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From Operator Performance to Systemic Performance of Water Services: A Conceptual Framework for African Contexts

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Abstract

This article proposes a conceptual framework for the systemic performance of water services as an alternative to approaches focused exclusively on the operator. Based on a critical review of the literature on public service governance, public-private partnerships, and utility performance, it argues that outcomes in water services must be analyzed as the product of an institutional co-production between three interdependent functions: service operation, asset management, and strategic sector oversight. The paper develops a multidimensional model structured around six performance dimensions, grouped into three core pillars, integrating feedback loops between the institutional, organizational, and operational levels. Furthermore, it introduces four systemic indicators IAPE (Asset-Operation Alignment Index), IGC (Contractual Governability Index), ICTS (Territorial Service Coherence Indicator), and ISPS (Synthetic Systemic Performance Index) as operational tools for this approach. The case of Senegal is used as an illustrative example to demonstrate the heuristic value of the framework in African contexts, which are characterized by stakeholder plurality, territorial fragmentation, and a growing dissociation between operation, assets, and regulation. Thus, the article contributes to the scientific debate by offering a more integrated reading of water service performance and opening perspectives for future comparative empirical research.

Keywords

Systemic Performance, Water Governance, Institutional Co-Production, Public Water Services, Africa, Senegal

1. Introduction

Access to drinking water constitutes a major challenge for contemporary public policies, particularly in African countries facing rapid demographic growth, sustained urbanization and strong investment constraints. Since the 1990s, reforms in the water sector have profoundly reconfigured the organization of services, under the joint effect of New Public Management standards, the promotion of public-private partnerships and the search for greater financial sustainability [1]. In many contexts, these transformations have resulted in a growing dissociation between service operation, asset management, regulation and strategic management [2] [3]. In this context, the performance of water services has become a central object of evaluation [4]. However, to avoid conceptual confusion, it is crucial to clearly define and distinguish the different levels of performance. In this article, we define operator performance as the internal technical and financial efficiency of the entity managing the service on a daily basis. Service performance encompasses the broader outcomes delivered to users, including accessibility and continuity, regardless of who manages the infrastructure. Systemic performance, the core concept of our framework, refers to the overall outcome resulting from the institutional co-production and alignment between service operation, asset management, and strategic sector oversight. Finally, systemic robustness designates the capacity of this system to maintain its systemic performance over time despite external shocks or internal tensions. However, the notion of performance applied to public water services raises conceptual and methodological challenges. Unlike commercial companies, water companies fulfill a public service mission which cannot be reduced to economic or financial criteria. Their performance must also integrate social and territorial objectives: universal access, distribution equity and environmental sustainability [5]. However, the dominant literature continues to understand it mainly through the results of the operator, by means of technical and financial indicators such as network performance, continuity of service, water quality, staff productivity or the recovery rate [6].These measures are useful for assessing certain aspects of operation, but they present a major limitation: they tend to attribute the results observed to the operator alone, even though they largely depend on variables that they do not fully control, notably the quality of the asset, investment choices, the contractual framework, regulatory mechanisms and territorial inequalities [7] [8]. Beyond its measurement issues, this analytical shift also responds to a recurring problem in the governance of water services: the tendency of actors to attribute success to themselves while attributing poor performance to other components of the system. In configurations where operation, assets, investment and regulation are institutionally dissociated, declines in performance frequently give rise to a real logic of cross-imputation ("blame game"), in which the operator invokes the insufficiency of assets or the delay in investments, while the public authorities or the asset entities call into question the operational efficiency or the quality of management. A strictly operator-centric approach often fuels this fragmented imputation logic. Conversely, a systemic read-

ing makes it possible to place the results in the chain of interdependencies that produce them, and to move from a logic of blame to a logic of intelligibility of distributed responsibilities. The article defends the idea that the performance of water services must be analyzed as a systemic performance, that is to say as the product of the articulation between several interdependent functions of the service system. From this perspective, the results do not only come from the internal efficiency of the operator, but also from the coherence between operation, asset management, planning, regulation and the social purpose of the service. This analytical shift appears particularly necessary in African contexts, where water services are frequently characterized by hybrid institutional arrangements, asymmetric capacities between actors, strong territorial fragmentation and a plurality of socio-political constraints. By mobilizing transaction cost economics [9], the theory of commons governance [10], network governance [11] and the hydro-social approach [12] [13], we propose a multidimensional conceptual framework integrating six dimensions of performance, grouped into three structuring poles. The contribution of the article is twofold. First, it offers a structured critique of operator-centered approaches by showing their institutional, territorial and social blind spots. Secondly, it constructs an original conceptual framework for the systemic performance of water services, articulated around six dimensions grouped into three structuring poles: service production, infrastructural sustainability and public governance oriented towards equity. Four systemic indicators IAPE, IGC, ICTS and ISPS are then proposed as instruments for operationalizing this framework. The article is based on a critical and structured review of the literature, supplemented by a reasoned mobilization of the Senegalese case for illustrative purposes. Senegal is not treated here as an area of exhaustive empirical validation, but as a heuristic case making it possible to shed light on the interest of the proposed framework in a configuration where operation, asset and sectoral management are institutionally dissociated. The article is organized as follows. Section 2 returns to the limits of traditional approaches to the performance of water services. Section 3 explains the theoretical foundations of the systemic approach. Section 4 presents the proposed conceptual framework, its six dimensions, its three structuring poles and its indicators proposed for operationalization. Section 5 discusses the heuristic interest of the framework for African contexts, drawing on the case of Senegal. Section 6 concludes by highlighting the contributions, limits and possible empirical extensions of the approach.

2. Conceptual Framework and Methodological Approach

2.1. Methodology of the Literature Review

To construct our conceptual framework, we conducted a critical literature review informed by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) principles [14]. The review aimed to identify the limitations of operator-centric approaches and to synthesize theoretical contributions regarding multi-actor governance in water services. We queried two major scientific data-

bases: Scopus and Web of Science. The search terms used were combinations of ("water service*" OR "water utility") AND ("performance" OR "governance" OR "public-private partnership" OR "institutional arrangement") AND ("Africa" OR "developing countries"). The inclusion criteria were: 1) peer-reviewed articles and institutional reports (e.g., World Bank), 2) published between 1990 and 2023, and 3) focusing on the institutional, contractual, or territorial dimensions of water service performance. Articles strictly focused on technical engineering without governance aspects were excluded. The selection process involved an initial screening of abstracts, followed by a full-text analysis of 45 relevant documents. Furthermore, the case of Senegal was selected not as an empirical dataset, but as a heuristic illustrative case. Senegal's trajectory since 1995 offers a well-documented example of institutional dissociation between operation, asset management, and regulation, making it an ideal configuration to highlight the relevance of our systemic approach.

2.2. The Limits of Traditional Approaches to the Performance of Water Services

2.2.1. The Predominance of Technical and Financial Indicators

The evaluation of the performance of water services has long been dominated by operator-centered approaches, derived from infrastructure economics and utility management. This perspective favors the analysis of the operational efficiency of companies providing public services [6]. These indicators, widely used in international benchmarking, notably by the World Bank through IBNET [15], are relevant for analyzing operational management and the immediate quality of the service. However, their exclusive focus on the operator leads to a reductive view of overall performance.

2.2.2. Dimensions Obscured by Traditional Approaches

Underestimation of institutional and organizational factors:

in systems that have adopted New Public Management reforms, the functions of asset management, operation and regulation are distributed between several distinct institutional actors [1]. The operator only controls part of the variables influencing overall performance, while others are the responsibility of public authorities or asset entities. The exclusive attribution of results to the operator therefore constitutes a major analytical bias.

Neglect of contractual arrangements and regulation

The operator-centric approach underestimates the importance of institutions and contractual arrangements. As established by the economic theory of regulation, results in infrastructure sectors largely depend on the quality of contractual arrangements and regulatory mechanisms [16]. Operational performance is therefore inseparable from the institutional framework in which it takes place, particularly in public service delegation arrangements where the design and enforcement of the contract determine the long-term efficiency and sustainability of the service [2] [16].

The omission of social and territorial dimensions

Classic approaches favor technical and economic dimensions to the detriment of social and territorial dimensions. However, performance must also be assessed with regard to the system's capacity to guarantee equitable access [7]. Research on African cities shows that reforms can improve efficiency while accentuating inequalities of access and the fragmentation of the spaces served [7] [8].

Failure to take systemic interactions into account

The performance of public services results from the articulation between strategic planning, infrastructure management, technical operation and regulation. Overall effectiveness depends on the coordination between these functions and the capacity of institutions to organize coherent relationships between actors [5]. This observation calls for an integrated perspective, embracing all the components of the management system. These limits show that the performance of water services cannot be analyzed solely as operational performance. It must be understood as the result of interactions between several functions of the service system, distributed between a plurality of actors and levels of governance. Such a perspective calls for a conceptual framework capable of simultaneously integrating the operational, asset, institutional, territorial and social dimensions of performance.

2.3. The Theoretical Foundations of a Systemic Approach

2.3.1. The Economics of Transaction Costs and Systemic Performance

According to transaction cost economics [9], organizations seek to minimize the costs associated with the exchange. In the water sector, the functional separation between operation, assets and regulation generates interdependencies which, if not correctly managed, produce high transaction costs: coordination, negotiation, monitoring and adaptation costs. The performance of the operator (Pole 1) thus depends not only on its internal efficiency, but also on the quality of the contracts which bind it to the asset entities (Pole 2) and to the regulatory authorities (Pole 3). An incomplete contractual framework or ineffective regulation generates underinvestment, pricing conflicts or low quality of service. The contribution of ECT to our framework lies in illuminating the micro-institutional mechanisms of coordination between the three poles.

2.3.2. Commons Governance and Collective Performance

[10] approach to common pool resources offers a complementary perspective. Water services constitute commons where the resource and infrastructure are shared and require collective management. Systemic performance, in this perspective, results from collective co-production where the rules, standards and monitoring mechanisms are developed by the actors themselves. The feedback loops of our model find a basis here: systemic performance informs actors about the effectiveness of their governance rules, allowing institutional learning. The specific contribution of this theory lies in shedding light on the conditions of multi-actor cooperation and mutual surveillance mechanisms.

2.3.3. Network Governance and Multi-Actor Coordination

The network governance perspective [11] recognizes that the production of public services is the work of interdependent actors operating within complex networks. Systemic performance does not arise from a single hierarchical authority, but from the network's capacity to coordinate actions and manage interdependencies. In Senegal, this network includes SONES (Société Nationale des Eaux du Senegal) or OFOR (Office des Forages Ruraux), Operators, Regulatory Authorities, Local Authorities and Users. Trust, information sharing and conflict resolution condition the transformation of interdependencies into synergies. The contribution of this theory complements the ECT by going beyond the bilateral perspective of the contract to embrace the reticular dimension of governance arrangements.

2.3.4. The Hydro-Social Approach: Performance as a Socio-Political Construct

The hydro-social approach [12] [13] deconstructs the purely technical vision of water to place it at the heart of power relations and political dynamics. Performance is no longer just a question of efficiency, but a socio-political construct, the result of struggles and negotiations between actors. Water infrastructure is not neutral: it shapes and is shaped by social relations and inequalities. The contribution of this theory to our framework lies in the integration of the political dimension and in the critical analysis of decision-making processes, technological choices and financing models as vectors of reproduction or mitigation of inequalities. The four theoretical frameworks used are not juxtaposed but articulated around the same problem: understanding how the performance of a water service is constructed when its functions are distributed between several actors, several devices and several temporalities. Transaction cost economics sheds light on coordination problems between functionally separated entities; commons governance emphasizes collective rules, cooperation and monitoring mechanisms; network governance makes it possible to understand network coordination between interdependent actors; finally, the hydro-social approach reintroduces the political, territorial and distributive dimension of performance. Together, these approaches make it possible to think of performance not as a simple operating result, but as an institutional, organizational and socio-political construct.

2.3.5. Summary: Theoretical Articulation

Table 1 summarizes the specific analytical contribution of each theoretical framework to the proposed model.

Taken together, these four theoretical frameworks converge towards the same idea: the performance of a water service cannot be understood either as a simple technical result, nor as the isolated effect of a single actor. It must be read as a collective production, structured by coordination mechanisms, governance rules, power relations and territorial arbitrations. This convergence makes it possible to justify the transition from a general reading of institutional co-production to a more operational formalization of performance. This is precisely the subject of the

following section, which translates these theoretical contributions into a conceptual framework structured around six complementary dimensions. The technical and economic dimensions refer to the daily production of the service; the asset and planning dimensions capture the materiality and long temporality of infrastructures; finally, the dimensions of management-regulation and equity restore the institutional, political and social dimension of performance. The three resulting poles thus constitute the analytical translation of the theoretical convergence explained above.

Table 1. Articulation of theoretical frameworks in the systemic performance model.

Theoretical Framework	Main Contribution	Pillar(s) Addressed	Key Mechanism
TCE (Williamson)	Micro-institutional coordination	Pillars 1-2, 1-3, 2-3	Minimization of transaction costs between functional entities
Commons (Ostrom)	Multi-stakeholder cooperation	Pillars 1-2-3	Collective rules, mutual monitoring, institutional learning
Network Governance (Klijn & Koppenjan)	Reticular coordination	Pillars 1-2-3	Trust, information sharing, conflict resolution
Hydro-social (Swyngedouw, Bakker)	Political dimension	Pillar 3, Dimension 6	Power relations, environmental justice, inclusion

2.4. The Systemic Performance Model

Poles and Dimensions To free ourselves from conventional approaches focused exclusively on operator efficiency, this article adopts a systemic reading of the performance of water companies. From this perspective, performance is no longer perceived as the simple result of operating efficiency, but as the product of a complex articulation between the institutional framework, the organization of the management system, infrastructural sustainability and the social purposes of the service.

2.4.1. Foundations of a Multidimensional Approach

Unlike commercial companies, water companies must reconcile the imperatives of continuity and quality, economic viability, asset preservation, investment planning, regulatory compliance and guarantee of equitable access. Performance cannot be reduced to a single indicator but must be understood as a set of complementary dimensions, sometimes in tension. This perspective is part of the broader conception of public performance proposed by Bouckaert and Halligan [4], who consider that the results of public action arise from complex interactions between objectives, resources, processes, outputs, outcomes and societal effects.

2.4.2. The Six Dimensions of Performance

Dimension 1—Technical and operational performance

This dimension evaluates the capacity of the system to ensure the production, treatment and distribution of drinking water. It encompasses continuity of service, water quality, network performance and daily operating efficiency. This is the most visible dimension, measured through indicators such as non-revenue-

generating water [15] [17]. Although fundamental, it is not sufficient to account for overall performance.

Dimension 2—Economic and financial performance

It concerns economic viability and operating balance: cost coverage, revenue recovery, cost control, pricing structure and financial sustainability [1]. Apparent economic performance, however, can mask underinvestment or social exclusion.

Dimension 3—Asset management performance

This dimension refers to the capacity of the system to maintain, maintain, renew and sustainably enhance existing infrastructure. It conditions the quality of service, future operating costs and long-term sustainability. It differs from operation by its focus on heavy maintenance and equipment renewal, generally entrusted to an entity separate from the operator.

Dimension 4—Planning and investment performance

It assesses the ability of stakeholders to anticipate needs, plan investments and carry out the necessary extensions or modernizations. In a context of population growth and rapid urbanization, adequate planning is essential for system resilience.

Dimension 5—Steering, control and regulation performance

This dimension assesses the capacity of the institutional system to define coherent strategic orientations, to monitor performance, to enforce contractual commitments and to guarantee the coherence of public action. The credibility of institutions and the clarity of responsibilities are decisive [16] [18]. This dimension is particularly critical in multi-actor governance systems [19].

Dimension 6—Social and equity performance

It measures the capacity of the service to guarantee equitable, affordable and socially sustainable access. This includes coverage, economic accessibility, consideration of vulnerable populations and reduction of inequalities [7] [8]. This dimension reinscribes evaluation in the very purpose of the public service.

2.4.3. Three Structuring Poles

Our model does not simply add indicators; he understands performance as a result of three poles in constant interaction. The first, centered on the immediate production of the service, is necessarily backed by a second pole dedicated to infrastructural sustainability, without which any technical efficiency is only ephemeral. Finally, the third pole, that of governance and social purpose, gives meaning to the whole by placing the service in a trajectory of equity and political regulation.

Pole 1—Production of the service.

It brings together dimensions 1 and 2 and represents the capacity of the system to provide the service on a daily basis in an efficient and economically sustainable manner within a defined perimeter. It is the most visible pole, but it cannot summarize the overall performance.

Pole 2—Infrastructural sustainability

It integrates dimensions 3 and 4 and refers to the capacity of the system to pre-

serve its assets and prepare for future extensions. It introduces a long-time frame, essential for sustainability.

Pole 3—Public governance and social purpose.

It includes dimensions 5 and 6 and corresponds to the capacity of institutions to strategically guide the sector, coordinate actors and guarantee the objectives of social and territorial justice. The interdependence of these poles constitutes the heart of the systemic approach: high performance in one pole does not guarantee systemic performance if the others are failing. This perspective shifts the analysis from a logic of attribution to a single actor towards a logic of institutional co-production.

2.4.4. Conceptual Framework for Systemic Performance of Water Companies

Figure 1 summarizes this analytical positioning by conceptualizing systemic performance as a multidimensional construct located at the nexus of three complementary poles: service production, heritage sustainability and public governance oriented toward equity. The model specifies distinct causal relationships between its components. Within the three poles, the relationships between the six dimensions are expected to be direct effects: for instance, asset management performance (Dimension 3) directly impacts technical and operational performance (Dimension 1). The territorial context acts as a moderating variable: it does not directly produce performance, but it modifies the strength of the relationship between governance arrangements and service outcomes (e.g., high urban growth can weaken the positive effect of good planning). The model integrates feedback loops: systemic performance outcomes inform and retroactively influence sectoral governance (macro level), triggering institutional learning and contractual adjustments. Finally, the diagram operationalizes this approach by integrating key indicators—IGC, IAPE, ICTS and ISPS thus demonstrating how each stratum of the system contributes to the overall and sustainable performance of the service.

The performance of water companies cannot be reduced to a simple operating metric but must be understood as a systemic construction. This model is based on the dynamic interaction of three interdependent performance poles. The first pole, dedicated to the production of the service, encompasses technical, operational and financial efficiency. The second, focused on infrastructural sustainability, deals with asset management and the alignment between planning and long-term investments. Finally, the third pole concerns public governance, integrating the imperatives of regulation, control and social equity. The originality of this framework lies in its hierarchical architecture. Upstream, sectoral governance (macro level) defines the institutional and contractual framework. At the center, the management system (meso level) acts as a pivot by articulating the operating and asset functions. This combination produces a systemic performance which is not the simple sum of the parts, but the result of their overall coherence. For the empirical analysis, two dynamic dimensions complete the model. On the one

hand, the territorial context acts as a moderating variable, explaining how local specificities (density, resources) condition the results. On the other hand, feedback loops ensure the reflexivity of the system, linking results to strategic adjustment mechanisms. The integration of the IGC, IAPE, ICTS and ISPS indicators makes it possible to operationalize this reading, thus providing a robust reading grid for assessing the connection between governability, technical alignment and overall efficiency.

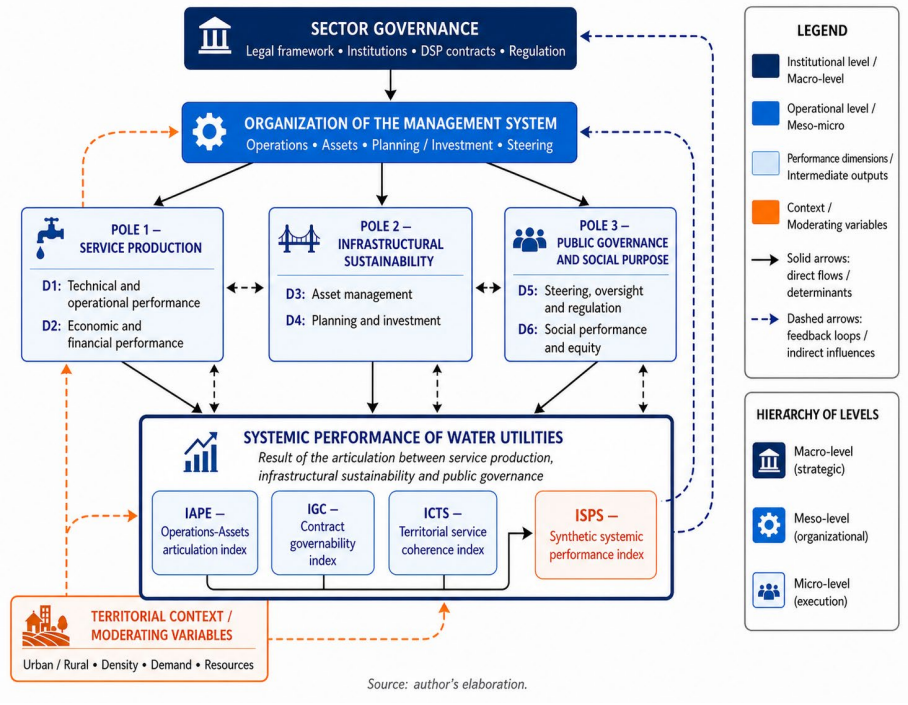

Figure 1. Conceptual framework of systemic performance of water companies.

2.4.5. Theoretical Propositions

Based on our conceptual framework, we formulate four testable propositions to guide future empirical research: **P1:** A higher degree of contractual coordination between the asset holding company and the operator (Pillar 2 - Pillar 1 alignment) directly improves the systemic performance of the water service. **P2:** Effective long-term asset management and investment planning positively impact the continuity and quality of the service, reducing the vulnerability of the operator. **P3:** Territorial conditions (such as rapid peri-urban expansion and low density) negatively moderate the relationship between institutional governance and equity outcomes. **P4:** A regulatory framework that explicitly integrates social and territorial objectives (Pillar 3) leads to a higher Territorial Service Coherence Indicator (ICTS) compared to purely financial regulation.

2.5. Operationalization by Systemic Indicators and Proxy Strategy

From a conceptual perspective, the interest of an analytical framework lies not

only in its theoretical coherence, but also in its capacity to guide future empirical investigations. It is in this spirit that four systemic indicators are proposed intended to operationalize the main articulations of the model: alignment between operations and assets (IAPE), contractual governability (IGC), territorial coherence of the service (ICTS) and overall systemic performance (ISPS).These indicators do not constitute, at this stage, universally stabilized instruments; they must be understood as analytical tools intended to structure observation, to make systemic misadjustments visible and to prepare future comparative empirical tests. Their interest lies less in the isolated measurement of a variable than in their capacity to reveal balances, tensions or structural misadjustments between constituent dimensions of the performance of the service: they make it possible to grasp the overall coherence of the water service.

2.5.1. The Asset-Operation Alignment Index (IAPE)

It aims to assess the degree of coherence between the operating dynamics of the service and the state of the technical assets that support it. It is based on the hypothesis according to which operating performance can only be considered sustainable if it is based on sufficient effort in renewal, maintenance and investment. The indicator thus seeks to go beyond an immediate reading of operational results to question their technical sustainability over time. It makes it possible to identify situations in which a good level of service actually masks aging assets, underinvestment or an essentially reactive maintenance logic. In this sense, the IAPE constitutes an indicator of structural coherence between daily management, preservation of assets and investment trajectory.

2.5.2. The Contractual Governability Index (IGC)

Its purpose is to assess the effective quality of the connection between contractual framework, institutional management and service regulation capacity. It is based on the idea that the performance of a delegated service does not depend only on the formal obligations included in the contract, but also on the ability of the actors to follow commitments, correct discrepancies and maintain a relatively stable governance framewok over time. The IGC thus makes it possible to assess not only the level of execution of contractual targets, but also the effectiveness of the control mechanisms and the robustness of the contractual system in the face of adjustments or renegotiations. It therefore offers a more substantial reading of governance, understood not as the simple existence of a contract, but as the capacity to produce effective and sustainable management of the service.

2.5.3. The Territorial Coherence Indicator of the Service (ICTS)

It aims to understand the way in which the water service adjusts to the spatial, social and demographic dynamics of the territories served. It starts from the observation that the performance of a service cannot be assessed solely on an aggregate scale, without considering intra-urban differentiations, service disparities or gaps between network extension and urban growth. The ICTS thus seeks to meas-

ure the capacity of the system to support the evolution of urban and peri-urban spaces, to limit territorial fragmentation of the service and to direct extension towards the most vulnerable or least well served areas. From this point of view, it constitutes an essential indicator to reinscribe the analysis of performance in its territorial and distributive dimension.

2.5.4. The Synthetic Systemic Performance Index (ISPS)

It aims to provide an integrated measurement of the overall performance of the water service. Unlike approaches focused on a single dimension, it aggregates several registers of performance technical, economic, patrimonial, planning, institutional and social in order to evaluate the overall coherence of the service model. This index is based on the idea that systemic performance is manifested in the capacity of the service to effectively articulate its different components, without excessive transfer of load from one register to another. The ISPS therefore does not seek to replace a single indicator for detailed analysis, but to offer a synthetic reading of the solidity of the system as a whole. It makes it possible to situate services according to profiles of robustness, fragility or structural imbalance.

2.5.5. Calculation Logic and Summary Table of the Indicators

In the spirit of the article, these indicators should not be interpreted as universally stabilized instruments, but as exploratory analytical tools designed to structure future empirical investigations. Their primary value lies in their capacity to make visible coherences, tensions, or misalignments between different dimensions of water service performance.

To ensure overall consistency of the framework, all elementary scores and all composite indices are brought to a common scale of 0 to 100, where 100 corresponds to the most favorable situation from the perspective of systemic performance. The thresholds proposed below should be understood as indicative benchmarks, intended to be adjusted according to data availability and quality, institutional contexts, and the scope of studies.

General Normalization Convention

General Principle: for any elementary indicator (X_i), a normalized score (S_i) is calculated between 0 and 100. When a high value of the indicator is favorable:

$$S_i = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}!} \times 100$$

when a high value of the indicator is unfavorable: $S_i = \frac{X_{\max} - X_i}{X_{\max} - X_{\min}!} \times 100$,

when data are heterogeneous or management thresholds already exist, a transformation by score classes may be retained. In this case, each variable is directly converted to a score out of 100 according to an explicit grid.

Aggregation Rule any composite index (I) is calculated by simple arithmetic mean of its components: $I_i = \frac{S_1 + S_2 + \cdots + S_n}{n} \times 100$ where (n) denotes the num-

ber of sub-indicators.

General Interpretation Scale

Score	Interpretation
85 - 100	Very high/very robust
70 - 84	High/robust
55 - 69	Moderate/intermediate
40 - 54	Fragile
0 - 39	Low to critical

IAPE—Index of Asset-Operation Alignment

$$\text{IAPE} = \frac{\text{SCRP} + \text{SCBI} + \text{SSEP} + \text{SMP} + \text{STEP}}{5}$$

where: SCRP: score for coverage of asset renewal, SCBI: score for coverage of investment needs, SSEP: score for sustainability of operation by assets, SMP: score for preventive maintenance, STEP: score for operation-asset tension

IGC—Index of Contractual Governability

$$\text{IGC} = \frac{\text{SACC} + \text{SMRC} + \text{SSCC}}{3}$$

where: SACC = score for achievement of contractual targets, SMRC = score for implementation of control recommendations, SSCC = score for corrected contractual stability

ICTS—Index of Territorial Service Coherence

$$\text{ICTS} = \frac{\text{SCCU} + \text{SDPR} + \text{SFTS} + \text{SESO}}{4}$$

where: SCCU = score for coverage of urban growth, SDPR = score for relative peri-urban service coverage, SFTS = score for territorial fragmentation of service, SESO = score for socially-oriented expansion

ISPS—Synthetic Index of Systemic Performance

$$\text{ISPS} = \frac{\text{STO} + \text{SEF} + \text{SGP} + \text{SPI} + \text{SPR} + \text{SSE}}{6}$$

where: STO = technical and operational score, SEF = economic and financial score, SGP = asset management score, SPI = planning and investment score, SPR = steering, control and regulation score, SSE = social and equity score

The Synthetic Index of Systemic Performance (ISPS) should not be perceived as a neutral measure, but as the reflection of a political trade-off between sometimes divergent objectives. We propose introducing explicit weighting (w_i) to simulate two governance scenarios:

"Economic Efficiency" Scenario: Priority is given to financial and technical viability $w_{\text{technical}} + w_{\text{financial}} > 0.5$. This scenario is favored in phases of sectoral re-

covery or the search for bankability.

"Social Justice" Scenario: Priority shifts toward social equity and territorial coverage $w_{\text{equity}} + w_{\text{territory}} > 0.5$. This scenario makes it possible to measure system performance in terms of its impact on vulnerable populations.

Table 2 presents the operationalization of the four systemic indicators—IAPE, IGC, ICTS, and ISPS—detailing their objectives, components, and data requirements. These composite indices are designed to evaluate the articulation and coherence between the three pillars of the framework. Specifically, the IAPE measures the alignment between asset management and operation, while the IGC assesses contractual governability and the stability of the institutional arrangement. The ICTS captures the adaptation of the service to territorial and environmental constraints. Finally, the ISPS provides a holistic evaluation of the system's overall performance by aggregating scores across six dimensions. The indicative thresholds provided in the table allow for a standardized assessment of systemic health, ranging from "Low/Critical" to "Very High" performance.

Table 2. Proposed operationalization of the proposed systemic indicators indicator objective.

Indicator	Objective	Proposed Operationalization	Required Data	Indicative Thresholds
IAPE (Asset-Operation Alignment Index)	Coherence Pillar 1 - Pillar 2	Composite index: 1) Asset renewal coverage rate; 2) Investment needs coverage rate; 3) Operational sustainability index via assets; 4) Preventive maintenance rate; 5) Operation-asset tension index	Asset financial reports, Investment plan, Operator operational data	85 - 100: Very high 70 - 84: High 55 - 69: Medium 40 - 54: Fragile 0 - 39: Low/Critical
IGC (Contractual Governability Index)	Articulation Pillar 1 - Pillar 3	Composite index: 1) Contractual targets achievement rate; 2) Audit and control recommendations implementation rate; 3) Adjusted contractual stability rate	Contracts, Monitoring/Audit/ Control reports, Recommendation tracking, Contractual chronology	85 - 100: Very high 70 - 84: High 55 - 69: Medium 40 - 54: Fragile 0 - 39: Low/Critical
ICTS (Territorial Service Coherence Indicator)	Adaptation capacity Pillar 1 & 2 + territorial context	Index integrating: 1) Urban growth coverage rate; 2) Relative peri-urban service rate; 3) Territorial service fragmentation index; 4) Socially-oriented extension rate	Performance data by zone, Demographic projections, Climate scenarios	85 - 100: Very high 70 - 84: High 55 - 69: Medium 40 - 54: Fragile 0 - 39: Low/Critical
ISPS (Synthetic Systemic Performance Index)	Model evaluation: Overall system coherence	Composite index: 1) Technical and operational score; 2) Economic and financial score; 3) Asset management score; 4) Planning and investment score; 5) Oversight, control, and regulation score; 6) Social and equity score	Scores across the six dimensions	85 - 100: Very high 70 - 84: High 55 - 69: Medium 40 - 54: Fragile 0 - 39: Low/Critical

Formulated in this way, systemic indicators are not only intended to complement traditional performance measurement instruments; they propose a shift in focus from the performance of the operator to the performance of the service system as a whole. By emphasizing the connections between operation, heritage, gov-

ernance and territory, they make it possible to understand more precisely the conditions of robustness, fragility or misalignment of urban water services.

2.5.6. Data Strategy in the Context of Documentary Fragility

The operationalization of the systemic performance framework in African contexts frequently encounters information asymmetry and the fragmentation of institutional databases. In order to guarantee the calculability of the indicators without compromising the rigor of the analysis, we propose a strategy of "proxy data" (substitution variables). This approach makes it possible to transform access constraints to primary data into indirect audit opportunities, thus ensuring the continuity of systemic evaluation even in situations of documentary fragility.

Table 3 provides a detailed overview of the critical variables, their typical availability, and the suggested proxy indicators used to operationalize the systemic performance framework. Given the information asymmetries and data scarcity inherent in many African contexts, these proxies are essential for ensuring the framework's applicability. For instance, the Maintenance cost/Revenue ratio is used to reveal structural underinvestment in asset preservation, while the Breakdown rate serves as a direct physical indicator of asset obsolescence. Furthermore, the Frequency of contractual amendments reflects the quality of regulation and institutional stability, and the Variance of service continuity effectively measures territorial inequities and spatial fragmentation

3. Performance Trajectories and Configurations

3.1. Why African Contexts Call for a Systemic Reading

3.1.1. Criticism of International Benchmarking and Institutional Mimicry

Classic approaches to performance, promoted through tools such as IBNET, rely largely on standardized indicators of yield, continuity, water quality, productivity or recovery [15] [20]. While these instruments are useful for international comparison, they have significant limitations when applied without context to African water services. As several studies on African cities have shown, aggregate results often mask hybrid institutional configurations, spatial disparities in service and implicit compromises between efficiency, equity and sustainability [21] [22]. This difficulty refers more broadly to a risk of institutional mimicry, in the sense that measurement systems designed in other environments are adopted as performance standards without truly questioning the local conditions of their relevance and appropriation [23]. In contexts marked by the plurality of actors, territorial fragmentation, informal areas, low rural densities and structural budgetary constraints, a seemingly simple indicator—for example low network efficiency - can refer to very different causes: insufficient asset renewal, weakness of public management, unabsorbed urban pressure or discrepancy between contractual scope and territorial reality. A reading strictly centered on the operator then tends to naturalize as poor performance what sometimes relates to a more global maladjustment of the system.

Table 3. Feasibility matrix and proxy indicators (Proxies).

Critical Variable	Typical Availability	Suggested Proxy Indicator	Justification of Correlation
Preventive Maintenance	Low	Maintenance cost/ Revenue ratio	Indicates deferred maintenance in favor of operation. A low ratio suggests that maintenance is being postponed or minimized, revealing structural underinvestment in asset preservation.
Asset Obsolescence	Medium	Breakdown rate (failures/km/year)	Direct physical indicator of asset degradation. Higher breakdown rates correlate with aging infrastructure and inadequate renewal efforts, making this a reliable proxy for asset condition.
Quality of Regulation	Low	Frequency of contractual amendments	Reflects regulation by adjustment due to lack of stable governance. Frequent amendments indicate institutional instability and weak regulatory capacity, revealing underlying governance fragility.
Territorial Equity	Medium	Variance of service continuity	Measures spatial fragmentation between centers and peripheries. High variance in service continuity across zones indicates unequal access and territorial inequities in service delivery.

3.1.2. Relevance of a Systemic Approach

It is precisely in this type of context that the systemic approach takes on its full meaning. Water services in Africa operate in environments where observed results rarely depend on a single actor or function. Rather, they come from an articulation between operation, asset management, investment planning, regulation and territorial registration of the service. The literature on public performance and infrastructure governance shows that results cannot be attributed to the entity responsible for operation alone, but must be related to all the institutional, organizational and contractual mechanisms that structure collective action [4] [19] [24]. The benefit of such an approach is twofold. On the one hand, it makes it possible to place the visible performances of the operation in a broader institutional architecture, where decisions relating to assets, investment and regulation strongly condition the quality of the service. On the other hand, it makes possible a more realistic reading of the gaps between apparent performance and actual performance, taking into account interdependencies between functions, capacity asymmetries between actors and constraints specific to the territories served. In this sense, the systemic approach appears more suited than traditional instruments to interpret the trajectories of water services in African contexts characterized by institutional hybridization and the growing dissociation of responsibilities.

3.1.3. Equity and Sustainability: Two Critical Dimensions

Two dimensions make this systemic reading particularly necessary: equity and sustainability. The first refers to the capacity of the service to guarantee fair, spatially balanced and economically affordable access. However, numerous studies have shown that reforms can improve certain efficiency indicators while allowing inequalities to persist, or even accentuate, between consolidated urban centers, peripheries and less dense areas [21] [22] [25]. A technically satisfactory but socially selective performance cannot, from this perspective, be considered fully satisfactory. The second dimension, that of sustainability, refers to the ability of the

system to maintain its performance over time without compromising the future quality of the service or degrading the infrastructural base that supports it. Short-term performance obtained at the cost of under-maintaining assets, insufficient renewal or postponement of necessary investments remains structurally fragile. Analyses of infrastructure governance show in this regard that sustainability does not depend only on immediate economic balance, but on the coherence between operation, maintenance, renewal, planning and institutional management [9] [18] [21]. Thus, in African contexts, the challenge is not only to improve performance indicators, but to understand under what institutional, territorial and asset conditions these results are produced. This is precisely what the systemic approach proposed in this article allows.

3.2. The Heuristic Case of Senegal (1995-2020)

The evolution of the governance of water services in Senegal between 1995 and 2020 cannot be understood without a detailed analysis of the contractual dynamics, illustrated by **Figure 2**. This figure highlights the institutional density of the urban model, marked by a succession of amendments to the initial leasing contract of 1996. These revisions (in particular Amendment No. 1 of 2002 on the income guarantee and the Amendmentsn°7 and 8 of 2014-2017 on the transfer of works) demonstrate a process of regulation through adjustment, where the contract serves as an "evolving compromise" between the State, the asset company (SONES) and the operator. At the same time, the rural trajectory, although later in its professionalization, shows a convergence towards this model with the creation of OFOR in 2014, while retaining a hybrid dimension. This dual trajectory confirms that the systemic performance of the sector is based on a capacity for institutional adaptation in the face of growing territorial and financial challenges.

Senegal constitutes a particularly relevant configuration to illustrate the interest of the proposed framework. The reform trajectory undertaken since the mid-1990s, summarized in **Figure 2**, highlights the progressive construction of a governance system based on the dissociation of functions between operation, asset management and public steering. In the urban sub-sector, this architecture is based on the coexistence of a delegated operator responsible for operation, an asset company responsible for infrastructure and a State retaining the functions of framing, contracting and supervision [26] [27]. In the rural sub-sector, professionalization is later and more hybrid, but it is also part of a trajectory of increased differentiation of roles, in particular with the creation of OFOR and the rise in power of public service delegations. **Figure 2** thus allows us to read Senegalese governance not as a fixed architecture, but as an evolving system, adjusted over time by contractual revisions, institutional reconfigurations and successive arbitrations between technical, financial and territorial imperatives. This dynamic is particularly visible in the urban model, where the succession of amendments to the initial contract reflects less pure instability than a process of regulation by adjustment, revealing the tensions running through the sector [3]. The Senegalese

case thus shows that the performance of a water service depends less on an isolated actor than on the quality of the connections between the components of the system. The heuristic interest of Senegal lies precisely in this legible dissociation of responsibilities. The progress observed in terms of continuity of service, performance or operational management cannot be interpreted independently of investments in assets, public arbitrations and the robustness of the contractual framework [19] [28]. In the same way, persistent territorial tensions – particularly in peri-urban areas—remind us that the aggregate performance of the service does not necessarily coincide with effective territorial coherence [3] [29].Senegal thus constitutes a particularly illuminating case to show that the proposed indicators are not aimed at multiplying measures, but at making visible misalignments which escape operator-centered approaches: misalignment between operation and assets, fragility of contractual management or gap between overall improvement and spatial inequalities of service. In this sense, the Senegalese case is not valid here as a field for exhaustive empirical demonstration. It functions rather as a revealing analytical configuration, in which the visible performances of the operation appear to be closely dependent on patrimonial choices, contractual arrangements, public regulation and territorial dynamics. It is precisely this overlap, more than just the performance of the operator, that the proposed systemic performance framework aims to make intelligible.

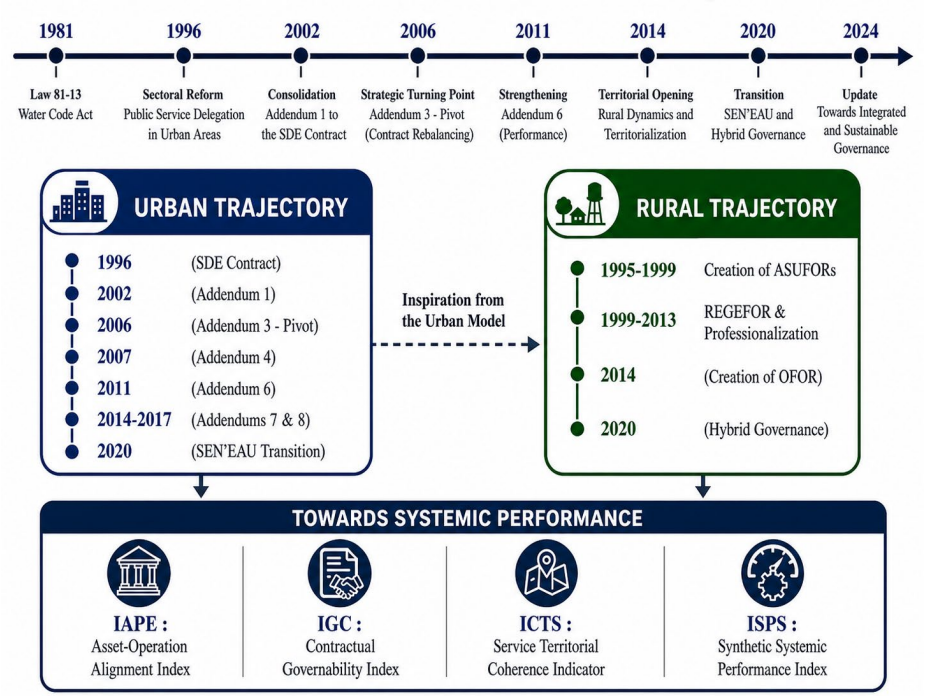

Figure 2. Genesis and evolution of water services governance in Senegal (1995-2020): from initial dissociation to differentiated governance.

3.3. Typology of African Configurations

A Comparative Analysis of Systemic Performance The heuristic interest of the

systemic performance framework lies in its capacity to compare divergent institutional architectures through a common reading grid. The analysis of West African trajectories makes it possible to identify three typical configurations, each shifting the center of gravity of performance towards distinct poles of the model.

3.3.1. The Integrated Model

Self-financing as a pivot of performance (Burkina Faso and Mali) In this configuration, illustrated by the National Water and Sanitation Office (ONEA) in Burkina Faso and Malian Drinking Water Management Company (SOMAGEP) in Mali, the asset, investment and operating functions are brought together within a single state company. Performance is here "endogenized". The success of ONEA, often cited as a model of public success in Africa [15], is based on a strong self-financing capacity and management autonomy vis-à-vis the supervisory authority. Point of vigilance: Systemic performance here depends on the robustness of the Plan Contract with the State. The major risk lies in the politicization of tariffs which can weaken Pole 2 (Infrastructural Sustainability) to the benefit of Pole 3 (Social Governance).

3.3.2. The Dissociation Model

Contractual alignment as a driving force (Senegal) The Senegalese model represents the most accomplished form of institutional dissociation. Performance cannot be understood through a single actor. It is the result of the contractual alignment between the asset company (owner of the assets) and the private operator (leasing). The center of gravity shifts towards inter-organizational coordination. As Pezon (2018) points out, tensions on the IAPE (Asset-Operation Alignment) indicator constitute the main risk of systemic failure, where delays in asset investment restrict the operational efficiency of the operator.

3.3.3. The Total Delegation Model

The maturity of the historic partnership (Côte d'Ivoire) With SODECI, Côte d'Ivoire has the oldest Public-Private Partnership (PPP) on the continent [30]. Unlike Senegal, the private operator has historically managed a larger part of the value chain, including certain renewal investments. Performance is driven by a global leasing contract with strong state regulation. The system benefits from great institutional stability and technical expertise accumulated over more than 50 years. The systemic challenge lies in maintaining territorial equity (Pole 3). The high efficiency of the urban model can mask growing disparities with peripheral and rural areas, requiring strong social regulation to avoid territorial fragmentation [7]. This typology demonstrates that while institutional arrangements vary, the six dimensions of systemic performance remain universally applicable. The difference lies in the weighting of interdependencies: where the integrated model relies on unity of command, the dissociation model (Senegal) requires high-precision contractual engineering to guarantee the coherence of the service.

4. Discussion: From Fragmentation to Systemic Performance

The main contribution of the proposed framework lies in its ability to make observable mechanisms that conventional approaches to performance tend to make invisible. By replacing a reading centered on the operator with a reading based on the articulation between operation, asset, management and territory, the model makes it possible to move the analysis from only immediate results to the structural conditions of production of performance.

First, the framework makes it possible to more clearly distinguish operating performance from systemic robustness. In many water services, satisfactory operational results (good efficiency, high continuity, improved recovery) can coexist with silent degradation of assets, insufficient renewal effort or inappropriate investment planning. One of the major contributions of the model is to make visible the risk of decoupling between apparent performance and real sustainability. From this perspective, the IAPE indicator does not only measure a technical state; it reveals the coherence, or on the contrary the tension, between the daily operating logic and the capacity of the system to preserve the infrastructural base which makes it possible.

Secondly, the framework makes visible the institutional dimension of performance, often underestimated in approaches based on benchmarking. He recalls that, in configurations of delegation or multi-actor governance, the results depend as much on the quality of the contractual arrangements and the management capacity as on the intrinsic performance of the operator. The same technical performance can thus correspond to very different institutional configurations: in one case, it results from a stable contractual framework, rigorous monitoring and credible regulation; in another, it can be obtained despite frequent renegotiations, weak implementation of control or persistent asymmetry of information between actors. In this sense, the IGC indicator makes it possible to shift attention from the simple existence of the contract to its effective governability, understood as the capacity of the contractual system to guide, supervise and correct the action.

Thirdly, the framework centrally reintroduces the territorial dimension into the analysis of performance. One of the recurring biases of aggregate approaches is to smooth spatial service gaps behind global averages. However, in many African contexts, performance varies greatly depending on central areas, peripheries, peri-urban areas and less dense areas. The proposed model makes it possible to make visible the gaps between network extension and urban growth, the service gaps between territories, as well as the tensions between economic viability and spatial coherence of the service. The ICTS indicator aims precisely to capture this dimension by assessing the system's capacity to support territorial dynamics, to limit the fragmentation of the service and to direct extension towards vulnerable or underserved areas. In doing so, the framework shows that performance cannot be considered satisfactory if it is based on localized, socially or spatially selective improvement.

Fourth, the framework highlights the presence of feedback loops between results and governance mechanisms. Unlike a linear representation in which the institutional framework would mechanically produce outputs, the proposed model suggests that the observed performance itself acts on the future arrangements of the system. Prolonged poor performance can lead to contractual reviews, an intensification of control, a redeployment of investments or a questioning of regulatory priorities. Conversely, apparently satisfactory performance can delay the consideration of deeper structural imbalances. The conceptual figure thus makes it possible to restore the reflexivity of the service system, that is to say its capacity to be continually reconfigured by the results it produces.

Fifth, the framework makes visible the interdimensional imbalances that often escape unidimensional approaches. A service can be technically efficient but financially fragile; financially balanced but territorially fragmented; institutionally stabilized but socially inequitable. In this sense, systemic performance does not correspond to the simple addition of positive sectoral results, but to a certain coherence between heterogeneous and partially tense dimensions. The ISPS is not intended to reduce this complexity to a single self-sufficient figure; rather, it aims to offer a synthetic measure of the overall coherence of the system, making it possible to distinguish robust situations from those based on unstable compromises or transfers of load from one dimension to another.

Finally, the framework makes it possible to move the scientific debate itself. It leads to no longer asking the question in terms of "good" or "bad" operator, but in terms of the quality of the institutional, patrimonial, contractual and territorial articulations which produce performance. This shift is particularly relevant in African contexts, where water services frequently face hybrid arrangements, unevenly distributed resources and differentiated institutional capacities. The interest of the model is therefore not only descriptive. It is also comparative and critical: it makes it possible to better interpret the gaps between services, to qualify forms of systemic robustness or fragility, and to lay the foundations for a less reductive evaluation of public performance. Thus, what the framework makes visible are not only new dimensions of performance, but above all relationships of coherence, tension, dependence and feedback between components of the system. Its contribution lies precisely in this capacity to transform the evaluation of performance into an analysis of the institutional, territorial and organizational conditions of its production. Our conceptual framework suggests that performance is not only the fault of the operator, but a socio-political construct.

5. Conclusion and Outlook

This article has argued that the evaluation of water services can no longer be reduced to the performance of the operator alone. In configurations marked by the growing dissociation between operation, assets, investment and regulation, performance must be analyzed as a systemic performance, produced by the articulation between several interdependent functions of the service. Based on a critical

reading of the literature, the article proposed a conceptual framework structured around six dimensions of performance, grouped into three complementary poles: service production, infrastructural sustainability and public governance oriented towards equity. The main contribution of the text is to offer an analytical framework making it possible to go beyond reductive readings of international benchmarking and to better account for the complex institutional configurations observed in numerous African contexts. In this sense, the article does not propose a new isolated indicator, but an analytical shift: moving from a logic of attribution of results to the operator to a logic of institutional co-production of performance. Practical implications: for public decision-makers, regulators and operators, this framework calls for an integrated vision of the management of water services. It underlines the need to strengthen coordination between actors, to invest in long-term asset management, and to design regulatory mechanisms balancing economic efficiency, social equity and sustainability. The four systemic indicators introduced IAPE, IGC, ICTS and ISPS must be understood as a first proposal for the operationalization of this framework. Their main interest lies in their ability to structure future empirical investigations, to guide data collection and to make dimensions often dissociated in traditional approaches comparable. However, their robustness remains to be tested on more extensive empirical materials. The article therefore presents the limits specific to a conceptual contribution. It does not intend to exhaustively validate the proposed indicators empirically, nor to generalize from the Senegalese case alone. It aims above all to lay the foundations of a research program on the systemic performance of water services, likely to be extended by comparative tests, field surveys and applications to different African contexts.

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Software, I.F.W. and C.N.;

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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