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Governance and Cost Management in Marine Decarbonization: A Systematic Review

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Abstract

This study examines the pivotal role of managerial accounting in supporting governance, cost management, and risk integration within low-carbon marine projects under the blue economy transition. Despite escalating global commitments to marine decarbonization and biodiversity protection, existing literature remains fragmented and largely focused on macro-level policy and finance, leaving a critical void in internal managerial mechanisms. Using a Systematic Literature Review (SLR) approach based on the PRISMA protocol, this study synthesizes 33 relevant articles published between 2022 and 2026, capturing the transformative impact of the Kunming-Montreal Global Biodiversity Framework (KM-GBF) and the Taskforce on Nature-related Financial Disclosures (TNFD). The findings reveal three core systemic issues. First, biodiversity-related costs are economically material yet systematically excluded from formal costing systems due to the absence of standardized metrics. Second, biodiversity risk remains difficult to integrate into capital budgeting, often manifesting indirectly through financial pressures and operational disruptions. Third, managerial accounting plays a critical but underutilized governance role, bridging external sustainability demands with internal control systems, though often limited by symbolic implementation. This study contributes by proposing an integrated conceptual framework that positions cost management, biodiversity risk, and governance as interdependent dimensions of a single managerial accounting challenge, providing a strategic roadmap for aligning financial precision with ecological necessity in the blue transition.

Keywords: Blue Economy, Managerial Accounting, Biodiversity Risk, Cost Management, Marine Decarbonization

1. Introduction

The global imperative to transition to a sustainable blue economy has emerged as a critical agenda in the twenty-first century. As the pursuit of Net Zero targets accelerates, the maritime domain, responsible for sequestering over 25% of anthropogenic CO₂ emissions, has become a strategic frontier for large-scale decarbonization (Visentin, 2026; Zeng et al., 2025). This shift is further intensified by the Kunming-Montreal Global Biodiversity Framework (2022), which catalyzed biodiversity finance as a vital instrument for marine conservation (Y. Li et al., 2025). However, while the potential for blue carbon sequestration and offshore energy is vast, these initiatives demand unprecedented levels of financial accountability and structured governance (Z. Liu et al., 2025a; G. Wang, 2026). Consequently, the blue economy has evolved into a complex arena of strategic financial management that requires rigorous accounting frameworks beyond mere ecological observation (Lin & Zheng, 2026).

Despite the escalating urgency of marine transition, current academic discourse remains heavily dominated by public policy, marine sciences, and macro-level finance (Ning & Yasuda, 2026; Salmi et al., 2023). A critical void persists in the application of managerial accounting, a discipline fundamental to cost planning, capital budgeting, and internal decision-making (Ramassa et al., 2026). Managing marine transition projects involves navigating extreme environmental risks and internalizing biodiversity externalities that have historically remained off-balance sheet (Amran et al., 2025; Zhou et al., 2025). Recent studies indicate a systemic disconnect: while high-level policy ambitions for the “blue transition” are high, the operational capacity for cost management and internal performance control remains underdeveloped (Karuppiyah et al., 2025; Z. Li et al., 2024). This suggests that maritime decarbonization is currently operating without the necessary managerial instruments to ensure economic efficiency (P. Bosmans & de Mariz, 2023).

The state-of-the-art literature in environmental accounting is largely restricted to terrestrial contexts, leaving the maritime dimension fragmented and under-researched (J. Wang & Lian, 2026; Zhang et al., 2025). Existing

reviews often discuss green finance at a market level, but fail to address the internal managerial innovations required for marine-based projects (Y. Liu et al., 2025; Y. Zhang et al., 2025). This research fills this gap by providing the first systematic synthesis that integrated governance, cost control, and biodiversity risk into a unified conceptual framework specifically for the marine sector (Ananta & Cabral, 2026). The novelty of this study lies in its focus on the internal accounting mechanisms, such as specialized capital investment appraisal and biodiversity integrated budgeting, which are absent in current systematic literature review publications (Azizi, Bärtsch, et al., 2025a; Hossain et al., 2024).

Literature Review

Governance Theory

Governance theory was introduced by Williamson in 1979 and Rhodes in 1996. This theory explains that in a complex system, adaptable governance is needed as authority and coordination are more likely to be considered as a self-organizing network structure. This explains that the success of governance depends on minimizing costs and building trust among interdependent actors to ensure the system's accountability and efficiency (Williamson, 1979; Rhodes, 1996). In the sustainability context, governance expanded into environmental governance, where it also includes government and public involvement as multiple actors, and it's not limited only to the organization anymore (J. Wang & Lian, 2026). Thus, environmental governance requires not only institutional coordination but also concrete accountability mechanisms, including managerial instruments, to translate governance commitments into measurable outcomes.

Marine transition projects represent one such context, where governance complexity arises from the involvement of multiple actors, each with distinct interests and accountability demands. Governance plays an important role in ensuring decarbonization commitment and protecting marine biodiversity sustainability (Ananta & Cabral, 2026). Through the transparent and timely carbon emissions reporting, accurate cost targeting, and good investment control, managerial accounting could serve as an instrument to support the governance (Hazar et al., 2025; Z. Li et al., 2024; Y. Liu et al., 2025). In the context of the blue economy, robust governance supported by managerial accounting has been identified as a critical determinant of sustainability performance, given its role in enhancing transparency, accountability, and strategic alignment across actors (Amran et al., 2025). This suggests that managerial accounting is not merely a financial tool, but an integral component of governance architecture in marine transition projects, through which accountability and sustainability commitments can be systematically monitored and enforced.

Risk Management Theory

Risk management theory provides a foundational lens for understanding how organizations operating in the blue economy identify, measure, and respond to environmental risks systematically. Enterprise Risk Management (ERM) integration in the blue economic sector requires robust governance mechanisms capable of capturing the complexity of environmental and biodiversity risks, where strong governance acts as a structural foundation for organizations to manage sustainable risk systematically (Amran et al., 2025). In the context of climate risk measurement, frameworks such as the Task Force on Climate-related Financial Disclosures (TCFD) demand accurate and transparent emissions data, as demonstrated by Z. Li et al. (2024) through the application of a real-time carbon accounting system. Extending beyond climate risk, the Task Force on Nature-related Financial Disclosures (TNFD) formally recognizes biodiversity risk as a distinct risk category, signaling a broader shift in how environmental risks are classified and governed. This recognition has accelerated the development of financial instruments such as blue bonds, which require standardized methodologies for measuring ecosystem impact (P. Bosmans & de Mariz, 2023). Thus, the transition in marine environment risk management has shifted from just a compliance-driven obligation into a strategic instrument for ensuring the long-term sustainability of marine biodiversity (Ananta & Cabral, 2026).

The strategic repositioning of risk management, however, only translates into meaningful outcomes when biodiversity risk is formally embedded within capital investment appraisal and capital budgeting decisions. Recent literature confirms that biodiversity risk has a significant and non-linear effect on global stock markets, necessitating managers in the marine sector to incorporate this risk as a component of the cost of capital (Zeng et al., 2025). In the absence of an integrated ERM framework such as TNFD, organizations in the marine sector lack the structured capacity to identify and quantify critical environmental externalities that could lead to information asymmetry for investors (Amran et al., 2025). Empirical findings from Ning & Yasuda (2026) shows that the integration of environmental risks disclosure into managerial deriskcision could significantly

reduce the stock price cash risk. Thus, integrating biodiversity through accurate carbon performance reporting and impact-based investment appraisal into managerial accounting instruments could be the key to ensuring that capital allocation decisions not only protect biodiversity but also ensure the stability of the organization's value in the capital markets.

Cost Management & Managerial Accounting Innovations

Cost management and managerial accounting innovations act as the primary lens through which environmental risks are operationalized into measurable financial decisions. Innovation, such as life cycle costing, which is operationalized through the Levelized Cost of Energy (LCOE) metric, is used to evaluate the long-term decarbonization technology cost efficiency (Hazar et al., 2025). Moreover, the presence of a real-time carbon accounting system enables the implementation of emission-based target costing that could set more dynamic control towards carbon taxes (Z. Li et al., 2024). Biodiversity risk integration into the managerial reporting through the TNFD framework complements the innovation by mitigating information asymmetry and stock price cash risk in the market (Ning & Yasuda, 2026). Collectively, these innovations ensure cost management is not only limited to pure financial aspects but also covers the critical environmental externalities that determine investment worthiness in the marine sector (Amran et al., 2025).

Capital Investment Appraisal & Biodiversity Risk Integration

The integration of biodiversity risk into capital investment appraisal represents the central theoretical concern of RQ2, wherein conventional methods such as NPV, IRR, and Payback Period demonstrate structural limitations in capturing the non-linear and irreversible nature of ecological externalities. Recent innovation involves optimized strategic investment models that can solve green supply chain uncertainty and interdependence between every actor in the marine sector (Y. Liu et al., 2025). In response to this uncertainty, Real Options Analysis (ROA) has emerged as a more adaptive appraisal framework, enabling organizations to incorporate ecological flexibility and defer irreversible investment commitments under conditions of biodiversity uncertainty, offering a superior alternative to conventional NPV under high regulatory and environmental uncertainty (Castillo Delgadillo & Díaz-Peña, 2025). Formal recognition of biodiversity risks as systemic financial risks forces organizations to integrate natural capital valuation into the capital budgeting to avoid stock price volatility (Zeng et al., 2025). Without systematically integrated risk management, investors' decisions in the marine sector would remain unable to account for the critical environmental risks that could permanently damage the organization's ecological integrity and financial stability.

Marine Decarbonization & Blue Economy

In the blue economy context, marine decarbonization encompasses the integration of offshore renewable energy, blue carbon ecosystems such as mangroves, seagrass, and salt marshes, and marine protected areas through strategic marine spatial planning (Yang et al., 2026). However, these projects face significant cost accountability challenges due to methodological difficulties in measuring the economic value of biodiversity and environmental transition risk with sufficient precision (Visentin, 2026; Azizi et al., 2025). The lack of transparency in environment-based risk disclosures not only obscures the assessment of the cost of capital but also increases the risk of capital market volatility and information asymmetry for investors (Ning & Yasuda, 2026; Zeng et al., 2025). Thus, accountability in the blue transition requires managerial accounting innovations capable of internalizing critical environmental externalities into governance frameworks to ensure long-term economic and ecological sustainability (Amran et al., 2025; Hossain et al., 2024).

Biodiversity Finance

Biodiversity finance covers various innovative mechanisms such as blue bonds, biodiversity offsets, and debt-for-nature swaps, which restructure sovereign debt in exchange for binding marine conservation commitments, though their implementation continues to face significant governance and transparency challenges (Visentin, 2026; Simeth, 2025; Zeng et al., 2025). In this context, managerial accounting plays a crucial role as verification instrument and control to ensure funds allocated transparently and free from agency problems (Ning & Yasuda, 2026b). Innovation in biodiversity accounting that involves stakeholders' participation enables organization to track the effectiveness of capital usage towards the ecosystem recovery target accurately (Azizi, Bärtsch, et al., 2025b). Complementing this, the adaptation of more flexible investment measurement method such as Real

Option Analysis helps manager to control biodiversity investment in uncertain regulation and physical risk condition (Castillo Delgadillo & Díaz-Peña, 2025). Thus, through this control mechanism, organizations could internalize environmental externalities into strategic decision making to ensure company's value stability in the stock market (Amran et al., 2025b).

Research Questions

The primary objective of this research is to bridge the gap between policy ambition and managerial execution through three fundamental research questions.,the study investigates:

- (1) What specific innovations are emerging in cost management practices within marine transition projects?
- (2) How is biodiversity risk integrated into capital budgeting and investment decisions in the maritime sector?
- (3) How does the role of managerial accounting play in the internal governance of low-carbon marine initiatives?

By answering these questions, this study provides a strategic roadmap for marine project managers, regulators, and accounting scholars to align financial precision with ecological necessity.

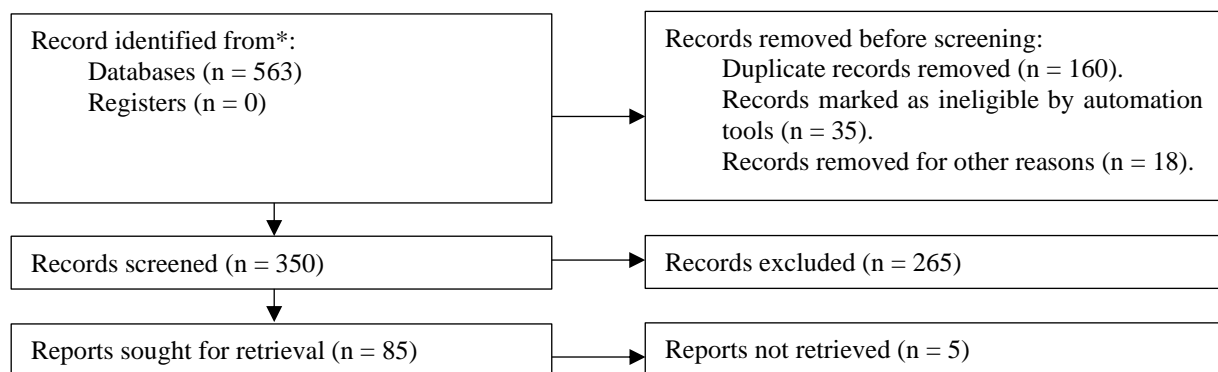
2. Research Methods

This research employs a Systematic Literature Review (SLR) design with a qualitative approach. The SLR methodology was selected because it enables a comprehensive synthesis of literature that remains scattered and unsystematically mapped within the blue transition topic. To ensure methodological rigor and transparency, this study refers to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol as the internationally recognized reporting standard for systematic reviews.

This study uses articles published from 2022 to 2026, during which the Kunming-Montreal Global Biodiversity Framework (KM-GBF) and the Taskforce on Nature-related Financial Disclosures (TNFD) Framework were released in 2022. This temporal scope ensures that the selected literature captures the most recent developments emerging in response to these global initiatives. The presence of KM-GBF and TNFD marked a pivotal shift, transforming biodiversity from a fragmented environmental issue into a policy-anchored, finance-integrated domain, thereby catalyzing a wave of academic and institutional responses that embed biodiversity risk into governance and financial decision-making.

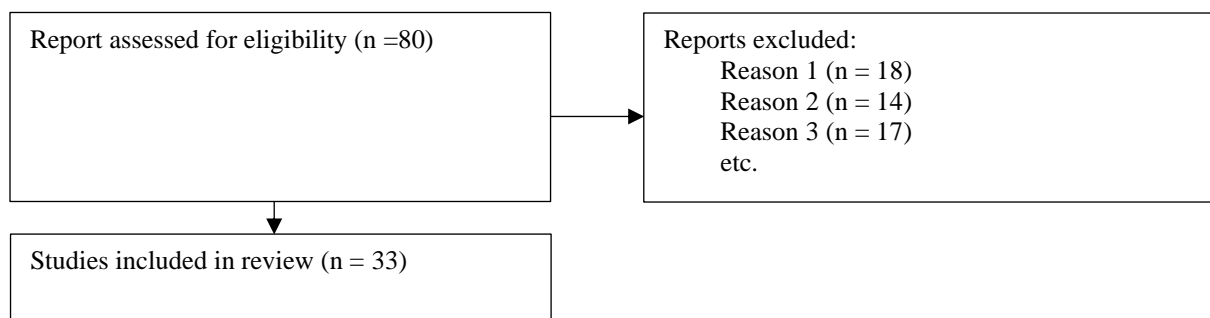
The article selection process is performed using relevant keywords related to the research aims, which are (“blue economy” OR “blue finance” OR “blue carbon” OR “marine decarbonization”) AND (“environmental management accounting” OR “sustainability governance” OR “biodiversity finance”), indexed by Scopus and accessed through Emerald Insight, ScienceDirect, MDPI, Taylor & Francis, and ResearchGate. Articles used are chosen based on these criteria: (a) examine managerial or management accounting; (b) relevant to marine, ocean, or blue economy; (c) related to sustainability, decarbonization, or biodiversity governance; and (d) published from the period 2022-2026.

The data were manually extracted using a content analysis approach, encompassing the author names, year of publication, article titles, research focus, research methods, and key findings related to blue economy governance and blue economy managerial accounting. The screening and mapping process of the articles in this study is presented in Figure 1.



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The screening stage commenced with the identification of all articles that matched the research keywords, followed by a selection process based on predefined inclusion and exclusion criteria. Articles that were not relevant to the research focus or did not support the objectives of the study were excluded. The outcome of this process resulted in a set of articles deemed relevant and suitable for further analysis. Based on this procedure, the articles included in the study were identified according to journal identity, journal indexing, and the total number of articles analyzed in this systematic literature review.

3. Results and Discussions

3.1. Cost Management Innovations

Current literature highlights a fundamental limitation in cost management systems, where biodiversity-related impacts remain both underestimated and structurally excluded from formal costing mechanisms. One key issue lies in the absence of a standardized and universally accepted metric for biodiversity, in contrast to climate-related measures such as CO₂ equivalents. As emphasized by Visentin (2026), biodiversity loss is inherently multidimensional and cannot be captured by a single indicator, resulting in fragmented approaches that depend heavily on analytical objectives. This lack of metric standardization creates a critical barrier to translating ecological degradation into quantifiable financial terms, thereby preventing its integration into internal accounting systems. Consequently, biodiversity impacts are often treated as externalities rather than operational costs. However, empirical evidence suggests that these “unaccounted” costs are, in fact, economically material. Li et al. (2025) demonstrate that firms exposed to higher biodiversity risk experience increased capital costs and greater external financing needs, ultimately reducing operational efficiency. This indicates that biodiversity-related costs do exist within organizational processes, but they emerge indirectly through financial pressures rather than being explicitly recognized in cost structures. Together, these findings reveal a structural gap in managerial accounting. Biodiversity is neither adequately measured nor formally incorporated into costing systems, leading to systematic underestimation of its true economic impact.

Building on the previous discussion, although biodiversity-related costs are not formally captured within accounting systems, the evidence suggests that they are nonetheless economically material and begin to shape corporate decision-making in indirect and often distorted ways. As shown by Li et al. (2025), biodiversity risk increases firms’ dependence on external financing and raises the cost of capital, which in turn disrupts resource allocation and reduces operational efficiency. Rather than being explicitly recognized and managed through structured costing mechanisms, these pressures emerge as financial constraints that influence managerial behaviour. This distortion becomes more evident in strategic decisions such as mergers and acquisitions, where biodiversity risk alters the design of payment structures. Liu et al. (2025) find that firms exposed to higher biodiversity risk are more likely to rely on stock-based financing instead of cash, to share uncertainty and preserve liquidity (Z. Liu et al., 2025). This shift reflects not only the presence of underlying cost pressures but also the difficulty in accurately valuing biodiversity-related risks due to high information asymmetry and measurement limitations. Consequently, instead of being systematically incorporated into cost management systems, biodiversity costs manifest through indirect financial adjustments that can distort decision-making processes, leading firms to adopt suboptimal or risk-sharing strategies rather than fundamentally addressing the underlying cost structures.

Building on the prior discussion, recent evidence suggests that biodiversity-related costs are not only influencing firms in distortionary ways but are also beginning to trigger more structured, albeit still incomplete, transformations in managerial responses. While earlier findings show that biodiversity risk reduces capital allocation efficiency and induces opportunistic behaviors such as real earnings management (Lin & Zheng,

2025), emerging studies indicate that firms are increasingly shifting from purely reactive adjustments toward more proactive strategic responses. For instance, exposure to biodiversity risk has been found to significantly increase firms' green investment activities, suggesting that environmental pressures are gradually being translated into forward-looking capital allocation decisions rather than merely short-term performance manipulation (G. Wang, 2025). In parallel, qualitative evidence from supply chain contexts shows that firms are developing biodiversity management practices, such as supplier engagement, restoration initiatives, and ecosystem-focused operational adjustments to mitigate ecological impacts and improve long-term sustainability outcomes (Salmi et al., 2023). These developments indicate an important shift in the role of biodiversity-related costs: from being invisible or indirectly distorting decisions, to increasingly shaping strategic investment and operational practices. However, this transformation remains uneven and conceptually underdeveloped within managerial accounting systems. The coexistence of long-term adaptive investments and short-term opportunistic behaviors suggests that firms are navigating biodiversity pressures through multiple, and sometimes conflicting, mechanisms. As a result, although biodiversity-related costs are beginning to be internalized through investment and operational adjustments, they have yet to be consistently embedded within formal costing, budgeting, and control systems, limiting their ability to fully realign decision-making processes.

3.2. Biodiversity Risk Integration

A fundamental challenge in integrating biodiversity risk into managerial accounting systems lies in the inherent difficulty of defining and measuring the risk itself. Unlike climate-related risks, which benefit from standardized metrics such as CO₂ equivalents, biodiversity risk is intrinsically multidimensional and lacks a universally accepted measurement framework. Existing biodiversity metrics differ significantly in their conceptual foundations, scope, and methodological approaches, capturing diverse aspects such as species abundance, ecosystem degradation, or extinction probability, without any single indicator consistently outperforming others (Visentin, 2026). As a result, the choice of metric is highly dependent on analytical objectives, making comparability and standardization across firms and contexts inherently problematic. This complexity is further exacerbated by the need to bridge ecological and financial domains, requiring interdisciplinary methodologies that remain underdeveloped in practice (Visentin, 2026). Consequently, biodiversity risk cannot be easily translated into a stable, quantifiable input for internal decision-making processes. From a managerial accounting perspective, this ambiguity creates a critical barrier to integration, as risk identification is a prerequisite for cost measurement, budgeting, and performance control. Without a clear and consistent definition of biodiversity risk, firms face significant difficulties in embedding it into formal accounting systems, leading to inconsistent recognition, selective measurement, and ultimately limiting its role in guiding implementation barrier managerial decisions.

The conceptual ambiguity detailed above directly translates into an implementation barrier where biodiversity risk cannot be integrated into formal management control systems. Because these risks are inherently site-specific and non-linear, they defy the aggregation required for traditional accounting consolidation (Ning & Yasuda, 2026). This integration gap is further widened by the lack of standardized valuation methods; when ecological impacts cannot be reliably converted into monetary terms, they are frequently excluded from capital investment appraisal and discounted cash flow models. Furthermore, the absence of robust "eco-control" mechanisms, such as biodiversity-adjusted budgets or variance analysis for natural capital, means that even when firms recognize the importance of the blue transition, the risk remains an unmanageable externality. Consequently, without a shift toward interdisciplinary accounting frameworks that can accommodate multi-metric ecological data, biodiversity risk will continue to be relegated to qualitative disclosures, failing to exert any substantive influence over core managerial decision-making processes (Visentin, 2026).

Given the difficulties in direct integration, biodiversity risk often manifests indirectly within managerial accounting frameworks, being translated into conventional financial or operational pressures. Instead of being identified as a standalone ecological threat, it frequently surfaces through the escalation of raw material costs, supply chain disruptions, or increased regulatory compliance expenses associated with marine-based activities. This indirect appearance is often driven by the "political economy of sustainability," where external pressures from stakeholders and policy shifts force firms to internalize ecological costs under the guise of operational risk management (Lin & Zheng, 2025). For instance, a decline in marine ecosystem health may be recorded in accounting systems simply as a drop in asset productivity or an increase in insurance premiums for offshore projects, rather than a specific loss of biodiversity value. While this allows for some level of recognition within existing reporting structures, such indirect manifestation masks the true scale of ecological dependency and may lead to reactive, rather than proactive, governance of the blue transition.

The indirect manifestation of these costs ultimately leads to a significant distortion in managerial decision-making processes, where the lack of granular visibility prevents an accurate evaluation of risk-adjusted returns in marine projects (Y. Li et al., 2025). This distortion is often driven by a "valuation gap," as traditional accounting signals fail to capture the substantive link between environmental performance and long-term financial stability (Y. Li et al., 2025). When firms prioritize short-term financial metrics over ecological resilience, the resulting resource allocation tends to favor projects with high "hidden" biodiversity liabilities, assuming they are economically viable based on incomplete data (Y. Li et al., 2025). Furthermore, without standardized internal metrics, the pressure for environmental disclosure may lead to symbolic reporting rather than substantive strategic shifts, as managers struggle to align external transparency with internal control systems (Y. Li et al., 2025). Consequently, these distorted accounting signals prevent the internal governance framework from effectively steering the organization toward a genuine and sustainable blue transition (Y. Li et al., 2025).

The multidimensional and non-standardized nature of biodiversity risk fundamentally shapes organizational behavior, where such risks are primarily reacted to rather than strategically managed through formal accounting frameworks. In many instances, firms only initiate biodiversity protection measures after facing external pressures or tangible supply chain disruptions, suggesting that nature-related practices remain peripheral to core management routines (Salmi et al., 2023). While risk exposure may stimulate an increase in green investments as a strategic response, the effectiveness of these actions is heavily contingent upon managerial incentives and corporate ESG performance, which often reflect short-term reputation mitigation rather than long-term natural capital stewardship (G. Wang, 2025). Consequently, without integration into proactive budgeting and internal control mechanisms, corporate actions tend to be limited to stakeholder compliance or reactive responses to ecological crises that have already materialized (Salmi et al., 2023). This underscores a governance gap in the blue transition, where biodiversity risk is treated as an incidental shock to be mitigated rather than a predictable and controllable business risk component (G. Wang, 2025).

3.3 The Role of Managerial Accounting in Governing Low-Carbon Marine Projects

Current literature suggests that managerial accounting in low-carbon marine projects extends beyond internal cost measurement and increasingly functions as a governance mechanism through performance reporting, accountability, and control. In marine transition settings, governance effectiveness depends on whether decarbonization and biodiversity commitments can be translated into measurable and decision-relevant organizational practices rather than remaining at the level of policy ambition. This is particularly evident in carbon performance reporting, where accounting systems enable firms to monitor emissions, evaluate operational efficiency, and align internal decisions with external climate obligations. Near real-time carbon accounting has been shown to enhance the accuracy and timeliness of emissions data, thereby strengthening managerial oversight and enabling more effective monitoring of decarbonization targets (Z. Li et al., 2024). Similarly, biodiversity-related disclosure under the TNFD has been found to reduce stock price crash risk, particularly in firms with stronger governance structures, suggesting that accounting-based transparency can operate as a disciplinary mechanism (Ning & Yasuda, 2026). Together, these findings indicate that managerial accounting contributes to governance by making ecological performance visible, reportable, and subject to organizational control.

The governance role of managerial accounting becomes more complex in low-carbon marine projects due to their embeddedness in multi-level governance systems involving regulators, corporations, financial institutions, and local stakeholders. Under these conditions, accounting does not merely support internal budgeting but also bridges external governance expectations with internal decision-making processes. Governance has been identified as the backbone of sustainable blue economy development, requiring alignment between strategy, governance approaches, and enabling mechanisms (Amran et al., 2025). In addition, blue finance has been shown to operate through policy-led, market-driven, and capability-supported pathways, indicating that governance effectiveness depends on the interaction of institutional support, financial standardization, and managerial capacity (J. Wang & Lian, 2026). In this context, managerial accounting can serve as a bridging mechanism by translating external sustainability pressures into internal targets, monitoring systems, and resource allocation decisions. This role also reflects the logic of integrated reporting, where internal accounting information is increasingly connected to broader stakeholder accountability and public governance concerns. From a governance perspective, such integration highlights the importance of accounting information in supporting coordination and decision-making across organizational and institutional boundaries.

This governance function is particularly visible in biodiversity finance and blue bond arrangements, where credibility depends on whether sustainability commitments can be verified and monitored internally. The blue bond market remains constrained by weak impact metrics, inconsistent reporting practices, and the risk of blue washing, indicating that financial innovation alone is insufficient without robust accounting systems (I. Bosmans & Mariz, 2023). In this regard, managerial accounting plays a critical role by linking financial commitments with measurable sustainability performance and enabling verification of fund allocation. At the same time, biodiversity accounting becomes more effective when combined with stakeholder engagement, as accountability is strengthened through participatory and transparent processes involving multiple actors. This also reflects broader limitations in biodiversity accounting practices, which often remain fragmented, symbolic, and weakly implemented, thereby limiting their effectiveness in supporting meaningful accountability and governance. (Azizi, Bärsch, et al., 2025). This suggests that the governance value of managerial accounting lies not only in measurement, but also in its ability to connect internal control mechanisms with broader stakeholder-based accountability structures.

Despite this potential, the literature also reveals that managerial accounting remains only partially embedded in the governance of low-carbon marine projects. Persistent coordination challenges and fragmented institutional arrangements in the blue economy limit the ability of organizational controls to influence substantive outcomes. This fragmentation also reflects the absence of a unified and operational framework capable of linking internal accounting practices with broader blue economy sustainability objectives (Amran et al., 2025). More critically, sustainability reporting remains vulnerable to impression management, where firms use selective disclosure and narrative strategies to legitimize their activities without fundamentally changing underlying practices (Ramassa et al., 2026). In marine transition contexts, this creates a paradox: accounting mechanisms can enhance transparency and coordination, yet they can also become symbolic when not supported by strong governance structures. Consequently, the governance problem lies not merely in the existence of accounting mechanisms but in the extent to which they are integrated into broader systems of enforcement, stakeholder accountability, and strategic decision-making. Without such integration, managerial accounting remains an important but underutilized instrument, unable to fully bridge the gap between sustainability commitments and actual managerial practice.

3.4. Synthesis Across Findings

Building on the previous discussion, the literature collectively suggests that the central challenge in low-carbon marine projects does not lie in the complete absence of biodiversity considerations, but in the fragmented way these considerations are treated across managerial accounting systems. As shown in the preceding sections, biodiversity appears separately as an invisible cost, an ambiguous risk, and a weakly embedded governance concern, rather than as an integrated managerial issue. This fragmentation is rooted in the absence of standardized metrics capable of translating ecological degradation into stable accounting inputs, which prevents biodiversity from being consistently incorporated into costing, budgeting, investment appraisal, and control systems (Visentin, 2026). This condition is also reflected in the biodiversity accounting literature itself, which remains fragmented across multiple sub-areas such as natural capital accounting, biodiversity disclosure, and economic valuation, without a unified managerial framework (Maione et al., 2024). Yet, the empirical evidence also shows that biodiversity is economically material, as greater exposure to biodiversity risk raises financing costs, reduces operational efficiency, and weakens firms' internal performance (Y. Li et al., 2025). This reveals a structural contradiction in current managerial accounting practice: biodiversity is financially consequential but remains only weakly visible within formal organizational systems.

The findings further suggest that the absence of formal integration generates a chain of distortions in managerial decision-making. When biodiversity cannot be clearly measured and valued, its effects tend to emerge indirectly through altered financing structures, operational pressures, and strategic adjustments rather than through explicit accounting recognition (Y. Li et al., 2025; Z. Liu et al., 2025). This indirect manifestation creates a valuation gap in which traditional accounting signals fail to capture the full relationship between ecological degradation and long-term organizational performance, thereby encouraging incomplete or distorted resource (Y. Li et al., 2025). Under such conditions, firms may respond through opportunistic mechanisms, including real earnings management, or through defensive risk-sharing strategies that mask uncertainty rather than resolve it (Lin & Zheng, 2025; Z. Liu et al., 2025). At the same time, the literature also points to the emergence of more adaptive responses, such as increased green investment and biodiversity-related supply chain practices, indicating that some firms are beginning to translate ecological pressure into more forward-looking action (Salmi et al., 2023;

G. Wang, 2025). However, these responses remain uneven and only partially embedded in formal costing, budgeting, and control systems, which limit their capacity to realign decision-making consistently. This aligns with prior research emphasizing that biodiversity remains one of the least prioritized sustainability dimensions in corporate practice, partly due to the lack of established accounting frameworks to support its integration into managerial decision-making (Schaltegger et al., 2023).

From a broader perspective, these limitations show that the weakness of managerial accounting in marine transition is not merely technical, but systemic. This limitation is further reinforced by evidence showing that existing ocean accounting frameworks remain heavily oriented toward economic valuation, often overlooking broader social, cultural, and ecological dimensions that are critical for sustainable decision-making (Perkiss et al., 2024). This challenge also reflects broader limitations in conventional accounting systems, which remain unable to coherently integrate environmental and social dimensions alongside economic performance (Loureiro et al., 2023). Effective decision-making in ocean ecosystem contexts requires the integration of multiple dimensions, including risks, costs, stakeholder interests, and governance mechanisms within a coherent decision-support framework (Figueiredo & Cabral, 2024). However, current accounting practices remain fragmented and only partially connected to the wider governance structures needed to enforce substantive organizational change (Amran et al., 2025). This gap becomes more problematic when disclosure itself turns symbolic, as sustainability reporting may strengthen external legitimacy without necessarily transforming internal practices (Ramassa et al., 2026). Taken together, these findings highlight the contribution of this study by showing that cost management innovation, biodiversity risk integration, and governance effectiveness should not be treated as separate themes, but as interdependent dimensions of a single managerial accounting problem in the blue transition. This integrative perspective suggests that the core challenge in low-carbon marine projects is a systemic limitation in managerial accounting, where ecological complexity remains insufficiently measured, inconsistently internalized, and only weakly governed.

4. Conclusion

This systematic literature review concludes that managerial accounting has not yet been systematically developed to support the blue transition, even though biodiversity and decarbonization pressures are becoming increasingly material to organizational decision-making. The review shows that innovations in cost management have emerged in marine transition contexts, but these innovations remain fragmented and are not yet consistently embedded within formal costing, budgeting, and control systems. Biodiversity-related costs are still rarely recognized directly in managerial accounting structures, despite already influencing firms through higher financing pressures, weaker operational efficiency, and altered strategic responses. This suggests that the first research question is answered by showing that current cost management innovations are still partial, uneven, and insufficiently integrated into a coherent managerial accounting framework for low-carbon marine projects. The review also finds that biodiversity risk has not yet been systematically integrated into capital budgeting and investment appraisal. Although biodiversity is increasingly recognized as financially consequential, its multidimensional nature and the absence of standardized metrics continue to prevent its translation into stable accounting inputs for valuation, planning, and control. As a result, biodiversity risk tends to shape managerial decision-making indirectly through distorted accounting signals, incomplete valuation, and reactive strategic adjustments rather than through explicit and structured accounting recognition. In relation to the third research question, the findings further show that managerial accounting has a potentially important role in governing low-carbon marine projects through performance reporting, accountability, and control, but this role remains only partially realized because accounting mechanisms are still weakly embedded in broader governance structures and may be used symbolically rather than substantively. Taken together, these findings indicate that the main challenge in the blue transition does not lie in the complete absence of biodiversity considerations, but in the fragmented and insufficiently integrated way they are treated across managerial accounting systems. The contribution of this review lies in showing that cost management innovation, biodiversity risk integration, and governance effectiveness should not be understood as separate issues, but as interdependent dimensions of a broader managerial accounting problem in low-carbon marine projects. This implies that organizations involved in marine decarbonization and biodiversity finance require more integrated accounting systems capable of capturing ecological complexity and coherently linking environmental, social, and economic dimensions in decision-making processes, supporting more reliable strategic decisions, and strengthening accountability over sustainability commitments. This also highlights the limitations of existing accounting frameworks, which remain insufficient to fully support the integration required for sustainable marine transition. Future research may therefore focus on developing and testing biodiversity-adjusted costing, budgeting, and control mechanisms

in specific marine sectors, as well as examining how these mechanisms influence both organizational performance and ecological outcomes.

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