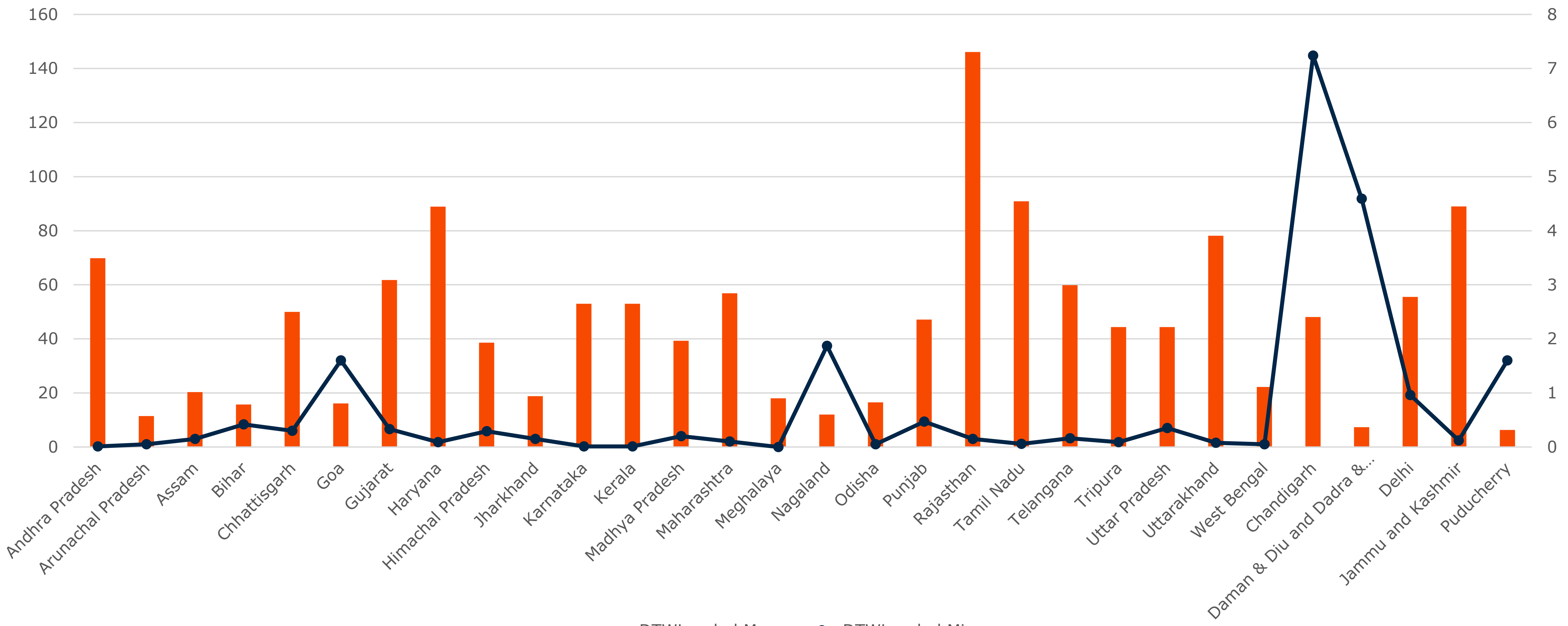
Jal Shakti Abhiyan (JSA) is being implemented in India by the government. The first JSA was launched in 2019 in water stressed blocks of 256 districts, with the primary goal of effectively harvesting monsoon rainfall through the creation of artificial recharge structures, watershed management, recharge and reuse structures, intensive afforestation, and awareness generation, among other things. In addition, The World Bank is assisting the government's national groundwater program, the Atal Bhujal Yojana, in its efforts to enhance groundwater management. This is the world's biggest community-led groundwater management initiative, with 8,220-gram panchayats spread across seven Indian states. Because groundwater conservation is in the hands of hundreds of millions of people and communities, the initiative assists villagers in understanding their water availability and consumption trends so that they may manage their water use properly.

FIGURE 67. GROUND WATER RECHARGE SCENARIO IN INDIA, 2023



Source: Central Ground Water Board (CGWB)

FIGURE 68. STATE-WISE DEPTH TO WATER LEVEL DISTRIBUTION OF PERCENTAGE OF OBSERVATION WELLS (JANUARY 2023), MBGL



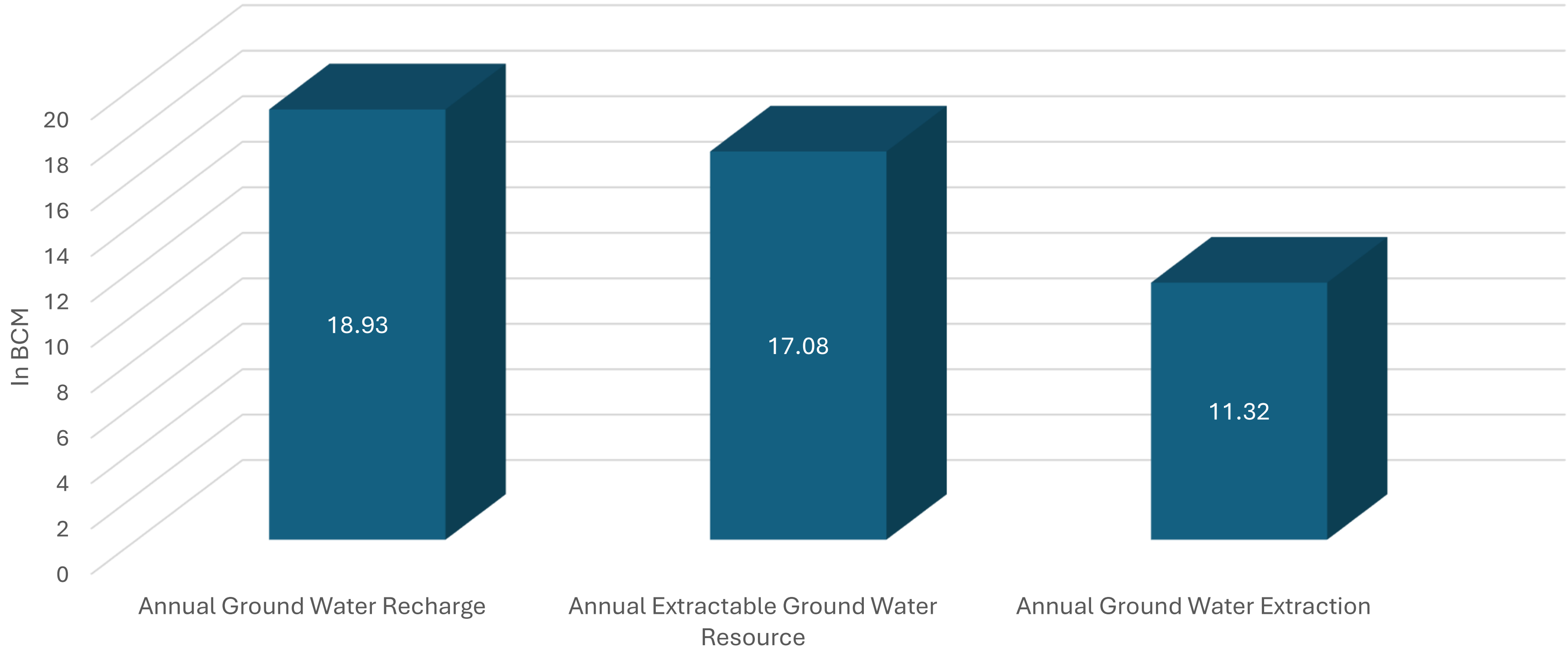
Source: Central Ground Water Board (CGWB)

6.8.2.1. OVERVIEW OF GROUNDWATER RECHARGING IN KARNATAKA

Over-exploitation and insufficient replenishment of groundwater have created an urgent need to preserve freshwater and reuse treated wastewater in Karnataka. To address this issue, the government has initiated a large-scale plan to recycle 440 million liters per day, aimed at indirectly recharging groundwater in the drought-prone Kolar district. This recycling effort employs Soil Aquifer Treatment (SAT) technology, which involves filling surface run-off tanks with treated sewage water (STW) that infiltrates and recharges aquifers. The facility treats wastewater up to the secondary level before pumping it into 137 designated tanks. Primary treatment removes floating particles like plastics and paper, secondary treatment uses microorganisms to remove dissolved organic matter, and tertiary treatment makes the water drinkable. Once in the tanks, the wastewater undergoes further natural filtration through sandy and loamy soil and soil microbes in Kolar. Results show that water in the revitalized tanks meets India's stringent discharge regulations, with groundwater levels in monitored boreholes increasing by 58-73% and quality improving significantly, converting hard water to soft. Land use studies indicated increases in water bodies, trees, and cultivated land, leading to a boost in agricultural output by 11-42%, milk productivity by 33%, and fish productivity by 341%. The KC Valley project demonstrates a viable solution for recharging groundwater using treated wastewater, significantly alleviating water scarcity in drought-prone areas. Inspired by this success, Karnataka has launched additional projects, including Phase II of the KC Valley and the Hebbal-Nagawara Valley Project, aiming to reuse around 865 million liters of treated wastewater per day for groundwater replenishment.

In parallel, the Karnataka government is actively formulating a new policy to enhance groundwater recharge statewide in response to the alarming decline in levels caused by rapid urbanization and deforestation. During a recent national conference on sustainable groundwater management, Minister N S Boseraju emphasized the urgent need for rainwater harvesting and other recharge methods. In Bengaluru, the 'Million Wells for Bengaluru' campaign, led by engineer S Vishwanath, has resulted in the construction of over 250,000 recharge wells, significantly reducing residents' reliance on municipal water and providing sustainable livelihoods for the well-digging community. This initiative highlights the critical importance of sustainable groundwater management in addressing the state's water scarcity issues.

FIGURE 69. KARNATAKA DYNAMIC GROUND WATER RECOURSES SCENARIO 2023



Source: Central Ground Water Authority (CGWA)

TABLE 33.WATER SOURCES IN KARNATAKA (% SHARE)

Sources	Percentage
Canals	36%
Tanks	6%
Wells	12%
Tube	34%
Lift Irrigation	4%

Source: Water Resource Department, GOK

6.8.3. TECHNOLOGY USED

Groundwater recharging in India involves the implementation of various technologies and methods to replenish and enhance the groundwater levels. Some of the commonly used technologies and techniques for groundwater recharging in India include direct surface techniques, and direct sub-surface techniques.

6.8.3.1. SURFACE SPREADING TECHNIQUES

These are intended to increase the contact area and residence duration of surface water over the soil in order to improve infiltration and increase ground water storage in phreatic aquifers. A variety of variables influence water travel downhill, including soil vertical permeability, the presence of grass or entrapped air in the soil zone, and the presence or absence of limiting layers of low vertical permeability at depth. Changes caused by physical, chemical, and bacterial impacts during the infiltration process are also essential in this respect. Important considerations in the selection of sites for artificial recharge through surface spreading techniques include:

- The area should have gently sloping land without gullies or ridges.
- The aquifer being recharged should be unconfined, permeable and sufficiently thick to provide storage space.
- The surface soil should be permeable and have a high infiltration rate.
- Vadose zone should be permeable and free from clay lenses.
- Ground water levels in the phreatic zone should be deep enough to accommodate the recharged water so that there is no water logging.
- The aquifer material should have moderate hydraulic conductivity so that the recharged water is retained for sufficiently long periods in the aquifer and can be used when needed.

6.8.3.1.1. FLOODING

This strategy is appropriate for fields next to rivers or irrigation canals when water levels stay deep even after monsoons and if there are adequate non-committed surface water supplies. To maintain adequate contact time and water distribution, embankments are constructed on both sides to direct unutilized surface water to a return canal, which transports the excess water to a stream or canal. The flooding approach reduces surface water system evaporation losses, is the least expensive of all artificial recharge technologies known and has extremely low maintenance costs.

6.8.3.1.2. DITCH AND FURROWS METHOD

This approach is digging shallow, flat-bottomed, closely spaced ditches or furrows to maximize water contact area for recharging from a source stream or canal. The ditches should have enough slopes to sustain flow velocity and minimize silt accumulation. The ditch widths are normally in the 0.30 to 1.80 m range. A collecting channel should also be created to transport the excess water back to the source stream or canal. Though this approach requires less soil preparation than recharging basins and is less susceptible to silting, the water contact area seldom surpasses 10% of the total recharge area.

6.8.3.1.3. RECHARGE BASIN

Artificial recharge basins are often dug or confined by dykes and levees and built parallel to ephemeral or intermittent stream systems. They can also be built parallel to canals or other sources of surface water. Multiple recharge basins can be built parallel to streams in alluvial areas to a) increase water contact time, b) reduce suspended material as water flows from one basin to another, and c) facilitate periodic maintenance such as silt scraping, etc. to restore infiltration rates by bypassing the basin under restoration.

6.8.3.1.4. RUNOFF CONSERVATION STRUCTURES

These are often multi-purpose practices that are mutually beneficial and promote soil and water conservation, afforestation, and higher agricultural output. They are appropriate for locations that get low to moderate rainfall mostly during a single monsoon season and have little or no capacity for water transfer from other places. There are several metrics available for the runoff zone, recharge zone, and discharge zone. Bench terracing, contour bunds, gully plugs, nalah bunds, check dams, and percolation ponds are all frequent constructions.

6.8.3.1.5. BENCH TERRACING

Bench terracing entails leveling sloping fields with surface gradients of up to 8% and having enough soil cover to put them under irrigation. It aids in soil conservation by retaining runoff water on terraced areas for extended periods of time, resulting in greater infiltration and ground water recharge. Terracing should be implemented once a map of the watershed has been created using level surveying and appropriate benchmarks have been established. A contour map with a contour interval of 0.3 m is then created. The width of each individual terrace should be calculated based on the land slope, but it should never be less than 12 m. The slope between two terraces should not be greater than 1:10, and the terraces should be flat. The land slope determines the vertical elevation difference and terrace width. Water exits of suitable proportions must be built in paddy cultivation regions to drain excess stored water and sustain water circulation. For rainfall intensities between 7.5 and 10 cm, the width of the outflows can range from 0.60 m for watersheds of up to 2 ha to 3.0 m for watersheds of up to 8 ha. Natural drainage channels should be linked to all outputs.

6.8.3.1.6. CONTOUR BUNDS

Contour bunding is a watershed management strategy that involves the construction of tiny embankments or bunds across the slope of the ground in order to increase soil moisture storage. The building of bunds following contours of equal land elevation gave rise to their names. This approach is commonly used in low rainfall locations (typically less than 800 mm) with gently sloping agricultural lands with exceptionally long slope lengths and permeable soils. They are not advised for clayey soils with inadequate internal drainage. Contour bunding entails building narrow-based trapezoidal embankments (bunds) following contours to impound water, which infiltrates into the soil and eventually augments ground water recharge. Prior to contour bunding, the ground must be leveled by removing local ridges and depressions, a map of the region must be prepared by level surveying, and benchmarks must be fixed. Elevation contours, ideally at 0.3 m intervals, are then produced, excluding places that do not require bunding, such as habitations, drainage, and so on.

The bund alignment should then be noted on the map. Contour bund design considerations include i) spacing, ii) cross section, and iii) deviation flexibility to go higher or lower than the contour bund elevation for better alignment on undulating ground.

6.8.3.1.7. PERCOLATION TANKS

Percolation tanks, which work on the same principles as nalah bunds, are among the most prevalent runoff collecting structures in India. A percolation tank is an intentionally produced surface water body that submerges a highly permeable land region, allowing surface runoff to percolate and recharge ground water storage. They are distinguished from nalah bunds by having bigger reservoir areas. They lack sluices or outlets for releasing water from the tank for irrigation or other uses. They may, however, be equipped with provisions for dumping away excess water that may enter the tank in order to prevent the tank bund from overflowing.

6.8.3.1.8. GULLY PLUGS, NALAH BUNDS AND CHECK DAMS

These constructions are built over gullies, nalahs, or streams to slow the flow of surface water in the stream channel and to keep water in the pervious soil or rock surface for extended periods of time. In contrast to gully plugs, which are often built over first order streams, nalah bunds and check dams are built across larger streams and in places with gentler slopes. These can be temporary constructions made of locally accessible materials, such as brush wood dams, loose / dry stone masonry check dams, Gabion check dams, and woven wire dams, or permanent structures made of stones, brick, and cement. For long-term dam stability, competent civil and agro-engineering approaches must be employed in the design, planning, and construction of permanent check dams to provide proper storage and adequate outflow of surplus water to minimize scours on the downstream side. The check dam location should have a sufficient thickness of permeable soils or weathered material to allow for quick recharging of stored water. The water retained in these constructions is usually restricted to the stream flow and the height is less than 2 m. These are built to accommodate the breadth of the stream and enable surplus water to flow over the wall. Water cushions are supplied on the downstream side to prevent scouring from excess runoff. A succession of similar check dams can be built on a regional scale to capture maximum runoff in the stream.

6.8.3.1.9. MODIFICATION OF VILLAGE TANKS AS RECHARGE STRUCTURES

Existing village tanks, which are usually silted and deteriorated, can be converted into recharge structures. Unlike properly engineered percolation tanks, village tanks do not have cut-off ditches or waste weirs. Desilting village tanks, together with the right placement of waste weirs and cut off trenches on the upstream side, can make them more suitable for use as recharge structures. With minimal adjustments, such tanks, which are plentiful in rural India, might be transformed into cost-effective structures for boosting ground water recharge.

6.8.3.1.10. STREAM CHANNEL MODIFICATION / AUGMENTATION

In regions where streams zigzag across large valleys, occupying just a tiny portion of the valley, the natural drainage channel can be changed to promote infiltration by retaining stream flow and increasing the surface of the streambed in contact with water. The channel is adjusted in such a way that the flow is dispersed over a larger area, resulting in increased contact with the streambed. The most common methods are a) widening, leveling, scarifying, or building ditches in the stream channel; b) building L-shaped finger levees or hook levees in the riverbed at the end of the high stream flow season; and c) low head check dams that allow flood waters to pass safely over them. Stream channel alteration can be used in locations with influent streams, which are mainly found in piedmont regions and areas with deep water tables, such as dry and semi-arid regions, as well as in valley fill deposits. The structures built for stream channel alteration are typically temporary, meant to supplement ground water recharge periodically, and are vulnerable to flooding. These approaches are often utilized in alluvial settings, but they can also be useful in hard rock places when thin river alluvium overlies excellent phreatic aquifers or the rocks in and around the stream channel are heavily worn or fractured. Artificial recharge by stream channel alterations might be more successful if surface storage dams exist upstream of the recharge locations since they allow for regulated water release.

6.8.3.2. SUBSURFACE TECHNIQUES

Subsurface approaches try to replenish deeper aquifers that are overlain by impermeable layers, preventing infiltration from surface sources that would normally recharge them. Injection wells or recharge wells, recharge pits and shafts, dug well recharge, borehole flooding, and recharge through natural holes and cavities are the most frequent ways for recharging such deeper aquifers.

6.8.3.2.1. INJECTION WELLS OR RECHARGE WELLS

Injection wells or recharge wells are constructions similar to bore/tube wells, but they are built to supplement ground water storage in deeper aquifers by supplying water under gravity or pressure. The aquifer to be restored is often desaturated owing to overexploitation of ground water. Artificial recharging of aquifers by injection wells can also be done in coastal zones to prevent saltwater infiltration and to counteract land subsidence concerns in places where constrained aquifers are intensively exploited.

6.8.3.2.2. RECHARGE PITS

Recharge pits are often dug pits that are deep enough to reach the low-permeability layers that overflow the unconfined aquifers. In concept, they are identical to recharge basins, with the exception that they are deeper and have a smaller bottom area. Because lateral hydraulic conductivity is significantly higher than vertical hydraulic conductivity in most layered sedimentary or alluvial material, the majority of infiltration occurs laterally through the pit walls in many such systems. Abandoned gravel quarry pits or brick kiln quarry pits in alluvial areas, as well as abandoned quarries in basaltic locations, can be utilized as recharge pits wherever permeable horizons exist. The Nalah trench is a type of recharge pit excavated across a streambed. Input portions of streams are ideal locations for such ditches. Contour trenches, as previously explained, fall into this type as well.

6.8.3.3. INDIRECT METHODS

Indirect techniques of artificial recharging of ground water do not require direct water delivery for recharging aquifers, but rather attempt to recharge aquifers indirectly. In this category, the most frequent approaches are induced recharge from surface water sources and aquifer alteration techniques.

6.8.3.3.1. INDUCED RECHARGE

Pumping water from an aquifer that is hydraulically coupled to surface water to induce recharge to a ground water reservoir is referred to as induced recharge. Once a hydraulic link is formed between the cone of depression and the river recharge border, surface water sources begin to contribute to the pumping yield. Because of its passage through the aquifer material, induced recharge can be employed to improve the quality of surface water resources under favorable hydrogeological circumstances. Collector wells and infiltration galleries, which are used to extract significant amounts of water from riverbeds, lakebeds, and waterlogged regions, also work on the idea of induced recharge.

6.8.3.3.2. AQUIFER MODIFICATION TECHNIQUES

These procedures alter the aquifer's properties in order to boost its ability to store and convey water via artificial means. The two most important procedures in this category are bore blasting and hydrofracturing. Though they are yield augmentation techniques rather than artificial recharge structures, they are also termed artificial recharge structures due to the increase in ground water storage in aquifers as a result.

6.8.3.4. COMBINATION METHODS

Under favorable hydrogeological circumstances, several combinations of surface and subsurface recharge technologies may be utilized in conjunction for optimal replenishment of ground water reservoirs. In such circumstances, the approaches to be integrated are site-specific. Combination methods that are commonly used include a) recharge basins with shafts, percolation ponds with recharge pits or shafts, and induced recharge with wells tapping multiple aquifers and allowing water to flow from upper to lower aquifer zones through the annular space between the walls and casing (connector wells), among others.

6.8.4. PROJECTS IN INDIA

- During 2021-22, Central Ground Water Board (CGWB) under this Ministry has taken up the project on 'Groundwater augmentation through artificial recharge in certain water stressed areas of Rajasthan and Haryana'. Artificial recharge structures will be constructed in water scarce areas of Jodhpur, Jaisalmer & Sikar districts of Rajasthan and Kurukshetra, Yamunanagar, Ambala & Panchkula districts of Haryana.
- Atal Bhujal Yojana (Atal Jal), launched by this Ministry in 2019, has its goal of demonstrating community-led sustainable ground water management which can be taken to scale. The major objective of the scheme is to improve the management of groundwater resources in select water stressed areas in identified states viz. Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh.
- CGWB has in the year 2018, taken up Artificial Recharge work in three aspirational districts, Osmanabad, Maharashtra, YSR Kadapa district, Andhra Pradesh and Jangaon district, Telangana. Under this, suitable structures were constructed to harvest the runoff water in stream to store at suitable locations for augmenting recharge to the ground water.

- Under Jal Shakti Abhiyan campaign, water conservation and rainwater harvesting structures, as well as reuse and recharge structures, are being developed by the State Governments.
- In 2018, CGWB took up a pilot project in the eastern region of Maharashtra covering districts of Wardha and Amravati at five locations for construction of Bridge cum Bandhara (BCB) for ground water recharge. The structures also serve a dual purpose of transportation as well as storage of water in the upstream side for drinking and irrigational needs. The project was completed in 2020.
- Since XII Plan, CGWB has also taken up Aquifer Mapping and Management Programme for the entire country, including low ground water level districts. Under this, aquifer mapping is aimed to delineate aquifer disposition and their characterization for preparation of aquifer/ area specific ground water management plans with community participation.
- Further, Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS) also has provisions for public works relating to natural resource management, water conservation and water harvesting structures to augment and improve ground water like underground dikes, earthen dams, stop dams, check dams and roof top rain water harvesting structures in public buildings.

TABLE 34.STATE-WISE PROJECTS FOR GROUNDWATER RECHARGING IN INDIA

STATE	PROJECTS FOR GROUNDWATER RECHARGING
Andhra Pradesh	• Andhra Pradesh Water, Land and Tree Act, 2002' stipulates mandatory provision to construct rainwater harvesting structures at new and existing constructions for all residential, commercial and other premises and open space having area of not less than 200 sq.m in the stipulated period, failing which the authority may get such Rain Water Harvesting (RWH) structures constructed and recover the cost incurred along with the penalty as may be prescribed
Bihar	• The Bihar Ground Water (Regulation and Control of Development and Management) Act, 2006 has been enacted which provides mandatory provision of RTRWH structures in the building plan in an area of 1000 sq. m. or more. • Bihar Ground Water (Regulation & Control of Development and Management) Act, 2006 enacted by the State Government of Bihar.
Delhi	• Modified Building Bye-laws, 1983 to incorporate mandatory provision of roof top RWH in new building on plots of 100 sq. Mt or above. through storage of rain water runoff to recharge underground aquifer in NCT, Delhi exists. • To encourage rain water harvesting by Resident Welfare Associations/Group Housing Societies, the Govt. of NCT Delhi has launched a scheme for financial assistance in the Bhagidari concept, where

	50% of the total cost of the project subject to a maximum of Rs. 50,000/- is being given to the RWAs as a grant if they adopt rain water harvesting.
Goa	• The "Goa Ground Water Regulation Act, 2002" has been enacted by the State Legislature • PWD, Goa has been asked to take up RWH structure for Government buildings. The PWD, Goa is studying various designs of roof top RWH for taking up other existing/new coming up large Government buildings.
Gujarat	• Gujarat Ground Water Authority (GGWA) has been constituted vide Government of Gujarat, notification No. GWR/1095/61/I-1/J-1 dated September 2001 for control and regulation of ground water resources. The State Govt. informed that the draft Bill is under process of finalization and suitable legislation will be enacted shortly. • Metropolitan Areas have notified rules under which no new building plan is approved without corresponding rainwater harvesting structure. The D/o Roads & Buildings have been directed to ensure that all major Govt. constructions including educational institutions had adequate rainwater harvesting facilities. The Urban Development and Urban Housing Department has issued necessary orders Gujarat Town Planning Act, 1976 to incorporate the rules for RWH.
Haryana	• Haryana Municipal Building Byelaws 1982 has been amended to incorporate the provision of compulsory Roof Top RWH. been amended to incorporate the provision of compulsory Roof Top Rain Water Harvesting.

Jharkhand	• The State Government has initiated action for construction of RTRWH structures in Government/Public buildings in a phased manner. A promotional scheme has also been started for awareness of protection of ground water and artificial recharge by grant of Rs. 25000/- for construction of artificial recharge structures. Ranchi Regional Development Authority (Jharkhand) has made Building Byelaws for RWH.
Karnataka	• The State Cabinet has approved the "Karnataka Ground Water (Regulation and Control of Development and Management) Bill, 2007. • The State has adopted a RWH policy to mandate this in all new construction. Bangalore City Corporation has already incorporated mandatory RWH in Building Bye-laws. Other ULB's are being encouraged to do so. Action to amend building bye-laws in major cities having population of more than 20 lakh to make RWH mandatory has been initiated. • Rural Development & Panchayati Raj Department has issued orders for implementation of roof top RWH in all Government buildings and also in rural schools. State has also extended help to the individual people also to the tune of 20% rebate on tax payment for 5 years duration.
Kerala	• The "Kerala Ground Water (Control and Regulation) Act, 1997" has been enacted. • Roof top RWH has become mandatory as per Kerala Municipality Building (Amendment) Rules, 2004 for all new buildings.
Madhya Pradesh	• The State Govt. vide Gazette notification dated August 2006, has made roof top RWH mandatory for all types of buildings having plot size of more than 140 sq.m. Govt. has also announced 6%

	rebate in property tax to individuals for the year in which the individual will go for installation of roof top RWH structures.
Maharashtra	• Maharashtra Water Resources Regulatory Authority Act was enacted in May 2005 and the State Govt. is considering amending this Act to incorporate the provision included in the Model Bill circulated by Ministry. • Maharashtra Government is promoting RTRWH under the "Shivkalin Pani Sthawan Yojana". It provides that all houses should have provision for rainwater harvesting without which house construction plan should not be approved. Bombay Municipal Corporation and Pimpri - Chinchwad Municipal Corporation have made RWH mandatory by enacting building bye-laws.
Punjab	• The Punjab Ground Water (Control and Regulation) Act, 1998 was prepared on the basis of Model Bill and was submitted to the Punjab State Water Resource Committee. The Committee observed that the draft is too harsh on users and Model Bill circulated by MOWR is not in the larger interest of the farmers and suggested that a system of incentives is better. The State Govt informed that the Govt is of the view that Ground Water Legislation should be attempted after thorough deliberations with all the stakeholders and comprehensive legal scrutiny. • Building Bye-laws amended to make RWH System mandatory in all buildings of above 200 sq. yds. The Punjab Urban Development Authority (PUDA) is in the process of amending the PUDA (Building) Rules 1996 for making this system mandatory. Municipal Corporation of Ludhiana and Jalandhar have framed Bye-laws to make RWH mandatory in new buildings.

Rajasthan	• The State Govt. of Rajasthan has presented "The Rajasthan Ground Water Management Bill, 2006" in the Vihaan Sabha on April 2006 and was referred to the Select Committee. The Bill is under consideration of the Select Committee. • Roof Top RWH has been made mandatory in State owned buildings of plot size more than 300 Sq.m with effect from January 2006. For violation of building bye-laws, punitive measures, viz. disconnection of water supply, has also been made. The Govt. has made provision of compulsory installation of rainwater harvesting system in all newly and existing construction building and Govt. offices.
Tamil Nadu	• The State Government of Tamil Nadu has passed an Act "Tamil Nadu Ground Water (Development and Management) Act, 2003" on March 2003 which includes provision of Tamil Nadu Ground Water Authority to regulate and control water development in the State of Tamil Nadu. Framing of rules and constitution of State Ground Water Authority is under consideration of State Govt. New provisions of the Model Bill, 2005 circulated by MoWR would be incorporated at appropriate time. • Vide Ordinance No. 4 of 2003 dated July, 2003 laws relating to Municipal Corporations and Municipalities in the State have been amended making it mandatory for all the existing and new buildings to provide RWH facilities. • The State has launched implementation of RWH scheme on massive scale in Government buildings, private houses/Institutions and commercial buildings in urban & rural areas. The State Government has achieved cent percent coverage in roof top RWH.

Uttarakhand	• The Govt. of Uttarakhand (Awas evam Shahari Vikas) has made rules for compulsory installation of RWH system and directed to adopt rules in building Bye-laws. Accordingly, all the Development Authorities had made partial amendments in the prevalent House Building and Development Bye-laws/Regulations.
Uttar Pradesh	• Mandatory rules have been framed for compulsory installation of RWH system in all the new housing schemes/plots/buildings of all uses, group housing schemes with provisions of separate network of pipes for combined RWH/Recharging system. Roof top RWH have been made mandatory for plots of 100-200 sq. mt. In Govt. Buildings (both new as well as old), installation of RWH structures has been made mandatory.
West Bengal	• Vide Rule 171 of the West Bengal Municipal (Building) Rules, 2007, installation of RWH system has been made mandatory. • West Bengal Ground Water Resources (Management, Control and Regulation) Act, 2005 came into effect on September 2005. Rules under the Act have also been framed by the State Govt.

Source: News Article, Ministry of Water Resources Government of India

6.8.5. STATE-WISE ARTIFICIAL RECHARGE PLANS

TABLE 35.STATE-WISE ARTIFICIAL RECHARGE PLANS IN INDIA

STATE	ARTIFICIAL RECHARGE PLANS
Andhra Pradesh	• A total of 26,228 artificial recharge facilities (13085 percolation tanks and 13143 check dams) are suggested for 83914.18 square kilometers scattered throughout 395 mandals in 13 districts of the state. Furthermore, for optimal recharging, 26,209 recharge shafts/recharge wells are proposed to be built in the specified Check dams and Percolation tanks. • The Check Dam unit cost is Rs. 8 Lakhs, the Percolation Tank is Rs. 13 Lakhs, and the Recharge Shaft is Rs. 2 Lakhs. The entire cost of the artificial recharge structures in the state is expected to be around Rs. 3276.67 Crore. • Under the WALTA legislation, the Government of Andhra Pradesh is required to create roof top rainwater collecting systems for buildings with roof areas of 200 square meters or more. Roof top rainwater harvesting construction has been estimated to cost Rs. 20,000/- for a 200 sq.m structure. It is projected that 15% of urban houses have a roof area of around 200 square meters, with the total cost for implementing 263694 RTRWH structures estimated to be Rs. 527.00 Crore.
Bihar	• According to state government estimates, rural parts of Bihar would require 163 Percolation Tanks, 2608 each of Gully Plug & Contour Bunding - Trenching, and 122 Check Dams. To improve groundwater recharge in adjacent marginal alluvial lands, 357 NalaBunding, 2842 Contour Bunding& Trenching, 5682 Recharge Shaft, and 265 Percolation Tank may be built.

	• It is projected that the de-silting of existing 10658 village tanks/ponds/talaos, the de-silting of 44 square kilometers of mauns (Ox-bow lake), the development of injection wells in 13811 village tanks, and the renovation of 2045 kilometers of traditional aharpyne system will result in an estimated rise in water table. The overall cost of the work is expected to be Rs. 2606.44 crore. • Roof-top rainwater gathering has the ability to supplement 216 MCM of rainfall to groundwater resources in the state. The first phase of roof-top rainwater collection application has the capacity to replenish 31.5 MCM of rainwater to groundwater aquifers. The total cost of the first phase of development is projected to be Rs. 500 crore.
Chhattisgarh	• According to Chhattisgarh's hydrogeological parameters, an average percolation tank has a filling capacity of 0.10 MCM. Because of frequent fillings during the monsoon, it may really store 200% of its capacity. As a result, an average gross storage capacity of 0.20 MCM was calculated. The total number of percolation tanks practicable in Chhattisgarh is 3426, at a cost of Rs. 1370.4 crore. • There is a lot of potential for building Nala bunds/Cement plugs in the state's many second and third order streams. Approximately 25% of excess monsoon runoff may be recharged by these structures. The average capacity of Nala bunds/Cement plugs was calculated to be 0.03 MCM. It is predicted that the state can build 11417 Nala bunds/Cement plugs for a total cost of 342.5 crore. • The viable recharge shafts and gravity head recharge well structures required for the whole State total 25687 and cost Rs. 1284.4 crore. • The overall cost of possible gully plugs, contour bunds, and gabion structures for the entire state is Rs 97.9 crore. • Even if 10% of the dwellings with an average roof area of 50 square meters are examined, a total roof area of 5.91 square kilometers is accessible to collect rainfall due to the different hydrogeological and other scenarios of space

	availability. The total amount of water accessible from roof top rainwater gathering was 6.812 MCM. The entire cost of roof top rainwater collection in 1,18,339 dwellings in Chhattisgarh's 114 proclaimed standard urban zones is Rs. 591.69 crore.
Delhi	• Recharge trenches and recharge shafts are recommended for construction in parks and gardens. In regions where it is practical, roof-top rainwater gathering systems are recommended. • The Yamuna flood plain has also been rejected since the water level is quite shallow, and it is recommended that surplus flood water be transferred to the Chhatarpur Basin, where the water level is deeper and can also accommodate recharged water. In steep locations, check dams have been proposed for construction. It is projected to build 22706 recharge trenches with recharge shafts, 304500 roof top rain water gathering systems, and 12 check dams. • The artificial recharge to groundwater in NCT of Delhi is of the order of 2206.08 Cr, which includes construction of CD, Recharge Trench with Recharge Shaft and Roof Top Rainwater harvesting structures.
Goa	• In the state, bhandaras and vented dams are acceptable constructions. These buildings may be able to harvest the excess run off and hence have been suggested in the State of at a cost of Rs 279.30 CR. • Roof top rainwater harvesting can be implemented in 45794 dwellings, government buildings, institutes, and other structures in the state's urban and municipal areas that are eligible for artificial recharge in the first phase. It will capture 27.43 MCM of rainwater to supplement groundwater supplies, assuming typical rainfall for the state and a system efficiency of 80%. • The overall cost of artificial recharge for the state of Goa is estimated to be Rs 425.84 Cr, with the rural region costing Rs 279.30 Cr and the urban area costing Rs 146.54 Cr.

Gujarat	• Weirs/check dams are regarded possible in hard rock locations with moderate relief, whereas percolation tanks are deemed acceptable in hard rock plateau and plain areas. Weirs/check dams are deemed possible in semi-consolidated formations. Percolation tanks are deemed acceptable in locations inhabited by alluvium. • There are about 52.83 Lakh households in such centers, and the total area available for harvesting (90% of total roof top) has been estimated to be 475.54 Lakh sq m, taking into account that approximately 25% of homes are appropriate for harvesting and 40 sq.m. as typical house hold roof top size. After allowing for storm rain and other factors, the source water available for harvesting has been calculated to be 60% of typical rainfall in the urban core. As a result, the total amount of source water accessible for harvesting has been calculated to be 26.3 MCM/yr. • The total cost for proposed artificial recharge is Rs 3462.73 Cr, out of which Rs 820.84 Cr is in rural areas and Rs 2641.89 Cr is urban areas.
Haryana	• Farm ponds, injection wells, and horizontal trenches with or without recharge shafts are the principal planned recharge structures in the state. In the Aravali Hills, the average cost of a recharge shaft to recharge 0.015 MCM water yearly is approximately Rs. 3.0 lakh, while the cost of a check dam to recharge 0.04 MCM water annually is around Rs. 50 lakhs and Rs. 40 lakhs in the Siwaliks. The average cost of building agricultural ponds is around 0.50 lakh, while the recharge pit in individual residences and clusters of buildings would cost 0.30 lakh. • It is recommended to build approximately 335 check dams, 44392 recharge shafts with recharge tube wells near percolation ponds and adjacent to canals to utilize surplus surface runoff, 393811 farm ponds in agricultural lands, and 304377 roof top rain water harvesting structures in urban and rural areas to divert runoff from the roof top area. • Roof top rainwater harvesting may be implemented in 30 lakh dwellings with 200 Sq.mt roof area, government buildings, institutes, and other structures in urban and municipal areas of the state appropriate for artificial recharge

	in the first phase. It will capture 24.5 MCM of rainwater to supplement groundwater supplies, assuming typical rainfall for the state and a system efficiency of 80%. • It is planned to use farm ponds to capture runoff from agricultural fields and farms located in rural areas. The runoff generated that can be used for recharging has been approximated by taking into account the 10% of total area of the districts covered by big farms where farm ponds can be built for recharge. It is anticipated that around 393811 agricultural ponds can be built to replenish approximately 3294.17 MCM of water.
Himachal Pradesh	• In general, in valley locations, Modification of Village Ponds/Tanks, Recharge Shaft, Injection well, Sub-surface dykes, and Roof Top Rainwater Harvesting Structures are considered, but in hilly areas, Gabbion, Check dams / Nala Bunds / Cement Plug, and Roof Top Rainwater Harvesting Structures are considered. • Rooftop rainwater may be collected and utilized to recharge ground water in hilly and urban locations. This method entails connecting the roof top output pipes to channel the water to either existing wells/tubewells/borewells or specifically developed wells. Large roof surfaces of urban housing complexes or institutional buildings can be used to capture roof top rain water to recharge aquifers in metropolitan regions. • The entire cost of artificial recharge for the state of Himachal Pradesh is in the range of Rs 1055.40 Cr, with an estimate of Rs 1018.65 Cr for artificial recharge buildings and 36.75 Cr for rooftop rainwater collection in urban areas.
Jharkhand	• As per Ranchi Rainwater Harvesting Regulation implemented by Ranchi Municipal Corporation, houses with 300 square meter of roof area or more are to be taken into consideration for roof top rain water harvesting. The cost of roof top rainwater harvesting of a roof area 300 square meters or above is estimated as Rs.1305 crores for 5.22 lakh buildings

Karnataka	• In the State, surface water spreading infrastructure such as percolation tanks, check dams, recharge shafts, sub-surface dykes, and vented dams (Dakshina Kannada District) are taken into account. The number of structures planned is based on the current structures built under various schemes in the state. The projected cost of artificial recharge structures in the state of Karnataka is Rs. 7111.64 Cr. • Roof top rain water harvesting may be implemented in 8.9 lakh dwellings, government buildings, institutes, and other structures in urban and municipal regions of the state appropriate for artificial recharge in the first phase. It will capture 149.64 MCM of rainwater to supplement ground water supplies, assuming typical rainfall for the state and a system efficiency of 80%.
North Eastern States	• The total cost towards artificial recharge works out to be Rs 7889.77 Cr, out of which the cost towards artificial recharge structures is Rs 4885.46 Cr, RWH in schools and Health centre is Rs 1683.49 Cr and for spring Development is Rs 1320.83 CR.
Kerala	• The annual rainfall in the urban area ranges from 2267 mm to 3428 mm, with an average of 3000 mm. After accounting for possible evapotranspiration, a total of 1755 mm of precipitation is available for conservation. A total of 57 MCM of rain water may be gathered from 4.8 lakh residential dwellings, according to estimates. Thus, the total cost of roof top rain water harvesting throughout the state in the first phase has been projected to be Rs. 724.18 crores. If the pilot project for RWH implementation in commercial buildings is a success, the remaining buildings can be considered in the second phase.

Madhya Pradesh	• The State Govt. vide Gazette notification dated August 2006, has made roof top RWH mandatory for all types of buildings having plot size of more than 140 sq.m. Govt. has also announced 6% rebate in property tax to individuals for the year in which the individual will go for installation of roof top RWH structures. • RTRWH considers a total of 408938 homes. Using an average of 50 square meters for each dwelling, the total roof area is projected to be 20446830 square meters (20.45 square kilometers). These methods are expected to recharge 17.41 MCM/year.
Maharashtra	• The total cost estimate for artificial recharge in Maharashtra is Rs 30834.06Cr with a break up of Rs 13893.74 Cr for rural areas & Rs 16940.31 Cr for urban areas. • The amount of surface water considered for artificial recharge plans is 2060.52 MCM. Based on the field circumstances, it has been estimated that 70% of the storage would be provided by percolation tanks, with the remainder provided by check dams (hard rock regions) or recharge shafts (alluvial areas). As a result, 1436.38 MCM (70%) will be kept in percolation tanks, 577.12 MCM in cement plugs/check dams, and 46.93 MCM in recharge shafts. As a result, 7188 percolation tanks, 19243 check dams/cement plugs, and 838 recharging shafts are recommended in Maharashtra's specified locations. • In the planned plan, 50% of the houses (56,46,772) with dugwells or borewells are targeted for replenishing the roof-top captured water. The average cost of making the necessary preparations to recharge existing wells will be roughly Rs. 30,000/- per dwelling. The anticipated total cost for covering all 537 urban towns is Rs. 16940.31 crores. • Except for Mumbai and Mumbai Sub-urban, it is predicted that roughly 8995 initiatives will be required across Maharashtra's 537 urban areas, with an average of 15 schemes per town/city. Suburban regions are planned with 100 schemes each, whilst the other 24 significant cities/towns under Municipal Corporations, such as Navi Mumbai,

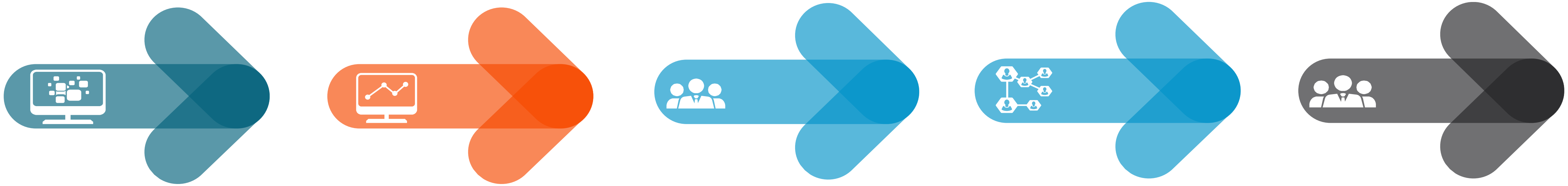
	Thane, Kalyan-Dombivali, Vasai-Virar, Pune, PCMC, Nashik, Aurangabad, Nagpur, and others, are proposed with 50 schemes each.
Punjab	• Uncommitted surplus run-off is to be used by the proposed Check dam and recharge shaft, while surplus canal water is to be recharged through injection wells and run-off from large agricultural land through farm ponds in respective farms, as well as provision of RTRWH in urban areas for roof-top rainwater. The number of injection wells has been decided based on the intake capacity of injection wells, and 1 farm pond per Ha has been recommended to gather run off from agricultural land. • In the first phase, it has been determined that roof top rainwater collecting may be implemented in government buildings, institutes, and 55 lakh dwellings in the state with 200 Sq.mt roof space for artificial recharge. It will use 52.49 MCM of rainwater to supplement groundwater supplies. • The total cost of artificial recharge in Punjab is of the order of Rs 6773.55 Cr, out of which artificial recharge in rural area is of the order of Rs 5119.63 Cr and RTRWH in urban areas is Rs 1653.92 Cr.
Rajasthan	• Ajmer, Alwar, Banswara, Baran, Bharatpur, Bhilwara, Bundi, Chittaurgarh, Dausa, Dholpur, Dungarpur, Jaipur, Jalore, Jhalawar, Karauli, Kota, Pali, Pratapgarh, Rajsamand, Sawai Madhopur, Sirohi, Tonk, and Udaipur are among the 23 districts of Eastern Rajasthan. Water conservation/augmentation solutions advocated in these locations include Catchment Area Treatment (Plantation, Staggered Trenches& CCT, etc.), Recharge Shaft in existing village ponds, Mini Percolation Tanks, Percolation Tanks, Pacca Check Dam, Anicut, MST, and Recharge/Farm Pond, among others. • Rajasthan's western desertic region includes ten districts: Barmer, Bikaner, Churu, Ganganagar, Hanumangarh, Jaisalmer, Jhunjhunu, Jodhpur, Nagaur, and Sikar. Artificial recharging has been proven to be almost impossible in

	these arid areas of the state under the current conditions. As a result, it is advocated to encourage rainwater collection using storage structures such as Tankas. • Total number of urban households: 48,00,000 Nos., The total number of harvesting jobs suggested for 20% of families is 9,60,000 and total cost of the harvesting works envisaged by the project is Rs. 1,440 crores.
Tamil Nadu	• In respect of rainwater harvesting, the State of Tamil Nadu was the first State to make it mandatory for all the buildings in the State and hence it is considered as an activity already completed. The proposed artificial recharge in the State of Tamil Nadu would have an estimated cost of Rs 2463.14. • July, 2003 laws relating to Municipal Corporations and Municipalities in the State have been amended making it mandatory for all the existing and new buildings to provide RWH facilities. The State has launched implementation of RWH scheme on massive scale in Government buildings, private houses/Institutions and commercial buildings in urban & rural areas. The State Government has achieved cent percent coverage in roof top RWH.
Uttarakhand	• The State Government (Avas and Shahri Vikas) has issued necessary regulations for the installation of Rainwater Harvesting Systems and has mandated that rules be incorporated into building bylaws. As a result, all development authorities have amended the existing house building and development by-laws/regulations. • Furthermore, the Directorate of Watershed Management has implemented water conservation measures in the state through various schemes, and rainwater harvesting and water conservation structures have been built under the Uttarakhand Decentralized Watershed Development Projects (UDWDP), Integrated Livelihood Support Program (ILSP), PMKSY-Watershed Development Program, and Gramya.

	• Aside from these initiatives, the Swajal Project's Project Management Unit (PMU) has taken up the basin/sub-basin catchments program as part of the Catchments Areas Conservation and Management Plan (CACMP). • The overall cost of the planned artificial recharge is Rs 40.57 Cr, with rural regions costing Rs 12.86 Cr and urban areas costing Rs 27.72 Cr.
Uttar Pradesh	• Based on the hydrogeology and terrain conditions, different structure, viz., Check Dam (CD)/ Nala Bund (NB)/ Cement Plug (CP), Ponds, Dug Well (DW) Recharge/ Tube Well (TW) Recharge/ Recharge Shafts & Percolation Tanks have been considered for artificial recharge. • The total cost of artificial recharge for the State of Uttar Pradesh is of the order of Rs 7156.45 Cr, out of which, cost estimate for Rural area is of the order of Rs 5099.23 Cr and Urban area is 2057.22 Cr.
West Bengal	• Given the terrain conditions, for hard rock terrains, percolation tanks, check dams, gabion structures/contour bunds, sub-surface dyke, recharge shaft/dug well recharge are proposed, whereas in alluvial areas, percolation tanks, re-excavation of existing tanks (renovation) with recharge shaft & injection wells, and RTRWH are proposed. • The overall cost of artificial recharge for the state of West Bengal is estimated to be Rs1698.17 crore, with the rural region costing Rs1631.15 crore and the urban area costing Rs67.02 crore.

Source: News Article, Ministry of Water Resources Government of India, Central Ground Water Board, Department of Water Resources, Ministry of Jal Shakti

6.9. VALUE CHAIN ANALYSIS



Raw Material Provider

- Veolia Water Technologies
- Suez Water Technologies & Solutions
- Xylem Inc.
- Aquatech International LLC
- Ecolab Inc.
- IDEXX Laboratories
- Danaher Corporation
- Kurita Water Industries Ltd.
- Pentair plc
- Thermo Fisher Scientific Inc.

Water Collectors

- Mueller Water Products Inc.
- Badger Meter Inc.
- IDEX Corporation (Including ADS Environmental Services)
- IDEX Corporation (Including EJ)
- CUES Inc.
- Xylem Inc. (Flygt brand)
- Aclara Technologies LLC
- Schneider Electric SE (Including Telvent)
- SUEZ - Water Technologies & Solutions (Innovyze)
- Clean Harbors Inc. (Including HydroChemPSC)

Treatment providers

- GE Water & Process Technologies (Now part of Suez)
- ABB Ltd.
- A.O. Smith Corporation
- Evoqua Water Technologies
- Trojan Technologies (Subsidiary of Danaher)
- Pall Corporation (Part of Danaher)
- Calgon Carbon Corporation (Now part of Kuraray)
- Nalco Water (Part of Ecolab)
- Kemira Oyj
- Ashland Global Holdings Inc.

Distributors

- American Water Works Company Inc.
- California Water Service Group
- Veolia North America
- Suez North America
- Aqua America Inc.
- EPCOR Utilities Inc.
- York Water Company
- Middlesex Water Company
- American States Water Company
- Global Water Resources Inc.

End-Users

- Pentair plc
- Ecolab Inc.
- Dow Inc. (Water Solutions business)
- Netafim Ltd.
- Jain Irrigation Systems Ltd.
- Toro Company
- Rain Bird Corporation
- Valmont Industries Inc.
- Lindsay Corporation
- Hunter Industries

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

6.10. PORTER'S FIVE FORCE ANALYSIS

FIGURE 70. PORTERS FIVE FORCE ANALYSIS

Bargaining Power of Buyers: Moderate to High

- Government and Municipalities: Major buyers with significant bargaining power.
- Private Sector Growth: Increasing private sector involvement can diversify buyer power.
- Price Sensitivity: Buyers are price-sensitive due to budget constraints and competitive pricing.

Threat of Substitution: Low to Moderate

- Alternative Water Sources: Innovations in water recycling and desalination as potential substitutes.
- Technological Advancements: Emerging technologies that offer more efficient water treatment solutions.
- Self-Reliance: Industries investing in their own water treatment solutions to reduce dependency.

Degree of Competition: Moderate to High

- High Competition: Numerous players, including both domestic and international companies.
- Market Fragmentation: Fragmented market with a mix of large, medium, and small players.
- Innovation Focus: Continuous need for innovation to improve efficiency and comply with regulations.
- Price Wars: Competitive pricing strategies to gain market share.

Bargaining Power of Suppliers: Moderate to High

- Limited Suppliers: Few specialized suppliers for equipment and chemicals.
- Switching Costs: High switching costs due to specialized nature of supplies.
- Supplier Expertise: High dependency on supplier expertise for technology and innovations.

Threat of New Entrants: High

- Capital Intensive: High initial investment in infrastructure and technology.
- Regulatory Barriers: Strict government regulations and compliance standards.
- Brand Loyalty: Established companies have strong brand recognition and trust.
- Economies of Scale: Existing players benefit from lower costs due to large-scale operations.

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 Treatment, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

6.10.1. 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.

6.10.2. 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.

6.10.3. 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.

6.10.4. 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.

6.10.5. 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.

6.11. PESTEL ANALYSIS

P POLITICAL	E ECONOMIC	S SOCIOCULTURAL	T TECHNOLOGICAL	E ENVIRONMENTAL	L LEGAL
• 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.	• 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.	• 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.	• 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.	• 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.	• 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

6.12. WATER AND WASTEWATER TREATMENT MARKET AVERAGE PRICE TREND ANALYSIS

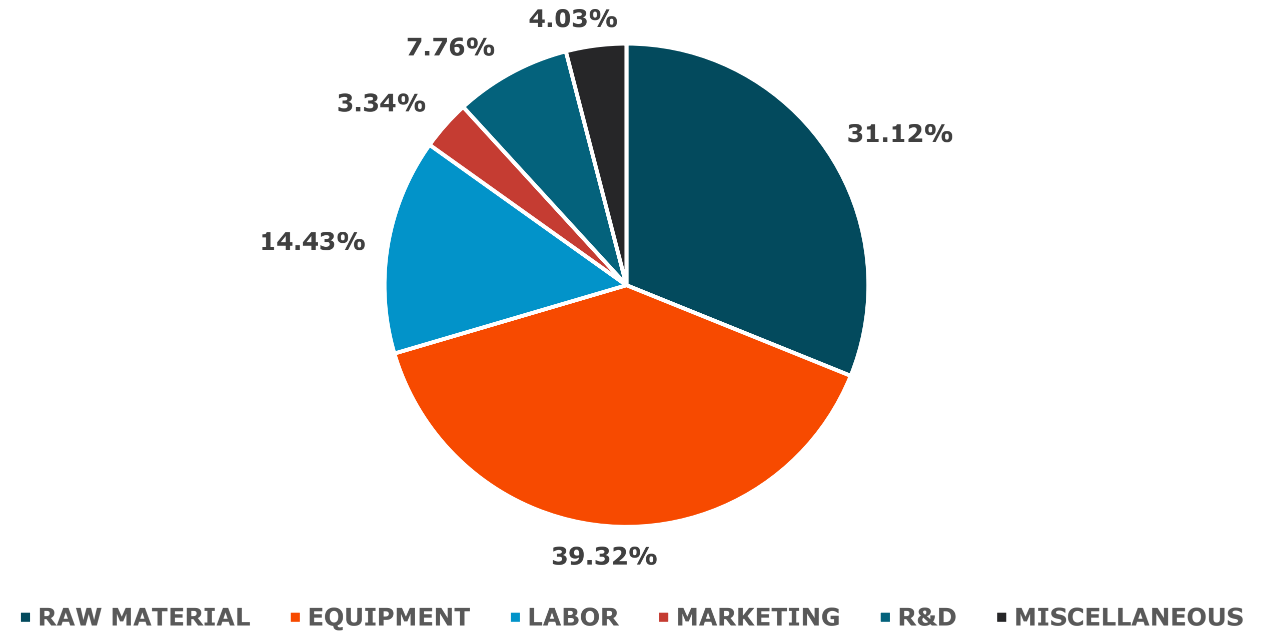
One of the economic tools for ensuring efficient water use and allocation is water pricing. A pricing policy may be the most effective tool for controlling water demand and achieving financial and economic objectives if it is well executed. Due to the enormous demand and the fact that the quality of the water has declined and now requires additional processing before being given to consumers, water costs have been continuously rising in recent years. Water sources that have collected a lot of pollution were left to today's water users, not as a result of their own behavior, but rather that of previous generations. Compared to the household and industrial sectors, agriculture has made less progress toward effective water pricing.

The Water Framework Directive states that a legally binding revenue requirement must be established in order for utilities to be able to cover the fair costs of delivering water and sewage services. Water pricing is based on average cost pricing or marginal cost pricing in the majority of OECD (Organization for Economic Cooperation and Development) nations and in the United States. Each kiloliter of water consumed results in a fee to the consumer. This price varies according to the city's pricing system. Additionally, water boards in many nations, including India, are also in charge of maintaining the sewerage system, and customers are charged for this service. Additionally, the "polluter pays principle" has been adopted by the majority of developed nations for the quantity of water pollution loads discharged by businesses. Urban water consumers pay the whole cost of wastewater treatment.

The water bill includes a minimum service fee in the majority of Indian cities. In India, water is a heavily subsidized good, which results in market inefficiencies and wasteful use of the already limited resource. In addition, contemporary wastewater treatment plants (WTPs) demand the employment of cutting-edge technology, including sensors, Internet of Things (IoT) gadgets, and AI-based trackers. This is a high-risk industry that discourages private sector participation due to the substantial upfront capital expenditures in machinery and equipment and the unpredictability of revenue streams. Therefore, these elements are likely to have an impact on water and wastewater treatment costs all over the world.

6.13. COST STRUCTURE ANALYSIS

FIGURE 71. 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. INDIA WATER AND WASTEWATER TREATMENT MARKET BY TYPE INSIGHTS & TREND

KEY TRENDS & HIGHLIGHTS

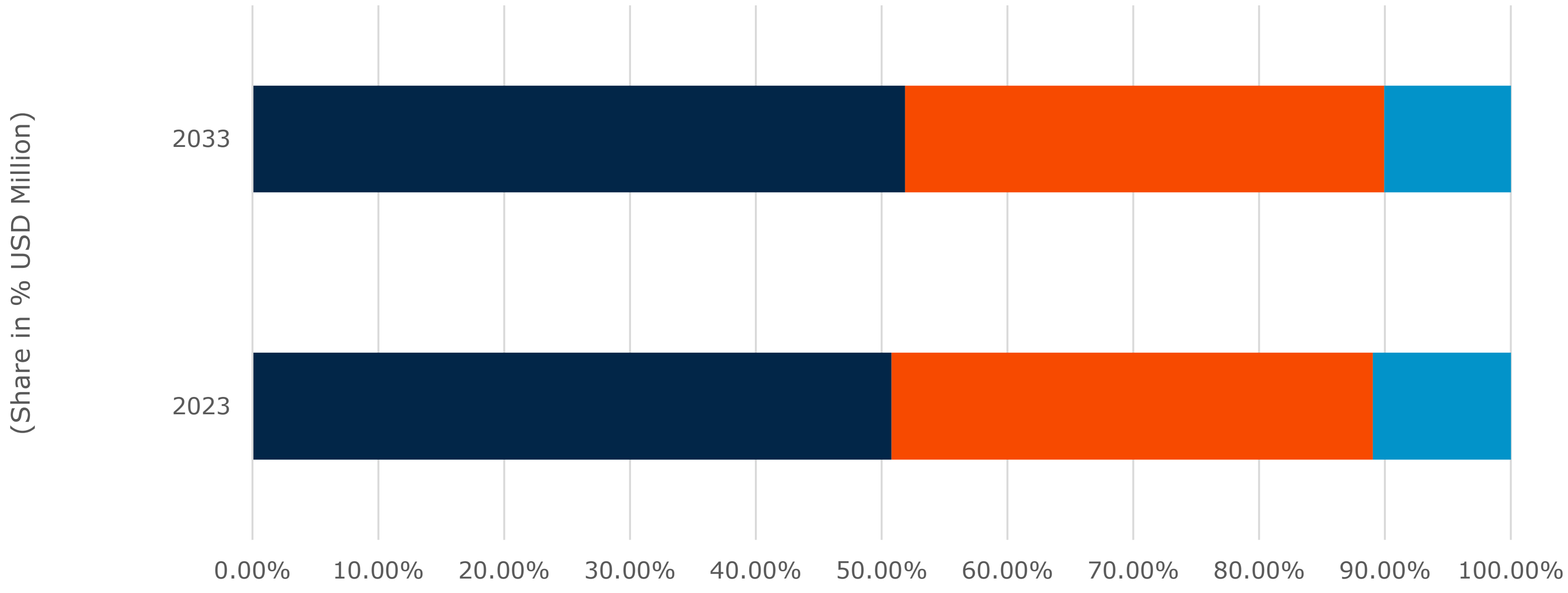
- The demand for Water Treatment accounted for over USD 6,654.796 Million in 2023 and is expected to grow at a CAGR of 6.42% in the forecast period.

7.1. TYPE DYNAMICS & MARKET SHARE, 2023 & 2033

By Type, the market is segmented into:

- Water Treatment
- Sewage Treatment
- Effluent Treatment

FIGURE 72. INDIA WATER AND WASTEWATER TREATMENT MARKET: TYPE DYNAMICS (SHARE IN % USD MILLION)



	2023	2033
Water Treatment	50.80%	51.85%
Sewage Treatment	38.23%	38.08%
Effluent Treatment	10.98%	10.06%

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. INDIA WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY TYPE, 2019-2033, (USD MILLION)

TABLE 36.INDIA WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY TYPE, 2019-2033, (USD MILLION)

Type	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Water Treatment	5,366.400	6,276.633	6,654.796	7,061.210	8,462.992	10,205.567	12,366.881	**6.42%**
Sewage Treatment	4,073.319	4,734.731	5,008.400	5,301.836	6,309.080	7,552.189	9,082.591	**6.16%**
Effluent Treatment	1,201.160	1,369.422	1,437.961	1,510.793	1,756.056	2,049.906	2,400.334	**5.28%**
Total	**10,640.878**	**12,380.787**	**13,101.158**	**13,873.839**	**16,528.128**	**19,807.663**	**23,849.806**	**6.20%**

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 MILLION)

TABLE 37. WATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	1,405.040	1,639.222	1,736.353	1,840.643	2,199.651	2,644.633	3,194.878	**6.32%**
West	1,391.265	1,637.825	1,740.699	1,851.525	2,235.710	2,716.918	3,318.422	**6.70%**
South	1,601.319	1,874.787	1,988.476	2,110.704	2,532.610	3,057.696	3,709.739	**6.47%**
East	968.776	1,124.799	1,189.268	1,258.339	1,495.021	1,786.321	2,143.843	**6.10%**
Total	**5,366.400**	**6,276.633**	**6,654.796**	**7,061.210**	**8,462.992**	**10,205.567**	**12,366.881**	**6.42%**

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. SEWAGE TREATMENT

The sewage treatment segment plays a pivotal role within the broader water and wastewater treatment market, addressing the critical need for effective purification of contaminated water before its release into the environment. As urbanization and industrialization continue to surge globally, the demand for efficient sewage treatment solutions has intensified. Sewage treatment is paramount not only for safeguarding public health but also for preserving aquatic ecosystems and ensuring sustainable water resources. Modern sewage treatment processes encompass a range of advanced technologies that collectively target the removal of pollutants, organic matter, and harmful pathogens from wastewater. Primary treatment involves physical separation to remove larger solids, while secondary treatment employs biological processes to break down organic contaminants. Tertiary treatment employs additional advanced techniques, such as filtration, chemical precipitation, and disinfection, to achieve the highest quality effluent standards.

The sewage treatment market is characterized by a dynamic landscape of innovation and adaptation to meet evolving regulatory standards and environmental imperatives. Key players in the industry continually invest in research and development to enhance treatment efficiency, reduce energy consumption, and minimize the environmental footprint of sewage treatment facilities. Moreover, the market's growth is not solely driven by regulatory compliance; it also stems from a growing awareness of the interconnectedness of water quality, human health, and ecological well-being. Governments, municipalities, and industries recognize the need for comprehensive sewage treatment solutions that align with broader sustainability objectives.

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

TABLE 38.SEWAGE TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	1,206.590	1,398.938	1,478.391	1,563.502	1,855.071	2,213.844	2,654.176	**6.06%**
West	1,087.822	1,272.189	1,348.780	1,431.089	1,714.961	2,067.801	2,505.369	**6.42%**
South	1,148.127	1,335.654	1,413.287	1,496.554	1,782.552	2,135.858	2,571.240	**6.20%**
East	630.780	727.950	767.942	810.692	956.495	1,134.686	1,351.807	**5.85%**
Total	**4,073.319**	**4,734.731**	**5,008.400**	**5,301.836**	**6,309.080**	**7,552.189**	**9,082.591**	**6.16%**

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

7.5. EFFLUENT TREATMENT

Effluent treatment plays a pivotal role in the water and wastewater treatment market by addressing the critical issue of managing industrial and municipal wastewater before its discharge into the environment. As industries continue to expand and urban populations grow, the volume of wastewater generated increases, necessitating effective treatment to safeguard ecosystems and public health. Effluent treatment involves a comprehensive set of processes designed to remove contaminants, pollutants, and harmful substances from wastewater, ensuring compliance with environmental regulations and sustainability goals. The effluent treatment process encompasses a range of physical, chemical, and biological techniques to achieve optimal purification. Physical methods include processes like sedimentation, filtration, and flotation, which aid in the removal of suspended solids, oil, and grease. Chemical treatments involve the use of coagulants, flocculants, and disinfectants to precipitate and neutralize contaminants. Biological treatment methods, such as activated sludge processes and biofiltration, utilize microorganisms to biodegrade organic matter and convert it into less harmful substances.

Driven by increasing environmental awareness and stringent regulatory frameworks, the INDIA WATER AND WASTEWATER TREATMENT MARKET has witnessed significant growth in the adoption of efficient effluent treatment solutions. Industries across sectors like pharmaceuticals, textiles, food and beverage, and petrochemicals are investing in advanced treatment technologies to minimize their environmental footprint. Municipalities are also upgrading their wastewater treatment facilities to mitigate pollution and protect water resources. Moreover, advancements in technology have led to the development of innovative effluent treatment solutions, including membrane filtration, ion exchange, and advanced oxidation processes. These cutting-edge methods offer higher efficiency in contaminant removal, reduced chemical consumption, and improved resource recovery, further driving the expansion of the market.

7.5.1. EFFLUENT TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 39. EFFLUENT TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	340.755	388.362	407.759	428.375	497.834	581.129	680.580	**5.28%**
West	345.816	397.212	418.259	440.693	516.719	608.692	719.491	**5.60%**
South	316.453	359.928	377.592	396.335	459.250	534.237	623.135	**5.16%**
East	198.136	223.921	234.351	245.390	282.253	325.849	377.128	**4.89%**
Total	**1,201.160**	**1,369.422**	**1,437.961**	**1,510.793**	**1,756.056**	**2,049.906**	**2,400.334**	**5.28%**

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. INDIA WATER AND WASTEWATER TREATMENT MARKET BY OFFERING INSIGHTS & TREND

KEY TRENDS & HIGHLIGHTS

- The demand for Process Control and Automation accounted for over USD 4,240.167 Million in 2023 and is expected to grow at a CAGR of 6.17% in the forecast period.

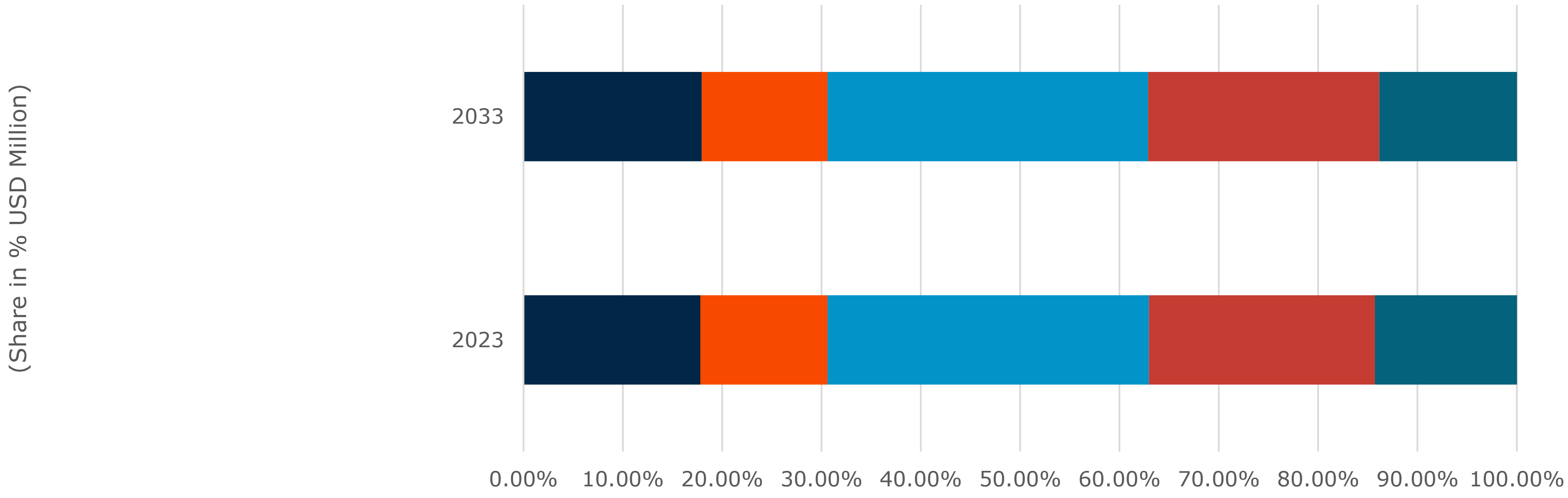
8.1. OFFERING DYNAMICS & MARKET SHARE, 2023 & 2033

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 73. INDIA WATER AND WASTEWATER TREATMENT MARKET: OFFERING DYNAMICS (SHARE IN % USD MILLION)



	2023	2033
Treatment Technologies	17.79%	17.96%
Treatment Chemicals	12.81%	12.66%
Process Control and Automation	32.36%	32.27%
Design, Engineering, and Construction Services	22.74%	23.26%
Operation and Maintenance Services	14.30%	13.85%

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. INDIA WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

TABLE 40.INDIA WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

Offering	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Treatment Technologies	**1,887.272**	**2,200.950**	**2,331.020**	**2,470.657**	**2,951.203**	**3,546.564**	**4,282.431**	**6.30%**
Activated Sludge Process	*715.327*	*831.030*	*878.887*	*930.190*	*1,106.218*	*1,323.330*	*1,590.445*	**6.14%**
Membrane Bio Reactor	*388.825*	*452.207*	*478.442*	*506.577*	*603.196*	*722.517*	*869.514*	**6.19%**
Moving Bed Bio Reactor	*293.292*	*343.771*	*364.773*	*387.361*	*465.402*	*562.660*	*683.600*	**6.51%**
Sequencing Batch Reactor	*173.776*	*204.628*	*217.503*	*231.375*	*279.475*	*339.745*	*415.113*	**6.71%**
Upflow Anaerobic Sludge Blanket Reactor	*141.170*	*163.808*	*173.164*	*183.190*	*217.558*	*259.892*	*311.903*	**6.09%**
Submerged Aerated Fixed Film Reactor	*121.197*	*141.767*	*150.314*	*159.499*	*191.183*	*230.573*	*279.433*	**6.43%**
Other Treatment Technologies	*53.685*	*63.739*	*67.939*	*72.466*	*88.171*	*107.848*	*132.423*	**6.93%**
Treatment Chemicals	**1,368.002**	**1,587.168**	**1,677.738**	**1,774.781**	**2,107.399**	**2,516.994**	**3,020.093**	**6.08%**
Corrosion Inhibitors	*360.870*	*417.800*	*441.293*	*466.445*	*552.514*	*658.239*	*787.768*	**6.00%**

Scale Inhibitors	23.453	27.033	28.506	30.080	35.449	42.011	50.008	5.81%
Biocides & Disinfectants	318.102	368.561	389.395	411.706	488.096	582.015	697.185	6.03%
Coagulants & Flocculants	94.112	109.961	116.541	123.610	147.973	178.222	215.695	6.38%
Chelating Agents	195.332	227.969	241.509	256.049	306.115	368.196	444.995	6.33%
Anti-Foaming Agents	268.383	310.310	327.597	346.096	409.330	486.885	581.749	5.94%
Ph Adjusters and Stabilizers	67.216	78.595	83.322	88.401	105.916	127.680	154.664	6.41%
Others	40.534	46.939	49.576	52.394	62.006	73.746	88.030	5.93%
Process Control and Automation	**3,447.321**	**4,008.099**	**4,240.167**	**4,489.020**	**5,343.394**	**6,398.142**	**7,697.036**	**6.17%**
Design, Engineering, and Construction Services	**2,401.085**	**2,809.630**	**2,979.416**	**3,161.918**	**3,791.625**	**4,574.857**	**5,546.857**	**6.44%**
Operation and Maintenance Services	**1,537.198**	**1,774.939**	**1,872.816**	**1,977.462**	**2,334.506**	**2,771.105**	**3,303.389**	**5.87%**
Total	**10,640.878**	**12,380.787**	**13,101.158**	**13,873.839**	**16,528.128**	**19,807.663**	**23,849.806**	**6.20%**

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 MILLION)

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

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	531.943	618.626	654.504	692.981	825.104	988.261	1,189.241	**6.18%**
West	546.263	640.907	680.308	722.702	869.278	1,052.150	1,279.815	**6.56%**
South	521.123	608.132	644.227	682.985	816.433	981.887	1,186.541	**6.33%**
East	287.944	333.285	351.982	371.990	440.388	524.267	626.834	**5.97%**
Total	**1,887.272**	**2,200.950**	**2,331.020**	**2,470.657**	**2,951.203**	**3,546.564**	**4,282.431**	**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

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 MILLION)

TABLE 42.ACTIVATED SLUDGE PROCESS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	200.436	232.242	245.374	259.438	307.596	366.809	439.428	**6.03%**
West	200.806	234.682	248.749	263.863	315.960	380.663	460.840	**6.39%**
South	201.154	233.857	247.391	261.902	311.721	373.217	448.942	**6.17%**
East	112.931	130.249	137.373	144.986	170.942	202.640	241.235	**5.82%**
Total	**715.327**	**831.030**	**878.887**	**930.190**	**1,106.218**	**1,323.330**	**1,590.445**	**6.14%**

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 MILLION)

TABLE 43. MEMBRANE BIO REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	110.378	128.006	135.289	143.091	169.825	202.730	243.128	**6.07%**
West	116.682	136.494	144.725	153.573	184.092	222.038	269.110	**6.43%**
South	104.954	122.128	129.239	136.867	163.071	195.452	235.367	**6.21%**
East	56.811	65.579	69.188	73.046	86.208	102.298	121.908	**5.86%**
Total	**388.825**	**452.207**	**478.442**	**506.577**	**603.196**	**722.517**	**869.514**	**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

8.3.4. 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 MILLION)

TABLE 44. MOVING BED BIO REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	81.706	95.511	101.244	107.405	128.643	155.027	187.729	**6.40%**
West	79.099	93.309	99.247	105.648	127.873	155.778	190.746	**6.79%**
South	84.630	99.282	105.380	111.942	134.628	162.927	198.153	**6.55%**
East	47.856	55.669	58.901	62.367	74.259	88.928	106.973	**6.18%**
Total	**293.292**	**343.771**	**364.773**	**387.361**	**465.402**	**562.660**	**683.600**	**6.51%**

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 MILLION)

TABLE 45. SEQUENCING BATCH REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	50.258	58.983	62.616	66.525	80.044	96.916	117.929	**6.57%**
West	56.964	67.480	71.886	76.643	93.215	114.124	140.457	**6.96%**
South	44.129	51.978	55.255	58.785	71.029	86.374	105.569	**6.72%**
East	22.425	26.186	27.747	29.422	35.187	42.330	51.158	**6.34%**
Total	**173.776**	**204.628**	**217.503**	**231.375**	**279.475**	**339.745**	**415.113**	**6.71%**

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 MILLION)

TABLE 46.UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	41.385	47.868	50.541	53.402	63.186	75.191	89.883	**5.96%**
West	48.399	56.458	59.801	63.389	75.742	91.050	109.976	**6.31%**
South	34.915	40.518	42.834	45.316	53.824	64.304	77.180	**6.09%**
East	16.470	18.963	19.988	21.082	24.807	29.347	34.864	**5.75%**
Total	**141.170**	**163.808**	**173.164**	**183.190**	**217.558**	**259.892**	**311.903**	**6.09%**

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 MILLION)

TABLE 47.SUBMERGED AERATED FIXED FILM REACTOR FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	32.874	38.366	40.645	43.092	51.516	61.963	74.886	**6.33%**
West	27.805	32.744	34.805	37.026	44.728	54.378	66.446	**6.71%**
South	37.886	44.371	47.068	49.967	59.979	72.445	87.930	**6.48%**
East	22.632	26.286	27.796	29.414	34.960	41.788	50.171	**6.11%**
Total	**121.197**	**141.767**	**150.314**	**159.499**	**191.183**	**230.573**	**279.433**	**6.43%**

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 MILLION)

TABLE 48. OTHER WATER & WASTEWATER TREATMENT TECHNOLOGIES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	14.905	17.650	18.795	20.028	24.295	29.624	36.259	**6.82%**
West	16.508	19.739	21.095	22.560	27.669	34.120	42.241	**7.22%**
South	13.455	15.997	17.060	18.205	22.182	27.168	33.400	**6.98%**
East	8.817	10.352	10.989	11.673	14.025	16.936	20.524	**6.47%**
Total	**53.685**	**63.739**	**67.939**	**72.466**	**88.171**	**107.848**	**132.423**	**6.93%**

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 MILLION)

TABLE 49. WATER & WASTEWATER TREATMENT CHEMICALS MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	371.255	429.814	453.979	479.852	568.384	677.138	810.382	**6.00%**
West	317.936	371.250	393.375	417.139	499.000	600.567	726.292	**6.36%**
South	416.801	484.159	512.017	541.879	644.332	770.676	926.094	**6.14%**
East	262.009	301.946	318.367	335.911	395.683	468.613	557.325	**5.79%**
Total	**1,368.002**	**1,587.168**	**1,677.738**	**1,774.781**	**2,107.399**	**2,516.994**	**3,020.093**	**6.08%**

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 MILLION)

TABLE 50.CORROSION INHIBITORS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	96.887	111.944	118.150	124.789	147.473	175.272	209.249	**5.91%**
West	81.001	94.384	99.930	105.882	126.353	151.688	182.971	**6.27%**
South	111.357	129.089	136.412	144.257	171.128	204.186	244.751	**6.05%**
East	71.626	82.383	86.801	91.517	107.561	127.093	150.797	**5.71%**
Total	**360.870**	**417.800**	**441.293**	**466.445**	**552.514**	**658.239**	**787.768**	**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

8.4.3. 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 MILLION)

TABLE 51.SCALE INHIBITORS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	7.058	8.112	8.545	9.007	10.579	12.494	14.820	**5.69%**
West	7.348	8.514	8.996	9.511	11.277	13.449	16.112	**6.03%**
South	6.215	7.166	7.557	7.975	9.402	11.146	13.272	**5.82%**
East	2.833	3.241	3.409	3.587	4.191	4.922	5.803	**5.49%**
Total	**23.453**	**27.033**	**28.506**	**30.080**	**35.449**	**42.011**	**50.008**	**5.81%**

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 MILLION)

TABLE 52. BIOCIDES & DISINFECTANTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	85.686	99.074	104.594	110.501	130.694	155.463	185.762	**5.94%**
West	72.171	84.159	89.130	94.466	112.827	135.573	163.682	**6.30%**
South	97.782	113.434	119.903	126.833	150.585	179.830	215.749	**6.08%**
East	62.463	71.894	75.769	79.907	93.990	111.149	131.991	**5.73%**
Total	**318.102**	**368.561**	**389.395**	**411.706**	**488.096**	**582.015**	**697.185**	**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

8.4.5. 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 MILLION)

TABLE 53.COAGULANTS & FLOCCULANTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	26.690	31.103	32.933	34.896	41.648	50.006	60.327	**6.27%**
West	25.019	29.417	31.251	33.226	40.065	48.620	59.298	**6.65%**
South	27.130	31.727	33.636	35.688	42.765	51.561	62.468	**6.42%**
East	15.273	17.713	18.721	19.800	23.494	28.036	33.602	**6.05%**
Total	**94.112**	**109.961**	**116.541**	**123.610**	**147.973**	**178.222**	**215.695**	**6.38%**

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 MILLION)

TABLE 54. CHELATING AGENTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	54.667	63.643	67.360	71.349	85.057	102.005	122.909	**6.23%**
West	49.931	58.648	62.280	66.189	79.716	96.616	117.683	**6.60%**
South	57.289	66.927	70.928	75.226	90.037	108.423	131.196	**6.37%**
East	33.445	38.751	40.941	43.285	51.305	61.152	73.207	**6.01%**
Total	**195.332**	**227.969**	**241.509**	**256.049**	**306.115**	**368.196**	**444.995**	**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

8.4.7. 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 MILLION)

TABLE 55.ANTI-FOAMING AGENTS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	71.838	82.896	87.449	92.319	108.938	129.275	154.093	**5.86%**
West	59.645	69.405	73.446	77.781	92.673	111.076	133.760	**6.21%**
South	83.110	96.217	101.626	107.417	127.233	151.574	181.395	**5.99%**
East	53.790	61.792	65.075	68.579	80.486	94.961	112.501	**5.65%**
Total	**268.383**	**310.310**	**327.597**	**346.096**	**409.330**	**486.885**	**581.749**	**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

8.4.8. 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 MILLION)

TABLE 56.PH ADJUSTERS AND STABILIZERS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	17.295	20.186	21.386	22.674	27.110	32.612	39.418	**6.34%**
West	13.030	15.347	16.314	17.355	20.968	25.495	31.157	**6.72%**
South	21.751	25.477	27.026	28.692	34.445	41.609	50.509	**6.49%**
East	15.140	17.586	18.597	19.680	23.393	27.965	33.580	**6.12%**
Total	**67.216**	**78.595**	**83.322**	**88.401**	**105.916**	**127.680**	**154.664**	**6.41%**

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 MILLION)

TABLE 57. OTHER CHEMICALS FOR WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	11.136	12.856	13.563	14.318	16.886	20.012	23.803	**5.81%**
West	9.791	11.376	12.029	12.729	15.121	18.051	21.629	**6.07%**
South	12.168	14.123	14.929	15.792	18.738	22.347	26.753	**6.03%**
East	7.440	8.585	9.055	9.556	11.262	13.335	15.845	**5.78%**
Total	**40.534**	**46.939**	**49.576**	**52.394**	**62.006**	**73.746**	**88.030**	**5.93%**

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 MILLION)

TABLE 58.WATER & WASTEWATER TREATMENT PROCESS CONTROL AND AUTOMATION MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	1,001.917	1,161.975	1,228.102	1,298.946	1,541.696	1,840.498	2,207.354	**6.07%**
West	912.891	1,067.938	1,132.362	1,201.603	1,440.463	1,737.462	2,105.916	**6.43%**
South	977.281	1,137.241	1,203.475	1,274.522	1,518.610	1,820.244	2,192.084	**6.21%**
East	555.232	640.946	676.228	713.948	842.626	999.938	1,191.682	**5.86%**
Total	**3,447.321**	**4,008.099**	**4,240.167**	**4,489.020**	**5,343.394**	**6,398.142**	**7,697.036**	**6.17%**

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 MILLION)

TABLE 59.WATER & WASTEWATER TREATMENT DESIGN, ENGINEERING, AND CONSTRUCTION SERVICES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	678.470	791.781	838.789	889.266	1,063.068	1,278.563	1,545.129	**6.33%**
West	621.490	731.855	777.912	827.535	999.598	1,215.192	1,484.780	**6.71%**
South	735.828	861.746	914.103	970.400	1,164.769	1,406.757	1,707.360	**6.48%**
East	365.298	424.249	448.612	474.717	564.190	674.345	809.588	**6.11%**
Total	**2,401.085**	**2,809.630**	**2,979.416**	**3,161.918**	**3,791.625**	**4,574.857**	**5,546.857**	**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

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 MILLION)

TABLE 60.WATER & WASTEWATER TREATMENT OPERATION AND MAINTENANCE SERVICES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	368.800	424.325	447.129	471.476	554.304	655.145	777.528	**5.72%**
West	426.323	495.277	523.781	554.327	659.050	788.039	946.478	**6.12%**
South	414.865	479.092	505.534	533.806	630.269	748.227	892.035	**5.87%**
East	327.209	376.245	396.372	417.854	490.883	579.694	687.348	**5.69%**
Total	**1,537.198**	**1,774.939**	**1,872.816**	**1,977.462**	**2,334.506**	**2,771.105**	**3,303.389**	**5.87%**

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. INDIA WATER AND WASTEWATER TREATMENT MARKET BY EQUIPMENT INSIGHTS & TREND

KEY TRENDS & HIGHLIGHTS

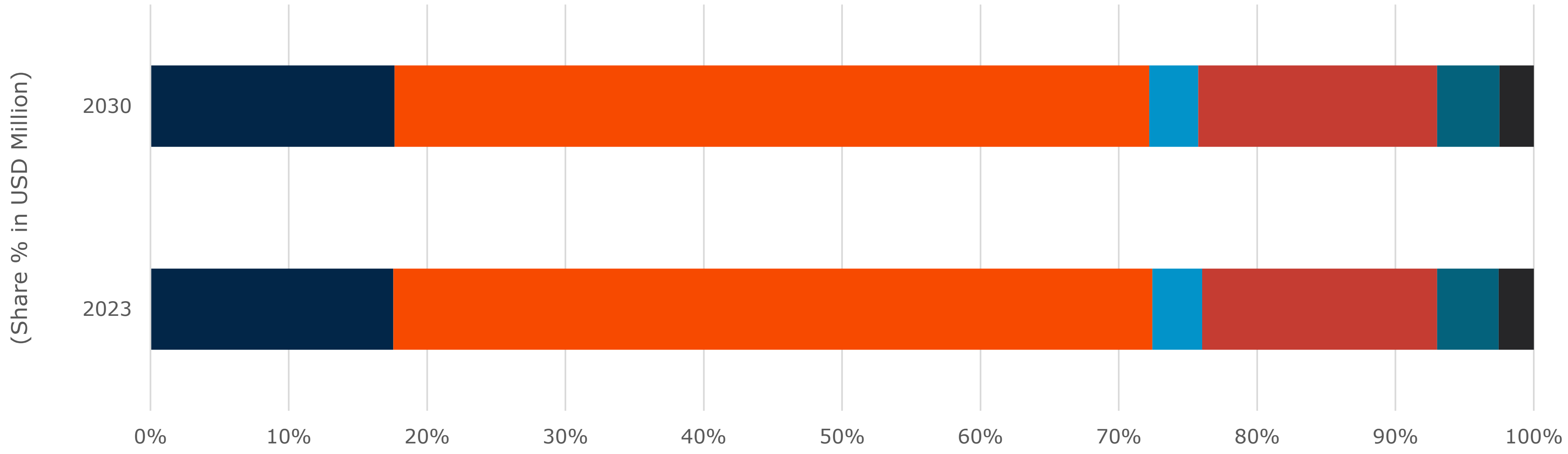
- The demand for Disinfection equipment accounted for over USD 7,188.642 Million in 2023 and is expected to grow at a CAGR of 6.12% in the forecast period.

9.1. EQUIPMENT DYNAMICS & MARKET SHARE, 2023 & 2033

By Equipment, the market is segmented into:

- Filtration
- Disinfection
- Adsorption
- Desalination
- Testing
- Others

FIGURE 74. INDIA WATER AND WASTEWATER TREATMENT MARKET: EQUIPMENT DYNAMICS (SHARE IN % USD MILLION)



	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. INDIA WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY EQUIPMENT, 2019-2033, (USD MILLION)

TABLE 61.INDIA WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY EQUIPMENT, 2019-2033, (USD MILLION)

Equipment	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Filtration	1,863.794	2,172.248	2,300.102	2,437.328	2,909.353	3,493.744	4,215.522	**6.28%**
Disinfection	5,854.987	6,798.517	7,188.642	7,606.780	9,040.888	10,808.624	12,982.111	**6.12%**
Adsorption	387.003	447.304	472.160	498.756	589.643	701.069	837.308	**5.93%**
Desalination	1,791.608	2,097.620	2,224.839	2,361.615	2,833.748	3,421.361	4,151.068	**6.47%**
Testing	471.751	550.708	583.470	618.655	739.833	890.140	1,076.143	**6.34%**
Others	271.735	314.390	331.944	350.706	414.662	492.725	587.656	**5.90%**
Total	**10,640.878**	**12,380.787**	**13,101.158**	**13,873.839**	**16,528.128**	**19,807.663**	**23,849.806**	**6.20%**

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 MILLION)

TABLE 62.FILTRATION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	527.296	612.866	648.270	686.229	816.520	977.303	1,175.222	**6.16%**
West	535.319	627.682	666.118	707.463	850.348	1,028.487	1,250.097	**6.53%**
South	516.604	602.501	638.120	676.360	807.961	971.011	1,172.550	**6.30%**
East	284.575	329.200	347.595	367.276	434.526	516.943	617.654	**5.95%**
Total	**1,863.794**	**2,172.248**	**2,300.102**	**2,437.328**	**2,909.353**	**3,493.744**	**4,215.522**	**6.28%**

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 MILLION)

TABLE 63.DISINFECTION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	1,626.174	1,883.493	1,989.713	2,103.452	2,492.791	2,971.301	3,557.871	**6.01%**
West	1,586.465	1,853.350	1,964.142	2,083.159	2,493.287	3,002.419	3,632.996	**6.37%**
South	1,658.651	1,927.558	2,038.806	2,158.078	2,567.421	3,072.485	3,694.104	**6.15%**
East	983.697	1,134.115	1,195.982	1,262.090	1,487.389	1,762.419	2,097.139	**5.80%**
Total	**5,854.987**	**6,798.517**	**7,188.642**	**7,606.780**	**9,040.888**	**10,808.624**	**12,982.111**	**6.12%**

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 MILLION)

TABLE 64.ADSORPTION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	105.400	121.582	128.244	135.367	159.672	189.401	225.667	**5.84%**
West	74.860	87.078	92.135	97.560	116.190	139.201	167.554	**6.19%**
South	137.352	158.957	167.871	177.413	210.054	250.134	299.217	**5.98%**
East	69.391	79.686	83.910	88.416	103.728	122.333	144.869	**5.64%**
Total	**387.003**	**447.304**	**472.160**	**498.756**	**589.643**	**701.069**	**837.308**	**5.93%**

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 MILLION)

TABLE 65. DESALINATION EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	494.820	577.879	612.352	649.380	776.946	935.247	1,131.235	**6.36%**
West	448.595	528.661	562.091	598.120	723.120	879.884	1,076.088	**6.74%**
South	542.388	635.675	674.483	716.222	860.414	1,040.086	1,263.477	**6.51%**
East	305.805	355.405	375.913	397.893	473.269	566.144	680.267	**6.14%**
Total	**1,791.608**	**2,097.620**	**2,224.839**	**2,361.615**	**2,833.748**	**3,421.361**	**4,151.068**	**6.47%**

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 MILLION)

TABLE 66.TESTING EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	156.476	182.186	192.836	204.262	243.532	292.091	351.991	**6.23%**
West	121.188	142.360	151.181	160.676	193.537	234.594	285.782	**6.61%**
South	131.527	153.670	162.862	172.738	206.771	249.026	301.366	**6.38%**
East	62.560	72.492	76.591	80.979	95.993	114.429	137.003	**6.02%**
Total	**471.751**	**550.708**	**583.470**	**618.655**	**739.833**	**890.140**	**1,076.143**	**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

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 MILLION)

TABLE 67.OTHER EQUIPMENT IN WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	42.219	48.515	51.089	53.830	63.097	74.262	87.648	**5.57%**
West	58.475	68.096	72.071	76.328	90.909	108.826	130.763	**6.16%**
South	79.376	92.009	97.214	102.782	121.791	145.048	173.400	**5.98%**
East	91.664	105.771	111.570	117.766	138.865	164.589	195.845	**5.81%**
Total	**271.735**	**314.390**	**331.944**	**350.706**	**414.662**	**492.725**	**587.656**	**5.90%**

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. INDIA WATER AND WASTEWATER TREATMENT MARKET BY END-USE INSIGHTS & TREND

KEY TRENDS & HIGHLIGHTS

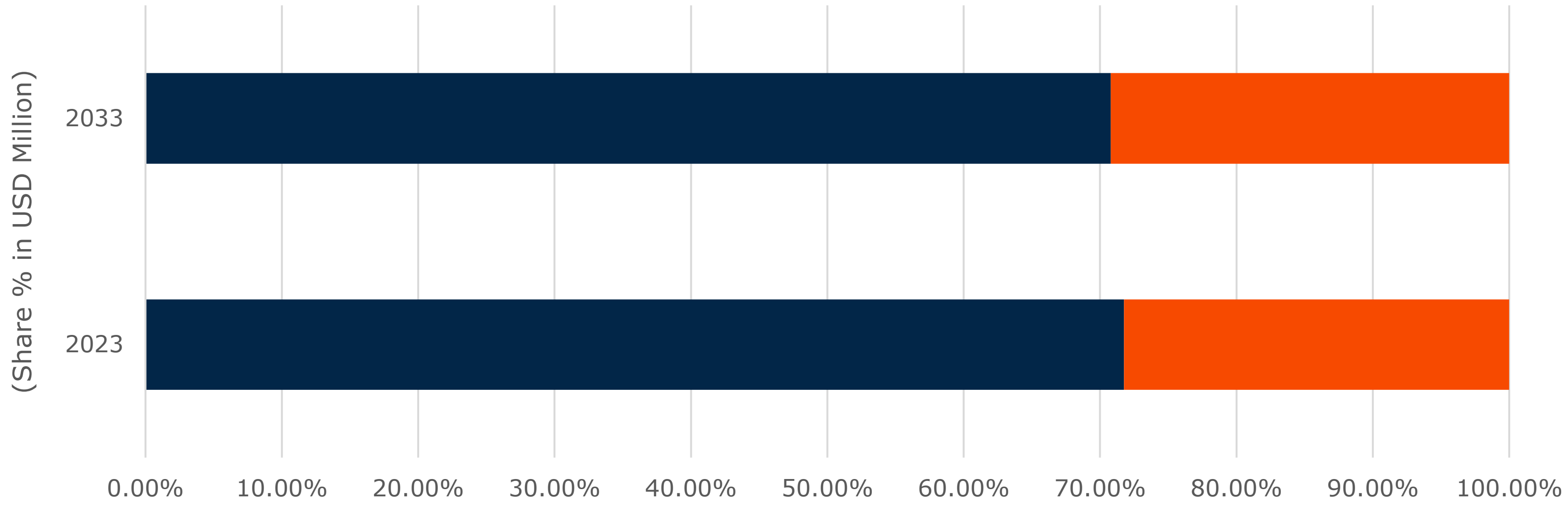
- The demand from municipal sector accounted for over USD 9,401.306 Million in 2023 and is expected to grow at a CAGR of 6.06% in the forecast period.

10.1. END-USE DYNAMICS & MARKET SHARE, 2023 & 2033

By end-Use, the market is segmented into:

- Municipal
  - Government & Public utilities
  - Local communities
- Industrial
  - Power Generation
  - Oil & Gas
  - Food & Beverages
  - Chemicals
  - Pharmaceuticals
  - Others

FIGURE 75. INDIA WATER AND WASTEWATER TREATMENT MARKET: END-USE DYNAMICS (SHARE IN % USD MILLION)



	2023	2033
Municipal	71.76%	70.78%
Industrial	28.24%	29.22%

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. INDIA WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY END-USE, 2019-2033, (USD MILLION)

TABLE 68.INDIA WATER AND WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY END-USE, 2019-2033, (USD MILLION)

End-Use	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Municipal	**7,672.408**	**8,895.905**	**9,401.306**	**9,942.704**	**11,797.477**	**14,079.875**	**16,881.269**	**6.06%**
Government & Public utilities	*5,065.533*	*5,903.346*	*6,250.596*	*6,623.287*	*7,905.160*	*9,491.999*	*11,451.661*	**6.27%**
Local communities	*2,606.875*	*2,992.558*	*3,150.710*	*3,319.417*	*3,892.316*	*4,587.876*	*5,429.608*	**5.62%**
Industrial	**2,968.471**	**3,484.882**	**3,699.852**	**3,931.135**	**4,730.651**	**5,727.788**	**6,968.537**	**6.57%**
Power Generation	*568.630*	*661.525*	*699.964*	*741.181*	*882.663*	*1,057.262*	*1,272.169*	**6.19%**
Oil & Gas	*254.547*	*294.594*	*311.109*	*328.783*	*389.207*	*463.325*	*553.986*	**5.97%**
Food & Beverages	*322.947*	*378.282*	*401.283*	*426.008*	*511.335*	*617.479*	*749.204*	**6.47%**
Chemicals	*399.791*	*471.457*	*501.378*	*533.624*	*645.484*	*785.728*	*961.180*	**6.76%**
Pharmaceuticals	*579.578*	*686.178*	*730.800*	*778.960*	*946.542*	*1,157.616*	*1,422.937*	**6.92%**
Others	*842.977*	*992.847*	*1,055.318*	*1,122.578*	*1,355.419*	*1,646.378*	*2,009.061*	**6.68%**
Total	**10,640.878**	**12,380.787**	**13,101.158**	**13,873.839**	**16,528.128**	**19,807.663**	**23,849.806**	**6.20%**

10.3. 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.

10.3.1. WATER & WASTEWATER TREATMENT FOR MUNICIPAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 69.WATER & WASTEWATER TREATMENT FOR MUNICIPAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	2,097.079	2,425.385	2,560.777	2,705.676	3,201.117	3,808.999	4,552.858	**5.95%**
West	2,052.292	2,393.860	2,535.512	2,687.593	3,211.033	3,859.668	4,661.544	**6.31%**
South	2,264.473	2,627.690	2,777.807	2,938.665	3,490.088	4,169.280	5,003.720	**6.09%**
East	1,258.564	1,448.970	1,527.209	1,610.771	1,895.238	2,241.927	2,663.148	**5.75%**
Total	**7,672.408**	**8,895.905**	**9,401.306**	**9,942.704**	**11,797.477**	**14,079.875**	**16,881.269**	**6.06%**

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

10.3.2. GOVERNMENT AND PUBLIC UTILITIES

Effective water and wastewater treatment is a cornerstone of modern society, ensuring access to clean and safe water while safeguarding the environment. Government agencies and public utilities play a pivotal role in managing these critical processes, maintaining the well-being of communities and ecosystems alike. The integration of advanced technologies and comprehensive regulatory frameworks is essential to address the growing challenges posed by population growth, urbanization, and industrial expansion. Government agencies shoulder the responsibility of formulating and enforcing regulations that govern water quality standards and wastewater discharge limits. These regulations not only protect human health but also preserve aquatic ecosystems. For instance, The Jal Jeevan Mission, a government initiative, aimed to provide piped water supply to all rural households by 2024. The mission's goal was to ensure access to tap water to every household, thus reducing the dependence on untreated water sources.

Public utilities, both at the local and national levels, are entrusted with the vital task of delivering potable water to households and industries, while effectively treating and managing wastewater. Cutting-edge technologies such as membrane filtration, UV disinfection, and advanced oxidation processes have revolutionized the treatment landscape, enhancing the removal of contaminants and pollutants. By embracing smart water management systems, utilities can optimize operations, reduce energy consumption, and minimize water loss. Collaboration between government agencies and public utilities is paramount to achieving sustainable water resource management. Robust investment in infrastructure upgrades and maintenance ensures the longevity of treatment facilities, reducing the risk of waterborne diseases and environmental degradation. Moreover, raising public awareness about water conservation and pollution prevention remains a shared endeavor, fostering a culture of responsible water usage.

10.3.2.1. WATER & WASTEWATER TREATMENT FOR GOVERNMENT AND PUBLIC UTILITIES REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 70.WATER & WASTEWATER TREATMENT FOR GOVERNMENT AND PUBLIC UTILITIES MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	1,391.412	1,617.249	1,710.688	1,810.874	2,154.751	2,579.120	3,101.521	**6.16%**
West	1,380.577	1,618.818	1,717.961	1,824.612	2,193.185	2,652.713	3,224.393	**6.53%**
South	1,481.645	1,728.042	1,830.218	1,939.912	2,317.429	2,785.177	3,363.352	**6.31%**
East	811.900	939.238	991.729	1,047.890	1,239.795	1,474.989	1,762.395	**5.95%**
Total	**5,065.533**	**5,903.346**	**6,250.596**	**6,623.287**	**7,905.160**	**9,491.999**	**11,451.661**	**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

10.3.3. LOCAL COMMUNITIES

Water and wastewater treatment play a pivotal role in ensuring the health and well-being of local communities by providing access to clean and safe water resources. In India, a country grappling with water scarcity and pollution challenges, efficient water and wastewater management is of paramount importance. The government has recognized the urgency of addressing these issues and has implemented various strategies to improve water quality and availability. According to government statistics, as of 2021, only about 40% of India's population has access to piped water supply, emphasizing the need for enhanced water treatment infrastructure. Moreover, a significant proportion of available water sources are contaminated with pollutants, jeopardizing public health. To combat these issues, the Indian government has launched ambitious initiatives such as the Swachh Bharat Mission and the Jal Jeevan Mission. These programs focus on improving water quality, sanitation facilities, and promoting community awareness about responsible water usage and conservation.

Local communities' benefit from these efforts through improved access to potable water and the prevention of waterborne diseases. Robust treatment processes involving physical, chemical, and biological methods are employed to purify raw water from various sources, making it safe for consumption. Additionally, wastewater treatment plants mitigate the environmental impact of untreated sewage and industrial effluents, safeguarding ecosystems and preserving the ecological balance. Community involvement is a crucial aspect of these initiatives. Local residents are educated about the importance of water conservation, pollution prevention, and the significance of proper waste disposal. Furthermore, decentralized treatment systems, such as constructed wetlands and community-based filtration units, are being introduced in rural areas to ensure sustainable water management.

10.3.3.1. WATER & WASTEWATER TREATMENT FOR LOCAL COMMUNITIES REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 71. WATER & WASTEWATER TREATMENT FOR LOCAL COMMUNITIES REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	705.667	808.136	850.089	894.802	1,046.366	1,229.879	1,451.337	**5.52%**
West	671.715	775.042	817.551	862.981	1,017.848	1,206.955	1,437.150	**5.83%**
South	782.828	899.649	947.589	998.753	1,172.659	1,384.104	1,640.368	**5.67%**
East	446.664	509.732	535.481	562.880	655.443	766.939	900.752	**5.36%**
Total	**2,606.875**	**2,992.558**	**3,150.710**	**3,319.417**	**3,892.316**	**4,587.876**	**5,429.608**	**5.62%**

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. INDUSTRIAL

The demand of water and wastewater treatment in industrial sector is anticipated to grow significantly in the forecast period. Several industries such as, food & beverages, pharmaceuticals and chemicals, power generation, pulp and paper, oil & gas, mining, petrochemical and semiconductors, among others usually implements water and wastewater treatment facilities. These treatment facilities comprise of mechanisms and processes for water treatment which is generated from anthropogenic industrial and commercial activities. The wastewater generated from these sectors consists of hazardous chemical components and other impurities and they can be harmful if this wastewater is directly released into the environment. As governments of a number of countries are implementing more stringent guidelines for industrial water and wastewater treatment and discharge, industries must treat their water and wastewater before releasing into the environment. Treated water can be reused for various industrial activities. Adoption of water and wastewater treatment in the industrial sector also offers benefits such reduced impact on the environment, enables recycling and reusing water, and strengthens the economy, among others. These benefits are expected to support demand for and use of these processes in an increasing number of industrial sett-ups and drive market revenue growth over the forecast period.

10.4.1. WATER & WASTEWATER TREATMENT FOR INDUSTRIAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 72. WATER & WASTEWATER TREATMENT FOR INDUSTRIAL REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	855.306	1,001.137	1,061.726	1,126.843	1,351.439	1,630.606	1,976.776	**6.44%**
West	772.611	913.366	972.226	1,035.714	1,256.357	1,533.742	1,881.738	**6.86%**
South	801.426	942.679	1,001.549	1,064.928	1,284.325	1,558.510	1,900.394	**6.65%**
East	539.128	627.700	664.351	703.650	838.531	1,004.929	1,209.630	**6.20%**
Total	**2,968.471**	**3,484.882**	**3,699.852**	**3,931.135**	**4,730.651**	**5,727.788**	**6,968.537**	**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

10.4.2. POWER GENERATION

The demand of water and wastewater treatment in power generation industry is likely to grow significantly in the forecast period. Purified water is an essential component in the power generation sectors such as, nuclear power plants, fossil power plants, cooling power plants and electricity generation, among others. This purified water aids to enhancing equipment life, assures lasting performance, and reduces chances of corrosion, among others. As a result of these benefits, water treatment is widely adopted in this sector. Usually, pretreating process is widely used for removing colloidal particles, solids, organics and minerals substances. However, high volume of water consumption in this sector has resulted in increasing adoption of water and wastewater treatment processes for internal water reuse for clean, renewable power generation. This treated water can be used for cooling towers, turbines and boilers, among others. Furthermore, rising concerns regarding wastewater generated from the power sector has resulted in large investment and adoption of wastewater treatment in order to meet the high energy requirements, and this is expected to continue to drive demand for water and wastewater treatment in the industry.

10.4.2.1. WATER & WASTEWATER TREATMENT FOR POWER GENERATION REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 73.WATER & WASTEWATER TREATMENT FOR POWER GENERATION MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	165.758	192.271	203.221	214.949	255.118	304.524	365.127	**6.06%**
West	156.067	182.735	193.816	205.725	246.808	297.882	361.224	**6.45%**
South	149.546	174.270	184.511	195.498	233.257	279.937	337.495	**6.25%**
East	97.259	112.250	118.417	125.009	147.479	174.919	208.324	**5.84%**
Total	**568.630**	**661.525**	**699.964**	**741.181**	**882.663**	**1,057.262**	**1,272.169**	**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

10.4.3. OIL AND GAS

The demand of water and wastewater treatment in oil & gas industry is estimated to grow significantly in the forecast period. Water is among one of the essential components in the oil & gas production without it companies cannot generate consistent revenue and optimize their system. Thus, for this water and wastewater treatment needed to be implemented. Furthermore, during the oil and gas production in a reservoir, water also gets seeps through owing to two major rock types including sandstone and limestone that are being drilled. These rocks are extremely porous which aids to fluids to pass through easily. These all activities are performed in the reservoir and there is need to separate it by the means of water treatment. This treatment helps in separating oil, gas and water for further usage. Furthermore, rising on focus in recycling and reusing the wastewater in order to replace or supplement the utilization of natural sources of water in process, minimize underground injection of waste water, reducing discharges and conserve water resources, among others. The water treatment technologies such as, coagulation and flocculation along with sedimentation and multimedia filtration can be used for removal of the particles. Further, the dissolved ions can be removed by reverse osmosis or ion exchange. This reverse osmosis brine is further treated through evaporation and crystallization for offering zero liquid discharge solutions for the companies. This, fresh water produced can be easily reused for the variety of process in the oil & gas sector which in turn enhances the demand for water and wastewater treatment.

10.4.3.1. WATER & WASTEWATER TREATMENT FOR OIL AND GAS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 74. WATER & WASTEWATER TREATMENT FOR OIL AND GAS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	67.997	78.437	82.733	87.325	102.985	122.123	145.442	**5.83%**
West	77.029	89.662	94.891	100.499	119.756	143.532	172.812	**6.21%**
South	71.728	83.110	87.807	92.836	110.042	131.171	157.047	**6.02%**
East	37.793	43.385	45.678	48.123	56.424	66.499	78.685	**5.62%**
Total	**254.547**	**294.594**	**311.109**	**328.783**	**389.207**	**463.325**	**553.986**	**5.97%**

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

10.4.4. FOOD AND BEVERAGE

The demand of water and wastewater treatment in food & beverages industry is estimated to grow significantly in the forecast period. Food and beverage manufacturers utilize larger volumes of water in their production process. This water is widely used for activities such as, ingredients, cleaning, boiling and chilling, among others. As there is rising in awareness regarding water scarcity food & beverage are more focusing on reusing the treated wash water and wastewater. The major food & beverage industries adopting water and wastewater treatment includes, fruit & vegetable processing, meat processing, dairy, aquaculture, soft drinks, distilleries, breweries and spirits, among others. There is more need of water treatment in these industries as microbiologically contaminated impure water quality can have adverse impact on the food & beverage product quality and also reduces the shelf life of the product. The treated water can be used for variety of activities in food & beverage sector including, equipment washing, evaporators, boilers, cooling towers, dust control, chillers and landscaping, among others. The UV disinfection is used for eliminating algae, bacteria, mold spores, protozoa, and viruses, among others and this treated water can be used in manufacturing of food and beverages. Thus, owing to wide range of application of water and wastewater treatment in food & beverages industry, would enhance the demand for it in the upcoming years.

10.4.4.1. WATER & WASTEWATER TREATMENT FOR FOOD AND BEVERAGE REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 75.WATER & WASTEWATER TREATMENT FOR FOOD AND BEVERAGE REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	94.939	110.837	117.431	124.510	148.880	179.079	216.409	**6.33%**
West	94.181	111.032	118.065	125.644	151.926	184.862	226.044	**6.74%**
South	84.550	99.186	105.275	111.823	134.445	162.628	197.657	**6.53%**
East	49.276	57.227	60.512	64.031	76.084	90.910	109.094	**6.10%**
Total	**322.947**	**378.282**	**401.283**	**426.008**	**511.335**	**617.479**	**749.204**	**6.47%**

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

10.4.5. CHEMICALS

In the chemical industry, effective water and wastewater treatment is of paramount importance to ensure both environmental compliance and sustainable operations. Water plays a critical role in various processes within chemical manufacturing, ranging from cooling and heating to mixing and reacting. However, these processes often generate wastewater containing a diverse array of contaminants, such as organic compounds, heavy metals, and chemicals. Proper treatment of this wastewater is essential to safeguard local ecosystems and public health. To address these challenges, the chemical industry employs advanced water and wastewater treatment technologies. Physicochemical treatment methods, including coagulation, flocculation, and sedimentation, are commonly used to remove suspended solids and certain contaminants. Additionally, biological treatment processes, such as activated sludge and anaerobic digestion, can effectively break down organic pollutants. Advanced techniques like membrane filtration, ion exchange, and adsorption are employed for the removal of dissolved contaminants. These approaches are complemented by stringent monitoring and analytical methods to ensure compliance with environmental regulations.

In India, the government has recognized the significance of water and wastewater management in the chemical sector. As of my last knowledge update in September 2021, the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) oversee the implementation of regulatory frameworks, setting discharge standards and monitoring compliance. The 'Zero Liquid Discharge' (ZLD) initiative has gained traction, encouraging industries to adopt technologies that minimize wastewater discharge by recovering and reusing water and treating residues effectively. Government statistics underline the urgency of sustainable water management in India's chemical industry. According to data available from 2020, the CPCB reported that around 30% of water pollution incidents in the country were attributed to industrial discharges, including those from the chemical sector. To mitigate this impact, the Indian government has been focusing on strengthening enforcement mechanisms, promoting green technologies, and fostering industry collaborations to drive innovation in water and wastewater treatment methods.

10.4.5.1. WATER & WASTEWATER TREATMENT FOR CHEMICALS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 76. WATER & WASTEWATER TREATMENT FOR CHEMICALS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	111.960	131.612	139.800	148.615	179.117	217.221	264.713	**6.62%**
West	111.797	132.767	141.562	151.066	184.209	226.097	278.935	**7.05%**
South	102.983	121.671	129.482	137.905	167.163	203.916	249.987	**6.83%**
East	73.052	85.407	90.533	96.039	114.995	138.493	167.545	**6.38%**
Total	**399.791**	**471.457**	**501.378**	**533.624**	**645.484**	**785.728**	**961.180**	**6.76%**

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

10.4.6. PHARMACEUTICALS

The demand of water and wastewater treatment in pharmaceuticals and chemicals industry is projected to grow significantly in the forecast period. In the pharmaceutical industry, effective water and wastewater treatment processes are of paramount importance to ensure compliance with environmental regulations and the production of high-quality products. Water serves as a critical ingredient in various pharmaceutical manufacturing processes, including formulation, cleaning, and cooling. However, the industry generates complex wastewater streams containing organic compounds, solvents, heavy metals, and other contaminants, necessitating rigorous treatment methods.

The water and wastewater treatment strategies adopted by the pharmaceutical sector are multifaceted and tailored to the specific requirements of each facility. Common treatment techniques encompass physical, chemical, and biological processes, such as coagulation, flocculation, activated carbon adsorption, membrane filtration, and advanced oxidation. Stringent monitoring and control measures are implemented to maintain water quality and minimize the release of pollutants into the environment. In the context of India, a major player in the global pharmaceutical market, government statistics underscore the significance of responsible water management. According to the Central Pollution Control Board (CPCB) of India, the pharmaceutical industry is identified as a significant water polluter, contributing to the nation's water pollution load. A 2019 report indicated that the pharmaceutical sector was responsible for releasing a considerable volume of effluents into water bodies, containing pollutants that could pose risks to aquatic ecosystems and public health. To address these concerns, the Indian government has implemented stringent regulations to govern water usage and wastewater discharge in the pharmaceutical industry. Firms are mandated to adhere to environmental norms, invest in advanced treatment technologies, and periodically report their effluent quality to regulatory bodies. This regulatory framework aims to mitigate environmental pollution, safeguard water resources, and promote sustainable practices within the pharmaceutical sector.

10.4.6.1. WATER & WASTEWATER TREATMENT FOR PHARMACEUTICALS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 77.WATER & WASTEWATER TREATMENT FOR PHARMACEUTICALS REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	168.495	198.831	211.502	225.161	272.570	332.058	406.544	**6.79%**
West	159.776	190.517	203.446	217.435	266.380	328.530	407.309	**7.22%**
South	152.431	180.803	192.692	205.532	250.269	306.724	377.826	**7.00%**
East	98.876	116.027	123.161	130.832	157.323	190.303	231.257	**6.53%**
Total	**579.578**	**686.178**	**730.800**	**778.960**	**946.542**	**1,157.616**	**1,422.937**	**6.92%**

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

10.4.7. OTHERS

The demand for water & wastewater treatment for other end-uses such as semiconductor, mining, paper & pulp, textiles, paints & coatings, and personal care, among others is expected to grow significantly during the forecast period. The pulp and paper industry are among key user of water for nearly every step of manufacturing process. This sector generates large volume of wastewater and residual sludge waste. The waste stream from this sector consists of variety of contaminants such as, chlorinated organic compounds, sediments, effluent solids, absorbable organic halides, chemical oxygen demand (COD) and biological oxygen demand (BOD) contaminants, among others. Thus, for treating these contaminants wastewater treatment is usually implemented by the players in the industry. Furthermore, in around 85 percent of water is used in this sector is uses as process water which generates large quantities of contaminated water that have been led to use of onsite wastewater treatment solutions. Treatments such as, primary, secondary and tertiary are being extensively used in this sector. Primary treatment such as, clarification is widely utilized for removal of solids and particulate matter. Secondary biological treatment is utilized for removal of removing biodegradable organic matter and decreasing the effluent toxicity. And tertiary treatment including, UV disinfection, membrane filtration, granular activated carbon and ion exchange, among others are used to treat effluent water to higher qualities. Thus, the demand for water and wastewater treatment in pulp and paper industry would have influence in the upcoming years.

Mining industry produces usually large amount of concentrated wastewater owing to contact between water and minerals resulting in production of distinct reactions. In addition to drainage from rainfall, the several mining activities can be found as the source of effluents. These effluents are composed of variety of composition relying on nature of each mineral. Some of them includes, hydrolysable and non-hydrolysable, more or less soluble and sorbents and non-sorbents, among others. As this wastewater cannot be released into environment without treatment and can also results in provoke serious consequences in mining. Asa result, companies operating in this sector are widely implementing wastewater treatment. Conventionally, treatment methods such as physico-chemical or biological methods were being used for treating these effluents. However, over the past few years, zero discharge methods are considered among the most efficient treatment methods. These methods have less impact on the ecosystem and also enables reusing water. These benefits are driving demand for water and wastewater treatment in the mining industry and supporting revenue growth of the market.

In the semiconductor industry, ultra-pure water (UPW) which is free from all ions, chlorine, silica and particles is widely used for manufacturing semiconductors that are free of contaminants. After the usage of the water, it is discharged from the system as a wastewater, and which need to be treated and then later discharged or can be reused. Mostly the wastewater is produced is from treatment of contaminants in the wafer cleaning process and air pollution prevention facility. As this wastewater cannot be used directly owing to its liquid and solid contaminants. Thus, companies extensively use activated carbon and a total phosphorous removing apparatus for treating this water. Furthermore, recycled water is reused after securing the required water quality as per semiconductor industry. As there is surge in growth in electronic sector which would enhance the demand for semiconductor manufacturing which in turn have positive influence on the water and wastewater treatment in semiconductors industry.

Textile wastewater contains a wide range of colours and chemical additives, posing an environmental issue for the textile sector not just as liquid waste but also due to its chemical makeup. The principal contaminants in textile wastewater include high suspended particles, chemical oxygen demand, heat, colour, acidity, and other soluble compounds from dyeing and finishing operations. Substances that must be removed from textile effluent include COD, BOD, nitrogen, heavy metals, and dyestuffs, necessitating the industry's need for wastewater treatment.

Furthermore, the paint and coating business consumes a lot of water throughout the manufacturing process and generates a lot of polluted effluent. Paint-coating industry wastewater is subject to stringent regulations due to high levels of organic and inorganic pollutants, biological oxygen demand (BOD), chemical oxygen demand (COD), flammable liquids, suspended solids, heavy metals, toxic materials, turbidity, colour, varnish, polish, insulation chemicals, rosins, and solvents. Physical, chemical, and biological procedures are the primary wastewater treatment processes in the paint-coating business.

10.4.7.1. WATER & WASTEWATER TREATMENT FOR OTHER END-USES REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 78.WATER & WASTEWATER TREATMENT FOR OTHER END-USES REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	246.157	289.150	307.040	326.283	392.768	475.601	578.542	**6.44%**
West	173.760	206.653	220.445	235.344	287.277	352.839	435.413	**6.94%**
South	240.187	283.640	301.782	321.334	389.148	474.134	580.382	**6.66%**
East	182.872	213.404	226.050	239.617	286.226	343.805	414.725	**6.17%**
Total	**842.977**	**992.847**	**1,055.318**	**1,122.578**	**1,355.419**	**1,646.378**	**2,009.061**	**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

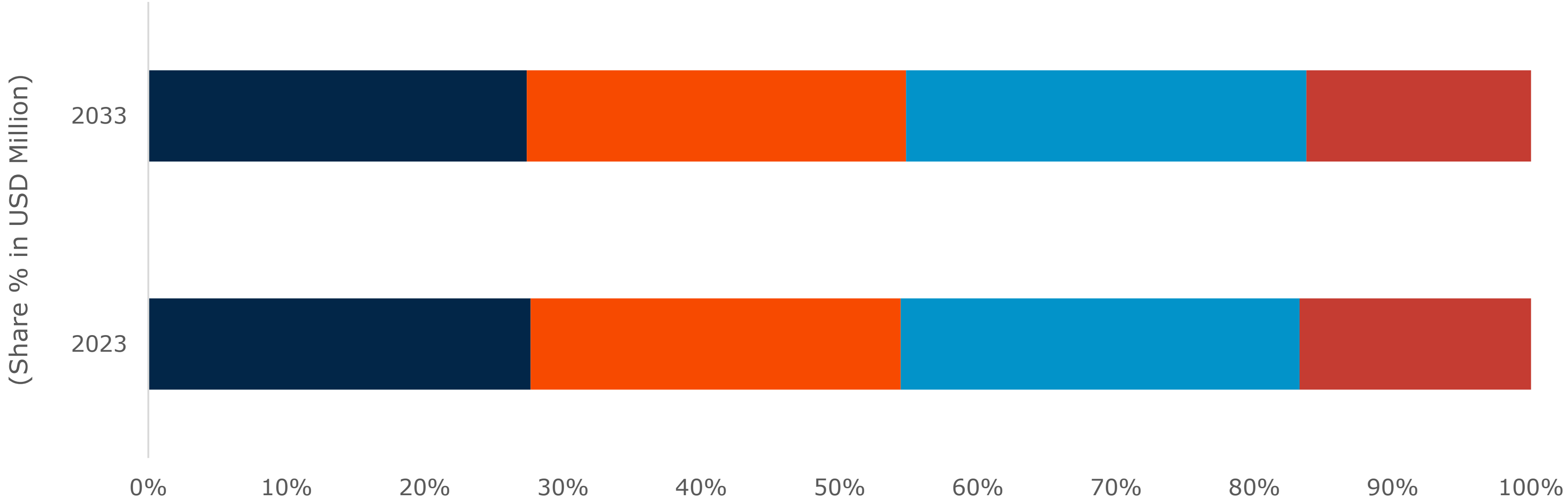
11. INDIA WASTEWATER TREATMENT MARKET BY REGION INSIGHTS & TRENDS

KEY REGIONAL TRENDS & HIGHLIGHTS

- South India is expected to account for a share of 52.70% in the Water & Wastewater Treatment Market in 2033.

11.1. REGION DYNAMICS & MARKET SHARE, 2023 & 2033

FIGURE 76. INDIA WATER & WASTEWATER TREATMENT MARKET: REGION DYNAMICS (SHARE IN % USD MILLION)



	2023	2033
North	27.65%	49.84%
West	26.77%	49.94%
South	28.85%	52.70%
East	16.73%	29.56%

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

11.2. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

TABLE 79. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY REGION, 2019-2033, (USD MILLION)

Region	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
North	2,952.385	3,426.522	3,622.503	3,832.519	4,552.556	5,439.605	6,529.634	**6.10%**
West	2,824.903	3,307.226	3,507.738	3,723.306	4,467.390	5,393.410	6,543.281	**6.47%**
South	3,065.899	3,570.369	3,779.356	4,003.593	4,774.413	5,727.791	6,904.113	**6.24%**
East	1,797.692	2,076.670	2,191.561	2,314.420	2,733.769	3,246.857	3,872.778	**5.89%**
Total	**10,640.878**	**12,380.787**	**13,101.158**	**13,873.839**	**16,528.128**	**19,807.663**	**23,849.806**	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

11.3. INDIA

According to 2018 NITI Aayog assessment, India is one of the most water-stressed countries in the world, with 600 million Indians suffering high water stress. And, by 2030, water demand may double than current supplies, causing acute water scarcity for millions of people. Consequently, it is more vital to comprehend and effectively manage the water needs and resources. A sustainable future requires the reuse and recycling of water resources. Since freshwater is a limited resource, wastewater treatment can provide a backup water source. Depending on the level of treatment, treated water may be obtained for direct consumption or may only be partially treated for use in irrigation and industry. Nitrate and phosphorus recovery from sewage waste has seen tremendous technological advancement. The by-product of wastewater treatment is high-quality manure.

The water and wastewater treatment market in India is expected to grow at a significant growth rate over the forecast period owing to the increasing technological advancements in water treatment coupled with rising demand from wastewater treatment industries to provide clean water. Also, India is making significant investments in wastewater networks and facilities as part of its plans for the remaining 50% of sewage produced in urban areas. The amount of STPs required to treat all of the sewage produced in India is projected to be 4500 or more due to the country's persistent, rapid urbanization and the need to treat sewage from semi-urban and rural areas. Furthermore, the Indian government implements new financial methods to finance the projects in addition to building more sewage treatment facilities. The National Mission for Clean Ganga (NMCG), for instance, implemented the Hybrid Annuity Model under the jurisdiction of the country's water resources department (HAM). In accordance with this plan, the developer is responsible for covering all operation and maintenance (O&M) costs as well as 60% of the capital costs, with the government covering the remaining 40%. Over time (often 15 years), the government pays the developer, plus interest. As a result, several financial institutions and investors have entered the market.

11.3.1. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033 (USD MILLION)

TABLE 80.INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033(USD MILLION)

Type	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Water Treatment	5,366.400	6,276.633	6,654.796	7,061.210	8,462.992	10,205.567	12,366.881	**6.42%**
Sewage Treatment	4,073.319	4,734.731	5,008.400	5,301.836	6,309.080	7,552.189	9,082.591	**6.16%**
Effluent Treatment	1,201.160	1,369.422	1,437.961	1,510.793	1,756.056	2,049.906	2,400.334	**5.28%**
Total	**10,640.878**	**12,380.787**	**13,101.158**	**13,873.839**	**16,528.128**	**19,807.663**	**23,849.806**	**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

11.3.2. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

TABLE 81.INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

Offering	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Treatment Technologies	**1,887.272**	**2,200.950**	**2,331.020**	**2,470.657**	**2,951.203**	**3,546.564**	**4,282.431**	**6.30%**
Activated Sludge Process	*715.327*	*831.030*	*878.887*	*930.190*	*1,106.218*	*1,323.330*	*1,590.445*	**6.14%**
Membrane Bio Reactor	*388.825*	*452.207*	*478.442*	*506.577*	*603.196*	*722.517*	*869.514*	**6.19%**
Moving Bed Bio Reactor	*293.292*	*343.771*	*364.773*	*387.361*	*465.402*	*562.660*	*683.600*	**6.51%**
Sequencing Batch Reactor	*173.776*	*204.628*	*217.503*	*231.375*	*279.475*	*339.745*	*415.113*	**6.71%**
Upflow Anaerobic Sludge Blanket Reactor	*141.170*	*163.808*	*173.164*	*183.190*	*217.558*	*259.892*	*311.903*	**6.09%**
Submerged Aerated Fixed Film Reactor	*121.197*	*141.767*	*150.314*	*159.499*	*191.183*	*230.573*	*279.433*	**6.43%**
Other Treatment Technologies	*53.685*	*63.739*	*67.939*	*72.466*	*88.171*	*107.848*	*132.423*	**6.93%**
Treatment Chemicals	**1,368.002**	**1,587.168**	**1,677.738**	**1,774.781**	**2,107.399**	**2,516.994**	**3,020.093**	**6.08%**
Corrosion Inhibitors	*360.870*	*417.800*	*441.293*	*466.445*	*552.514*	*658.239*	*787.768*	**6.00%**

Scale Inhibitors	*23.453*	*27.033*	*28.506*	*30.080*	*35.449*	*42.011*	*50.008*	**5.81%**
Biocides & Disinfectants	*318.102*	*368.561*	*389.395*	*411.706*	*488.096*	*582.015*	*697.185*	**6.03%**
Coagulants & Flocculants	*94.112*	*109.961*	*116.541*	*123.610*	*147.973*	*178.222*	*215.695*	**6.38%**
Chelating Agents	*195.332*	*227.969*	*241.509*	*256.049*	*306.115*	*368.196*	*444.995*	**6.33%**
Anti-Foaming Agents	*268.383*	*310.310*	*327.597*	*346.096*	*409.330*	*486.885*	*581.749*	**5.94%**
Ph Adjusters and Stabilizers	*67.216*	*78.595*	*83.322*	*88.401*	*105.916*	*127.680*	*154.664*	**6.41%**
Others	*40.534*	*46.939*	*49.576*	*52.394*	*62.006*	*73.746*	*88.030*	**5.93%**
Process Control and Automation	**3,447.321**	**4,008.099**	**4,240.167**	**4,489.020**	**5,343.394**	**6,398.142**	**7,697.036**	**6.17%**
Design, Engineering, and Construction Services	**2,401.085**	**2,809.630**	**2,979.416**	**3,161.918**	**3,791.625**	**4,574.857**	**5,546.857**	**6.44%**
Operation and Maintenance Services	**1,537.198**	**1,774.939**	**1,872.816**	**1,977.462**	**2,334.506**	**2,771.105**	**3,303.389**	**5.87%**
Total	**10,640.878**	**12,380.787**	**13,101.158**	**13,873.839**	**16,528.128**	**19,807.663**	**23,849.806**	**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

11.3.3. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033 (USD MILLION)

TABLE 82.INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033(USD MILLION)

Equipment	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Filtration	1,863.794	2,172.248	2,300.102	2,437.328	2,909.353	3,493.744	4,215.522	**6.28%**
Disinfection	5,854.987	6,798.517	7,188.642	7,606.780	9,040.888	10,808.624	12,982.111	**6.12%**
Adsorption	387.003	447.304	472.160	498.756	589.643	701.069	837.308	**5.93%**
Desalination	1,791.608	2,097.620	2,224.839	2,361.615	2,833.748	3,421.361	4,151.068	**6.47%**
Testing	471.751	550.708	583.470	618.655	739.833	890.140	1,076.143	**6.34%**
Others	271.735	314.390	331.944	350.706	414.662	492.725	587.656	**5.90%**
Total	**10,640.878**	**12,380.787**	**13,101.158**	**13,873.839**	**16,528.128**	**19,807.663**	**23,849.806**	**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

11.3.4. INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033 (USD MILLION)

TABLE 83.INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033(USD MILLION)

End-Use	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Municipal	**7,672.408**	**8,895.905**	**9,401.306**	**9,942.704**	**11,797.477**	**14,079.875**	**16,881.269**	**6.06%**
Government and Public Utilities	*5,065.533*	*5,903.346*	*6,250.596*	*6,623.287*	*7,905.160*	*9,491.999*	*11,451.661*	**6.27%**
Local Communities	*2,606.875*	*2,992.558*	*3,150.710*	*3,319.417*	*3,892.316*	*4,587.876*	*5,429.608*	**5.62%**
Industrial	**2,968.471**	**3,484.882**	**3,699.852**	**3,931.135**	**4,730.651**	**5,727.788**	**6,968.537**	**6.57%**
Power Generation	*568.630*	*661.525*	*699.964*	*741.181*	*882.663*	*1,057.262*	*1,272.169*	**6.19%**
Oil and Gas	*254.547*	*294.594*	*311.109*	*328.783*	*389.207*	*463.325*	*553.986*	**5.97%**
Food and Beverage	*322.947*	*378.282*	*401.283*	*426.008*	*511.335*	*617.479*	*749.204*	**6.47%**
Chemicals	*399.791*	*471.457*	*501.378*	*533.624*	*645.484*	*785.728*	*961.180*	**6.76%**
Pharmaceuticals	*579.578*	*686.178*	*730.800*	*778.960*	*946.542*	*1,157.616*	*1,422.937*	**6.92%**
Others	*842.977*	*992.847*	*1,055.318*	*1,122.578*	*1,355.419*	*1,646.378*	*2,009.061*	**6.68%**
Total	**10,640.878**	**12,380.787**	**13,101.158**	**13,873.839**	**16,528.128**	**19,807.663**	**23,849.806**	**6.20%**

11.3.5. NORTH INDIA

The water and wastewater treatment sector in North India stands at a critical juncture, as the region grapples with the dual challenge of ensuring sustainable water supply and effectively managing wastewater. Comprising states like Delhi, Uttar Pradesh, Punjab, Haryana, among others this region harbors a vast population and industrial base, exacerbating the strain on water resources and necessitating robust treatment solutions. Government statistics underscore the urgency of the situation. According to the latest data from the Central Pollution Control Board (CPCB), a staggering percentage of water bodies in North India are contaminated, rendering them unfit for consumption or recreation. This alarming scenario has prompted concerted efforts by federal and state governments to ramp up investments in water and wastewater treatment infrastructure. The National Mission for Clean Ganga (NMCG) and various state-level pollution control boards are spearheading initiatives to improve water quality in iconic rivers like the Ganges and Yamuna, a task that involves the augmentation of treatment plants, stringent effluent regulations, and public awareness campaigns.

The market for water and wastewater treatment solutions is witnessing remarkable growth, driven by a fusion of technological innovation and policy imperatives. A surge in urbanization and industrialization has propelled the demand for advanced treatment technologies such as membrane filtration, UV disinfection, and anaerobic digestion. Market players, both domestic and international, are partnering with local stakeholders to implement integrated water management systems that encompass treatment, distribution, and conservation. While the potential for growth is promising, challenges persist. Inadequate infrastructure, lack of proper maintenance, and resource limitations remain impediments to achieving comprehensive water security. Moreover, the intermittent water availability exacerbates stress on treatment facilities and necessitates adaptive solutions like decentralized treatment plants and rainwater harvesting systems.

11.3.5.1. NORTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033 (USD MILLION)

TABLE 84.NORTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033(USD MILLION)

Type	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Water Treatment	1,405.040	1,639.222	1,736.353	1,840.643	2,199.651	2,644.633	3,194.878	**6.32%**
Sewage Treatment	1,206.590	1,398.938	1,478.391	1,563.502	1,855.071	2,213.844	2,654.176	**6.06%**
Effluent Treatment	340.755	388.362	407.759	428.375	497.834	581.129	680.580	**5.28%**
Total	**2,952.385**	**3,426.522**	**3,622.503**	**3,832.519**	**4,552.556**	**5,439.605**	**6,529.634**	**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

11.3.5.2. NORTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

TABLE 85.NORTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

Offering	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Treatment Technologies	**531.943**	**618.626**	**654.504**	**692.981**	**825.104**	**988.261**	**1,189.241**	**6.18%**
Activated Sludge Process	*200.436*	*232.242*	*245.374*	*259.438*	*307.596*	*366.809*	*439.428*	**6.03%**
Membrane Bio Reactor	*110.378*	*128.006*	*135.289*	*143.091*	*169.825*	*202.730*	*243.128*	**6.07%**
Moving Bed Bio Reactor	*81.706*	*95.511*	*101.244*	*107.405*	*128.643*	*155.027*	*187.729*	**6.40%**
Sequencing Batch Reactor	*50.258*	*58.983*	*62.616*	*66.525*	*80.044*	*96.916*	*117.929*	**6.57%**
Upflow Anaerobic Sludge Blanket Reactor	*41.385*	*47.868*	*50.541*	*53.402*	*63.186*	*75.191*	*89.883*	**5.96%**
Submerged Aerated Fixed Film Reactor	*32.874*	*38.366*	*40.645*	*43.092*	*51.516*	*61.963*	*74.886*	**6.33%**
Other Treatment Technologies	*14.905*	*17.650*	*18.795*	*20.028*	*24.295*	*29.624*	*36.259*	**6.82%**
Treatment Chemicals	**371.255**	**429.814**	**453.979**	**479.852**	**568.384**	**677.138**	**810.382**	**6.00%**
Corrosion Inhibitors	*96.887*	*111.944*	*118.150*	*124.789*	*147.473*	*175.272*	*209.249*	**5.91%**
Scale Inhibitors	*7.058*	*8.112*	*8.545*	*9.007*	*10.579*	*12.494*	*14.820*	**5.69%**
Biocides & Disinfectants	*85.686*	*99.074*	*104.594*	*110.501*	*130.694*	*155.463*	*185.762*	**5.94%**

Coagulants & Flocculants	26.690	31.103	32.933	34.896	41.648	50.006	60.327	6.27%
Chelating Agents	54.667	63.643	67.360	71.349	85.057	102.005	122.909	6.23%
Anti-Foaming Agents	71.838	82.896	87.449	92.319	108.938	129.275	154.093	5.86%
Ph Adjusters and Stabilizers	17.295	20.186	21.386	22.674	27.110	32.612	39.418	6.34%
Others	11.136	12.856	13.563	14.318	16.886	20.012	23.803	5.81%
Process Control and Automation	**1,001.917**	**1,161.975**	**1,228.102**	**1,298.946**	**1,541.696**	**1,840.498**	**2,207.354**	**6.07%**
Design, Engineering, and Construction Services	**678.470**	**791.781**	**838.789**	**889.266**	**1,063.068**	**1,278.563**	**1,545.129**	**6.33%**
Operation and Maintenance Services	**368.800**	**424.325**	**447.129**	**471.476**	**554.304**	**655.145**	**777.528**	**5.72%**
Total	**2,952.385**	**3,426.522**	**3,622.503**	**3,832.519**	**4,552.556**	**5,439.605**	**6,529.634**	**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

11.3.5.3. NORTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033 (USD MILLION)

TABLE 86.NORTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033(USD MILLION)

Equipment	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Filtration	527.296	612.866	648.270	686.229	816.520	977.303	1,175.222	**6.16%**
Disinfection	1,626.174	1,883.493	1,989.713	2,103.452	2,492.791	2,971.301	3,557.871	**6.01%**
Adsorption	105.400	121.582	128.244	135.367	159.672	189.401	225.667	**5.84%**
Desalination	494.820	577.879	612.352	649.380	776.946	935.247	1,131.235	**6.36%**
Testing	156.476	182.186	192.836	204.262	243.532	292.091	351.991	**6.23%**
Others	42.219	48.515	51.089	53.830	63.097	74.262	87.648	**5.57%**
Total	**2,952.385**	**3,426.522**	**3,622.503**	**3,832.519**	**4,552.556**	**5,439.605**	**6,529.634**	**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

11.3.5.4. NORTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033 (USD MILLION)

TABLE 87.NORTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033(USD MILLION)

End-Use	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Municipal	**2,097.079**	**2,425.385**	**2,560.777**	**2,705.676**	**3,201.117**	**3,808.999**	**4,552.858**	**5.95%**
Government and Public Utilities	*1,391.412*	*1,617.249*	*1,710.688*	*1,810.874*	*2,154.751*	*2,579.120*	*3,101.521*	**6.16%**
Local Communities	*705.667*	*808.136*	*850.089*	*894.802*	*1,046.366*	*1,229.879*	*1,451.337*	**5.52%**
Industrial	**855.306**	**1,001.137**	**1,061.726**	**1,126.843**	**1,351.439**	**1,630.606**	**1,976.776**	**6.44%**
Power Generation	*165.758*	*192.271*	*203.221*	*214.949*	*255.118*	*304.524*	*365.127*	**6.06%**
Oil and Gas	*67.997*	*78.437*	*82.733*	*87.325*	*102.985*	*122.123*	*145.442*	**5.83%**
Food and Beverage	*94.939*	*110.837*	*117.431*	*124.510*	*148.880*	*179.079*	*216.409*	**6.33%**
Chemicals	*111.960*	*131.612*	*139.800*	*148.615*	*179.117*	*217.221*	*264.713*	**6.62%**
Pharmaceuticals	*168.495*	*198.831*	*211.502*	*225.161*	*272.570*	*332.058*	*406.544*	**6.79%**
Others	*246.157*	*289.150*	*307.040*	*326.283*	*392.768*	*475.601*	*578.542*	**6.57%**
Total	**2,952.385**	**3,426.522**	**3,622.503**	**3,832.519**	**4,552.556**	**5,439.605**	**6,529.634**	**6.10%**

Sources: 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

11.3.6. WEST INDIA

The water and wastewater treatment sector in West India including Maharashtra, Goa, Gujarat, Chhattisgarh, Madhya Pradesh, among others stands at the crossroads of challenges and opportunities, driven by the region's rapid urbanization, industrial growth, and environmental concerns. With its vibrant cities, industrial hubs, and diverse ecosystems, West India faces escalating pressures on its water resources, demanding robust solutions for effective water and wastewater management. The government's role in addressing these challenges is pivotal. According to the latest available statistics, sourced from the Ministry of Jal Shakti, Government of India, West India contributes significantly to the nation's water consumption. In Maharashtra alone, as of 2021, water demand had surged to approximately 18.6 billion cubic meters, underscoring the urgency for sustainable water management practices. Furthermore, Gujarat witnessed a surge in industrial activity, leading to an increased discharge of industrial effluents, highlighting the need for stringent wastewater treatment measures.

In response, the water and wastewater treatment market in West India is witnessing a remarkable transformation. Municipalities and industries are investing in advanced treatment technologies and infrastructure to meet stringent water quality standards. The market has seen a surge in the adoption of decentralized water treatment systems, water recycling, and smart water management solutions. Companies specializing in membrane filtration, chemical treatment, and bioremediation are gaining traction as the demand for innovative solutions rises. However, the journey towards efficient water and wastewater management is not without its hurdles. West India's complex topography, seasonal water scarcity, and uneven distribution pose logistical challenges. Moreover, socio-economic disparities and awareness gaps underscore the need for comprehensive public outreach and education campaigns to promote water conservation and responsible wastewater disposal practices.

11.3.6.1. WEST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033 (USD MILLION)

TABLE 88.WEST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033(USD MILLION)

Type	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Water Treatment	1,391.265	1,637.825	1,740.699	1,851.525	2,235.710	2,716.918	3,318.422	**6.70%**
Sewage Treatment	1,087.822	1,272.189	1,348.780	1,431.089	1,714.961	2,067.801	2,505.369	**6.42%**
Effluent Treatment	345.816	397.212	418.259	440.693	516.719	608.692	719.491	**5.60%**
Total	**2,824.903**	**3,307.226**	**3,507.738**	**3,723.306**	**4,467.390**	**5,393.410**	**6,543.281**	**6.47%**

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

11.3.6.2. WEST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

TABLE 89.WEST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

Offering	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Treatment Technologies	**546.263**	**640.907**	**680.308**	**722.702**	**869.278**	**1,052.150**	**1,279.815**	**6.56%**
Activated Sludge Process	*200.806*	*234.682*	*248.749*	*263.863*	*315.960*	*380.663*	*460.840*	**6.39%**
Membrane Bio Reactor	*116.682*	*136.494*	*144.725*	*153.573*	*184.092*	*222.038*	*269.110*	**6.43%**
Moving Bed Bio Reactor	*79.099*	*93.309*	*99.247*	*105.648*	*127.873*	*155.778*	*190.746*	**6.79%**
Sequencing Batch Reactor	*56.964*	*67.480*	*71.886*	*76.643*	*93.215*	*114.124*	*140.457*	**6.96%**
Upflow Anaerobic Sludge Blanket Reactor	*48.399*	*56.458*	*59.801*	*63.389*	*75.742*	*91.050*	*109.976*	**6.31%**
Submerged Aerated Fixed Film Reactor	*27.805*	*32.744*	*34.805*	*37.026*	*44.728*	*54.378*	*66.446*	**6.71%**
Other Treatment Technologies	*16.508*	*19.739*	*21.095*	*22.560*	*27.669*	*34.120*	*42.241*	**7.22%**
Treatment Chemicals	**317.936**	**371.250**	**393.375**	**417.139**	**499.000**	**600.567**	**726.292**	**6.36%**
Corrosion Inhibitors	*81.001*	*94.384*	*99.930*	*105.882*	*126.353*	*151.688*	*182.971*	**6.27%**
Scale Inhibitors	*7.348*	*8.514*	*8.996*	*9.511*	*11.277*	*13.449*	*16.112*	**6.03%**
Biocides & Disinfectants	*72.171*	*84.159*	*89.130*	*94.466*	*112.827*	*135.573*	*163.682*	**6.30%**

Coagulants & Flocculants	*25.019*	*29.417*	*31.251*	*33.226*	*40.065*	*48.620*	*59.298*	**6.65%**
Chelating Agents	*49.931*	*58.648*	*62.280*	*66.189*	*79.716*	*96.616*	*117.683*	**6.60%**
Anti-Foaming Agents	*59.645*	*69.405*	*73.446*	*77.781*	*92.673*	*111.076*	*133.760*	**6.21%**
Ph Adjusters and Stabilizers	*13.030*	*15.347*	*16.314*	*17.355*	*20.968*	*25.495*	*31.157*	**6.72%**
Others	*9.791*	*11.376*	*12.029*	*12.729*	*15.121*	*18.051*	*21.629*	**6.07%**
Process Control and Automation	**912.891**	**1,067.938**	**1,132.362**	**1,201.603**	**1,440.463**	**1,737.462**	**2,105.916**	**6.43%**
Design, Engineering, and Construction Services	**621.490**	**731.855**	**777.912**	**827.535**	**999.598**	**1,215.192**	**1,484.780**	**6.71%**
Operation and Maintenance Services	**426.323**	**495.277**	**523.781**	**554.327**	**659.050**	**788.039**	**946.478**	**6.12%**
Total	**2,824.903**	**3,307.226**	**3,507.738**	**3,723.306**	**4,467.390**	**5,393.410**	**6,543.281**	**6.47%**

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

11.3.6.3. WEST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033 (USD MILLION)

TABLE 90.WEST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033(USD MILLION)

Equipment	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Filtration	535.319	627.682	666.118	707.463	850.348	1,028.487	1,250.097	**6.53%**
Disinfection	1,586.465	1,853.350	1,964.142	2,083.159	2,493.287	3,002.419	3,632.996	**6.37%**
Adsorption	74.860	87.078	92.135	97.560	116.190	139.201	167.554	**6.19%**
Desalination	448.595	528.661	562.091	598.120	723.120	879.884	1,076.088	**6.74%**
Testing	121.188	142.360	151.181	160.676	193.537	234.594	285.782	**6.61%**
Others	58.475	68.096	72.071	76.328	90.909	108.826	130.763	**6.16%**
Total	**2,824.903**	**3,307.226**	**3,507.738**	**3,723.306**	**4,467.390**	**5,393.410**	**6,543.281**	**6.47%**

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

11.3.6.4. WEST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033 (USD MILLION)

TABLE 91.WEST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033(USD MILLION)

End-Use	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Municipal	**2,052.292**	**2,393.860**	**2,535.512**	**2,687.593**	**3,211.033**	**3,859.668**	**4,661.544**	**6.31%**
Government and Public Utilities	*1,380.577*	*1,618.818*	*1,717.961*	*1,824.612*	*2,193.185*	*2,652.713*	*3,224.393*	**6.53%**
Local Communities	*671.715*	*775.042*	*817.551*	*862.981*	*1,017.848*	*1,206.955*	*1,437.150*	**5.83%**
Industrial	**772.611**	**913.366**	**972.226**	**1,035.714**	**1,256.357**	**1,533.742**	**1,881.738**	**6.86%**
Power Generation	*156.067*	*182.735*	*193.816*	*205.725*	*246.808*	*297.882*	*361.224*	**6.45%**
Oil and Gas	*77.029*	*89.662*	*94.891*	*100.499*	*119.756*	*143.532*	*172.812*	**6.21%**
Food and Beverage	*94.181*	*111.032*	*118.065*	*125.644*	*151.926*	*184.862*	*226.044*	**6.74%**
Chemicals	*111.797*	*132.767*	*141.562*	*151.066*	*184.209*	*226.097*	*278.935*	**7.05%**
Pharmaceuticals	*159.776*	*190.517*	*203.446*	*217.435*	*266.380*	*328.530*	*407.309*	**7.22%**
Others	*173.760*	*206.653*	*220.445*	*235.344*	*287.277*	*352.839*	*435.413*	**7.08%**
Total	**2,824.903**	**3,307.226**	**3,507.738**	**3,723.306**	**4,467.390**	**5,393.410**	**6,543.281**	**6.47%**

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), World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.3.7. SOUTH INDIA

The water and wastewater treatment sector in South India including Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, among others has emerged as a pivotal player in maintaining ecological equilibrium amidst the region's burgeoning urbanization and industrial growth. With an emphasis on sustainable development and resource conservation, the market for water and wastewater treatment solutions has witnessed steady expansion, driven by the region's pressing need for efficient water management. South India's unique geographical and demographic dynamics, coupled with a proactive government stance, have propelled the growth of this sector. The government of South India has recognized the urgency of addressing water scarcity and pollution concerns, leading to the implementation of robust policies and initiatives. According to recent statistics, over the past five years, the region has invested significantly in wastewater treatment infrastructure, resulting in a substantial increase in the number of treatment plants. The government's allocation of funds towards improving water treatment facilities has played a pivotal role in attracting private sector investments, further boosting the market. Furthermore, the rising consciousness about water conservation has prompted the public and industries to adopt water-efficient technologies, thereby fostering a culture of responsible water consumption.

South India's water and wastewater treatment market is characterized by a diverse range of technologies and solutions, including advanced filtration systems, membrane technologies, and innovative sludge management techniques. The market's competitive landscape is marked by the presence of both domestic and international players, each striving to provide cutting-edge solutions tailored to the region's specific challenges. The demand for decentralized treatment systems has gained traction, particularly in rural areas, reflecting a holistic approach to addressing both sanitation and environmental concerns.

11.3.7.1. SOUTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033 (USD MILLION)

TABLE 92.SOUTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033(USD MILLION)

Type	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Water Treatment	1,601.319	1,874.787	1,988.476	2,110.704	2,532.610	3,057.696	3,709.739	**6.47%**
Sewage Treatment	1,148.127	1,335.654	1,413.287	1,496.554	1,782.552	2,135.858	2,571.240	**6.20%**
Effluent Treatment	316.453	359.928	377.592	396.335	459.250	534.237	623.135	**5.16%**
Total	**3,065.899**	**3,570.369**	**3,779.356**	**4,003.593**	**4,774.413**	**5,727.791**	**6,904.113**	**6.24%**

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

11.3.7.2. SOUTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

TABLE 93.SOUTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

Offering	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Treatment Technologies	**521.123**	**608.132**	**644.227**	**682.985**	**816.433**	**981.887**	**1,186.541**	**6.33%**
Activated Sludge Process	*201.154*	*233.857*	*247.391*	*261.902*	*311.721*	*373.217*	*448.942*	**6.17%**
Membrane Bio Reactor	*104.954*	*122.128*	*129.239*	*136.867*	*163.071*	*195.452*	*235.367*	**6.21%**
Moving Bed Bio Reactor	*84.630*	*99.282*	*105.380*	*111.942*	*134.628*	*162.927*	*198.153*	**6.55%**
Sequencing Batch Reactor	*44.129*	*51.978*	*55.255*	*58.785*	*71.029*	*86.374*	*105.569*	**6.72%**
Upflow Anaerobic Sludge Blanket Reactor	*34.915*	*40.518*	*42.834*	*45.316*	*53.824*	*64.304*	*77.180*	**6.09%**
Submerged Aerated Fixed Film Reactor	*37.886*	*44.371*	*47.068*	*49.967*	*59.979*	*72.445*	*87.930*	**6.48%**
Other Treatment Technologies	*13.455*	*15.997*	*17.060*	*18.205*	*22.182*	*27.168*	*33.400*	**6.98%**
Treatment Chemicals	**416.801**	**484.159**	**512.017**	**541.879**	**644.332**	**770.676**	**926.094**	**6.14%**
Corrosion Inhibitors	*111.357*	*129.089*	*136.412*	*144.257*	*171.128*	*204.186*	*244.751*	**6.05%**
Scale Inhibitors	*6.215*	*7.166*	*7.557*	*7.975*	*9.402*	*11.146*	*13.272*	**5.82%**
Biocides & Disinfectants	*97.782*	*113.434*	*119.903*	*126.833*	*150.585*	*179.830*	*215.749*	**6.08%**

Coagulants & Flocculants	*27.130*	*31.727*	*33.636*	*35.688*	*42.765*	*51.561*	*62.468*	**6.42%**
Chelating Agents	*57.289*	*66.927*	*70.928*	*75.226*	*90.037*	*108.423*	*131.196*	**6.37%**
Anti-Foaming Agents	*83.110*	*96.217*	*101.626*	*107.417*	*127.233*	*151.574*	*181.395*	**5.99%**
Ph Adjusters and Stabilizers	*21.751*	*25.477*	*27.026*	*28.692*	*34.445*	*41.609*	*50.509*	**6.49%**
Others	*12.168*	*14.123*	*14.929*	*15.792*	*18.738*	*22.347*	*26.753*	**6.03%**
Process Control and Automation	**977.281**	**1,137.241**	**1,203.475**	**1,274.522**	**1,518.610**	**1,820.244**	**2,192.084**	**6.21%**
Design, Engineering, and Construction Services	**735.828**	**861.746**	**914.103**	**970.400**	**1,164.769**	**1,406.757**	**1,707.360**	**6.48%**
Operation and Maintenance Services	**414.865**	**479.092**	**505.534**	**533.806**	**630.269**	**748.227**	**892.035**	**5.87%**
Total	**3,065.899**	**3,570.369**	**3,779.356**	**4,003.593**	**4,774.413**	**5,727.791**	**6,904.113**	**6.24%**

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

11.3.7.3. SOUTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033 (USD MILLION)

TABLE 94.SOUTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033(USD MILLION)

Equipment	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Filtration	516.604	602.501	638.120	676.360	807.961	971.011	1,172.550	**6.30%**
Disinfection	1,658.651	1,927.558	2,038.806	2,158.078	2,567.421	3,072.485	3,694.104	**6.15%**
Adsorption	137.352	158.957	167.871	177.413	210.054	250.134	299.217	**5.98%**
Desalination	542.388	635.675	674.483	716.222	860.414	1,040.086	1,263.477	**6.51%**
Testing	131.527	153.670	162.862	172.738	206.771	249.026	301.366	**6.38%**
Others	79.376	92.009	97.214	102.782	121.791	145.048	173.400	**5.98%**
Total	**3,065.899**	**3,570.369**	**3,779.356**	**4,003.593**	**4,774.413**	**5,727.791**	**6,904.113**	**6.24%**

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

11.3.7.4. SOUTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033 (USD MILLION)

TABLE 95.SOUTH INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033(USD MILLION)

End-Use	2019	2022	2023	2024	2027	2030	2033	CAGR% (2024-33)
Municipal	**2,264.473**	**2,627.690**	**2,777.807**	**2,938.665**	**3,490.088**	**4,169.280**	**5,003.720**	**6.09%**
Government and Public Utilities	*1,481.645*	*1,728.042*	*1,830.218*	*1,939.912*	*2,317.429*	*2,785.177*	*3,363.352*	**6.31%**
Local Communities	*782.828*	*899.649*	*947.589*	*998.753*	*1,172.659*	*1,384.104*	*1,640.368*	**5.67%**
Industrial	**801.426**	**942.679**	**1,001.549**	**1,064.928**	**1,284.325**	**1,558.510**	**1,900.394**	**6.65%**
Power Generation	*149.546*	*174.270*	*184.511*	*195.498*	*233.257*	*279.937*	*337.495*	**6.25%**
Oil and Gas	*71.728*	*83.110*	*87.807*	*92.836*	*110.042*	*131.171*	*157.047*	**6.02%**
Food and Beverage	*84.550*	*99.186*	*105.275*	*111.823*	*134.445*	*162.628*	*197.657*	**6.53%**
Chemicals	*102.983*	*121.671*	*129.482*	*137.905*	*167.163*	*203.916*	*249.987*	**6.83%**
Pharmaceuticals	*152.431*	*180.803*	*192.692*	*205.532*	*250.269*	*306.724*	*377.826*	**7.00%**
Others	*240.187*	*283.640*	*301.782*	*321.334*	*389.148*	*474.134*	*580.382*	**6.79%**
Total	**3,065.899**	**3,570.369**	**3,779.356**	**4,003.593**	**4,774.413**	**5,727.791**	**6,904.113**	**6.24%**

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), World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

11.3.8. EAST INDIA

The water and wastewater treatment sector in East India has witnessed significant growth and transformation in recent years, driven by the region's expanding industrial and urban landscape. With its burgeoning population and burgeoning industries, the demand for efficient water management solutions has intensified, making the water and wastewater treatment market a focal point of development. East India, comprising states such as West Bengal, Odisha, Bihar, Jharkhand, and the northeastern states, has been actively investing in upgrading its water infrastructure to meet the escalating water scarcity challenges and to mitigate environmental degradation caused by inadequate wastewater management. Government initiatives and policies have played a pivotal role in shaping the water and wastewater treatment landscape in East India. The governments of these states have consistently emphasized sustainable water resource management through initiatives that promote water conservation, pollution control, and efficient wastewater treatment practices. Schemes such as the Namami Gange project and the Clean Ganga Fund have also extended their influence on the region, catalyzing efforts to rejuvenate and cleanse major rivers flowing through East India.

Government statistics further underscore the importance of this market segment. According to the latest available data, East India's water demand has surged by over 30% in the last decade, propelled by rapid urbanization and industrialization. To address this, the government has allocated substantial funds to bolster water and wastewater treatment infrastructure, with an annual increase of 15% in budgetary allocation for the sector. Additionally, the implementation of advanced technologies, including membrane filtration, reverse osmosis, and water recycling systems, has gained momentum, facilitating the sustainable management of water resources and ensuring compliance with environmental norms.

11.3.8.1. EAST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033 (USD MILLION)

TABLE 96.EAST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY TYPE, 2019-2033(USD MILLION)

Type	2019	2020	2021	2022	2023	2025	2030	CAGR% (2023-30)
Water Treatment	968.776	1,124.799	1,189.268	1,258.339	1,495.021	1,786.321	2,143.843	**6.10%**
Sewage Treatment	630.780	727.950	767.942	810.692	956.495	1,134.686	1,351.807	**5.85%**
Effluent Treatment	198.136	223.921	234.351	245.390	282.253	325.849	377.128	**4.89%**
Total	**1,797.692**	**2,076.670**	**2,191.561**	**2,314.420**	**2,733.769**	**3,246.857**	**3,872.778**	**5.89%**

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

11.3.8.2. EAST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

TABLE 97. EAST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECASTS, BY OFFERING, 2019-2033, (USD MILLION)

Offering	2019	2020	2021	2022	2023	2025	2030	CAGR% (2023-30)
Treatment Technologies	**287.944**	**333.285**	**351.982**	**371.990**	**440.388**	**524.267**	**626.834**	**5.97%**
Activated Sludge Process	*112.931*	*130.249*	*137.373*	*144.986*	*170.942*	*202.640*	*241.235*	**5.82%**
Membrane Bio Reactor	*56.811*	*65.579*	*69.188*	*73.046*	*86.208*	*102.298*	*121.908*	**5.86%**
Moving Bed Bio Reactor	*47.856*	*55.669*	*58.901*	*62.367*	*74.259*	*88.928*	*106.973*	**6.18%**
Sequencing Batch Reactor	*22.425*	*26.186*	*27.747*	*29.422*	*35.187*	*42.330*	*51.158*	**6.34%**
Upflow Anaerobic Sludge Blanket Reactor	*16.470*	*18.963*	*19.988*	*21.082*	*24.807*	*29.347*	*34.864*	**5.75%**
Submerged Aerated Fixed Film Reactor	*22.632*	*26.286*	*27.796*	*29.414*	*34.960*	*41.788*	*50.171*	**6.11%**
Other Treatment Technologies	*8.817*	*10.352*	*10.989*	*11.673*	*14.025*	*16.936*	*20.524*	**6.47%**
Treatment Chemicals	**262.009**	**301.946**	**318.367**	**335.911**	**395.683**	**468.613**	**557.325**	**5.79%**
Corrosion Inhibitors	*71.626*	*82.383*	*86.801*	*91.517*	*107.561*	*127.093*	*150.797*	**5.71%**
Scale Inhibitors	*2.833*	*3.241*	*3.409*	*3.587*	*4.191*	*4.922*	*5.803*	**5.49%**
Biocides & Disinfectants	*62.463*	*71.894*	*75.769*	*79.907*	*93.990*	*111.149*	*131.991*	**5.73%**

Coagulants & Flocculants	*15.273*	*17.713*	*18.721*	*19.800*	*23.494*	*28.036*	*33.602*	**6.05%**
Chelating Agents	*33.445*	*38.751*	*40.941*	*43.285*	*51.305*	*61.152*	*73.207*	**6.01%**
Anti-Foaming Agents	*53.790*	*61.792*	*65.075*	*68.579*	*80.486*	*94.961*	*112.501*	**5.65%**
Ph Adjusters and Stabilizers	*15.140*	*17.586*	*18.597*	*19.680*	*23.393*	*27.965*	*33.580*	**6.12%**
Others	*7.440*	*8.585*	*9.055*	*9.556*	*11.262*	*13.335*	*15.845*	**5.78%**
Process Control and Automation	**555.232**	**640.946**	**676.228**	**713.948**	**842.626**	**999.938**	**1,191.682**	**5.86%**
Design, Engineering, and Construction Services	**365.298**	**424.249**	**448.612**	**474.717**	**564.190**	**674.345**	**809.588**	**6.11%**
Operation and Maintenance Services	**327.209**	**376.245**	**396.372**	**417.854**	**490.883**	**579.694**	**687.348**	**5.69%**
Total	**1,797.692**	**2,076.670**	**2,191.561**	**2,314.420**	**2,733.769**	**3,246.857**	**3,872.778**	**5.89%**

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

11.3.8.3. EAST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033 (USD MILLION)

TABLE 98.EAST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY EQUIPMENT, 2019-2033(USD MILLION)

Equipment	2019	2020	2021	2022	2023	2025	2030	CAGR% (2023-30)
Filtration	284.575	329.200	347.595	367.276	434.526	516.943	617.654	**5.95%**
Disinfection	983.697	1,134.115	1,195.982	1,262.090	1,487.389	1,762.419	2,097.139	**5.80%**
Adsorption	69.391	79.686	83.910	88.416	103.728	122.333	144.869	**5.64%**
Desalination	305.805	355.405	375.913	397.893	473.269	566.144	680.267	**6.14%**
Testing	62.560	72.492	76.591	80.979	95.993	114.429	137.003	**6.02%**
Others	91.664	105.771	111.570	117.766	138.865	164.589	195.845	**5.81%**
Total	**1,797.692**	**2,076.670**	**2,191.561**	**2,314.420**	**2,733.769**	**3,246.857**	**3,872.778**	**5.89%**

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

11.3.8.4. EAST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033 (USD MILLION)

TABLE 99.EAST INDIA WATER & WASTEWATER TREATMENT MARKET REVENUE ESTIMATES AND FORECAST, BY END-USE, 2019-2033(USD MILLION)

End-Use	2019	2020	2021	2022	2023	2025	2030	CAGR% (2023-30)
Municipal	**1,258.564**	**1,448.970**	**1,527.209**	**1,610.771**	**1,895.238**	**2,241.927**	**2,663.148**	**5.75%**
Government and Public Utilities	*811.900*	*939.238*	*991.729*	*1,047.890*	*1,239.795*	*1,474.989*	*1,762.395*	**5.95%**
Local Communities	*446.664*	*509.732*	*535.481*	*562.880*	*655.443*	*766.939*	*900.752*	**5.36%**
Industrial	**539.128**	**627.700**	**664.351**	**703.650**	**838.531**	**1,004.929**	**1,209.630**	**6.20%**
Power Generation	*97.259*	*112.250*	*118.417*	*125.009*	*147.479*	*174.919*	*208.324*	**5.84%**
Oil and Gas	*37.793*	*43.385*	*45.678*	*48.123*	*56.424*	*66.499*	*78.685*	**5.62%**
Food and Beverage	*49.276*	*57.227*	*60.512*	*64.031*	*76.084*	*90.910*	*109.094*	**6.10%**
Chemicals	*73.052*	*85.407*	*90.533*	*96.039*	*114.995*	*138.493*	*167.545*	**6.38%**
Pharmaceuticals	*98.876*	*116.027*	*123.161*	*130.832*	*157.323*	*190.303*	*231.257*	**6.53%**
Others	*182.872*	*213.404*	*226.050*	*239.617*	*286.226*	*343.805*	*414.725*	**6.28%**
Total	**1,797.692**	**2,076.670**	**2,191.561**	**2,314.420**	**2,733.769**	**3,246.857**	**3,872.778**	**5.89%**

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, World Bank, Journals & Articles, Press Releases, Company Websites, Investor Presentations & Whitepapers, Annual Reports, Primary Interviews, Reports and Data

12. COMPETITIVE LANDSCAPE

12.1. INDIA WATER AND WASTEWATER TREATMENT MARKET: COMPANY SNAPSHOT:2022

Competition Landscape – India Water & Wastewater Treatment Market

Company	Megha Engineering and Infrastructures Ltd (MEIL)	EMS Limited	VA TECH WABAG LTD	SPML Infra Limited
Headquarter	Telangana, India	Uttar Pradesh, India	Chennai, India	Kolkata, India
Revenue (USD)	-	USD 69.12 Million	USD 295.85 Million	USD 111.23 Million
Product & Service	• Irrigation • Drinking Water	• Sewerage Management • Design and construction • Water supply • Road & Allied works	• Wastewater Treatment • Water Treatment	• Water Treatment • Wastewater treatment
Market Presence	• Internationally	• India	• India • Rest of the World • Unallocated	• India • Overseas
Market Strategy				

Agreements & Partnerships P New Product Development N Investment & Expansion I Mergers & Acquisition M

Source: Company Annual report, Reports and Data, Primary Interview

Key participants in the India water & wastewater infrastructure market are VA TECH WABAG LTD., SPML Infra Limited, Megha Engineering and Infrastructures Ltd (MEIL), EMS Limited, among others.

The market is currently witnessing increasing efforts by players in terms of new product development as companies try to gain a competitive edge over the market by sharing ideas and resources with their counterparts. Market players are also resorting to strategies like mergers & acquisitions, agreement & partnership and investment and expansions wherein they are strategically forming alliances with crucial end-users or organizations in both the public and private sectors. This is helping them to gain a competitive advantage in terms of sales.

12.2. STRATEGY BENCHMARKING

The water & wastewater infrastructure market is expected to grow significantly in the coming years, owing to the increasing demand from various end-use industries. This growth is driving companies to adopt diverse strategies to gain a competitive advantage in the market. Investment and expansion are being pursued to increase production capacity and meet the growing demand for water & wastewater infrastructure.

Agreements and partnerships are being formed to leverage the expertise of other players in the market and to gain access to new technology and markets. Mergers and acquisitions are being pursued to consolidate market share and eliminate competition, while also allowing companies to diversify their product offerings. In addition to these strategies, companies are ramping up their efforts in research and development to develop more innovative and distinctive products. This is aimed at meeting the evolving needs of consumers and staying ahead of competitors in the market. Companies are also focusing on improving their existing products and making them more environmentally friendly.

12.3. COMPANIES ENGAGEAD IN LIFT IRRIGATION PROJECT

Lift irrigation is a critical agricultural practice in India, particularly in regions with water scarcity. It involves the transportation of water from a lower source, such as a river or canal, to a higher elevation where it can be distributed for irrigation purposes. Several top companies in India are actively engaged in lift irrigation projects, aiming to enhance agricultural productivity, support rural communities, and mitigate water stress in various parts of the country.

Kirloskar Brothers Limited:

Kirloskar Brothers Limited (KBL) is a renowned player in the field of lift irrigation projects in India. Founded in 1888, the company has a long-standing history of providing innovative pumping solutions. KBL offers a wide range of pumps and systems that are specifically designed for lift irrigation. Their efficient and reliable products are crucial in raising water from source points to agricultural fields, thereby enabling water resource management and crop cultivation in water-deficient areas. KBL's solutions include submersible pumps, vertical turbine pumps, and electric motors, all of which are designed to cater to the diverse needs of lift irrigation projects. Their expertise in pump technology and commitment to quality has established them as a key player in the industry.

KBL's SPP Pumps:

SPP Pumps, a subsidiary of Kirloskar Brothers Limited (KBL), is another noteworthy player in the lift irrigation sector. With a global presence, SPP Pumps brings its expertise in manufacturing fire pumps and industrial pumps to the Indian market. Their products are widely used in lift irrigation projects to ensure the efficient transport of water. SPP Pumps offers a comprehensive range of pumps designed to handle high flow rates and challenging conditions. Their advanced technologies and commitment to quality have made them a preferred choice for many lift irrigation projects in India.

KSB Pumps Limited:

KSB Pumps Limited is another leading company contributing to lift irrigation projects in India. With a global presence and a significant foothold in the Indian market, KSB specializes in providing reliable pumping solutions for various applications, including lift irrigation. Their pumps are designed to handle the challenges of lifting water from lower sources to higher elevations efficiently. KSB offers a wide range of submersible and centrifugal pumps that are well-suited for lift irrigation systems. Their products are known for their durability and energy efficiency, making them a preferred choice for water management projects across the country.

Crompton Greaves Consumer Electricals Ltd:

Crompton Greaves Consumer Electricals Ltd (CGCEL), a part of the Avantha Group, is a prominent player in the lift irrigation sector. The company is known for its electrical and consumer products, and it has successfully expanded its offerings to include solutions for lift irrigation projects. CGCEL provides a range of water pumps and motors that are suitable for various lift irrigation applications, helping farmers access water efficiently. Their product portfolio includes submersible pumps, monoblock pumps, and electric motors that are designed for energy efficiency and reliability. CGCEL's commitment to delivering high-quality products has made them a trusted choice for lift irrigation systems.

Texmo Industries:

Texmo Industries, a part of the Texmo Group, is a well-established company that has been actively involved in lift irrigation projects in India. Texmo specializes in manufacturing submersible pumps, openwell pumps, and centrifugal pumps, which are widely used for lifting water for agricultural purposes. These pumps are designed to handle the unique challenges of lift irrigation systems, ensuring that water is efficiently transported to the required elevation. Texmo Industries is known for its robust and durable pumps, which are essential components in ensuring the success of lift irrigation projects across the country.

Aquatec Pumps:

Aquatec Pumps, a part of the Texmo Group, specializes in manufacturing submersible pumps that are well-suited for lift irrigation applications. These pumps are designed to meet the specific needs of farmers and agricultural projects, offering energy-efficient solutions for water transportation. Aquatec Pumps' commitment to providing reliable and efficient products has contributed to its recognition in the lift irrigation industry, ensuring that water is made available to agriculture in water-sc arce regions.

Shakti Pumps (India) Ltd:

Shakti Pumps (India) Ltd is a prominent manufacturer of submersible pumps and electric motors that cater to various industries, including agriculture and lift irrigation. With a strong focus on energy efficiency and performance, Shakti Pumps offers a range of products that are suitable for lift irrigation applications. Their pumps are designed to operate in challenging conditions, making them a valuable asset for enhancing water accessibility in agriculture. Shakti Pumps has gained recognition for its commitment to innovation and providing reliable solutions for lift irrigation projects, contributing significantly to India's agricultural sector.

Conclusion:

The role of lift irrigation projects in India is of paramount importance in addressing water scarcity and supporting agricultural growth. The top companies engaged in lift irrigation projects, such as Kirloskar Brothers Limited, KSB Pumps Limited, Crompton Greaves Consumer Electricals Ltd, Texmo Industries, Shakti Pumps (India) Ltd, KBL's SPP Pumps, and Aquatec Pumps, play a vital role in ensuring the success of these projects. These companies provide innovative and reliable pumping solutions, submersible pumps, electric motors, and other essential equipment required for efficiently raising water to higher elevations. Their dedication to quality, energy efficiency, and technological innovation has made them trusted partners in India's ongoing efforts to enhance agricultural productivity, support rural communities, and manage water resources effectively through lift irrigation projects.

12.4. KEY SUCCESS FACTORS ON TECHNOLOGICAL AND INFRASTRUCTURE DEVELOPMENT FOR KEY MARKET PLAYERS

TABLE 100. SUCCESS FACTORS FOR WATER AND WASTEWATER TREATMENT COMPANIES

Company Name	Technological Advancements	Speed to Market	Operational Efficiency	Quality Control and Monitoring	Regulatory Compliance	Supply Chain Management	Financial Management
VA TECH WABAG LTD.	★★	★★★★	★★★	★★	★★★	★★★★	★★★
SPML Infra Limited	★★	★★★	★★	★★★★★	★★★	★★★	★★
Megha Engineering and Infrastructures Ltd (MEIL)	★★★	★★★★	★★★	★★★★★	★★★	★★★★	★★★★
EMS Limited	★★	★★★	★★	★★★	★★	★★	★★★
Excellent ★★★★★ Good ★★★★ Average ★★★ Below Average ★★							

Source: Company Website, Annual Report, News & Press Releases, Primary Interviews and Reports and Data

The water and wastewater treatment industry in India has witnessed significant growth over the past few years, driven by increasing urbanization, industrialization, and environmental concerns. Market leaders in this sector are continually striving to achieve sustainable, efficient, and innovative solutions to address the country's water management challenges. To succeed in this evolving landscape, companies must focus on several key success factors related to technological advancement and infrastructure development.

- **Technological Innovation:** Staying at the forefront of technological advancements is crucial for market leaders. Developing innovative treatment processes, materials, and equipment that enhance efficiency, reduce costs, and minimize environmental impact can provide a significant competitive advantage. Technologies such as membrane filtration, advanced oxidation, and intelligent process control systems can enable efficient water purification and resource recovery.
- **Research and Development (R&D):** Investing in R&D efforts is vital for maintaining a competitive edge. Market leaders should allocate resources to research institutions, collaborations, and in-house R&D teams to continuously develop new solutions and improve existing technologies. This could involve exploring novel treatment methods, optimizing chemical dosing, and developing predictive maintenance algorithms.
- **Customization and Scalability:** Successful companies understand that water treatment solutions need to be adaptable to diverse customer requirements and scalable to handle various project sizes. Providing customizable systems that can be tailored to specific industry needs and geographical conditions will strengthen a company's position in the market.
- **Regulatory Compliance:** India's water and environmental regulations are becoming increasingly stringent. Market leaders must ensure that their solutions not only meet current regulatory standards but also anticipate future requirements. Maintaining compliance demonstrates commitment to environmental responsibility and builds trust with clients and stakeholders.

- **Energy Efficiency:** Energy consumption is a significant operating cost in water and wastewater treatment. Developing energy-efficient technologies and processes, such as incorporating renewable energy sources and optimizing system designs for lower energy consumption, can improve a company's competitiveness and appeal to sustainability-conscious clients.
- **Data-Driven Decision Making:** Embracing digitalization and data analytics can transform how companies operate. Implementing real-time monitoring, data collection, and analytics can optimize process performance, enhance maintenance practices, and reduce downtime. Predictive analytics can also be employed to anticipate equipment failures and optimize system efficiency.
- **Local Manufacturing and Sourcing:** Setting up local manufacturing facilities and sourcing materials domestically can help market leaders reduce costs, minimize supply chain disruptions, and contribute to the country's economic growth. Additionally, proximity to clients allows for faster response times and better customization.
- **Collaboration and Partnerships:** Collaboration with research institutions, technology providers, and industry peers can foster knowledge exchange, accelerate innovation, and enhance market visibility. Strategic partnerships can lead to joint development of cutting-edge solutions, shared resources, and expanded market reach.
- **Talent Development:** A skilled workforce is essential for successfully implementing advanced technologies. Market leaders should invest in training programs, workshops, and educational initiatives to ensure their employees possess the necessary skills to operate, maintain, and innovate in the water and wastewater treatment sector.
- **Sustainability and Circular Economy:** Adopting a circular economy approach, which emphasizes resource recovery and minimizing waste, can resonate well with environmentally conscious clients. Market leaders can explore opportunities to recover valuable resources from wastewater and explore sustainable reuse options.

12.5. CHALLENGES AND THREATS FACED BY DENTA WATER AND INFRA SOLUTIONS LIMITED IN THE INDIAN MARKET

Denta Water and Infra Solutions Limited, a prominent player in the water and wastewater treatment sector in India, confronts multiple challenges and threats that could impact its operations and growth prospects. Navigating these complexities requires strategic planning and adaptive measures.

Challenges

- One of the primary challenges is the regulatory environment. Compliance with stringent environmental and safety standards is mandatory, which can increase operational costs and necessitate continuous updates to processes and technologies. The company must also deal with the complexities of obtaining necessary approvals and adhering to government guidelines, any lapse in which can result in project delays and financial penalties.
- Financial constraints are another significant challenge. The company is currently raising Rs 150 crore through an initial public offering (IPO) to meet its working capital requirements. This indicates potential liquidity issues and the need for substantial funds to sustain operations and ensure project completion. Moreover, securing financing for large-scale infrastructure projects can be difficult, with slow returns on investment making it less attractive to investors.
- Project execution and managing an extensive order backlog also pose challenges. As of late 2024, Denta Water has an order book worth Rs 7,842.30 million. Efficiently managing these projects within stipulated timelines and budgets is

crucial to maintaining profitability and reputation. Delays or inefficiencies can lead to increased costs and adversely affect the company’s market standing.

- Technological challenges further complicate the landscape. Rapid advancements in water treatment technologies necessitate continuous innovation and significant investment in research and development. Staying ahead of technological changes is vital for maintaining competitiveness, which also involves ongoing training and development programs for the workforce.

Threats

- The market's competitive nature represents a substantial threat. The Indian water and wastewater treatment sector is crowded with numerous domestic and international players. Competitors often adopt aggressive pricing strategies, leverage innovative technologies, and demonstrate superior project execution capabilities, making it challenging for Denta Water to secure contracts and maintain market share.
- Regulatory risks are ever-present, with potential changes in environmental laws or new compliance requirements potentially increasing operational costs and complicating project timelines. Non-compliance can result in significant penalties and damage to the company’s credibility.
- Economic volatility poses a significant threat, with fluctuations impacting infrastructure investments and government spending on water projects. Economic downturns or budget cuts can lead to reduced project allocations, delays, or cancellations, affecting the company’s revenue and profitability.

- Technological disruption is another critical threat. The fast pace of technological advancements in the sector means that failure to adopt new technologies can lead to obsolescence. Competitors using cutting-edge solutions may offer more efficient and cost-effective services, attracting clients away from Denta Water.
- Supply chain disruptions can also threaten project timelines and costs. Any issues in the supply chain, whether due to geopolitical tensions, natural disasters, or logistical problems, can delay projects and increase operational expenses.
- Environmental and climate risks are increasingly pertinent, with climate change affecting water availability and project feasibility. Projects must be adaptable to changing environmental conditions to remain viable and sustainable, adding to the complexity and cost.
- Political and social unrest in project areas can disrupt operations, leading to delays or cancellations. Additionally, changes in government policies or priorities can influence funding and support for infrastructure projects, impacting the company's project pipeline and financial stability.
- Lastly, financial risks associated with dependence on external funding and market conditions can affect the company’s ability to raise capital. Market fluctuations, changes in investor sentiment, and varying interest rates can influence the terms and availability of necessary funding.

13. GLOBAL WATER AND WASTEWATER TREATMENT COMPANY PROFILES

13.1. MEGHA ENGINEERING AND INFRASTRUCTURES LTD (MEIL)

Megha Engineering and Infrastructures Ltd (MEIL)	**Type:** Private
	Industry: Environmental Service & Construction
	Founded: 1989
	Headquarters: Telangana, India
	Website: www.meil.com

13.1.1. COMPANY SUMMARY

MEIL, founded in 1989, is a varied industrial group. It is a rapidly expanding worldwide corporation that has built several great landmark projects depicting historical changes and celebrating economic and cultural growth. It has also constructed several important infrastructure projects throughout the world to better people's livelihoods. MEIL does business in several areas, including water management, engineering, construction, manufacturing, transportation, hydrocarbons, electricity, process industries, and military. MEIL aims to use indigenous technical advances for the benefit of all segments of society. For over 30 years, the firm has maintained its leadership position in its key industries by putting the customer first and complying to safety and environmental regulations. MEIL is dedicated to delivering projects 'On-Time' by continuously growing industry-leading knowledge, skills, and experience, as well as applying new and flawless process approaches and technologies.

13.1.2. PRODUCT AND SERVICE INSIGHTS

Service	Description
Irrigation	• Investigation, design, engineering and construction of dams, spillways, reservoirs, canals including distribution systems. • Investigation, design and execution of minor and major lift irrigation projects. • Design, engineering and execution of water transmission mains. • Design, engineering and execution of micro irrigation projects (e.g. Ramthal Drip Irrigation Project) • Design, engineering and execution of piped irrigation canal system (e.g. Khargone Project, SSNNL Project) • Design, engineering and execution of Hydraulic Tunnels and Underground pump houses for major irrigation projects
Drinking Water	• The MEIL has created robust drinking water systems, marshalling its expertise in creating solutions for the efficient utilisation of water. • The company has changed the portrait of potable water across several geographies in the world. It has worked closely with the States, the Government of India, and governments of several other nations on drinking water projects. • It has built water infrastructure to cater to the drinking water needs of rural and urban landscapes.

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.1.3. MAJOR PROJECTS

13.1.3.1. IRRIGATION PROJECTS

Project	Description
Handri-Niva Sujala Sravanthi Project	The Handri-Niva Sujala Sravanthi (HNSS) project was conceived as a dream project for water-starved regions of Andhra Pradesh. The project is an engineering wonder comprising India's longest canal that will flow from the project to a distance of 565 km. It envisages withdrawal of 40 TMC of flood water of Krishna River from the foreshore of Srisailam reservoir in 120 flood days during the period of August to November. The aim is to provide irrigation facilities to an extent of 6.02 lakh acres in Kurnool, Anantapur, Cuddapah, and Chittoor districts of Andhra Pradesh. The project also provides drinking water facilities to a population of 33 lakhs in 81 mandals and 437 villages en route the canal.
Khargone project	MEIL commissioned this project within a month's notice period from the client. The chief minister of Madhya Pradesh Mr. Shivraj Singh Chauhan inaugurated and dedicated the Khargone Lift Irrigation Project of the Narmada Valley Development Authority (NVDA) on January 13, 2015. After completion of the three phased project, irrigation facility to 33,140 hectares of land will be augmented, benefiting 18,536 farmers' families in 152 villages. Subsequently, Khargone will emerge as the 'number one' district in cash crop production.
Veligonda Project	Veligonda Project, as a whole, envisages to provide irrigational facilities to 4.38 lakh acres of farmlands and drinking water to 15 Lakh people in 29 mandals of fluorine and drought affected upland areas in Prakasam, Nellore and Cuddapah Districts by diverting 43.5 TMC of floodwater of Krishna from foreshore of Srisailam Reservoir near Kollamvagu and proposed to store in Nallamalasagar Reservoir. MEIL's scope in the project has the potential to irrigate more than 65000 acres.
Chintalapudi LIS	The project involves the construction of a lift irrigation scheme for withdrawal of and lifting of water from river Godavari near Pattiseema village in West Godavari district of A.P. to proposed reservoir near Routugudem village in West Godavari district. The project will serve an ayacut of 2.45 lakh acres.

Pranahita-Chevella LIS	The aim of the project in its entirety is to utilise 160 Tmcft of Pranahita water and serve 16.4 lakh acres in the water scarcity areas of Adilabad, Karimnagar, Warangal, Nizamabad, Medak, Nalgonda and Ranga Reddy districts in the state of Telangana. MEIL's scope of work includes the execution of more than 10 packages of the project.
Sauni Yojana Project	The total scope of the project translates to a carrying capacity of 1200 cusecs of excess over flowing flood water of Narmada at an estimated cost of Rs. 1533 crore. 30 reservoirs of Rajkot and Jamnagar Districts will be filled and more than 2 lakh acres of agriculture will be benefited. MEIL is assigned works relating to the execution of two packages of Link-1 of the project.
Devadula - Phase-III Pkg. I	The overall project (including all phases) is the second biggest of its kind in Asia. Devadula is the place in Warangal District, Telangana, where the scheme's intake well is located. The project is specially designed to lift water from the River Godavari to irrigate lakhs of acres in the drought prone areas of the state. MEIL is assigned to deliver 3 packages in Phase-3 of the project. The completed works in this specific package of the project include the construction of super structure of pump house, erection of pumps & motors, construction of control room, fabrication & erection of manifold, outfall structure, laying of 3 rows of pipeline of 3000 mm diameter that run across a length 116.25 km, the entire surge protection system including 18 nos. of vessels and 6 nos. of one-way surge tanks (OWST). All the 18 surge vessels (of length-18.38 Mt. and capacity-124 Cub. Mt.) were manufactured in MEIL's Pressure Vessel Division.

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.1.3.1. DRINKING WATER PROJECTS

Project	Description
Mission Bhagiratha	Mission Bhagiratha, executed by MEIL, aims to provide safe drinking water to over 50 lakh households across 33 districts in Telangana. The project involves laying a 25,000-km pipeline network, twice the earth's diameter, ensuring tap connections in every household. This initiative has alleviated the burden of fetching water over long distances, addressing long-standing water scarcity issues in the state.
Sripada Yellampally Project under GDWSS	To address Hyderabad's drinking water needs, MEIL executed the Godavari Drinking Water Supply Scheme (GDWSS), sourcing water from the Sripada Yellampally Project in Peddapalli district. The project includes the construction of Asia's largest 735 MLD water treatment plant and essential infrastructure like reservoirs, substations, and pumping stations. Additionally, a massive 150 MLD master balancing reservoir was built.
Odisha Projects	MEIL has significantly improved living standards in Odisha through various drinking water projects. Sundergarh: MEIL provided drinking water to rural households in 88-gram panchayats by utilizing river Sankha water. Bhadrak: The project supplied piped drinking water to 526 villages using river Kharasrota water, benefiting mining-hit and saline-affected households. Keonjhar: Overcoming challenges of hilly terrains, MEIL ensured safe drinking water delivery to rural areas. Jajpur: The ongoing project addresses water scarcity by creating infrastructure to utilize waters from Brahmani, Baitarani, and Genguti rivers.
MEIL's Surpura project	In Jodhpur, Rajasthan, MEIL's Surpura project tackles the city's long-standing drinking water deficit. It provides continuous clean drinking water to villages near the Thar Desert, significantly improving the quality of life in these arid regions.
Uddanam Project	The Uddanam Project is a transformative initiative in Srikakulam District, Andhra Pradesh, aiming to supply clean drinking water to a community severely affected by polluted underground water. Launched by the Jaljeevan Mission, the project addresses the

	high incidence of kidney diseases caused by water contamination, affecting 35,000 individuals in 2015. The initiative focuses on seven mandals, covering 807 habitations with a projected population of 7.82 lakhs by 2051. Utilizing water from the Vamsadhara River and Hiramandalam Reservoir, the project involves a vast network of pipelines and multiple pumping stations to ensure a 22-hour water supply. The second phase extends the network by an additional 200 kilometers, benefiting another 4 lakh people. Beyond infrastructure, the project symbolizes hope and improved living standards for the region's residents.
Adichunchanagiri Drinking Water	The Adichunchanagiri Drinking Water Project in Karnataka's Mandya district aims to provide pure drinking water to 128 villages in the Nagamangala taluk, which suffer from water scarcity and contamination. Executed by MEIL, the project sources water from the Markonahalli reservoir and involves constructing a water treatment plant, a comprehensive pipeline network, overhead tanks, and balancing reservoirs. The project utilizes an automation system (CADA) for efficient water flow and storage management. Once completed, it will benefit a population of 1.12 lakh, significantly improving the health and living conditions of the villagers. The project is currently ongoing.
Kadana - Water Project	The Kadana Water Project in Gujarat is crucial for supplying irrigation and drinking water to the state's eastern districts, particularly during water shortages in the Narmada River. Utilizing water from the Kadana reservoir, the project involves lifting and pumping water into the River Mahisagar and then into the Narmada. MEIL constructed pump houses and installed high-capacity machines to facilitate this process. This project is significant for sustaining agriculture and providing potable water in the region. The project is completed and operational, reinforcing the water supply infrastructure of Gujarat.

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.1.4. SWOT ANALYSIS

S STRENGTHS	W WEAKNESS	O OPPORTUNITIES	T THREATS
▪ Extensive experience in water and wastewater infrastructure projects. ▪ Strong financial position and access to capital. ▪ Robust project management capabilities. ▪ Diversified portfolio of water and wastewater projects. ▪ Established relationships with government agencies and stakeholders.	▪ Dependency on government contracts and regulations. ▪ Competition from other established players in the industry. ▪ Potential for cost overruns in complex projects.	▪ Expansion into international markets. ▪ Innovation in water treatment technologies. ▪ Public-private partnerships for project financing. ▪ Potential for diversification into related sectors.	▪ Regulatory changes affecting project approvals and tariffs. ▪ Economic downtums impacting government spending. ▪ Rising construction and material costs.

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.2. EMS LIMITED

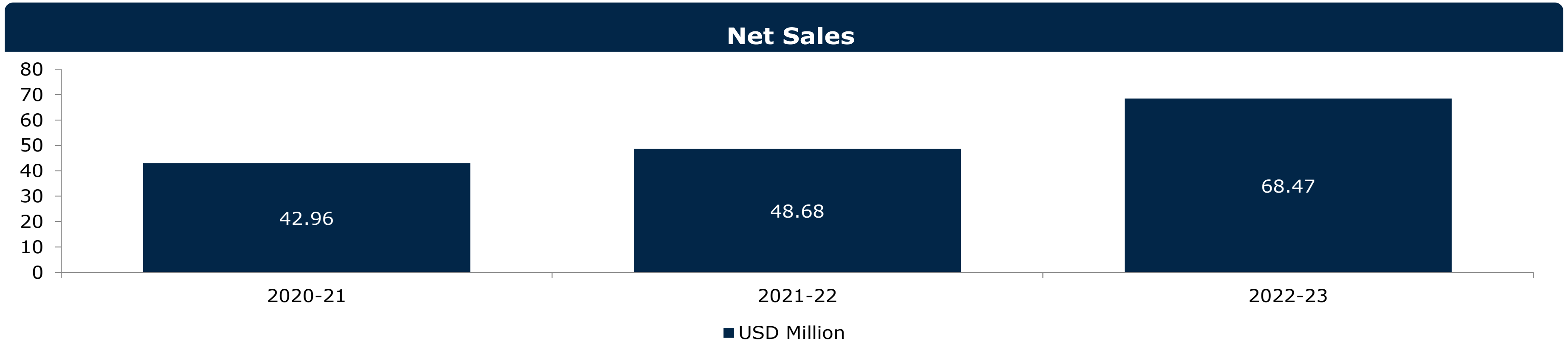
EMS Limited	**Type:** Public
	Industry: Environmental Service & Construction
	Founded: 1998
	Headquarters: Uttar Pradesh, India
	Website: www.ems.com

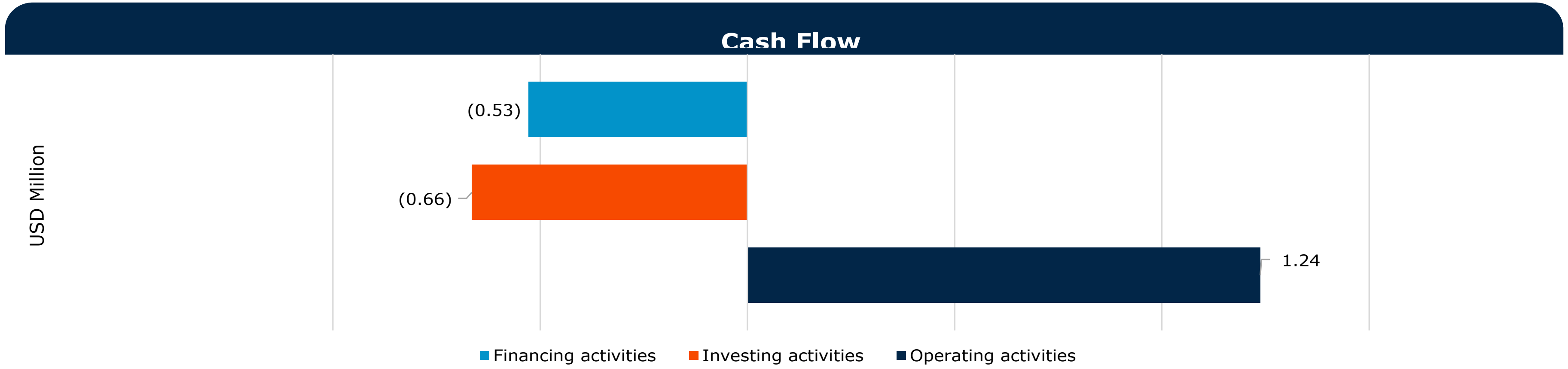
13.2.1. COMPANY SUMMARY

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.

13.2.2. 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

TABLE 101. FINANCIAL INSIGHTS OF EMS LIMITED

FINANCIAL INSIGHTS	2020-21	2021-22	2022-23
OPERATING INCOME	▪ 42.959	▪ 49.119	▪ 69.121
OPERATING INCOME GROWTH	▪ NA	▪ 16.51%	▪ 2.09%
OPERATING PROFIT	▪ 20.415	▪ 14.906	▪ 12.271
OPERATING PROFIT MARGIN	▪ 22.554	▪ 34.213	▪ 56.850
OPERATING PROFIT GROWTH	▪ NA	▪ NA	▪ NA

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.2.3. PRODUCT AND SERVICE INSIGHTS

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, Annual Report, News & Press Releases, and Reports and Data

13.2.4. MAJOR PROJECTS

Project	Description
Common effluent treatment plant at Sidcul, Haridwar	Common Effluent Treatment Plant (CETP) of 4.5 MLD capacity (expandable upto 9 MLD) in SIDCUL, Haridwar on Build, Operate, Own and Transfer (BOOT) model under Public Private Partnership with State Industrial Development Corporation of Uttarakhand Limited. Under this project, the industrial units located in the SIDCUL, Haridwar discharge their industrial waste into the metered collection network laid by the company which then is treated at the CETP and discharged after proper treatment and filtration. The industrial units are charged as per volume of the effluent released by them. The concession period of the CETP is till the year 2035.

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.2.5. SWOT ANALYSIS

S STRENGTHS	W WEAKNESS	O OPPORTUNITIES	T THREATS
▪ Established reputation in the water and wastewater industry ▪ Strong technical expertise in water treatment and infrastructure ▪ Robust client portfolio with long-term contracts ▪ Efficient operations and cost-effective solutions	▪ Vulnerability to regulatory changes and compliance issues ▪ Limited geographic diversification in the market ▪ High capital requirements for infrastructure development ▪ Competition from larger, well-established firms	▪ Growing demand for sustainable water and wastewater solutions ▪ Potential for expansion into emerging markets ▪ Technological advancements in water treatment ▪ Partnerships with government agencies and environmental organizations	▪ Economic downturns impacting infrastructure spending ▪ Fluctuations in raw material prices ▪ Environmental concerns and public scrutiny ▪ Increased competition from new entrants and incumbents

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.3. VA TECH WABAG LTD

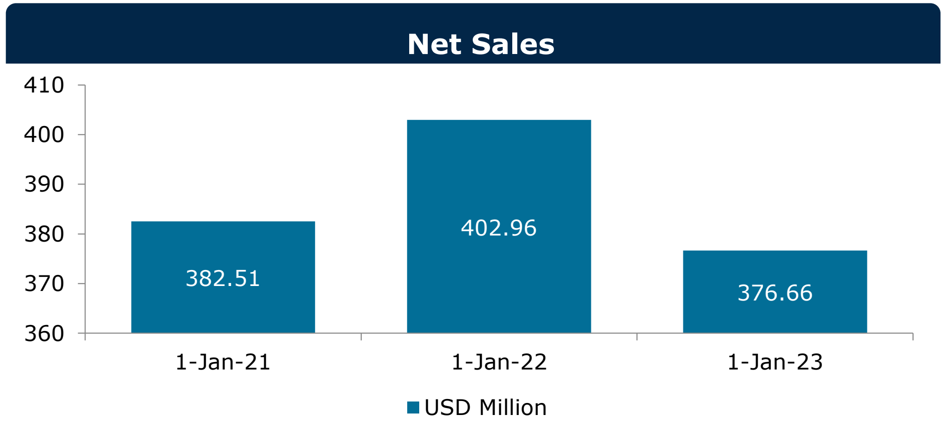
VA TECH WABAG LTD	
	Type: Public
	Industry: Water and Wastewater Treatment
	Founded: 1924
	Headquarters : Chennai, India
	Website: www.wabag.com

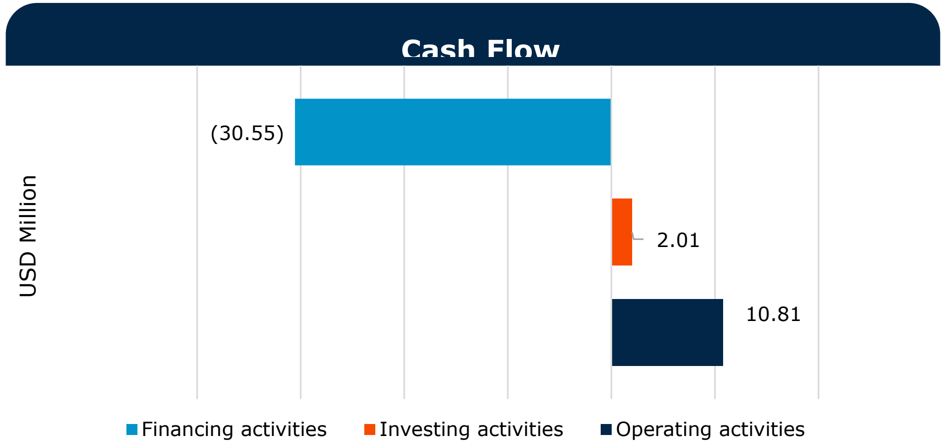
13.3.1. COMPANY SUMMARY

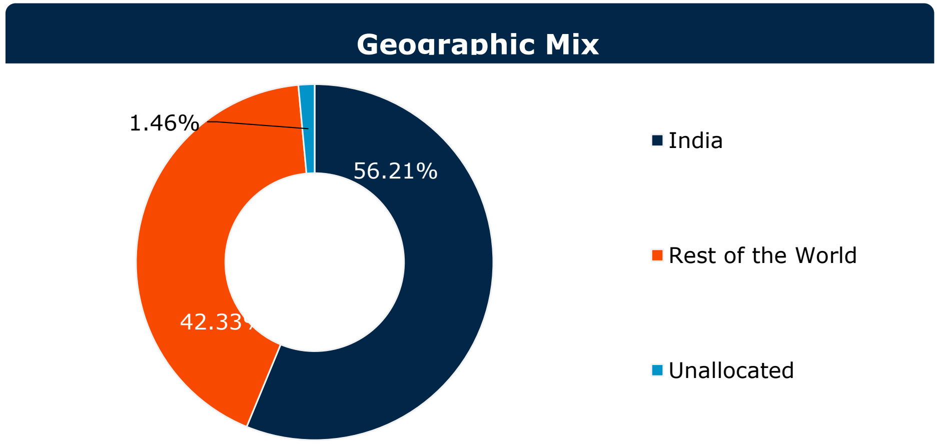
VA TECH WABAG LTD provides comprehensive solutions for water and wastewater treatment, including design, engineering, construction, operation, and maintenance of water treatment plants, sewage treatment plants, and recycling systems. Their solutions cover a range of technologies, such as filtration, 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.

13.3.2. 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 5,000 people across the globe.







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

TABLE 102. FINANCIAL INSIGHTS OF VA TECH WABAG LTD

FINANCIAL INSIGHTS	2020	2021	2022
OPERATING INCOME	▪ 248.73	▪ 289.79	▪ 295.85
OPERATING INCOME GROWTH	▪ NA	▪ 16.51%	▪ 2.09%
OPERATING PROFIT	▪ 17.65	▪ 22.78	▪ 38.94
OPERATING PROFIT MARGIN	▪ 231.08	▪ 267.02	▪ 256.91
OPERATING PROFIT GROWTH	▪ NA	▪ 15.55%	▪ -3.79%
NET PROFIT MARGINS	▪ 5.40%	▪ 4.40%	▪ 0.10%
GEARING RATIO / DEBT LEVELS	▪ 22.00%	▪ 32.00%	▪ 16.00%
INTEREST COVERAGE RATE	▪ 2.45	▪ 2.92	▪ 5.65

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.3.3. PRODUCT INSIGHTS

Product	Type	Description
▪ Water Treatment	• BIODEN • PACOPUR • CERAMOPUR • CERAMOZONE	• These water treatment facilities are highly scalable and can be established to suit any business model, be it EPC, DBO or BOOT. • These solutions ensure efficient extraction of potable water from all the available sources of fresh water as well as used water for direct or indirect potable reuse.
▪ Wastewater Treatment	• Nereda • SBR (CYCLOPUR) • MARAPUR • BIOPUR • FLUOPUR	• It promotes sustainability with wastewater treatment solutions that ensure environmentally friendly discharge or reuse of treated wastewater. • It promotes a comprehensive wastewater treatment model that focuses on resource recovery through a combination of innovative technologies.

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.3.4. MAJOR PROJECTS

Project	Description
Koyambedu Water Reuse Plant	The Koyambedu Tertiary Treatment Reverse Osmosis (TTRO) Plant in Chennai, India, designed and built by WABAG in partnership with IDE, is a cutting-edge water reuse facility with a capacity of 45,000 m^3/day. This project, commissioned by the Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB), represents a significant advancement in municipal water recycling and urban water governance. The plant employs advanced technologies including chlorine dioxide dosing for pre-disinfection, dual media rapid gravity filters for pre-treatment, ultrafiltration (UF) for wastewater polishing, and a three-stage reverse osmosis (RO) system achieving an 80% recovery rate. It is the first reuse plant in India to use ozonation technology for disinfection, conserving over 1600 crore liters of fresh water annually under a 15-year design-build-operate (DBO) contract.
IOCL Paradip ETP	Located in Paradip, Odisha, the IOCL Paradip Effluent Treatment Plant (ETP) addresses the critical water scarcity faced by the port town due to industrial overexploitation of groundwater. IOCL's refinery, which requires substantial water for its operations, collaborated with WABAG to establish an effluent treatment and water reclamation facility to reduce dependency on external water sources. This plant, the largest industrial recycling facility in India, recycles approximately 54,000 m^3 of treated water daily for the refinery, significantly reducing freshwater consumption by over 17,000 ML annually. The treatment process includes multiple stages to handle complex effluent types, utilizing technologies like API and TPI separators, dissolved air flotation (DAF), bio-towers, activated sludge processes, ultrafiltration, and high-efficiency reverse osmosis, achieving a recovery rate of around 85%. This initiative underscores the importance of sustainable water management in industrial operations.
Kodungaiyur Power Neutral Plant	North Chennai, an area with a substantial population and a history of manufacturing activities, faced significant health and environmental issues due to inadequate wastewater management infrastructure. To address these challenges, the Chennai Metro Water Supply and Sewage Board (CMWSSB) initiated a sustainable wastewater infrastructure project. VA Tech WABAG was selected to design, build, and operate a biological sewage treatment plant at Kodungaiyur, commissioned in 2006 with a capacity of 110 million liters per day (MLD). The plant employs a two-stage process: aerobic treatment for safe sewage discharge and anaerobic sludge digestion to generate biogas and achieve power neutrality. This project not only improved the

	environmental conditions but also enhanced the productivity and economic progress of the region. The plant has become a model of energy efficiency and sustainability, producing green power and significantly reducing environmental pollution.
Nemmeli Desalination Plant	Chennai, a city facing severe water scarcity due to irregular rainfall and over-reliance on surface water sources, turned to seawater desalination as a solution. VA Tech WABAG was entrusted with the design, construction, and operation of a 100 MLD desalination plant at Nemmeli, which was later enhanced to 110 MLD. The plant uses advanced technology to treat seawater, including a lamella clarifier for pretreatment, ultra-filtration, and a single pass SWRO system to reduce salinity. The innovative pressure exchange mechanism optimizes power consumption, making the desalination process efficient and sustainable. The Nemmeli plant provides high-quality drinking water to over a million residents in South Chennai and serves as a testament to the feasibility of desalination as a sustainable water source. Recognized globally, the plant has received several awards and continues to play a crucial role in addressing Chennai's water security challenges, with further expansions planned to enhance its capacity.
Panjrapur Water Treatment Plant	Client: Municipal Corporation of Brihanmumbai Location: Panjrapur, Maharashtra, India Capacity: 455,000 m^3/d The Panjrapur Water Treatment Plant is one of the largest drinking water treatment facilities in India, utilizing advanced technologies to optimize space and efficiency. Key components of the plant include an inlet chamber, flash mixing, flocculation, lamella clarification, rapid gravity sand filtration, chlorination, and a recirculation tank.
Complex Effluent Treatment & Recycling in Dahej Manufacturing Division	Client: Reliance Industries Location: Dahej, Gujarat, India WABAG established the largest PTA effluent recycling plant in India for Reliance Industries in Dahej, Gujarat. The plant employs a custom-designed process combining activated sludge (MBR) and anaerobic treatment (UASB) in one unit. It features ultrafiltration and reverse osmosis technologies, achieving 80% water recovery. The biogas generated (34,000 m^3/d) is used for

	heating, saving about 40% on heating costs. The plant processes effluent streams from polyester production, oily water, sanitary wastewater, and treated effluent from existing treatment plants.
High Salinity Raw Water Treatment in Dahej Manufacturing Division	Client: Reliance Industries Location: Dahej, Gujarat, India To address salinity issues in intake water from the Narmada River, this project was completed in a record 8¾ months, encompassing engineering, supply, construction, testing, and commissioning. The treatment package includes basket strainer, ultrafiltration, reverse osmosis, and reject reverse osmosis, achieving a high recovery rate of 80-85%.
Water Reclamation in Panipat Refinery	Client: IOCL Location: Panipat, Haryana, India The Panipat Refinery project is India's first refinery wastewater recycling system based on membrane technology and one of the largest globally, with a 90% recovery rate. The treatment process includes clarification, filtration, ultrafiltration, reverse osmosis, and demineralization, enabling the reuse of water as boiler feed water.

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.3.5. SWOT ANALYSIS

S STRENGTHS	W WEAKNESS	O OPPORTUNITIES	T THREATS
▪ VA TECH WABAG has a strong international presence, with operations and projects in multiple countries. This global reach provides them with diverse revenue streams and exposure to various markets. ▪ The company is known for its technical know-how and expertise in water and wastewater treatment technologies. This gives them a competitive edge in providing innovative and efficient solutions to clients. ▪ VA TECH WABAG offers a wide range of services, including design, engineering, construction, and operation of water and wastewater treatment plants. Their comprehensive portfolio enables them to serve various industries and customer needs. ▪ The company has successfully completed numerous projects worldwide, earning a reputation for reliability and quality. This track record helps them secure new contracts and partnerships. ▪ With increasing emphasis on environmental sustainability, VA TECH WABAG's expertise in providing sustainable water management solutions positions them well to meet growing market demands.	▪ The company's revenue is linked to capital spending by industries and governments on water and wastewater treatment projects. Economic fluctuations or budget cuts in these sectors can impact VA TECH WABAG's financial performance. ▪ Large-scale water treatment projects can be complex and involve multiple stakeholders, regulatory approvals, and technical challenges. Delays or issues in project execution can affect the company's reputation and profitability.	▪ Increasing global awareness of water scarcity and environmental concerns presents opportunities for VA TECH WABAG to provide solutions that address these issues, such as water reuse and resource recovery. ▪ Infrastructure development, especially in emerging markets, offers potential projects for VA TECH WABAG's services, including water treatment plants, desalination plants, and sewage treatment facilities. ▪ Advances in water treatment technologies and digitalization provide opportunities for VA TECH WABAG to develop and implement cutting-edge solutions, staying ahead in the competitive market. ▪ Collaborations with governments and private entities to address water management challenges can open doors for VA TECH WABAG to secure long-term contracts and contribute to public welfare.	▪ The water and wastewater treatment industry is competitive, with both domestic and international players vying for projects. Maintaining market share and pricing power can be challenging. ▪ Evolving environmental regulations and compliance requirements can impact project design and execution, potentially increasing costs or affecting project feasibility. ▪ Dependence on suppliers for equipment and materials could expose VA TECH WABAG to supply chain disruptions, affecting project timelines and costs. ▪ Economic downturns, currency fluctuations, and political uncertainties in the regions where the company operates can impact project investments and profitability.

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

13.4. DENTA WATER AND INFRA SOLUTIONS LIMITED

Denta Water and Infra Solutions Limited	**Type:** Public
	Industry: Water and Wastewater Treatment
	Founded: 2016
	Headquarters : Karnataka, India

13.4.1. COMPANY SUMMARY

Established in 2016, Denta Water and Infra Solutions Limited, commonly known as "Denta Water," has emerged as one of the key players in the field of water engineering, procurement, and construction (EPC) services. With a meritorious track record in infrastructure project installations, including groundwater recharging through recycled water, Denta Water has been a contributor to addressing the rising demand for water-related solutions in the country. Their notable achievements encompass pivotal projects like the Byrapura and Hiremagaluru LIS Project, Karagada LIS Project, and others, primarily executed through lift irrigation systems. Notably, Denta Water played a substantial role in the first phase of the KC Valley project, contributing to Bengaluru's reputation as the second-largest city globally in terms of treated wastewater quantity. The company's significant involvement in the "Jal Jeevan Mission" of the Government of India reflects its commitment to critical water management initiatives. Furthermore, Denta Water secured contracts for lift irrigation projects in various regions, such as Makali, Makali Hosahalli, Krishnapura, and neighboring villages in the Channapatna Taluk of Ramanagar District, Karnataka. Their growth is inherently linked to the nation's infrastructure development, with a focus on design and engineering consultancy that aligns with the ongoing and anticipated projects in the Karnataka Government's water management sector. As water remains a critical resource, Denta Water is poised to continue making substantial contributions to the industry's growth and development in the future.

13.4.2. MAJOR PROJECTS

Project	Description
▪ Koramangala-Challaghatta (KC) Valley project – Phase II	• This project is under the Minor Irrigation department, Government of Karnataka for second stage lifting or pumping secondary treated water from available sources to various ridge points to fill additional 272 tanks in Kolar District and Chintamani Taluk of Chikkaballapura District under ongoing KC Valley Project. Project includes design, construction, commissioning, repair and maintenance for a period of five years.
▪ Bangalore East Lift Irrigation Scheme (LIS)	• With this project the company engages in lifting/pumping of secondary treated water from KR Puram STP to feed 22 tanks in Bangalore (East) Taluk of Bangalore Urban District through LIS. Project includes design, construction, commissioning, repair and maintenance for a period of five years.
▪ Multi Village scheme for drinking water supply – Kopal District	• The company signed the contract with Rural Drinking Water and Sanitation Department, Government of Karnataka, for supplying drinking water to Kerehalli and other 103 habitations of Koppal Taluk in Koppal District in Karnataka. The project comprises designing and engineering for lifting water from Tungabhadra river, installation of water treatment plant with capacity of 14.5 MLD and 8.5 MLD and laying of 388.605 km of pipelines for supply of drinking water.

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data (Note: we have profiled major ongoing projects only)

13.5. SPML INFRA LIMITED

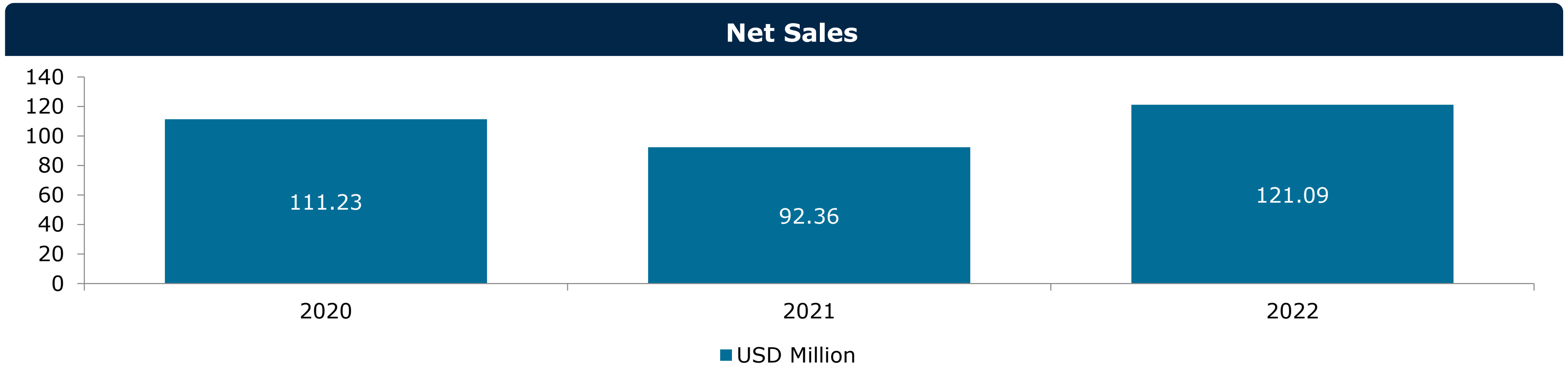
SPML Infra Limited	**Type:** Public
	Industry: Infrastructure Development
	Founded: 1981
	Headquarters: Kolkata, India
	Website: www.spml.co.in

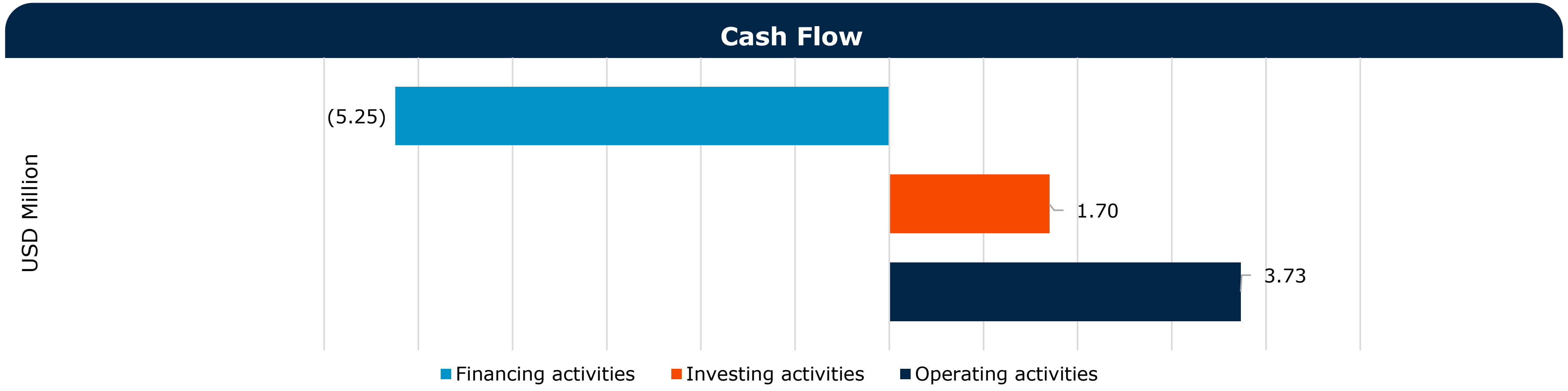
13.5.1. COMPANY SUMMARY

SPML Infra Limited is an Indian infrastructure company specializing in providing integrated water supply, sewerage, and sewage treatment solutions, as well as power and environment management services. It is known for its expertise in designing, constructing, and maintaining water supply projects, including distribution systems and water treatment plants. The company is involved in building sewage collection and treatment systems to improve sanitation and environmental conditions. It is also engaged in power transmission and distribution projects, contributing to India's growing energy needs. The company offered services related to environmental infrastructure, waste management, and green solutions. The company received awards and recognition for its contributions to the infrastructure sector and its commitment to quality and innovation.

13.5.2. FINANCIAL INSIGHTS

Founded in 1981 and headquartered in Kolkata, India. SPML Infra Limited is a public company. As of 2022, the company employed about 10,000 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

TABLE 103. FINANCIAL INSIGHTS OF SPML INFRA

FINANCIAL INSIGHTS	2020	2021	2022
OPERATING INCOME	▪ 124.89	▪ 100.98	▪ 124.83
OPERATING INCOME GROWTH	▪	▪ -19%	▪ 24%
OPERATING PROFIT	▪ 0.21	▪ (15.30)	▪ 1.13
OPERATING PROFIT MARGIN	▪ 124.67	▪ 116.29	▪ 123.70
OPERATING PROFIT GROWTH	▪	▪ -7%	▪ 6%
NET PROFIT MARGINS	▪	▪ -17.40%	▪ 1.17%
INTEREST COVERAGE RATE	▪ 1.03	▪ (1.37)	▪ 1.27

Source: Annual Reports, Primary Interviews, and Reports and Data

13.5.3. PRODUCT INSIGHTS

Product	Description	Scope of Services
▪ WASTEWATER	• It has the capabilities to provide reuse with recovery of resources from waste as well as solutions for proper treatment and disposal of wastewater with specific processes such as anaerobic, anoxic, and aerobic. • It builds plants which are fully equipped with PLC and SCADA system with reliable treatment technology for efficient operation and maintenance.	• Sewage Treatment Plant • Effluent Treatment Plant • Tertiary Treatment Plant • Water Reuse & Recycling • Integrated Sewerage Network • Sewage Pumping Station/Pipeline • Sludge Treatment & Energy Recovery • Storm Water Drainage • Sewer Pipeline Rehabilitation
▪ WATER TREATMENT	• The water treatment plants are essential for modern infrastructure to make drinking water available which comes from groundwater, lakes, streams, rivers, canals or sea, and should be treated and cleaned before being distributed for potable and non-potable use. • With strong foothold in the domain of design, construction, operation and maintenance of high-capacity water treatment plants (WTP), SPML has infrastructure and resources required to implement drinking water supply and distribution system with required technology to monitor quantity and quality of water supplies including billing system.	• Design and planning • Construction of flocculation and filters • Pre-ozonisations and chemical dosing • Lamella settling, sludge beds and pulsating beds. • Single-layer and multi-layer filtration • Adsorption on activated carbon beds • Treatments with Membrane Filtration, Ultra Filtration, Reverse Osmosis, Iron and Arsenic Removal and Electro-dialysis Reversal membranes • Cleaning water recovery system • Operation & maintenance

13.5.4. MAJOR PROJECTS

Project	Description
Pokaran Water Supply Project	SPML Infra's Pokaran Water Supply Project aims to provide clean drinking water to 580 villages in Jaisalmer and Barmer districts and nearby towns, serving over 1.2 million people, as well as meeting the water demands of defense and industries. The project scope includes a 125 MLD water treatment plant, 400 km of water pipeline, a 300 ML raw water reservoir, three 10,850 KL clear water reservoirs, 16 pumping stations, two master control centers, and operations & maintenance for 10 years.
SAUNI Yojana Phase III, Gujarat	SPML Infra is laying 139 km of pipelines (1000-2700 mm diameter) and constructing a pumping station and allied works under Phase III of the SAUNI Yojana. The project aims to irrigate 1.8 million hectares in Saurashtra, Kutch, and north Gujarat, benefiting millions of farmers and providing potable water to 39 million people across 132 towns and 11,456 villages in Gujarat, addressing the scarcity of drinking water. SPML Infra had previously completed Phase I of the project, inaugurated by Prime Minister Narendra Modi in April 2017.
Mira Bhayandar Sewerage System, Maharashtra	SPML Infra is implementing India's first comprehensive underground sewerage system in Mira Bhayandar, Maharashtra. The project includes designing, supplying, laying, and commissioning 113 km of sewer lines, 10 pumping stations, and 10 sewage treatment plants with a total capacity of 115 MLD using MBBR technology. The system will eliminate existing septic tanks and improve hygiene and living standards by draining sewage through stormwater drains.
Kanpur Sewerage Network and Treatment Plant	SPML Infra has constructed a sewerage network and sewage treatment plant in Kanpur. The project includes a 130 km sewerage network with RCC pipes (150-1800 mm diameter), three pumping stations (14, 40, and 42 MLD), and a 42 MLD sewage treatment plant using the activated sludge process, including power generation from biogas.

Source: Annual Reports, Primary Interviews, and Reports and Data

13.5.5. SWOT ANALYSIS

S STRENGTHS	W WEAKNESS	O OPPORTUNITIES	T THREATS
▪ Strong track record in executing water and wastewater projects. ▪ Established relationships with government agencies and clients. ▪ Diversified portfolio of water and wastewater services. ▪ Technically skilled workforce.	▪ Dependence on government contracts for revenue. ▪ Vulnerability to regulatory changes in the water sector. ▪ Limited international market presence. ▪ Competition from larger, more established firms.	▪ Growing demand for water and wastewater infrastructure in emerging markets. ▪ Potential for public-private partnerships (PPPs) in the sector. ▪ Expansion into innovative water treatment technologies. ▪ Focus on sustainability and eco-friendly solutions.	▪ Economic downturns impacting infrastructure spending. ▪ Environmental regulations and compliance challenges. ▪ Fluctuating raw material costs. ▪ Emerging competitors and disruptive technologies.

Source: Company Website, Annual Report, News & Press Releases, and Reports and Data

DISCLAIMER

Reports and surveys are based purely on data or information accumulated from the authorized personals not limited to stakeholders and field marketing executives of reputed companies, brands, organizations or bodies. The information is also derived based on further discussion with subject matter experts heading the practice or at reputed companies.

When placing an order with Reports and Data, the buyer or user understands and agrees to use our analytical solutions or products for their internal use. We in no form extend permission to use the asset for general publication or disclose the content to a third party.

The data in our market research report should be used as indicative guidance only. Experts at Reports and Data assert that no business including but not limited to investments should be made purely on the data presented in these reports. We highly recommend that business owners or stakeholders should seek professional advice before making a business decision

Any resale, lending, disclosure or reproduction of this publication can only be made with prior written permission from Reports and Data. Transmission and/or reproduction of this document by any means or in any form (includes photocopying, mechanical, electronic, recording or otherwise) are prohibited without the permission of Reports and Data.

Reports and Data

40 Wall St. 28th floor New York City,
NY 10005 United States

+1-212-710-1370

sales@reportsanddata.com

www.reportsanddata.com