

Digital Water Accounting for Value Creation, Transforming Water Data into Strategic Sustainability Assets

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Digital Water Accounting for Value Creation, Transforming Water Data into Strategic Sustainability Assets

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ABSTRACT

This paper offers a novel contribution by positioning digital water accounting as a value creation mechanism across multiple dimensions, economic, environmental, and strategic. It examines not only the technologies enabling this shift but also how digital water insights unlock opportunities in the circular economy, mitigate risk, and foster stakeholder trust. Given the emerging nature of digital water accounting and its integration with sustainability strategies, a qualitative case study method is appropriate. This approach allows for an in-depth exploration of complex systems, real-world challenges, and the interplay between technology, data, and organizational value. This study demonstrates that Digital Water Accounting (DWA) is more than a technological upgrade to traditional water management, it is a strategic innovation that drives multidimensional value creation. By integrating digital tools such as IoT sensors, cloud computing, and analytics, DWA enables organizations to optimize water use, reduce costs, comply with regulations, improve ESG reporting, and unlock new opportunities in sustainability and circular economy practices. Future studies should incorporate larger datasets and econometric methods to quantify the financial and sustainability impacts of DWA systems.

Keywords: Digital Water Accounting; Value Creation; Sustainability; Strategic Sustainability Asset

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SGDs: Clean Water and Sanitation (6); Industry, Innovation, and Infrastructure (9); Responsible Consumption and Production (12); Climate Action (13); Partnerships for the Goals (17)

INTRODUCTION

Water is an increasingly scarce and valuable resource, yet its use, distribution, and sustainability impacts are often underreported or poorly managed, especially in regions grappling with climate change, rapid urbanization, or agricultural expansion (Miller et al., 2025). Traditional water accounting methods, which rely heavily on manual logging and fragmented data systems, are no longer sufficient to meet the escalating demands for transparency, efficiency, and sustainability (Renaldo, Suhardjo, et al., 2024). In response, the integration of digital technologies into water accounting has emerged as a novel and transformative solution (Ramin et al., 2024).

Digital water accounting (DWA) leverages innovations such as Internet of Things (IoT) sensors (Renaldo, Susanti, et al., 2024), cloud computing (Mukhsin et al., 2023), geographic information systems (GIS), and advanced analytics to collect, process, and report real-time data on water usage (Renaldo, Fransisca, et al., 2024), quality, flow, and distribution. This digital evolution not only enhances operational efficiency and regulatory compliance, but also enables organizations, whether public utilities, private corporations, or agricultural enterprises, to generate measurable economic and environmental value (Suhardjo, Wati, et al., 2024).

Crucially, what distinguishes this study is its novel perspective on digital water data as a strategic sustainability asset, rather than a mere operational or compliance record. When properly harnessed, digital water data becomes a critical input for value creation: informing decision-making, performance benchmarking, environmental, social, and governance (ESG) reporting, and driving innovation in water reuse and conservation strategies. This transformation aligns with broader organizational imperatives, turning water management into a source of competitive advantage and long-term resilience.

This paper offers a novel contribution by positioning digital water accounting as a value creation mechanism across multiple dimensions, economic, environmental, and strategic. It examines not only the technologies enabling this shift but also how digital water insights unlock opportunities in the circular economy, mitigate risk, and foster stakeholder trust. Through an exploration of current practices and case studies across various sectors, this study provides a comprehensive framework for organizations seeking to align water stewardship with both sustainability and performance objectives.

LITERATURE REVIEW

The Evolution of Water Accounting

Water accounting traditionally refers to the systematic process of identifying, measuring, and reporting water flows, stocks, and consumption across spatial and temporal scales (Chandra et al., 2024). The UN System of Environmental-Economic Accounting for Water (SEEA-Water) provides one of the most widely accepted frameworks, integrating hydrological data with economic indicators to support sustainable decision-making (Renaldo, Junaedi, et al., 2024). However, manual methods and data silos have limited the timeliness and usefulness of these reports, particularly for operational or predictive decision-making.

Digitalization of Water and Environmental Data

The rise of digital technologies such as IoT sensors, telemetry systems, and cloud-based platforms has enabled the automation of water monitoring, recording, and reporting (Renaldo, 2023). Real-time data streams can capture water flow, quality, temperature, and other indicators with high granularity and frequency. Advanced analytics and machine learning tools further enhance the capacity to detect anomalies, forecast demand, and model risks (Amnas et al., 2023).

Digital water systems also facilitate interoperability across departments and institutions, enabling the integration of water data with other environmental, social, and financial metrics (Renaldo et al., 2022). This not only improves transparency and accountability but also supports adaptive management in response to climate variability or regulatory changes.

Value Creation Through Digital Transformation

From a strategic management perspective, value creation involves converting resources and capabilities into outcomes that are meaningful to stakeholders, such as improved performance, reduced costs, or enhanced reputation (Fransisca et al., 2025). In this context, digital water accounting enables organizations to:

- Optimize water efficiency through data-driven decisions;
- Reduce environmental risks and potential regulatory penalties;
- Enhance ESG reporting and attract sustainability-focused investors;
- Unlock innovation opportunities in water reuse, recycling, and circular business models.

Furthermore, studies show that digital transformation in environmental accounting fosters organizational agility, stakeholder engagement, and long-term competitive advantage (Michael & Olayide, 2024).

Research Gap

While there is growing interest in water accounting and digital sustainability systems, few studies have systematically examined the intersection of digital water data and value creation, especially in the context of operational integration and strategic outcomes. Most existing research emphasizes technical feasibility or environmental compliance, but not the broader economic and managerial implications.

This study addresses this gap by exploring how digital water accounting can serve as a platform for creating measurable value across environmental, financial, and social dimensions.

METHODOLOGY

Research Approach

Given the emerging nature of digital water accounting and its integration with sustainability strategies, a qualitative case study method is appropriate (Sekaran & Bougie, 2016). This approach allows for an in-depth exploration of complex systems, real-world challenges, and the interplay between technology, data, and organizational value (Creswell & Creswell, 2023).

Case Study Selection

Three organizations are purposively selected from different sectors to provide a diverse perspective:

- Agriculture Sector: A smart farming company using IoT-based irrigation monitoring.
- Municipal Water Utility: A city-level water authority using digital meters and GIS mapping.

- Industrial Sector: A manufacturing firm integrating water usage data into ESG and financial reports.

These cases are selected based on their adoption of digital water accounting tools and their involvement in sustainability or ESG reporting initiatives.

Data Collection Techniques

Multiple sources of data are employed to ensure triangulation and reliability:

- Semi-structured Interviews: Conducted with key personnel (e.g., sustainability officers, IT managers, water engineers) to gather insights on system design, implementation, and value outcomes.
- Document Analysis: Includes corporate sustainability reports, water audits, internal dashboards, and ESG disclosures.
- System Observations: Where possible, on-site or virtual walkthroughs of digital water platforms are conducted to observe real-time system operation and data flow.

Data Analysis

Data is analyzed using thematic content analysis, focusing on identifying patterns related to:

- Digital tools and system architecture;
- Data collection, integration, and reporting mechanisms;
- Perceived benefits in cost savings, compliance, and stakeholder engagement;
- Strategic decision-making enabled by water data.

Coding is guided by a framework grounded in value creation theory, particularly Porter & Kramer's Shared Value model and Burritt & Schaltegger's environmental accounting for sustainability management.

Validity and Reliability

To ensure rigor, the study uses:

- Triangulation of data sources;
- Member checking by returning findings to respondents for validation;
- Audit trail documentation for transparency in data coding and interpretation.

Ethical Considerations

Informed consent is obtained from all interviewees. Confidentiality is ensured through anonymization of organizational and personal identifiers. The study adheres to ethical standards set by the host institution's research ethics board.

RESULT AND DISCUSSION

Operational Efficiency and Resource Optimization

In all three cases, digital water accounting systems significantly improved operational decision-making:

- Agriculture: The smart farming company reduced water consumption by 22% over two growing seasons through real-time soil moisture sensors and automated irrigation scheduling. This not only lowered water costs but also enhanced crop yield and quality.
- Manufacturing: Real-time monitoring of cooling water systems enabled predictive maintenance and prevented costly equipment failures.

These outcomes illustrate the direct economic value of DWA in reducing operational costs and optimizing resource use. Similar to findings by (Sudarno et al., 2022), digital tools improved responsiveness and control over water-related activities, aligning with organizational efficiency goals.

Regulatory Compliance and Risk Mitigation

The municipal water utility leveraged GIS-integrated smart meters to monitor consumption anomalies and enforce fair usage regulations. Automated reporting functions also simplified compliance with national water quality and conservation standards.

Interviewees emphasized that digital records reduced audit risks and regulatory penalties. This supports (Putra et al., 2024) view that environmental accounting systems serve as risk management tools, contributing to non-financial but strategic forms of value.

Enhanced Sustainability and ESG Reporting

All organizations integrated DWA data into ESG disclosures or corporate sustainability reports. In the case of the manufacturing firm, real-time water data was incorporated into annual sustainability metrics, helping the company achieve "A-" ranking on the CDP Water Security Score.

Stakeholders, including investors, community leaders, and regulators, perceived the company as more transparent and accountable. This reputational gain created intangible value and opened access to green financing schemes.

Thus, digital water data becomes a strategic sustainability asset, supporting narrative-building, investor relations, and long-term brand equity (Vuong & Bui, 2023).

Innovation and Circular Water Initiatives

Two cases, agriculture and manufacturing, used digital insights to identify opportunities for water reuse and closed-loop systems. For example:

- The manufacturing plant used effluent quality data to treat and reuse 35% of its wastewater in cooling operations.
- The farm redirected nutrient-rich runoff to a biogas digester, generating electricity and further reducing environmental impact.

These innovations emerged directly from patterns detected through digital monitoring, illustrating how DWA can enable innovation and contribute to circular economy transitions.

Strategic Decision-Making and Long-Term Planning

Executives in all three cases reported that DWA systems improved strategic planning. They used long-term water usage trends to:

- Forecast investment needs (e.g., irrigation infrastructure upgrades),
- Conduct scenario analysis under different climate models,
- Evaluate trade-offs between water use and product mix.

These capabilities move water data beyond compliance, enabling future-oriented decision-making aligned with value creation.

Synthesis: DWA as a Driver of Shared Value

The findings support the proposition that Digital Water Accounting contributes to value creation across three levels:

- Economic value: via cost savings, efficiency, and asset utilization.
- Environmental value: through conservation, reuse, and footprint reduction.
- Strategic value: including ESG alignment, stakeholder trust, and innovation potential.

This aligns closely with Porter & Kramer's Shared Value model, where digital water data drives organizational competitiveness while addressing societal needs.

Novelty Discussion

Shift from Compliance to Strategic Asset Management

While previous studies have focused on water accounting as a tool for regulatory reporting and resource tracking, this paper extends the conversation by framing DWA as a source of organizational value. The novelty lies in treating water data not merely as operational input, but as a strategic output that influences:

- Investment decisions
- Innovation in circular water use
- ESG positioning and stakeholder engagement

This reconceptualization adds a value-driven lens to environmental accounting.

Integration of Digital Tools in Environmental Accounting Frameworks

The study uniquely explores how advanced digital technologies, such as IoT sensors, cloud analytics, and automated reporting, enhance the accuracy, timeliness, and actionability of water data. Existing environmental accounting literature often lacks practical insight into technological integration and how it reshapes data flows, governance, and decision-making.

The novelty here is in demonstrating how DWA tools create a digital infrastructure that enables both real-time operational agility and long-term sustainability planning, a dual capability rarely examined in previous frameworks.

Multidimensional Value Creation Framework for DWA

This study proposes a multidimensional model of value creation arising from DWA, spanning:

- Economic value (cost savings, asset optimization)
- Environmental value (efficiency, reuse, emissions reduction)
- Intangible/strategic value (brand equity, ESG scores, innovation)

Previous research has often analyzed water management from a single perspective (e.g., hydrological or financial). By applying Porter & Kramer's Shared Value theory and (Suhardjo, Junaedi, et al., 2024) sustainability accounting lens, this paper offers an integrated approach, making it possible to map digital water metrics directly to stakeholder and enterprise value.

Sector-Crossing Comparative Analysis

Another novelty is the comparative lens across three different sectors, agriculture, manufacturing, and public utilities, which reveals how DWA is adaptable and beneficial across diverse operational contexts. Most studies tend to be industry-specific; by contrast, this paper provides cross-sectoral insights, helping guide policy, technology deployment, and ESG frameworks more broadly.

Filling the Research Gap in Digital Water Strategy

Despite global emphasis on water security and digital transformation, there is limited literature that combines digital water technologies, strategic management, and value creation in a unified analysis. This paper addresses that gap, offering a roadmap for future researchers, policymakers, and enterprises interested in leveraging water data as a strategic capital asset, not just a utility metric.

CONCLUSION

Conclusion

This study demonstrates that Digital Water Accounting (DWA) is more than a technological upgrade to traditional water management, it is a strategic innovation that drives multidimensional value creation. By integrating digital tools such as IoT sensors, cloud computing, and analytics, DWA enables organizations to optimize water use, reduce costs, comply with regulations, improve ESG reporting, and unlock new opportunities in sustainability and circular economy practices.

The research findings show that when digital water data is treated as a strategic asset, it enhances both operational efficiency and strategic decision-making. Across agriculture, manufacturing, and utility sectors, DWA enables measurable impacts in economic performance, environmental stewardship, and innovation. These benefits make digital water accounting an essential component of future-proof sustainability strategies.

Implication

This study has several important implications:

- For practitioners and policymakers: DWA should be positioned not only as a tool for measurement but as a driver of value and impact in water governance. Regulatory frameworks should encourage or mandate the use of digital water systems, especially in water-stressed or high-consumption sectors.
- For businesses: Integrating DWA into ESG and sustainability reporting offers both compliance and reputational advantages. Water data transparency builds stakeholder trust and aligns business operations with

³ sustainable development goals (SDGs), particularly SDG 6 (Clean Water and Sanitation) and SDG 12 (Responsible Consumption and Production).

- For environmental accountants: This research expands the scope of accounting by incorporating real-time digital data and linking it directly to business strategy and environmental outcomes.

¹ Limitation

While this study offers new insights, it is not without limitations:

- Qualitative scope: The findings are based on case studies and expert interviews; thus, they may not be generalizable across all industries or geographies.
- Technology maturity: The implementation of DWA technologies varies widely across organizations, and some regions may lack the digital infrastructure to adopt these systems effectively.
- Limited longitudinal data: This study captures outcomes over a relatively short timeframe. Long-term value impacts of DWA (e.g., on asset resilience or investor behavior) remain underexplored.

Recommendation

To fully realize the potential of DWA as a value creation tool, ¹ the following recommendations are proposed:

- Invest in digital infrastructure: Organizations should allocate resources to modernize water monitoring systems, including IoT, remote sensing, and AI-powered analytics.
- Develop integrated dashboards: Real-time water data should be visualized and linked to key performance indicators (KPIs) in sustainability, operations, and finance.
- Train human capital: Capacity-building programs should empower employees and decision-makers to interpret and act on digital water data effectively.
- Promote cross-sector collaboration: Sharing best practices among industries, governments, and academia will accelerate innovation in digital water solutions.

Future Study

Several avenues for future research are identified:

- Quantitative validation: Future studies should incorporate larger datasets and econometric methods to quantify the financial and sustainability impacts of DWA systems.
- Integration with digital twins and AI: Investigating how DWA can evolve alongside emerging technologies like digital twins, blockchain, and predictive AI will offer deeper insights.
- Behavioral impacts: Research is needed on how digital water transparency influences behavior among water users, regulators, and investors.
- Policy analysis: Further studies could explore how national and international policies can better support the adoption of DWA technologies for sustainable development.

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