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Environmental sanitation in the Rio de Janeiro Metropolitan Region: a critical analysis of progress, challenges, and prospects toward universalization

Saneamento ambiental na Região Metropolitana do Rio de Janeiro: uma análise crítica dos avanços, desafios e perspectivas rumo à universalização

Saneamiento ambiental en la Región Metropolitana de Río de Janeiro: un análisis crítico de los avances, desafíos y perspectivas hacia la universalización

Waldir Ruggieri Peres¹

¹Instituto Estadual de Engenharia e Arquitetura do Estado do Rio de Janeiro, Campo de São Cristóvão, 138, RJ, 20921-440, ORCID 0009-0007-5656-6002, waldirperes@gmail.com

Abstract

The Rio de Janeiro Metropolitan Region advances toward universal sanitation through the Strategic Plan for Integrated Urban Development, coordinated by the Rio Metr pole Institute. Plans like PlanSAN and PMetGIRS, focused on sanitation and solid waste, are milestones for sustainability. Projects such as Dry Weather Flow and nature-based solutions show results, but challenges like urban macro-drainage and environmental liabilities persist. Effectiveness hinges on robust financing and integrated management to overcome fragmentation and achieve universal sewage coverage by 2033.

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*Corresponding author
waldirperes@gmail.com

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Resumo

A Região Metropolitana do Rio de Janeiro avança rumo à universalização do saneamento com o Plano Estratégico de Desenvolvimento Urbano Integrado, coordenado pelo Instituto Rio Metr pole. Planos como o PlanSAN e o PMetGIRS, focados em saneamento e res duos s lidos, s o marcos para a sustentabilidade. Projetos como Capta  o de Tempo Seco e solu  es baseadas na natureza mostram resultados, mas desafios como macrodrenagem e passivos ambientais persistem. A efetividade depende de financiamento robusto e gest o integrada para superar fragmenta  es e alcan ar a universaliza  o do esgotamento sanit rio at  2033.

Palavras-chave: saneamento ambiental, solu  es baseadas na natureza, governan a metropolitana, universaliza  o

Resumen

La Regi n Metropolitana de R o de Janeiro avanza hacia la universalizaci n del saneamiento a trav s del Plan Estrat gico de Desarrollo Urbano Integrado, coordinado por el Instituto Rio Metr pole. Planes como PlanSAN y PMetGIRS, centrados en saneamiento y residuos s lidos, son hitos para la sostenibilidad. Proyectos como la Captaci n en Tiempo Seco y soluciones basadas en la naturaleza muestran resultados, pero persisten desaf os como el macrodrenaje urbano y los pasivos ambientales. La efectividad depende de un financiamiento s lido y una gesti n integrada para superar la fragmentaci n y lograr la cobertura universal de alcantarillado para 2033.

Palabras clave: saneamiento ambiental, gobernanza metropolitana, soluciones basadas en la naturaleza, universalizaci n



1 Introduction

The Rio de Janeiro Metropolitan Region (RJMR) faces complex challenges in the field of environmental sanitation, resulting from decades of disorderly urban growth and insufficient investment in basic infrastructure. In response to this scenario, the metropolitan region consolidated, through the Strategic Plan for Integrated Urban Development (PEDUI/RMRJ), a planning framework that structures a vision for the future until 2040. The PEDUI, approved by the RJMR Deliberative Council in December 2022 and currently under review in the Legislative Assembly of the State of Rio de Janeiro as Bill No. 6,031/2025, established Sanitation and Environmental Resilience (SRA) as one of its six strategic axes.

This strategic plan served as the basis for the development of two sectoral instruments of fundamental importance: the Metropolitan Basic Sanitation Plan (PlanSAN) and the Metropolitan Integrated Solid Waste Management Plan (PMetGIRS). Both plans were developed in accordance with the new legal framework for basic sanitation, Law No. 14,026/2020. The materialization and coordination of these instruments are the responsibility of the Rio Metr pole Institute (IRM), an executive body created by Complementary Law No. 184/2018 for metropolitan governance.

This article aims to critically analyze the recent developments of the PEDUI in the area of environmental sanitation. The analysis is based on empirical evidence and updated data on the implementation of the sectoral plans, including dry weather flow interception (CTS) projects, environmental recovery projects, and investments in macro-drainage infrastructure. In addition to highlighting significant advances, the document explores persistent structural challenges and the prospects for the full achievement of the universalization targets set for 2033.

2 The New Metropolitan Governance Architecture: The Role of the Rio Metr pole Institute

The creation and consolidation of the Rio Metr pole Institute (IRM) represents the most significant structural advancement in the field of metropolitan governance of the RJMR in recent decades. Established as the executive body responsible for coordinating public functions of common interest, the IRM has assumed a central role in implementing the PEDUI and in articulating actions among the 22 metropolitan municipalities.

Historically, interventions in the RJMR's sanitation sector have been marked by institutional fragmentation. The IRM, however, inaugurated a new phase of management by coordinating technical working groups to solve complex issues, such as the construction of the second adductor from Ribeir o das Lajes. The Institute has also demonstrated growing operational capacity, with the inauguration of the Operational Control Center (CCO) – an investment of R\$71 million for real-time monitoring of the water distribution system. The creation of coordination mechanisms such as the Water Supply System Council (CSFA) and specialized technical groups has proven essential to face emergency challenges, like the energy crisis that affected the water supply in 2025.

Despite notable advances in metropolitan governance, the new sanitation services concession model, a milestone in attracting private investment, introduced a new layer of complexity to management. The sanitation sector in the RJMR is now distributed among the concession holders  guas do Rio (Blocks 1 and 4), Igu  Saneamento (Block 2), and Rio+ Saneamento (Block 3), while the State Water and Sewage Company of Rio de Janeiro (CEDAE) remains responsible for water collection and treatment at the major stations, selling it to the concession holders for distribution. This structure, although designed to accelerate universalization, creates a "managed fragmentation," where the strategic vision is unified by the IRM, but execution and customer relations are fragmented among multiple actors. Niter i and Petr polis, for example, did not participate in the CEDAE concession, maintaining

services through municipal concession holders.

The State Regulatory Agency for Energy and Basic Sanitation of Rio de Janeiro (AGENERSA) plays a crucial role in harmonizing this new architecture. Normative Instruction No. 124/2024, for instance, standardized technical criteria and procedures among the concession holders, aligning them with the reference standards of the National Water Agency (ANA). This regulatory harmonization is essential to mitigate the asymmetry between the concession blocks and ensure consistency in service provision. However, the inherent complexity of this multifaceted model of operation and regulation represents an ongoing challenge that needs to be monitored to prevent discontinuities and conflicts that could impact the population.

3 Universalization of Sanitary Sewage: Analysis of Dry Weather Flow Interception Projects

Progress towards the universalization of sanitation in the RJMR is materialized through engineering projects and new approaches to environmental recovery. The combination of traditional and innovative solutions has produced tangible results in improving the quality of life and urban resilience.

3.1 Universalization of Sanitary Sewage: Analysis of Dry Weather Flow Interception Projects

Dry Weather Flow Interception (CTS) projects are one of the main technical innovations in the strategy for universalizing sanitary sewage. These transitional solutions, which intercept sewage illegally discharged into storm drains during periods without heavy rain, have already demonstrated significant results in reducing water body pollution.

The concession holder Águas do Rio, responsible for part of the RJMR, implemented a CTS system that prevents the discharge of more than 100 million liters of contaminated water daily into the Guanabara Bay ecosystem.

The diversion of the final stretch of the Carioca River was a crucial measure that significantly improved the water quality for bathing at Flamengo Beach. With this intervention, the river was redirected to the Ocean Interceptor, transporting the pollution to the Ipanema Submarine Outfall, where natural dispersion in the ocean minimizes the impact on the beaches. This action had a notable effect on Flamengo Beach, which began to register significantly better balneability indexes. Prainha da Glória also benefited from the same works and started to be monitored by INEA, presenting positive results that make it, on many occasions, suitable for bathing, a milestone for a historically contaminated area.

In Mesquita, the system benefits 65,000 inhabitants and intercepts more than 15 million liters of sewage daily. In São Gonçalo, investments of R\$120 million in the first phase of the CTS works are expected to treat 12 million liters of contaminated water daily. Iguá Saneamento, which operates in Block 2, is developing a R\$126 million project for the installation of 54 dry weather flow interception points. In the Canal das Taxas, the already implemented system intercepts 17 liters per second, benefiting more than 4,000 people.

3.2 Restoration of Water Bodies: The Potential of Nature-Based Solutions (NBS)

The success of the Rodrigo de Freitas Lagoon recovery project, based on Nature-Based Solutions (NBS), offers a promising model for the revitalization of other ecosystems. Initiatives such as the "Lagoa.Rio" project and the replanting of mangroves have resulted in a significant improvement in water quality and an explosion of biodiversity. Among the measurable results, the following stand out:

- The reduction of the discharge of millions of liters of sewage into the lagoon through the restructuring of the sewage system.
- The application of the "sponge city" concept with the "naturalization" of areas to combat flooding.
- The emergence of native species such as mangroves and swamp fern, and the return of local fauna, including capybaras, guaiamum crabs, snooks, and even migratory species like the roseate spoonbill.

These principles are being replicated. Iguá Saneamento began a historic dredging project in the Jacarepaguá Lagoon Complex in April 2024, with an investment of R\$250 million. The "Juntos pela Vida das Lagoas" project plans for the total removal of 2.3 million m³ of sediment, the creation of 350,000 m² of mangrove area, and the planting of 240,000 seedlings of native species. Initial results include the return of bird species.

Another successful example is the Orla Piratininga Project (POP) in Niterói, which uses filtering gardens and other NBS. The POP generated measurable improvements in water quality, an increase in biodiversity, and served as a model for environmental recovery.

The depollution of Guanabara Bay is another pillar of this strategy. The CEDAE auction in 2021 allocated R\$2.6 billion specifically for depollution projects. As a result, the balneability of beaches like Flamengo has improved significantly. In 2024, the beach was suitable for bathing on 80% of the days of the year, a rate that demonstrates a remarkable recovery. The environmental recovery of the bay is essential for the "blue economy," with the OECD estimating socioeconomic gains of R\$25 billion for the state with the universalization of sanitation.

4 Structural Challenges and the Need for Integrated Planning

Despite the advances described, the universalization process faces persistent challenges that require immediate attention and strategic planning. A critical analysis of the situation reveals that macro-drainage and the remediation of environmental liabilities are the most vulnerable axes of the sanitation policy in the RJMR.

4.1 The Critical Deficit in Urban Macro-Drainage

Urban macro-drainage constitutes the most deficient axis of environmental sanitation in the RJMR. The PlanSAN recognizes the need for more detailed studies and specific metropolitan planning for drainage.

The absence of a unified metropolitan plan for macro-drainage contrasts with the progress in sanitary sewage and solid waste. This asymmetry creates a scenario where the universalization of one service may be achieved, while the risk of disasters remains, with investments estimated at only R\$ 4.5 billion until 2044. The Iguaçu and Alcântara river basins are critical areas that demand priority interventions. The drainage systems implemented in the Baixada Fluminense, for example, face structural problems such as non-functional floodgates, lack of maintenance, and garbage accumulation. Projects like the Sarapuí Transversal Axis and a new phase of the Iguaçu Project (R\$ 700 million) are urgent for the region's resilience. The lack of an integrated drainage plan is, however, a governance failure to be overcome.

It is worth highlighting the efforts made by the Rio Águas Foundation in executing projects for flood control in the Maracanã River – Praça da Bandeira watershed. In the first stage, the Praça da Bandeira reservoir, already inaugurated, operates successfully in reducing flooding. The second phase, which includes the construction of a 1,030-meter diversion tunnel with the capacity to transport 35 m³/s of excess water from the Maracanã River to the Joana River, is in the contracting phase. With the diversion of the excess water from the Maracanã River, a 75%

reduction in the volume of water reaching the lower course of the Maracanã River during heavy rains is expected.

The future Metropolitan Drainage Plan could be supported by the "sponge city" concept, created by Chinese architect Kongjian Yu. This concept consists of an urban planning approach that aims to transform the city into a system capable of absorbing, retaining, and reusing rainwater within the urban space itself. This model promotes water retention to reduce floods and ensure reserves, integrating nature-based solutions (NBS), such as floodable parks, permeable pavements, rain gardens, and green roofs, as opposed to traditional concrete infrastructure.

4.2 Solid Waste Management: Innovation and Environmental Liabilities

The PMetGIRS introduced an innovative perspective by prioritizing the recovery of municipal solid waste (MSW). The RJMR generates approximately 17,000 tons of MSW per day, and the proposal for Sorting Stations and Energy Recovery Units (URE) aims to recycle, generate energy, and reduce the volume of waste sent to landfills. The utilization of biogas to produce electricity and biomethane contributes to climate change mitigation goals.

In this regard, the Metropolitan Region has advanced in recent years with the consolidation of three major landfills located in Seropédica, Nova Iguaçu, and São Gonçalo, each with a distinct approach to waste recovery. In Seropédica, the largest landfill in Latin America, the focus is on producing biomethane, a high-quality renewable fuel. The biogas generated from 10,000 tons of daily waste undergoes an advanced purification process, using technologies such as Pressure Swing Adsorption (PSA) and molecular membranes, resulting in a production of 130,000 m³ per day. In Nova Iguaçu, the Waste Treatment Center is notable for being the first global project approved by the UN's Clean Development Mechanism (CDM). There, the biogas powers 12 engines that generate 16.5 MW of electricity, capable of supplying about 65,000 households. Finally, the Ecoparque in São Gonçalo adopts a circular economy model, transforming waste into energy and biogas, in addition to differentiating itself by treating leachate through reverse osmosis, converting it into water for reuse. These three ventures, often in partnership with Gás Verde, demonstrate the transition from disposal landfills to value-generation complexes, transforming an environmental liability into an economic and energy asset.

However, waste management in the RJMR is a paradox: while it invests in cutting-edge technologies, it is still hostage to environmental liabilities from the past. The Gramacho Landfill, closed in 2012, continues to require leachate treatment with monthly costs of R\$ 2 million. The PMetGIRS identified 23 dump site areas that have caused environmental liabilities, but only 10 have initiated the first stage of remediation. The persistence of 13 areas without any action for about 10 years demonstrates a significant gap in the application of the National Solid Waste Policy (PNRS) and a need to strengthen the legal and regulatory framework.

5 Financing and Regulatory Instruments for Universalization

For the materialization of sanitation goals, a complex set of financing and regulatory instruments has been established. The New Growth Acceleration Program (Novo PAC) provides for billions of reais in investments, and the Brazilian Development Bank (BNDES) has structured a multi-billion real project portfolio. In another support avenue, the Rio de Janeiro Metropolitan Region Development Fund (FDRM), managed by the IRM, allocates resources for project development in the RJMR, with its main contribution coming from sanitation service concession grants.

Despite the availability of resources, their effective implementation faces obstacles. Many municipalities in the RJMR have limited payment capacity. Furthermore, the lack of ready engineering projects in municipal governments impedes access to Novo PAC resources. The IRM can play a crucial role by mobilizing FDRM resources to contract and develop these projects, overcoming the limited municipal

technical capacity.

Financial analysis reveals the magnitude of the challenge: R\$38.5 billion until 2044, with R\$30.7 billion (78.5%) projected until 2033 to meet the universalization target. Investment in macro-drainage is estimated at R\$4.5 billion until 2044.

Regulatory harmonization by AGENERSA is vital in this complex scenario. The agency has consolidated its role by standardizing technical criteria and procedures among the concession holders, reducing asymmetries. The State Environmental Institute (INEA) has also been fundamental, expediting environmental licensing for projects such as the CTS systems.

Table 1 below summarizes the investment projections for sanitation in the RJMR:

Table 1 - Investment projections for sanitation in the RJMR

Investment Type	Value (R\$)	Time Horizon
Total in Sanitation	38.5 billion	Until 2044
Sewage and Water Universalization	30.7 billion	Until 2033
Macro-drainage and Stormwater	4.5 billion	Until 2044
CEDAE Auction	2.6 billion	Allocated to depollution projects
Águas do Rio Works	3.1 billion	Already invested
Lagoon Complex Works	250 million	Iguá Saneamento dredging project
São Gonçalo Works (CTS)	120 million	First phase

Source: Prepared based on reports and databases from the Rio Metrópole Institute

6 Conclusions and Strategic Recommendations

The analysis demonstrates that the RJMR has achieved significant technical and institutional maturity in the field of environmental sanitation. Integrated planning, the institutionalization of metropolitan governance through the IRM, and the attraction of private investments are unprecedented structural advances. Tangible results, such as the interception of over 100 million liters of sewage per day, the recovery of balneability in Guanabara Bay, and the success of the Rodrigo de Freitas Lagoon naturalization project, are evidence that the strategy is technically sound and produces measurable impacts on the metropolitan environmental quality.

However, the universalization of sanitation will not be achieved through large contracts alone. Persistent criticism regarding service quality and the discrepancy between universalization projections and the reality in informal areas, as pointed out by studies from the Rio de Janeiro Public Defender's Office, require continuous monitoring and adjustment efforts.

Based on the analysis, the following strategic recommendations are proposed to ensure the success of the endeavor:

1. Urgent Elaboration of a Metropolitan Macro-Drainage Plan: The absence of specific planning for urban drainage is the main gap to be filled. The plan must be systemic, addressing the micro-watersheds and defining clear responsibilities among government spheres so that interventions in the Iguaçu and Alcântara rivers are not isolated.
2. Strengthening the Technical Capacity of Municipalities (IRM/FDRM): The limited

payment capacity and the absence of ready engineering projects in municipal governments hinder access to federal funding lines, such as the Novo PAC. The IRM, through the FDRM, should act proactively, developing and capacitating municipalities for project elaboration.

3. Acceleration of Environmental Liability Remediation: The fact that 13 areas with environmental liabilities have not started remediation demonstrates a failure in the application of the National Solid Waste Policy. It is crucial that INEA, together with the municipalities, reinforces inspection and the application of instruments such as the Ecological ICMS tax to incentivize remediation.
4. Promotion of Nature-Based Solutions (NBS): The success of the projects at Rodrigo de Freitas Lagoon and Piratininga Shore demonstrates that NBS offer sustainable, economically viable alternatives with measurable environmental and social results. Creating centers of excellence could encourage the replication of these models in other lagoon systems of the RJMR.

The RJMR's integrated planning model offers a reference for other Brazilian metropolises. However, the final success will depend on the capacity to transform quality planning into coordinated action on the ground, supported by adequate funding and effective governance.

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About the Author

Waldir Ruggieri Peres holds a PhD in Environmental Monitoring from the Graduate Program in Environment at the State University of Rio de Janeiro (UERJ). He is a Geographer at the State Institute of Engineering and Architecture of the State of Rio de Janeiro, currently on assignment to the Directorate of Integrated Metropolitan Sanitation at the Rio Metrópole Institute (IRM).

Author Contributions

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Conflicts of Interest

This article reflects a critical assessment of the available data and does not necessarily represent the official position of the author's affiliated institutions.

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Coleção Estudos Cariocas (ISSN 1984-7203) is a publication dedicated to studies and research on the Municipality of Rio de Janeiro, affiliated with the Pereira Passos Institute (IPP) of the Rio de Janeiro City Hall.

Its objective is to disseminate technical and scientific production on topics related to the city of Rio de Janeiro, as well as its metropolitan connections and its role in regional, national, and international contexts. The collection is open to all researchers (whether municipal employees or not) and covers a wide range of fields — provided they partially or fully address the spatial scope of the city of Rio de Janeiro.

Articles must also align with the Institute's objectives, which are:

1. to promote and coordinate public intervention in the city's urban space;
2. to provide and integrate the activities of the city's geographic, cartographic, monographic, and statistical information systems;
3. to support the establishment of basic guidelines for the city's socioeconomic development.

Special emphasis will be given to the articulation of the articles with the city's economic development proposal. Thus, it is expected that the multidisciplinary articles submitted to the journal will address the urban development needs of Rio de Janeiro.