

India AMR Overview

AMR Technology for Water Sector Market Study in India



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1. Management Summary

Antimicrobial resistance (AMR) is a major global health concern today and India carries one of the largest burdens of drug-resistant pathogens worldwide. AMR in India is a significant challenge due to the large and growing pharmaceutical manufacturing base, and untreated or partially treated wastewater discharges from hospitals and sewage systems. As part of this market study, the present situation with respect to AMR across three sectors including pharmaceutical manufacturing, hospitals, and municipal sewage treatment was reviewed and analyzed focusing on the states of Telangana and Andhra Pradesh which are major pharmaceutical manufacturing hubs and fast growing states in India. The core objective of the study was to provide Dutch stakeholders from industry, academia, government, and civil society with a clearer picture and analysis of the short, medium, and long-term scope of business opportunities in the field of AMR-reducing technologies and services in India, with a focus on water and waste treatment.

The One Health approach has been prioritized by the Government of India. Various activities have been planned with that perspective by government agencies and private stakeholders including Ministries of health, water and animal husbandry. In April 2017, India came up with a National Action Plan (NAP) in alignment with the Global Action Plan to address AMR. In June 2022, the Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) was formed to oversee the implementation of the One Health Mission including AMR in India.

Pharmaceutical Manufacturing, Environment and AMR

The Indian pharmaceutical industry is a significant player in the global market, known for its high-quality, low-cost generic drugs. The industry is divided into two main sectors: the bulk drug sector, which includes Active Pharmaceutical Ingredients (API) manufacturers and accounts for around 20% of the global market for APIs, and the formulation sector, which includes drug formulators and accounts for around 10% of the global market. Significant quantity of antibiotics and antimicrobials manufacturing takes place in the states of Andhra Pradesh and Telangana. The Indian pharmaceutical industry is facing a number of challenges, including increasing competition from other countries, rising raw material costs, and regulatory hurdles, but it continues to grow and is expected to reach a value of \$120 to \$130 billion by 2030.

Spread of AMR is an important concern for Indian pharmaceutical manufacturers because of growing regulatory and international procurement pressures for more responsible manufacturing. New policies and guidelines for monitoring and treatment of pharmaceutical waste streams



require manufacturers to install expensive technologies and increase investments in managing environmental infrastructure such as Zero Liquid Discharge (ZLD) and API monitoring technologies. However, due to lack of infrastructure, technical knowhow and investment capacity the Indian pharmaceutical industry (especially the small and medium size manufacturers) is expected to face growing pressures.

Hospital Wastewater and AMR

The hospital healthcare sector in Andhra Pradesh and Telangana is diverse, highly fragmented and complex, with a mix of public (30%) and private facilities (70%) providing healthcare services to the large and growing population. Hospital wastewater treatment in India is regulated, however only basic (equivalent to sewage) treatment is required as per present regulations. Further, there are significant gaps and limitations in the proper treatment of wastewater from hospitals and data for the operations of the hospital wastewater management is difficult to secure. There is a general lack of proper treatment facilities and awareness among hospitals about the importance of wastewater treatment that can help curb the spread of AMR¹. This is compounded due to lack of regulations for discharge of pharmaceutical and antimicrobial compounds in the wastewater from hospitals.

Municipal Sewage and AMR

The municipal sewage sector in India is responsible for the collection, treatment, and disposal of wastewater and sewage generated in urban areas. A significant portion of the sewage generated in Andhra Pradesh and Telangana is discharged untreated or partially treated (>50% of sewage is discharged untreated) into the environment. Further, presently there are no regulations or guidelines for determining or controlling the impact of sewage treatment on spread of AMR beyond the minimum regulatory compliance requirements. Most stakeholders consulted as part of this study emphasised the urgent need for the government and stakeholders to invest in building and properly operating sewage treatment plants which will significantly help in reducing the spread of AMR - however it must be noted there there are no AMR specific design or operations required for sewage treatment beyond the typical municipal sewage treatment standards.

¹ Hospitals and doctors are generally aware of the spread of AMR due to indiscriminate use of antibiotics, however, based on stakeholder consultations it was found that the awareness and discussions around spread of AMR due to wastewater discharge from hospitals are limited.



Recommendations for Dutch Agencies and Companies for conducting AMR related business in

Through stakeholder consultations a number of business opportunities were identified for Dutch technology and engineering companies in the three target sectors. The opportunities broadly classify under three main heads:

1. Awareness and capacity building initiatives,
2. Technology and infrastructure development for improving the surveillance of antibiotics in the environment to help measure the spread of AMR and generate data for planning corrective measures and building treatment infrastructure, and
3. Investments into technology and wastewater treatment infrastructure for industrial, hospital effluents and sewage.

Sector Prioritization for Business Development by Dutch agencies and companies

1. At the present moment, out of the three sectors, the pharmaceutical manufacturing sector is most aware and advanced in terms of finding and adopting solutions for curbing spread of AMR through environmental pollution. There are existing guidelines and upcoming regulations, which provide a significant business force for enforcing action, making this sector most attractive from an immediate business point of view. A reference list of potential project opportunities with categorization based on timelines (short, medium and long term) is provided in Section 5.4 on page 51. Further, the pharmaceutical industry is attracting new growth investments such as Performance Linked Incentive (PLI) scheme where approximately \$2 billion is planned to be invested to supporting growth of the Indian pharmaceutical sector.
2. Spread of AMR from hospital wastewater and sewage is not a widely discussed or studied topic. At the moment there is little thought and work that has been put into ascertaining the role and contribution of hospital waste as a pollution source in the spread of AMR in India. There are no regulations or clear business drivers for hospitals or municipalities to build or upgrade their wastewater treatment facilities with technologies to remove antibiotics or antimicrobials that can help curb spread of AMR. At the present moment, the business opportunities in these sectors are expected to be fewer and difficult to identify. Developing business opportunities in these sectors would require significant stakeholder consultations involving one-on-one business meetings to identify any business opportunities. Further, for the identified business opportunities significant collaboration efforts with Indian and state government and business stakeholders would be needed to develop business opportunities.



How can Dutch agencies and businesses create value?

1. Dutch experts and companies can play an important role in partnering with Indian and state government stakeholders to fast track the development of policies and regulations to help India build the necessary regulatory frameworks and ecosystem for implementing solutions for reducing the spread of AMR.
2. Dutch research scientists and engineers can partner with Indian academic institutions, startups and engineering companies to develop and demonstrate effectiveness of low-cost technologies and infrastructure solutions with the objectives of achieving increased monitoring of antibiotics in waste streams in all the three focus sectors as well as monitoring of spread of AMR in and around areas of pollution.
3. Since the discussions on AMR are still at a very nascent stage in India and specifically in Andhra Pradesh and Telangana, a collaborative and multi-stakeholder consultative approach will be best suited for co-designing and co-developing programs and infrastructure projects. This could be done through investing in building Government to Government partnerships with key state government agencies (eg. Hyderabad Pharma City), business ecosystems (eg. Bulk Drug Manufacturers Association of India (BDMAI), Pharmaceutical Supply Chain Initiative (PSCI), Confederation of Indian Industry (CII) etc) and academic institutions (such as NIPER-Hyderabad, IIT Bombay and IIT Hyderabad²) for bringing together Indian and Dutch experts and entrepreneurs to co-create technologies and solutions for monitoring and treating antibiotics in the environment.

The key immediately actionable recommendations are summarized in the table below. Detailed list of potential business opportunities that could be worked upon are listed in section 5.4 (page 52)

Research Recommendations in developing AMR monitoring technologies and improved, cost effective wastewater treatment technologies

- Aim to set up bilateral research. Efforts should be made for investigating the potential for bilateral research collaboration agreements between universities, with the involvement of the industry, to secure funding for joint research on the topics of environment and AMR.
- Aim to establish talent and expert exchange programs. To facilitate the effective and cost-efficient development of infrastructure in India for monitoring and managing AMR, consider establishing talent and expert exchange programs. These programs can focus on AMR research, as well as the development of new technologies for monitoring AMR and managing waste in the environment.
- Consider leveraging bilateral academic programs, along with technology and infrastructure

² For abbreviations, please refer page 11.



design consultancy projects, to address the issue of AMR and promote the One Health approach. This can involve the development of innovative technologies and infrastructure to combat AMR, as well as the sharing of knowledge and expertise between academic institutions to advance research in this area.

- Consider establishing an Indo-Dutch Centre of Excellence to carry out pilot projects, training, capacity building, testing, and technology benchmarking infrastructure in the field of AMR. This center could potentially complement the existing AMR CoE development initiative of the Government of Telangana.
- Initiate multi-stakeholder collaboration efforts to develop standards, guidelines, and regulations aimed at monitoring and treating waste to reduce the spread of AMR in the environment. This collaboration can promote the One Health approach, which emphasizes the interconnection between human health, animal health, and the environment.

Business recommendations for the development of AMR monitoring solutions and wastewater treatment and reuse infrastructure.

- To promote the effective management of AMR, it may be beneficial to explore joint venture projects involving Ministry of Environment, Forests and Climate Change (MoEFCC), Central Pollution Control Board (CPCB), and private environmental and health monitoring laboratories. These projects can focus on the development of infrastructure and monitoring systems for AMR, contributing towards protecting the environment and the health of humans and animals.
- To address the issue of safe disposal of waste and spread of AMR, explore business collaboration projects with Indian private sector hospitals such as Apollo, Yashoda, Care, Continental, Manipal etc and pharmaceutical manufacturing industries such as Dr Reddy's Laboratories, Aurobindo Pharma, Divis Laboratories, Covalen etc. These projects can focus on developing waste treatment infrastructure, ultimately contributing to the reduction of AMR spread in the environment.
- Explore joint venture projects with state industrial infrastructure development corporations Telangana State Industrial Infrastructure Corporation (TSIIC), Hyderabad Pharma City Limited (HPCL) and Andhra Pradesh Industrial Infrastructure Corporation (APIIC) for developing common waste management infrastructure for pharmaceutical manufacturing industrial parks.
- Explore consulting opportunities for infrastructure development especially developing state wide AMR monitoring programs and infrastructure with CPCB, Telangana State Pollution Control Board (TSPCB) and Andhra Pradesh Pollution Control Board (APPCB), especially utilizing of Dutch technologies, systems and processes.
- Explore co-development and manufacturing collaborations for Dutch technology companies to leverage Indian manufacturing capabilities with focus on reducing the cost of new technologies and serving a global market with Dutch technologies and equipment manufactured in India.
- Create joint venture opportunities with Indian environmental and waste engineering companies such as Ramky Enviro, VA Tech Wabag, Thermax etc as well as with industry associations such as BDMAI, IDMA etc for serving the growing Indian industrial wastewater



treatment market.

- Set up joint projects with nodal public sector organizations such as NCDC, ICMR, NIPER, etc for demonstration projects for AMR monitoring and waste treatment technologies.

Government Recommendations

- The Ministry of Environment, Forest, and Climate Change (MoEFCC) and Central Pollution Control Board (CPCB), the nodal ministry and agency for the development of new regulations and technology recommendations for the waste treatment and discharge and the Embassy of The Netherlands in Delhi can form a joint action group with members from other ministries and organisations including representatives from industry, academic institutions and think tanks. The group can focus on developing road map for joint collaborations for awareness programs, new policies, guidelines, R&D initiatives and development of waste treatment and management infrastructure for reducing the impact of environmental pollution on the spread of AMR.
- The National Centre for Disease Control (NCDC), the focal point for implementation and coordination of the AMR program and action plan in India, and the Embassy of The Netherlands in Delhi can form a joint action group with members from other ministries and organisations including representatives from industry, academic institutions and think tanks. The group can focus on developing road map for joint collaborations for developing AMR reducing approaches and plans leveraging the One Health approach.
- Design a focused call for research and development cooperation with Netherlands and DST. The call could be focused on developing new low-cost and efficient AMR monitoring technologies with a focus on transfer and co-development of new technologies in the areas of hardware, machine-learning and artificial intelligence, big data etc.
- State-level government-to-government collaborations can be explored with the state governments of Telangana and Andhra Pradesh and state government owned public sector enterprises for collaboratively planning and developing technologies and infrastructure for monitoring of AMR and waste treatment infrastructure.
- To enhance collaboration opportunities and partnerships between Indian and Dutch stakeholders, it is proposed to organize a joint trade mission. The mission will aim to facilitate Dutch businesses to explore new markets in India through a collective approach. Representatives from Dutch academia and industry will visit India to gain a better understanding of the opportunities for collaboration. This will foster joint collaborations between Dutch and Indian businesses, promoting the local presence and representation of Dutch businesses and technologies in India. Establishing a local presence would enhance the visibility of Dutch solutions, making it easier for Indian businesses to explore collaboration opportunities and request proposals. This approach has proven successful for other trading partner countries, such as Israel, Australia, the UK, and Switzerland.
- To facilitate a mutually beneficial collaboration, a delegation from the Indian government, industry, and academia can be arranged to visit the Netherlands. During this visit, they can explore the projects and facilities implemented in the Netherlands to monitor and manage AMR, following the One Health approach.



Abbreviations

AMR	Antimicrobial Resistance
AMRIA	AMR Industry Alliance
API	Active Pharmaceutical Ingredient
APPCB	Andhra Pradesh Pollution Control Board
BDMAI	Bulk Drug Manufacturers Association of India
CDSCO	Central Drugs Standard Control Organization
CETP	Combined Effluent Treatment Plant
CII	Confederation of Indian Industry
COE	Centre of Excellence
CPCB	Central Pollution Control Board
DCGI	Drug Controller General of India
DOP	Department of Pharmaceuticals
EHS	Department of Pharmaceuticals
ETP	Effluent Treatment Plant
FAO	Food and Agriculture Organisation
FICCI	Federation of Indian Chambers of Commerce and Industry
GMP	Good Manufacturing Practices
ICMR	Indian Council for Medical Research
IDMA	Indian Drugs Manufacturers Association
IIT	Indian Institute of Technology
IPA	Indian Pharmaceutical Association
MEE	Multi-Effect Evaporator
MLD	Million Liters per day



MoEFCC	Ministry of Environment, Forest and Climate Change
MoU	Memorandum of Understanding
NAP	National Action Plan
NGO	Non-Governmental Organisation
NGT	National Green Tribunal
OPPI	Organisation Of Pharmaceutical Producers of India
Pharmexcil	Pharmaceuticals Export Promotion Council of India
PLI	Performance Linked Incentive Scheme
PNEC	Predicted No-Effect Concentration
Pre-PPS	Pre-Public-Private Partnership
PSCI	Pharmaceutical Supply Chain Initiative
R&D	Research and Development
RAMP	Responsible Antibiotics Manufacturing Platform
RO	Reverse Osmosis
SAP	State Action Plan
STP	Sewage Treatment Plant
SWOT	Strength, Weakness, Opportunities, Threats
TDS	Total Dissolved Solids
TSPCB	Telangana Pollution Control Board
UKRI	United Kingdom Research and Innovation
UNEP	United Nations Environment Program
WHO	World Health Organization
ZLD	Zero Liquid Discharge



2. Introduction

Antimicrobial resistance (AMR) is a major global health concern today and India carries one of the largest burdens of drug-resistant pathogens worldwide³. There are various contributing factors that lead to a rise in AMR. While steps have been taken to curb the overuse and misuse of antibiotics in humans and animals, as well as water and sanitation, much is to be done to control the release of inadequately treated antibiotics into the environment through untreated and treated wastewater from industrial effluent⁴, hospital wastewater and even sewage.

India is a country of spatial expanse and large population. Thus, the legislation in India is divided into three tiers - central, state, and concurrent - each having control over different subject matters. Water and sanitation, as a subject, come under the purview of the states with some central agencies that legislate and regulate policy guidelines and programs for the country's water resources. The central agencies include the Ministry of Water Resources, Ministry of Environment, Forest and Climate Change (MoEFCC), Central Pollution Control Board (CPCB), etc.

The Netherlands has distinguished expertise in the water sector, including the detection and treatment of pollutant loads from municipal, hospital, and pharmaceutical industry wastewater, which are a few of the major contributors to AMR. The Netherlands Embassy in New Delhi, along with RVO (Netherlands Enterprise Agency) decided to carry out a Pre-Public-Private Partnership (Pre-PPS) study with the goal of exploring opportunities for Dutch companies to provide solutions and cater to the growing demand to address issues around AMR in India and work towards potential associations with local entities, both private and public, that could help them establish themselves on the market and move further towards One Health.

2.1. Objectives of the Pre-PPS Study

The main purpose of this study was to provide stakeholders (from industry, academia, government, the Netherlands diplomatic network in India, and RVO.nl) with a clearer picture and analysis of the short, medium, and long-term scope of business opportunities in the field of AMR reducing technologies and services in India, with a focus on water and waste treatment.

³ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6437806/>

⁴ <https://www.siwi.org/publications/reducing-emissions-from-antibiotic-production/>



2.2. Scope of the Pre-PPS Study

The study focussed on the following potential customer groups that have a direct or indirect impact on the spread of AMR.

1. Pharmaceutical industry: impact of manufacturing and discharge of treated or untreated wastewater containing antibiotics into the environment.
2. Hospitals (private and public) - impact of discharge or treated or untreated wastewater from hospitals that could contain unabsorbed antibiotics from the patients. The wastewater from the hospitals could have a direct release of antibiotics at the hospital sites or through discharge of human waste.
3. Generic water treatment (municipality level): sewage treatment plants receive wastewater from cities and can contain residual antibiotics concentrations that could potentially aid the spread of AMR through various mechanisms.

Geographical scope: The study studied the following key states of India to review the current set of activities and efforts made for the control of spread of AMR so that tangible business opportunities could be identified for Dutch technology companies.

1. Andhra Pradesh⁵
2. Telangana⁶

Technological scope: The study focused on identifying potential business opportunities for Dutch technology companies that have solutions for one or more of the following

1. Monitoring/ surveillance (including lab infrastructure & data exchange)
2. Testing
3. Water treatment

2.3. Methodology

The market study was carried out by using the following key data collection and analysis methods.

1. Desk-based review for review of ongoing efforts, programs and projects

⁵Map of Andhra Pradesh : <https://tinyurl.com/dutch-ap>

⁶ Map of Telangana: <https://tinyurl.com/dutch-telangana>



2. Stakeholder consultations with key AMR-related stakeholders⁷
3. Match-making of Dutch technologies with specific opportunities in India. This is proposed to be done by organizing an online seminar where the findings shall be shared with interested Dutch companies, and by subsequently organizing a trade mission to India in mid-2023.

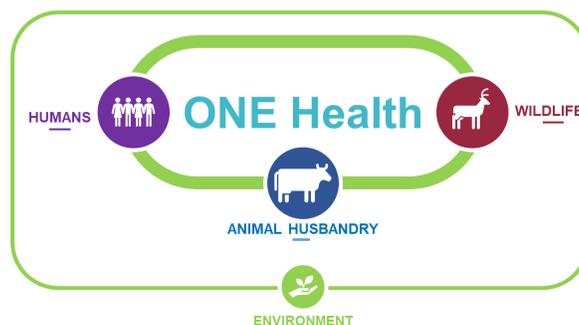
3. AMR in India Overview

3.1. The Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) One Health Mission

The PM-STIAC is the national overarching governing council that facilitates the office of the Principal Scientific Adviser to the Government of India in specific science and technology domains, comprehend challenges, formulate interventions, develop a futuristic roadmap and advise the Prime Minister accordingly.

PM-STIAC recently (June-July 2022) launched the 'One Health Mission' which will serve to coordinate, support, and integrate all the existing One Health activities, including Antimicrobial Resistance (AMR) in the country, and fill gaps where it is appropriate.

In India, the concept of One Health has been prioritized and has now entered the common parlance after the COVID-19 pandemic. The One Health Mission aims to integrate and bring together different sectors to solve health, productivity, and conservation issues and thus, has major implications for India. While wildlife diversity, large livestock populations, and a high population density together contribute to the inter-compartmental spread of diseases, this also opens up opportunities for leveraging the complementarity and strengths that are inherent to each sector.

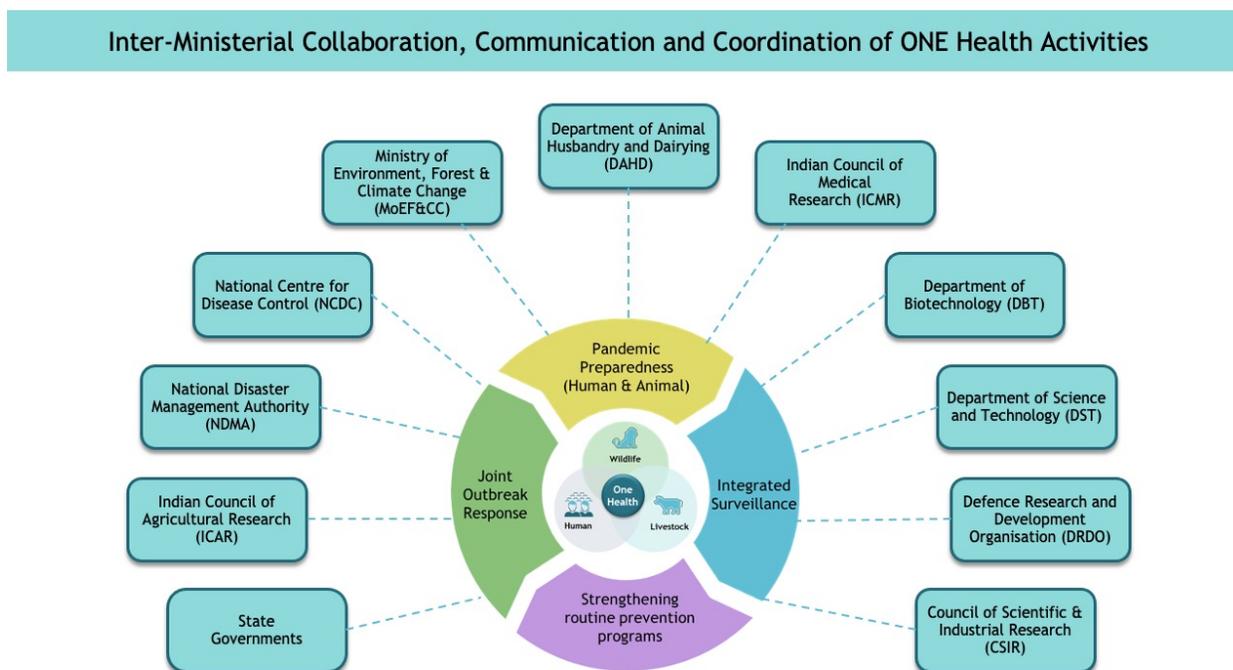


⁷ List of stakeholders consulted has been provided in Appendix.



The One Health Mission is intended to overarch the various efforts that are already underway in various Ministries of the Government of India, in private organizations in addition to a range of activities globally. The Mission will develop a unified framework for addressing priority 'One Health diseases' as well as diseases of epidemic/pandemic potential through cross-ministerial coordination. This Mission is envisaged to bring together not only key governmental but also non-governmental stakeholders (such as academic institutions, the private sector, and international agencies that are active in this area) towards achieving the outcome of better disease control and preparedness.

The following image outlines the various interlinkages and coordination activities under the One Health Mission.



The following are the key priority areas identified under One Health Mission.

1. Integrated disease surveillance
2. Targeted R&D for gaps in disease preparedness (vaccines, therapeutics, diagnostics, and platforms)
3. Joint Outbreak Response
4. Pandemic preparedness (human and animal)
5. Streamlining the regulatory aspects



6. Mechanisms for data/information sharing
7. Strengthening routine prevention programs
8. Linking appropriate activities to the global efforts

The One Health Mission is geared towards working closely with the various ministries for identifying gaps and leveraging an integrated mission approach to bridge the gaps.

3.2. National Action Plan

The national AMR action plan was launched on 19th April 2017 with its strategic initiatives aligned with the Global Action Plan (GAP). The National Action Plan (NAP) for AMR focuses on comprehending the knowledge base about AMR through education, training, and interdepartmental communication. It stresses on the One Health approach to upgrade the existing infrastructure for the detection and measurement of the effects of AMR on humans as a community, food, animals, and the environment. The standardized and validated data collected through surveillance and other channels will be used by various regulatory organizations to come up with standards for antibiotic residues and contaminants in waste coming from food (dairy, meat, poultry, and fish), farms, factories, and veterinary and human health settings.

NAP also sets out activities to prevent infection, maintain hygiene and sanitation and adopt appropriate and optimal use of high-quality antimicrobial products in humans and animals which in turn will reduce the burden on the already weak health infrastructure in India. It also puts forth activities required to promote investments in AMR activities, research, and innovations in the field that should be carried out by stakeholders in public sector organizations, industries, and academia to recycle the knowledge back to healthcare professionals and industries.

NAP for AMR adopted an additional priority other than the initiatives given by Global Action Plan, that is, to strengthen India's commitments and collaborations on AMR at international, national, and subnational levels through international forums, disease control programs, and workshops. This further offloaded the efforts and collaborations required from stakeholders at the state level and developing State Action Plans (SAP) for formulating regional policies regarding AMR and its implementation.

3.3. State Action Plans

Under the National Action Plan for AMR, the Ministry of Health & Family Welfare in India adopted a strategic priority to strengthen commitments and collaborations at sub-national levels. Guidelines for making State Action Plans on Containment of Antimicrobial Resistance (SAP-CAR)



were developed under this initiative which made way for states to endorse and align their policies and activities to curb problems related to AMR.

Practicing on these guidelines, 3 states, Kerala, Madhya Pradesh, and Delhi, have come up with a State Action Plan (SAP) so far while Andhra Pradesh State Action Plan has been approved by the Health, Medical & Family Welfare Department. The plans released by these states are designed in parallel to the National Action Plan and are currently under implementation.

A critical review of these SAPs reveals some gray areas in the initiatives and activities provided in the plan, such as - inadequate representation of some departments (veterinary, fisheries, agriculture) in the formation and implementation mechanism of SAPs, lack of community engagement and political support, limitations due to the technical language of the documents, etc.

4. AMR Sectoral overview

AMR spread can be accelerated due to exposure to antibiotics in the environment. The states of Andhra Pradesh and Telangana in India are particularly susceptible to the spread of antimicrobial resistance (AMR) due to exposure to antibiotics in the environment from multiple sources. The primary sources of antibiotics in the environment include waste generated from pharmaceutical manufacturing, hospitals, and sewage.

This chapter aims to provide an overview of the AMR sector in these areas, with a focus on the states of Andhra Pradesh and Telangana. The objective is to equip Dutch technology companies with an understanding of the sector, including regulations, typical waste management technologies, key market drivers, and government schemes. Depending on specific business opportunities, Dutch technology companies may choose to explore sub-sectors of interest in more detail.

4.1. Pharmaceutical Industry

The Indian pharmaceutical industry is a significant player in the global market and is known for its high-quality, low-cost generic drugs. The country is home to a large number of active pharmaceutical ingredient (API) manufacturers and formulators, and the API and formulation pharmaceutical industry is a crucial contributor to the country's economy.

The Indian pharmaceutical industry is highly regulated and follows strict guidelines set by the government's regulatory body, the Central Drugs Standard Control Organization (CDSCO). Under



the Drug and Cosmetics Act (1940), the regulation of manufacturer, sale and distribution of Drugs is primarily the concern of the state authorities while the central authorities are responsible for approval of new drugs, clinical trials and laying down standards for drugs, quality of imported drugs, and coordination of the activities of the state drug control organizations.

The pharmaceutical industry is divided into two main sectors: the bulk drug sector, which includes API manufacturers, and the formulation sector, which includes drug formulators. The bulk drug sector in India accounts for around 20% of the global market for APIs and is known for its cost-effective production of generic drugs. The country is a major exporter of APIs and is home to several large API manufacturers, including Zydus Cadila, Dr. Reddy's Laboratories, and Sun Pharmaceutical Industries.

The formulation sector in India is also significant and accounts for around 10% of the global market. The country is home to a large number of drug formulators, including both domestic and multinational companies. Some of the major players in the formulation sector in India include Cipla, Lupin, and Aurobindo Pharma.

The Indian pharmaceutical industry is facing a number of challenges, including increasing competition from other countries, rising raw material costs, and regulatory hurdles etc. However, the industry continues to grow and is expected to reach a value of \$120 to \$130 billion by 2030. One of the biggest challenges facing the industry is its dependence on China for Active Pharmaceutical Ingredients (APIs). The COVID-19 pandemic highlighted this vulnerability, as disruptions in the supply chain from China caused shortages of critical medicines. To reduce this dependence, the government has initiated a plan to incentivize domestic production of APIs and reduce imports.

Another challenge is the fragmentation and lack of consolidation in the industry, which makes it difficult for small and medium-sized firms to compete with larger players. Quality control is another area of concern, as Indian pharmaceutical products have been subject to scrutiny by international regulatory authorities for compliance with GMPs and environmental standards which may impact the exports.

Despite these challenges, the Indian pharmaceutical industry also presents numerous opportunities. The government's Production-Linked Incentive (PLI) scheme aims to encourage domestic production of high-value products, which could lead to the development of new, innovative drugs. The industry also has the potential to shift its export focus from low-cost generics to higher-end products, targeting markets with higher profit margins. One of the key strengths of the Indian pharmaceutical industry is its research and development (R&D)



capabilities and many companies in the sector have dedicated R&D centers and are involved in the development of new drugs and formulations. The industry is also supported by a strong network of research institutes and universities, which helps to drive innovation and development.

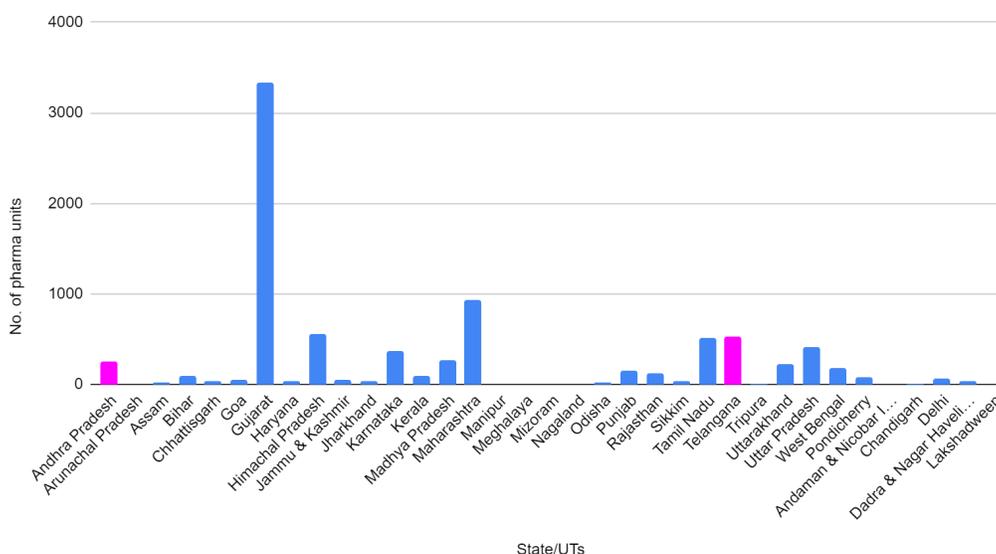
Overall, the Indian API and formulation pharmaceutical industry is a significant contributor to the country's economy and plays a vital role in the global market. Despite facing challenges, the industry is expected to continue growing in the coming years and will remain a key player in the global pharmaceutical market.

The growth of the pharmaceutical industry in India and the spread of the pharmaceutical manufacturing units across different states in India are given below⁸.

(Pharma Sector's Growth at Current Prices)

Item/Year	Output (₹ in Cr.)	Growth Rate
2015-16	3,03,352	16.56
2016-17	3,21,472	5.97
2017-18	3,28,677	2.24
2018-19	3,98,852	21.35
2019-20	3,89,094	-2.45
2020-21*	4,27,109	9.77

No. of pharma units per State/UTs

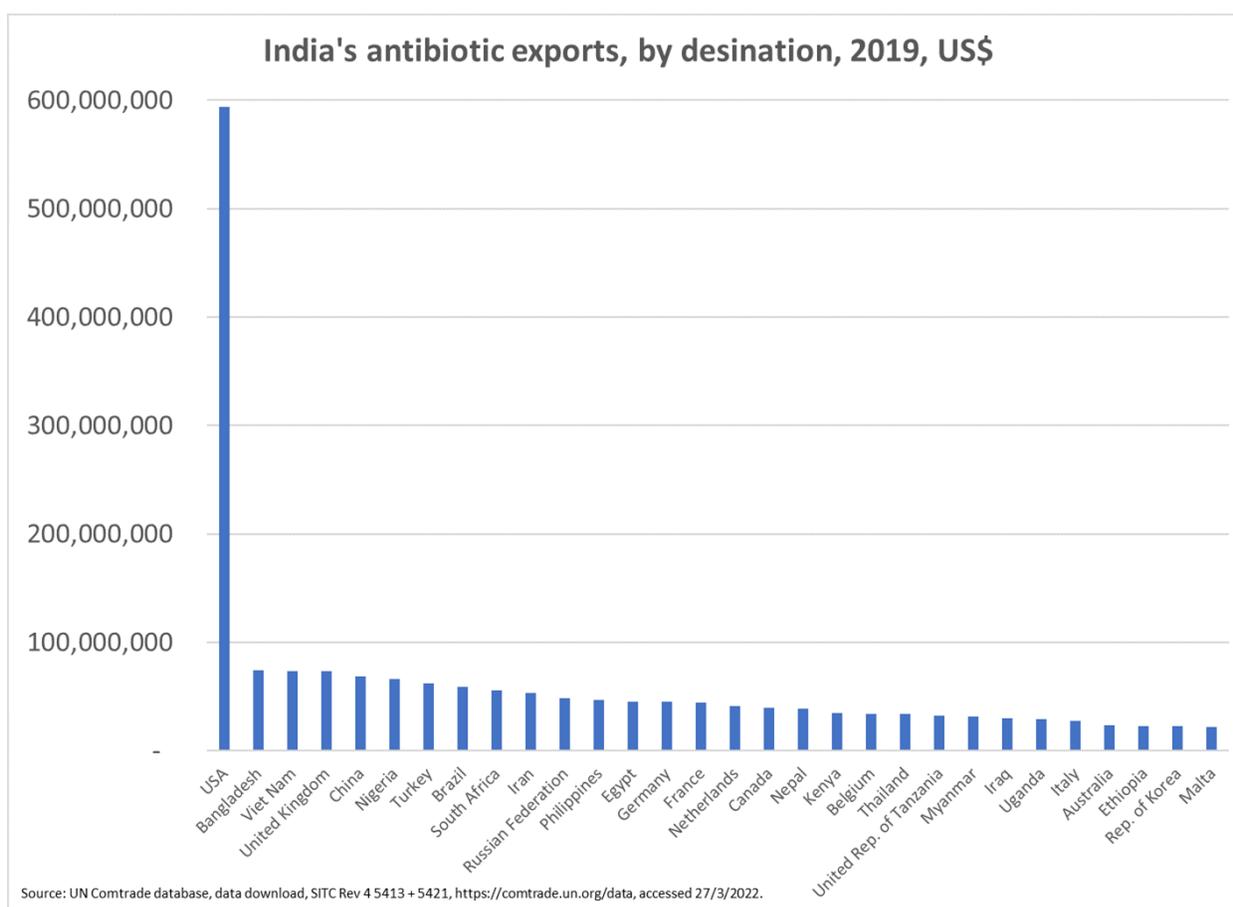


⁸ ~INR 1.0 Crore = Euro 125,000



The key states with significant pharmaceutical manufacturing capacity include Gujarat, Maharashtra, Himachal Pradesh, Telangana, and Andhra Pradesh. While the data for antibiotics manufacturing was not available, it is estimated based on stakeholder consultations that significant antibiotics manufacturing takes place in the target states of Andhra Pradesh and Telangana. It should be noted that this Market Study focused on the states of Andhra Pradesh and Telangana, however, other business opportunities in the pharmaceutical industry are also expected in industrial states of Maharashtra and Gujarat.

As mentioned earlier in the report, India is a key producer and exporter of antibiotics. The following graphs summarize the antibiotics exports to key global markets.





Pharmaceutical and Drugs Regulations

The regulation of the pharmaceutical industry in India is carried out by the Central Drugs Standard Control Organization (CDSCO), which is the country's regulatory body for pharmaceuticals and medical devices. The CDSCO (<https://cdsco.gov.in/>) is responsible for ensuring the quality, safety, and efficacy of drugs and medical devices in the country.

The CDSCO follows strict guidelines and regulations to ensure the safety and quality of pharmaceutical products in India. All pharmaceutical products must be registered with the CDSCO before they can be sold in the country. The registration process involves the submission of detailed information about the product, including its composition, manufacturing process, and clinical data. The CDSCO reviews this information and grants approval only if the product meets the required standards.

The CDSCO also conducts regular inspections of pharmaceutical manufacturing facilities to ensure that they are following good manufacturing practices (GMP). Any facility found to be non-compliant with GMP guidelines can be shut down until the necessary corrective measures are taken.

In addition to the CDSCO, the Indian pharmaceutical industry is also regulated by other government agencies, such as the Drug Controller General of India (DCGI) and the Ministry of Health and Family Welfare. These agencies work together to ensure the safety and quality of pharmaceutical products in the country.

Overall, the regulation of the pharmaceutical industry in India is strict and ensures that only high-quality, safe, and effective products are available to the public.

Pharmaceutical Environmental Regulations

The regulation of the pharmaceutical industry in India with regard to environmental issues is carried out by the Central Pollution Control Board (CPCB) and the Ministry of Environment, Forest, and Climate Change (MOEFCC). These agencies are responsible for enforcing environmental laws and regulations related to the pharmaceutical industry in the country.

The pharmaceutical industry in India is required to follow the Environmental Protection Act, 1986 and the Water (Prevention and Control of Pollution) Act, 1974, which set out the guidelines for the protection of the environment. The industry is also required to obtain environmental clearance from the MOEFCC before setting up any new manufacturing facilities or expanding existing ones.



The CPCB is responsible for monitoring the environmental impact of the pharmaceutical industry and enforcing environmental regulations. The agency conducts regular inspections of pharmaceutical manufacturing facilities to ensure that they are in compliance with environmental laws and regulations. Any facility found to be non-compliant can be fined or shut down until the necessary corrective measures are taken.

In addition to the CPCB and the MOEFCC, the Indian pharmaceutical industry is also regulated by other agencies, such as the Central Drugs Standard Control Organization (CDSCO) and the Drug Controller General of India (DCGI). These agencies work together to ensure that the pharmaceutical industry in India is environmentally responsible and complies with all relevant laws and regulations.

Overall, the regulation of the pharmaceutical industry in India with regard to environmental issues is strict and ensures that the industry operates in an environmentally responsible manner.

Market Drivers for Indian Pharmaceutical Industry

Based on literature review^{9,10,11} and stakeholder consultations, the following are the key drivers for environmental sustainability in the pharmaceutical industry in India:

1. **Regulations:** The pharmaceutical industry in India is subject to a number of environmental regulations that seek to minimize the impact of the industry on the environment. These regulations¹² play a key role in driving sustainability and pollution control efforts in the sector. Presently there are no regulations or standards for the discharge of antibiotics from bulk drug or formulation pharmaceutical manufacturing facilities. However, it is likely that more stringent standards and regulations are going to be developed and enforced in the near future.
2. **Public pressure:** Consumers, advocacy groups, and other stakeholders are increasingly demanding that companies in the pharmaceutical industry adopt sustainable practices. This public pressure is a key driver of sustainability efforts in the sector.

⁹ BDMAI Newsletters: <https://bdmai.org/news-letter/>

¹⁰ Eg. Dr. Reddy's Laboratories Sustainability Reports: <https://www.drreddys.com/business-responsibility-and-sustainability>

¹¹ Inputs from stakeholder consultations and meetings

¹² Key regulations such as Zero Liquid Discharge (ZLD), bio-medical waste management rules, Draft Regulations for discharge of antibiotics from pharmaceutical manufacturing plants etc



3. Resource conservation: The pharmaceutical industry is a resource-intensive sector, and there is a growing recognition of the need to conserve resources in order to minimize the environmental impact of the industry.
4. Cost savings: Sustainability efforts can help companies in the pharmaceutical industry reduce costs by improving resource efficiency and reducing waste.
5. Brand reputation: Companies in the pharmaceutical industry rely on their reputation to build trust with consumers and stakeholders. Adopting sustainable practices can help companies maintain a positive reputation and build customer loyalty.

PLI Scheme for pharmaceutical manufacturing

The Production-Linked Incentive (PLI) scheme is a program implemented by the Government of India to boost domestic manufacturing of critical goods, including pharmaceuticals. The objective of the scheme is to promote the growth of the domestic pharmaceutical industry by providing financial incentives to manufacturers who increase their production of specific products.

Under the PLI scheme, eligible companies can apply for incentives based on the incremental increase in their production of certain specified medicines. The incentives are in the form of a reimbursement of a percentage of the capital investment made by the company for increasing production. The scheme is expected to attract significant investments in the domestic pharmaceutical sector, creating new jobs and boosting economic growth.

The scheme is open for all domestic and foreign pharmaceutical companies that are operating in India and are willing to increase their production of specified products. To be eligible for the scheme, companies must meet certain conditions, such as having a minimum production capacity and adhering to specific quality standards. The scheme is also open to companies that are looking to set up new manufacturing facilities in India.

The PLI scheme is part of the Government of India's larger effort to promote the growth of the domestic pharmaceutical industry and reduce the country's dependence on imported drugs. Overall PLI scheme aims to promote domestic pharmaceutical production by providing an incentive in the form of capital investment reimbursement to companies that increase their production of certain specified products, so as to make India less dependent on imported drugs.

The core objective of the PLI scheme is to enhance India's manufacturing capabilities by increasing investment and production in the pharmaceutical sector, and contributing to product diversification to high value goods. Another key objective of the scheme is to create global champions out of India who has the potential to grow in size and scale using cutting edge technology and thereby participate in global value chains. The selection of companies under the



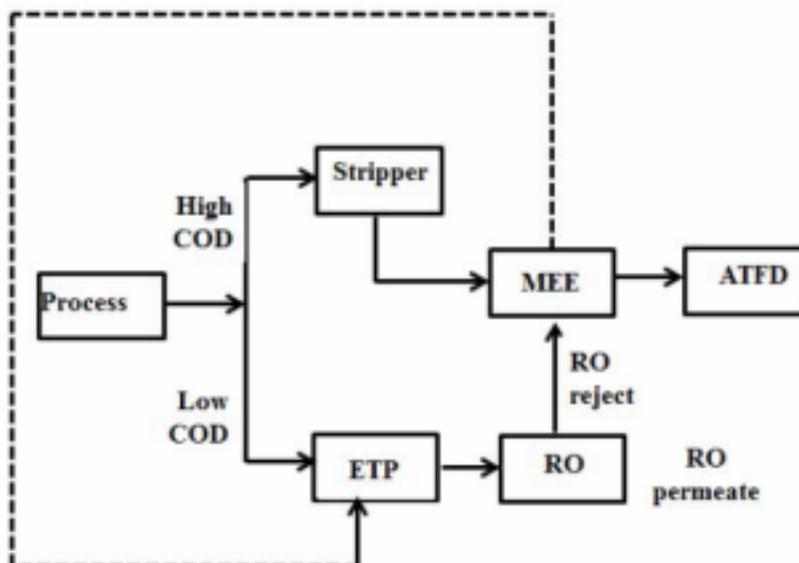
PLI scheme is based on the above objective criteria to assess the experience, capacity to grow in scale and innovate.

There are no specific environmental sustainability or AMR linked goals of the PLI scheme.

Details about the PLI scheme and other schemes for pharmaceutical manufacturing can be found at the following website: <https://pharmaceuticals.gov.in/schemes>. The list of Approved Applicants under Production Linked Incentive (PLI) Scheme for Bulk Drug as on 8th August, 2022 can be found at <https://tinyurl.com/dutch-pli-companies>

Treatment of Pharmaceutical Wastewater

In the pharmaceutical industry, TDS (total dissolved solids) is a measure of the concentration of dissolved substances in a wastewater sample. High TDS wastewater refers to wastewater with a high concentration of dissolved solids, while low TDS wastewater refers to wastewater with a low concentration of dissolved solids.



During the production of active pharmaceutical ingredients (APIs), high TDS wastewater is typically generated as a result of chemical reactions and precipitation of dissolved substances. This wastewater is often high in organic and inorganic contaminants, such as heavy metals, dissolved organic matter, and byproducts of chemical reactions.



Low TDS wastewater, on the other hand, is typically generated from processes such as washing and rinsing and may be relatively free of contaminants.

In India, the treatment of high TDS wastewater from pharmaceutical API production typically involves a combination of high energy-intensive evaporation processes including air stripping, multi-effect evaporators (MEE) followed by thermal drying to help achieve zero liquid discharge (ZLD) from the manufacturing unit. The condensate from the MEE is sent to the Effluent Treatment Plant (ETP) which typically consists of physical, chemical, and biological processes, such as sedimentation, advanced oxidation, and aerobic and anaerobic digestion, which are used to break down organic contaminants using microorganisms.

Low TDS wastewater is generally treated using biological processes in the ETP. Post the ETP, the treated wastewater is recovered using a multi-stage reverse osmosis (RO) process. The rejects from the RO system are sent for evaporation to the MEE and thermal dryer and the permeate (pure water) is reused on-site for non-potable uses such as cooling water makeup water and also for horticulture. As per the CPCB guidelines (January 2022), the API pharmaceutical manufacturing units are required to be ZLD compliant, which also requires the manufacturing units to not reuse any treated wastewater for horticulture. The salts generated from the drying processes are classified as hazardous solids wastes and it is either disposed of at designated hazardous landfills or sent to cement manufacturing plants where it is used in the cement manufacturing process.

From an AMR point of view, it is important to properly treat both high TDS and low TDS wastewater from pharmaceutical API and formulation production to ensure that they do not pose a risk to the spread of AMR.

AMR and Pharmaceutical Wastewater

In Telangana and Andhra Pradesh, AMR is a growing concern^{13,14}. The states are home to a number of pharmaceutical companies, both large and small, that manufacture antibiotics and other antimicrobials, and the increasing demand for these products has led to the proliferation of antimicrobial manufacturing facilities in the region. However, there are concerns about the environmental impacts of these facilities, including the release of antimicrobials and other contaminants into the environment through the discharge of wastewater. While the larger manufacturers have the resources and technical capabilities to meet the evolving regulations on

¹³ Pharmaceutical Pollution of World's Rivers: <https://www.pnas.org/doi/pdf/10.1073/pnas.2113947119>

¹⁴ Study raises alarm over presence of antibiotic-resistant bacteria in Hyderabad's Musi river, <https://tinyurl.com/2y5c76dt>



AMR, the smaller manufacturers face the risk of not being able to invest in adopting new technologies and processes for monitoring and treatment of their waste streams. Further, techniques like Powdered Activated Carbon (PAC), Granular Activated Carbon (GAC), Advanced Oxidation, Electro De-Ionization (EDI), Reverse Osmosis (RO) and membrane filtration and other ZLD technologies are available in Indian markets and are installed in pharmaceutical ETPs and CETPs but their effectiveness in implementation and removal of antibiotics needs to be validated.

There is also a lack of regulation and oversight¹⁵ of the antimicrobial manufacturing sector in Telangana and Andhra Pradesh, which has led to concerns about the quality and safety of the products being produced. In addition, there is a lack of awareness about the risks associated with the overuse and misuse of antimicrobials, which has contributed to the problem of AMR in the region.

To address these issues, it will be necessary to implement effective regulatory, monitoring and oversight mechanisms to ensure the safe and responsible manufacturing of antimicrobials in Telangana and Andhra Pradesh. It will also be important to raise awareness about the risks associated with the overuse and misuse of antimicrobials and to encourage the responsible use of these drugs. In addition, it will be necessary to invest in the development of new antimicrobials and other strategies to address AMR and to improve the treatment and disposal of sewage to reduce the risk of antimicrobial contamination of the environment.

SWOT Analysis for Dutch Wastewater Businesses in the Pharmaceutical Industry in Andhra Pradesh and Telangana

SWOT analysis for a new business in wastewater management in pharmaceutical companies in Andhra Pradesh and Telangana is presented below.

Strengths:

- High demand for wastewater management services due to increasing awareness of environmental concerns and spread of AMR.
- Favorable government policies and regulations promoting sustainable practices in the pharmaceutical industry.
- Andhra Pradesh and Telangana form a key hub for pharmaceutical manufacturing, providing a ready market for the services.

¹⁵ There are presently no regulations for discharge or monitoring of antibiotics or pharmaceutical compounds in the wastewater from manufacturing units



- Availability of skilled labor and expertise in the field of wastewater management. Academic institutes like NIPER, IIT Hyderabad are fore-runners in the research on AMR

Weaknesses:

- High competition in the market with established local players that typically would have a lower cost structure compared to Dutch companies.
- Initial high capital investment required for setting up a wastewater treatment plant that would be AMR compliant.
- Limited knowledge and awareness of the benefits of wastewater management among smaller pharmaceutical companies.

Opportunities:

- Potential for establishing Dutch technologies and businesses as thought leaders in providing technologies for monitoring and treating wastewater for the reduction in the spread of AMR.
- Opportunities in partnering with government agencies and local businesses to provide high end expertise and technical services for waste monitoring, and treatment. Further there could be good opportunities to provide services for both liquid and solid waste management and treatment.
- Partnership with existing players to expand business services in India.

A detailed list of business opportunities for Dutch companies is presented in Section 5 (page 48) of this report.

Threats:

- Changes in government policies and regulations may affect the market and operations of the business.
- Fluctuations in the economy and demand for pharmaceutical products may affect the market for wastewater management services.
- Technological advancements and innovations may provide competition or barriers to entry in the market.

Overall, a new business in wastewater management in pharmaceutical companies in Andhra Pradesh and Telangana has good potential for growth, provided it can overcome initial challenges such as high competition in the market. There have to be clear technological and business advantages that are offered by the Dutch companies. By leveraging opportunities such



as partnerships and diversification, the business can establish an initial foothold in the market and contribute to sustainable business growth opportunities.

4.2. Hospital Sector

The hospital healthcare sector in India is diverse and complex, with a mix of public and private facilities providing healthcare services to the country's large and growing population. The public sector is made up of hospitals and clinics run by the central and state governments, while the private sector includes a range of for-profit and nonprofit hospitals and clinics.

There are several challenges facing the hospital healthcare sector in India, including a shortage of healthcare workers, inadequate infrastructure and funding, and a high out-of-pocket expenditure for healthcare by patients. In addition, the sector is highly regulated, with the government playing a significant role in setting standards and policies.

Despite these challenges, the hospital healthcare sector in India has made significant progress in recent years, with improvements in access to healthcare and the quality of care being provided. There has also been a trend toward the privatization of healthcare in India, with an increase in the number of private hospitals and clinics, and a corresponding increase in the use of private healthcare by patients.

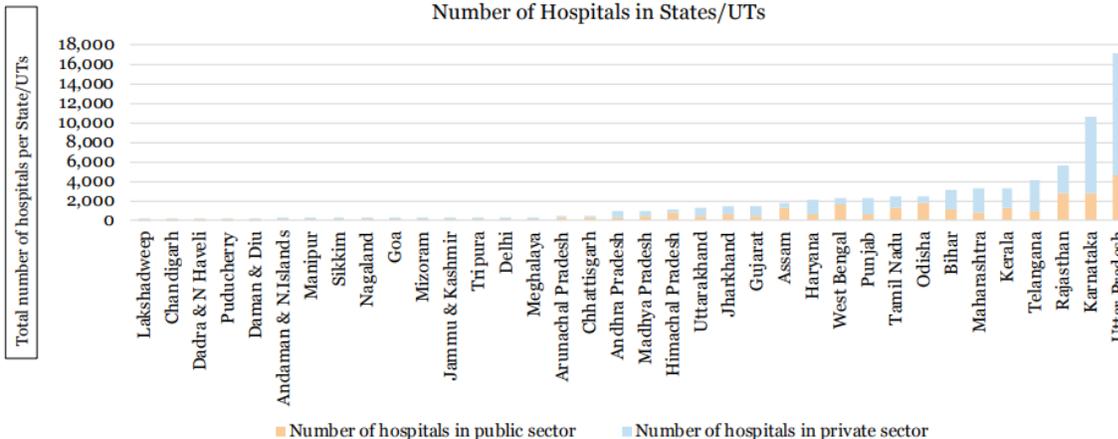
Overall, the hospital healthcare sector in India is an important part of the country's healthcare system and plays a vital role in the health and well-being of its population. The following images summarize the presence of hospitals across India.



Hospitals in States/UTs

India Total	Number of hospitals in public sector	Number of hospitals in private sector	Total number of hospitals (public+private)
	25,778	43,487	69,265

Number of Hospitals in States/UTs



Number of hospitals in private sector are estimated values
States have been arranged in increasing order of total number of hospitals
Height of column represents total number of hospitals in that States



Hospital Beds in States/UTs

India Total	Number of hospital beds in public sector	Number of hospital beds in private sector	Total number of hospital beds (public+private)
	7,13,986	1,185,242	18,99,228

	States/UTs	Number of hospital beds in public sector	Number of hospital beds in private sector	Total number of hospital beds (public+private)
1	Lakshadweep	300	126	426
2	Dadra & Nagar Haveli	619	322	941
3	Daman And Diu	240	1,010	1,250
4	Andaman Nicobar Islands	1,075	219	1,294
5	Manipur	1,427	363	1,790
6	Sikkim	1,560	392	1,952
7	Mizoram	1,997	499	2,496
8	Nagaland	1,880	681	2,561
9	Arunachal Pradesh	2,404	220	2,624
10	Goa	3,012	1,572	4,584
11	Tripura	4,429	238	4,667
12	Puducherry	3,569	1,603	5,172
13	Meghalaya	4,457	787	5,244
14	Chandigarh	3,756	1,875	5,631
15	Jammu And Kashmir	7,291	704	7,995
16	Himachal Pradesh	12,399	3,641	16,040
17	Chhattisgarh	9,412	8,018	17,430
18	Uttarakhand	8,512	15,331	23,843

	States/UTs	Number of hospital beds in public sector	Number of hospital beds in private sector	Total number of hospital beds (public+private)
19	Assam	17,142	7,036	24,178
20	Odisha	18,519	7,131	25,650
21	Jharkhand	10,784	15,712	26,496
22	Bihar	11,664	19,193	30,857
23	Haryana	11,240	24,901	36,141
24	Delhi	24,383	15,072	39,455
25	Punjab	17,933	43,064	60,997
26	Gujarat	20,172	44,690	64,862
27	Madhya Pradesh	31,106	33,833	64,939
28	Andhra Pradesh	23,138	60,092	83,230
29	Rajasthan	47,054	46,122	93,176
30	Kerala	38,004	61,223	99,227
31	Telangana	20,983	78,936	99,919
32	West Bengal	78,566	34,969	1,13,535
33	Tamil Nadu	77,532	77,843	1,55,375
34	Maharashtra	51,446	1,80,293	2,31,739
35	Karnataka	69,721	1,92,388	2,62,109
36	Uttar Pradesh	76,260	2,05,142	2,81,402
37	Ladakh	NA	NA	NA



Number of hospital beds in private sector are estimated values
States/UTs have been arranged in increasing order of total number of hospital beds





Wastewater from Hospitals

Hospital wastewater treatment in India is an important issue, as the proper treatment of wastewater from hospitals is essential to protect public health and the environment. In India, hospitals generate large amounts of wastewater¹⁶, which can contain a wide range of contaminants, including chemicals, pharmaceuticals, and infectious agents.

There are several challenges to hospital wastewater treatment in India, including a lack of proper treatment facilities and a lack of awareness among hospitals about the importance of wastewater treatment. In addition, many hospitals in India do not have the financial resources or expertise to properly treat their wastewater.

To address these challenges, the government of India has implemented a number of policies and programs to improve hospital wastewater treatment. These include the establishment of treatment facilities and the promotion of best practices for wastewater treatment in hospitals. In addition, there has been a push toward the adoption of sustainable technologies for wastewater treatment, such as the use of constructed wetlands and bioremediation.

Overall, the treatment of hospital wastewater in India is an important issue and addressing it will require the efforts of both the government and hospitals to ensure that the country's water resources are protected and public health is safeguarded.

Regulations for Hospital Waste Management

Wastewater treatment regulations are an important aspect of hospital waste and wastewater management, as they help to protect public health and the environment by ensuring that hospital wastewater is properly treated before it is released into the environment.

In India, the central government has enacted a number of regulations related to hospital wastewater treatment, including the Bio-Medical Waste (Management and Handling) Rules¹⁷, which prescribe the standards and procedures for the management and handling of bio-medical waste from hospitals. In addition, the central government has also enacted the Water (Prevention and Control of Pollution) Act, which sets standards for the discharge of wastewater into the environment and establishes a system for the prevention and control of water pollution.

¹⁶ A review of hospital wastewater treatment: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7680650/>

¹⁷ Bio Medical Waste Management Rules: <https://cpcb.nic.in/bio-medical-waste-rules/>, and Guidelines for Management of Healthcare Waste as per Biomedical Waste Management Rules (2016) https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/Guidelines_healthcare_June_2018.pdf



At the Telangana and Andhra Pradesh state level, hospital wastewater management is regulated by the Telangana State Pollution Control Board (TSPCB) and the Andhra Pradesh Pollution Control Board (APPCB), respectively. The APPCB and TSPCB are responsible for implementing the provisions of the Water (Prevention and Control of Pollution) Act, which sets standards for the discharge of wastewater into the environment and establishes a system for the prevention and control of water pollution.

Under the Act, hospitals in states are required to obtain consent to operate from the APPCB and TSPCB before they can discharge wastewater into the environment. In order to obtain consent to operate, hospitals must submit a wastewater management plan to the APPCB and TSPCB, which must be approved by the board before the consent is granted.

In addition to the Water (Prevention and Control of Pollution) Act, hospitals in Andhra Pradesh and Telangana are also subject to the Bio-Medical Waste (Management and Handling) Rules (2016), which prescribe the standards and procedures for the management and handling of bio-medical waste from hospitals. These rules require hospitals to properly segregate, store, transport and dispose of bio-medical waste in order to protect public health and the environment.

Overall, the regulations related to hospital wastewater treatment in India are designed to ensure that hospitals are properly managing and treating their wastewater, and that they are not causing harm to the environment or public health. These regulations are important for protecting the quality of the environment and for maintaining the trust of the public in the healthcare sector.

Biomedical Waste (Management and Handling) Rules, 2016

The Ministry of Environment, Forest and Climate Change (MoEFCC) published the Biomedical Waste (Management and Handling) Rules, 2016 that provide a regulatory framework for the management of biomedical waste generated in India. Implementation of these rules is monitored and authorized by CPCB, SPCBs, State Health Ministries, and District level Monitoring Committees under the envelope of the MoEFCC. These rules are applicable for any bio-medical waste generated in any form and from hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, blood banks, ayush hospitals, clinical establishments, research or educational institutions, health camps, medical or surgical camps, vaccination camps, blood donation camps, first aid rooms of schools, forensic laboratories and research labs.



The prescribed authority for enforcement of the provisions of these rules in respect of all the health care facilities located in any State/Union Territory is the respective State Pollution Control Board (SPCB) i.e. APPCB and TPCB for the states of Andhra Pradesh and Telangana.

These regulations apply to the entities handling such wastes from the generation stage to all the treatment or disposal stages. It sets out the duties and procedures to be followed by the waste handlers apart from the rules for storage, treatment, and transportation of biomedical waste.

Following are the standards currently defined for liquid waste generating in the hospitals:

Parameter	Permissible Limits
pH	6.5 to 9.0
Suspended Solids	100 mg/l
Oil & Grease	10 mg/l
BOD	30 mg/l
COD	250 mg/l
Bioassay test	90% survival of fish after 96 hours in 100% effluent

Commentary on Biomedical Waste Policy:

- The current biomedical waste policy does not have any limits on antibiotic API discharges in hospital wastewater.
- The COD/BOD limits are fairly lenient and often hospitals reuse treated wastewater for horticulture and other non-potable uses. This could potentially increase the discharge of antibiotic compounds and increase exposure to residual antibiotics in the environment.

Market Drivers for Indian Hospital Industry

Based on literature review¹⁸ and stakeholder consultations, the following key drivers¹⁹ for environmental sustainability for hospitals have been identified:

¹⁸ Eg. Apollo Hospitals Sustainability Reports: <https://www.apollohospitals.com/corporate/sustainability/>

¹⁹ The industry is highly fragmented based on size, level of awareness, availability of investment availability, hence the exact relevance of the key drivers for particular projects and/or technologies would need to be explored on a case-by-case basis.



1. **Regulations:** Hospitals in India are subject to a number of environmental regulations, including the Bio-Medical Waste (Management and Handling) Rules and the Water (Prevention and Control of Pollution) Act (2016), which prescribe standards and procedures for the management and handling of bio-medical waste and the discharge of wastewater into the environment. These regulations play a key role in driving sustainability efforts in the sector. Presently there are no regulations for the discharge of antibiotics in wastewater from hospitals.
2. **Public pressure:** Consumers, advocacy groups, and other stakeholders are increasingly demanding that hospitals adopt sustainable practices. This public pressure is a key driver of sustainability efforts in the sector.
3. **Resource conservation:** Hospitals are resource-intensive facilities, and there is a growing recognition of the need to conserve resources in order to minimize the environmental impact of the industry.
4. **Cost savings:** Sustainability efforts can help hospitals reduce costs by improving resource efficiency and reducing waste.
5. **Brand reputation:** Hospitals rely on their reputation to build trust with consumers and stakeholders. Adopting sustainable practices can help hospitals maintain a positive reputation and build customer loyalty.

Typical Wastewater Treatment Technologies for Hospital Wastewater Treatment

Hospital wastewater is a type of industrial wastewater that is generated by hospitals and other healthcare facilities. It typically contains a wide range of contaminants, including pharmaceuticals, medical devices, and infectious microorganisms, which can pose a risk to public health and the environment if not properly treated.

There are several different technologies and processes that can be used for the treatment of hospital wastewater. The specific treatment process used will depend on the type and quantity of contaminants present in the wastewater, as well as local regulations and environmental considerations.

One common treatment technology for hospital wastewater is activated sludge. This process involves the use of microorganisms to break down organic contaminants in wastewater. The microorganisms are grown in a tank, known as an aeration tank, where they consume the organic matter and convert it into biomass. The biomass is then separated from the treated water in a sedimentation tank, and the resulting sludge is typically disposed of in a landfill.



Another technology that is often used for the treatment of hospital wastewater is anaerobic digestion. This process involves the use of microorganisms to break down organic matter in the absence of oxygen. The resulting biogas can be collected and used as a renewable energy source, while the remaining sludge can be used as a soil amendment or disposed of in a landfill.

Other treatment technologies and processes that may be used for the treatment of hospital wastewater include chemical treatment, physical treatment, and membrane filtration. Chemical treatment involves the use of chemicals to break down or remove contaminants from the wastewater, while physical treatment uses physical processes, such as sedimentation and filtration, to remove solid particles from the wastewater. Membrane filtration involves the use of membrane filters to remove contaminants from wastewater.

In addition to these treatment technologies and processes, it is also important to properly manage and dispose of any hazardous or infectious materials that may be present in hospital wastewater. This may involve special handling and disposal procedures to ensure the safe and environmentally responsible management of these materials.

Overall, the treatment of hospital wastewater is a complex and advanced biological, chemical and physical treatment process that requires the use of a range of technologies and processes to effectively remove contaminants and ensure the safe and environmentally responsible disposal of the treated wastewater.

AMR and Hospital Wastewater

There is evidence^{20,21} to suggest that hospital wastewater may contribute to the problem of antimicrobial resistance (AMR) in Telangana and Andhra Pradesh^{22,23, 24, 25}. When antimicrobials (such as antibiotics, antivirals, and antifungals) are released into the environment through the discharge of hospital wastewater, they can enter the water cycle and be taken up by

²⁰ Pharmaceutical Pollution of World's Rivers: <https://www.pnas.org/doi/pdf/10.1073/pnas.2113947119>

²¹ CPCB Draft Guidelines for Monitoring of River Hygiene: https://cpcb.nic.in/wqm/Draft_Guidelines_Monitoring_of_River_Hygiene.pdf

²² Detection of antibiotics in hospital effluents in India: https://www.researchgate.net/publication/228856836_Detection_of_antibiotics_in_hospital_effluents_in_india

²³ Antibiotic resistant bacteria found in river water: <https://vigyanprasar.gov.in/isw/Antibiotic-resistant-bacteria-found-in-river-water.html>

²⁴ Antimicrobial resistance in the environment: The Indian scenario: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6563737/>

²⁵ Specific data on hospital wastewater and its impact on AMR in Andhra Pradesh and Telangana was not found through desk-based research or through stakeholder consultations.



microorganisms. This can lead to the development of resistance to these antimicrobials by the microorganisms, which can make it difficult or impossible to treat infections and diseases caused by these microorganisms.

To address this issue, it is important to ensure that hospital wastewater is regularly tested and properly treated to remove contaminants and infectious microorganisms. This may involve the use of technologies and processes such as activated sludge, anaerobic digestion, chemical treatment, physical treatment, and membrane filtration. It is also important to properly manage and dispose of any hazardous or infectious materials that may be present in hospital wastewater, including antimicrobials.

Overall, to address the issue of AMR in Telangana and Andhra Pradesh, it will be necessary to implement effective strategies to reduce the release of antimicrobials into the environment, including the proper treatment and disposal of hospital wastewater. In addition, it will be necessary to invest in the development of infrastructure to improve the treatment and disposal of wastewater from hospitals to reduce the risk of antimicrobial contamination of the environment.

SWOT Analysis for Dutch Wastewater Businesses in the Hospital Sector in Andhra Pradesh and Telangana

SWOT analysis for new business opportunities in wastewater management in public and private hospitals in Andhra Pradesh and Telangana is presented below.

Strengths:

- Growing demand: With the increasing number of hospitals in Andhra Pradesh and Telangana, there is a growing demand for better wastewater management services.
- Regulatory support: The government of Andhra Pradesh and Telangana have set regulations to ensure that hospitals follow proper wastewater management practices. National and State Action Plans also focus a lot on the waste from hospitals
- Experienced team: If the business has an experienced team with expertise in hospital wastewater management, it can give them an edge over competitors.
- Opportunity for expansion: As the business grows, there may be opportunities to expand to other regions or even other sectors.

Weaknesses:

- High initial investment: The cost of wastewater treatment requires a high initial investment in terms of equipment and infrastructure, which can be a challenge for new hospitals,



especially if the cost of new technologies for monitoring and controlling discharge of antibiotics significantly increases the operations costs or complexity for the hospitals.

- The market size for wastewater management services in hospitals in Andhra Pradesh and Telangana may be limited due to lack of clear regulations on AMR and environment.
- The wastewater suppliers to the hospital sector are highly competitive and fragmented, which can make it difficult for new Dutch businesses to gain traction.

Opportunities:

- Collaboration with hospitals: The business can collaborate with hospitals to offer bundled services such as wastewater management and monitoring of antibiotics in the treated wastewater streams, which can improve customer satisfaction.
- Diversification: The business can diversify into related areas such as water treatment and recycling, which can open up new revenue streams.
- Technological advancements: With advancements in technology, the business can explore innovative solutions to improve wastewater management processes.
- Government incentives: The government may offer incentives such as tax breaks or subsidies to businesses that promote sustainable practices, which can benefit the business.

A detailed list of business opportunities for Dutch companies is presented in Section 5 (page 48) of this report.

Threats:

- Economic downturns: Economic downturns can lead to decreased demand for wastewater management services in hospitals.
- Environmental regulations: The government may impose stricter environmental regulations, which can increase compliance costs for the business.
- Technological disruption: Technological disruption can render current business models obsolete, making it challenging for new businesses to stay competitive.

4.3. Generic Municipal Wastewater (Sewage)

The municipal sewage sector in India is a complex and multifaceted system that is responsible for the collection, treatment, and disposal of wastewater and sewage generated in urban areas. It is a vital component of the overall infrastructure of a city or town and plays a critical role in ensuring public health and environmental sustainability.



The sewage sector in India is managed by a combination of local governments, public utilities, and private companies. Local governments are responsible for the planning and development of sewage infrastructure, including the construction and maintenance of sewage treatment plants and sewage networks. Public utilities are responsible for the operation and management of sewage treatment plants, while private companies may be involved in the construction and maintenance of sewage infrastructure.

One of the major challenges facing the sewage sector in India is the lack of adequate infrastructure. Many cities and towns in India do not have sufficient sewage treatment capacity, and as a result, raw sewage is often released into rivers, lakes, and other water bodies. This can lead to a range of environmental problems, including water pollution, eutrophication, and the proliferation of disease-causing organisms.

Another challenge is the lack of proper management and maintenance of sewage infrastructure. Many sewage treatment plants in India are not operated and maintained to the required standards, leading to inefficient treatment and the release of poorly treated or untreated sewage into the environment.

In recent years, the Government of India has taken steps to address these challenges and improve the municipal sewage sector. This has included the implementation of various policy measures and initiatives, such as the Swachh Bharat Abhiyan (Clean India Mission), which aims to improve sanitation and waste management in urban areas. The government has also introduced financial incentives and subsidies to encourage the construction and expansion of sewage treatment plants and other sewage infrastructure.

Despite these efforts, significant challenges remain. A lack of funding and technical expertise is a major barrier to the development and improvement of sewage infrastructure in India. In addition, there is often a lack of political will to invest in sewage treatment and other related projects, as they are often seen as less glamorous and less politically popular than other infrastructure projects.

To address these challenges and improve the sewage sector in India, it will be necessary to increase investment in infrastructure and technical capacity, as well as to improve the management and maintenance of existing facilities. It will also be important to raise awareness about the importance of sewage treatment and the need for proper waste management and to engage all stakeholders, including local governments, utilities, and private companies, in the process of improving the sector.



In conclusion, the municipal sewage sector in India is an essential component of the country's infrastructure, but it is facing a range of challenges, including a lack of adequate infrastructure, poor management and maintenance, and a lack of funding and technical expertise. To address these challenges and improve the sector, it will be necessary to increase investment in infrastructure and technical capacity, and to improve the management and maintenance of existing facilities. It will also be important to raise awareness about the importance of sewage treatment and the need for proper waste management and to engage all stakeholders in the process of improving the sector.

Municipal Sewage Overview in Telangana

Following are the key highlights of the municipal sewage treatment sector in Telangana.

1. According to the Telangana State Pollution Control Board (TSPCB), the state generates an estimated 2,660 million liters of sewage per day. And only 33.8% (901 MLD) of the total sewage generated in the state is treated.²⁶
2. The TSPCB estimates that only around 50% of this sewage is treated, while the remaining 50% is released into the environment untreated.
3. The main sources of sewage in Telangana are households, commercial establishments, and industrial establishments.
4. The sewage sector in Telangana is managed by a combination of local governments, public utilities, and private companies.
5. There are several sewage treatment plants (STPs) in Telangana, including the Himayat Sagar STP, the Osman Sagar STP, and the Nalgonda STP. Further a total of new 31 STPs under development are expected to bring Hyderabad close to 100% sewage treatment capacity in the near future as per information provided by Municipal Administration and Urban Development (MAUD), Government of Telangana²⁷.
6. In recent years, the Government of Telangana has implemented several initiatives to improve the sewage sector, including the Telangana State Sanitation Policy, which aims to improve sanitation and waste management in the state.
7. However, significant challenges remain, including a lack of adequate sewage treatment infrastructure and a lack of proper management and maintenance of existing facilities.

²⁶

<https://www.thehindu.com/news/national/andhra-pradesh/only-15-of-daily-sewage-is-being-treated-in-ap-sa-ys-report/article66306721.ece>

²⁷ <https://www.siasat.com/31-stps-bringing-hyderabad-close-to-100-sewage-treatment-capacity-2405076/>



8. To address these challenges and improve the sewage sector in Telangana, it will be necessary to increase investment in infrastructure and technical capacity, as well as to improve the management and maintenance of existing facilities. It will also be important to raise awareness about the importance of sewage treatment and the need for proper waste management and to engage all stakeholders in the process of improving the sector.
9. In Telangana, the sewage sector is regulated by a combination of national and state-level laws and regulations.
 - a. At the national level, the sewage sector in Telangana is regulated by the Water (Prevention and Control of Pollution) Act, 1974, and the Water (Prevention and Control of Pollution) Cess Act, 1977. These acts establish standards and guidelines for the treatment and disposal of sewage and provide the legal framework for the prevention and control of water pollution in the state.
 - b. At the state level, the sewage sector in Telangana is regulated by the Telangana State Pollution Control Board (TSPCB). The TSPCB is responsible for enforcing sewage regulations in the state and for issuing permits and licenses for the construction, operation, and maintenance of sewage treatment plants and other sewage infrastructure.
 - c. In addition to these regulations, the sewage sector in Telangana is also subject to other laws and regulations that relate to public health, environmental protection, and waste management. These include the Municipal Solid Wastes (Management and Handling) Rules, 2000, which regulate the management and disposal of solid waste in the state, and the Public Health Act, 1939, which provides for the prevention and control of infectious diseases.

Municipal Sewage Overview in Andhra Pradesh

Following are the key highlights of the municipal sewage treatment sector in Andhra Pradesh.

1. According to the Andhra Pradesh Pollution Control Board (APPCB), the state generates an estimated 2,282 million liters of sewage per day. And only 15% (443 MLD) of the total sewage generated in the state is treated.²⁸
2. The APPCB estimates that only around 50% of this sewage is treated, while the remaining 50% is released into the environment untreated.

²⁸<https://www.thehindu.com/news/national/andhra-pradesh/only-15-of-daily-sewage-is-being-treated-in-ap-says-report/article66306721.ece>



3. The main sources of sewage in Andhra Pradesh are households, commercial establishments, and industrial establishments.
4. The sewage sector in Andhra Pradesh is managed by a combination of local governments, public utilities, and private companies.
5. There are several sewage treatment plants (STPs) in Andhra Pradesh, including the Visakhapatnam STP, the Vijayawada STP, and the Guntur STP.
6. In recent years, the Government of Andhra Pradesh has implemented several initiatives to improve the sewage sector, including the Swachh Andhra Pradesh Mission, which aims to improve sanitation and waste management in the state.
7. However, significant challenges remain, including a lack of adequate sewage treatment infrastructure and a lack of proper management and maintenance of existing facilities.

Key Drivers for sewage treatment in Andhra Pradesh and Telangana

There are several key drivers²⁹ that are contributing to the development and improvement of the sewage treatment sector in Telangana and Andhra Pradesh. These include

1. **Population growth:** Both Telangana and Andhra Pradesh are experiencing rapid population growth, which is increasing the demand for sewage treatment facilities and infrastructure.
2. **Environmental concerns:** The release of untreated sewage into the environment can have a range of negative impacts on public health and the environment, including water pollution, eutrophication, and the proliferation of disease-causing organisms. As a result, there is growing awareness and concern about the need to properly treat and dispose of sewage to protect the environment.
3. **Government initiatives:** The governments of Telangana and Andhra Pradesh have implemented various initiatives to improve the sewage treatment sector, including the Telangana State Sanitation Policy and the Swachh Andhra Pradesh Mission. These initiatives aim to increase the capacity and efficiency of sewage treatment facilities, and to improve the management and maintenance of sewage infrastructure.
4. **Economic development:** The sewage treatment sector is a key component of the overall infrastructure of a city or town, and plays a critical role in supporting economic

²⁹ Presently there are no specific requirements for treating pharmaceuticals or antibiotics in the STPs. The relevance of the key drivers for particular projects and/or technologies would need to be explored on a case-by-case basis with the state government agency, eg. Ministry of Urban Development (MoUD) in Andhra Pradesh and Telangana or with city level municipalities.



development and attracting investment. As a result, there is growing recognition of the importance of investing in sewage treatment and other related infrastructure.

5. Public health: The proper treatment and disposal of sewage is essential for protecting public health, as untreated sewage can contain a wide range of contaminants and infectious microorganisms. As a result, there is a growing awareness of the importance of sewage treatment in protecting public health.

4.4. AMR and Environment: Key Stakeholders

The stakeholder analysis was done based on the relative level of awareness and actions currently being taken to reduce the impacts of antibiotics manufacturing on the spread of AMR. The stakeholder mapping based on level of awareness, action on the ground, and level of influence on the antibiotics manufacturing sector.

Guide on how to read the stakeholder map

- The map represents various stakeholders/stakeholder groups on a coordinate plane in the form of coloured bubbles.
- The X-axis shows the level of awareness of the stakeholders. Awareness increases from low to high as we go from left to right on the map.
- The Y-axis shows the level/intensity of actions from low to high as we go from bottom to top on the map.
- The size of the bubble represents the influence of the stakeholders on reducing AMR from manufacturing.



Key observations from the stakeholder mapping.

- The majority of stakeholders consulted were found to have a good understanding of the problem related to the spread of AMR from pharmaceutical manufacturing in India.
- Most government agencies in India, including the Ministry of Environment, Forest and Climate Change and Pollution Control Boards, were deemed to have high influence, hence any action from these agencies could have significant impacts on the reduction of spread of AMR. However, the level of action taken by them mostly falls in low to medium intensity, despite their relative awareness levels ranging from medium to high.
- Academic and research institutes in India are carrying out some activities, mostly around studies of pollution levels and research and development of new ways of monitoring antibiotics and drug-resistant microorganisms. They were found to have a good understanding of the problem, but their reach and influence was generally limited to academic circles.



- International agencies were deemed to be aware of the situation and taking actions ranging from medium to high intensity. However, relative to government agencies, the influence of international agencies is considered to be less impactful.
- Awareness levels in the industries and industrial associations were found to be quite dispersed, indicative of the diverse nature of industries in India, from small to large scale, and international vs local industries. In general, the awareness and action of this stakeholder group was found to be mixed. While larger pharma companies and industrial groups claim to be taking significant actions to reduce the impact of their operations on the spread of AMR, smaller manufacturers were considered to be less aware of the impact of antibiotic discharge in the environment, especially in the veterinary sector. This is likely due to the stewardship the AMR Industry Alliance and its members have demonstrated over the last few years.
- Most civil society organisations surveyed were found to be aware of the AMR challenge in India. The bulk of their efforts were focused on awareness-raising. Some NGOs have attempted to measure levels of antibiotics in local rivers, and in one case, their actions have resulted in a legal case in the National Green Tribunal.

4.5. Competitors and Market Analysis

The wastewater sector in India is still at a nascent stage. As a developing economy, India is still facing significant challenges due to a combination of rapid urbanization, industrialization, and population growth. It is estimated that only about 30% to 40% of the country's wastewater is treated, with the remainder being discharged into water bodies without any treatment. This has led to widespread water pollution and has negative impacts on public health and the environment.

The Government of India has recognized the importance of addressing these challenges and has taken steps to improve wastewater management in the country. This includes the development of policies and regulations to improve wastewater treatment and the implementation of wastewater treatment plants. The government has also launched various programs to support the treatment of wastewater and the reuse of treated wastewater for non-potable purposes.

Despite these efforts, there is still a significant gap between the demand for wastewater treatment and the capacity to treat it. Many municipalities in India do not have the necessary infrastructure or financial resources to effectively treat and manage wastewater, and there is a need for increased investment in the sector. There is also a need for greater awareness among



the public and industry about the importance of wastewater treatment and the role that they can play in improving the management of wastewater in the country.

There are numerous business opportunities in the wastewater sector in India, as the country is facing significant challenges in managing and treating its wastewater. The government of India has recognized the importance of addressing these challenges and has taken steps to improve wastewater management in the country, including the development of policies and regulations to improve wastewater treatment and the implementation of wastewater treatment plants.

The key business opportunity in the Indian wastewater sector is the construction and operation of wastewater treatment plants for different types of wastewater (including sewage, industrial and hospital wastewater). These plants are typically built and operated by private companies, either through partnerships with the government or through independent projects. The construction and operation of these plants can be a lucrative business, as there is a significant demand for wastewater treatment in the country.

Another opportunity is the provision of technologies and services related to wastewater treatment, such as consulting services, equipment, and chemicals. There is a growing need for innovative technologies and services that can help improve the efficiency and effectiveness of wastewater treatment in India.

There is also an opportunity for companies to engage in the reuse and recycling of treated wastewater. This includes the use of treated wastewater for irrigation, industrial processes, and other non-potable purposes. This can help to reduce the demand for freshwater resources and reduce the burden on the environment.

Overall, the wastewater sector in India presents significant business opportunities for companies that are able to offer solutions to the country's wastewater management challenges.

There are 1000+ water and wastewater engineering firms in India. The following are the key classifications of companies that operate in the water sector.

- Engineering Consulting companies - these companies provide engineering design and consulting services for water and wastewater projects
- Technology companies - these companies provide proprietary technologies (e.g. RO membranes, evaporation technologies etc) for water and wastewater treatment projects
- Engineering Procurement and Construction (EPC) companies - these companies provides turnkey solutions for water and wastewater engineering projects



- Trading companies - there are a large number of trading companies that help with the sales and service of various equipment and materials used in the water and wastewater treatment processes

The following summarizes the typical scale of operations of most of the companies operating in the wastewater engineering space in India.

Core Business	Manpower strength	Estimated Annual Revenue³⁰
Consulting ³¹	10 to 50 people	\$100k to \$5 million
Technology providers	10 to 100 people	\$1 to \$10 million
EPC Companies	10 to 500 people	\$1 to \$500 million
Trading companies	1 to 100 people	\$100k to \$10 million

A list of key competitors in the wastewater treatment industry is provided in Appendix.

4.6. Size of the Indian Wastewater Market

As per NITI Aayog, India's wastewater treatment plants market stood at USD 2.4 billion in 2019 and is projected to reach USD 4.3 billion by 2025³² owing to increasing demand for municipal as well as industrial water treatment. It is estimated that 70% to 80% of the investments in wastewater infrastructure are made by the government and the remaining by the industrial sectors.

While the exact investments in waste treatment from an AMR perspective (i.e. for filtering out medicine residues and killing bacteria) could not be ascertained through this study, it is estimated that < 5% of the Indian wastewater market is presently allocated for directly monitoring and managing wastewater that contains APIs. It should also be noted that presently no clear budget has been allocated under the National or State Action Plans on AMR. The estimated investment is based on discussions with industry experts and stakeholders and the extrapolation of data.

³⁰ Based on Spans Industry Research and experience of working with industry partners and Annual Reports of companies such as VA Tech Wabag and Larsen and Toubro

³¹ This is only accounting for the water and wastewater consulting practice.

³²

https://www.business-standard.com/article/news-cm/india-s-wastewater-treatment-plants-market-likely-to-reach-4-3-billion-by-2025-amitabh-kant-121021800304_1.html



4.7. Cost of existing solutions for monitoring and treatment

In this section, the estimated costs of monitoring and treatment of pharmaceutical wastewater are summarized. It should be noted that these are based on data collected during stakeholder consultations and are unverified numbers and should be used only for indicative purposes. It should also be noted that at present the following treatment schemes do not directly address AMR issues and are only designed and built to meet the current environmental regulations.

Industry	Typical Treatment System	Capital and Operating Costs ^{33 34}
Sewage Treatment	Activated Sludge Systems + Filtration (sand and activated carbon) + Disinfection (mostly chlorine)	Capex: USD 300 to 400 per m ³ Opex: USD 0.2 to 0.3 per m ³
Hospital Wastewater Treatment	Activated Sludge Systems + Filtration + Disinfection (mostly chlorine) UF and RO systems are also commonly adopted where reuse of water is being undertaken	Capex: USD 300 to 500 per m ³ Opex: USD 0.3 to 0.5 per m ³
Pharmaceutical Wastewater - Bulk Drugs (API manufacturing)	Zero Liquid Discharge (ZLD) systems including Multi-Effect Evaporation + Thermal Drying + Activated Sludge Treatment + UF + RO Note: this also includes the costs for sludge treatment and disposal Note: Since API manufacturers are required to have ZLD systems, no treated or untreated wastewater from the bulk drug manufacturing sites is expected to be legally discharged into the environment.	Capex: USD 6,000 to 10,000 per m ³ Opex: USD 10 to 25 per m ³

³³ Based on Spans Industry Research and experience of working on similar projects

³⁴ NMCG Compendium of Sewage Treatment Technologies:
https://nmcg.nic.in/writereaddata/fileupload/15_Technologies%20Involved.pdf



Industry	Typical Treatment System	Capital and Operating Costs ^{33 34}
Pharmaceutical Wastewater - Formulation units	Physical-Chemical Treatment + Activated Sludge Treatment + UF + RO	Capex: USD 500 to 800 per m ³ Opex: USD 1.5 to 3 per m ³

Presently very few recognized laboratories have the necessary equipment (HPLC-MS-MS, GC-MS and other instruments) for testing and monitoring of antibiotics residues in water samples. The estimated cost for testing water samples for antibiotics residues is approximately USD 50 to \$ 75 per sample³⁵.

³⁵ Rates as available from IIT Bombay Sophisticated Analytical Instrument Facility (SAIF) labs
https://saifora.iitb.ac.in/crnets/Online_Ext_Reg/Web_Portal_DST_SAIIF/current_facility_ins_code_test_mode_charges_status_wait_period_fmc.jsp?current_data_for=chargesoffacilities&selcentrenm=wTfh9Mr1/+9aWfj7isOa1Q==&cal_for_IITB_user_online_module=



5. Business Opportunities for Dutch Companies

5.1. Criteria for identifying and ranking business opportunities

The following table summarizes the key drivers and filtering criteria that were used to identify and rank business opportunities linked to antimicrobial resistance for Dutch technology companies in Andhra Pradesh and Telangana.

Sector	Drivers	Suggest Activities to tap business opportunities ³⁶
General (manufacturing, hospitals and STPs)	NAP/SAP - Every state in India is coming up with its own action plans to address AMR through various government departments and projects	Align projects with NAP/SAP - Programmes / projects controlled and channelized by government agencies in the state of Andhra Pradesh and Telangana
	Regulations - India is working on drafting regulations for the discharge of antibiotics in the wastewater and the regular monitoring of antibiotics in the different waste streams which would create new business opportunities	Align projects with regulations - States like Andhra Pradesh and Telangana are one of the leading producers of pharmaceuticals in India and will likely adopt stringent regulations to be followed by industries, hospitals, and sewage treatment facilities
	Citizen/ngo pressure - Several NGOs and civil society organizations (e.g., CSE, Veterans Forum, Council of EHS Professionals) are pursuing the public and private stakeholders to take action	Though most of these groups / organizations are localized, they play a major part in creating awareness and helping different agencies to collaborate with local governments to work on the ground. Collaboration with these agencies could be beneficial
	Applicability of Dutch technologies in the Indian context (including both technical, and cost factors)	To be confirmed during joint workshop and trade mission to India
	Procurement: Various global	Align project with procurement specifications

³⁶ A detailed list of business opportunities for Dutch companies is presented in Section 5 (page 48) of this report.



Sector	Drivers	Suggest Activities to tap business opportunities ³⁶
Manufacturing Specific	medicine procurement agencies (eg. UK NHS, Swedish Medical Procurement Agency etc) have begun to include environmental factors in their antibiotics procurement specifications that require manufacturers to adopt responsible manufacturing practices.	for responsible antibiotic manufacturing, monitoring and treatment of waste streams
	Operational improvements: Businesses are interested in adopting new technologies and solutions for improving operational practices that can help them run their business more efficiently	Dutch technologies that can help reduce cost of operations (capex or opex) for the businesses are likely to find good business opportunities

Further, the business opportunities that have been detailed out in Section 5.4 (page 48) were also ranked based on the anticipated timelines that would be needed for project preparation and development activities.

Immediate	< 1 year
Short-Medium Term	1 to 3 years
Long Term	> 3 years

5.2. Suggested collaboration approaches

While the exact collaboration approach will vary from project to project, the following are some suggested approaches that could be adopted for building Indo-Dutch partnerships for collaborating on AMR-focused projects.

- Government-to-government: The Dutch Innovation Mission through the Dutch Embassy could work on signing a memorandum of understanding or creating a Joint Venture program for developing a Government to Government association to co-design and co-develop strategies and projects for combating AMR. This would need to be discussed with the state government agencies such as the Department of Industries and Commerce



for manufacturing, the Municipal and Urban Development Department for sewage treatment, State Pollution Control Boards for monitoring and surveillance technologies and projects, and the Department of Health for hospital wastewater management.

- **Business-to-Business:** Trade missions with members of the Dutch water sector could be commissioned over the next few years to increase awareness about Dutch technology companies in India. This could be done by organizing both online and in-person events and workshops. For these workshops, ground partnerships with academic institutions as well as industry associations, such as PSCI, BDMAI, IDMA, CII, FICCI, Pharmexcil etc, could be leveraged.
- **Academic & Research Collaborations:** Call for joint proposals could be set up for R&D and project development activities with co-funding from both Indian and Dutch governments where various AMR-specific problem statements could be given to technical experts and entrepreneurs. This could be structured in a way to ensure greater collaboration and partnership between the Indian and Dutch entrepreneurs and businesses. For example, Dutch water testing laboratories could partner with Indian laboratories to innovate and develop the most cost-effective solutions for antibiotics monitoring technologies for more widespread testing. This would help create an enabling environment to increase collaboration and success could be measured in terms of the number of MoUs signed and JVs (joint ventures) created.

5.3. AMR Market Challenges, Risks, and Gaps

Following are some of the key market challenges, risks, and suggested mitigation measures that Dutch companies can face while working on business opportunities in India. The challenges are from the view of Dutch technologies and solutions providers that are looking to conduct business in the Antimicrobial Resistance (AMR) related space in India.

Challenges and Risks	Mitigation Strategy
<u>Unclear or missing regulations:</u> presently there are no clear regulations that require monitoring or treatment of antibiotics in the waste from manufacturing, hospitals or sewage	Align projects and investments based on existing regulations and policies.
<u>Lack of funding:</u> there are no clear budgets assigned for monitoring or treatment of antibiotics containing wastewater	Align funding sources from multiple partners, both from India and the Netherlands to reduce risk
<u>Lack of awareness of AMR problems:</u> AMR is a	Focus on continuous capacity building and



Challenges and Risks	Mitigation Strategy
fairly new topic in India and there are significant awareness and knowledge gaps among the stakeholders	sharing of information and knowledge to increase the capacity of stakeholders and partners. Leverage partnerships with Indian stakeholders
<u>Cost competitiveness</u> : India is generally a very cost-sensitive market and there is significant competition in the wastewater treatment industry. This typically results in very thin margins for businesses operating in the sector	Import only key project components from the Netherlands while leveraging engineering and manufacturing capacities available in India
<u>IP protection risk</u> : Dutch AMR technologies may come with specific intellectual properties that may need to be protected from duplication	Ensure proper legal documentation and align interests with partners through well-detailed MOUs and agreements.
<u>Lack of reliable data</u> : There are few research papers and engineering studies that have data on the role of antibiotics in the environment from wastewater from manufacturing, hospitals, and sewage in the spread of AMR.	Collect data from multiple sources and angles and make conservative assumptions, especially on business growth and profit margins while computing investment returns
<u>Political uncertainty and differences in central and state government priorities</u> : Since water is a state subject, every state may have a different approach to addressing the issue - regulations, incentives, subsidies, etc.	Investment decisions should be based on prevailing and anticipated political priorities at both central and state government levels.
<u>Changing priorities of different stakeholders</u> : AMR is a relatively new topic of concern and clear multi-stakeholder (government, industry, and civil society) alignment may not be fully established. Further, due to a lack of data and common understanding, the priorities of the different stakeholders may change from time to time.	Given that AMR is a multi-sectoral problem and understanding is different among different stakeholders, it will be important to ensure proper stakeholder alignment for any projects and investment opportunities. It will be necessary to continuously align the project goals and objectives to ensure alignment with the core priorities of the various stakeholders.
Other business risks	Follow good engineering and business practices to ensure different business risks are identified early in the project and appropriate strategies are put in place. Eg. construction risk, operations risks, delays in payment risks, tax regime change risk etc



5.4. List of potential business opportunities

The following table lists the various business opportunities that have been identified based on the above criteria and through desk research and various stakeholder consultations. The scope of the project and the business opportunity would need to be discussed and prioritized with interested Dutch companies. Subsequently, the interested Dutch companies would need to actively collaborate with the potential partner agency and other relevant government departments to carry out detailing of the shortlisted opportunities.

Sector	Opp. Driver	Opportunity	State	Potential Partner Agency & suggested action	AMR Impact Timeline	Project Size	Investment Range
Manufacturing	Surveillance, Awareness	<p>Co-Develop Antimicrobial Resistance (AMR) Centre of Excellence (CoE) for Responsible Antibiotics Manufacturing of Antibiotics</p> <p>Hyderabad Pharma City Limited (HPCL)³⁷ is in the process of setting up a one of a kind Centre of Excellence (CoE) on AMR with help of grant funding from the Department of Pharmaceuticals and contributions from industry partners including Dr. Reddy's Laboratories to provide leadership in the following key areas:</p> <p>a) Academic training and awareness raising on AMR topics</p>	Telangana	<p>Hyderabad Pharma City Limited (HPCL)</p> <p>https://lifesciences.telangana.gov.in/life-sciences-grid/clusters/hyderabad-pharma-city/</p> <p><u>Suggested steps:</u></p> <ul style="list-style-type: none"> • Connect with HPCL to learn more about the CoE project. • Share details of technology for monitoring or treatment that can be leveraged by the CoE • Explore equity partnership with HPCL for the development and operations of the CoE 	Immediate	Small	€1 to €2 mn

³⁷ For more details on the Centre of Excellence (CoE) project, CEO, HPCL (Mr. Shakthi Nagappan) could be contacted for partnership and collaboration opportunities.



Sector	Opp. Driver	Opportunity	State	Potential Partner Agency & suggested action	AMR Impact Timeline	Project Size	Investment Range
		<ul style="list-style-type: none"> b) Build capacity for monitoring technologies and testing solutions c) Treatment technologies to increase sustainability and profitability d) Policy research and advocacy for AMR Guidelines and Policies 					
All 3 sectors	Surveillance	Developing and installing monitoring technologies for antibiotics in the environment based on CPCB guidelines	Telangana	<p>Telangana Pollution Control Board</p> <p><u>Suggested steps:</u></p> <ul style="list-style-type: none"> • Approach TPCB to share information on Dutch monitoring technologies and explore collaboration opportunities for designing and development of the monitoring systems for the state of Telangana 	Short-Medium Term	Small	€1 to €2 mn
All 3 sectors	Surveillance	Developing and installing monitoring technologies for antibiotics in the environment based on CPCB guidelines	Andhra Pradesh	<p>Andhra Pradesh Pollution Control Board (APPCB)</p> <p><u>Suggested steps:</u></p> <ul style="list-style-type: none"> • Approach APPCB to share information on Dutch monitoring technologies and explore collaboration 	Short-Medium Term	Small	€1 to €2 mn



Sector	Opp. Driver	Opportunity	State	Potential Partner Agency & suggested action	AMR Impact Timeline	Project Size	Investment Range
				opportunities for designing and development of the monitoring systems for the state of Andhra Pradesh			
All 3 sectors	Surveillance	<p>Collaborate with CPCB/MoEF to develop a technical framework for surveillance of antibiotics in the environment. The current PNEC value approach proposed by AMRIA has been criticized for limitations</p> <ul style="list-style-type: none"> - Dynamic nature of PNEC value, difficulty in standardization - Based on toxicology on one type of bacteria, may not be reflective of actual toxicity in the local conditions - Expensive and technically difficult <p>sponsor R&D, PhD studies</p> <p>Opportunities:</p> <ul style="list-style-type: none"> - more robust monitoring mechanism - reduce the cost of regular monitoring 	India	Central Pollution Control Board / MoEFCC	Short-Medium Term	Small	€1 to €2 mn
All 3 sectors	Surveillance	Support development of hand-held sensor-based technology for monitoring of antibiotics	India	IIT Bombay & IIT Chennai <u>Suggested steps:</u>	Short-Medium Term	Small	€1 to €2 mn



Sector	Opp. Driver	Opportunity	State	Potential Partner Agency & suggested action	AMR Impact Timeline	Project Size	Investment Range
				<ul style="list-style-type: none"> Approach IIT researchers and professors working in the area of AMR to promote joint research and development efforts through joint research and student exchange programs. 			
Manufacturing	Surveillance, Awareness, Treatment	Working with Netherlands Medical Procurement Agencies to audit the environmental performance (with respect to AMR) of a few (2 or 3) manufacturing sites in India and benchmark those with international best practices for reducing the risks of spread of AMR from environment/manufacturing caused pollution.	India	Partners: Dutch procurers, Dutch technology companies, Indian manufacturers	Short-Medium Term	Small	< €1 mn
Hospital	Treatment	Pilot project with a large and responsible hospital to develop monitoring and treatment systems for hospital wastewater for reducing the impact of hospital waste on the spread of AMR	Telangana	<p>Osmania Hospital / Yashodha Hospital</p> <p><u>Suggested steps:</u></p> <ul style="list-style-type: none"> Approach hospitals as well as state health departments to explore development of pilot and demonstration projects for treatment of hospital wastewater with the 	Short-Medium Term	Medium	€2 to €5 mn



Sector	Opp. Driver	Opportunity	State	Potential Partner Agency & suggested action	AMR Impact Timeline	Project Size	Investment Range
				objective of reducing the impact of discharge of hospital wastewater on the spread of AMR.			
Hospital	Treatment	Pilot project with a large and responsible hospital to develop monitoring and treatment systems for hospital wastewater for reducing the impact of hospital waste on the spread of AMR	Andhra Pradesh	<p>Apollo Hospital (Vishakapatnam), King George Hospital (Vishakapatnam)</p> <p><u>Suggested steps:</u></p> <ul style="list-style-type: none"> Approach hospitals as well as state health departments to explore development of pilot and demonstration projects for treatment of hospital wastewater with the objective of reducing the impact of discharge of hospital wastewater on the spread of AMR. 	Short-Medium Term	Medium	€2 to €5 mn
Manufacturing	Treatment	<p>Improved ZLD technologies for removal of APIs from pharmaceutical wastewater (both bulk drug and formulation units) - this could be applicable for both individual ETPs and CETPs.</p> <p>Opportunities for:</p> <p>1. greater recovery of water</p>	India	PSCI, BDMAI and IDMA	Short-Medium Term	Medium	€2 to €5 mn



Sector	Opp. Driver	Opportunity	State	Potential Partner Agency & suggested action	AMR Impact Timeline	Project Size	Investment Range
		<p>2. reduced O&M costs 3. Better removal of APIs, ensuring reduction in discharge from the ETP</p> <p>Dutch technology companies could partner with existing facilities such as Jeedimetla CETP</p>					
Manufacturing	Treatment	Improved ZLD technologies for the treatment of sludge from bulk drug and formulation units - this would be applicable for both individual ETPs and CETPs	India	BDMAI and IDMA	Short-Medium Term	Medium	€2 to €5 mn
STPs	Surveillance, Awareness	Develop surveillance infrastructure for existing and upcoming STPs in Telangana	Telangana	Municipal Administration & Urban Development, Government of Telangana	Short-Medium Term	Medium	€2 to €5 mn
STPs	Surveillance, Awareness	Develop surveillance infrastructure for existing and upcoming STPs in Andhra Pradesh	Andhra Pradesh	Municipal Administration & Urban Development, Government of Andhra Pradesh	Short-Medium Term	Medium	€2 to €5 mn
Manufacturing	Treatment	Developing CETP for the Hyderabad Pharma City	Telangana	Hyderabad Pharma City, Govt of Telangana	Short-Medium Term	Large	> €10 mn
Manufacturing	Treatment	Developing CETP for Genome Valley and other pharmaceutical manufacturing hubs	Telangana	Hyderabad Pharma City, Govt of Telangana	Short-Medium Term	Large	> €10 mn



Sector	Opp. Driver	Opportunity	State	Potential Partner Agency & suggested action	AMR Impact Timeline	Project Size	Investment Range
All 3 sectors	Monitoring & Treatment	<p>Develop a special economic zone/business in India for R&D and manufacture of innovative AMR surveillance and treatment technologies. This could be a focused business park with a high concentration of technology companies from the Netherlands and beyond. The Netherlands govt could partner with the Govt of Telangana to develop a new business park in Hyderabad. The technologies developed and manufactured at this business park could potentially serve the Indian and global client base, making a strong proposition for GoT by:</p> <ol style="list-style-type: none"> 1. Bringing in investment for high-tech R&D and innovation 2. Bringing in long-term FDI investments 3. Smaller Dutch and other technology companies could benefit from the ecosystem and infrastructure available in Telangana (eg. Hyderabad pharma city, tech city, genome valley etc) 	Telangana	<p>Ministry of Industry & Commerce (Life Sciences & Pharma)</p> <p><u>Suggested steps:</u></p> <ul style="list-style-type: none"> • If there is sufficient interest and scope for setting up R&D and manufacturing facilities in India, the ministry could be approached with a project proposal for setting up of a business hub for AMR related technologies for seeking grants, investment opportunities. 	Long Term	Large	> \$10 mn
All 3 sectors	Surveillance Regulations are enforced	Provide technologies for regular monitoring of wastewater from manufacturing for APIs that cause	India	Commercial Activity across multiple sites/projects	Long term	Large	> €10 mn



Sector	Opp. Driver	Opportunity	State	Potential Partner Agency & suggested action	AMR Impact Timeline	Project Size	Investment Range
		AMR to Indian pharmaceutical manufacturing industries		<p><u>Suggested steps:</u></p> <ul style="list-style-type: none"> • Approach Industry Associations such as PSCI, BDMAI, CII etc to explore business requirements and share information about Dutch technologies. • Approach central and state pollution control boards to share technical information about technologies provide and explore collaboration opportunities to provide consultations on developing AMR monitoring systems and infrastructure. 			
Hospital	Treatment, regulations are enforced	Provide treatment technologies for treating wastewater with high concentration of APIs in the hospitals wastewater	India	<p>Commercial Activity across multiple sites/projects</p> <p><u>Suggested steps:</u></p> <ul style="list-style-type: none"> • Approach Industry Associations such as PSCI, BDMAI, CII etc to explore business requirements and share information about Dutch technologies. • Approach individual industries to identify wastewater treatment 	Long term	Large	> \$10 mn



Sector	Opp. Driver	Opportunity	State	Potential Partner Agency & suggested action	AMR Impact Timeline	Project Size	Investment Range
				requirements and get invited for procurement from these companies.			
Manufacturing	Treatment, regulations are enforced	Provide treatment technologies for treating wastewater with high concentration of APIs in the wastewater from antibiotics manufacturing	India	<p>Commercial Activity across multiple sites/projects</p> <p><u>Suggested steps:</u></p> <ul style="list-style-type: none"> • Approach Industry Associations such as PSCI, BDMAI, CII etc to explore business requirements and share information about Dutch technologies. <ul style="list-style-type: none"> • Approach individual industries to identify wastewater treatment requirements and get invited for procurement from these companies. • Participate in Indian trade shows and conferences to increase awareness of Dutch technologies and solutions. 	Long term	Large	> €10 mn



Sector	Opp. Driver	Opportunity	State	Potential Partner Agency & suggested action	AMR Impact Timeline	Project Size	Investment Range
STPs	Treatment	Rehabilitation of existing polluted water bodies (eg. Musi river)	Telangana	<p>Municipal Administration & Urban Development, Government of Telangana</p> <p><u>Suggested steps:</u></p> <ul style="list-style-type: none"> • Approach state government urban development department and pollution boards to increase awareness of the environmental pollution and public health challenges in key water bodies. • Explore collaboration to provide consultancy and share knowledge of how these environmental challenges can be best addressed using Dutch technologies and solutions. 	Long term	Large	> \$10 mn



6. Recommendations on next steps

As the awareness on Antimicrobial Resistance (AMR) increases in India, there is likely to be greater pressure on the government, industry and civil society to take corrective action to reduce the impact of environmental pollution from pharmaceutical manufacturing, and hospital wastewater and untreated sewage discharges. At present, efforts to curb pollution and its impact on the spread of AMR are fairly limited however there are a lot of positive discussions and actions being taken both at the national and state levels.

In the near future, it is anticipated that significant investments are likely to be made to both monitor and treat wastewater from manufacturing, hospitals, and sewage to reduce the risk of the spread of AMR. Investments are expected to be made for both surveillance and treatment of waste streams. Following are some important recommendations based on this market study:

1. Dutch companies and government agencies should look at opportunities in the pharmaceutical manufacturing space as there are stronger pressures, business drivers, access to capital and clearer pathways for building for new projects.
2. Hospital sector in India is highly fragmented with no clear business or regulatory drivers required for adoption of new technologies or solutions for monitoring and reducing the discharge of wastewater from hospitals to the environment. While the awareness in the hospital sector is higher, because of other efforts in One Health and AMR linked to access to medicine programs, the scope of environmental business opportunities is currently in a very nascent stage.
3. Dutch companies as well as academic, research, and innovation programs that offer technologies and processes to solve environmental pollution-led AMR can significantly benefit by partnering with the Indian central and state governments, research institutes as well as industry associations such as PSCI, BDMAI, IDMA, OPPI, CII, etc to provide cost-effective solutions and technologies to reduce the impacts on the spread of AMR. Since the understanding and availability of data on the spread of AMR because of environmental causes is still in its initial stage, there is a need to invest in scientific and technical research to ascertain cause-effect relationships and also in development of engineering solutions for managing the different types of wastewater in a responsible and sustainable manner.
4. Opportunities should be explored to work with Indian counterparties to implement pilot / demonstration projects with the objectives of increasing awareness, capacity building and demonstrating the benefits of adopting new monitoring and wastewater treatment technologies for the reduction in spread of AMR in India.



5. Workshops and trade missions should be organized to increase interactions between the Dutch and Indian scientific and engineering community. This would help with increasing awareness, capacity building and would result in potential collaboration and business opportunities both in the areas of research and development and providing engineering solutions for practical challenges in all the three focus sectors.
6. Since the identified business opportunities are in the nascent stages of discussions, it is recommended that a collaborative approach is adopted to partner with the government agencies and/or industry to co-design and develop the project concepts. The recommended next steps are to organize a hybrid workshop for the Dutch companies where the opportunities can be discussed and prioritized and following the workshop a trade mission of selected Dutch companies can be organized for the two project states sometime in mid-2023.

The key immediately actionable recommendations are summarized in the table below.

Research Recommendations in developing AMR monitoring technologies and improved, cost effective wastewater treatment technologies

- Consider investigating the potential for bilateral research collaboration agreements between universities, with the involvement of the industry, to secure funding for joint research on the topics of environment and AMR.
- To facilitate the effective and cost-efficient development of infrastructure in India for monitoring and managing AMR, consider establishing talent and expert exchange programs. These programs can focus on AMR research, as well as the development of new technologies for monitoring AMR and managing waste in the environment.
- Consider leveraging bilateral academic programs, along with technology and infrastructure design consultancy projects, to address the issue of AMR and promote the One Health approach. This can involve the development of innovative technologies and infrastructure to combat AMR, as well as the sharing of knowledge and expertise between academic institutions to advance research in this area.
- Consider establishing an Indo-Dutch Centre of Excellence to carry out pilot projects, training, capacity building, testing, and technology benchmarking infrastructure in the field of AMR. This center could potentially complement the existing AMR CoE development initiative of the Government of Telangana.
- Initiate collaboration efforts to develop standards, guidelines, and regulations aimed at monitoring and treating waste to reduce the spread of AMR in the environment. This collaboration can promote the One Health approach, which emphasizes the interconnection between human health, animal health, and the environment.

Business recommendations for the development of AMR monitoring solutions and wastewater treatment and reuse infrastructure.



- To promote the effective management of AMR, it may be beneficial to explore joint venture projects involving MoEF, CPCB, and private environmental and health monitoring laboratories. These projects can focus on the development of infrastructure and monitoring systems for AMR, contributing towards protecting the environment and the health of humans and animals.
- To address the issue of safe disposal of waste and spread of AMR, explore business collaboration projects with Indian private sector hospitals such as Apollo, Yashoda, Care, Continental, Manipal etc and pharmaceutical manufacturing industries such as Dr Reddy's Laboratories, Aurobindo Pharma, Divis Laboratories, Covalen etc. These projects can focus on developing waste treatment infrastructure, ultimately contributing to the reduction of AMR spread in the environment.
- Explore joint venture projects with state industrial infrastructure development corporations Telangana State Industrial Infrastructure Corporation (TSIIC), Hyderabad Pharma City Limited (HPCL) and Andhra Pradesh Industrial Infrastructure Corporation (APIIC) for developing common waste management infrastructure for pharmaceutical manufacturing industrial parks.
- Explore consulting opportunities for infrastructure development especially developing state wide AMR monitoring programs and infrastructure with CPCB, Telangana State Pollution Control Board (TSPCB) and Andhra Pradesh Pollution Control Board (APPCCB), especially utilizing of Dutch technologies, systems and processes.
- Explore co-development and manufacturing collaborations for Dutch technology companies to leverage Indian manufacturing capabilities with focus on reducing the cost of new technologies and serving a global market with Dutch technologies and equipment manufactured in India.
- Create joint venture opportunities with Indian environmental and waste engineering companies such as Ramky Enviro, VA Tech Wabag, Thermax etc as well as with industry associations such as BDMAI, IDMA etc for serving the growing Indian industrial wastewater treatment market.
- Set up joint projects with nodal public sector organizations such as NCDC, ICMR, NIPER, etc for demonstration projects for AMR monitoring and waste treatment technologies.

Government Recommendations

- The Ministry of Environment, Forest, and Climate Change (MoEFCC) and Central Pollution Control Board (CPCB), the nodal ministry and agency for the development of new regulations and technology recommendations for the waste treatment and discharge and the Embassy of The Netherlands in Delhi can form a joint action group with members from other ministries and organisations including representatives from industry, academic institutions and think tanks The group can focus on developing road map for joint collaborations for new policies, guidelines, R&D initiatives and development of waste treatment and management infrastructure for reducing the impact of environmental pollution on the spread of AMR.
- The National Centre for Disease Control (NCDC), the focal point for implementation and coordination of the AMR program and action plan in India, and the Embassy of The



Netherlands in Delhi can form a joint action group with members from other ministries and organisations including representatives from industry, academic institutions and think tanks. The group can focus on developing road map for joint collaborations for developing AMR reducing approaches and plans leveraging the One Health approach.

- Design a focused call for research and development cooperation with Netherlands and DST. The call could be focused on developing new low-cost and efficient AMR monitoring technologies with a focus on transfer and co-development of new technologies in the areas of hardware, machine-learning and artificial intelligence, big data etc.
- State-level government-to-government collaborations can be explored with the state governments of Telangana and Andhra Pradesh and state government owned public sector enterprises for collaboratively planning and developing technologies and infrastructure for monitoring of AMR and waste treatment infrastructure.
- To enhance collaboration opportunities and partnerships between Indian and Dutch stakeholders, it is proposed to organize a joint trade mission. The mission will aim to facilitate Dutch businesses to explore new markets in India through a collective approach. Representatives from Dutch academia and industry will visit India to gain a better understanding of the opportunities for collaboration. This will foster joint collaborations between Dutch and Indian businesses, promoting the local presence and representation of Dutch businesses and technologies in India. Establishing a local presence would enhance the visibility of Dutch solutions, making it easier for Indian businesses to explore collaboration opportunities and request proposals. This approach has proven successful for other trading partner countries, such as Israel, Australia, the UK, and Switzerland.
- To facilitate a mutually beneficial collaboration, a delegation from the Indian government, industry, and academia can be arranged to visit the Netherlands. During this visit, they can explore the projects and facilities implemented in the Netherlands to monitor and manage AMR, following the One Health approach.





Appendix A: India Water Sector Overview

Overview of India

India is a fast-growing developing nation. Following are the key highlights of the Indian economy. As India's per capita GDP increases beyond \$2000 per capita, the demand for healthcare, and other discretionary services. This would also impact the demand for better quality infrastructure across all sectors as well as an increase in the manufacture and use of antibiotics.

Key Highlights

28 states, 8 union territories

Population: 1.41 billion

GDP: \$3.47 trillion

per capita GDP: ~\$2300

Stable Government

GST: One Country, One Tax

Digitization: across all sectors (eg. JAM Yojana - Jan Dhan, Aadhar, Mobile, UPI etc)



India - Global Trade

India is an important global trade partner with significant imports and exports of a variety of products and services. The following charts (source: commerce.gov.in) provide an overview of India's international trade partners and the top commodities for export and import.



INDIA'S INTERNATIONAL TRADE

		FY23 TILL SEP	YoY Chg.
MERCHANDISE	Exports	231.9	17.0%
	Imports	380.3	38.6%
	Trade Balance	-148.5	-94.7%
SERVICES	Exports	150.4	27.9%
	Imports	89.1	34.5%
	Net of Services	61.3	-19.3%
OVERALL TRADE	Exports	382.3	21.0%
	Imports	469.5	37.8%
	Trade Balance	-87.2	-250.5%



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Source: commerce.gov.in

TOP 10 IMPORTED COMMODITIES

		Value (in Bn)	Share
Crude, Petroleum		\$115.0	30.4%
Electronics		\$39.6	10.5%
Coal, Coke, Briquettes		\$30.2	8.0%
Machinery		\$21.8	5.8%
Gold		\$20.1	5.3%
Chemicals		\$18.7	4.9%
Pearls, Gems		\$16.5	4.4%
Resins, Plastic		\$12.4	3.3%
Transport Equipment		\$11.5	3.1%
Vegetable Oil		\$11.1	2.9%



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Value for April to Sep 2022

TOP 10 EXPORTED COMMODITIES

		Value (in Bn)	Share
Engineering Goods		\$54.5	23.8%
Petroleum Products		\$49.9	21.8%
Gems & Jewellery		\$20.5	8.9%
Chemicals		\$15.7	6.9%
Drugs & Pharma		\$12.6	5.5%
Electronics		\$10.2	4.5%
RMG of Textiles		\$8.1	3.6%
Cotton, Yarn, Madups		\$5.8	2.5%
Rice		\$5.4	2.4%
Plastic & Linoleum		\$4.5	2.0%



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Value for April to Sep 2022



TOP 10 IMPORT DESTINATIONS



Value for April to Aug 2022

TOP 10 EXPORT DESTINATIONS



Value for April to Aug 2022

Commentary on international trade:

- India is a net importer with crude oil and petroleum being the major import commodities and engineering goods and petroleum products being the major exported commodities
- India imports from many countries of which China, UAE, and USA are the top 3 contributors. The Netherlands presently does not appear in the top 10 countries for import into India.
- Major export destinations include the USA, UAE, and The Netherlands in the top three. Other major exports happen in China, South-East Asia, Brazil, and the UK
- Export of pharmaceutical products makes up a major portion of 5.5% of the total exports from India which is likely to increase in the coming years due to several global effects, especially after the COVID-19 pandemic

Water Sector: Legal and Regulatory Environment

- Due to the spatial expanse and large population, India follows federalism with legislative powers categorized under Union List, State List and Concurrent List (representing powers shared among union and state governments)
- Water and sanitation, as a subject, comes under the purview of the state governments
- Central agencies legislate and regulate policy guidelines and programs for the country's water resources. The central agencies include the Ministry of Water Resources, Ministry of Environment, Forest and Climate Change (MoEFCC), Central Pollution Control Board (CPCB), National Green Tribunal (NGT) etc.



- Central Pollution Control Board is responsible for operationalizing the policies and acts and provide technical advisory to the ministry & states
- State Pollution Control Boards (SPCB) are operational units at the state level to advise respective state governments to control and protect the environment. All manufacturing units or industries in the states have to take a Consent to Establish (CTE) before starting the construction work for the facility and Consent to Operate (CTO) before commercial operations from the respective state pollution control boards



Appendix B: List of Key AMR Stakeholders

List of key stakeholders in the management of monitoring and control of the spread of Antimicrobial Resistance (AMR) in India

Category	Stakeholder Entity	Overview / Responsibilities
Government	Ministry of Environment, Forest and Climate Change (MoEF&CC)	<ul style="list-style-type: none">• Sets policies and provisions related to the environment• Implementation of the provisions across the country
Government	Central Pollution Control Board (CPCB)	<ul style="list-style-type: none">• Plan and develop programs for prevention, control and abatement of water and air pollution• Provide technical services to MoEF&CC
Government	State Pollution Control Boards (SPCBs) of Andhra Pradesh and Telangana	<ul style="list-style-type: none">• plan and execute programs for the prevention, control and abatement of water and air pollution• Provide technical services to respective state governments
Government	Department of Pharmaceuticals	<ul style="list-style-type: none">• Formulate and implement policies relating to drugs and pharmaceuticals, dyestuff and dye intermediates
Government	Department of Biotechnology	<ul style="list-style-type: none">• Administrating development and commercialisation in the field of modern biology and biotechnology in India
Government	Ministry of Health	<ul style="list-style-type: none">• Develop policies and regulations related to food, health and medicinal research• Implementation of the rules in the country
Government	National Centre for Disease Control	<ul style="list-style-type: none">• Research in epidemiology• Control of communicable diseases• Plan and organize activities in various disease control programs in India
Government	Indian Council for	<ul style="list-style-type: none">• Formulation, coordination and promotion of



Category	Stakeholder Entity	Overview / Responsibilities
	Medical Research	biomedical research
Government	National Green Tribunal	<ul style="list-style-type: none"> Deals in environmental justice for disposal of cases relating to environmental protection and conservation of forests and other natural resources
Industries and Industry Associations	Indian Drug Manufacturers Association (IDMA)	<ul style="list-style-type: none"> Planning and development of pricing, regulations and policies related to pharmaceutical manufacturing Inform the government and public about the industry
Industries and Industry Associations	Indian Pharmaceutical Association (IPA)	<ul style="list-style-type: none"> Promote and publish research in pharmaceutical sector Education and training of members
Industries and Industry Associations	Bulk Drug Manufacturer's Association of India (BDMAI)	<ul style="list-style-type: none"> Represent bulk drug industry in policy making Research, development and education of members on related matters
Industries and Industry Associations	Antimicrobial Resistance Industry Alliance (AMRIA)	<ul style="list-style-type: none"> Private sector coalition set up to provide solutions to curb antimicrobial resistance Consists of biotech, diagnostics, generics and research-based pharmaceutical companies and associations
Industries and Industry Associations	Pharmaceutical Export Promotion Council of India (PharmExcil)	<ul style="list-style-type: none"> Represent and suggest Govt on policies related to pharmaceutical exports Certifications for export of pharmaceuticals Promote education and trade
Industries and Industry Associations	Organization Of Pharmaceutical Producers of India (OPPI)	<ul style="list-style-type: none"> Represents the research-based pharmaceutical companies in India
Industries and Industry Associations	Confederation of Indian Industry (CII)	<ul style="list-style-type: none"> Association of Indian industry to promote growth and development Spread awareness on quality, environment, energy management, and consumer protection among industries



Category	Stakeholder Entity	Overview / Responsibilities
		<ul style="list-style-type: none"> Address needs of special and small sector
Industries and Industry Associations	Dr. Reddy's Laboratories	<ul style="list-style-type: none"> One of the major Indian multinational pharmaceutical company based in Telangana Vocal about the efforts required to contain AMR and contribute through various industrial associations and groups
Industries and Industry Associations	Aurobindo Pharma	<ul style="list-style-type: none"> One of the major Indian multinational pharmaceutical company based in Telangana Vocal about the efforts required to contain AMR and contribute through various industrial associations and groups
Industries and Industry Associations	Centrient Pharmaceuticals	<ul style="list-style-type: none"> Netherlands based pharmaceutical company having manufacturing units in Punjab and Gujarat Vocal about the efforts required to contain AMR and contribute through various industrial associations and groups
Industries and Industry Associations	Covalent Laboratories	<ul style="list-style-type: none"> One of the major Indian multinational pharmaceutical company based in Telangana Vocal about the efforts required to contain AMR and contribute through various industrial associations and groups
Academic Research Institutes	BITS Hyderabad	<ul style="list-style-type: none"> Academic Institute with a campus in Hyderabad, Telangana Developed a platform called RightBiotic for rapid bacterial culture and antibiotic sensitivity test results suitable for both biological and environmental samples
Academic Research Institutes	National Institutes of Pharmaceutical Education and Research (NIPER), Hyderabad	<ul style="list-style-type: none"> Academic Institute with a campus in Hyderabad, Telangana Conducted several researches in the field of AMR
Academic Research Institutes	IIT Hyderabad	<ul style="list-style-type: none"> Academic Institute in Hyderabad, Telangana Conducted research to explore the role played by Indian rivers in increasing AMR



Category	Stakeholder Entity	Overview / Responsibilities
Academic Research Institutes	IIT Chennai	<ul style="list-style-type: none"> Academic Institute in Chennai, Tamil Nadu Developed a paper-based sensor which can detect antimicrobial pollutants
Academic Research Institutes	University of Hyderabad	<ul style="list-style-type: none"> Academic Institute in Hyderabad, Telangana Conducted a study that reports that AMR is a problem, but it cannot be attributed to the pharma industry.
Academic Research Institutes	IIT Bombay	<ul style="list-style-type: none"> Academic Institute in Mumbai, Maharashtra
Civil Society Organizations	Centre for Science and Environment	<ul style="list-style-type: none"> Public interest research and advocacy organization based in New Delhi Released a publication - "Ethnoveterinary medicine: An alternative to antibiotics for the dairy sector" which involves the use of traditional/herbal preparations in treating diseases of cattle CSE has written several blog articles and publications on AMR
Civil Society Organizations	Veterans Forum	<ul style="list-style-type: none"> Veterans Forum for Transparency in Public Life (VFTPL) is a nonprofit organization of retired Indian armed forces officers The Veterans Forum filed a case in the National Green Tribunal (NGT) against partially treated or untreated wastewater being discharged into the rivers in Baddi, Himachal Pradesh
Civil Society Organizations	Council of EHS Professionals	<ul style="list-style-type: none"> Group formed by the Environment, Health and Safety professionals working across different industries in Hyderabad
International Agencies and Experts	World Organization for Animal Health (WOAH) [formerly OIE]	<ul style="list-style-type: none"> WOAH collects and analyzes scientific information on animal disease control and makes it available to the Member Countries to improve the methods used to control and eradicate these diseases Part of quadripartite AMR multi-stakeholder partnership program



Category	Stakeholder Entity	Overview / Responsibilities
International Agencies and Experts	WHO	<ul style="list-style-type: none"> Provides leadership on global health matters, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends Part of quadripartite AMR multi-stakeholder partnership program
International Agencies and Experts	FAO	<ul style="list-style-type: none"> Works to improve nutrition, agricultural productivity, standard of living in rural populations and contribute to global economic growth Part of quadripartite AMR multi-stakeholder partnership program
International Agencies and Experts	Wellcome Trust	<ul style="list-style-type: none"> Charitable foundation based in London. Funds research, leads policy and advocacy campaigns, and builds global partnerships for improvements in health sector
International Agencies and Experts	UK Research and Innovation (UKRI)	<ul style="list-style-type: none"> A UK based non-departmental public body sponsored by the Department for Business, Energy and Industrial Strategy (BEIS) Supports research and knowledge exchange at higher education institutions Funded and supported various studies related to AMR detection and measurement
International Agencies and Experts	UNEP	<ul style="list-style-type: none"> Global UN organization formed to provide leadership and encourage partnership in caring for the environment to improve quality of life without compromising that of future generations Part of quadripartite AMR multi-stakeholder partnership program
Academic Research Institutes	Centre for Cellular and Molecular Platforms (CCAMP) https://www.ccamp.res.in/india-amr-innovation-hub	<ul style="list-style-type: none"> Part of Department of Biotechnology, Govt that promotes research and innovation in life sciences Develops and provides technology by promoting research, education and training in industry and academia for entrepreneurship



Category	Stakeholder Entity	Overview / Responsibilities
		<ul style="list-style-type: none"><li data-bbox="771 394 1388 457">• Mentoring biotech startups to develop novel antibiotics to tackle AMR



Appendix C: List of stakeholders consulted

List of stakeholders consulted for this report

1. Apoorv Devgan - Member Secretary, Himachal Pradesh Pollution Control Board (HPPCB)
2. Dr. Shanta Datta - Indian Council for Medical Research (ICMR) and Director, National Institute of Cholera and Enteric Diseases (NICED)
3. Steve Brooks - AMR Industry Alliance
4. Vivek Sehgal - Director General, Organisation Of Pharmaceutical Producers of India (OPPI)
5. Thakur Pherwani - Head SHE & Sustainability, Dr. Reddy's Laboratories
6. JVN Reddy - Aurobindo Pharmaceuticals
7. Manjeet Singh - Director of Corporate Sustainability, Centrient Pharmaceuticals
8. Suman Sharma - Centrient Pharmaceuticals
9. Dr. Suparna Mukherji - Professor, IIT Bombay
10. Dr. Soumyo Mukherji - Professor, IIT Bombay
11. Dr. BP Singh - Veterans Forum
12. Tapas Saha - Head, Council of EHS Professionals
13. Sian Williams - Wellcome Trust
14. Dr. Gyanendra Gongal - Senior Public Health Officer, WHO (South East Asia)
15. Nicolai Schaaf - RAMP Platform Manager
16. Jyoti Joshi - AMR Advisor, International Centre for Antimicrobial Resistance Solutions (ICARS)
17. Dr. Brajesh Barse - Director, Confederation of Indian Industry
18. Dr. Srinivas Nanduri, Director, NIPER Hyderabad
19. Dr. Venkata Nageswar, Member of Telangana Pollution Control Board
20. Shakthi Nagappan, CEO, Hyderabad Pharma City Limited



Appendix D: List of engineering consulting companies

Non-exhaustive list of the key engineering consulting companies that actively do business in India

1. Black & Veatch - A global engineering and consulting firm with expertise in the design and construction of wastewater treatment plants.
2. CH2M - A global engineering and consulting firm with expertise in the design and construction of wastewater treatment plants.
3. AECOM - A global engineering and consulting firm with expertise in the design and construction of wastewater treatment plants.
4. Arcadis - A global engineering and consulting firm with expertise in the design and construction of wastewater treatment plants.
5. CDM Smith - A global engineering and consulting firm with expertise in the design and construction of wastewater treatment plants.
6. Jacobs Engineering - A global engineering and consulting firm with expertise in the design and construction of wastewater treatment plants.
7. Louis Berger - A global engineering and consulting firm with expertise in the design and construction of wastewater treatment plants.
8. Mott MacDonald - A global engineering and consulting firm with expertise in the design and construction of wastewater treatment plants.
9. Parsons - A global engineering and consulting firm with expertise in the design and construction of wastewater treatment plants.
10. Ramboll - A global engineering and consulting firm with expertise in the design and construction of wastewater treatment plants.
11. Royal HaskoningDHV - is an independent Dutch consultancy that integrates 140 years of engineering expertise with digital technologies and software solutions.
12. STUP Consultants Private Limited is an Indian engineering consulting firm that provides a range of services in the infrastructure, construction, and engineering sectors.



Appendix E: List of engineering and technology service companies

Non-exhaustive list of the key companies that offer engineering and technologies services for the wastewater sector in India

1. VA Tech Wabag - A global leader in the design and construction of wastewater treatment plants and water management systems.
2. L&T - A large engineering and construction company with a strong presence in the water and wastewater treatment sector.
3. Thermax - A leading provider of water and wastewater treatment solutions, including technologies for the treatment of industrial wastewater.
4. Suez - A global leader in water and wastewater treatment solutions, with a strong presence in the Indian market.
5. Ion Exchange - A leading provider of water treatment solutions, including technologies for the treatment of industrial and municipal wastewater.
6. ACI Aqua - A provider of water and wastewater treatment solutions, including technologies for the treatment of industrial and municipal wastewater.
7. Aquatech - A global leader in water and wastewater treatment solutions, with a strong presence in the Indian market.
8. Ecolab - A global provider of water and wastewater treatment solutions, including technologies for the treatment of industrial wastewater.
9. Veolia - A global leader in water and wastewater treatment solutions, with a strong presence in the Indian market.
10. GE Water - A global provider of water and wastewater treatment solutions, including technologies for the treatment of industrial and municipal wastewater.
11. Siemens - A global provider of water and wastewater treatment solutions, including technologies for the treatment of industrial and municipal wastewater.
12. Murugappa Water Technology & Solutions Pvt Ltd - MWT&S is a leading player in water treatment engineering services in India that specifically focuses on providing solutions to various industrial sectors.
13. Pacques is a Dutch engineering company that specializes in the design and construction of wastewater treatment plants. They have been active in India for several years and focus on delivering projects for various industrial sectors.



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14. Triveni Engineering and Industries Limited is an Indian engineering and infrastructure company that operates in various sectors, including water and wastewater treatment, power generation, and transportation. The company was founded in 1965 and has a presence in more than 20 countries around the world.
 15. Toshiba Water UEM is a joint venture between Toshiba Corporation and UEM Group that specializes in water and wastewater treatment solutions.
 16. Geo Miller is an Indian global engineering and consulting firm that specializes in the design and construction of water and wastewater treatment plants. The company was founded in 1960 and has completed projects in more than 50 countries around the world.
 17. Ramky Enviro Engineers Limited is an Indian engineering and construction company that specializes in the design and construction of water and wastewater treatment plants. The company was founded in 1994 and has completed projects in various countries around the world, including India, the Middle East, and Southeast Asia.
 18. Rochem Separation Systems India Private Limited (RSSI) is an Indian subsidiary of Rochem Separation Systems, a global engineering and consulting firm that specializes in the design and construction of water and wastewater treatment plants.
 19. Arvind Envisol is an Indian engineering and consulting firm that specializes in the design and construction of water and wastewater treatment plants.
 20. Tata Projects Limited is an Indian engineering and construction company that provides a range of services in the infrastructure, power, and industrial sectors.