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Asset Management: Evolution from Terotechnology to ISO 5500X Standards and its Consolidation in the Brazilian Context

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Abstract: This paper traces the historical evolution of asset management, highlighting its origins, consolidation, and contemporary application. The discipline stems from terotechnology, developed in the United Kingdom during the 1970s and 1980s, when initial efforts were made to integrate maintenance, costs, and asset life cycles. In subsequent decades, the field matured and gained international recognition with the publication of PAS 55 and later the global standardization of the ISO 55000 series. In Brazil, ABRAMAN played a pivotal role in disseminating and adapting these concepts, progressively expanding its National Documents from a narrow maintenance focus to a comprehensive framework for strategic asset management. A key challenge faced by organizations lies in transforming maturity diagnostics and established methodologies into robust, institutionalized systems aligned with corporate governance. The purpose of this article is to examine the chronological development of asset management and to show how national surveys reflect both progress and limitations in the Brazilian context. Methodologically, it combines a specialized literature review with comparative analysis of the 2022 and 2024 editions of the ABRAMAN National Document. Findings reveal advances in maturity diagnostics and performance indicators, alongside persistent barriers such as short-termism, resource scarcity, and governance weaknesses. Emerging trends indicate greater integration with ESG practices, professional certification, and strategic governance, consolidating asset management as a key discipline for organizational competitiveness.

Keywords: Asset Management, Terotechnology, PAS 55, ISO 55001, ABRAMAN

Gestão de Ativos: Evolução desde a Terotecnologia às normas ISO 5500X e sua Consolidação no Contexto Brasileiro

Resumo: Este artigo analisa a trajetória histórica da gestão de ativos, desde suas origens na terotecnologia britânica das décadas de 1970 e 1980, quando surgiram as primeiras tentativas de integrar manutenção, custos e ciclo de vida dos ativos, até sua consolidação como disciplina estratégica. O campo alcançou reconhecimento internacional com a publicação da PAS 55 e, posteriormente, com a padronização global promovida pela série ISO 55000. No Brasil, a ABRAMAN teve papel decisivo na difusão e adaptação desses conceitos, expandindo seus Documentos Nacionais de um enfoque restrito em manutenção para uma abordagem abrangente de gestão de ativos. O desafio central das organizações consiste em transformar diagnósticos de maturidade e metodologias já consolidadas em sistemas robustos, institucionalizados e alinhados à governança corporativa. O estudo adota revisão bibliográfica e análise comparativa das edições de 2022 e 2024 do Documento Nacional ABRAMAN. Os resultados indicam avanços em diagnósticos de maturidade e no uso de indicadores, mas também revelam barreiras persistentes, como imediatismo cultural, falta de recursos e fragilidades de governança. As tendências apontam

para maior integração com práticas ESG, valorização da certificação profissional e fortalecimento da governança estratégica, consolidando a gestão de ativos como disciplina essencial para a competitividade.

Palavras-chave: Gestão de Ativos, Terotecnologia, PAS 55, ISO 55001, ABRAMAN

1. Introduction

Asset management has consolidated itself as an essential pathway in corporate management, gaining prominence in recent decades as a strategic discipline for organizations in complex, capital-intensive environments. Its roots lie in terotechnology, developed in the United Kingdom during the 1970s and 1980s, when efforts were first made to integrate maintenance, costs, and life cycles. Manuals, glossaries, and technical guides were created to standardize concepts and practices, fostering greater effectiveness and sustainability.

The field achieved international recognition in the early 2000s with the publication of PAS 55 by the British Standards Institution, which set formal requirements for physical asset management. This milestone aligned maintenance and reliability strategies with broader business objectives. The release of the ISO 55000 series in 2014 established a global framework, providing principles, requirements, and guidelines for integrated asset management across industrial, infrastructure, and public sectors.

In Brazil, development has been closely tied to ABRAMAN, which formally incorporated asset management in 2012 when expanding its scope beyond maintenance. The biennial National Documents became a reliable barometer of corporate practices, mapping progress, barriers, and trends. The 2022 and 2024 editions highlight a transition from detailed, ISO 55001-aligned questionnaires to a more strategic and synthetic approach focused on maturity, cultural barriers, human capital, and governance.

This article therefore analyzes the historical evolution of asset management, emphasizing both its international consolidation and the Brazilian trajectory. It also examines how the National Documents reflect advances, challenges, and trends, pointing to pathways for consolidating asset management as a pillar of corporate and public governance.

2. Methodological Approach

This paper adopts comparative analysis as its methodological foundation. Comparative analysis is a scientific approach that systematically evaluates two or more cases to identify similarities, differences, and explanatory patterns. Rooted in the works of Durkheim and Weber and later formalized by Ragin (1987), it can be applied qualitatively, through in-depth case studies, or quantitatively, using comparable indicators (Lieberson, 1991). In management research, it is widely employed for benchmarking, policy evaluation, and identifying best practices. Its main strength lies in generating controlled generalizations, enabling researchers to discern key factors and understand complex causal relationships (Collier, 1993).

In this study, the objects of analysis are the 2022 and 2024 editions of the ABRAMAN National Document (ABRAMAN, 2022; 2024), with a specific focus on the survey blocks dedicated to asset management.

3. A Chronological Perspective on the Evolution of Asset Management

The origins of asset management lie in terotechnology, developed in the United Kingdom during the 1970s and 1980s, when governmental bodies and technical institutes produced

manuals, glossaries, and guides to integrate maintenance, costs, and equipment life-cycle considerations (GREAT BRITAIN, 1975; 1978; 1984; 1992; 1993; HUSBAND, 1976). This movement promoted effectiveness in productive systems by linking reliability, maintainability, and availability, while reference manuals consolidated practices in asset-intensive industries (IRANI, 2015; RADEK, 2022; RADEK; SZCZOTOK, 2024).

In the early 2000s, physical asset management gained prominence with the British specifications that set requirements and guidelines for optimized management (BSI, 2008a; 2008b). These standards became international milestones and influenced the creation of global references. At the same time, academic works emphasized life-cycle analysis and the importance of economic and technical decision-making (CAMPBELL; JARDINE; MCGLYNN, 2011). The discipline expanded further as scholars and professionals defined concepts, principles, and certification systems, consolidating shared terminology and governance models (AMADI-ECHENDU; BROWN; WILLETT; MATHEW, 2010; AMADI-ECHENDU; HEYNS; GRABE, 2015). International congresses reinforced interdisciplinary debate and practical consolidation (AMADI-ECHENDU, 2015a).

Since 2014, the ISO 55000 standard has become the global benchmark, offering requirements, guidelines, and complementary standards for industries, infrastructure, and public services (ABNT, 2020; 2024a–e). Professional associations contributed with competency frameworks, self-assessment methodologies, thematic guides, and maturity scales, thereby expanding the reach of these standards (AMC, 2014a; 2014b; IAM, 2014; 2021; 2022; 2024a–c; 2025; IFRAMI, 2017; IPWEA, [n.d.]). The GFMAM – Global Forum on Maintenance and Asset Management – consolidated networks of good practices with maturity guides, conceptual landscapes, performance indicators, and references on digital transformation (GFMAM, 2021; 2024a–h; 2025). National and international authors bridged theory and practice, offering manuals and case-based approaches that emphasized fundamentals, organizational maturity, and integration with corporate strategy (HARDWICK; LAFRAIA, 2015; LAFRAIA, 2020a; 2020b; [n.d.]a; [n.d.]b; HASTINGS, 2021; KARDEC et al., 2014; WOODHOUSE, 2014; AZEVEDO, 2009; 2018; 2019; 2023).

Thus, the evolution of asset management reveals a continuous path: from terotechnology as a technical and economic foundation, through the normative consolidation of physical asset management, to the global standardization of the ISO 5500X family, which today underpins sustainable value creation worldwide.

In Brazil, debates on terotechnology and life-cycle costs arrived indirectly through translations of British documents and initial applications in large-scale industries such as steelmaking, energy, and oil. These were initially linked to maintenance and critical asset reliability. With the publication of PAS 55 in 2004 and its revision in 2008, Brazilian companies began adopting more formalized practices, aligning maintenance, reliability, engineering, and finance. ABRAMAN, active in maintenance since 1984, assumed a leading role by incorporating this broader vision into its congresses and technical publications.

The release of the ISO 55000 family in 2014 (ISO 55000, ISO 55001, ISO 55002) was a watershed. Brazil, through ABNT/CEE-251, translated and published national versions in 2014, later updated in 2020 and 2024. In 2012, ABRAMAN officially changed its name to the Brazilian Association for Maintenance and Asset Management, signaling its expanded scope, and the country became one of the most active members of GFMAM.

Today, Brazil is recognized as the regional leader in asset management in Latin America, with experts engaged in GFMAM and WPIAM. Its trajectory evolved from advanced maintenance inspired by terotechnology, progressed with PAS 55, consolidated with ISO 55000, and now constitutes an essential component of both corporate and public governance.

4. Characterization and Comparative Analysis of ABRAMAN's Asset Management Survey

The ABRAMAN National Document, first published in 1986 as the National Maintenance Document, was initially conceived to map practices, indicators, and trends in Brazilian industrial maintenance. Its primary purpose was to provide a comprehensive overview of costs, organizational structures, and technological challenges, thereby offering an unprecedented reference for companies. Over subsequent decades, the Document consolidated its standing as one of the main sources of information for the sector, published biennially and focused primarily on corrective, preventive, and predictive maintenance, as well as performance metrics and contracting practices.

A decisive shift occurred with the publication of PAS 55 in 2004 and 2008 and, more significantly, with the introduction of ISO 55000 in 2014. These milestones expanded the conceptual horizon of the ABRAMAN National Document beyond maintenance toward the broader domain of asset management. The 2016 edition explicitly reflected this transition by incorporating dedicated blocks of questions on strategy, governance, asset life cycle, and alignment with organizational objectives. Since then, the Document has consistently evolved to align with both national and global advances in the discipline: in 2016, it included the first blocks aligned with ISO 55000; in 2018, it consolidated asset management terminology and introduced integration with HSE and sustainability; in 2020, it emphasized digital transformation, Maintenance 4.0, and risk-based management; in 2022, it presented a detailed structure with 22 questions directly aligned with ISO 55001; and in 2024, it underwent a significant simplification to six key questions, focusing on asset age, maturity diagnostics, CAMA professionals, and cultural barriers.

This evolution may be understood in four stages: from a maintenance-centered approach (1986–2000), to a format influenced by PAS 55 and ISO 55000 (2004–2014), to the full incorporation of asset management (2016–2020), and most recently to a strategic and synthetic methodology (2022–2024). The differences between the 2022 and 2024 editions are particularly significant. While the 2022 edition contained 22 questions addressing governance, policies, objectives, SAMP, KPIs, audits, and continuous improvement, the 2024 edition reduced the scope to only six questions, covering asset age, maturity diagnostics, professional certification, implementation status, and cultural barriers. This reduction represents a deliberate strategic shift from an in-depth diagnostic tool to a more accessible, high-level instrument.

The 2022 survey functioned as a technical-operational thermometer, structured in close alignment with ISO 55001 requirements and designed to identify specific gaps in governance, processes, and performance indicators. In contrast, the 2024 survey sought to broaden participation by focusing on strategic indicators, such as average asset age and cultural resistance, producing results that are more easily interpretable by senior management. While the 2022 edition offered robust technical detail and diagnostic depth, the 2024 edition prioritized simplicity, speed, and managerial relevance.

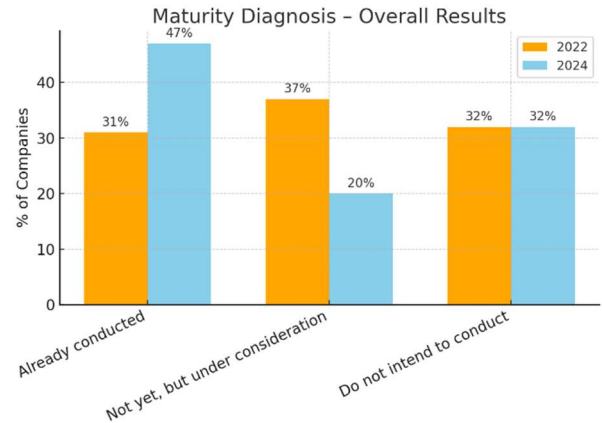
This deliberate repositioning carries advantages and disadvantages. On one hand, reducing the questionnaire from 22 to six questions makes the survey more agile, improves comparability across sectors, and potentially raises response rates. On the other hand, it reduces analytical depth and limits the ability to conduct detailed benchmarking or identify operational deficiencies in accordance with ISO 55001. Thus, while the 2024 format may serve strategic decision-making and public policy, the 2022 edition remains more appropriate for supporting audits, detailed asset management plans, and continuous improvement processes.

The differences between the two editions also extend to methodology and coverage. The 2022 survey approached 1,762 managers, securing 290 respondents, with a margin of error of $\pm 4.5\%$ and a one-month data collection period. By contrast, the 2024 survey approached approximately 1,000 managers, with 183 respondents, a margin of error of $\pm 7.0\%$, and a two-month collection period. Despite the longer period, the 2024 edition achieved fewer responses and lower statistical robustness, underscoring the trade-offs inherent in the simplification strategy.

The comparative analysis of results highlights both progress and limitations. Between 2022 and 2024, there was a national increase of 16 percentage points in companies that had conducted formal asset management maturity assessments, indicating consolidation of practices in certain sectors and regions. However, the simultaneous reduction in methodological rigor and detail points to the enduring challenge of reconciling strategic accessibility with technical robustness.

The subsequent figures present a visual comparison of the 2022 and 2024 results.

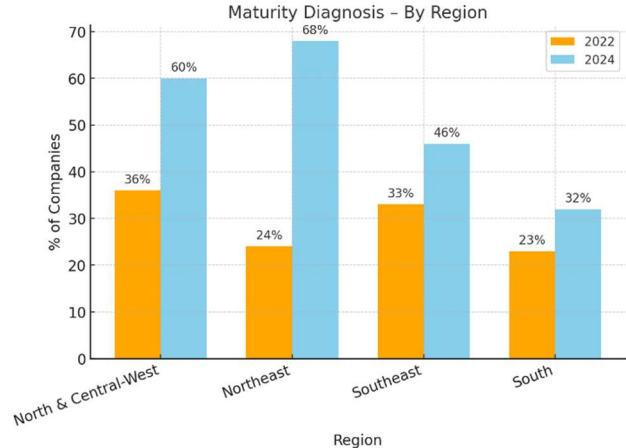
Figure 1 – Asset Management Maturity Assessment: Overall Results.



Source: Elaborated by the author from ABRAMAN’s survey results

Regionally, the Northeast (+44 p.p.) and the North/Central-West (+24 p.p.) demonstrated more accelerated development.

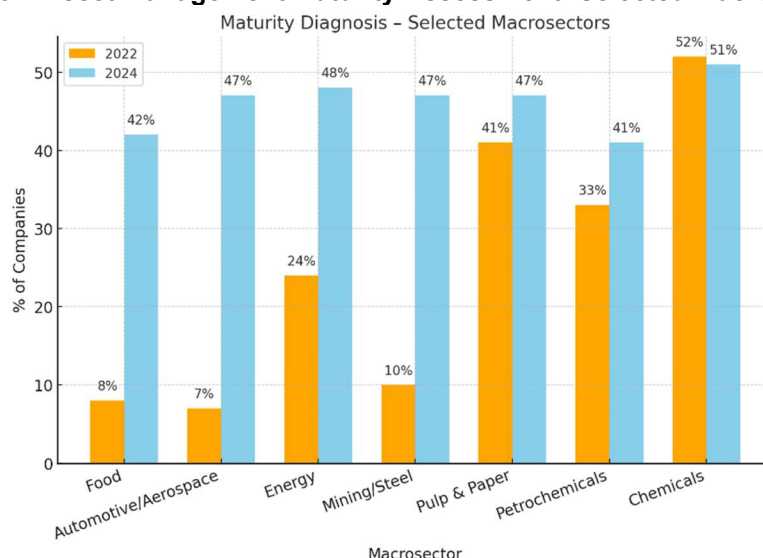
Figure 2 – Asset Management Maturity Assessment: by Region



Source: Elaborated by the author from ABRAMAN’s survey results

In terms of sectors, the Food (+34 p.p.), Automotive/Aerospace (+40 p.p.), and Mining/Steel (+37 p.p.) industries registered significant leaps. Conversely, stagnation was observed in Agribusiness, Chemicals, Sanitation, Services, and Transportation, where no meaningful progress occurred.

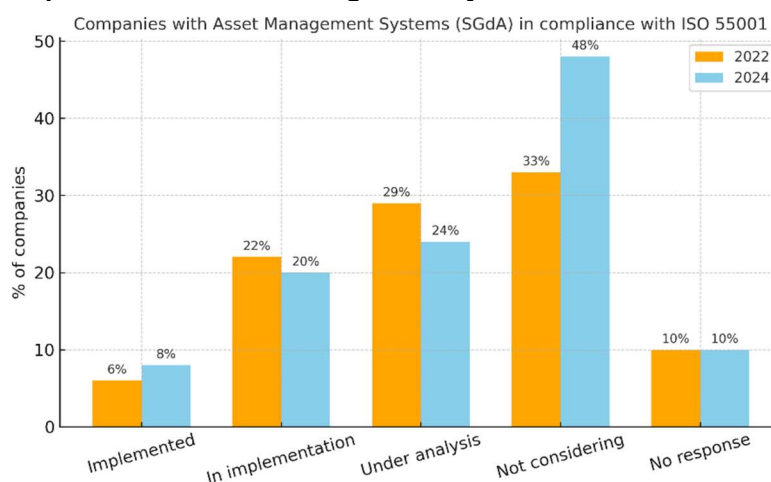
Figure 3 – Asset Management Maturity Assessment: Selected Macrosectors



Source: Elaborated by the author from ABRAMAN's survey results

These results confirm the consolidation and partial diffusion of asset management practices, with notable advances in certain sectors and regions but persistent gaps in services and public infrastructure.

Figure 4 – Companies with Asset Management Systems in accordance with ISO 55001



Source: Elaborated by the author from ABRAMAN's survey results

It is observed that, between 2022 and 2024, there was only a marginal increase in the proportion of companies that had already implemented an ISO 55001 Asset Management System (+2 p.p.), accompanied by a decline in those that were in the process of implementation (–2 p.p.) or still under consideration (–5 p.p.). The significant rise in the group that does not envisage adoption at all (+15 percentage points) reveals a scenario of stagnation and even relative regression, in stark contrast to the progress identified in maturity diagnostics.

The data concerning the effective implementation of Asset Management Systems in conformity with ISO 55001 indicates stagnation or even relative regression. Despite a slight increase in the number of companies reporting a fully implemented ISO 55001-compliant

Asset Management Systems (+2 p.p.), there was a decline in the proportion of organizations still in the analysis or implementation stages (–7 p.p. combined), alongside a marked growth in the group that does not intend to pursue adoption (+15 p.p.).

With regard to the strengths and weaknesses in the implementation of asset management systems, the 2022 and 2024 editions revealed recurring strengths in the following areas: integration with strategic planning (Attribute 2), a consistent Asset Management Policy (Attribute 4), business-aligned objectives (Attribute 6), and performance indicators and KPIs (Attribute 12). In addition, the 2024 edition identified as further strengths the emergence of asset plans (Attribute 11) and the establishment of timelines and monitoring mechanisms (Attribute 10).

Conversely, the main weaknesses consistently observed in both the 2022 and 2024 editions were the Strategic Asset Management Plan – SAMP (Attribute 8), the full coverage of the asset life cycle (Attribute 13), and internal audits and management reviews (Attributes 15, 16, 19, 20, 21, and 22). These shortcomings reflect persistent fragilities in governance, feedback mechanisms, and continuous improvement.

In summary, the 2022 survey reflected an early stage of maturity, with emphasis on policies and objectives. The 2024 survey introduced technical advances in performance indicators and asset plans, yet weaknesses in governance remained. The current challenge lies in converting methodological maturity into systems that are robust, auditable, and sustainable.

The following figure synthesizes the number of attributes classified as strengths and weaknesses in the 2022 and 2024 editions.

Figure 5 – Strongest and weakest attributes in the implementation of asset management



Source: Elaborated by the author from ABRAMAN's survey results

With regard to the barriers to implementing asset management systems, the ABRAMAN surveys reveal that maturity in asset management is hindered by challenges that vary according to company size:

- Small enterprises: strategic dispersion and low prioritization.
- Medium enterprises: insufficient resources and lack of integration.
- Large enterprises: cultural barriers associated with short-termism and organizational resistance.

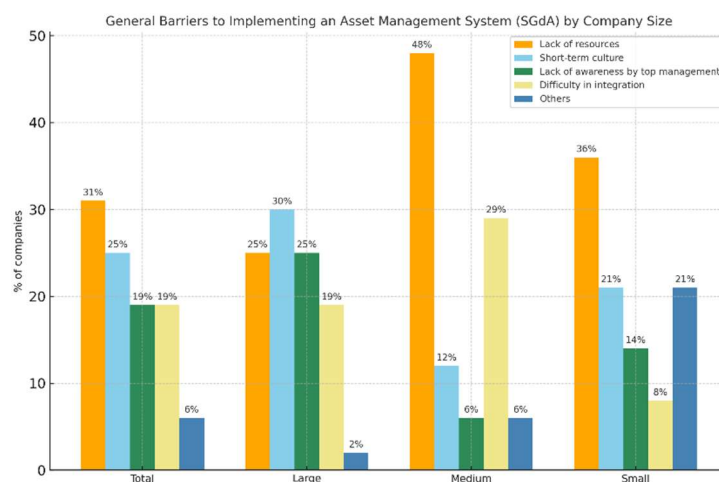
In small enterprises, the main cultural barrier is the prioritization of other issues (59%), which diverts attention from asset management. In medium-sized companies, short-termism and resource constraints prevail. In large organizations, short-termism persists, combined with difficulties in cross-departmental integration. Although differing in nature, all categories demonstrate that short-term orientation and lack of resources remain persistent, transversal obstacles.

Based on the barriers identified in the 2022 and 2024 surveys, the following practical recommendations are proposed, differentiated by company size, with the objective of supporting the successful implementation of Asset Management Systems.

Table 1 – Comparison of Barriers and Practical Recommendations by Company Size

Company Size	Main Barriers Identified	Practical Recommendations
Small Enterprises (≤100 employees)	Lack of resources (36%) Culture of short-termism (21%) Other barriers (21%) Focus on competing priorities (59%)	Access to financing lines specifically designed for asset management initiatives. Basic training programs in ISO 55001. Awareness campaigns for top management to prioritize asset management. Use of simple, low-cost digital solutions.
Medium Enterprises (101–500 employees)	Lack of resources (47%) Difficulty of integration across departments (29%) Culture of short-termism (12%)	Establishment of interdisciplinary teams to improve cross-functional integration. Structured planning of investments in asset management. Training programs targeted at mid-level managers. Gradual implementation of processes, with quick wins to mitigate cultural resistance.
Large Enterprises (>500 employees)	Culture of short-termism (30%) Lack of awareness at the senior management level (25%) Integration difficulties (19%)	Cultural change programs and leadership engagement. Implementation of corporate governance structures for asset management. Periodic internal audits to reinforce organizational discipline. Adoption of international benchmarking and external certifications to validate practices.

Figure 6 – General barriers to the implementation of an asset management system by company size.



Source: Elaborated by the author from ABRAMAN's survey results

The comparative results of the 2022 and 2024 surveys highlight the principal barriers encountered by organizations in implementing asset management systems, distinguishing them by company size and by cultural characteristics.

5. Conclusion

This paper traces the historical trajectory of asset management, beginning with the emergence of British terotechnology in the 1970s, progressing through the consolidation of PAS 55, and culminating in the global standardization of the ISO 5500X family. Particular emphasis is placed on the Brazilian context, where ABRAMAN assumed a decisive role in disseminating and adapting these principles. The evolution of its National Document, especially the comparative analysis of the 2022 and 2024 editions, illustrates both advances and enduring challenges in the practice of asset management.

The study's central objective was to demonstrate how asset management has matured into a strategic discipline while assessing how national surveys capture this process in the Brazilian scenario. Methodologically, the research employed comparative analysis, enabling a systematic evaluation of similarities and differences between the 2022 and 2024 survey blocks dedicated to asset management.

The findings reveal a dual reality. Progress was observed in maturity diagnostics, alignment with strategic planning, and the adoption of performance indicators and KPIs. However, persistent weaknesses remain, including limitations in strategic asset management planning (SAMP), incomplete life-cycle integration, fragile governance structures, and cultural barriers rooted in short-termism. The 2022 edition offered technical rigor and closer alignment with ISO 55001, whereas the 2024 edition adopted a simplified, strategic format designed to facilitate managerial accessibility, though at the expense of analytical depth.

The contribution of this work lies in providing a structured understanding of how asset management has advanced historically and contextually, positioning Brazil as both a leader and a field of ongoing challenges. Nevertheless, the reliance on secondary survey data limits comparability across sectors and regions. Future research should incorporate longitudinal organizational case studies and explore links with ESG practices, digital transformation, and cultural change, thereby strengthening the transformation of methodological maturity into robust, auditable, and sustainable management systems.

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Conflict of Interest

The author declares that there are no commercial, financial, or personal relationships that could be construed as a potential conflict of interest in the research, analysis, and publication of this article.

Ethical Approval

The author declares that the research underlying this article was conducted in full compliance with recognized ethical standards for academic research. All procedures followed the appropriate protocols of integrity, transparency, and responsibility, ensuring adherence to ethical principles throughout the design, execution, analysis, and reporting of the study.

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