

Dignity in Delivery:

The Social and Economic Impact of WASH Services in the Brazilian Amazon



**WORKSHOP IN SUSTAINABLE DEVELOPMENT
PRACTICE 2024-2025**

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Executive Summary

This report presents the findings and strategic recommendations from a comprehensive socio-economic impact assessment of water and sanitation services provided by Aegea in the Brazilian Amazon regions of Manaus and Barcarena. The study focuses on evaluating how Aegea's interventions, specifically in water and wastewater services, have impacted local communities, particularly vulnerable populations residing in informal settlements and flood-prone areas.

Aegea, as a key player in Brazil's sanitation sector, aims to improve public health, economic productivity, and community well-being through innovative service delivery. In Manaus and Barcarena, areas previously underserved or affected by deteriorated infrastructure have seen improvements in access to clean water and proper sanitation, contributing significantly to the quality of life for residents.

Key findings of the report include:

- 1. Water Access and Infrastructure:** There have been significant improvements, especially in Manaus, but challenges remain in certain communities in Barcarena, particularly those with informal land tenure. In Manaus, even informal communities are now able to access water, but in Barcarena, issues such as incomplete water connections and reliance on untreated river water continue to affect health outcomes and quality of life.
- 2. Sanitation and Drainage:** While sanitation infrastructure is being gradually introduced, implementation has been marked by uneven planning and affordability concerns. Many low-income areas still lack reliable sewer systems, with human waste often being discharged into nearby streams, exacerbating environmental and public health risks.
- 3. Health and Economic Impact:** The introduction of water and sanitation services has led to tangible health benefits, with reductions in waterborne illnesses and improved hygiene behaviors. Economically, residents report better productivity, fewer work disruptions due to illness, and improved quality of life, particularly for women who manage water collection and sanitation at home.
- 4. Community Engagement and Perceptions:** Community trust in Aegea's services has grown, particularly in Manaus, where the Trata Bem Manaus and Afluentes programs have provided progress and a platform for residents to connect with service providers. However, distrust persists in Barcarena, largely due to the need to accelerate services to

achieve universalization by 2025. Barcarena's infrastructure is being developed at a record pace and promises to bring transformative outcomes once completed.

5. **Gender and Social Inclusion:** Women, as primary caregivers, play a crucial role in household water management. Despite the efforts of water utilities, even in their communities they are often excluded from planning and decision-making processes. The report emphasizes the need for more inclusive and gender-sensitive approaches to service delivery.

The report concludes with strategic recommendations aimed at improving service delivery, enhancing community participation, and addressing the lingering issues of affordability and infrastructure gaps. By adopting a more inclusive and transparent planning process paired with regular socio-economic impact assessments, Aegea can further build trust and ensure that its interventions continue to benefit the most vulnerable populations in the Amazon.

Key Deliverables provided in this report include:

- **Socioeconomic Impact Assessment Framework and Scorecard (Toolkit):** A comprehensive toolkit designed to assess the socio-economic impact of Aegea's water and sanitation services across various metrics.
- **Household Survey Tool and Focus Group Guide:** A revised tool aimed at collecting data to measure the effectiveness of service delivery and its socioeconomic impact on local communities.
- **WhatsApp Community Feedback Survey Template:** A template for gathering real-time feedback from communities through WhatsApp, ensuring a continuous flow of information and enabling adaptive management of services.

This capstone project aligns with Brazil's national sanitation goals and Aegea's commitment to sustainable development and social responsibility, contributing to a broader understanding of how water and sanitation services can drive socio-economic change in underserved regions.

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List of Acronyms

- I. **Aegea**: Aegea Saneamento S.A.
- II. **PMSB**: Plano Municipal de Saneamento Básico (Municipal Basic Sanitation Plan)
- III. **WASH**: Water, Sanitation, and Hygiene
- IV. **PROAMA**: Programa de Água para Manaus (Water Program for Manaus)
- V. **ETEs**: Estações de Tratamento de Esgoto (Sewage Treatment Stations)
- VI. **EEEs**: Estações Elevatórias de Esgoto (Sewage Lift Stations)
- VII. **UASB**: Upflow Anaerobic Sludge Blanket
- VIII. **IBGE**: Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of Geography and Statistics)
- IX. **SINISA**: Sistema Nacional de Informações sobre Saneamento (National System of Sanitation Information)
- X. **MPPA**: Ministério Público do Estado do Pará (Public Ministry of the State of Pará)
- XI. **NGO**: Non-Governmental Organization

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Client Agency

Aegea is a leading private sanitation company in Brazil, founded in 2010 with the goal of improving access to clean water and sanitation for communities throughout the country. Headquartered in São Paulo, Aegea serves over 30 million people across more than 700 municipalities, making it one of the leading providers in Brazil's sanitation sector. The company's operations are driven by a commitment to sustainability, community engagement, and technological innovation, which together form the foundation of its service delivery.

Aegea employs twenty thousand professionals in various regions of Brazil, operating through a network of subsidiaries. This decentralized model allows the company to tailor its services to meet local needs while maintaining high standards of quality and operational efficiency. The team consists of engineers, technicians, sustainability experts, and community engagement specialists who collaborate to design and implement projects. Aegea's governance structure promotes strong local management at field office levels while aligning with strategic directives from its central headquarters.

The company focuses on three core areas of service: (1) potable water supply, (2) sewage collection, and (3) wastewater treatment. By integrating modern technology and innovative practices into its operations, Aegea enhances the efficiency and effectiveness of its service delivery. This dual emphasis on operational excellence and community impact has established Aegea as a leader in addressing Brazil's long-standing sanitation challenges.

Aegea's operations in the Amazon region are particularly significant due to their complexity and alignment with Brazil's updated National Sanitation Law (Law 11.445/2007, revised by Law 14.026/2020), which mandates universal access to clean water and sewage services by 2033. In regions like Manaus, the capital of Amazonas state, these national goals intersect with local realities of environmental fragility and socio-economic vulnerability. Many residents live in stilt houses (*palafitas*) along rivers and streams, where inadequate infrastructure exacerbates public health risks and environmental degradation. These unique living conditions present substantial challenges for implementing sustainable sanitation solutions, which Aegea addresses through tailored, decentralized approaches that consider the region's geographic and cultural specificities.

Aegea has been operating in Manaus since 2018, has over 5,000 employees and serves over 600,000 families with social tariffs, i.e., they pay 50% of the normal sanitation tariff. Over 30,000 families benefit from Tariff 10, i.e., they pay R\$10.00 per month for water and sewage. Since 2013, drinking water services have been universal in Manaus, with over 200,000 people now having access to drinking water for the first time in their lives.

Aegea has been operating in Barcarena, in Pará state, since 2014, preceding its operations in Manaus, which began in 2018. In Barcarena, Aegea is focused on universalizing access to water and wastewater collection and treatment by 2025, significantly ahead of the 2033

deadline established by Brazil's Sanitation Law. This initiative underscores Aegea's commitment to advancing sustainable sanitation solutions and improving public health in the Amazon region. Additionally, Barcarena's progress serves as a key reference point for Aegea's broader sanitation efforts, including those showcased at COP30 in Belém in 2025.

In Manaus, the company Águas de Manaus launched the Trata Bem Manaus program with the aim of accelerating sewage collection and treatment services and complying with Brazilian legislation to provide sewage services to 90% of the population, including indigenous communities. More than 1.7 million people will be included in the sewage service and 36 more Wastewater Treatment Plants (ETEs – Estações de Tratamento de Esgoto) will be built.

In Barcarena, the company Águas de São Francisco has made a great effort and now serves 82% of the population with drinking water coverage and 33% with sewage collection and treatment coverage. More than 10 thousand people benefit from social tariffs. Recently, the concessionaire launched the Tariff 10 program, for even lower-income families, and the Trata Bem Barcarena program, which foresees the construction of almost 300 km of sewage networks and 6 new Treatment Plants (ETEs).

The Aegea Institute serves as the company's social responsibility arm, dedicated to fostering positive social, economic, and environmental outcomes in the communities it serves. Often referred to as Aegea's social intelligence center, the Institute develops and implements programs that address critical local needs, such as health, education, income generation, workforce development, entrepreneurship, and support for local community projects. It also conducts research and collaborates with academic institutions to assess the long-term impacts of sanitation services on community well-being.

Aegea's initiatives align closely with the objectives of the workshop project, which aims to evaluate the social and economic impacts of water and sanitation in the Brazilian Amazon region. The company's focus on vulnerable communities in Manaus and Barcarena presents an opportunity to study real-world applications of sanitation services and their effects on public health, education, and economic productivity. Additionally, Aegea's interest in adopting artificial intelligence to optimize service delivery and monitoring complements the project's exploration of innovative solutions.

Aegea's operations are guided by its sustainability policy, which emphasizes the balance between environmental preservation, social equity, and economic efficiency. This commitment supports its broader mission to universalize access to water and sanitation in the municipalities where the company operates, in alignment with national development goals. Through its integrated approach, Aegea demonstrates how private sector leadership can effectively address public health and environmental challenges.

Background

I. Introduction to Brazil

Geographical and Environmental Overview

Brazil, the largest and most populous country in South America, spans a vast and diverse landscape that includes the Amazon rainforest, the Pantanal wetlands, and the Brazilian Highlands. The Amazon Basin, which occupies more than 60% of the country, is home to unparalleled biodiversity but faces significant deforestation challenges, losing approximately 52,000 square miles annually. The Brazilian Highlands dominate the southeastern region, characterized by extensive uplands that drop steeply at the Atlantic Coast, forming the Great Escarpment. Brazil's climate is predominantly tropical or subtropical, with a humid environment and a rainy season during the summer months. While much of the country is lush and wet, eastern regions frequently suffer from drought.¹

The ongoing drought in the Amazon has emerged as one of Brazil's most pressing environmental crises, with far-reaching consequences for its ecosystems, economy, and people. Driven by a combination of climate change, deforestation, and intensified El Niño patterns, the drought has led to historically low water levels in the Amazon River and its tributaries, disrupting transportation, isolating remote communities, and threatening freshwater supplies. Prolonged dry conditions have fueled devastating wildfires, releasing vast amounts of carbon dioxide and diminishing the rainforest's ability to act as a carbon sink—accelerating global warming. The Amazon's biodiversity is also under siege, as aquatic species, including river dolphins and fish vital for local livelihoods, struggle to survive in shrinking waterways. For Brazil, a country heavily reliant on hydropower, reduced rainfall has caused significant energy production declines, leading to rationing and blackouts that ripple through industries and households alike. The Amazon drought underscores the delicate balance between Brazil's natural resources and its economic stability, highlighting the urgent need for sustainable policies to mitigate climate impacts and protect this vital ecosystem.

Brazil's geographic position near the center of the South American Plate means it experiences little seismic or volcanic activity, contributing to the stability of its natural landscape.² The country's strategic location allows it to share borders with nearly every South American nation except Ecuador and Chile, making it a central player in regional geopolitics. Administratively, Brazil is divided into 26 states and the Federal District, which houses the capital city, Brasília, a master-planned urban center built on the Mato Grosso plateaus in the late 1950s.³

¹ Encyclopaedia Britannica, "Climate of Brazil," Encyclopaedia Britannica, last modified March 22, 2024, <https://www.britannica.com/place/Brazil/Climate> (accessed December 1, 2024).

² Matt Rosenberg, "Geography, Politics, and Economy of Brazil," ThoughtCo, March 2, 2019, <https://www.thoughtco.com/geography-of-brazil-1435538> (accessed November 23, 2024).

³ Central Intelligence Agency (CIA), "Brazil," The World Factbook, April 30, 2024, <https://www.cia.gov/the-world-factbook/countries/brazil/> (accessed November 17, 2024).

Economic Landscape

As the 10th largest economy in the world, Brazil is a major player in global markets, driven by its robust agriculture, mining, energy, and services sectors. The country has achieved significant growth, with its real GDP expanding by 2.9% in 2023. However, systemic challenges, including a complex tax system, limited infrastructure investment, and barriers to entrepreneurship, hinder long-term development. Inequality remains a persistent issue, particularly in rural areas and among marginalized populations.⁴

Afro-Brazilians, Indigenous Peoples, and women disproportionately experience systemic barriers, including unequal access to quality education, healthcare, and employment opportunities. Brazil's Human Capital Index underscores these disparities, with children in some regions achieving only 55% of their potential productivity due to gaps in health and education. The economic divide is also stark geographically, with the wealthier Southeast region enjoying OECD-level metrics, while the North and Northeast regions lag behind, comparable to Sub-Saharan Africa in some areas.⁵

Political Landscape

Brazil operates under a federal presidential republic with a decentralized governance system that divides responsibilities between federal, state, and municipal levels. While this structure supports localized decision-making, it often leads to inefficiencies and disparities in service delivery.⁶ Recent decades have seen political turbulence, including corruption scandals and the impeachment of former President Dilma Rousseff. Operation Lava Jato exposed a vast corruption scheme that implicated numerous high-profile politicians, highlighting the challenges of governance and accountability.⁷

Following Operation Lava Jato, Brazil's political landscape experienced further polarization, culminating in the election of Jair Bolsonaro in 2018. Environmental degradation escalated under Bolsonaro's tenure, particularly in the Amazon rainforest. His administration weakened environmental regulations, reduced funding for enforcement agencies like IBAMA, and encouraged economic exploitation of protected areas.⁸ Deforestation rates in the Amazon surged by 75% during his first three years in office compared to the previous decade, reaching a peak of 13,235 square kilometers in 2021 — the highest annual figure since 2006.⁹

⁴ World Bank, "Brazil Overview," October 4, 2023, <https://www.worldbank.org/en/country/brazil/overview> (accessed November 27, 2024).

⁵ World Bank, "Brazil Overview".

⁶ Freedom House, "Brazil," *Freedom in the World 2024*, 2024, <https://freedomhouse.org/country/brazil/freedom-world/2024> (accessed November 11, 2024).

⁷ BTI Project, "Brazil Country Report," n.d., <https://bti-project.org/en/reports/country-report/BRA> (accessed November 14, 2024).

⁸ IBAMA stands for the, or the Brazilian Institute of Environment and Renewable Natural Resources. It is Brazil's federal environmental protection agency, established in 1989.

⁹ Greenpeace International, "Deforestation in Brazil's Amazon Surged Under Bolsonaro: Can Lula Turn It Around?" December 2, 2022, <https://www.greenpeace.org/international/story/57219/brazil-amazon-deforestation-2022-bolsonaro-lula/> (accessed November 14, 2024).

Despite these difficulties, Brazil has positioned itself as a leader in sustainable development and climate action under President Luiz Inácio Lula da Silva. Recent initiatives aim to balance economic growth with environmental stewardship, promoting green energy, reforestation, and poverty alleviation efforts.

Social and Demographic Landscape

Brazil's population of over 203 million people reflects a variety of ethnicities, cultures, and socioeconomic backgrounds. Rapid urbanization has transformed cities while also exacerbating inequalities. Informal settlements, or favelas, are common in urban areas, where residents face limited access to clean water, sanitation, education, and healthcare.¹⁰

In the Amazonas state region, these challenges are particularly acute. Manaus faces a significant sanitation deficit. While 99.5% of the population has access to treated water, only 33% are connected to a sewage collection system. This disparity contributes to the prevalence of waterborne diseases and public health problems in the region. However, these investments in sanitation have been steadily increasing, with the municipality investing R\$23.11 million in 2012, rising to R\$215.54 million by 2022, showing the growing recognition of the need to improve sanitation infrastructure. In Manaus, hospitalizations for diarrhea fell by 39% in the last three years, dropping from 99,974 to 60,958 cases, according to the Fundação de Vigilância em Saúde do Amazonas. These improvements were achieved through expanding treated water access to over 400,000 people in areas like still houses (palafitas), alleyways, and rip raps, with inclusion under the social tariff program.¹¹

Despite such advancements in Manaus, poverty and poor sanitation remain widespread in the North. In the Vale do Rio Purus (Amazonas state), 66% of the population lives in poverty, a figure far exceeding the national average of 27.4%. Similarly, 62.3% of people in the Manaus Metropolitan Area face similar conditions. Sanitation coverage further highlights the disparity: while the Southeast region boasts 86.2% of its population in homes with sewage collection, the North lags far behind, with a rate of just 22.8%. Among states, São Paulo has the highest coverage at 90.8%, while Amapá ranks the lowest at 11.0%. These figures underscore the stark inequalities in living conditions between regions, with the North remaining disproportionately affected.

II. Brazil's Governance and Public Service Delivery

Decentralized Governance System

Brazil operates as a federal presidential republic, with power distributed across the executive, legislative, and judicial branches. The president serves as both the head of state and government, while legislative authority rests with the bicameral National Congress, comprising the Chamber of Deputies and the Senate. Judicial oversight is provided by the Supreme Federal

¹⁰ World Bank, "Brazil Overview".

¹¹ World Bank, "Brazil Overview".

Court. This structure, mirroring the U.S. system, emphasizes a balance of power among branches, allowing for checks and balances within governance.¹²

The country is further divided into 26 states and a Federal District, each with its own government. This federal structure grants significant autonomy to states and municipalities, enabling localized policies tailored to community needs. However, it also results in disparities in public service quality, with wealthier regions like the Southeast benefiting from better infrastructure and resources compared to poorer regions such as the North and Northeast since poorer states financially rely more on the federal government rather than on their own local tax collection.¹³ Municipalities in resource-constrained areas often lack the capacity and have more limited resources to address basic needs like clean water and sanitation, creating significant inequalities in service access.¹⁴

In recent years, Brazil has sought to modernize governance through the digitalization of public services. The *gov.br* platform serves as a unified portal offering access to thousands of services, with approximately 140 million users by 2022.¹⁵ Recognized as one of the world's leading digital government initiatives, the platform demonstrates the potential of technology to improve service delivery. However, gaps in infrastructure and digital literacy in less developed regions limit its effectiveness.

Public vs. Private Sector Involvement

Public-private partnerships (PPPs) have become a cornerstone of Brazil's strategy to modernize infrastructure and improve public service delivery. Introduced during the neoliberal reform wave of the mid-1990s, PPPs aim to leverage private sector expertise while maintaining state oversight. Brazil's PPP Law (Law No. 11.079/2004) provides a legal framework for these partnerships, including mechanisms like sponsored concessions, where public funds complement user fees, and administrative concessions, where the government is the primary funder.¹⁶ This approach balances public interest with private profitability, ensuring that critical infrastructure projects receive adequate investment.

PPPs have been employed across sectors such as transportation, energy, sanitation, and public health, fostering innovation and improving service quality. Notable successes include public lighting projects and sanitation initiatives, which have enabled municipalities to expand infrastructure coverage. However, challenges persist. Critics highlight issues like limited

¹² Chatham House, "Democracy in Brazil," August 2022, <https://www.chathamhouse.org/2022/08/democracy-brazil> (accessed November 20, 2024).

¹³ T. H. C. Silva and J. C. Gonçalves Neto, "Partnerships Between Public and Private Sectors in Brazil: Towards Efficiency?" *Revista Eletrônica Direito e Sociedade* 11, no. 2 (2023): 01–21, <https://doi.org/10.18316/REDES.v11i2.9299>.

¹⁴ Chatham House, "Democracy in Brazil."

¹⁵ Agência Brasil, "Brazil: One of the World Leaders in Digitization of Public Services," November 2022, <https://agenciabrasil.ebc.com.br/en/geral/noticia/2022-11/brazil-one-world-leaders-digitization-public-services> (accessed December 3, 2024).

¹⁶ Silva and Gonçalves Neto, "Partnerships Between Public and Private Sectors in Brazil."

transparency, inadequate oversight, and the tendency of PPPs to focus on profitable urban areas at the expense of rural and underserved communities.¹⁷

III. Water, Sanitation, and Hygiene (WASH) Issues in Brazil

Overview of WASH Challenges

A large portion of Brazil's population still lacks reliable access to potable water and sewage collection, despite significant advances in urban areas.¹⁸ In fact, nearly 15% of Brazil's population lacks access to clean drinking water, and more than 50% in the Amazonas state does not have access to sewage treatment.¹⁹ These gaps are often felt most acutely in the northern and northeastern parts of the country, which are the poorest regions.

Vulnerable populations, especially those living in informal settlements or slum areas, face the greatest barriers to accessing clean water and sanitation. Women and girls are disproportionately affected, as they often bear the responsibility of collecting water in areas without reliable access, exposing them to safety risks and reducing their time for education and economic activities.²⁰ In addition, women are also usually the caregivers when children or elderly are sick, due to bad water quality. The challenges are further exacerbated by rapid urbanization, particularly in cities like Manaus, where population growth continues to outpace the development of necessary infrastructure.²¹ These inequities exacerbate health risks, especially in low-income and rural areas where communities often rely on unsafe water sources.

Public perception of governance further complicates service delivery in Brazil, as many citizens express skepticism toward institutional effectiveness. According to a 2024 Pew Research Center survey, Brazilians have mixed views of institutions, with significant skepticism toward the court system.²² Digitalization and reform efforts aim to rebuild trust and improve efficiency, but challenges remain in aligning public expectations with institutional performance. Similarly, the

¹⁷ Silva and Gonçalves Neto, "Partnerships Between Public and Private Sectors in Brazil."

¹⁸ Agência Brasil, "More Than 50% of Brazilians Do Not Have Access to Sewage Networks," December 2021, <https://agenciabrasil.ebc.com.br/en/geral/noticia/2021-12/more-50-brazilians-do-not-have-access-sewage-networks-says-mdr> (accessed November 27, 2024).

¹⁹ Trata Brasil, *Life Without Sanitation: Who Lacks It and Where Does This Population Live?*, February 2024, <https://tratabrasil.org.br/wp-content/uploads/2024/02/Life-without-Sanitation-Who-Lacks-It-and-Where-Does-This-Population-Live.pdf> (accessed November 27, 2024).

²⁰ UNICEF, "Women and Girls Bear the Brunt of Water and Sanitation Crisis," 2022, <https://www.unicef.org/press-releases/women-and-girls-bear-brunt-water-and-sanitation-crisis-new-unicef-who-report> (accessed December 1, 2024).

²¹ Inter-American Development Bank, *Facing the Challenges of Informal Settlements in Urban Centers: The Re-Urbanization of Manaus, Brazil*, 2020, <https://webimages.iadb.org/publications/english/document/Facing-the-Challenges-of-Informal-Settlements-in-Urban-Centers--The-Re-urbanization-of-Manaus-Brazil.pdf> (accessed December 1, 2024).

²² Pew Research Center, "Brazilians' Views of Institutions and Government Systems," September 23, 2024, <https://www.pewresearch.org/global/2024/09/23/brazilians-views-of-institutions-and-government-systems> (accessed November 11, 2024).

decentralized governance of WASH services, primarily managed by municipalities, exacerbates these challenges. Programs like the Social Tariff, offering a 50% discount on water and sanitation bills for vulnerable families, and the "10 Tariff," which charges just BRL 10.00 for extremely vulnerable families, aim to address inequities. These programs are assessed by comparing service expansion to concession agreement milestones and analyzing the number of beneficiaries relative to Bolsa Família recipients. Despite these efforts, uneven implementation highlights the need for stronger coordination and investment to ensure universal and equitable access to WASH services. It is worth emphasizing that it is not enough for the concessionaire to want to expand these possibilities even further; approval by the local City Hall and the Sanitation Services Regulatory Agency is essential, due to the financial balance of the contract.

Health-Related Issues

The lack of access to clean water and sanitation services has severe health implications for many Brazilians. Waterborne diseases such as cholera, dysentery, and gastrointestinal infections are widespread in areas lacking adequate sanitation systems.²³ In informal settlements, where many residents are forced to rely on contaminated water sources, these health problems are even more pronounced. Poor sanitation, often coupled with inadequate waste management, leads to the transmission of diseases, further exacerbating public health challenges. For example, in the Northeastern and Amazon regions, communities that lack proper sewage systems are especially vulnerable to diseases such as leptospirosis and diarrhea, particularly among vulnerable populations such as children and the elderly.²⁴ The IBGE's Sanitation Atlas highlights that, between 2008 and 2019, diseases related to poor environmental sanitation accounted for approximately 0.9% of all deaths in Brazil, with Chagas disease being the most prevalent. Notably, in the Central West and Northeast regions, these diseases represented 42.9% and 27.1% of deaths from infectious and parasitic diseases, respectively.²⁵

In addition, there is insufficient education about the importance of clean water access, hygiene practices, and the health risks associated with contaminated water. This lack of awareness is a significant barrier to improving public health outcomes. In areas where sanitation services are scarce or unreliable, residents may not fully understand the risks of unsafe water and poor hygiene practices. This, in turn, leads to continued unsafe water consumption and poor sanitation practices, reinforcing the cycle of disease and poor health. Community education efforts focusing on the risks of contaminated water and the benefits of proper sanitation are essential for improving health outcomes, in these areas.

²³ World Health Organization, "Drinking Water," n.d., <https://www.who.int/news-room/fact-sheets/detail/drinking-water> (accessed November 23, 2024).

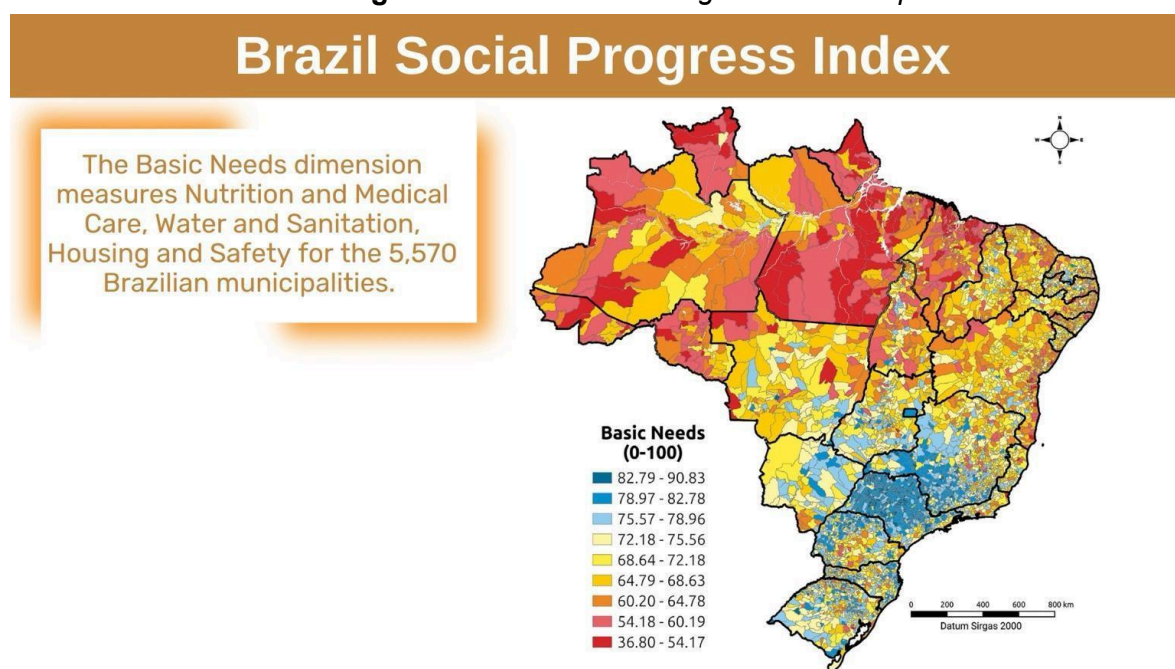
²⁴ H. Khalil et al., "Poverty, Sanitation, and Leptospira Transmission Pathways in Residents from Four Brazilian Slums," *PLOS Neglected Tropical Diseases* 15 (2021): e0009256, <https://doi.org/10.1371/journal.pntd.0009256>.

²⁵ Instituto Brasileiro de Geografia e Estatística (IBGE), "Sanitation Atlas Spatializes Data on the Environment and Health," IBGE, November 26, 2021, <https://nada.ibge.gov.br/en/agencia-news/2184-news-agency/news/32325-sanitation-atlas-spatializes-data-on-the-environment-and-health>? (accessed November 23, 2024).

Geographic and Social Inequities

Inequities in water and sanitation services in Brazil are deeply influenced by geographic, socio-economic, racial, and regional disparities. The northern and northeastern regions, home to the country's poorest populations, suffer from the worst access to WASH services. These areas are often characterized by a lack of infrastructure, compounded by limited government investment in these remote and rural regions.²⁶ Meanwhile, informal housing communities in major cities like Rio de Janeiro continue to lack access to basic sanitation services, leaving residents more vulnerable to diseases associated with poor sanitation. Rapid urbanization, especially in cities like Manaus, has created additional pressure on water and sanitation services, exacerbating existing inequities and making it harder to meet the needs of these growing populations. A thematic map from the Social Progress Index visually depicts these regional disparities, illustrating the uneven social and economic conditions that influence access to vital services. Community education efforts focusing on the risks of contaminated water and the benefits of adequate sanitation are essential to improving health outcomes and convincing families of the need to connect their homes to water and sewage collection networks.

Figure 1. Brazil Social Progress Index Map



Source: Social Progress Imperative. n.d. "Brazil Social Progress Index."²⁷

²⁶ Agência de Notícias IBGE, "North and Northeast Have Limited Access to Basic Sanitation," n.d., <https://agenciadenoticias.ibge.gov.br/en/agencia-news/2184-news-agency/news/20992-north-and-northeast-have-limited-access-to-basic-sanitation> (accessed November 23, 2024).

²⁷ Social Progress Imperative, "Brazil Social Progress Index," n.d., <https://www.socialprogress.org/thematic-webpages/brazil-social-progress-index> (accessed November 23, 2024).

Impact of Climate Change and Environmental Factors

Climate change has exacerbated water scarcity in Brazil, with extreme weather events such as droughts and flooding significantly affecting water quality and availability, particularly in the Amazon region.²⁸ The Rio Negro, a key water source for the city of Manaus, has seen historically low water levels in recent years due to prolonged droughts, which has led to water supply shortages.²⁹ Furthermore, environmental degradation, such as deforestation in the Amazon, impacts water sources by reducing the natural filtration systems provided by forests.³⁰ This environmental degradation further compounds the difficulties in providing safe water and sanitation services to vulnerable communities, particularly in remote and rural areas.

IV. WASH and Development Goals

Policy Developments and Solutions

In 2020, Brazil enacted a new law that established a target to achieve universal access to potable water (99%) and sewage treatment (90%) by 2033.³¹ This law was designed to reduce regional disparities and attract private investment into the WASH sector.³² While this law provides a clear framework for addressing water and sanitation issues, achieving these ambitious targets, particularly in remote and underserved regions, remains a significant challenge. Brazil's complex political landscape and decentralized governance structure make it difficult to implement large-scale reforms and investments in water and sanitation infrastructure.³³ To address infrastructure gaps, private companies like Aegea have entered the WASH sector, particularly in underserved municipalities. Aegea's involvement in Manaus, for example, has focused on improving water access through innovative infrastructure solutions.

²⁸ Nic Gedney, Conrado Rudorff, and Richard A. Betts, "Future Amazon Basin Wetland Hydrology under Projected Climate Change," *PLOS Water*, September 30, 2024, <https://doi.org/10.1371/journal.pwat.0000225>.

²⁹ NASA Earth Observatory, "Drought on the Rio Negro," n.d., <https://earthobservatory.nasa.gov/images/151961/drought-on-the-rio-negro> (accessed November 23, 2024).

³⁰ P. Tovar, M. O. Adarme, and R. Q. Feitosa, "Deforestation Detection in the Amazon Rainforest with Spatial and Channel Attention Mechanisms," *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XLIII-B3-2021 (June 2021): 851–858, <https://doi.org/10.5194/isprs-archives-XLIII-B3-2021-851-2021>.

³¹ Government of Brazil, "New Legislation Facilitates Private Investments in Basic Sanitation in Brazil," 2022, <https://www.gov.br/en/government-of-brazil/latest-news/2022/new-legislation-facilitates-private-investments-in-basic-sanitation-in-brazil> (accessed November 23, 2024).

³² Organisation for Economic Co-operation and Development (OECD), "Driving Performance at Brazil's National Agency for Water and Basic Sanitation," 2024, https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/06/driving-performance-at-brazil-s-national-agency-for-water-and-basic-sanitation_a5eb3264/5b7dffa0-en.pdf (accessed November 23, 2024).

³³ P. R. P. Sampaio and R. S. R. Sampaio, "The Challenges of Regulating Water and Sanitation Tariffs under a Three-Level Shared-Authority Federalism Model: The Case of Brazil," *Utilities Policy* 64 (2020): 101049, <https://doi.org/10.1016/j.jup.2020.101049>.

Private sector involvement is seen as a way to improve service delivery and attract investment, particularly in rural and hard-to-reach areas where government resources are often limited. In addition to public-private partnerships, non-governmental organizations (NGOs) continue to play a crucial role in advocating for improved WASH access in Brazil and working directly with communities to raise awareness about hygiene and sanitation practices. Many NGOs focus on addressing the root causes of water and sanitation issues, such as environmental degradation and lack of education.³⁴ Collaboration between government, private companies, and civil society organizations is essential for achieving sustainable improvements in water and sanitation access across Brazil.

Rationale

This capstone research project is critical to addressing the quality of life and well-being of vulnerable communities in the Brazilian Amazon region. Placing emphasis on the city of Manaus and Barcarena, a hub of economic and social activity but also home to marginalized populations living in precarious conditions, the research directly meets the clients need to assess the broader impacts of their interventions. The project aligns directly with Aegea's core mission, reinforcing its longstanding strategic goal of sustainability and community engagement by providing essential sanitation services to the region. Through research and analysis, the findings provide a scientific foundation for evaluating the success of the services in improving public health, economic productivity, education levels, and environmental needs.

The relevance of this project advances beyond Aegea's operational objectives, aligning closely with Brazil's national commitment to universalize access to drinking water and sanitation by the year 2033. As the largest private sanitation company in Brazil, Aegea serves over 33 million people across more than 500 municipalities in 15 states. With its significant reach and a reported pro forma net revenue of R\$10.4 billion for the first nine months of 2023, the company plays a pivotal role in advancing the country's sanitation goals.³⁵ This makes the development of a rigorous socio-economic impact assessment methodology both timely and essential. Understanding how access to sanitation is transforming vulnerable communities will guide Aegea's strategic planning and ensure that its investments deliver maximum value to both the communities it serves and stakeholders. This research project will also contribute to Brazil's broader sustainable development agenda by addressing social inequalities and fostering environmental sustainability.

The inclusion of artificial intelligence in this project underscores Aegea's innovative approach to addressing systemic challenges in water and sanitation service delivery, mirroring broader

³⁴ UNICEF Brazil, *Policy Brief: WASH in Response to COVID-19*, 2020, <https://www.unicef.org/brazil/media/9746/file/policy-brief-wash-in-response-to-covid-19.pdf> (accessed December 3, 2024).

³⁵ Aegea Saneamento, *Earnings Release 3Q23 and 9M23*, 2023, <https://api.mziq.com/mzfilemanager/v2/d/9aa4d8c5-604a-4097-acc9-2d8be8f71593/4b04d1f8-29bb-b6de-4738-0899ebea6b73?origin=1> (accessed April 14, 2025).

trends in Latin America where AI tools, such as the Inter-American Development Bank's Pavimentados platform, are enhancing infrastructure resilience and efficiency.³⁶ By exploring how AI tools can enhance the efficiency, accessibility, and monitoring of these services, the project aligns with Aegea's sustainability policy, which emphasizes continuous improvement and the adoption of cutting-edge technologies. The relevance of this research is amplified by its potential scalability, as the findings will not only enhance service delivery in Manaus but could also serve as a model for other regions, such as Barcarena, where Aegea is advancing the timeline for the universalization of services by 2033 (as outlined by the Sanitation Law), ahead of the COP30 climate summit.

Finally, this project is an opportunity to address immediate service needs while contributing to Aegea's long-term mission of narrowing social gaps and fostering sustainable development. By combining scientific rigor with innovative tools, the findings will empower Aegea to better serve vulnerable communities, strengthen its role as a leader in Brazil's sanitation sector, and contribute to global efforts in sustainable water and sanitation management.

Objectives

The main objective of this project is to assess the social and economic improvements resulting from Aegea's water and sanitation services in Manaus and Barcarena, with a particular focus on vulnerable populations living in palafitas and other low-income communities. The study delves into the local perceptions of Aegea as a service provider by the communities it serves, examining how improved access to water and sanitation has affected residents' lives, particularly in terms of health, education, productivity, and overall well-being.

The second objective is to explore how artificial intelligence (AI) can be harnessed to enhance the delivery of water and sanitation services to vulnerable communities. While Aegea already utilizes predictive statistical modeling and automation tools on the supply side in Manaus, this study considers opportunities to expand AI applications on the policy and consumer sides. This includes the potential of using AI to support planning and decision-making processes and developing feedback mechanisms to ensure community needs and concerns are effectively addressed.

The third objective is to provide actionable recommendations for improving Aegea's water and sanitation services. Firstly we develop a comprehensive framework to evaluate the economic and social effects of its services in Manaus and Barcarena. The project was locally hosted by Águas de São Francisco and Águas de Manaus, local concessionaires operated by the Aegea Saneamento group through local partnerships to manage and expand water and sanitation services in Barcarena and Manaus, respectively. The aim is for the toolkit to be flexible to

³⁶ Valor Econômico, "Saneamento em Manaus Avança Com Investimentos de Mais de R\$ 500 Milhões," December 23, 2021, <https://valor.globo.com/patrocinado/aegea/noticia/2021/12/23/saneamento-em-manaus-avanca-com-investimentos-de-mais-de-r-500-milhoes.ghtml> (accessed November 11, 2024).

facilitate its use in other regions where Aegea operates as well. Then by looking at the larger picture to identify Aegea's contribution to the broader goal of achieving universal access to water and sanitation in the Brazilian Amazon. This analysis will help identify existing gaps in service delivery and areas for further improvement in the future and long term.

Finally, the project aims to support Aegea's strategic planning and contribute to its preparations for the COP30 climate summit in Belém. The research provides insights that demonstrate Aegea's commitment to sustainable development by highlighting both the immediate impacts of its services and its innovative approaches to incorporate technology. This will equip Aegea to develop strategies necessary to reinforce its leadership in Brazil's water and sanitation sector and continue advancing healthier, more inclusive communities.

Methodology

I. Research Framework

Research Questions

The research questions for this study are as follows:

- What are the social and economic improvements from the water and sanitation services in Manaus and Barcarena?
- What is the community perception of water and sanitation services by Aegea, especially low-income communities in urban areas of Manaus and Barcarena?
- How can artificial intelligence be used to improve the delivery of water and sanitation services to vulnerable communities?
- What are the key steps for a socio-economic impact assessment of water and sanitation services that can inform a replicable framework for Aegea?

Research Framework

The proposed research framework follows a multi-component approach designed to generate actionable insights and tools for Aegea's future WASH strategies. It is organized around four interrelated components, culminating in the development of a replicable socio-economic impact assessment toolkit.

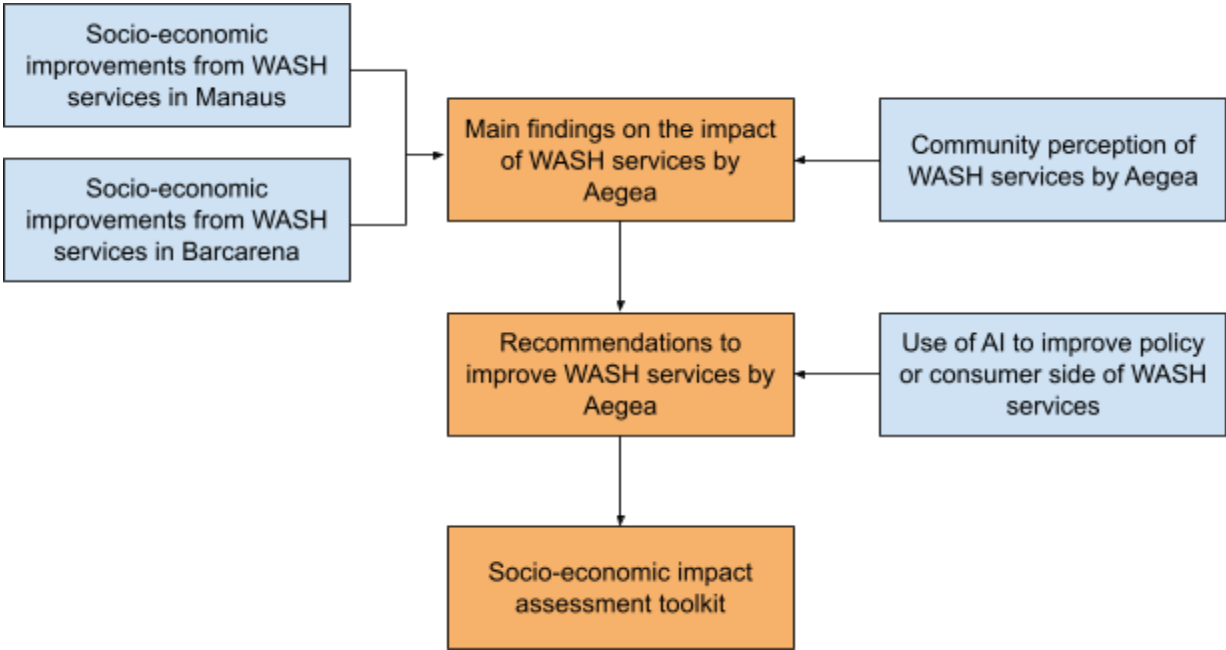
The first phase involved assessing socio-economic improvements from WASH services in Manaus and Barcarena, focusing on measurable outcomes such as public health, economic productivity, and overall well-being. These two locations serve as case studies to compare the impacts of Aegea's interventions across different urban contexts.

Simultaneously, the team gathered data on community perceptions, especially from low-income urban populations, to understand public sentiment and capture lived experiences with Aegea's services. These perspectives will enrich the interpretation of socio-economic outcomes and help contextualize the qualitative findings.

Together, these findings were synthesized into the main analysis of Aegea’s impact on social and economic conditions, which inform a set of recommendations for improving WASH service delivery. In parallel, the research examines how artificial intelligence (AI) can support more equitable and efficient WASH services, either through improving strategic decision making or enhancing consumer experience.

The final deliverable, contained in Appendix M, is a socio-economic impact assessment toolkit that consolidates the study’s methodology, evaluation indicators, and implementation steps. Crucially, the toolkit will incorporate lessons learned and best practices identified throughout the research process, making it a flexible and scalable resource that Aegea and the Aegea Institute can use to assess and improve WASH programs across other service areas and time periods.

Figure 2. Proposed Research Framework



(Source: Own elaboration)

II. Key Concepts and Conceptual Framework

Sanitation Ladder

The JMP sanitation ladder³⁷ provides a globally standardized classification system to benchmark and compare sanitation service levels across countries, making it a critical tool for

³⁷ Joint Monitoring Programme (JMP) for Water Supply, Sanitation and Hygiene, "Sanitation," WHO/UNICEF, n.d., <https://washdata.org/monitoring/sanitation> (accessed December 3, 2024).

monitoring progress toward achieving the Sustainable Development Goals (SDGs). The ladder consists of five levels:

- **Safely managed**, which refers to the use of improved facilities that are not shared with other households, where excreta are safely disposed of in situ or treated offsite
- **Basic**, which includes improved facilities not shared with other households but without safe excreta management
- **Limited**, which involves improved facilities shared between households
- **Unimproved**, which includes pit latrines without a slab, hanging latrines, or bucket latrines
- **Open defecation**, where human waste is disposed of in open areas

This classification system is integral to global monitoring frameworks, including SDG target 6.2 in achieving access to adequate and equitable sanitation and hygiene and ending open defecation, paying special attention to the needs of women and girls and those in vulnerable situations. This project uses these JMP sanitation ladder classifications as a reference point to assess and evaluate sanitation services in Manaus and Barcarena.

Drinking Water Ladder

The JMP drinking water ladder³⁸ provides a globally standardized framework to assess and compare levels of drinking water service across countries, supporting progress monitoring toward Sustainable Development Goal (SDG) target 6.1: universal and equitable access to safe and affordable drinking water for all. The ladder consists of five service levels:

- **Safely managed**, which refers to the use of improved drinking water sources that are located on premises, available when needed, and free from faecal and priority chemical contamination
- **Basic**, which includes improved sources that are accessible within a 30-minute round trip, including queuing
- **Limited**, which refers to improved sources that require more than 30 minutes per round trip to collect water
- **Unimproved**, which includes unprotected dug wells or unprotected springs that do not adequately protect against contamination
- **Surface water**, where water is collected directly from bodies such as rivers, lakes, ponds, or irrigation canals without treatment or protection

This classification system is essential to global monitoring frameworks and allows stakeholders to track disparities and progress in access to clean drinking water. This project uses the JMP drinking water ladder as a reference to evaluate service levels in Manaus and Barcarena and to analyze the extent to which residents, particularly in vulnerable areas, are accessing safely managed drinking water services.

³⁸ Joint Monitoring Programme (JMP) for Water Supply, Sanitation and Hygiene, "Drinking Water," WHO/UNICEF, n.d., <https://washdata.org/monitoring/drinking-water> (accessed December 3, 2024).

Sanitation Service Chain

Safely managed sanitation is achieved when all parts of the sanitation service chain are effectively fulfilled, ensuring hygienic practices and environmental safety.³⁹ The sanitation service chain consists of four key steps:

1. **Containment:** which involves capturing excreta in facilities such as septic tanks or sewer-connected toilets
2. **Transport/conveyance:** where the excreta is safely removed or conveyed via trucks or sewer systems to a treatment site
3. **Treatment:** where the waste undergoes processes to reduce pathogens and environmental risks
4. **Disposal/reuse:** where treated waste is either safely disposed of or repurposed, such as in agriculture

This chain is adaptable to both on-site sanitation systems, like septic tanks, and off-site systems, such as piped sewerage networks, ensuring flexibility in achieving safely managed sanitation in diverse urban and rural settings.

Drinking Water Service Chain

Safely managed drinking water is achieved when all components of the drinking water service chain function effectively, ensuring that water remains safe, accessible, and reliable from source to point of use.⁴⁰ The drinking water service chain comprises four key steps:

- **Source:** the origin of the water, which may include protected springs, boreholes, surface water, or piped water systems. To qualify as safely managed, the source must be improved and protected from contamination
- **Abstraction and Treatment:** water is extracted and undergoes treatment to remove microbial and chemical contaminants, ensuring it meets safety standards for human consumption
- **Distribution:** treated water is delivered to users through infrastructure such as pipes, tanks, or water vendors. To be safely managed, water must be available when needed and protected from recontamination during transport
- **Point of Use:** the final step where water is stored and consumed at the household level. Safe storage and handling practices are essential to preserve water quality and avoid recontamination

³⁹ Joint Monitoring Programme (JMP) for Water Supply, Sanitation and Hygiene, *Monitoring Safely Managed On-site Sanitation: Synthesis Report*, 2021, WHO/UNICEF, <https://washdata.org/report/jmp-2021-smoss-synthesis-report> (accessed December 3, 2024).

⁴⁰ U.S. Agency for International Development (USAID), *Safe Water Programming in the WASH Sector: A Conceptual Framework*, 2020, <https://www.globalwaters.org/resources/assets/usability-water-programming-conceptual-framework> (accessed December 3, 2024).

This chain applies to both centralized piped systems and decentralized solutions, such as community-managed water points or household filtration systems. Understanding and strengthening each step in the chain is crucial to achieving universal access to safely managed drinking water, particularly for vulnerable and underserved populations.

Participatory Approach in Water and Sanitation Development

Participatory and community-driven approaches to water and sanitation development emphasize community involvement in decision-making, behavior change, and long-term management. Community-Led Total Sanitation (CLTS), a widely used method, engages communities through facilitated meetings to trigger emotional responses like shame and disgust, driving collective action to eliminate open defecation.⁴¹ Follow-up visits support the community in maintaining behavior changes, achieving high latrine coverage, and obtaining Open Defecation Free certification.⁴² Similarly, the Community-Driven Development (CDD) approach, as implemented in Pakistan, empowers rural communities to extend sanitation services while fostering cultural shifts, such as changes in water tariffs and hygiene practices.⁴³

Key lessons from international experiences show that participation must be integrated into all project stages, supported by multi-tiered organizations and inclusive structures.⁴⁴ Successful approaches prioritize two-way communication, power-sharing, and cultural adaptation to local contexts. When effectively implemented, participatory processes empower communities, enhance the legitimacy of interventions, and improve the sustainability of water and sanitation systems. These strategies highlight the importance of addressing social norms and fostering collective ownership beyond infrastructure development.

Multidimensional Impacts of Improved Water and Sanitation

Water and sanitation development generates significant positive externalities, contributing holistically to the quality of life through interrelated impacts on public health, environmental health, economic productivity, and equity for vulnerable groups.

- ***Public Health***

Improved water and sanitation access directly improves public health by reducing the prevalence of waterborne and vector-borne diseases such as diarrhea, cholera, and malaria. It mitigates malnutrition linked to repeated infections and improves life expectancy through decreased morbidity and mortality rates. These health gains not only

⁴¹ A. Jiménez et al., "The Enabling Environment for Participation in Water and Sanitation: A Conceptual Framework," *Water* 11 (2019): 308, <https://doi.org/10.3390/w11020308>.

⁴² V. Venkataramanan et al., "Community-Led Total Sanitation: A Mixed-Methods Systematic Review of Evidence and Its Quality," *Environmental Health Perspectives* (2018), <https://doi.org/10.1289/EHP1965>.

⁴³ R. Padawangi, "Community-Driven Development as a Driver of Change: Water Supply and Sanitation Projects in Rural Punjab, Pakistan," *Water Policy* 12, suppl. 1 (2010): 104–120, <https://doi.org/10.2166/wp.2010.116>.

⁴⁴ S. Manikutty, "Community Participation: Lessons from Experiences in Five Water and Sanitation Projects in India," *Development Policy Review* 16 (1998): 373–404.

enhance individual well-being but also ease the burden on healthcare systems, freeing up resources for broader public health initiatives.⁴⁵

- **Environmental Health**

Proper water and sanitation systems contribute to environmental health by preventing the contamination of water bodies and soil with human waste. Clean and healthy environments reduce the proliferation of disease vectors, improve water quality, and support biodiversity. These outcomes also enhance community resilience against climate and environmental challenges.⁴⁶

- **Economic Productivity and Poverty Alleviation**

Water and sanitation drive economic productivity by reducing healthcare expenses and minimizing workdays lost due to illness. Healthy individuals are more capable of engaging in productive economic activities, leading to increased household incomes and overall economic growth. School retention, particularly for children in rural and underserved areas, also improves with better sanitation, contributing to the development of human capital. Together, these benefits reduce poverty and create a socio-economic upliftment.⁴⁷

- **Equity for Vulnerable Groups**

Water and sanitation improvements address disparities faced by vulnerable groups, including women, children, the elderly, and people with disabilities. For women and girls, access to safe and private sanitation facilities enhances dignity, reduces the risk of harassment, and supports menstrual hygiene management. Children benefit from better hygiene conditions at schools, enabling uninterrupted education and development. Elderly and disabled individuals experience improved mobility and safety through accessible water and sanitation infrastructure. By reducing inequalities and empowering these groups, water and sanitation fosters inclusive social and economic participation, contributing to equitable and sustainable development.⁴⁸

Socio-Economic Impact Evaluation

Socio-economic impact evaluation is a crucial component of the proposed research framework. This subsection outlines various methodologies in socio-economic impact assessments and explores potential adaptations to the context of water and sanitation in Manaus and Barcarena.

⁴⁵ Annette Prüss-Ustün and World Health Organization, *Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health* (Geneva: World Health Organization, 2008), <https://iris.who.int/handle/10665/43840> (accessed November 14, 2024).

⁴⁶ L. Fewtrell et al., "Water, Sanitation, and Hygiene Interventions to Reduce Diarrhoea in Less Developed Countries: A Systematic Review and Meta-Analysis," *The Lancet Infectious Diseases* 5, no. 1 (2005): 42–52, [https://doi.org/10.1016/S1473-3099\(04\)01253-8](https://doi.org/10.1016/S1473-3099(04)01253-8).

⁴⁷ G. Hutton, L. Haller, and J. Bartram, "Global Cost-Benefit Analysis of Water Supply and Sanitation Interventions," *Journal of Water and Health* 5, no. 4 (2007): 481–502, <https://doi.org/10.2166/wh.2007.009>.

⁴⁸ V. Zuin et al., "How Do Rural Communities Sustain Sanitation Gains? Qualitative Comparative Analyses of Community-Led Approaches in Cambodia and Ghana," *Sustainability* 13, no. 10 (2021): 5440, <https://doi.org/10.3390/su13105440>.

Several established methods are commonly used in socio-economic impact evaluations. Cost-Benefit Analysis (CBA) quantifies and compares the monetary costs and benefits of a program to assess feasibility and efficiency. Cost-Effectiveness Analysis (CEA) evaluates outcomes relative to their costs, particularly useful when benefits are difficult to monetize. Multi-Criteria Appraisal (MCA) incorporates a range of qualitative and quantitative indicators, making it well-suited for complex development scenarios that span economic, social, and environmental dimensions.⁴⁹

Different case studies illustrate how these frameworks can be adapted. For instance, a multi-criteria assessment of sanitation technologies in rural Tanzania utilized ethnographic methods—including household and key informant interviews and focus group discussions—to develop a sustainability evaluation framework.⁵⁰ Another example is the Ekoreef project, which employed a scoring system to categorize and assess impacts using principal component scales and time horizons, promoting clarity and comparability across projects.⁵¹

While these approaches provide valuable models, this study will focus on a qualitative approach, drawing inspiration from the socio-economic impact assessment conducted following the 2015 flood in Rio Branco, Brazilian Amazon.⁵² However, the Rio Branco case and this present study differ in important ways, including the introduction of services and their distinct physical and socio-economic contexts. This study draws methodological inspiration from the socio-economic impact assessment conducted after the 2015 flood in the Brazilian Amazon. That assessment prioritized community narratives gathered through interviews and focus group discussions, alongside contextual analysis, to reveal broader social and economic implications. Adopting a similar qualitative approach is particularly appropriate here for capturing lived experiences, trust in service providers, and perceived changes in well-being especially in vulnerable, low-income communities.

⁴⁹ Z. Juan, J. Wu, and M. Mike, "Socio-Economic Impact Assessment of Intelligent Transport Systems," *Tsinghua Science and Technology* 11, no. 4 (2006): 339–350, [https://doi.org/10.1016/S1007-0214\(06\)70198-5](https://doi.org/10.1016/S1007-0214(06)70198-5).

⁵⁰ A. Seleman and M. G. Bhat, "Multi-Criteria Assessment of Sanitation Technologies in Rural Tanzania: Implications for Program Implementation, Health, and Socio-Economic Improvements," *Technology in Society* 46 (2016): 70–79, <https://doi.org/10.1016/j.techsoc.2016.04.003>.

⁵¹ S. J. Cripps and J. P. Aabel, "Environmental and Socio-Economic Impact Assessment of Ekoreef, a Multiple Platform Rigs-to-Reefs Development," *ICES Journal of Marine Science* 59, suppl. (2002): S300–S308, <https://doi.org/10.1006/jmsc.2002.1293>.

⁵² Dorien Irene Dolman et al., "Re-Thinking Socio-Economic Impact Assessments of Disasters: The 2015 Flood in Rio Branco, Brazilian Amazon," *International Journal of Disaster Risk Reduction* 31 (2018): 212–219, <https://doi.org/10.1016/j.ijdrr.2018.04.024>.

Case Study: Manaus

I. Context

Manaus' WASH Challenges

Manaus, the capital of Amazonas, is a major urban center in the heart of the Amazon rainforest with a population of over 2 million people. Despite its growing size, a significant portion of its population still lacks reliable access to sanitation services, leading to critical public health and environmental challenges.⁵³ A key feature of Manaus' infrastructure issues is the large number of residents who live in informal settlements, often built on stilts over the rivers (palafitas).⁵⁴ These communities, which lack adequate sanitation systems, rely on the river as both a water source and a waste disposal system, contributing to widespread contamination.

The persistent problem of water contamination in Manaus is particularly serious during the rainy season, especially for residents who do not yet use the drinking water network. For these residents, floods cause river water to mix with water from illegal pipe connections. This contamination worsens the quality of the water from these siphons, making it even more unfit for consumption, and increases the risk of waterborne diseases such as cholera, diarrhea, and other gastrointestinal illnesses. The lack of use of formal sanitation systems exacerbates health risks. Where there is no infrastructure for garbage collection and sewage treatment, waste is often dumped directly into the river, further polluting water sources and contributing to the spread of disease.

In addition to these health challenges, Manaus faces rapid urbanization, which intensifies demand for essential services like water and sanitation. The city's infrastructure struggles to keep up with population growth, particularly in informal settlements where residents often lack access to basic services. This situation results in a significant gap between the availability of public services and the needs of the expanding population.⁵⁵ In Manaus, irregular settlements now make up more than half of the city's housing, with 53.3% of the population residing in these areas.⁵⁶ This marks a significant rise from 2010, when the proportion was just 15.7.⁵⁷ These areas, often called favelas (shantytowns), one example of which is stilt houses, are informal urban communities built on land without legal authorization.

⁵³ Painel Saneamento Brasil, "Localidade 130260," n.d., <https://www.painelsaneamento.org.br/localidade/index?id=130260> (accessed January 23, 2025).

⁵⁴ InfoAmazonia, "Amazon's Largest City Dumps Almost Everything in the River," March 26, 2021, <https://infoamazonia.org/en/2021/03/26/amazons-largest-city-dumps-almost-everything-in-the-river/> (accessed November 27, 2024).

⁵⁵ E. Kresch et al., "Sanitation and Property Tax Compliance: Analysing the Social Contract in Brazil," VoxDev, January 12, 2024, <https://voxdev.org/topic/infrastructure-urbanisation/sanitation-and-property-tax-compliance-analysing-social-contract-brazil> (accessed November 23, 2024).

⁵⁶ Instituto Brasileiro de Geografia e Estatística (IBGE), "Aglomerados Subnormais," n.d., <https://www.ibge.gov.br/geociencias/organizacao-do-territorio/tipologias-do-territorio/15788-aglomerados-subnormais.html> (accessed November 20, 2024).

⁵⁷ InfoAmazonia, "Amazon's Largest City Dumps Almost Everything in the River."

Urbanization

Manaus spans a total area of 11,401 km², of which only 277 km² are urban—an imbalance that underscores the spatial pressures contributing to its unstructured expansion. The urbanization of Manaus has been shaped by cycles of economic expansion and decline, contributing to a pattern of rapid, unplanned growth that continues to challenge city planners today. With the decline of rubber, the city faced an economic crisis and disorderly growth, with riverbank areas occupied by palafitas (stilt houses). The creation of the Manaus Free Trade Zone in 1967 revived the economy and increased the value of central areas, but also intensified irregular occupation.

In the 1980s and 1990s, urban expansion continued in a scattered manner, affecting environmentally fragile areas. The Manaus Master Plan (Law No. 1.839/2014)⁵⁸ seeks to curb this horizontal expansion, especially in the North and East zones, and optimize existing infrastructure, highlighting the need for planning in the face of accelerated urbanization. The most current version of the Master Plan is from 2019, and the technical responsibility lies with the Urban Planning Institute (Implurb). A revision is underway in 2025 to include the Sustainable Development Goals (SDGs), the New Urban Agenda, and the Paris Agreement.

Aegea's Role in Manaus

Aegea has been operating in Manaus since 2018, after acquiring Companhia de Saneamento do Norte (CSN), which was responsible for water and sewage services in the city.⁵⁹ Before the privatization in 2000, the state-owned company Cosama (Companhia de Saneamento do Amazonas) operated the water and sewage systems in Manaus. After the concession contract was signed in the year 2000, Cosama no longer operated in Manaus, continuing to manage water services in 15 other cities in the Amazonas state, while other municipalities in the region have their water services managed by municipal entities.⁶⁰ In 2018, Aegea bought out the shares of Solvi, which had previously formed a joint venture with Águas do Brasil, a company based in Rio.

Since its entry into Manaus, Aegea has taken proactive steps to address the city's unique WASH challenges, recognizing the complex geographic and environmental conditions. Águas de Manaus, a concessionaire operated by the Aegea Saneamento group, manages water and sanitation services in the city through a long-term public-private partnership contract with the municipality, overseeing infrastructure, billing, and community engagement in line with national

⁵⁸ Manaus, *Urban and Environmental Master Plan of Manaus and Its Complementary Laws: Municipal Urban Legislation* (Manaus: Municipal Urban Planning Institute – Implurb, 2021).

⁵⁹ Aegea, "Aegea Announces Agreements for Acquisition of All the Shares of Companhia de Saneamento do Norte and Specific Shareholders' Agreement for Capital Contributions from Shareholders," n.d., <https://ri.aegea.com.br/en/noticia/aegea-announces-agreements-for-acquisition-of-all-the-shares-of-companhia-de-saneamento-do-norte-and-specific-shareholders-agreement-for-capital-contributions-from-shareholders/> (accessed December 1, 2024).

⁶⁰ Acrítica, "Empresa Aegea Assume Abastecimento de Água e Serviços Sanitários de Manaus," n.d., <https://www.acritica.com/manaus/empresa-aegea-assume-abastecimento-de-agua-e-servicos-sanitarios-de-manau-1.103044> (accessed November 14, 2024).

sanitation goals. Over the first five years of its concession, the company invested over R\$ 500 (\$90 million, WISE) million, with plans to invest more than R\$ 1 billion.⁶¹ These investments are aimed at expanding the water supply and increasing sewage treatment coverage from 19.2 percent to 90 percent by 2033. A significant intervention has been the installation of above-ground pipes that provide permanent access to potable water. This system ensures that residents, particularly those living in stilted homes over rivers, have continuous access to safe drinking water. The design of the infrastructure also safeguards the pipes during the flood season, maintaining their functionality year-round.⁶² This infrastructure solution helps mitigate the health risks associated with contaminated river water.⁶³

Águas de Manaus has also implemented several technological advancements to improve water service management. The company has also created a digital twin of the water supply system, integrating data from SCADA, GIS, hydraulic modeling, and customer information to enhance asset management decisions.⁶⁴ This digital twin enables real-time monitoring of infrastructure assets, such as pipes, pumps, and tanks, leading to better leak detection and optimized operational workflows. Furthermore, Aegea expanded its use of TaKaDu's Central Event Management (CEM) solution, a cloud-based service that detects and manages network events such as leaks, bursts, and operational failures, improving operational efficiency and reducing water loss.⁶⁵

In addition to infrastructure and technological improvements, Águas de Manaus has placed a strong emphasis on community engagement. The company has launched programs like "Vem Com a Gente" and "Trata Bem Manaus" to engage with local communities, understand their challenges, and improve service delivery. Furthermore, the "Afluentes Program" focuses on integrating community leaders to enhance sanitation efforts. Through these educational initiatives, Aegea aims to reduce the spread of waterborne diseases and improve overall public health outcomes in Manaus.⁶⁶ Aegea's role in Manaus demonstrates the potential for private sector involvement in addressing WASH challenges in Brazil's most underserved urban areas. The company's model, which combines innovative infrastructure with community engagement and education, has been successful in improving access to clean water and sanitation. These

⁶¹ Valor Econômico, "Saneamento em Manaus Avança."

⁶² Journal of Advanced Engineering Research and Studies (IJAERS), "Extension of the Water Distribution Network in Subnormal Regions in the Manaus City," *IJAERS* 8, no. 6 (2021), <https://doi.org/10.22161/IJAERS.86.19>.

⁶³ Water Action Hub, "Ensuring Continuity of Service and Hygiene in Brazil," n.d., <https://wateractionhub.org/projects/1248/d/ensuring-continuity-of-service-and-hygiene-in-brazil/> (accessed November 17, 2024).

⁶⁴ Bentley, *Aegea Manaus: Enhancing Water Services with Digital Twin Technology*, n.d., <https://www.bentley.com/wp-content/uploads/CS-AEGEA-Manaus-LTR-EN-LR.pdf> (accessed November 11, 2024).

⁶⁵ Water Online, "Aegea Will Use TaKaDu's Central Event Management (CEM) Solution in Manaus," n.d., <https://www.wateronline.com/doc/aegea-will-use-takadu-s-central-event-management-cem-solution-in-manau-0001> (accessed November 20, 2024).

⁶⁶ Aegea, "Aegea Saneamento Supports 1st Amazon Conference to Raise Funds for Forest Restoration," 2020, <https://www.aegea.com.br/en/2020/12/14/aegea-saneamento-supports-1st-amazon-conference-to-raise-funds-for-forest-restoration/> (accessed November 20, 2024).

solutions could serve as a replicable model for other Brazilian cities facing similar challenges, especially in remote or rapidly urbanizing regions where access to basic services remains limited.

Social Tariffs and Demographics

Key element of Aegea's inclusive system in Manaus is its social tariff program, which ensures that access to clean water and sanitation is affordable for low-income families. This approach aligns with Brazil's recognition of water and sanitation as essential human rights and national efforts to ensure affordability for vulnerable populations. Currently, 20 percent of Manaus' population benefits from this program, with an ambitious goal to expand coverage to an additional 35 percent of the city's residents. The Social Water and Sanitation Tariff (TSAE), established under Federal Law No. 14.898 in June 2024, guarantees discounted rates for low-income families registered in the federal CadÚnico system or receiving the Benefício de Prestação Continuada (BPC). In practice, this means Aegea's local application of TSAE includes automatic discounts for Bolsa Família recipients and a manual application process for others who meet socio-economic criteria.

As of today, Aegea has been using three different social tariffs in Manaus:

1. **“Tarifa Social”**: Automatic discount for families participating in the “Bolsa Família” program, a federal income transfer initiative that supports low-income families.
2. **“Tarifa Manauara”**: Allows residents who are not automatically enrolled, but still meet certain income and household criteria, to manually request reduced tariffs.
3. **“Tarifa 10”**: Allows families with even lower incomes to pay R\$10.00 (\$1.78 per , WISE conversion) month for water and sewage services.

This multi-system Tariff strategy enables for greater flexibility in reaching underserved communities and ensures that both formally registered and informally vulnerable populations can access important WASH services. The viability of these differentiated tariffs relies on internal subsidies and cross-subsidies, allowing affordability without compromising overall system sustainability.

In parallel, Aegea has continued to improve infrastructure in most vulnerable areas. Over 600,000 people, many of them living in palafita neighborhoods, have gained access to treated water. The results are tangible: hospitalizations due to diarrhea dropped by 39 percent over a three-year period, from 99,974 to 60,958 cases.⁶⁷ This shows the public health impact of combining affordable service provision with expanded access.

Despite infrastructural developments, demographic challenges still persist. Manaus has a large youth population, high unemployment rates, and many people working in the informal economy

⁶⁷ F. Garcia de Freitas, *Economic Benefits Associated to Expanding Sanitation Access in Manaus* (presentation, Instituto Trata Brasil, March 2025).

without stable income or benefits. Indigenous and Afro-Brazilian communities are often the most affected by service gaps. By addressing both financial barriers and physical infrastructure needs, Aegea's efforts demonstrate how socially targeted WASH initiatives can enhance health, equity, and inclusive urban development.

Additional data on isolated sewage systems across Manaus, including those serving specific housing complexes and subdivisions, is provided in Table 1. This offers insight into the decentralized infrastructure still in use in various parts of the city.

Table 1. Data on the Sanitary Sewage System of Manaus: Isolated Systems (2014)

Housing Complex	Collector Network Length (Km)	# of Families Served	# of EEEs	ETE and Type	Treatment System
Nova Cidade - Panamá	29	4,000	4	One ETE of Deep Shaft type	
Área 13	20	4,000	3	One ETE of Stabilization Pond type	
Área 14	14	1,300	1	One ETE of Stabilization Pond type	
Jardim Versailles	3	380	-		Septic tank followed by an anaerobic biological filter
Vila Nova	4.6	-	-	Three EEEs	
Vila da Barra	3.6	-	-	Three EEEs	
Vila Rica	2.6	200	-	-	
Vila Real	4.7	450	-	-	
Ribeiro Júnior	3.3	900	-	Three EEEs	
Renato S. Pinto II	3.4	320	-	-	

São Judas Tadeu	0.8	700	-	-	
Augusto Montenegro II & III	3.4	700	-	-	
João Bosco (Torquato)	2.5	1,100	-	-	
Parque dos Rios II	0.5	120	-	-	
Galileia	7.4	1,100	-	-	
Lula (Formerly Cidadão IX)	3	460	-	-	
Nascente do Mindú	4.1	-	-	-	Ecological filter septic tank
Viver Melhor III	2.3	-	-	-	
Sistema Barra Bela	1.1	91	-	-	
Eldorado	2.8	1,500	-	-	Activated sludge
Jornalistas	0.5	1,600	-	-	
Déborah	2.9	219	-	-	
Ouro Verde	1.4	427	-	-	
Samambaias	1.8	60	-	-	
Cidade Nova - Timbiras	163.98	13,700	-	-	
Eliza Miranda	4.3	1,600	-	-	
Ayapuá	1.7	1,600	-	-	

Vista Bela	3.5	480	-	-	Upflow Anaerobic Blanket (UASB)
Dom Pedro - Kíssia - Tocantins	18.3	3,600	-	One ETE	
João Bosco (Aleixo)	2.18	260	-	-	
Petrópolis	0.18	192	-	-	
Ozias Monteiro	0.9	-	-	-	
Viver Melhor I	8.7	-	2	One ETE	
Viver Melhor III	-	-	-	One ETE	
TOTAL	326,44	41.059	10	15	-

Source: Adapted, PMSB-MANAUS (2014).

Water Supply System

The main water supply source in Manaus is the Negro River, which accounts for approximately 87 percent of the municipality's raw water intake. Despite the release of untreated sewage into the river, its high self-purification capacity and large volume—around 35,000 (cubic meters per second) m³/s during the dry season—help maintain water quality within acceptable standards.⁶⁸ However, the river presents challenges for conventional treatment due to its acidic pH, low turbidity, and high coloration, requiring chemical corrections.

Groundwater is also used in Manaus and is of good quality, requiring only disinfection with chlorine to become potable. These groundwater resources are at risk of depletion, especially since Amazonas is the Brazilian state that uses the most groundwater, accounting for about 25% of the region's total volume.⁶⁹ There are several community wells built by public agencies, NGOs, and the Manaus Environmental S.A. concessionaire. The current proposal is to gradually replace these wells with surface water systems as new improvements are implemented.

⁶⁸Aegea Saneamento. (2022). *Sustainability Report 2021*.

https://www.aegea.com.br/relatorio/2022/archive/RAS_Aegea_2021_en.pdf (accessed April 14, 2025).

⁶⁹Duque et al. (2025). *Urban drinking water systems in the Amazon Basin: Diversity and challenges*. *One Earth*, Elsevier.

<https://www.sciencedirect.com/science/article/abs/pii/S2352801X25000384> (accessed April 14, 2025).

According to the Municipal Basic Sanitation Plan (2014), there are 179 deep wells in Manaus, 96 of which are operational—most notably in the PROAMA and Ponta do Ismael systems—while 83 are in reserve and 24 serve independent systems, with a total production of 1.43 m³/s. Surface intake occurs mainly in the Ponta do Ismael, PROAMA, and Mauazinho systems. The intake structures are in good physical and operational condition, with special mention to the PROAMA system, which is modern and efficient. The raw water intake lines operate normally; however, some treated water intake lines require replacement or expansion due to corrosion and increasing water demand.

Manaus has four main treatment stations (ETAs), according to the 2014 Municipal Basic Sanitation Plan. The Ponta do Ismael System includes ETA I (4 m³/s), which is conventional and operates a complete cycle including rapid mixing, flocculation, sedimentation, filtration, chlorination, and pH correction; and ETA II (3.3 m³/s), which follows a similar process but uses flotation instead of sedimentation. The Mauazinho ETA (0.22 m³/s) uses upward direct filtration, considered inadequate for the Negro River. The PROAMA ETA (2.5 m³/s) is a modern, conventional system with coagulation, flocculation, sedimentation, filtration, disinfection, and fluoridation. Additionally, the Well System contributes a production of 1.5 m³/s, bringing the total system capacity to 11.5 m³/s.

The distribution network in Manaus extends over 3,537 km, with a significant portion located in irregular occupation areas, complicating system maintenance. Problems such as old pipes, corrosion, unstable soil, and disorderly urban settlements contribute to high water loss rates. The water loss index from distribution reached 60% and was reduced to 55.4% in 2022, according to SINISA data, which is still considered high. The system includes reservoirs with a total capacity of 210,486 m³, although some of these are deactivated or require repairs and protection against vandalism.

In terms of expansion and universalization,⁷⁰ the supply system covered 72.63 percent of the population in 2013. Since 2018, with the involvement of Aegea through the Águas de Manaus concessionaire, significant expansion has occurred, with over 200 km of new network installed in vulnerable areas, benefiting 200,000 people. The universalization of supply was achieved in 2023, reaching over 2 million residents.⁷¹

II. Research and Data Gathering

Fieldwork and Data Gathering Methods

Our fieldwork in Manaus employed a mixed-methods approach combining quantitative and qualitative techniques to assess the socio-economic, health, and infrastructural impacts of sanitation services provided by Águas de Manaus:

⁷⁰ Municipal Government of Manaus, *Municipal Basic Sanitation Plan: Potable Water Supply and Sanitary Sewage System*, 2014.

⁷¹ Aegea, *Trata Bem 2025 Presentation*, [n.p.], 2025, <https://www.aguasdemanous.com.br> (accessed April 14, 2025).



SURVEYS

42 respondents from: Raiz, Educandos, Viver Melhor 4, Parque das Nações Indígenas Tarumã, Praça das Flores, Av. das Flores (Nova Cidade), São Francisco



FOCUS GROUP DISCUSSIONS

- 2 Male Groups (6 participants each)
 - 2 Female Groups (5 participants each)
- Total: 12 Community Leader Participants



INTERVIEWS

11 Interviews with Community Leaders, Research Scientists, Águas de Manaus Operations Staff, local NGOs, and Municipal Regulators

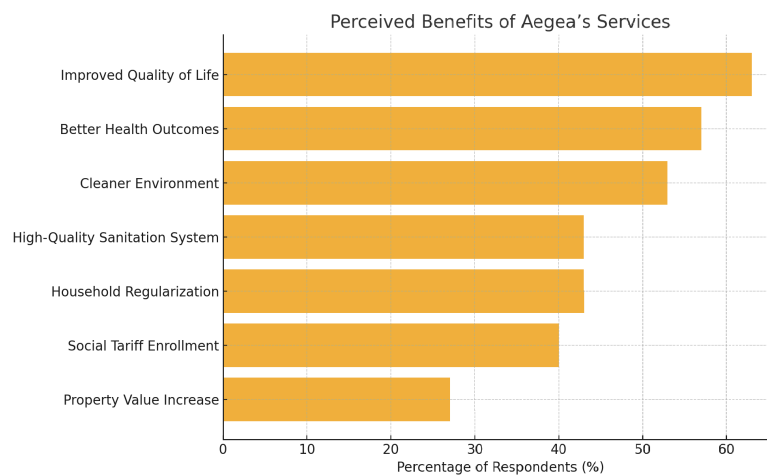
SURVEY RESULTS

Perceived Benefits of Aegea's Services

Residents reported a range of positive changes in their lives following Aegea's sanitation service improvements:

- 63%: Improved overall quality of life
- 57%: Better health outcomes
- 53%: Cleaner living environment
- 43%: Access to high-quality sanitation systems
- 43%: Gained proof of residence (household regularization)
- 40%: Enrolled in Aegea's social tariff program
- 27%: Reported increase in property value

Figure 3. *Perceived Benefits of Aegea's Services*



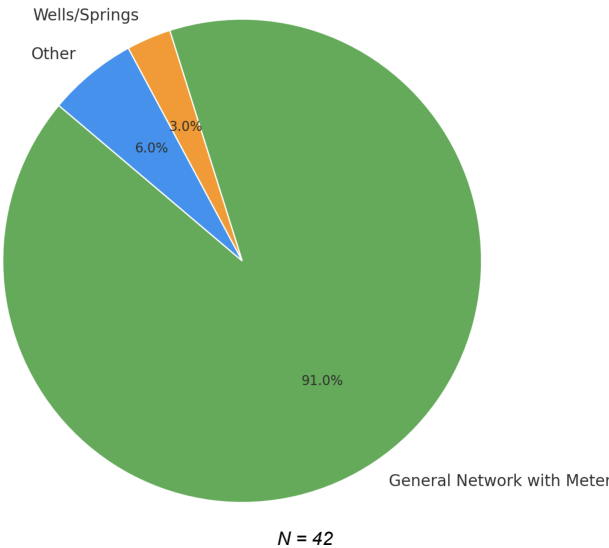
N = 42

Household regularization, such as the ability to obtain proof of residence, was also noted by 43 percent. Additionally, 40 percent acknowledged their enrollment in Aegea’s social tariff program, and 27 percent believed that their property values had increased due to the enhanced sanitation infrastructure. These results underscore the multifaceted nature of the impact, blending physical infrastructure with social and economic benefits.

Service Delivery

In terms of water access, 91 percent of households reported receiving water through the general distribution network with a meter, indicating a high level of formal service coverage. In terms of water access, 91 percent of households reported their primary source of water as the general distribution network with a meter, indicating strong formal service coverage. Only a small number cited wells or springs (3 percent) or other means (6 percent) as their main source. This suggests that piped access is the dominant and most relied-upon method — though secondary reliance on alternative sources may still exist.

Figure 4. Primary Water Access Methods in Manaus Households



Sanitation services have significantly improved access to clean water and private toilets in informal settlements. The perceived quality of water was assessed based on color and odor:

- 61% described their water as clear
- 82% said their water was odorless
- Discoloration levels: 9% slight, 18% moderate, 12% heavy
- Odor levels: 12% slight, 6% strong

This reflects overall satisfaction with water quality, though some issues persist in pockets.

Sanitation Access – Before vs After Aegea

- Before: 68% used private toilets; 16% used pit latrines; 6% relied on rivers/lakes
- After: 77% reported private toilet use, showing a substantial drop in unsafe methods

Satisfaction with Sanitation Services

- Pre-intervention: 28% rated services as excellent/good; 41% rated them very poor
- Post-intervention: 56% rated services as excellent/good

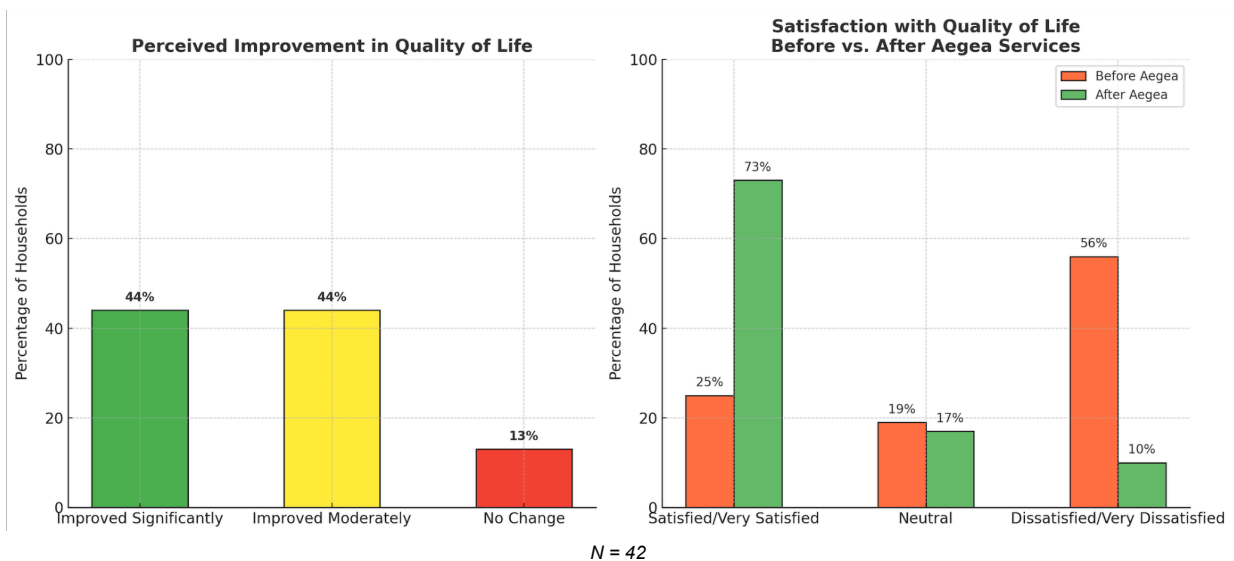
Customer Service Experience

- 23% rated customer service as excellent, 27% as good
- 10% rated it poor, while 30% had no opinion
- 39% contacted Aegea by phone when issues occurred
- Only 3% used digital tools like WhatsApp or the app
- 35% reported no service issues

Dignity and Quality of Life

There was strong support for civic participation as a means of improving neighborhood well-being, with 94% of respondents agreeing that activities such as clean-up efforts, health talks, and sanitation campaigns could help improve the community's quality of life. mobilization.

Figure 5. Perceived Change in Quality of Life



When asked about their overall quality of life following Aegea's intervention, 44 percent of respondents reported that it had improved significantly, while another 44 percent indicated moderate improvement. Only 13 percent felt there was no change. Comparing satisfaction

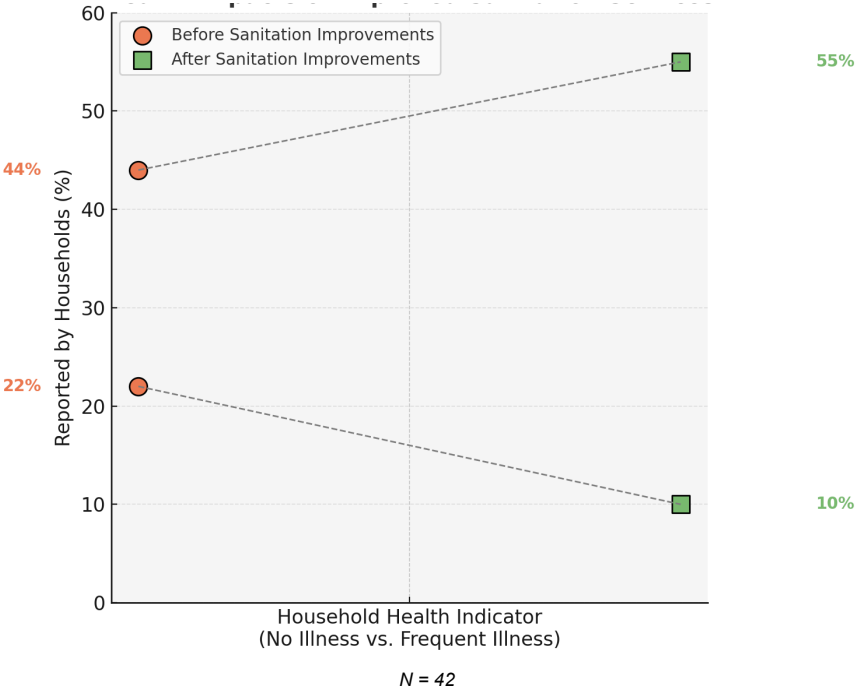
levels before and after Aegea’s service delivery further highlights the impact: prior to the intervention, only 25 percent were satisfied or very satisfied with their living conditions, while 56% were somewhat or very dissatisfied. After the intervention, 73 percent of respondents said they were satisfied or very satisfied with their quality of life, and only 10 percent reported dissatisfaction.

Health Impacts

Health data collected through the survey indicates a positive correlation between improved sanitation services and household health. Before Aegea’s involvement, 44% of respondents said their household members had not experienced any illness over the past year, while 22% indicated that someone in their household had fallen ill more than four times annually.

Following the service expansion, the percentage of households reporting no illness rose to 55%, and those experiencing frequent illness (4 or more episodes per year) dropped to just 10%.

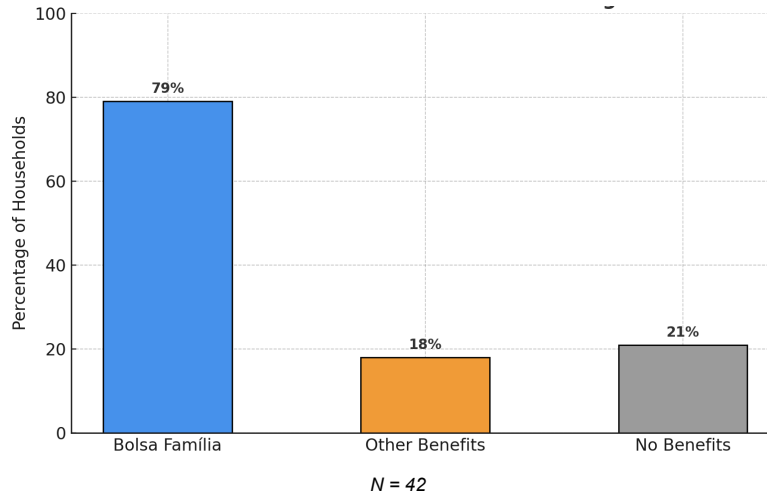
Figure 6. Health Impacts of Improved Sanitation Services



Economic Impacts

In terms of economic resilience, the survey found that 79 percent of households were enrolled in Programa Bolsa Família, Brazil’s flagship cash transfer program. A small minority received other government benefits such as BPC/LOAS or emergency relief, while 21 percent of respondents said they were not enrolled in any public welfare schemes.

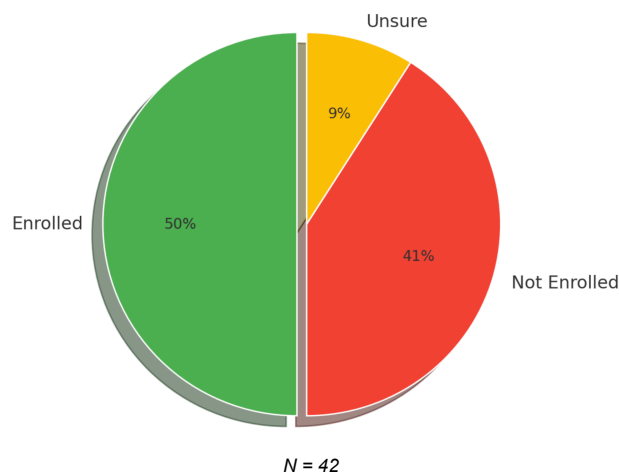
Figure 7. Enrollment in Government Welfare Programs



Respondents also reflected on their ability to manage household expenses. While 38 percent reported paying all their bills on time, 28 percent could pay most of their bills, and 16 percent said they could only pay about half. Alarming, 9 percent of respondents said they were unable to pay any of their bills, indicating economic fragility among a significant portion of the population.

Finally, respondents were asked about their participation in Aegea's social tariff program, which subsidizes water and sanitation services for low-income households. Half of the respondents confirmed that they were enrolled in the program, while 41% said they were not, and 9% were unsure.

Figure 8. Participation in Aegea's Social Tariff Program



FOCUS GROUP DISCUSSIONS

Four focus group discussions were conducted in Manaus — two with male and two with female community leaders — to explore perceptions and strategies related to water, sanitation, and hygiene (WASH) in informal settlements. This section presents brief qualitative overviews of those conversations, highlighting key themes of grassroots leadership, trust, and institutional gaps. A more detailed, multi-method analysis integrating these insights is presented in the sections below.

Focus Group Discussion 1 – Female Community Leaders in Manaus⁷²

In neighborhoods excluded from formal planning, female leaders have become informal service negotiators and accountability agents. Despite lacking official recognition, they facilitate dialogue between underserved communities and Águas de Manaus. Their experiences underscore how institutional neglect is often met with grassroots resolve.

- *“You might think I’m a counselor, but I’m not—I’m just a volunteer. Still, they call me a leader because I fight for them.”*
- *“Before, it was all paperwork and waiting. Now, I send a photo and the team is there the next day.”*

Legal constraints, like inability to modify federal roads, have limited connection infrastructure—even where internal piping exists. Still, women emphasized the symbolic shift sanitation brings: from marginality to visibility, and from stigma to dignity.

Focus Group Discussion 2 – Male Community Leaders in Manaus⁷³

This discussion reflected on the dual challenge of physical exclusion and behavioral inertia. Leaders acknowledged improved response times and water quality post-privatization, but stressed that infrastructural delivery in flood-prone zones—especially stilt-house areas—is still constrained by geography and weak planning frameworks.

- *“You can’t install a sewage system where houses are literally sitting over streams.”*
- *“People want the benefits but don’t want to change habits.”*

They stressed that sanitation is not just about hardware—it demands co-produced solutions involving civic awareness, environmental stewardship, and community mobilization.

Focus Group Discussion 3 – Male Community Leaders in Manaus⁷⁴

Leaders from neighborhoods like Redenção and Terra Nova described tangible improvements in water access and service quality since privatization. Yet, sanitation remains the

⁷² See Appendix A for a Detailed Summary

⁷³ See Appendix B for a Detailed Summary

⁷⁴ See Appendix C for a Detailed Summary

bottleneck—especially in communities along natural watercourses. The discussion traced how infrastructure, when combined with political will and inclusion, can shift aspirations.

- *“Today, the water from Águas de Manaus is drinkable. That was unthinkable 10 or 15 years ago.”*
- *“If people aren’t involved, the services won’t last.”*

They emphasized the role of incentives like social tariffs, while also criticizing limited outreach and lingering stigma around registration. Engagement, they argued, must extend beyond service provision to foster ownership and adaptive planning at the neighborhood scale.

Focus Group Discussion 4 – Female Community Leaders in Manaus⁷⁵

This discussion illuminated how sanitation directly intersects with women’s roles in caregiving, household management, and community cohesion. Women reflected on the health burdens they bore prior to service provision—particularly for children—and the invisible labor involved in navigating service breakdowns.

- *“My kids were always sick with diarrhea or skin rashes.”*
- *“They came and did the work, but no one asked us anything. We want to be heard.”*

While they expressed trust in Aegea and noted improved health and cleanliness, participants critiqued confusing billing systems and the lack of participatory mechanisms. For them, dignity is not just about access—it’s also about agency, representation, and accountability in urban governance.

SUMMARY OF FOCUS GROUPS:

Theme	Findings
a. Water Access and Infrastructure	<ul style="list-style-type: none"> • Despite progress, there are still informal settlements, especially stilt houses, without access to piped water. • Pipelines installed by Aegea remain disconnected in some areas due to legal and classification issues (e.g., federal roads). • Those residents still without access to clean water rely on untreated river water or informal connections, increasing health risks. • Leaders voiced frustration at non-functional visible infrastructure. • Inconsistent water access forces trade-offs between hygiene and other essentials. • Communities continue to advocate via programs like Afluentes and meetings with AEGEA. • Access remains uneven; marginalized areas are still excluded. • These inequities erode dignity and deepen social exclusion.

⁷⁵ See Appendix D for a Detailed Summary

<p>b. Sanitation and Drainage</p>	<ul style="list-style-type: none"> ● Sanitation and drainage are ongoing, unresolved concerns. ● Most stilt house residents still do not have access to formal sewage systems. ● Stilt-house residents lack access to formal sewage systems. ● Human waste is discharged into streams/open spaces, creating health and environmental hazards. ● Flooding during rainy seasons mixes sewage with water, worsening living conditions. ● Residents reported increased waterborne illnesses like diarrhea and skin infections. ● During times of flooding, residents have reported an increase in waterborne diseases, such as diarrhea and skin infections.
<p>c. AEGEA's Service and Engagement</p>	<ul style="list-style-type: none"> ● Community leaders praised AEGEA's responsiveness and the Afluentes program. ● WhatsApp-based communication was seen as efficient for service reporting. ● However, challenges persist in reaching the most vulnerable groups. ● Many residents are unaware of or struggle to access Tarifa Social due to lack of documentation or digital literacy. ● Technological tools like digital twins have not visibly improved service in underserved areas. ● Leaders suggest AEGEA expand outreach via door-to-door campaigns and in-person registration. ● AEGEA is viewed as capable but constrained by systemic and institutional limitations. ● Deeper, more empathetic engagement is widely desired.
<p>d. Gendered Perspectives on WASH Priorities</p>	<ul style="list-style-type: none"> ● Women disproportionately manage water collection, hygiene, and caregiving. ● Scarcity compromises their own hygiene and affects education and income. ● Unsafe or shared sanitation disproportionately affects girls, especially during menstruation. ● Some girls miss school due to lack of toilets or hygiene access. ● Women lead advocacy, negotiate with service providers, and organize their communities. ● They call for gender-sensitive infrastructure (e.g., women-friendly toilets). ● More inclusive communication and decision-making are needed. ● WASH access is deeply linked to gender justice and social resilience.

INTERVIEW FINDINGS

As part of our fieldwork in Manaus, we conducted a series of interviews with a diverse set of stakeholders, including officials from Águas de Manaus, community leaders from neighborhoods such as Cidade de Deus, Japiim, and Aleixo, and representatives from the municipal regulatory agency AGEMAN. These conversations offered valuable insights into the technical, institutional, and social dynamics shaping water and sanitation services in the city. The findings from these interviews are presented below.

Interview With Professor Fernando Garcia de Freitas⁷⁶:

In an interview based on a study conducted by Instituto Trata Brasil in collaboration with Aegea, Professor Fernando Garcia de Freitas presented a comprehensive evaluation of the socio-economic, environmental, and public health impacts of expanding sanitation services in Manaus. He emphasized the city's strategic importance—housing over 50 percent of the Amazonas state population and generating nearly 80 percent of its GDP. While access to treated water had become nearly universal by 2022 (with only 0.5 percent lacking access), 74 percent of residents remained excluded from formal sewage systems. He described this not as a technical shortcoming but as a structural barrier affecting all facets of urban life. Investment in sanitation increased significantly—from R\$23 million to R\$215 million annually (about 4 million USD to 37.7 million USD at April 25, 2025 exchange rate), creating over 1,400 jobs and R\$144 billion in returns. These returns stemmed from direct employment, indirect demand in related sectors, and induced consumption effects. Health outcomes improved, with reduced rates of diarrhea and pneumonia; neighborhoods with sewer connections saw statistically significant drops in hospitalizations. He noted that overcrowded housing and limited hygiene access had exacerbated COVID-19 vulnerability. “If you don’t have water, you don’t have prevention,” he remarked. The study also found educational benefits: children with sanitation access attended school more regularly and performed better in national exams, enhancing their long-term employability and income.

Key Highlights:

- **Zero point five percent** of the population lacked treated water access by 2022; **74%** still lacked sewage coverage.
- **Sanitation investment** rose from R\$23M to R\$215M annually; yielded **R\$144B** in returns.
- **Health benefits** included reduced diarrhea, pneumonia, and COVID-19 vulnerability.
- **Educational gains** linked to improved school attendance and exam performance.
- **Economic resilience** through job creation, increased income, and property value appreciation.

The professor further highlighted the urban and symbolic gains of sanitation access. Sewer connections were linked to increased property values, catalyzing wealth creation for low-income households. Neighborhood upgrades—like paved roads, lighting, and overall revitalization—often followed. He observed a feedback loop between environmental improvements and broader urban

⁷⁶ Fernando Garcia de Freitas, interview with author, Research Consultant to Instituto Trata Brasil, former FGV Professor, and Partner-Director at Ex Ante Consultoria Econômica, March 17, 2025.

transformation: “Once you clear the open drains and clean the streams, sidewalks and urban order follow.” Between 2012 and 2022, sanitation investments totaled R\$4.2 billion (about 737.4 million USD at April 25, 2025 exchange rate), while benefits reached R\$11.4 billion. Looking forward, an estimated R\$11.9 billion in investments from 2024–2040 could generate R\$34 billion in returns. Sanitation was also tied to improved women’s safety and reductions in domestic violence, drawing on global studies. “Sanitation must be understood not just as infrastructure, but as dignity, opportunity, and safety,” he asserted. He concluded that Manaus should serve as a model for other northern capitals, provided there is political will and inclusive implementation.

Interview With Elson Andrade, President of AGEMAN⁷⁷:

Established in 2018, the Agência Reguladora dos Serviços Públicos Delegados do Município de Manaus (AGEMAN) is Manaus’s municipal regulatory agency, responsible for overseeing essential public services including water, sewage, public lighting, and parking, with plans to expand to solid waste regulation.

In an interview, President Elson Andrade offered a nuanced perspective on the governance and infrastructure challenges facing the sanitation sector. He identified the agency’s core dilemma: “If the tariff doesn’t cover costs, you can’t guarantee good service; but if it’s too high, the population can’t pay.” Manaus’s rapid, unplanned growth and large number of informal settlements complicate service delivery. Utilities are reluctant to invest in areas without formal land tenure or legal recognition. As Andrade explained: “You can’t install water systems in places where ownership isn’t defined.”

Despite these barriers, he highlighted progress—especially in extending water access to palafitas (stilt houses). One of the more transformative effects has been the role of utility bills in providing address-based documentation, which serves as a pathway to economic inclusion. Targeted social tariff programs like Tarifa Manauara and Tarifa 10 now benefit over 130,000 residents, substantially reducing costs for vulnerable households.

Key Highlights:

- AGEMAN operates under the tension of maintaining **affordable yet financially viable** tariffs.
- Infrastructure expansion is limited by **informality and lack of land rights**.
- **Water access has improved** in stilt-house communities, providing social and legal benefits.
- Subsidized programs now serve about **20 percent of the city’s population**.
- **Documentation through water bills** has enabled access to banking and credit for many.

Sewage, however, remains a deeply entrenched challenge. Cultural norms and perceptions play a key role—many households, including those in middle-income areas, continue to discharge wastewater into storm drains, unaware of the environmental impact. “People don’t think they’re polluting—they just see the water go away,” he observed. Resistance to sewer connections is

⁷⁷ Elson Andrade, interview with author, President of Agência Reguladora dos Serviços Públicos Delegados do Município de Manaus (AGEMAN), March 18, 2025.

common due to structural costs and perceived redundancy. Moreover, poor coordination between municipal agencies and utilities undermines public confidence. Streets recently paved are often damaged for infrastructure upgrades and left unrestored—“The main complaint now isn’t about water—it’s about road damage,” the president noted. AGEMAN’s capacity is stretched thin, with just 13–14 staff overseeing sanitation across the city. Describing the agency’s struggle, he remarked: “It’s like trying to fix a tire while the car is speeding down the highway.”

III. Data Analysis

AEGEA INTERVENTIONS

Table 2. Activities by Aegea in Manaus

	Baseline Condition	Service Chain Intervention	Target Condition
Drinking Water	Safely Managed Basic Limited Unimproved Surface Water	Source - River Abstraction & Treatment - Water treatment plant Distribution - Water distribution network	Safely Managed Basic Limited Unimproved Surface Water
Sanitation	Safely Managed Basic Limited Unimproved Open Defecation	Containment Transportation - Wastewater collection network - Pumping stations Treatment - Wastewater treatment plant (activated sludge) Reuse/Disposal	Safely Managed Basic Limited Unimproved Open Defecation

Before receiving services from Aegea, access to water and sanitation in many communities fell far below safely managed standards, as defined by the *WHO/UNICEF Joint Monitoring Programme (JMP)*.

For water, many households relied on piped systems that were neither reliably available nor consistently safe to drink—placing them at the *basic* or *limited service levels* on the JMP ladder. For example, during the rainy season, flooding often caused contaminated river water to mix with household supplies. In some informal settlements, residents had access only to makeshift connections or collected untreated water directly from rivers.

Sanitation conditions were even more concerning. Disposal into rivers remained common, while others used unimproved latrines discharging into streams or open ground. These setups lacked hygienic separation of human excreta, placing them within the *unimproved* or *open defecation*

categories of the JMP ladder. Even homes with private toilets were often not connected to sewer systems or treatment units. During focus groups, women described living with open sewage outside their doors and wastewater entering homes during floods.

For water, the company sources supply from the Rio Negro and nearby rivers, treats it at centralized plants, and distributes it through a piped network—including above-ground pipes designed for stilt homes. This system is engineered to withstand seasonal flooding and ensures service continuity in vulnerable areas.

For sanitation, Aegea's system transports wastewater through a dedicated collection network and pumping stations, followed by treatment using the activated sludge method. These interventions are especially critical in areas where raw sewage previously entered waterways, posing environmental and public health risks.

Aegea's integrated system represents a major upgrade from fragmented, unsafe practices to a structured urban sanitation network. As a result, households connected to Aegea's services now reach the JMP's highest classification: *safely managed*.

SIGNIFICANT FINDINGS

1. Improved Dignity and Quality of Life

The introduction of reliable water and sanitation services in Manaus has led to substantial improvements in dignity and quality of life, especially for low-income communities living in informal settlements such as palafitas. Survey and focus group findings consistently indicate that the community perceives clear benefits from Aegea's intervention, including reductions in waterborne diseases, drinking water contamination, and general illness prevalence. A cleaner environment and expanded access to sewerage systems have collectively contributed to better health outcomes and restored a sense of pride in one's home. Residents have expressed how the ability to host guests without shame, or to send their children to school in clean clothes, has restored their sense of social belonging and dignity.

These public health improvements also have direct implications for economic productivity. Informal workers who represent a significant share of low-income households in Manaus are especially vulnerable to income loss when illness strikes. As health improves, so do attendance at school and participation in the workforce. Focus group participants and survey respondents alike mentioned fewer sick days, reduced caregiving burdens, and increased availability to work. Such outcomes demonstrate that sanitation infrastructure is not only a social good but also an enabler of economic resilience.

2. Communication and Feedback Mechanism

Aegea's Afluentes network has been instrumental in bridging the communication gap between the company and communities. By leveraging simple and accessible platforms like WhatsApp, community leaders can report problems and receive timely responses. This responsiveness has

led to higher satisfaction with service delivery. Community leaders praised this shift, noting the contrast with the delays and bureaucratic hurdles faced under previous systems.

However, the fieldwork also highlighted that more can be done to improve transparency and accessibility. Based on our surveys, water bills remain confusing and difficult to track for many residents. Some women in the focus groups voiced frustration over unclear charges. This signals an opportunity for Aegea to develop a consistent and user-friendly system for disseminating information about service costs, tariffs, and bill calculations. Doing so would reinforce trust and help low-income customers plan their household finances more effectively.

3. Urgency to Promote Behavior Change

The community's willingness to engage in sanitation-related activities presents a valuable entry point for driving long-term behavior change. The majority of survey respondents agreed that educational campaigns and neighborhood clean-up events can enhance quality of life. Community leaders echoed this sentiment, calling for expanded campaigns to boost awareness and trust in sanitation services. These initiatives are critical for increasing demand and encouraging consistent use of WASH infrastructure, not just its presence. The supply of services through building infrastructure must be accompanied by the demand for services driven by behavior change, so that the community wants to get service and continues to use it. The demand must grow at the same rate and at the same time as the supply.

While Aegea already runs engagement programs like “Vem Com a Gente” and the Afluentes network, the company must continue capitalizing on its positive reputation. Behavior change efforts are particularly important in addressing resistance to payment and issues such as illegal dumping or pipe tampering. Residents need to understand the benefits of sanitation beyond the bills they pay. If community trust falters, future outreach will become far more difficult.

4. Service Affordability

Economic vulnerability is a defining characteristic of many households in Manaus. Nearly 80% of surveyed respondents reported being enrolled in the federal Bolsa Família program, and only a fraction reported consistently paying their utility bills on time. These findings underscore the critical role of Aegea's social tariff system, which provides subsidized rates to low-income households. With 50% of respondents currently benefiting from the program, and many others either unaware or unsure, the need for ongoing outreach is evident.

To ensure business sustainability, Aegea should continuously assess the distribution of service beneficiaries by income level. The aim should be to support those in greatest need without jeopardizing the financial viability of the utility. A flexible tariff system, which includes both automatic and manual enrollment as currently implemented, helps balance inclusivity with operational stability.

5. Lack of Long-Term Urban Planning

Urban sprawl and the proliferation of informal settlements in Manaus present significant challenges to service delivery. The lack of legal land status prevents many communities from being fully connected to water and sanitation systems, even when infrastructure has already been installed. Focus group participants described situations where internal piping was ready but remained unusable due to unresolved legal restrictions. As a result, households continue to rely on unsafe water sources. Conversely, the existence of water and sanitation services can increase a household's ability to obtain proof of residence.

This vicious cycle requires strategic intervention from municipal authorities. While Aegea can provide technical solutions, it has no authority to resolve land tenure or regulatory constraints directly. However, it can play a supporting role by engaging in policy dialogue or coordination efforts with relevant government agencies. The government must facilitate solutions to these legal constraints and offer affordable housing options in areas with access to essential services. In cases where settlements are located in flood-prone or environmentally unsustainable zones, a long-term plan including possible relocation should be considered. Long-term planning is essential, as quick fixes may appear cost-effective in the short run but often result in higher expenditures down the line.

6. The Need for Rapid Expansion

The pace of infrastructure expansion in Manaus has not kept up with its explosive population growth, particularly in hard-to-reach areas such as stilt-house communities and neighborhoods along streams. While Aegea has made progress, most notably in Beco Nonato where above-ground pipes have been successfully installed, many communities still lack access to safe water and sanitation. Survey data and focus group discussions consistently point to unmet needs in these marginalized zones. According to the concessionaire Águas de Manaus, all other areas will be served as the Trata Bem Manaus program advances, even before 2033.

What is needed is not only innovative technical solutions but also improved environmental conditions and stronger institutional alignment. Trash buildup and fragmented service mandates often undermine the effective rollout of infrastructure. To expand services efficiently, Aegea should work with municipal authorities to streamline integration with other service providers and identify high-need zones. Equally important is maintaining a balance between reaching low-income communities and ensuring financial sustainability through cross-subsidization from higher-income households.

7. Lack of Multi-Sector Collaboration and Inclusive Participation

The provision of water and sanitation services in a city as complex as Manaus cannot rest solely on the shoulders of a single actor. Effective service delivery requires shared responsibility: government institutions must provide regulatory oversight and clear policy direction, while private operators like Aegea must maintain transparent and responsive operations. At present, coordination remains limited, and it is unclear whether critical stakeholders such as

environmental authorities, housing agencies, and civil society groups are included in the conversation.

Focus groups revealed that women, despite being primary caregivers and water managers in the home, are frequently excluded from planning processes. Their participation is essential, particularly in designing gender-sensitive infrastructure and service delivery models. Additionally, many low-income residents lack formal representation, even though they are directly impacted by tariff decisions and infrastructure planning.

To address these gaps, both the government and Aegea should adopt a more inclusive, participatory planning approach. This includes stakeholder mapping, regular community consultations, and the formal integration of grassroots leaders into decision-making processes.

RELEVANCE

Manaus showcases how strategic, technically sound water and sanitation interventions—when adapted to the unique geography of Amazonian cities—can substantially improve public health, dignity, and economic resilience. Yet, the case also highlights that infrastructure alone is not enough. **Without coordinated urban planning, strong affordability frameworks, and participatory governance, the transformative potential of WASH services risks being unevenly realized. The city's rapid growth, complex legal landscape, and persistent social inequities require a model of service delivery that is as inclusive and adaptive as it is ambitious.**

For Aegea, Manaus presents one of its most significant challenges. As one of Brazil's fastest-growing capitals, the demand for basic services is both urgent and continuously evolving. In this context, the company has managed to establish itself as a generally trusted actor, delivering tangible improvements in health, dignity, and quality of life for many low-income households. The technical and social complexity of Manaus means that fallbacks and frustrations—such as delays, coordination gaps, or limited uptake—should be understood within the city's intricate urban fabric rather than viewed as failures of intent or effort.

Aegea's work in Manaus is laying the groundwork for a new model of urban service delivery in the Amazon. Its ability to expand access to safely managed services under challenging conditions deserves recognition. Still, for this impact to be durable, community engagement must remain central—especially with those historically left out of decision-making processes. Manaus is not just a city in need of infrastructure; it is a city in need of systems alignment. As Brazil looks toward national WASH goals and global climate forums like COP30, Manaus can emerge as a leading example of how bold, locally attuned investments in basic services can catalyze both social inclusion and urban resilience.

Case Study: Barcarena

I. Context

Barcarena's WASH Challenges

Barcarena, a municipality located in the state of Para, in northern Brazil, lying near the city of Belém and has a total population of around 130,000 people. Primarily known for its port infrastructure and industrial activities, Barcarena is considered to be both economically influential and environmentally vulnerable. Despite its industrial presence, the city faces major issues when it comes to basic public services, particularly clean water and sanitation. Like many areas in the Amazon, Barcarena struggles with high poverty levels, environmental degradation, and a weak infrastructure, which makes it a critical area for intervention and improvement.

Barcarena's population is diverse, with many residents living below the poverty line, lacking access to formal employment, healthcare, or even quality education. This contributes to poor health indicators, high vulnerability, and persistent inequality. In terms of sanitation, the region is critically underserved. According to Trata Brasil, only 14 percent of the population has access to sewage collection and treatment, and millions across the North region still live without clean water. Despite being home to major industrial facilities, such as aluminum refineries and port terminals, these have not translated into broad based development or equitable service delivery.

Many households rely on private wells, and some residents resist connecting to public systems due to perceived sufficiency or lack of awareness. Overcoming these behavioral and infrastructural barriers is key to delivering universal access to these cities and regions.

Urbanization Process

In recent years, Barcarena has been experiencing increasing urban growth, mostly due to its expanding industrial sector. However, this growth has not always translated into an improved living condition. Several new residents have settled in informal or precarious housing areas that lack adequate access to clean water, sewage treatment, and waste management. Like Manaus, Barcarena encounters difficulties associated with unplanned urbanization, where the population grows faster than public services can keep up.

The urban growth in Barcarena has led to a rise in irregular settlements on environmentally sensitive land. In multiple cases, communities are built in flood-prone zones or near industrial sites, exposing residents to both environmental hazards and health risks. Poor waste disposal and untreated sewage still contaminate rivers and groundwater, worsening living conditions. Also, Barcarena's flat topography and volatile river systems, influenced more by ocean tides than rainfall, make infrastructure planning and water management more complex. Some rivers fall under state authority while others are federally regulated, adding legal and coordination challenges to sanitation projects.

To better understand the roots of these urbanization challenges, it is important to consider the historical trajectory and institutional planning frameworks that have shaped Barcarena's spatial development. Barcarena's urban trajectory began with early settlements by the Aruan indigenous people, who were evangelized in the 17th century by Jesuit missionaries. The area became the religious mission of Vila de São Francisco Xavier, later a parish, then a town in 1897, and finally gained municipal status in 1943.

Until the 1970s, Barcarena's economy relied on family agriculture, artisanal fishing, and extractivism—an economic model that suffered significant disruptions in terms of land tenure. Urbanization accelerated in the 1980s when the municipality became a base for large-scale industrial projects like the Alunorte Industrial Complex, one of the largest ventures in the Amazon. This rapid expansion triggered significant population growth, but it followed business-driven patterns rather than inclusive planning, deepening territorial inequalities.

The first Urban Development Master Plan (PDDU-Barcarena), created in 2006, initially focused on economic development and strengthening local institutions. A major revision in 2016 shifted the plan's priorities toward territorial equity, sustainable water use, and universal access to basic sanitation—responding to growing demands for inclusive and resilient urban development.

Aegea's Role in Barcarena

Aegea is rapidly expanding its services to Barcarena through “Águas do São Francisco”, the local sanitation operator since 2014. Although operations are not yet fully active, the company is building a foundation for a sustainable and inclusive sanitation system, drawing on successful strategies used in Manaus.

Barcarena currently has nine water treatment plants, of which three are active, and four new plants are under development. These facilities use exhaustive treatment process involving underground water intake, aeration to oxidize iron, dual filtration, and chemical dosing with chlorine. Water quality is closely monitored in a dedicated chemical lab, which tracks manganese, iron, pH, and other key indicators using automated systems.

To improve coverage across the city's isolated neighborhoods, the water system currently includes 38 pump stations, with more planned as expansion continues. So far, 70 km of the sewage networks have been completed out of a projected 235 km, and the goal is to achieve full sanitation coverage by 2044. However, the urgency of COP30 has pushed forward the timeline for visible progress by 2025, giving Barcarena a chance to serve as a model for sanitation reform in the Amazon region. Another key reason why Barcarena is relevant to this project is its proximity to Belém, the host city of COP30 in 2025. This places Barcarena in the spotlight as both a site of environmental concern and a symbol of efforts toward sustainable development in the Amazon. With an expected influx of 400,000 visitors and \$3.2 billion in planned development investments across Pará, the region is under growing pressure to show real progress on sanitation and urban infrastructure.

Social Tariffs and Demographics

In line with its approach in Manaus, Aegea is expected to implement a social tariff program in Barcarena to make water and sanitation more affordable for low income households. This follows Brazil's federal framework under Law No. 14.898 (June 2024), which guarantees discounted water and sanitation services for low-income families registered in the CadÚnico system or receiving the Benefício de Prestação Continuada (BPC). Currently, around 10,000 people benefit from the program. Two distinct tariff models are being implemented:

1. **Social Tariff:** Offers a 50 percent discount for consumption up to 10 cubic meters per month, targeting households registered in government programs such as Bolsa Familia.
2. **Tarifa 10:** Offers a fixed tariff of 10 Brazilian Reals (about 1.75 USD at April 25, 2025 exchange rate), targeting households registered in government programs such as Bolsa Familia and including women headed households, victims of gender based violence, elderly persons, children under 12, BPC recipients, and those living in precarious housing conditions.

These programs are of course quintessential for providing inclusion in sanitation reforms. The goal is not simply affordability, but to ensure access does not compromise families' ability to meet other basic needs such as food, housing, and healthcare. However, community engagement is equally essential. As conducted interviews suggest, many residents continue to rely on dug wells or informal systems and may be unaware of, or reluctant to join, the formal network. Educational efforts and outreach will be essential to increasing adoption and usage.

Barcarena's demographic profile reflects high social vulnerability. Many families lack job security, public healthcare access is limited, and infrastructure in schools is often poor, with missing bathrooms and no clean water. Improving WASH services could yield far reaching and long term benefits, not only in reducing disease, but also in boosting school attendance, public health outcomes, and economic opportunity.

By combining infrastructure investments, social pricing models, and community inclusion, Aegea's work in Barcarena contributes not only to local development but also to broader goals tied to the 2033 universal sanitation target and the global agenda for sustainable development. These efforts show how socially targeted tariffs can act as tools of public policy—advancing equity and sustainable development, not only service access.

Water Supply System

The water supply infrastructure in Barcarena is composed of 11 independent subsystems serving key urban areas, including Barcarena Sede, Pioneiro, Vila do Conde, São Felipe/Arapari, São Francisco, Vila do Cafezal, Bairro Industrial, and the Central Treatment Station (ETA) in Vila dos Cabanos.⁷⁸ The municipality primarily relies on groundwater, with over

⁷⁸ Águas de São Francisco, *Works for the Universalization of Treated Water and Sewage Treatment Reach 100 km of New Networks Installed in Barcarena*, April 8, 2024,

50 percent of supply coming from wells—most of which are artesian and tubular—while the public network contributes around 40 percent, and streams account for less than 1 percent.⁷⁹ In total, Barcarena operates 27 active wells with a combined flow capacity of 753 m³/h. Major contributors include wells P01, P05, and P06, each providing 120 m³/h, and P09 contributing 70 m³/h.⁸⁰

The main ETA is located in Vila dos Cabanos and is managed by the Águas de São Francisco concessionaire. It serves seven neighborhoods and employs a full treatment cycle including aeration, pre-alkalization, flocculation, filtration, and disinfection. Distribution networks, built primarily from PVC materials, range in diameter from 40 mm to 110 mm but are often compromised by unauthorized modifications and the use of non-standard parts. The estimated network density is 4.0 meters per inhabitant, based on comparisons with municipalities of similar size. Barcarena's total reservoir capacity⁸¹ is 4,403 m³, with notable reservoirs such as R01⁸² (1,200 m³, semi-buried), R02⁸³ (600 m³, elevated), and R05⁸⁴ (1,200 m³, semi-buried). However, maintenance issues persist—R01 shows infiltration and cracking, R02 has several leaks, and R05 is partially overgrown with vegetation.

Water service coverage now reaches 82 percent of the population, and sewage coverage has also improved significantly over the last decade. Currently, according to SINISA 2022, this number has risen to 33 percent. Universalization efforts, aligned with the COP30 goals, aim to reach 99 percent of the population with drinking water and 90 percent with sewage systems.

Despite these advances, the system still struggles with high water loss: the estimated distribution loss rate is 40 percent, with SINISA 2022 data indicating actual losses of 49.36 percent. Contributing factors include aging asbestos and cast iron pipes, insufficient leak detection, and a lack of micro-measurement systems.

In parallel with improvements to the water supply system, Barcarena's sewage infrastructure has also undergone notable modernization. Since Águas de São Francisco, a concessionaire operated by the Aegea Saneamento group, began operations in 2014 under a 30-year concession, the municipality has expanded its treatment capacity beyond the original single system in Vila dos Cabanos. Historically underdeveloped and prone to blockages due to poor waste management and limited maintenance equipment, the sewage network has seen a turnaround since 2020. Barcarena inaugurated multiple treatment stations, including ETE Vila dos Cabanos I and II, both using efficient RAFA technology. Coverage expanded to 22 percent

<https://aguasdesaofrancisco.com.br/obras-para-universalizacao-de-agua-tratada-e-tratamento-de-esgoto-chegam-a-100-km-de-novas-redes-implantadas-em-barcarena/> (accessed April 19, 2025).

⁷⁹ Augusto C. Zoli, *Municipal Basic Sanitation Plan: Water Supply and Sanitary Sewage Services in Barcarena – PA* (Barcarena: Municipal Government of Barcarena; Department of Works – Water and Sewage Division, 2010) (accessed April 14, 2025).

⁸⁰ Águas de São Francisco, *Works for the Universalization of Treated Water*.

⁸¹ Zoli, *Municipal Basic Sanitation Plan*.

⁸² See Appendix I-J

⁸³ See Appendix K

⁸⁴ See Appendix L

of the population by 2022,⁸⁵ with additional projects underway—such as ETEs in Pioneiro, Sede, Beira Rio, and Itupanema. Nevertheless, some facilities face operational challenges, including land disputes and a lack of transparency. According to recent SINISA⁸⁶ data, sewage collection and treatment volumes continue to rise, indicating promising progress while underscoring the need for inclusive planning and enhanced monitoring systems.

Table 3. Sewage Treatment Coverage In the Municipality of Barcarena

	Period		
	2019 - 2020	2020 - 2021	2021 - 2022
Urban population	45,319	46,172	47,010
Population served with sewage treatment	6,888	14,432	20,470
Active connections	3,315	3,599	3,014
Collected (1,000 m ³ per year)	15.7	148.06	237.02
Treated (1,000 m ³ per year)	15.7	148.06	237.02
Sewage network extension (km)	52.27	52.27	52.27

Source: Adapted, SINISA (2021).

This progress is also reflected in quantitative data. As shown in Table 3, the number of residents with access to sewage treatment in Barcarena nearly tripled between 2019 and 2022, while the volume of sewage treated grew from just 15.7 thousand m³ to over 237 thousand m³ annually.

II. Research and Data Gathering

The fieldwork in Barcarena used a combination of semi-structured interviews and focus group discussions to explore community and institutional perspectives on water and sanitation services:

⁸⁵ Zoli, *Municipal Basic Sanitation Plan*.

⁸⁶ European Commission, *The BraSIS Project: A EU–Brazil Sector Dialogue Project on Basic Sanitation* (JRC Scientific and Policy Reports No. LB-NA-26384-EN-N), Joint Research Centre, 2013, <https://publications.jrc.ec.europa.eu/repository/handle/JRC85562> (accessed April 14, 2025).



FOCUS GROUP DISCUSSIONS

- 2 Male Groups (6 participants each)
 - 2 Female Groups (5 participants each)
- Total: 12 Community Leader Participants



INTERVIEWS

10 Interviews with Community Leaders, Research Scientists, Águas de São Francisco Operations Staff, local NGOs, and Municipal Regulators

FOCUS GROUP DISCUSSIONS

Focus Group Discussion 01 – Male Community Leaders in Barcarena⁸⁷

In Barcarena, male community leaders discussed the infrastructural and environmental constraints of expanding sanitation services in tidal regions. While decentralized wastewater systems are being implemented, tidal fluctuations from Marajó Bay and uneven construction progress complicate operations and planning. Despite near-universal water access, connection hesitancy remains high due to affordability concerns and limited community trust.

- *“Each system has its own network... some are working, others are still being built.”*
- *“The river’s level changes a lot because of the tide, so we have to deal with that.”*

They stressed that achieving high infrastructure coverage alone is insufficient without behavioral engagement and environmental responsiveness.

Focus Group Discussion 02 – Mixed Gender Community Leaders in Barcarena⁸⁸

Mixed-gender leaders voiced concern over the financial inaccessibility of services, poor communication, and technical shortcomings. Although infrastructure exists, many rely on unsafe alternatives due to unaffordable tariffs. Planning failures—like digging up newly paved roads—undermined trust and highlighted institutional disorganization.

- *“I have water at home, but I drink from the well because I can’t pay R\$300 every month.”*
- *“We waited years for pavement, and now it’s gone—again—because they didn’t plan properly.”*

Participants called for better interagency coordination, affordability measures, and sustained community dialogue.

⁸⁷ See Appendix E for a Detailed Summary

⁸⁸ See Appendix F for a Detailed Summary

Focus Group Discussion 03 – Female Community Leaders in Barcarena⁸⁹

Women leaders from Murucupi emphasized how misaligned project sequencing and unclear communication about costs bred frustration. Roads and sidewalks were damaged during sewer installations and not adequately repaired, further burdening residents already asked to pay for connections.

- *“The asphalt came before the sanitation system, and this causes a lot of disturbance.”*
- *“They broke the sidewalk and now they want the resident to pay for the connection?”*

Despite setbacks, leaders acknowledged the value of sanitation and pressed for fairer cost-sharing models, accountability, and follow-through from service providers.

Focus Group Discussion 04 – Female Community Leaders in Barcarena⁹⁰

Women leaders described the community’s transition from illegal water systems (“gato”) to regulated supply, largely triggered by the 2018 industrial spill. They led educational campaigns promoting safe water, though **high monthly bills and bureaucratic barriers** to subsidies continue to limit access.

- *“The neighborhood always used the ‘gato’... it was already part of the community.”*
- *“There should be a special price for the community.”*

While health improvements are recognized, participants urged broader inclusion, equity in service delivery, and integration of WASH within a more holistic development agenda.

SUMMARY OF FOCUS GROUPS:

Theme	Findings
a. Water Access and Infrastructure	<ul style="list-style-type: none"> • Limited access to piped water in informal settlements, especially in palafitas (stilt houses) • AEGEA pipelines remain unused in certain areas due to legal and jurisdictional restrictions (e.g., federal roads) • Continued dependence on untreated or informal water sources for household use • Monthly water bills ranging from R\$200 to R\$400 are unaffordable for many low-income households • Gaps in coordination between infrastructure implementation and municipal planning processes

⁸⁹ See Appendix G for a Detailed Summary

⁹⁰ See Appendix H for a Detailed Summary

Theme	Findings
b. Sanitation and Drainage	<ul style="list-style-type: none"> ● Sewer construction often starts after road paving, leading to rework and public dissatisfaction ● High sewage connection fees (R\$800–900) remain out of reach for most residents ● Land tenure issues prevent full connection to sewage networks in some neighborhoods ● Rainy season flooding mixes sewage and stormwater, raising exposure to contamination ● Residents frequently experience waterborne diseases like diarrhea and skin infections due to poor drainage
c. AEGEA's Service and Engagement	<ul style="list-style-type: none"> ● Afluentes program in Manaus praised for enabling quick reporting through WhatsApp. ● Mistrust in Barcarena due to AEGEA's past industrial spills and unmet service promises. ● Digital barriers and low awareness limit access to the Social Tariff subsidy. ● Services are seen as reactive and inconsistent, with infrastructure gaps left unresolved. ● Residents call for more proactive, in-person engagement and transparent planning by AEGEA.
d. Gendered Perspectives on WASH Priorities	<ul style="list-style-type: none"> ● Women across focus groups emerged as key actors managing water, hygiene, and community responsibilities ● Water scarcity disproportionately affects women's hygiene and caregiving roles ● Girls often miss school due to lack of private and safe toilets, especially during menstruation ● Women emphasized the need for inclusive infrastructure like gender-sensitive toilets and equitable pricing ● Strong demand for vocational training, leadership recognition, and inclusion in decision-making processes

III. Data Analysis

AEGEA INTERVENTIONS

Prior to Aegea's intervention, Barcarena's drinking water and sanitation services fell well below safely managed standards. According to the JMP ladder, water access was mostly basic or limited—many households relied on private wells or informal “gato” connections, and concerns over affordability and water quality led residents to continue using untreated sources, even when piped water was available.

Table 4. Activities by Aegea in Barcarena

	Baseline Condition	Service Chain Intervention	Target Condition
Water	Safely Managed Basic Limited Unimproved Surface Water	Source - Groundwater Abstraction & Treatment - Water treatment plant Distribution - Water distribution network	Safely Managed Basic Limited Unimproved Surface Water
Sanitation	Safely Managed Basic Limited Unimproved Open Defecation	Containment Transport - Wastewater collection network - Pumping stations Treatment - Wastewater treatment plant (upflow anaerobic sludge blanket) Reuse/Disposal	Safely Managed Basic Limited Unimproved Open Defecation

Sanitation conditions were even more severe, with most of the population lacking access to formal sewer systems. Waste was often discharged into open drains or directly into the environment, placing households in the unimproved or open defecation categories. Some residents were unable to connect to the new sewer network due to high one-time connection fees, and several neighborhoods without paved roads were excluded from installation efforts entirely.

For water, the company uses groundwater intake, treatment, and distribution through a growing network supported by pump stations. For sanitation, wastewater is transported through new collection networks and pumping stations, and treated using the Upflow Anaerobic Sludge Blanket (UASB) method. Households connected to Aegea’s systems in Barcarena are expected to reach safely managed levels of access.

SIGNIFICANT FINDINGS

1. Service Expansion Challenges

Aegea’s efforts to accelerate service expansion in Barcarena are both ambitious and necessary. However, Barcarena’s uniquely tide-influenced geography poses significant engineering challenges that result in uneven progress across neighborhoods. As noted by community leaders, sewerage systems are under development, but each requires tailored networks, which increase operational complexity and slow the pace of uniform coverage. Although the city

aspires to achieve 90% sewage coverage, actual implementation is fragmented due to the configuration of people's occupation in the territory, with separate housing clusters.

These technical hurdles are compounded by growing mistrust toward the sanitation rollout process. Focus group participants repeatedly raised concerns about construction activities that disrupted streets and sidewalks, often newly paved, and left behind safety hazards or incomplete repairs. This has led to public frustration, particularly because residents are now being asked to pay connection fees, despite the disruptions and lack of coordination.

2. Service Affordability

Although piped water coverage in Barcarena is nearing universal levels, usage remains inconsistent due to affordability concerns. Residents from low-income households reported relying on private wells, even when piped water is available, simply because monthly bills are unaffordable. This is particularly troubling given that groundwater in the region often contains high levels of salinity and metals, which increases the cost of safe water production. These technical constraints raise the baseline cost of service, but without strong affordability mechanisms, uptake among the most vulnerable will remain limited. This is one of the reasons why the concessionaire launched the Trata Bem Barcarena program and Tarifa 10, to quickly make it possible for people to access the networks and pay the tariffs.

Currently, about 10,000 people benefit from Aegea's social tariff program, which includes targeted models such as Tarifa 10 and Social Tariff. While these programs are essential, they may not be sufficient. Many residents are unable to access the benefits due to ineligibility or limited awareness. Aegea should consider expanding outreach and simplifying enrollment processes, while also reassessing the adequacy of existing discount levels. In the longer term, exploring cross-subsidy models where higher-income consumers subsidize services for lower-income users could help build a more inclusive and financially sustainable pricing structure.

3. Urgency to Promote Behavior Change

Just as in Manaus, Barcarena faces the challenge of building community demand alongside infrastructure supply. While pipes and treatment systems are being installed at an impressive pace, the behavioral shift required for full adoption remains a significant hurdle. Community leaders, particularly women, have taken the lead by organizing door-to-door campaigns and information sessions to explain the health and dignity benefits of connecting to regulated systems. However, resistance is growing, especially in response to rising utility bills. Based on our focus groups and interviews, many residents remain skeptical that the benefits justify the financial burden.

To sustain progress, Aegea must strengthen public engagement, emphasizing the long-term value of safe water and sanitation not merely as services, but as investments in health and economic resilience. Helping residents understand the connection between water and sanitation is critical: access to clean water is essential for practicing safe sanitation, while the absence of adequate sanitation systems can lead to the recontamination of water sources. By framing

WASH services as interconnected pillars of public health, Aegea can begin to shift community perceptions.

4. *Communication and Feedback Mechanism*

Despite improvements in coverage, service quality in Barcarena remains a point of concern. Residents in multiple neighborhoods described receiving water that appeared cloudy or had an overpowering chlorine smell. In sanitation, complaints centered around unpleasant odors from venting systems and poor pipe placement. These quality issues undermine public trust, especially when compounded by high bills or property disruptions. Several participants shared that, although channels like WhatsApp or complaint forms are available, responses are often delayed or insufficient.

This underscores the need for a proactive and transparent feedback mechanism. Aegea should develop a structured system for receiving and responding to quality complaints in real-time. Not only would this help improve service quality, but it would also reassure the community that their concerns are being taken seriously.

5. *Lack of Multi-Sector Coordination*

Barcarena's WASH expansion marks a significant step forward, but the process has revealed critical gaps in coordination between Aegea and other public entities. Focus group participants expressed frustration that newly paved roads were soon dug up again to install sanitation pipes—an avoidable disruption that could have been prevented with better planning. These oversights have fueled public resentment and reinforced perceptions of mismanagement and poor communication between sectors.

To prevent such issues in the future, Aegea and the municipal government should establish a coordinated planning framework that synchronizes infrastructure timelines across departments. Stakeholder mapping, which is already recommended in the context of Manaus, is equally essential in Barcarena. This would enable Aegea to align with housing, transportation, and environmental authorities, ensuring that infrastructure development enhances rather than disrupts community life and reinforces public trust in urban service delivery.

RELEVANCE

Barcarena represents both the urgency and complexity of extending equitable WASH services in poor regions of Brazil. While infrastructure is expanding rapidly, its full potential will only be realized through deeper institutional coordination, community trust, and inclusive affordability mechanisms. The challenges faced here—fragmented planning, uneven uptake, and public skepticism—are not anomalies but signals of the need for a more integrated, people-centered approach to service delivery. As Aegea and its public partners look ahead, Barcarena offers a critical learning opportunity: that the long-term success of sanitation systems lies not only in the technology that carries the water, but in the systems of trust, governance, and engagement that sustain its flow.

Yet, Barcarena is also poised to become an outlier—a rare case study of a small Brazilian city that has moved from minimal water and sanitation coverage to near-universal access in a matter of months. The speed at which infrastructure is being deployed is remarkable, and Aegea’s bold commitment to achieving this transformation ahead of COP30 reflects both ambition and courage. Many of the issues raised by residents—such as construction disruptions, pipe placement concerns, and temporary inconvenience—can be understood as the growing pains of a city undergoing rapid and large-scale development. Given the scale and pace of implementation, such short-term disruptions are expected. We remain hopeful that once the infrastructure is fully completed, Aegea’s continued engagement and support will help communities fully benefit from the investments made. As such, Barcarena offers valuable lessons for other regions—particularly small municipalities—seeking to close their WASH gaps under tight timelines. Its experience may well serve as a replicable model for accelerating inclusive service delivery across Brazil.

Data Limitations

In our initial meetings with Aegea, we were briefed on their efforts to expand water and sanitation services to vulnerable communities in Manaus and Barcarena. Our original goal was to survey families in these areas about how their lives had been impacted by the provision of such services, focusing on changes in their social, economic, and health conditions before and after the intervention. However, our team initially assumed that all the communities had received both water and sanitation services. During our first interviews, we quickly realized that, among the communities we visited, only the community of Beco Nonato had received sanitation services so far.

Our questionnaire included six questions specifically about sanitation conditions before and after service provision. Given the reality on the ground, these questions were no longer applicable. Because our team was divided into eight pairs conducting simultaneous interviews, it was difficult to coordinate a unified response to this discovery. As a result, data collection was inconsistent across the groups: some skipped the sanitation questions, others adapted them to refer only to water services, and some recorded them as “no response” or “not applicable.” After this initial round, our team regrouped and decided to revise the questionnaire to focus solely on water services moving forward. However, this inconsistency in data collection limited our ability to generate strong quantitative insights, particularly regarding sanitation. From the first day, it became clear that our surveys would primarily serve a qualitative purpose.

Another challenge in collecting robust data was the length of residence of some respondents. Several families had only recently moved into the communities—some had lived there for less than a year or even just a month—and were therefore unable to provide a comparative perspective on life before and after water service implementation. Still, the information we gathered about current experiences with water access proved to be extremely valuable.

We also encountered limitations during one of the focus groups. Our intention was to conduct gender-segregated sessions to allow female community leaders, in particular, to speak freely without fear of judgment or interruption. This approach worked well in all the focus groups held in Manaus. However, in one focus group in Barcarena, male leaders chose to invite their female counterparts to join the session. While this allowed us to gather insights from male participants—who contributed meaningfully—the dynamic shifted, and the women became less vocal. It's unclear whether they felt fully comfortable sharing their views. Nonetheless, when they did speak, their comments were thoughtful and showed a strong commitment to improving community conditions.

Lastly, it's important to acknowledge that Aegea employees were present during most of our activities. While they did not sit with us during interviews or directly interfere, they were often in the vicinity. For example, during surveys, we were accompanied by Aegea staff as we moved through the communities. Even when they stepped away during questioning, they rejoined us afterward, which may have influenced how comfortable residents felt sharing their honest opinions—particularly regarding service satisfaction. In the case of the focus groups, Aegea representatives were not present in the room, but all sessions were hosted at Aegea facilities in both cities. While many participants voiced strong opinions, including criticisms, it is possible that the setting had an inhibiting effect on some.

At the same time, all the researchers' teams collected a considerable amount of comments from the residents, which suggests that participants were comfortable and chose to contribute voluntarily, with independence and autonomy. It is also important to recognize that the presence of Aegea staff was essential to the feasibility and safety of the fieldwork. Many of the sites visited are located in vulnerable areas—some of which are partially controlled by drug trafficking or militia groups—and the logistical support and accompaniment provided by Aegea employees helped ensure the security of students and faculty throughout the research process. Moreover, given the limited time available for the visits, Aegea's facilities were the most practical and secure locations to conduct several of the focus group interviews.

AI Integration

Artificial intelligence (AI) offers transformative potential for improving water and sanitation service delivery. Across the WASH sector, AI has been used to monitor water and wastewater quality, detect leaks, forecast demand, model consumption, optimize treatment processes, and optimize tariff and operational cost. In sewage treatment, studies have shown that neural network models can achieve over 90% accuracy in predictive planning by processing large-scale operational data. These models outperform traditional approaches, which often fall short in rapidly changing and data-dense environments. As the AI research scientist noted in an interview, the core strength of AI lies in its ability to filter trillions of possibilities into a handful of actionable solutions, which is a capability that is highly relevant for sanitation planning in areas with limited resources and difficult terrain. AI also holds promise for enhancing community

engagement, enabling real-time monitoring of water use, detecting anomalies in quality, and supporting behavior change campaigns through mobile and community-based platforms.

Despite its promise, integrating AI into water and sanitation service delivery in Brazil faces several structural challenges. Data limitations remain a major obstacle as many public datasets in Brazil are outdated, inconsistently reported, or too aggregated to support localized modeling. Reliable, anonymized, and high-frequency data is essential to train AI models, yet it is often unavailable in the regions most in need. Moreover, institutional trust and technological maturity present additional barriers. The adoption of AI tools frequently requires a cultural shift, where decision-makers and engineers must be willing to rely on algorithmic outputs. These shifts are often met with skepticism, especially when models are viewed as opaque or difficult to interpret. Budget constraints, interoperability with existing systems, and the need for low-maintenance solutions also limit the feasibility of deploying cutting-edge AI tools in low-resource environments such as the Amazon.

Nevertheless, Aegea has already taken important steps toward technological innovation in its Manaus operations, primarily on the supply and infrastructure side. The company has implemented a digital twin of the water supply system to enable real-time monitoring of assets. In addition, Aegea uses TaKaDu's Central Event Management (CEM) solution, which is a cloud-based AI tool that detects and manages leaks, bursts, and operational failures across the network. These systems have improved leak detection, reduced water losses, and enhanced operational workflows. However, their scope is largely limited to technical and operational efficiency, with less emphasis on community-facing applications or broader planning and policy functions.

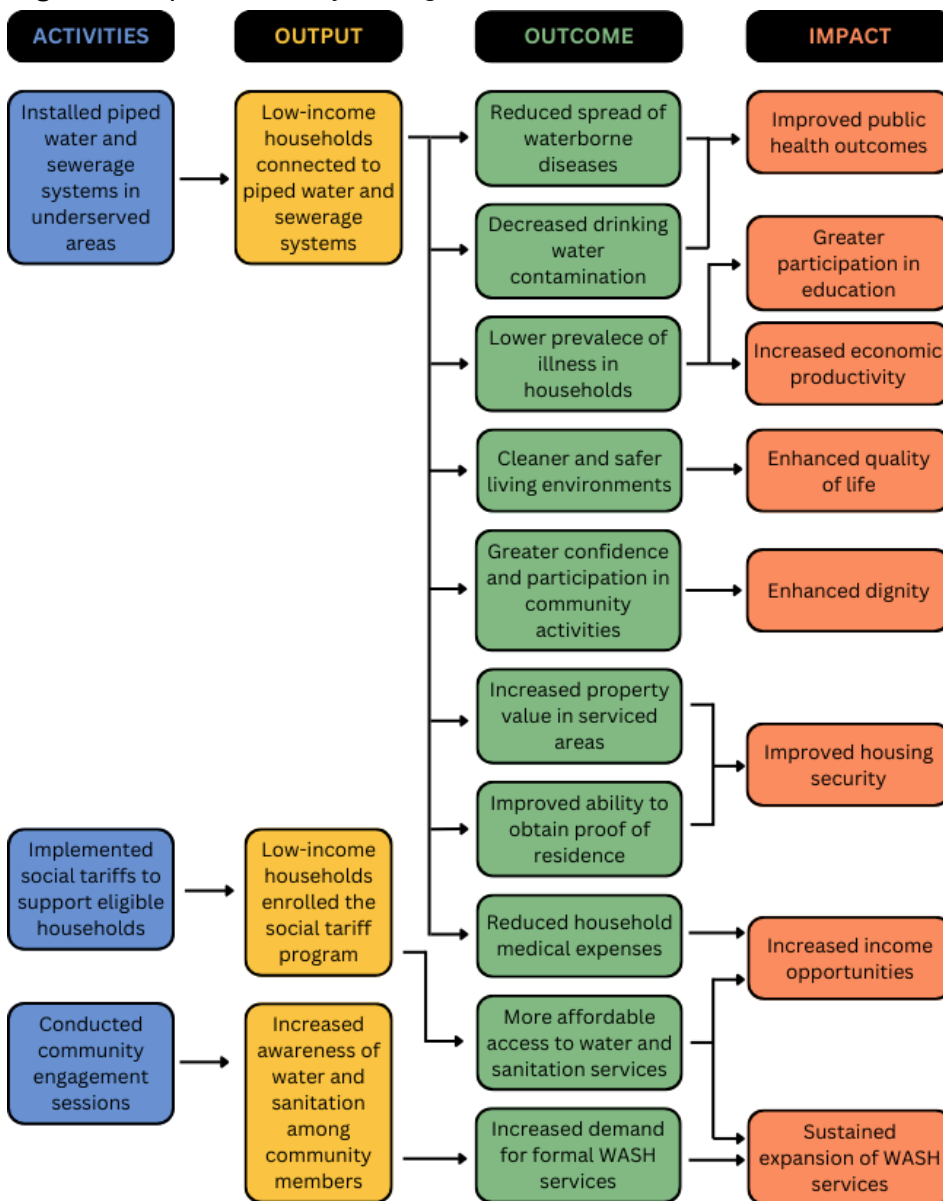
To build on these advances, Aegea should consider expanding its use of AI into domains that improve responsiveness, equity, and community inclusion.⁹¹ On the consumer side, AI-enabled platforms could analyze customer service data, social media inputs, and community surveys to detect patterns in service gaps, affordability concerns, and emerging needs, particularly in vulnerable neighborhoods like palafitas. Predictive analytics could also be used to forecast water demand and sanitation infrastructure needs in fast-growing informal settlements, allowing Aegea to plan more targeted and anticipatory interventions. In low-connectivity environments, hybrid systems using edge computing where only key data is transmitted to the cloud could reduce technical barriers, while pre-trained models can be fine-tuned using minimal local data. Importantly, AI can also be leveraged to support education and behavior change efforts, enabling more effective sanitation outreach through mobile tools and participatory platforms. To ensure that these innovations serve the public good and avoid unintended harm, it is essential that Aegea integrates strong ethical safeguards in the design, deployment, and monitoring of AI systems. These strategies would not only improve service delivery but also help Aegea position itself as a leader in deploying inclusive, sustainable, and technologically adaptive WASH solutions.

⁹¹ See Appendix Q

Impact Pathway

An impact pathway is a visual representation that traces the sequence of changes resulting from a set of interventions, linking activities to outputs, outcomes, and ultimately long-term impacts. It helps clarify how and why specific results are expected to occur. The impact pathway presented here summarizes findings from Aegea’s water and sanitation interventions in Manaus and Barcarena, drawing from both field observations and community feedback. It outlines the key activities undertaken, the immediate outputs delivered, the outcomes experienced by local residents, and the broader impacts emerging over time.

Figure 9. Impact Pathway of Aegea’s WASH Services in Manaus and Barcarena



(Source: Own elaboration)

Recommendations

The following are strategic recommendations and an implementation roadmap for integrating and maximizing the use of the socio-economic impact tools provided by the consulting team. These tools are designed to support Aegea's mission of delivering equitable, sustainable, and measurable WASH services in vulnerable communities across Brazil. Key deliverables provided include:

- A Socioeconomic Impact Assessment Framework and Scorecard (Toolkit)⁹²
- A Household Survey Tool for Socioeconomic and Service Delivery Metrics⁹³
- A Focus Group Discussion Guide⁹⁴
- A WhatsApp Community Feedback Survey Template⁹⁵

1. Delivering Inclusive Outcomes: Health, Equity, and Dignity in WASH

(How can Aegea measure and strengthen the broader social impacts of WASH for the most vulnerable communities?)

1.1 Strengthen Community-Level Data Collection & Impact Tracking

Deploy the provided household survey tool in selected municipalities, in partnership with local academic or NGO partners. Leverage the scorecard framework to monitor impacts across health, equity, and community well-being.

Implementation Roadmap:

- Form local partnerships to oversee survey implementation and data collection.
- Use the updated household survey and guidance notes provided by the team.
- Deploy surveys quarterly or semi-annually, using disaggregated data entry tools.
- Share scorecard results in community meetings and via the public-facing dashboard.
- Include SDG-aligned indicators from the mapping sheet in internal and external reporting.

1.2 Embed WASH Education in Service Roll-Outs

Use survey insights to identify knowledge gaps and go beyond hygiene promotion: co-design environmental education and waste management campaigns with local leaders, building on existing grassroots practices (e.g., upcycling, clean-up drives). Align awareness-building with behavioral outcomes around proper sanitation practices.

⁹² See Appendix M

⁹³ See Appendix N

⁹⁴ See Appendix O

⁹⁵ See Appendix P

Implementation Roadmap:

- Create a baseline of awareness and practices using the survey tool.
- Co-develop visual materials and WASH messages with teachers and community health agents.
- Integrate campaigns into existing education efforts and infrastructure rollout schedules.
- Track behavior change outcomes (e.g., reported graywater management) in follow-up surveys.

1.3 Prioritize Gender & Vulnerable Groups in Program Design

- Ensure water points and sanitation facilities are safe, accessible, and adapted for women, elderly, and persons with disabilities.

Implementation Roadmap:

- Support informal female leadership through stipends, training, and formal inclusion in service planning.

1.4 Monitor Indirect Impacts on Health, Education, and Employment

Link WASH outcomes to broader well-being indicators, such as hospitalization rates or missed school days. Track progress using the impact scorecard and build a compelling case for investment through visualization tools.

Implementation Roadmap:

- Share the scorecard format with local government partners for shared tracking.
- Digitize and centralize external data on school attendance and health outcomes.
- Update the dashboard biannually with new insights.
- Use trend analysis to identify success stories and gaps requiring response.

2. Aegea Service Delivery Enhancements

(What operational or strategic shifts could improve equity and efficiency?)

2.1 Standardize a Participatory Planning Toolkit

Establish formal processes for integrating community input into Aegea's service planning and delivery. Build on existing programs (like Vem Com a Gente and Afluentes) by institutionalizing inclusive dialogue channels and ensuring that local voices meaningfully shape priorities and outcomes.

Implementation Roadmap:

- Adapt the participatory planning tools provided in the toolkit (e.g., focus group guide, feedback channel mapping) across all Aegea subsidiaries.
- Institutionalize recurring engagement mechanisms such as quarterly town halls, citizen advisory panels, and WhatsApp-based surveys.
- Incorporate findings from focus groups and surveys into decision-making via a local planning dashboard, linking community input to action items.

- Map informal settlements using survey and observational data to co-design rollout strategies that address legal, logistical, and infrastructural barriers.
- Track how community input influences service design and use this data to inform the Community Engagement and Planning Coordination indicators in the Impact Scorecard.

2.2 Institutionalize the Social Tariff as a Flagship Equity Program

Link survey data on affordability perceptions with efforts to improve outreach, eligibility, and automated enrollment.

Implementation Roadmap:

- Improve outreach and transparency around eligibility and application process.
 - Increase accessibility by providing enrollment assistance in areas with low literacy rates (consider door-to-door registration and visual communication strategies)
- Create automatic enrollment mechanisms linked to Bolsa Família data.
 - Allow enrollment without full documentation through proxy indicators (e.g., Bolsa Família, self-declared income ranges).
 - The Brazilian Congress recently approved a federal law that automatically grants low-income families linked to a national income transfer program access to the Social Tariff, which will facilitate the mentioned equity.⁹⁶
- Launch targeted outreach via radio, WhatsApp, and community visits to increase awareness, especially in areas with low digital access.
- Advocate with government partners to allow alternate eligibility (e.g., self-attestation or proxy indicators).

2.3 Improve Service Affordability and Billing Transparency

Build trust and accountability by using findings from the survey and dashboard to clarify billing questions and trends.

Implementation Roadmap:

- Establish transparent billing guides distributed through digital and physical channels.
 - Publish clear, visual guides on how tariffs work, including real-life examples and infographics.
- Host monthly customer support events by setting up a customer “ombudsperson” unit or monthly pop-up grievance desks in key neighborhoods.
- Document and respond to trends raised in the feedback sections of the survey.

⁹⁶ “El gobierno brasileño propone una reforma del sector eléctrico con tarifas sociales ampliadas y apertura del mercado a todos los consumidores,” *pv magazine Latin America*, April 21, 2025, <https://www.pv-magazine-latam.com/2025/04/21/el-gobierno-brasileno-propone-una-reforma-del-sector-elctrico-con-tarifas-sociales-ampliadas-y-apertura-del-mercado-a-todos-los-consumidores/> (accessed May 7, 2025).

2.4 Coordinate Infrastructure Rollout with Urban Planning

Leverage findings from the impact assessment and service access maps to improve coordination with municipal development agendas.

Implementation Roadmap:

- Overlay service access maps with planning schedules for street paving and drainage.
- Align timing with housing formalization and land regularization efforts.
 - Advocate for formal agreements with federal and municipal authorities to resolve legal barriers preventing connection (e.g., along federal roads).
- Use findings to justify urgent investment or realignment of delivery timelines

2.5 Monitor Water Quality Through a Community-Centered Testing System

Ensure that improved access is matched by consistently safe and reliable water through routine quality testing and transparent reporting.

Implementation Roadmap:

- Establish a routine testing schedule for water quality indicators (e.g., turbidity, chlorine, coliforms, pH, iron, manganese).
- Deploy portable testing kits in informal or remote areas where lab access is limited.
- Train local staff or health agents to conduct on-site tests and document results.
- Share findings with communities via posters, SMS alerts, WhatsApp groups, or local bulletin boards.
- Invite community leaders to participate in periodic sampling and public reporting to build trust and accountability.

3. Socioeconomic Impact Assessment Framework

(How can Aegea evaluate and replicate its success across municipalities?)

3.1 Adopt a Multi-Criteria Assessment Model

Apply the impact scorecard and assessment framework provided to track multidimensional outcomes across health, equity, education, trust, and productivity. Use this to demonstrate social return on investment.

Implementation Roadmap:

- Customize scorecard scoring rules and categories with local teams.
- Incorporate stakeholder input into indicator weighting and categories.
- Use the tool in Manaus and Barcarena as pilots, and refine prior to broader rollout.

3.2 Standardize Tools for Replication Across Cities

Deploy the full toolkit (survey, scorecard, indicator map) in new cities, adjusting for local contexts and languages.

Implementation Roadmap:

- **Step 1:** Baseline Data Collection (Pre-Implementation)
 - Collect health, access, and socioeconomic data
 - Map informal settlements and existing service gaps

Category	Possible Sources
Health data (illness rates, hospitalizations)	Local health posts, municipal health departments, community health agents
Water access and collection time	Household surveys, focus group discussions, observation
Sanitation methods used	Household interviews, local NGOs, municipal sanitation offices
Household income estimates	Cadastro Único (Single Registry), Bolsa Família enrollment records, proxy indicators
Education levels	Local schools, census or IBGE data, interviews with school officials
Housing conditions	Field observations, housing surveys, community leader insights

- **Step 2:** Program Implementation
 - Expand infrastructure (e.g., above-ground pipes in palafitas)
 - Launch social tariff outreach and WASH education campaigns
 - Engage communities via Afluentes & door-to-door efforts
- **Step 3:** First Impact Assessment (6–12 Months Later)
 - Use the Impact Scoreboard & Dashboard Toolkit
 - Measure changes in health, access, education, trust, and income
 - Compare with baseline to identify improvements and gaps
- **Step 4:** Ongoing Monitoring & Feedback
 - Update dashboard annually or biannually
 - Use WhatsApp feedback, mini-surveys, and service logs
 - Feed results into strategic planning and community updates

3.3 Train Aegea Institute Staff in Impact Evaluation

Build internal capacity to lead and institutionalize the use of the framework and dashboard across all units.

Implementation Roadmap:

- Host a training with staff from Manaus and Barcarena, and other implementing municipalities.
- Recognize staff champions with microgrants or awards for implementation innovations.

3.4 Align Impact Indicators with National and COP30 Priorities

The provided SDG mapping sheet demonstrates alignment with Brazil’s sanitation law and international benchmarks like SDG 6.2 and COP30. Use the findings from Manaus and Barcarena as a model for Amazon-focused development, especially in the lead-up to COP30 in Belém

The following set of indicators are recommended because each one is directly aligned with Brazil’s sanitation laws and relevant SDG targets, ensuring Aegea’s impact measurement reflects both service quality and broader social value. By tying results to legal benchmarks and global commitments, Aegea can demonstrate compliance, highlight contributions to national development goals, and identify areas for targeted improvement — positioning itself as a trusted and forward-looking public service partner.

Table 5. Linking Impact indicators to SDGs and Policy Regulations

Indicator	What It Measures	Linked Regulation / Policy	Linked SDG Target
Health	Reduction in illness rates, improved hygiene	Brazil National Basic Sanitation Law (14.026/2020), SUS guidelines	SDG 3.3 / 3.9 (Reduce illness from water contamination)
Education	School attendance and reduced absenteeism due to WASH	National Education Plan; WASH in Schools Guidelines	SDG 4.1 / 6.2 (Inclusive, safe schools and hygiene)
Income	Economic resilience through time/cost savings	National Strategy to Combat Poverty (Plano Brasil Sem Miséria)	SDG 1.2 / 8.5 (Reduce poverty, promote decent work)
Equity	Inclusion of marginalized groups (e.g. women, Bolsa Família recipients)	Constitutional Right to Equality, Bolsa Família access laws	SDG 5.1 / 10.2 (End discrimination, promote inclusion)
Access	Availability of basic water and sanitation services	National Sanitation Law (14.026/2020), municipal concession agreements	SDG 6.1 / 6.2 (Universal access to WASH)
Trust	Public confidence in service provider and system	Consumer Protection Code, Transparency Laws	SDG 16.6 / 16.7 (Transparent, accountable institutions)
Water Quality	Compliance with safety standards for potable water	Ministry of Health Water Quality Norms (Portaria GM/MS 888/2021)	SDG 6.1 (Safe and affordable drinking water)
Sanitation Services	Extent of sewage coverage and safe waste management	CONAMA Resolution 375/2006; ANA and SNIS data standards	SDG 6.3 (Improve water quality by reducing pollution)

Affordability	Access to subsidized tariffs for vulnerable households	Tarifa Social Regulation (ANEEL/ANEAS guidelines)	SDG 1.3 / 10.4 (Access to social protection)
Reliability	Service uptime, issue response time	Municipal service charters, ANEAS operational standards	SDG 9.1 / 6.b (Reliable infrastructure, inclusive mgmt)
Community Engagement	Presence of community channels (e.g. Afluentes, WhatsApp)	Programa Afluentes; public participation standards in sanitation plans	SDG 6.b / 11.3 (Participatory, local governance)
Communication	Clarity and responsiveness of customer communication	Código de Defesa do Consumidor; Municipal communication norms	SDG 16.10 (Access to information, transparency)
Planning Coordination	Integration with local development and infrastructure planning	Plano Municipal de Saneamento Básico (PMSB), Urban Planning Guidelines	SDG 11.3 / 17.14 (Policy coherence for sustainable development)

Conclusion

Access to safe water and sanitation is more than a public utility—it is a foundation for dignity, health, and economic opportunity. Through this capstone project, we sought to understand the social and economic impacts of Aegea’s water and sanitation services in Manaus and Barcarena, two municipalities at the heart of Brazil’s efforts to meet its 2033 universalization goals. Our findings affirm that these services have generated meaningful improvements in household well-being, from better health outcomes and increased school attendance to greater financial stability and social inclusion.

Yet, our research also revealed persistent structural challenges—from infrastructure gaps in informal settlements to limited awareness of the social tariff program and a need for deeper participatory mechanisms in decision-making. These insights underscore that infrastructure alone is not enough. Achieving true universalization requires a people-centered approach that addresses affordability, trust, communication, and community engagement.

We offer this report not only as an evaluation of Aegea’s work, but as a toolkit for replication and a roadmap for future planning. By strengthening participatory governance, aligning service expansion with urban planning, and adopting a robust impact assessment framework, Aegea can deepen its leadership role in Brazil’s sanitation sector. With COP30 on the horizon and growing attention to climate-resilient development in the Amazon, Aegea is well-positioned to demonstrate how private-sector innovation can drive public good—sustainably, equitably, and inclusively.

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Appendix A – Focus Group Discussion 1: Female Community Leaders, Manaus

Focus Group Discussion 1 – Female Community Leaders in Manaus

This discussion highlighted the role of female community leaders as vital connectors between underserved communities and service providers in Manaus. Most participants emphasized that their work is voluntary but deeply impactful. “You might think I’m a counselor, but I’m not—I’m just a volunteer. Still, they call me a leader because I fight for them,” one woman shared, illustrating how informal leadership emerges out of necessity. A major theme was the lack of formal urban planning in Manaus; many communities began as “invasions” without legal recognition, leading to long-term exclusion from basic services. A striking example was the case of a neighborhood where Águas de Manaus had installed internal piping for 500 homes, but couldn’t connect them due to legal constraints on modifying a federal road. “Everything is ready, but they can’t open the street because it’s a federal route,” a participant explained.

Despite these systemic barriers, Águas de Manaus was praised for their responsiveness and community engagement. The “Afluentes” network—a WhatsApp-based communication platform between leaders and the water company—was described as revolutionary. “Before, it was all paperwork and waiting. Now, I send a photo and the team is there the next day,” one leader said. The company’s follow-up practices, including confirming repairs and seeking feedback, were appreciated as signs of accountability. Participants contrasted this with previous experiences dealing with municipal offices, which were described as unresponsive or slow.

Crucially, the discussion emphasized how access to clean water transforms daily life. One woman reflected, “Kids used to wear plastic bags on their feet just to reach school. Now they can go in shoes.” Another added, “It’s not just water—it’s dignity.” The group called for continued expansion of infrastructure and more community-focused campaigns to raise awareness and strengthen trust.

Appendix B – Focus Group Discussion 2: Male Community Leaders, Manaus

Focus Group Discussion 2 – Male Community Leaders in Manaus

This focus group brought together male community leaders from diverse neighborhoods across Manaus. Participants discussed both progress and persistent gaps in water and sanitation services, emphasizing the importance of community engagement and environmental education. Many leaders acknowledged improvements under Águas de Manaus, especially in terms of quicker response times, better water quality, and more direct communication channels. “Before, we had to walk through flooded streets with water leaking for weeks—now we can call and get things resolved in a day or two,” one leader noted.

However, challenges remain. Several participants mentioned that neighborhoods built near or over streams, such as stilt-house communities, still lack basic sanitation. Waste is often discharged directly into waterways, creating serious public health and environmental hazards. The lack of formal urban planning and housing alternatives has left many residents in legally

precarious areas where service provision is nearly impossible. “You can’t install a sewage system where houses are literally sitting over streams,” a participant explained.

Leaders stressed that infrastructure alone is not enough—behavioral change is key. Illegal dumping, littering, and resistance to paying for services were common concerns. “People want the benefits but don’t want to change habits,” one man observed. To address this, participants are organizing clean-up drives, environmental workshops, and crafts programs that repurpose waste. One leader described transforming plastic bottles into urban gardens and Christmas decorations to raise awareness and foster community pride.

Overall, participants called for sustained investment in infrastructure, especially in precarious zones, alongside robust community engagement. They emphasized the need for long-term planning, relocation from environmentally hazardous areas, and stronger partnerships between government, companies, and local leaders. As one speaker concluded, “Sanitation is about more than pipes. It’s about dignity, awareness, and shared responsibility.”

Appendix C – Focus Group Discussion 3: Male Community Leaders, Manaus (Terra Nova, Redenção, etc.)

Focus Group Discussion 3 – Male Community Leaders in Manaus

The second focus group with male community leaders in Manaus revealed a complex landscape of infrastructural improvements, persistent challenges, and grassroots environmental engagement. Participants from neighborhoods such as Terra Nova, Redenção, Educandos, and Planalto shared their lived experiences with water and sanitation access, especially following the privatization of utilities under Águas de Manaus.

Before privatization, “there were constant leaks in the streets, and repairs took weeks,” one leader recalled. Now, most agreed that water service has improved significantly, both in quality and response time. “Today, the water from Águas de Manaus is drinkable. That was unthinkable 10 or 15 years ago.” However, gaps in sewer coverage remain a serious concern, especially in low-income and flood-prone areas built atop or near streams. “You can’t just install sewage pipes in a community of stilt houses.”

Community education and environmental stewardship were strong themes. Leaders described organizing clean-up drives and awareness events to promote sustainability. “We’re teaching kids to reuse bottles, make crafts, and even grow vegetables in old tires,” said one participant. These grassroots initiatives aim to shift public behavior and strengthen collective responsibility for environmental care. Social tariffs were seen as essential for affordability. “The social tariff really helps—people only pay more if they exceed 15 cubic meters,” explained a community leader. Yet, awareness remains limited, and some residents are hesitant to register due to stigma or lack of information.

Crucially, participants emphasized that long-term success depends on meaningful community engagement. “If people aren’t involved, the services won’t last,” one leader warned. They advocated for stronger collaboration between government, private utilities, and communities to address unsafe housing, protect riparian zones, and ensure equitable service.

Ultimately, the conversation reflected cautious optimism: a recognition that while progress has been made, lasting change will require coordinated, participatory urban planning.

Appendix D – Focus Group Discussion 4: Female Community Leaders, Manaus

Focus Group Discussion 4 – Female Community Leaders in Manaus

A focus group discussion was held with women from low-income communities in Manaus to understand the impact of sanitation services introduced by Aegea. The discussion revealed how these interventions have affected their health, economic activities, and daily lives.

Participants vividly recalled the challenges faced before the sanitation improvements. “We used to live with open sewage right outside our door,” said one woman. “During the rainy season, the water would mix with sewage and come into our homes.” The health toll was especially harsh on children. “My kids were always sick with diarrhea or skin rashes,” another woman shared. Since the sanitation infrastructure was installed, many reported tangible improvements. “Now my children haven’t missed school because of stomach problems,” said one mother. Several women noted they now had more time to work or focus on household tasks. “Before, I stayed home to care for sick kids. Now I work more hours.”

Still, economic concerns persist. “The bill is confusing,” said one woman. “I don’t understand why I’m paying so much. We need more information and clear communication.” Despite this, most participants expressed trust in Aegea and appreciation for the service. Beyond health and finances, sanitation also improved women’s sense of dignity and social participation. “Now I feel comfortable receiving guests. My house doesn’t smell anymore,” said one woman. However, many felt excluded from the decision-making process. “They came and did the work, but no one asked us anything. We want to be heard.”

This discussion highlights how sanitation is deeply connected to women’s roles in caregiving, economic participation, and social well-being. While the infrastructure has brought positive change, the women emphasized the need for continued engagement, transparency, and inclusion in future planning and maintenance

Appendix E – Focus Group Discussion 1: Male Community Leaders, Barcarena

Focus Group Discussion 01 – Male Community Leaders in Barcarena

The male community leader in Barcarena emphasized the layered infrastructural and environmental challenges in expanding sanitation services to isolated and tidal-influenced

regions. He highlighted that although the city is striving to achieve 90% sewer coverage, progress is uneven across neighborhoods. With seven distinct wastewater treatment systems at various stages of development, each requiring its own lift stations and pressurized pipelines, he remarked, “Each system has its own network... some are working, others are still being built.” This decentralization, while adaptive, increases operational complexity and interconnection costs.

A key environmental constraint is tidal fluctuation from the Marajó Bay, which directly affects system design and discharge planning. The leader noted, “The river’s level changes a lot because of the tide, so we have to deal with that,” reflecting the vulnerability of sanitation infrastructure to climate-linked hydrological variability. Rainy seasons exacerbate these pressures, requiring real-time management of flow surges, for which telemetry systems are being installed to monitor pressure and direct response: “We use pumps and lift stations according to fluctuations.”

Water access is reportedly nearing universal coverage (98–99%), but challenges remain in system reliability and user integration. A major concern is community resistance to connecting to the grid, attributed to cost perceptions: “Some people don’t see the benefits... they only think of the bill.” This indicates that technical success is not sufficient; behavioral change and participatory communication are vital for uptake. Furthermore, water quality issues—such as high salinity and metal content in groundwater—necessitate reliance on surface sources or deeper wells, adding to system costs.

Overall, the FGD reveals that while Barcarena is a front-runner in infrastructure rollout, full success hinges on aligning engineering solutions with environmental realities and sustained community engagement. This case offers critical lessons for scalability in similar Amazonian contexts.

Appendix F – Focus Group Discussion 2: Mixed Gender Community Leaders, Barcarena

Focus Group Discussion 02 – Male and Female Community Leaders in Barcarena

Community leaders from Barcarena expressed a mix of cautious appreciation and deep frustration regarding recent improvements to water and sanitation services. Participants acknowledged that piped water access had expanded across neighborhoods, but they noted that financial barriers continue to prevent many from using the service consistently. Several participants emphasized that even with infrastructure available, the monthly bills remain unaffordable for families not covered under social tariffs. One leader shared, “I have water at home, but I drink from the well because I can’t pay R\$300 every month.” The discussion revealed that reliance on unsafe well water persists—not due to availability, but due to the intersection of poverty and pricing structures.

Concerns about water quality further eroded trust in the system. Participants described cases of water arriving with an “overpowering chlorine smell,” or appearing cloudy. One woman stated, “We fought to get piped water, but now we don’t trust what comes out.” Leaders suggested that

the utility company had not adequately communicated water treatment processes, nor provided consistent quality monitoring feedback to the community.

Sanitation issues were equally contentious. While sewer lines had been introduced in some areas, many residents found the R\$800 connection fee to be prohibitive. A participant asked, “Why should someone who already lives in poverty pay to be connected to a public system?” Additionally, residents raised complaints about poorly designed venting systems. “They didn’t bury the pipes deep. The smell of sewage now comes through the vents into our homes,” one leader explained, pointing to both environmental and public health concerns.

Participants also highlighted implementation failures and lack of coordination between the municipality and the utility. Newly paved roads were dug up again for pipe installations, leading one resident to note, “We waited years for pavement, and now it’s gone—again—because they didn’t plan properly.” This breakdown in planning and communication was seen as emblematic of broader issues with how WASH services are delivered and managed in Barcarena.

Appendix G – Focus Group Discussion 3: Female Community Leaders (Murucupi), Barcarena

Focus Group Discussion 03 – Female Community Leaders in Barcarena

Women leaders from the Murucupi neighborhood discussed the impact of recent water and sanitation works on their community, revealing frustrations with poor coordination, communication gaps, and unclear cost expectations. One of the central concerns was the disorganized sequencing of infrastructure projects. Paved streets were destroyed soon after being completed to install sewer networks. As one participant stated, “The asphalt came before the sanitation system, and this causes a lot of disturbance.”

The destruction extended beyond roads to sidewalks and curbs, many of which have not been properly repaired. Residents report that temporary patches collapse during rain, leaving behind safety hazards and stagnant wastewater pools. This has fostered mistrust, especially because residents have been told they might have to pay nearly R\$900 for sewage connections, even though construction has already disrupted their properties. One woman asked, “They broke the sidewalk and now they want the resident to pay for the connection?”

Despite these issues, participants recognized that sanitation is crucial for community well-being. “Sanitation is quality of life,” one said, while another emphasized that proper infrastructure would reduce disease and improve property values. Yet, they noted that many households still discharge greywater into streets because connections remain incomplete or unaffordable.

Communication between the community and service providers was another key theme. While residents use WhatsApp and official complaint forms to contact Águas de São Francisco, leaders noted that follow-up is often delayed. In contrast, they found the public utilities regulatory agency to be the most effective channel for responses.

Although around 40% of households benefit from a social tariff, leaders pointed out that access depends on federal welfare eligibility, leaving many working poor without assistance. Tariff fairness, accountability, and timely implementation remain pressing issues across the neighborhood.

Appendix H – Focus Group Discussion 4: Female Community Leaders (Multiple Neighborhoods), Barcarena

Focus Group Discussion 04 – Female Community Leaders in Barcarena

In this focus group with women leaders from several neighborhoods in Barcarena, participants discussed the shift from informal, unsafe water systems to piped access through the Águas de São Francisco project. Many households historically relied on illegal water connections, referred to locally as “gato,” which were normalized over decades. One participant noted, “The neighborhood always used the ‘gato’, since the time of Codebar. It was already part of the community.” The 2018 industrial spill marked a turning point, leading residents to question the safety of well water. “It was only after the spill that people started to believe... the wells were contaminated,” one woman shared, reflecting a growing awareness of the link between water quality and health.

Leaders played a key role in shifting community perceptions, organizing door-to-door campaigns and educational sessions to explain the benefits of regulated water systems. “There were three itineraries, door-to-door, explaining that water brings health and dignity,” a participant recounted. Still, affordability remains a challenge. While residents acknowledged the importance of safe water, they expressed concern over high bills, with some paying R\$300 to R\$400 per month. “They just cancel because they can’t afford it,” one woman said. The social tariff program exists but is underutilized due to limited awareness and bureaucratic barriers. “They ask for documents, and many don’t know how or where to apply,” a participant explained.

The rollout of sanitation infrastructure initially brought significant disruption, especially during the rainy season. “The first week was chaos. Children couldn’t get to school, streets were flooded with mud,” said one woman. Nonetheless, most participants viewed these disruptions as temporary and worthwhile. “It was hard, but now the ground is solid again, and we see the benefit.” Yet, coverage remains uneven—areas without paved roads were excluded from connection efforts. “The only roads left out were the eight that weren’t paved,” a participant observed.

Health improvements were discussed, with many linking the new system to reduced illness. “In the past, children were constantly sick with diarrhea,” one woman recalled. However, trust in the piped supply is not universal. “Even now, some still buy bottled water—they don’t fully trust the tap,” another added. Participants called for greater equity in service provision, suggesting a tiered pricing model for low-income households. “There should be a special price for the community,” one participant argued. They also criticized the government’s selective focus on sanitation as a development showcase. “They put a spotlight on sanitation, but our health

system is collapsing. What's the point?" asked one leader, underscoring the need for broader, integrated public investment.

Appendix I – Photo of R01 illustrating the lack of waterproofing (PMSB)



Appendix J – Photo of R01 illustrating the cracks and leaks (PMSB)



Appendix K – Photo of R02 illustrating the leaks (PMSB)



Appendix L – Photo of R05 illustrating the surface being overtaken by vegetation(PMSB)



Aegea Socio-Economic Impact Assessment Toolkit

Companion User Guide

Why This Toolkit Matters

Water and sanitation are more than technical services — they are fundamental to health, dignity, and economic opportunity. But how do we measure that impact? This toolkit was designed for Aegea and its partners to do just that.

It provides a structured yet flexible way to understand:

- How communities are benefiting
- Who may still be left out
- Where services are working — or not
- What changes over time

What the Toolkit Includes

This toolkit equips users with tools to evaluate both socio-economic impact and service delivery performance in a consistent way:

- Step-by-step assessment process
- Integrated quantitative and qualitative data collection
- A built-in scoring system for tracking outcomes over time
- Community voice and lived experience at the center
- Ready-to-use formats for reporting and internal learning

Who Should Use This Toolkit?

Role	What You Contribute
Field staff & community liaisons	Local knowledge, relationship-building, facilitation
Monitoring & evaluation leads	Survey design, data analysis, impact tracking
Aegea Institute / HQ teams	Strategic use of findings, learning across regions

When Should It Be Used?

You can use this toolkit:

- After a major service rollout (e.g., new water connections)
- As a midline check-in to inform ongoing work
- To prepare evidence for strategic moments, such as SDG reporting, regulatory review, or COP30

The toolkit is designed for repetition — every 6-12 months — to build a time series of community impact and delivery performance.

What Makes It Different

Unlike technical audits or one-off reports, this toolkit:

- Puts people at the center (not just infrastructure)
- Integrates quantitative and qualitative data
- Tracks not only outputs — but outcomes like trust, equity, and dignity
- Builds a foundation for community feedback, transparency, and learning

Support Tools Provided

To make implementation easier, the following optional tools can accompany the framework:

- **This Guide:** A short orientation for any team member using the toolkit
 - **Scoring Rubric:** Explains how to assign numerical scores using community feedback
 - **Summary Template:** A 1-page dashboard for reporting headline results
- **Data Collection Tools:**
 - **Household Survey** for Socioeconomic and Service Delivery Metrics
 - **Focus Group Discussion Guide**
 - **Digital Options:** WhatsApp survey template for remote data collection

This toolkit is not just about measurement — it's about improving lives, deepening trust, and ensuring that Aegea's services reach those who need them most. Use it not only to assess but to listen, adapt, and lead.

Socio-Economic Impact Assessment Framework

1. Define the Assessment Scope

Identify Geographic Area (e.g., neighborhood, municipality):

Define Target Population Segment (e.g., informal settlements, social tariff recipients):

Time Frame for Assessment (e.g., 1 year post-intervention):

What specific services were introduced or expanded?

Set objectives: What do you want to learn or demonstrate?
Objectives of the Assessment:

2. Baseline Data Check

Before completing the Impact Scoreboard, review whether relevant baseline data already exists. This step ensures you're assessing progress against a clear starting point.

Indicator	Source to Check	Notes
Water access (connection rates, collection time)	Aegea service logs, municipal data, past surveys	<input type="checkbox"/> Data available <input type="checkbox"/> Needs update
Sanitation access/type (latrines, open defecation, sewer)	Household records, past focus groups	<input type="checkbox"/> Data available <input type="checkbox"/> Needs update
Health outcomes (diarrhea, skin infections)	Municipal health office, local clinics	<input type="checkbox"/> Data available <input type="checkbox"/> Needs update

Social tariff enrollment (baseline %)	Cadastro Único, Aegea records	<input type="checkbox"/> Data available <input type="checkbox"/> Needs update
School attendance (if linked to WASH)	Local schools, education office	<input type="checkbox"/> Data available <input type="checkbox"/> Needs update
Income levels / vulnerability	Bolsa Família registry, proxy indicators	<input type="checkbox"/> Data available <input type="checkbox"/> Needs update

3. Collect Data

Quantitative Data:

Tool Used:

- Household Survey Template (*includes water access, hygiene behavior, household expenses, perception of service quality*)⁹⁷

ACTION STEPS:

Conduct door-to-door surveys in communities receiving services from Aegea.

Areas surveyed:

Number of households surveyed:

Survey method (e.g., paper, KoBoToolbox, WhatsApp):

Notes or challenges:

→ _____

→ _____

Qualitative Data:

Tools Used (check all that apply):

⁹⁷ Attached at the end

Focus Group Guide (segmented by gender, age, or occupation)

ACTION STEPS:

Conduct focus groups when surveying is limited, as well as key informant interviews.

Focus Groups Conducted:

Number of FGDs: _____

Community groups engaged (e.g., women, youth, leaders):

Key Informants Interviewed:

Number of interviews: _____

Roles represented (e.g., health workers, teachers):

Insights or Quotes to Highlight:

→ _____

→ _____

Tips to Implement (check if applied):

Translated into local dialects

Used icons or visuals for low-literacy households

Used digital tools (specify): _____

Map Community Feedback Channels:

Tools Used:

WhatsApp Community Feedback Survey

Tools known/used (e.g., WhatsApp, Afluentes):

Community satisfaction with follow-up:

Identify barriers (e.g., digital access, documentation):

4. Analyze Key Impact Areas

The Impact Scoreboard is a structured tool designed to help Aegea teams assess the full range of social, economic, and community outcomes resulting from water and sanitation services. It must be completed in all relevant categories to ensure a comprehensive understanding of local impact.

Instructions:

1. Review All Categories: The scoreboard includes fixed categories—Health, Education, Economic Resilience, Gender Equity, Trust in Service, and Environmental Conditions. These reflect core areas aligned with national and SDG priorities.

2. Assign a Score (0–5): For each category, use field data (e.g., surveys, focus groups, local interviews) to assign a score:

- 0 = No impact or negative impact
- 5 = Strong, clearly demonstrated positive impact

3. Add Brief Justifications: Use the comments column to include a short explanation for each score, citing specific data or quotes when possible.

4. Complete for Each Community: Ensure the scoreboard is filled out for every assessment location to support comparison, reporting, and strategic planning.

The completed scoreboard helps identify high-performing areas, flag persistent challenges, and guide targeted improvements in future service rollout.

Impact Scorecard

IMPACT SCORECARD					
SOCIO ECONOMIC IMPACT					
ELEMENTS <i>(Indicators listed below)</i>	LEVEL 1 No Impact	LEVEL 2 Limited Impact	LEVEL 3 Moderate Impact	LEVEL 4 Strong Impact	LEVEL 5 Transformational Impact
HEALTH <i>(Reductions in waterborne illness and improved hygiene behavior)</i>	Ongoing waterborne illness	Slight reduction in illness rates	Some improvements; services not universal	Significant drop in illness; access expanded	Widespread public health gains; resilience built
EDUCATION <i>(School attendance, especially for girls and caregivers)</i>	Frequent absences due to illness	Minor gains; mostly anecdotal	Notable improvement for girls & caregivers	Attendance up; hygiene access in schools	Structural shift in educational outcomes
INCOME <i>(Household cost savings, time savings, and ability to work)</i>	High cost of water; missed work	Income/time savings for some	Informal work time increases	Cost savings + improved productivity	Economic mobility & new livelihood potential
EQUITY <i>(Inclusion of vulnerable groups (e.g., Bolsa Família, women-led households, migrants))</i>	Exclusion of vulnerable groups	Outreach exists but inconsistent	Informal leaders engaged	Social tariffs expanded; inclusive design	Marginalized voices embedded in governance
DIGNITY & TRUST <i>(Community satisfaction, perceived quality of life)</i>	Community mistrust; ad-hoc access	Mixed satisfaction	Trust improving through local leadership	Services valued; dignity restored	High satisfaction; shared ownership evident
SERVICE DELIVERY IMPACT					

ELEMENTS <i>(Indicators listed below)</i>	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
	No System	Ad Hoc Delivery	Standardized Service	Community-Responsive Delivery	Co-Designed & Inclusive Delivery
ACCESS <i>(Infrastructure coverage, especially in informal or remote areas)</i>	No or limited coverage	Infrastructure exists but incomplete	Reliable access in most areas	Adapted solutions for hard-to-reach areas (e.g., stilt houses)	Full geographic and demographic coverage
WATER QUALITY <i>(Cleanliness, safety, smell, color, and taste of water)</i>	Contaminated or untreated	Unpredictable quality; often discolored or odorous	Mostly clean but occasional complaints	Water meets safety standards; monitored	High consumer trust; fully meets WHO standards
SANITATION SERVICES <i>(Connection to sewer system or safe waste disposal)</i>	No formal system; open defecation common	Partial rollout; some neighborhoods excluded	Connected system in main areas	Expansion into informal and marginal zones	Fully integrated sanitation with user feedback
AFFORDABILITY <i>(Accessibility of water/sewage bills and social tariff uptake)</i>	Costs unaffordable for low-income households	Social tariffs exist but underutilized	Tariffs available; awareness growing	Streamlined enrollment & field support	Automatic subsidies; inclusive pricing models
RELIABILITY <i>(Frequency of service interruptions, outages, or complaints)</i>	Frequent outages and long delays	Irregular service delivery	Stable service with some gaps	Responsive troubleshooting (e.g., digital tools)	Real-time support; predictive maintenance
COMMUNITY ENGAGEMENT <i>(Involvement in reporting, planning, and response)</i>	No engagement channels	Occasional campaigns; low trust	Communication via Afluentes & WhatsApp	Regular consultation with community leaders	Community governance structures embedded
COMMUNICATION <i>(Clarity of billing, complaint systems, info access)</i>	No clarity on billing or services	Unclear messaging, no feedback loop	Multi-channel but uneven	Localized, inclusive communications	Clear, culturally adapted, two-way communication

PLANNING COORDINATION <i>(Alignment with roadworks, housing plans, disaster risks)</i>	Poor sequencing (e.g., roadworks redone)	Misaligned infrastructure rollout	Some alignment with local plans	Joint planning with local officials and leaders	Fully integrated, future-resilient infrastructure delivery
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5. Assess Gaps and Unintended Consequences

Checklist:

- Are any groups excluded? (e.g., renters, new migrants)
- Are bills unaffordable despite social tariffs?
- Are legal/land status issues preventing connections?
- Were roads or homes damaged during infrastructure rollout?

Notes:

→ _____

→ _____

6. Generate Strategic Recommendations

ACTION STEPS:

- Highlight key wins and replicable practices.
- Flag urgent gaps needing investment or policy change.

7. Communicate the Results

Once the Impact Scoreboard is complete, use the 1-page dashboard on the next page to summarize key findings in a clear and accessible format. This visual tool is designed to support communication with internal teams, community leaders, and external partners.

Summary Template (1-Page Dashboard)

Section	Details
Municipality	<hr/>
Date of Assessment	<hr/>
Assessment Team	<hr/>
Key Scores (from Scorecard)	- Health: ___ - Education: ___ - Trust: ___ - Access: ___ - Equity: ___
Top 3 Community Successes	1. <hr/> 2. <hr/> 3. <hr/>
Top 3 Community Concerns	1. <hr/> 2. <hr/> 3. <hr/>
Next Steps / Recommendations	→ <hr/> <hr/> → <hr/> <hr/>

8. Repeat and Scale

- Action Steps:
 - Schedule assessments every 6-12 months.
 - Build a database of findings across municipalities, consider this dashboard model to continuously map the indicators.

To create a dashboard using the scores from the impact scorecard:

1. **Collect Impact Scores:** Gather the scores from the impact scorecard for each municipality (e.g., water quality, accessibility, satisfaction).
2. **Design Dashboard:** Use tools like Power BI or Tableau to visualize the impact scores for key metrics, updating in real time.
3. **Map the Scores:** Plot the scores geographically, showing trends or gaps across municipalities.
4. **Ensure Usability:** Design the dashboard to allow easy filtering and comparison of scores.
5. **Update Regularly:** Continuously update the scores in the dashboard to reflect new data and inform service improvements.

Appendix N - Aegea Socio-Economic Impact Assessment Household Survey

Household Survey Questionnaire

Participants: Individuals residing in households who have received water and sanitation services from Aegea.

Estimated Time: 15-20 minutes

This survey will provide insights into the conditions surrounding water and sanitation access and its impact on health, economic productivity, and quality of life. The questions will cover various aspects, such as respondent demographics, service quality, socio-economic impacts.

Introduction

Good [morning/afternoon/evening] and thank you for speaking with us. My name is _____. I am part of a study team with Aegea, the water and sanitation firm, to understand the impacts of water and sanitation on households and the community. We would like to ask you some questions about your experiences. This shouldn't take more than [20 minutes]. This survey is completely voluntary and you can stop answering questions at any time. There is no penalty if you decide not to participate. We will be recording your responses on [this tablet], but we will not record your name. Are you happy to continue? [Wait for agreement before asking questions.]

RESPONDENT DEMOGRAPHICS

First, we would like to ask some questions about your household.

Q1) How long have you been living in your current residence?

- 1-2 years
- 3-5 years
- 6-10 years
- More than 10 years

Q2) How many people currently live in your residence?

Q3) What is the age range of people who currently live in your residence? (Select all that apply)

- Children (0-11 years old)
- Adolescents (12-17 years old)

- Youth (18-24 years old)
- Adults (25-59 years old)
- Elderly (60 or more years old)

Q4) Are you (or any members of your household) enrolled in or receiving any government benefits? (Select all that apply)

- Programa Bolsa Familia (PBF)
- Benefício de Prestação Continuada (BPC/LOAS)
- Auxílio Emergencial
- Another program (please specify: _____)
- None

Q5) What is the status of your monthly bills?

- All bills paid on time
- Most bills paid on time
- Half of bills paid on time
- Few bills paid on time
- No bill paid on time
- Unsure

Q6) What is the highest level of education in your household? (Select the best answer)

- Higher education (Undergraduate/Technologist/Postgraduate)
- High school (formerly Secondary School) or Technical (Vocational)
- Elementary School II (formerly Middle School)
- Elementary School I (formerly Primary School)
- Did not attend school

SERVICE QUALITY

Now we would like to ask some questions about water and sanitation in your community.

Q7) How long have you been receiving water services from Aegea?

Q8) Before Aegea provided services in your neighborhood, how did you typically access water in your household? (Select all that apply)

- Through the general distribution network with a meter
- Through a well or spring
- Others (please specify: _____)
- Don't know or unsure

Q9) After Aegea provided services in your neighborhood, how do you typically access water in your household? (Select all that apply)

- Through the general distribution network with a meter
- Through a well or spring
- Others (please specify: _____)
- Don't know or unsure

Q10) How would you describe the color of water in your household?

- Clear (no noticeable color)
- Slightly colored (minor tint)
- Moderately colored (noticeable tint)
- Heavily colored (strong discoloration)
- Don't know or unsure

Q11) How would you describe the odor of water in your household?

- Odorless
- Slight odor
- Noticeable odor
- Strong odor
- Don't know or unsure

Q12) How would you describe the availability at all times for water services in your household?

- Never disrupted
- Rarely disrupted
- Sometimes disrupted
- Often disrupted
- Always disrupted
- No opinion or prefer not to say

Q13) How long have you been receiving sanitation services from Aegea?

Q14) Before Aegea provided services in your neighborhood, how did you typically access sanitation in your household? (Select all that apply)

- Private toilet with pipe connection
- Private toilet with septic tanks
- Private toilet without pipe connection or septic tanks
- Pit latrine
- River or lake
- Other (please specify: _____)

- Don't know or unsure

Q15) After Aegea provided services in your neighborhood, how do you typically access sanitation in your household? (Select all that apply)

- Private toilet with pipe connection
- Private toilet with septic tanks
- Private toilet without pipe connection or septic tanks
- Pit latrine
- River or lake
- Other (please specify: _____)
- Don't know or unsure

Q16) How would you describe the cleanliness of sanitation disposal in your household?

- Excellent
- Good
- Fair
- Poor
- Very poor
- No opinion or prefer not to say

Q17) How would you describe the availability at all times for sanitation services in your household?

- Never disrupted
- Rarely disrupted
- Sometimes disrupted
- Often disrupted
- Always disrupted
- No opinion or prefer not to say

Q18) Before Aegea provided services in your neighborhood, what did you think of the quality of water and sanitation services available to you?

- Excellent
- Good
- Fair
- Poor
- Very poor
- No opinion or prefer not to say

Q19) After Aegea provided services in your neighborhood, what do you think of the quality of water and sanitation services available to you?

- Excellent

- Good
- Fair
- Poor
- Very poor
- No opinion or prefer not to say

Q20) When you have a problem with the water and/or sanitation service, what do you do?

- Call the company directly
- Wait for an employee to visit the neighborhood and complain
- Use the company's digital channels (Website, App, Social Media, WhatsApp)
- Visit a company agency in the city
- Others (please specify: _____)
- Haven't had a problem

Q21) What do you think of the customer service provided by Aegea related to water and/or sanitation?

- Excellent
- Good
- Fair
- Poor
- Very poor
- No opinion or prefer not to say

SOCIO-ECONOMIC IMPACTS

Now we would like to ask some questions about impacts from the availability of water and sanitation services in your community.

Q22) Is your household part of Aegea's social tariff program (Aegea's subsidized service for low income vulnerable households)?

- Yes
- No
- Don't know or unsure

Q23) If yes, which type of social tariff program is your household enrolled in?

Q24) How did you get enrolled in the social tariff program?

- Automatically enrolled because of participation in other programs
- Applied to Aegea
- Others (please specify: _____)
- Don't know or unsure

Q25) Would you participate in activities to improve the community's quality of life such as clean-up efforts, health talks, and basic water/sanitation initiatives?

- Yes
- No
- Maybe
- Not sure or don't know

Q26) What is the reason to participate or not participate?

Q27) What are the benefits you have experienced since the arrival of water and sanitation services provided by Aegea? (Select all that apply)

- High-quality sanitation system
- Cleaner environment
- Better health
- Better quality of life
- Household regularization (e.g. proof of residence)
- Social tariff
- Property value appreciation
- Others (please specify: _____)
- None of the above

Q28) Before Aegea provided services in your neighborhood, did your household experience any of the following situations due to health problems? (Select all that apply)

- Children got sick and missed school
- Adults got sick and missed work
- Elderly people got sick and couldn't perform daily activities
- Children needed medication
- Adults or elderly needed medication
- People needed medical attention
- People needed hospitalization
- People passed away
- None of the above

Q29) After Aegea provided service in your neighborhood, did your household experience any of the following situations due to health problems? (Select all that apply)

- Children got sick and missed school
- Adults got sick and missed work
- Elderly people got sick and couldn't perform daily activities
- Children needed medication
- Adults or elderly needed medication
- People needed medical attention
- People needed hospitalization
- People passed away

- None of the above

Q30) Do you think the overall health improved since your house had access to water and/or sanitation by Aegea?

- Yes
- No
- Maybe
- Don't know or not sure

Q31) How would you describe your quality of life after Aegea provided water and/or sanitation services in your neighborhood? (i.e. health conditions of the family members, participation at school or work, etc.)

- Improved a lot
- Improved a little
- Neither improved or nor worsened (stayed the same)
- Worsened a little
- Worsened a lot

Q32) How would you describe your dignity after Aegea provided water and/or sanitation services in your neighborhood? (i.e. relationship with neighbors, active involvement with the community, etc.)

- Improved a lot
- Improved a little
- Neither improved or nor worsened (stayed the same)
- Worsened a little
- Worsened a lot

Q33) Is there anything else that you would like to share, related to water or sanitation in your community?

Thank you very much for sharing this valuable information with us. Your experiences and views will be extremely helpful to Aegea so they can further improve the services they are delivering in Brazil.

Appendix O - Focus Group Discussion Guide

How to Conduct a Focus Group Discussion

- **Prepare the Setting:** Choose a quiet, comfortable space, ensuring seating is arranged for easy communication. Have materials ready, including pens, paper, or visual aids if needed.
- **Introduce the Purpose:** Briefly explain that the goal is to gather community feedback on Aegea’s water and sanitation services. Highlight that participation is voluntary and confidential.
- **Set Ground Rules:** Encourage open, respectful communication. Emphasize that all opinions are welcome, and there are no wrong answers. Remind participants that their feedback is vital for improving services.
- **Facilitate the Discussion:** Use the provided Discussion Questions to guide the conversation.
- **Ask open-ended questions:** Allow participants to elaborate, and probe for more details where needed (e.g., “Can you explain that further?”).
- **Manage Group Dynamics:** Ensure everyone has an opportunity to speak. Encourage quieter participants to share, and gently redirect the conversation if it strays from the focus on Aegea’s services.
- **Capture Responses:** Take detailed notes or record (with consent) to accurately document the feedback for analysis.
- **Close the Session:** Thank participants for their valuable input. Summarize key points discussed and explain how their feedback will influence improvements to Aegea’s services.
- **Analyze and Share Results:** Review the collected feedback, and share actionable insights by filling out the toolkit.

Welcome and Informed Consent:

“Good [morning/afternoon], everyone, and thank you for being here today. My name is [Name], and I’m part of the Aegea team. We are conducting this group discussion as part of our ongoing efforts to ensure that the water and sanitation services we provide meet the needs of the community. The goal of today’s session is to hear directly from you—our community members—about your experiences with Aegea’s services. We want to understand what’s working well, what could be improved, and how we can make our services even better. Your feedback is critical in helping us shape the future of these services.

Before we begin, I’d like to go over a few simple guidelines to ensure that everyone feels comfortable sharing their thoughts:

- **Respectful Communication:** Please feel free to express your opinions openly, but remember to be respectful of one another’s perspectives.

- **Confidentiality:** Your responses are anonymous, and everything shared here will remain confidential.
- **Open Participation:** This is a space for everyone to share. Whether you have positive feedback or concerns, we want to hear it all. Your voice matters.
- **Focus on the Service:** We'll be discussing Aegea's water and sanitation services, so please focus your comments on that area.

We really value your input today, and we appreciate you taking the time to be here. This discussion will help us understand the experiences of different community members, and it will guide us as we continue to improve our services.

So, with that, let's get started! I'm going to ask a few questions, and I'd love to hear your thoughts on each one. Feel free to share anything that comes to mind, and if something isn't clear, don't hesitate to ask for clarification. There are no right or wrong answers here—just your experiences and opinions.”

With that, let's begin by briefly introducing ourselves to the group:

Phase 0 – Introduction & Ice-Breaker (to help build trust)

1. What do you see as the most important responsibilities of a community leader in Manaus?
2. What were the biggest water/sanitation-related concerns for the community, before Aegea?

Phase 1 – Initial Perceptions of the Project

1. How did you first learn about Aegea's water/sanitation project?
2. What were your initial thoughts about the project's objectives?
3. Did community members express any concerns before implementation? If so, what were they?
4. How did you, as a leader, help communicate the project's goals to the community?

Phase 2 – Socioeconomic / Environmental Impact

1. Before the project, what were the main sanitation-related challenges affecting economic activities?
2. Since the improvements, have you observed changes in overall community productivity (employment)?
3. Have you seen any improvements in public health indicators (illness or better hygiene practices)?
4. What, if any, environmental effects have you noticed as a result of the Aegea's project?

Phase 3- Long-Term Effect

1. What are the biggest challenges in maintaining the new sanitation services in the long run?
2. How engaged have local authorities and Aegea been in addressing community concerns post-implementation?
3. What role do you think community leaders should play in ensuring water/sanitation sustainability?
4. Are there any lessons from this project that should be applied to future infrastructure or public health initiatives?

Phase 4 – Feedback

1. What aspects of the project could be improved to better serve the community?
2. How effective has communication been between Aegea, the government, and the community?
3. If you could propose one policy or initiative to further improve sanitation and public health, what would it be?
4. Is there anything else you would like to share that we didn't discuss?

Thank you very much for joining us today. Your experiences and opinions will be very valuable to our company.

Appendix P - WhatsApp Community Feedback Survey

WhatsApp Community Feedback Survey

Use a surveying platform to distribute a community feedback survey for more regular and informal data collection. Below is a possible template:

Hi! This is a short survey from Aegea to improve our water and sanitation services. It takes less than 3 minutes. Your answers help us serve you better.

1. Do you currently receive piped water in your home?
 - Yes
 - No
 - Sometimes

2. How would you describe the quality of the water you receive?
 - Very good – clear and safe
 - Okay – sometimes unclear or smells
 - Poor – often dirty or unsafe
 - I don't know
3. Are you connected to the sewage system?
 - Yes
 - No
 - I'm not sure
4. Have you or your family had fewer health issues (like diarrhea or rashes) since Aegea started services?
 - Yes, much better
 - A little better
 - No change
 - Worse
5. Do you receive the social tariff (discounted water bill)?
 - Yes
 - No
 - I don't know what that is
6. Have you ever contacted Aegea for a problem or question?
 - Yes – and it was resolved
 - Yes – but no one helped
 - No – I didn't know how
 - No – I haven't needed to
7. What's the best way for us to share information with you?
 - WhatsApp
 - Email
 - Radio or loudspeaker
 - Flyers or posters
 - Local leader meetings
8. Anything else you would like to share?

Thank you! Your voice matters. We'll use your feedback to improve our services and reach more families.

Appendix Q - Findings From AI Research Scientist Interview - RIO

Artificial intelligence (AI) holds substantial promise for transforming water and sanitation service delivery, particularly in regions like the Brazilian Amazon where infrastructure gaps, geographic complexity, and fragmented service delivery pose persistent challenges. AI's most compelling advantage lies in its capacity to accelerate decision-making in data-dense but operationally constrained environments. Drawing on examples from applied research, the expert described how AI systems are capable of filtering trillions of possibilities into a small set of optimal solutions. This capability—while originally applied in scientific contexts—offers meaningful parallels for sanitation planning. In areas like Manaus and Barcarena, AI could help prioritize network expansions, predict system failures, and optimize maintenance cycles, especially in hard-to-reach or high-risk communities such as those living in palafitas.

The expert also outlined key challenges to AI deployment. Human trust is a critical barrier. *“Persuading seasoned experts to trust the model is often the biggest hurdle,”* he noted, highlighting the cultural and institutional shifts required for successful adoption. Technological maturity is another concern, as many AI applications in sanitation remain at the experimental stage. Reliable, anonymized data is essential for building effective models, yet is often scarce in low-resource settings. Moreover, innovations must align with on-the-ground realities such as budget constraints, ease of maintenance, and system interoperability.

Practical applications in the sanitation sector were explored. AI can support consumers by monitoring water consumption, detecting anomalies in quality, or identifying leaks—empowering households with real-time feedback. On the operator side, AI can optimize treatment operations, forecast service disruptions, and enable more targeted infrastructure investments. *“AI can help both the consumer and the operator,”* the expert emphasized, underlining its dual benefit.

Importantly, the expert proposed strategies to overcome infrastructural limitations common in the Amazon. Hybrid architectures involving edge devices that transmit only key information to the cloud can minimize connectivity burdens. Pre-trained AI models can be adapted with minimal local data, offering scalable solutions even in data-poor settings.

Beyond infrastructure, AI was also recognized as a tool for social impact. It can support sanitation education and behavioral change campaigns, particularly through mobile and community-based platforms. This expands the scope of AI from a technical enabler to a participatory instrument—directly aligning with the goals of the Aegea capstone to create inclusive, responsive, and sustainable sanitation services for vulnerable populations.