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# The Technological Gap in Monitoring and Evaluation Practices of Water Quality in Aden, Yemen: A Study of Challenges and Implications

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**Keywords**

1. Monitoring and Evaluation (M&E)
2. Water Quality
3. Technology Gap
4. Aden
5. Yemen

## Abstract:

Effective monitoring and evaluation (M&E) systems constitute the cornerstone of any effort to ensure drinking water safety and public health protection. In a notoriously challenging context such as the city of Aden in Yemen, a lack of technological application in M&E practices would emerge as a primary barrier to achieving sound water governance. This research paper therefore aims to investigate the nature and implications of the non-use of technologically-aided water quality M&E practices in Aden. A qualitative-descriptive approach was adopted to analyze the study data collected by means of in-person interviews with key stakeholders from public authorities (e.g. the Local Corporation for Water and Sanitation, the National Water Resources Authority, and the Environmental Health Department) and private water purification station operators. The findings revealed a near-total absence of digital tools for field data collection (e.g., ODK), a complete reliance on manual paper-based records, limited and unsystematic use of Geographic Information Systems (GIS), and a lack of interactive dashboards for performance monitoring. This gap leads to data inconsistency, slow incident response, and difficulty in analyzing trends, which significantly weakens the ability of institutions to make informed decisions. The paper concludes that the technological gap is not merely a resource deficit but a symptom of a broader institutional paralysis that impedes public health protection and the sustainable development goals in the water sector.

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# الفجوة التكنولوجية في ممارسات متابعة وتقييم جودة المياه في عدن، اليمن: دراسة للتحديات والآثار

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**الكلمات المفتاحية**

١. المتابعة والتقييم
٢. جودة المياه
٣. فجوة تكنولوجية
٤. عدن
٥. اليمن

## الملخص:

تُعد أنظمة المتابعة والتقييم (M&E) الفعالة حجر الزاوية لضمان سلامة مياه الشرب وحماية الصحة العامة. في سياق يواجه تحديات معقدة مثل مدينة عدن، اليمن، تبرز الفجوة التكنولوجية كعائق أساسي أمام تحقيق الحوكمة المائية الرشيدة. تهدف هذه الورقة البحثية إلى تحليل طبيعة وآثار الفجوة التكنولوجية في ممارسات متابعة وتقييم جودة المياه في عدن. بالاعتماد على منهج وصفي نوعي، تم إجراء مقابلات شخصية متعمقة مع أصحاب المصلحة الرئيسيين من الهيئات الحكومية (مثل المؤسسة المحلية للمياه والصرف الصحي، والهيئة الوطنية للموارد المائية، وإدارة صحة البيئة) ومشغلي محطات تنقية المياه الخاصة. كشفت النتائج عن غياب شبه كامل للأدوات الرقمية لجمع البيانات الميدانية (مثل ODK)، والاعتماد الكلي على السجلات الورقية اليدوية، والاستخدام المحدود وغير المنهجي لنظم المعلومات الجغرافية (GIS)، وانعدام وجود لوحات معلومات تفاعلية لمراقبة الأداء. تؤدي هذه الفجوة إلى عدم اتساق البيانات، وبطء الاستجابة للحوادث، وصعوبة تحليل الاتجاهات، مما يضعف بشكل كبير من قدرة المؤسسات على اتخاذ قرارات مستنيرة. تخلص الورقة إلى أن الفجوة التكنولوجية ليست مجرد نقص في الموارد، بل هي عرض لشلل مؤسسي أوسع يعيق حماية الصحة العامة وأهداف التنمية المستدامة في قطاع المياه.

## 1. Introduction:

Monitoring and Evaluation (M&E) practices are an essential component of any management system aimed at continuous improvement, as they provide the necessary feedback to adjust processes and correct course (Hatry, 2006). In the context of vital resource management, M&E systems serve as a cornerstone for the effective management of water quality, an indispensable practice for protecting public health and environmental sustainability (WHO, 2022). Globally, these systems are recognized as fundamental tools for assessing water quality parameters, enabling policymakers and water institutions to implement targeted interventions, ensure the provision of safe drinking water, and support aquatic ecosystems (United Nations, 2015; UN-Water & World Health Organization, 2019). This is directly linked to the Sustainable Development Goals (SDGs), specifically SDG 6, which aims to "ensure availability and sustainable management of water and sanitation for all" (UN-Water, 2021).

In Yemen, which is one of the world's most water-scarce countries (Aljawzi et al., 2022), these challenges escalate to a crisis level. Approximately 15.3 million people, more than half the population, lack access to sufficient and safe water for personal and domestic use (Human Rights Watch, 2023). In the city of Aden, a vital administrative and economic hub, these issues are particularly acute due to rapid urbanization, industrial pressure, and the deterioration of infrastructure resulting from years of conflict and mismanagement (Terry, 2023; World Bank, 2024). Furthermore, the city's precarious environmental situation is compounded by coastal vulnerabilities; for instance, its primary aquifers are under direct threat from saltwater intrusion due to sea-level rise, jeopardizing a vital water source (Al Saafani et al., 2015). This fragile situation has led to a marked decline in water quality, evidenced by the sudden and alarming surge in suspected cholera cases in Aden, highlighting the direct health risks faced by the population (WHO EMRO, 2024).

While the challenges facing Aden's water sector are multifaceted, encompassing institutional, financial, and human resource aspects. This research paper argues that the technological gap represents a fundamental structural barrier that merits independent and in-depth analysis. The scarcity of reliable data on water quality in Aden impedes a comprehensive understanding of the problem's scale and nature, underscoring the urgent need for research that explores the root causes of this deficiency (UNICEF, 2020). This data deficiency is so foundational that, until recently, even basic geographic metrics like the exact length of Yemen's shoreline were subject to wide-ranging discrepancies across various reports, highlighting a systemic challenge in establishing reliable baseline data for environmental management (Nagi, 2021). The absence of modern digital tools and the near-total reliance on traditional methodologies not only hinder operational efficiency but also systematically undermine data integrity, report credibility, and the ability of institutions to respond effectively to risks. Researchers like Heeks (2002) noted that, adopting technology in developing contexts involves challenges that extend beyond mere funding to include issues of institutional inertia and the necessity of aligning with local realities.

Therefore, the present research seeks to fill a knowledge gap by providing an in-depth descriptive analysis of the nature of the technological gap in water quality M&E practices in Aden. This paper will argue that this gap is not merely a resource deficit but a symptom of a broader institutional paralysis that impedes sound water governance and public health protection. To achieve this, the paper will begin by defining its problem, objectives, and significance, then present its methodology, followed by an integrated analysis and discussion of the findings, and will conclude with practical, evidence-based recommendations.

## 2. The Research Problem and Questions

The core problem that this paper addresses is that the M&E systems for water quality in Aden

are severely deficient, and the technological dimension of this deficiency has not been given adequate attention in previous studies. The reliance on manual practices creates a data gap that weakens the ability of institutions to make informed decisions to protect public health (World Bank, 2019). This paper, therefore, seeks to answer the following main question:

What is the nature of the technological gap in water quality M&E practices in Aden, and what are its direct consequences on data management and regulatory effectiveness?

**To answer this question, the following sub-questions need to be explored:**

What are the specific technological deficiencies (in tools and systems) in the processes of data collection, storage, and analysis among the entities responsible for water quality in Aden?

How does this technological deficiency impact data accuracy, response speed, and the ability of institutions to enforce effective oversight?

## 3. The Research Objectives

**This study aims to achieve the following specific objectives:**

To identify the key dimensions of the technological gap in the current M&E systems, by documenting the absence of digital tools and the reliance on manual systems.

To analyze the impacts resulting from this gap, including information isolation, delayed response to risks, and a weakened capacity for evidence-based decision-making.

To provide practical and targeted recommendations to bridge this technological gap, contributing to a more efficient and resilient M&E system.

## 4. Significance of the Research

The practical and theoretical significance of this research lies in its focus on a critical yet neglected dimension of Aden's water crisis. On a practical level, its findings contribute to protecting public health by providing critical insights into the weaknesses of the early warning system for contaminants, which can enable decision-makers in local authorities and international organizations to design more precise and effective interventions (Perveen & Haque, 2023). It also provides a scientific basis for assessing compliance with water quality standards and stimulates the development of corrective measures to protect consumers (WHO, 2022). On a theoretical level, this work contributes to the literature on resource management in crisis and conflict contexts by offering a deep case study that illustrates how a technological gap can deepen governance failure—an insight of significance for researchers and experts working in similar fragile contexts.

Scope and Limitations of the Research

This study was defined by the following scope and limitations:

**Scope:**

Geographic Scope: This research was applied within the geographical boundaries of Aden city in Yemen, focusing specifically on the practices and challenges within this city.

Human Scope: The research included a sample of stakeholders directly involved in the M&E practices of drinking water quality in Aden, including key public institutions such as the Local Corporation for Water and Sanitation, the National Water Resources Authority, and the Environmental Health Departments, in addition to the private sector represented by the owners and operators of water purification stations.

**Limitations:**

The study faced difficulty in applying probability sampling to select private water purification stations due to the lack of an official directory or a unified database for these stations. Consequently, the researcher resorted

to snowball sampling, a non-probability method that may carry a risk of selection bias.

The findings of this research may be closely tied to the specific geographic and institutional context of Aden city, which could limit the generalizability of its results to other regions with different conditions.

The researcher encountered some fieldwork challenges, such as logistical difficulties in identifying the locations of some stations and initial hesitation from some owners to participate, fearing the research might be for regulatory purposes. This required additional effort to build trust and clarify the academic objectives of the study.

Operational and Procedural Definitions

**This research included the following terms:**

Monitoring and Evaluation: Operationally defined in this research as the ongoing administrative processes and practices undertaken by public authorities and private water treatment stations in Aden to manage, monitor, and document water quality. These practices include data collection, analysis, reporting, and subsequent decision-making. Evaluation is defined as the reflective and informal process through which institutions and private actors assess the relevance, utility, and limitations of their monitoring efforts, a definition that suits the context of Aden where formal evaluation systems are largely absent.

Water Quality: Operationally defined in this research as the condition of water in Aden's supply systems, characterized by its physical, chemical, and biological attributes that affect its safety and suitability for human consumption. Due to the absence of centralized monitoring systems and the prevalence of informal water distribution networks, assessments of water quality are often based on sporadic testing and community reports.

Research Methodology and Procedures

To achieve the objectives of this research, a qualitative-descriptive approach was adopted. This methodology was chosen as it is best suited for exploring and understanding complex phenomena by gathering rich and in-depth insights from participants in their natural context. This methodology was designed to reflect the on-the-ground reality and to help identify the institutional challenges and operational gaps within the currently existing M&E systems.

The fieldwork for this research was conducted in Aden Governorate. The study sample was carefully selected to ensure the representation of key actors, with a total sample size of 29 participants (16 from public water authorities and 13 from the private water purification sector). To achieve accurate representation, two sampling strategies were used; Purposive Sampling was applied to select participants from the public sector based on their institutional positions and technical expertise. In contrast, Snowball Sampling was used to select participants from the private purification stations sector, due to the lack of comprehensive official lists for these stations.

The primary tool for data collection was semi-structured in-depth interviews. This tool was chosen for its flexibility and its ability to enable participants to express their insights freely while ensuring all research themes were covered. Two interview guides were designed, each tailored to a specific category of participants, with a focus on extracting detailed information about current procedures, challenges, and proposed solutions. After collecting the qualitative data, it was systematically analyzed to identify key themes and patterns related to the research questions, which allowed for the transformation of the rich data into organized findings and an in-depth discussion.

## Findings and Discussion

The qualitative analysis of interviews conducted with stakeholders in Aden's water sector reveals a complex picture of a monitoring and evaluation system struggling to

perform its basic functions amidst a near-complete technological void. The challenges identified are not limited to a lack of resources but extend to deep-rooted structural and cultural issues. In this section, the main findings will be presented and discussed in an integrated manner, organized around key thematic axes that directly answer the research questions, thus linking field evidence with explanatory analysis.

**The Pen-and-Paper Reality: Manual Systems as an Institutional Norm**

In response to the first research question regarding the nature of the technological deficiency in M&E processes, the findings reveal that the dominant characteristic of current practices is the near-absolute reliance on manual and paper-based systems. This reality is not merely a temporary technical shortfall but a deeply entrenched institutional norm that reflects a more profound state of operational inertia.

Participants from all government institutions, including the LCWS and the EHD, reported the absence of any unified digital system for managing water quality data. Test results are recorded in physical paper ledgers or isolated Excel files on personal computers, without any networking or a central database. This situation creates what can be described as isolated "data islands," where information becomes captive to the department or even the individual employee who recorded it. One inspector summarized this situation by stating that "Test results are recorded on paper and stored in a small archive. We don't have any system that logs these results electronically for easy retrieval." An employee from a different entity confirmed that "Results are often saved locally on individual computers without any integration between departments or a central database." This "small archive" mentioned by the inspector is often just a disorganized file cabinet, susceptible to damage from humidity or loss, making the "institutional memory" of the organization extremely fragile and dependent on individuals rather than systems.

This reality extends to the field, where the findings revealed a complete absence of digital data collection tools like ODK or KoBoToolbox in routine work. The journey of information from the water source to the decision-maker is a perilous one. An inspector commented on this, saying: "The field survey is done using paper, and sometimes these papers get lost or damaged during work or transport. This often forces the team to redo the data collection or ignore the missing data entirely." This means that data integrity is compromised at every step: from the accuracy of manual notation in the field, to the potential for human error during data re-entry in the office, to the complete loss of data. Even when technology is used, it remains limited and temporary. For instance, Geographic Information Systems (GIS) were used in the past to locate wells, but these systems have not been updated for years and are no longer linked to water quality data, rendering them mere static maps lacking a vital analytical dimension. All participants also confirmed the absence of interactive dashboards for displaying performance indicators, meaning that reports remain static, printed documents that reach a manager's desk weeks after data collection, having already lost their operational relevance for proactive measures.

The dominance of manual systems is not merely a result of financial resource scarcity; it is a reflection of what is known in institutional theory as "Path Dependency." Years of operating in this manner have created a familiar and stable path that is difficult to deviate from, especially in a crisis environment characterized by uncertainty (North, 1990). These manual practices have become entrenched "Organizational Routines," which function not only as work procedures but also as a coping and survival mechanism under harsh conditions, providing a minimum level of predictability and control (Feldman & Pentland, 2003).

This inertia is reinforced by the absence of external pressures that typically drive change,

known as "Isomorphic Pressures" (DiMaggio & Powell, 1983). There is no central authority enforcing a digital transformation (coercive pressure), nor are there successful and sustainable local models to imitate (mimetic pressure). Even the technological initiatives implemented through donor-funded projects, such as the temporary use of KoBoToolbox, failed to create mimetic pressure because they were not sustained and did not become institutionalized practices.

Consequently, the "pen-and-paper reality" is a symptom of a deeper institutional paralysis. It represents a vicious cycle: the absence of technology prevents the collection of accurate data; the absence of accurate data prevents effective planning; and the absence of effective planning prevents the securing of resources needed to adopt technology. This cycle is what makes the technological gap a structural barrier that is difficult to overcome with partial or temporary solutions, and it makes it challenging to answer even the most basic questions about water quality in the city in a comprehensive and reliable manner.

**Consequences of Information Isolation: From Data Gaps to Governance Gaps**

In response to the second research question concerning how technological deficiency impacts data accuracy, response speed, and oversight, the findings reveal that the reliance on manual systems has severe consequences that extend beyond mere operational inefficiency to undermine the very core of the M&E system, creating dangerous governance gaps.

The first and most critical consequence is the deterioration of data integrity. Manual processes are inherently prone to human error, whether in recording field readings or when re-copying them in the office. A lab technician noted that "the paper reports we sometimes receive contain illogical numbers or empty fields, and we have no easy way to verify them except by going back to the field team, which takes a long time." This is in addition to the previously mentioned problem of data loss, meaning that the evidence base upon which decisions are supposed to be built is fragile and incomplete.

The second direct consequence is a slow response to health risks. The interviews revealed a complete absence of any early warning mechanism. If bacterial contamination is detected in a sample, the process of notifying the relevant authorities and taking necessary action can take days, if not weeks. This delay is due to the long paper-based procedural cycle: from sending the sample to the lab, waiting for results, writing a paper report, and then sending it through official administrative channels. During this period, the contaminated water source remains in use, directly exposing citizens' health to risk. An official from the Environmental Health Department confirmed that "the response is often after the problem has occurred, meaning after we receive complaints from citizens about cases of illness, not before."

The third consequence is a weakened capacity for effective oversight, especially over the growing private sector of water purification stations. Without a centralized and updated database, regulatory authorities lack a comprehensive view of the number of operating stations, their locations, or their history of compliance with standards. One inspector explained, "We rely on our memory and personal experience to follow up on the stations in our area. There is no system that tells us which station is late for its periodic test, or which area is seeing the emergence of new, unlicensed stations." This situation makes oversight a random and unsystematic process, dependent on the individual efforts of inspectors rather than an institutional, risk-based strategy.

These operational consequences collectively create a deep governance gap. From the perspective of Governance Theory, the fundamental principles of transparency, accountability, and evidence-based decision-making cannot be achieved in the absence of reliable and timely data (Stoker, 1998). The "information isolation" resulting from manual systems prevents transparency, as citizens or

even other institutions cannot access the real situation of water quality. It also undermines accountability, as it is difficult to hold any entity responsible for its failures if there is no clear and documented data to incriminate it.

This data vacuum directly weakens the state's ability to perform its role as a "Market Regulator." In the absence of effective oversight, the relationship between the state and the private sector shifts from a regulatory one to a mere formality, leaving the quality of water consumed by a large portion of the population at the mercy of the individual practices of station owners.

At a broader level, this technological gap and its consequences directly obstruct the achievement of Sustainable Development Goals. Long-term plans for managing scarce water resources or improving infrastructure cannot be developed without a baseline of accurate data. The inability to track changes in water quality over time means that any future investments in the sector will be based on guesswork rather than evidence, threatening their sustainability and effectiveness.

**Table (1): Summary of Key Findings on the Technological Gap in M&E Systems**

| Technological Dimension of the Deficiency | Direct Consequences |
|---|---|
| **Absence of Unified Digital Systems** | • **Information Isolation:** Data remains captive within departments and individuals, preventing a comprehensive overview<br>• **Deterioration of Data Integrity:** Reliance on paper archives exposes data to the risk of damage and loss. |
| **Lack of Digital Field Data Collection Tools (e.g., ODK)** | • **Slow Information Flow:** It takes weeks for data to travel from the field to the decision-maker<br>• **High Rate of Human Error:** Errors are common in manual recording and re-entry. |
| **Limited Use of Geographic Information Systems (GIS)** | • **Difficulty in Spatial Analysis:** Inability to identify pollution "hotspots" or link complaints to precise locations<br>• **Weak Proactive Planning:** Impossibility of creating risk maps to guide resources effectively. |
| **Absence of Interactive Dashboards** | • **Reactive Decision-Making:** Management relies on outdated paper reports instead of real-time performance indicators<br>• **Lack of Transparency:** Difficulty in continuously monitoring performance and evaluating the effectiveness of interventions. |
| **Shortage of Portable Field-Testing Kits** | • **Delayed Early Warning:** Total reliance on central laboratories delays the detection of health risks<br>• **Inefficient Resource Allocation:** Sending all samples to the lab, even those that could be screened in the field, wastes time and resources. |

## Recommendations

Based on the in-depth analysis of the findings, which showed that the technological gap is a structural barrier and not just a lack of equipment, this research provides a set of practical and targeted recommendations aimed at building a resilient and evidence-based M&E system. These recommendations are divided into strategic and operational to ensure a comprehensive approach to the problem.

## Strategic Recommendations (Long-Term):

Develop and Adopt a National Framework for Digital Transformation in the Water Sector: Partial and temporary solutions have proven ineffective. Therefore, the primary recommendation is for the Ministry of Water and Environment, in collaboration with local authorities and international partners, to adopt a clear national strategy for digital transformation. This strategy should include a

roadmap for establishing a unified digital platform for managing water quality data, serving as a central database and a reliable source of information for all stakeholders. This platform should support the geo-referencing of data (GIS), provide analytical tools, and be scalable for the future.

Reform Data Governance to Enhance Coordination and Accountability: Technology alone is not enough; it must be supported by an effective governance framework. It is recommended to form a permanent coordinating committee for water quality, including representatives from all relevant bodies. The committee's mission would be to oversee the digital platform, establish unified protocols for data collection and sharing, and ensure that this data is used in decision-making and strategic planning. This would break down the "data islands" and foster a culture of evidence-based accountability.

**Operational Recommendations (Short- to Medium-Term):**

Equip Field Teams with Essential Technology Toolkits: As an urgent and practical step, inspectors and field teams must be provided with basic toolkits. These kits should include portable field-testing devices (for measuring chlorine, pH, and TDS), in addition to tablets equipped with data collection applications like ODK or KoBoToolbox. This measure will immediately improve the accuracy of field data, speed up its collection, and reduce reliance on inefficient paper-based procedures.

Implement Intensive and Sustainable Capacity-Building Programs: Comprehensive and continuous training programs must be designed and implemented for staff at all levels. These programs should not be limited to technical training on using new devices and applications but must also include essential skills in data management, simple statistical analysis, interpretation of results, and creating visual reports using tools like Power BI. Investing in human capital is the true guarantee for the sustainability of any technological transformation.

Launch Pilot Projects for Innovation and Learning: Instead of attempting to implement large-scale solutions all at once, it is recommended to start with pilot projects in specific areas or districts. These projects can be used to test new technologies (such as smart sensors at certain points in the network, or community-based reporting systems via mobile phones) and to evaluate their effectiveness, cost, and suitability for the local context. These projects will provide valuable lessons that can be leveraged before scaling up successful solutions, thereby reducing the risk of failure and waste of resources.

**Recommendations for Future Research**

The findings of this research open the door to new and innovative research paths that go beyond simply calling for more funding or training. The technological gap, as the analysis has shown, is a complex problem with behavioral, economic, and institutional dimensions. Accordingly, this paper recommends focusing on the following applied and experimental research avenues:

A Quantitative Study to Assess the Costs of the Technological Gap: This qualitative research has shown that manual systems lead to a slow response to health risks. Future research could build on this finding by conducting a quantitative or mixed-methods study aimed at measuring the tangible costs of this deficiency. For example, what is the annual economic and health cost resulting from the delay in detecting and treating contaminated water sources? Such research could calculate the costs of treating waterborne diseases that could have been prevented and the economic losses resulting from inefficient oversight. Providing concrete data and figures on the cost of the "status quo" would create a stronger argument for policymakers and donors to invest in digital transformation.

Action Research to Test Low-Cost Technological Models: Instead of merely recommending the adoption of technology, future research can take a practical step forward by designing, implementing, and evaluating a

pilot project for a simplified monitoring system in one of Aden's districts. This action research could test the application of a system based on mobile phones and open-source applications (like ODK or KoBoToolbox) in collaboration with field inspectors. The research would measure the improvement in data accuracy, reporting speed, and operational costs compared to the traditional paper-based system. Such research would not only provide practical evidence of the effectiveness of the proposed solutions but would also reveal the real challenges facing implementation on the ground.

Analysis of Institutional and Cultural Readiness for Digital Transformation: This research has indicated that institutional inertia is one of the reasons for the persistence of the technological gap. Future research could delve deeper into this aspect by conducting a qualitative case study focused on assessing the "institutional and cultural readiness for digital transformation" within a major water authority in Aden. This study would analyze internal power dynamics, resistance to change, organizational culture, and the current digital skills of employees. Understanding these intangible factors is crucial for designing successful change strategies that ensure new technology is adopted effectively and sustainably, rather than being rejected or neglected by staff.

## Conclusion

This research has sought to provide an in-depth analysis of one of the most critical and neglected aspects of the water crisis in Aden: the technological gap in the monitoring and evaluation systems for water quality. This paper argues that this deficiency is not merely a lack of equipment or resources, but rather a symptom of a deeper institutional paralysis and part of a vicious cycle that impedes any serious attempt to ensure water safety and achieve good governance in this vital sector.

The field findings have revealed a reality dominated by manual and paper-based systems, leading to acute "information isolation" among institutions. The analysis has shown that this reality has severe consequences, manifested in the deterioration of data integrity, a slow response to health risks, and a weakened capacity for effective oversight, especially over the growing private sector. These data gaps do not only lead to operational inefficiency but transform into governance gaps that undermine the principles of transparency and accountability, making long-term, evidence-based planning nearly impossible.

The significance of these findings extends beyond the local context of Aden to offer valuable lessons on resource management in fragile and conflict-affected environments. They confirm that technological solutions must be part of a more comprehensive institutional reform, and that investing in technology without addressing institutional inertia and the prevailing work culture is an investment doomed to fail.

In conclusion, bridging the technological gap in Aden's water sector is not a luxury but an imperative and a foundation for rebuilding trust between citizens and service institutions. The adoption of technology, supported by political will and institutional reform, is the first step toward building a resilient and effective monitoring and evaluation system capable of protecting public health, ensuring the sustainability of water resources, and contributing to a more secure and prosperous future for the city's residents.

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