Mix Sustentável

ESG IN THE MANAUS FREE TRADE ZONE FROM A DESIGN PERSPECTIVE

ESG NO POLO INDUSTRIAL DE MANAUS SOB A ÓTICA DO DESIGN

ESG EN EL POLO INDUSTRIAL DE MANAUS BAJO LA ÓPTICA DEL DISEÑO

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Resumo: O objetivo deste estudo é analisar o cenário de implementação dos critérios Environmental, Social and Governance (ESG) no Polo Industrial de Manaus (PIM), identificando desafios práticos e propondo estratégias para superar barreiras organizacionais sob a ótica do Design Centrado no Humano (DCU). A pesquisa fundamenta-se na dicotomia entre a premissa de extrafiscalidade da Zona Franca de Manaus (ZFM) e a crítica ao modelo como um enclave econômico. Trata-se de uma pesquisa exploratória e descritiva, com abordagem qualitativa, baseada em revisão bibliográfica e documental de teses e relatórios técnicos. Os resultados indicam que a adoção do ESG é dificultada pela escassez de mão de obra qualificada, alta complexidade dos sistemas de reporte e baixa percepção de valor. Conclui-se que a tecnologia é necessária, mas insuficiente; a efetividade

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do ESG depende de abordagens centradas no humano, para engajar a cultura organizacional e transformar a obrigação regulatória em vantagem competitiva.

Palavras-chave: Design Estratégico; ESG; Polo Industrial de Manaus; Design Centrado no Humano; Gestão de Dados.

Abstract: This study aims to analyze the implementation scenario of Environmental, Social, and Governance (ESG) practices in the Manaus Free Trade Zone (PIM), identifying practical challenges and proposing strategies to overcome organizational barriers from a Human-Centered Design (HCD) perspective. The research is grounded in the dichotomy between the extrafiscal rationale underlying the Manaus Free Trade Zone (ZFM) and critical interpretations of the model as an economic enclave. This exploratory and descriptive study adopts a qualitative approach, based on a bibliographic and documentary review of academic theses and technical reports. The findings indicate that ESG adoption is constrained by a shortage of skilled labor, the high complexity of reporting systems, and a low perceived value of ESG practices within organizations. The study concludes that technology is a necessary but insufficient condition; ESG effectiveness depends on human-centered approaches capable of engaging organizational culture and transforming regulatory compliance into competitive advantage.

Keywords: Strategic Design; ESG; Manaus Free Trade Zone; Human-Centered Design; Data Management.

Resumen: El objetivo de este estudio es analizar el escenario de implementación de los criterios Environmental, Social and Governance (ESG) en el Polo Industrial de Manaus (PIM), identificando desafíos prácticos y proponiendo estrategias para superar barreras organizacionales bajo la óptica del Diseño Centrado en el Humano (HCD). La investigación se fundamenta en la dicotomia entre la premisa de extrafiscalidad de la Zona Franca de Manaus (ZFM) y la crítica al modelo como un enclave económico. Se trata de una investigación exploratoria y descriptiva, con enfoque cualitativo, basada en revisión bibliográfica y documental de tesis y reportes técnicos. Los resultados indican que la adopción del ESG es dificultada por la escasez de mano de obra calificada, alta complejidad de los sistemas de reporte y baja percepción de valor. Se concluye que la tecnología es necesaria, pero insuficiente; la efectividad del ESG depende de enfoques centrados en el humano para involucrar la cultura organizacional y transformar la obligación regulatoria en ventaja competitiva.

Palabras clave: Diseño Estratégico; ESG; Polo Industrial de Manaus; Diseño

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1 INTRODUCTION

The Manaus Free Trade Zone (ZFM) represents one of Brazil's most complex regional development models. Established in 1967, it operates under the geopolitical and environmental premise that industrial concentration in the Manaus Free Trade Zone (PIM) prevents deforestation in the interior, promoting socio-economic development linked to the "standing forest" (Chaar et al., 2023; Castro, 2024; Sandrini, 2024; Nascimento, 2024). The PIM has consolidated itself as an industrial giant with revenues exceeding R$ 204 billion (Suframa, 2025a) and is a motor for job creation in the region, maintaining a level of over 115,000 direct jobs (Suframa, 2025b), aligning with the Sustainable Development Goals (SDGs) of the 2030 Agenda (IBGE, 2025).

However, the real sustainability of this model faces questioning. Critical studies point out that the pole often functions as an "economic enclave," generating socio-environmental liabilities such as industrial waste and disordered urban expansion, without fully integrating with local socio-biodiversity (Almeida, 2024; Meireles, 2023). This challenge becomes critical with the need for evidence required by the Environmental, Social, and Governance (ESG) agenda and the adoption of international reporting standards (IFRS S1 and S2), mandatory in Brazil starting in 2026 (PwC Brasil, 2023c).

The implementation of ESG, which could address these management failures, hits barriers that are not only technical but deeply cultural and organizational. Recent research indicates that data opacity, the complexity of reporting systems, and the lack of employee engagement are the main obstacles to the effectiveness of the agenda on the factory floor (Alves, 2025; KPMG, 2024). It is at this point that the perspective of Design becomes fundamental. Contemporary sustainability imposes a challenge that transcends engineering: it requires the design of new "satisfaction systems." As Lepre and Santos (2008) point out, Design has evolved from a practice focused on the shape of the object to a strategic discipline, capable of addressing complex problems and proposing systems that integrate economic, social, and environmental dimensions.

ESG, therefore, should be understood not only as compliance, but as a Systems Design and Information Management problem: how can complex global requirements (Redecker; Machado, 2023) be translated into locally comprehensible and engaging practices?

In this context of a gap between available technology and the organizational capacity to absorb it, this article aims to analyze ESG implementation in the PIM from a Human-Centered Design perspective. The objective is to identify how design-led approaches can overcome barriers related to opacity and organizational culture, transforming regulatory obligation into a tool for innovation and transparency that validates the region's sustainable vocation.

2 THEORETICAL FRAMEWORK

2.1 Systemic Complexity of ESG

The contemporary understanding of sustainability requires a break with linear industrial thinking in favor of a systemic approach capable of addressing the complexity of interactions among natural, social, and economic systems. Lepre and Santos (2008) argue that Design has evolved from an activity focused on the formal configuration of tangible products to the design of complex systems, in which the objective is not merely the object itself, but the satisfaction of needs within the limits of planetary resilience. It is within this context of complexity that the concept of ESG emerges, not only as a financial metric, but as an organizational design artifact oriented toward business longevity.

Historically, corporate management was dominated by the logic of "shareholder capitalism," strongly influenced by Milton Friedman, who advocated profit maximization as the company's sole social responsibility (Redecker; Machado, 2023). However, this model proved insufficient to respond to global climate crises and social inequalities. The transition to "stakeholder capitalism" introduced the need to generate shared value, requiring organizations to reconfigure their purposes and processes (Redecker; Machado, 2023).

The term ESG was formally coined in 2004 in the report Who Cares Wins, an initiative of the UN Global Compact in partnership with the World Bank, prompted by Kofi Annan to integrate social, environmental, and governance factors into capital markets (Redecker; Machado, 2023). Unlike traditional corporate philanthropy, ESG operates as a risk management and brand valuation strategy, structured around three interdependent pillars:

Environmental (E): Focuses on eco-efficiency and impact minimization, encompassing waste management, greenhouse gas (GHG) emissions, and biodiversity conservation. It seeks to reconcile production and consumption with the resilience capacity of ecosystems (Nascimento, 2012 apud Redecker; Machado, 2023).

Social (S): Refers to engagement with stakeholders, including human rights, labor relations, diversity, and community impact. Hope and Laasch (2024) emphasize that responsible management has evolved from a peripheral ethical practice into a core legitimacy competence.

Governance (G): Constitutes the system of values and rules that governs the organization, ensuring transparency, equity, accountability, and corporate responsibility (IBGC, 2022 apud Redecker; Machado, 2023).

From a Design perspective, ESG implementation can be interpreted as the design of a Product–Service System (PSS). Rapôso, César, and Kiperstok (2014) explain that, in sustainability contexts, the focus shifts from the sale of physical products to the provision of integrated "units of satisfaction." Similarly, ESG requires organizations to design information and governance flows that dematerialize value, transforming raw operational data into intangible assets of reputation and trust.

Currently, ESG has shifted from a voluntary trend to a market and regulatory imperative. The initial lack of regulation generated informational asymmetries and greenwashing risks, but the global landscape is moving toward the standardization of metrics, driven by entities such as the International Sustainability Standards Board (ISSB) (Redecker; Machado, 2023). In Brazil, recommended practices are becoming certifications, such

as ABNT PR 2030:2022, which provides guidelines for structuring this journey by establishing maturity stages ranging from legal compliance to regenerative strategy (ABNT, 2022). Therefore, ESG is now consolidated as a complex management system that requires Design to mediate between technique (indicators) and culture (behavior), with the aim of achieving long-term sustainability.

2.2 Scenario of the Manaus Free Trade Zone

The PIM operates under a distinctive public policy design logic. Established by Decree-Law No. 288/1967, the model is legally justified by the concept of "extrafiscality": the use of tax incentives not as an end in themselves, but as instruments for inducing behavior in order to achieve constitutional objectives, notably the reduction of regional inequalities and environmental protection (Sandrini, 2024; Castro, 2024). The theoretical foundation of this premise is supported by the classic work of Samuel Benchimol (1999; 2010), who defended the ZFM not merely as a fiscal model, but as a geopolitical strategy of "economic density." For Benchimol (2010), the concentration of manufacturing activity in Manaus functions as a "shield," preventing the dispersion of predatory activities into the interior of the state and enabling what he referred to as "making man happy with the forest standing." This vision holds that socioeconomic development should seek a balance between the "ecological zenith" and the "economic-social nadir" (Benchimol, 2010) by concentrating economic activity within a delimited urban area and reducing pressure for deforestation in the interior of the state (Nascimento, 2024; Chaar et al., 2023).

However, this thesis faces a critical antithesis that reveals a failure in the integration of the current model with the territory. Almeida (2024) characterizes the PIM as an "economic enclave" that, focused on the instrumental rationality of tax benefits and the assembly of exogenous components, fails to integrate with regional sociobiodiversity. The author argues that the model operates with its back to the forest, creating an island of industrial prosperity surrounded by socio-environmental liabilities, such as disordered urban expansion and insufficient waste management, without effectively leveraging the local bioeconomy.

This paradox between the declared environmental function (extrafiscality) and actual operation (enclave) generates a legitimacy problem that Strategic Design must address. If the PIM was designed to protect the forest, the lack of metric evidence of this protection renders the model vulnerable. The systemic disconnection identified by Almeida (2024) suggests that the current "system of satisfaction" responds to financial incentives, but fails to deliver regenerative value to the ecosystem, thus requiring a redesign of its management and transparency processes to correct the mismatch between the historical sustainability discourse and contemporary operational reality.

2.3 Regulatory Urgency and the Data Problem

The tension between the preservation narrative and the operational reality of the PIM, tolerated in past decades, now faces a breaking point triggered by a structural shift in global capitalism.

This transition has culminated in a scenario of "regulatory urgency." The initial milestone of this "new order" is the UN 2030 Agenda, which established 17 Sustainable Development Goals (SDGs). IBGE (2025) highlights that, ten years into the Agenda, Brazil enters the so-called "Decade of Action," in which the monitoring of indicators ceases to be an aspiration and becomes a requirement for sovereignty and competitiveness. Castro (2024) reinforces that, in order to maintain its legitimacy, the ZFM must demonstrate its factual contribution to targets such as SDG 10 (Reduced Inequalities) and SDG 9 (Industry, Innovation, and Infrastructure). The global market, saturated with greenwashing, has shifted from voluntary guidelines to mandatory standards upon realizing that the lack of metric standardization generated informational asymmetry and eroded investor trust (Redecker; Machado, 2023).

The materialization of this new order is the adoption of IFRS S1 and IFRS S2 standards by the International Sustainability Standards Board (ISSB), which were internalized in Brazil by the Brazilian Securities and Exchange Commission (CVM), with mandatory application from 2026 onward. IFRS S1 requires companies to communicate, in an integrated manner, any sustainability-related risk or opportunity that affects their cash flows, detailing governance and strategy. IFRS S2, in turn, focuses specifically on climate, demanding the precise disclosure of greenhouse gas emissions (Scopes 1, 2, and 3) and climate transition plans (PwC Brasil, 2023c).

To operationalize this compliance within the national context, ABNT PR 2030:2022 was introduced. Unlike international standards, this Recommended Practice offers a roadmap adapted to the Brazilian reality for structuring the ESG journey, defining maturity stages ranging from "Incipient" to "Strategic" (ABNT, 2022). Certification based on PR 2030 thus becomes a crucial "quality seal" for companies that need to demonstrate to the market that their data are reliable and auditable.

Although the initial legal obligation falls on publicly traded companies, the impact on the PIM occurs through a "cascade effect" along the value chain. For large players to comply with the requirement to report indirect emissions, they will inevitably demand auditable carbon and environmental compliance data from their local suppliers. Thus, for industries within the ZFM, the justification of "extrafiscality" can no longer be sustained solely by incentive laws, but must be substantiated by granular data that meet this new global standard.

However, the informational reality in the Amazon presents a challenging contrast. Industrial management in the PIM suffers from a critical problem: data scarcity and fragmentation. Cunha et al. (2023) identify the lack of standardized measurement tools as a central barrier for local companies. Alves (2025) corroborates this diagnosis by pointing to the "absence of integration between environmental data and operational indicators" as a structural obstacle.

In this context, where global instruments such as CORSIA require precise metrics that often fail to

capture local nuances (Gonçalves, 2022), the "opacity of reports" (Almeida, 2024) places PIM industries in a vulnerable position. The gap between the regulatory demand for radical transparency and the low level of data maturity on the factory floor increases the risk of greenwashing and climate litigation (Lehmen, 2021), requiring the PIM to urgently redesign its information systems in order to ensure integrity and trust.

2.4 Organizational Barriers: Culture, Qualifications, and Engagement

If regulatory urgency imposes what must be done (compliance with IFRS standards and data transparency), the organizational reality of the PIM imposes severe constraints on how this transition can be executed. The literature and recent data indicate that the greatest bottleneck for ESG implementation is not the absence of technology, but rather the human and cultural dimension of organizations.

A diagnostic study conducted with 76 industries in the PIM identified that the most significant barriers to the adoption of sustainable practices are "cultural and organizational" in nature (Alves, 2025). The study highlights internal resistance to change and the lack of employee engagement as obstacles that prevent standards from moving beyond paper. This reflects a national scenario in which, according to research by Aberje and Nexus (2024), the ESG maturity of companies still struggles to overcome the discourse stage and become a consistent cultural practice across all hierarchical levels.

The issue of skills and qualifications constitutes another critical point of social materiality. Conte de Melo et al. (2024) point out that the shortage of qualified labor to interpret and operationalize complex environmental legislation is one of the main challenges faced by companies in the industrial pole, especially smaller firms. Torchia and Torchia (2022) reinforce that the Social (S) pillar of ESG requires organizations to make substantial investments in continuous learning programs, as technological transformation without adequate training generates exclusion and inefficiency.

This gap in "human capacity" is not exclusive to the PIM, but rather a global phenomenon. Research by KPMG (2024) reveals that organizations worldwide face constraints in executing their sustainability strategies precisely due to the lack of prepared teams and adequate structures. In the Manaus context, this creates a vicious cycle: the high complexity of reporting systems collides with the low qualification of operational teams, resulting in poor data input or the underutilization of available technological tools.

3 METHODOLOGY

The study is exploratory and descriptive, adopting a qualitative approach, grounded in bibliographic and documentary review (Gil, 2019). The research design employed the dialectical method to structure the analysis of the problem, confronting the theoretical premise of sustainability in the Manaus Free Trade Zone (thesis) with empirical evidence from the operational reality and the socio-environmental liabilities identified in the region (antithesis), with the aim of proposing a design-based synthesis grounded in Design strategies.

To ensure the validity and reliability of the results, the data triangulation technique was applied, cross-referencing global regulatory sources with local primary diagnoses. The analytical corpus consisted of market documents, technical standards, and recent regional academic production (2016–2025), selected to cover the multiple dimensions of the problem. The organization of these sources and their role in the construction of the argument are detailed in Table 01.

Table 1 – Synthesis of the Data Triangulation Strategy and Analysis Corpus

Analysis Axis	Source Category	Main Documents/Authors	Research Function
1. Regulatory Scenario (The "Ought to Be")	Technical Standards and Global Reports	IFRS S1 and S2 (ISSB); ABNT PR 2030 (2022); PwC, KPMG, and Aberje Reports	Establish the compliance and transparency standard required by the global and national market.
2. Local Context (The "Is")	Regional Theses and Dissertations (UFAM/UEA)	Almeida (2024) and Nascimento (2024); Castro (2024) and Sandrini (2024); Suframa Data (2025)	Diagnose the operational reality of the PIM, identifying the paradox between the "standing forest" premise and the "enclave" practice.
3. Operational Barriers (The Problem)	Field Research and Sectoral Diagnostics	Alves (2025) – *Survey* with 76 industries; Meireles (2016; 2023) ; Pereira (2025)	Prove with empirical data the management gaps (waste) and cultural barriers (engagement/qualification).
4. Solution Approach (The Synthesis)	Design and Innovation Theory	Lepre & Santos (2008); Campos et al. (2025); Manzini (2008)	Provide the theoretical basis to propose Human-Centered Design as a tool to overcome identified barriers.

Source: Authors.

The analytical procedures consisted of the thematic categorization of the information collected across these four axes. Data interpretation was conducted from a Human-Centered Design perspective, aiming to identify interface gaps between the required management systems (Axis 1) and the installed operational capacity (Axis 3), thereby grounding the proposition of engagement- and transparency-oriented solutions (Axis 4).

4 ANALYSIS AND RESULTS DISCUSSION

The application of the proposed methodology, through the triangulation of global standards, local diagnostics, and design theory, revealed that ESG adoption within the Manaus Free Trade Zone occurs in an environment of high systemic complexity. The analysis of the documentary corpus indicates that the transition toward sustainability in the PIM is not merely a technical issue, but rather a challenge of value and process reconfiguration. To understand how Design can operate within this context, the following discussion is struc-

tured around the four identified materiality axes, beginning with the economic motivation that underpins this transition: the shift from a cost-based perspective to one of strategic investment.

4.1 The opportunity for value creation and risk mitigation

The incorporation of the ESG agenda within the Manaus Free Trade Zone should not be viewed through a narrow cost-based perspective, but rather as a strategic vector for value creation and long-term viability. The specialized literature demonstrates that a robust ESG proposition translates into tangible financial returns. Henisz, Koller, and Nuttall (2019) identify five essential pathways through which ESG creates value:

(1) facilitating revenue growth through access to new markets;

(2) reducing operational costs (e.g., energy and waste efficiency);

(3) minimizing regulatory and legal interventions;

(4) increasing employee productivity through a clear sense of purpose; and

(5) optimizing investments and capital expenditures (CAPEX).

Within the Latin American context, the relationship between sustainable practices and corporate performance presents important nuances. Teixeira (2024), in an investigation of regional companies, concludes that although the correlation with immediate financial performance may vary by sector, the adoption of ESG practices is fundamental for risk mitigation (volatility) and for long-term business sustainability. According to the author, companies that integrate these criteria demonstrate greater resilience in crisis scenarios, as transparency and good governance act as a "buffer" against market shocks.

For industries operating within the PIM, this risk mitigation logic is critical. Operating in a region under constant global scrutiny, the reputational liability associated with deforestation or environmental inefficiency is extremely high. In this context, ESG functions as a mechanism for validating the "social license to operate" (Redecker; Machado, 2023). By adopting robust practices, companies within the industrial pole have the opportunity to transform the "Free Trade Zone" brand, often externally perceived merely as a fiscal incentive, into an asset of reputational value linked to the bioeconomy and the preservation of the standing forest.

In this sense, the adoption of ESG criteria tends to strengthen the competitive position of the PIM, serving as a strategy for territorial differentiation and reputational risk mitigation.

4.2 The technological opportunity and data integration

The realization of this value-oriented strategy and the effective mitigation of risks depend, in practice, on the organization's ability to move from subjectivity to evidence. For the "reputational shielding" discussed previously to be sustained in the eyes of investors and regulators, an infrastructure capable of monitoring impacts in real time is required. It is at this point that technology ceases to be merely operational support and becomes the engine of ESG strategy.

The operationalization of value creation is intrinsically dependent on the capacity to capture, process, and interpret data. Tou and Watanabe (2023), in their analysis of global R&D leaders, demonstrate that the ability to transform ESG risks into "innovation springboards" depends on the fusion of diverse bodies of knowledge and the intensive use of digital technologies. According to the authors, companies that adopt a growth mindset use technology not only for compliance purposes, but also to create new learning cycles that simultaneously mitigate risks and generate brand value.

In this context, advanced analytical tools become indispensable. Gao et al. (2024) emphasize that the use of sophisticated technological instruments is crucial for managing the complexity of investment portfolios and ensuring the level of transparency demanded by stakeholders. Digital technology, including Artificial Intelligence (AI) and Big Data, offers the potential to transform auditing and management processes by enabling the absorption of large-scale data and the generation of predictive insights into socio-environmental performance (PwC Brasil, 2024a).

However, the mere acquisition of software does not resolve management challenges. BARC's (2023) study on the state of sustainability reporting warns that organizations face severe difficulties in integrating dispersed data. The report indicates that many companies still struggle with manual processes and a lack of interoperable tools, creating execution gaps in ESG strategies.

Within the PIM, this reality constitutes a classic Information Design problem. While technologies to monitor the forest or the production line do exist, there is a lack of interface and information flow design capable of making these data integrated and intelligible for decision-making. Without a systemic design approach that connects the endpoints, shop floor, management, and reporting, the "technological opportunity" remains underutilized, resulting in the opacity that characterizes the current scenario.

4.3 Environmental Materiality

If technology provides the data infrastructure, Design defines the quality of the industry's material interaction with the territory. Within the Environmental (E) pillar, the materiality of the PIM lies in overcoming the linear production model ("extract–produce–discard"), which Almeida (2024) criticizes as a generator of "enclaves" and environmental liabilities. Pereira (2025) reinforces this diagnosis in the agroindustrial sector by identifying a critical disconnect between waste generation and its productive reuse, revealing a failure in the practical implementation of the Sustainable Development Goals (SDGs) in the region.

From a design perspective, this waste generation is not merely an economic externality, but rather a systemic design failure: the productive system was conceived without anticipating the closure of material life cycles.

The strategic response to this critical risk is the transition toward Circular Design. Meireles (2023) demonstrates that sustainable waste management in the PIM requires more than end-of-pipe treatment; it demands the redesign of processes to integrate Reverse Logistics and Cleaner Production from the earliest stages of conception. Design operates here as the discipline capable of planning "recircularity," transforming what

would otherwise be waste into inputs for new productive chains, as advocated by Lepre and Santos (2008) in the evolution toward Product–Service Systems (PSS).

Complementarily, Sousa (2025), in analyzing the strategies of local recycling companies, finds that the viability of circularity depends on project-based integration between waste generators and recyclers. The design challenge thus shifts from the isolated product to the design of the value network: it becomes necessary to design the connections and information flows that allow the waste of one industry to become, efficiently and traceably, the raw material of another, thereby validating the sustainability premise of the ZFM model through practical eco-efficiency.

4.4 Social and Governance Materiality

The viability of any environmental strategy in the PIM ultimately depends on the execution capacity of its agents. The cross-analysis of the data presented in the theoretical framework reveals that materiality within the Social (S) and Governance (G) pillars is not limited to external indicators, but rather resides in cultural maturity and the integrity of internal information.

While Alves' (2025) diagnosis identifies "cultural resistance" as a primary barrier, the discussion must focus on the origins of this resistance. This study proposes a critical reinterpretation of this scenario: from a Design perspective, lack of engagement is not a moral failure on the part of workers, but a symptom of low organizational usability.

ESG fails when it is perceived as complex bureaucracy disconnected from the factory floor routine. In this sense, the "scarcity of human capacity" cited by KPMG (2024) must be addressed not only through training, but through the redesign of work processes. The proposal by Torchia and Torchia (2022) regarding the need for "continuous learning" requires that the corporate environment be designed to facilitate knowledge absorption, transforming the complexity of environmental legislation (Conte de Melo et al., 2024) into intuitive task interfaces.

In parallel, Governance (G) materiality in the PIM manifests itself in the struggle against opacity. The "lack of data integration" identified by Alves (2025) creates information silos that undermine the radical transparency required by IFRS standards. Here, a technical IT problem becomes an Information Design problem: Without a clear visual hierarchy and auditable data flows, governance becomes ineffective. Macedo and Lemos (2025) emphasize that modern governance depends on the qualified provision of informational resources, which requires a deliberate design of how information is collected, processed, and visualized.

This analysis corroborates the perspective of Bouzon, Falcão, and Ruschival (n.d.), who point out that design management in Manaus still lacks a more strategic application to address complex problems. The evidence indicates that the final bottleneck for ESG implementation in the Manaus Free Trade Zone is not the technology itself, but rather the human and informational interface. It is this gap that justifies the adoption of Human-Centered Design as a decisive competence, capable of designing the "bridge" that connects abstract global strategy to the concrete operational reality of the factory floor.

4.5 ESG Practical Implications: Design as a Facilitator of ESG Information Flows

To understand the necessary intervention of Design in the ESG ecosystem of the PIM, it is essential to frame it within the disciplinary evolution of Strategic Design oriented towards sustainability. Recent studies published in Mix Sustentável highlight that the transition to sustainable practices requires overcoming cultural barriers and moving beyond mere compliance, integrating ESG as a core competitive strategy capable of creating shared value (Dantas et al., 2026). As Franzato (2022) points out, Strategic Design shifts the focus from traditional product development to the orchestration of new organizational logics and collaborative networks capable of driving systemic transitions toward sustainability. In this context, the designer acts not merely as a formalizer of reports, but as a facilitator of collective intelligence (Garcia; Freire; Franzato, 2023).

However, as Unes, Yamanaka, and Araujo (2026) point out in their analysis of project management, strategic sustainability goals often remain aspirational unless they are supported by formal frameworks capable of translating abstract strategic intent into concrete operational practices. Furthermore, Franco et al. (2021) emphasizes that effective sustainability depends on transparent communication and the integration of social and environmental indicators to engage both internal stakeholders and the local community.

To operate effectively within complex organizational structures, this study proposes that Design acts across three interdependent levels of operability:

At the Strategic level (Strategic Design), design works alongside top management to build a shared vision of value (Dantas et al., 2026), utilizing co-creation methods to align the ESG materiality with the core business model, mitigating the "purpose asymmetry" (Almeida, 2024).

At the Tactical level (Human-Centered Design - HCD), design translates the global strategy into tangible service blueprints and data flow journeys. This level addresses the operational gap identified by Unes, Yamanaka, and Araujo (2026), reducing departmental silos and friction during the sustainability data collection processes.

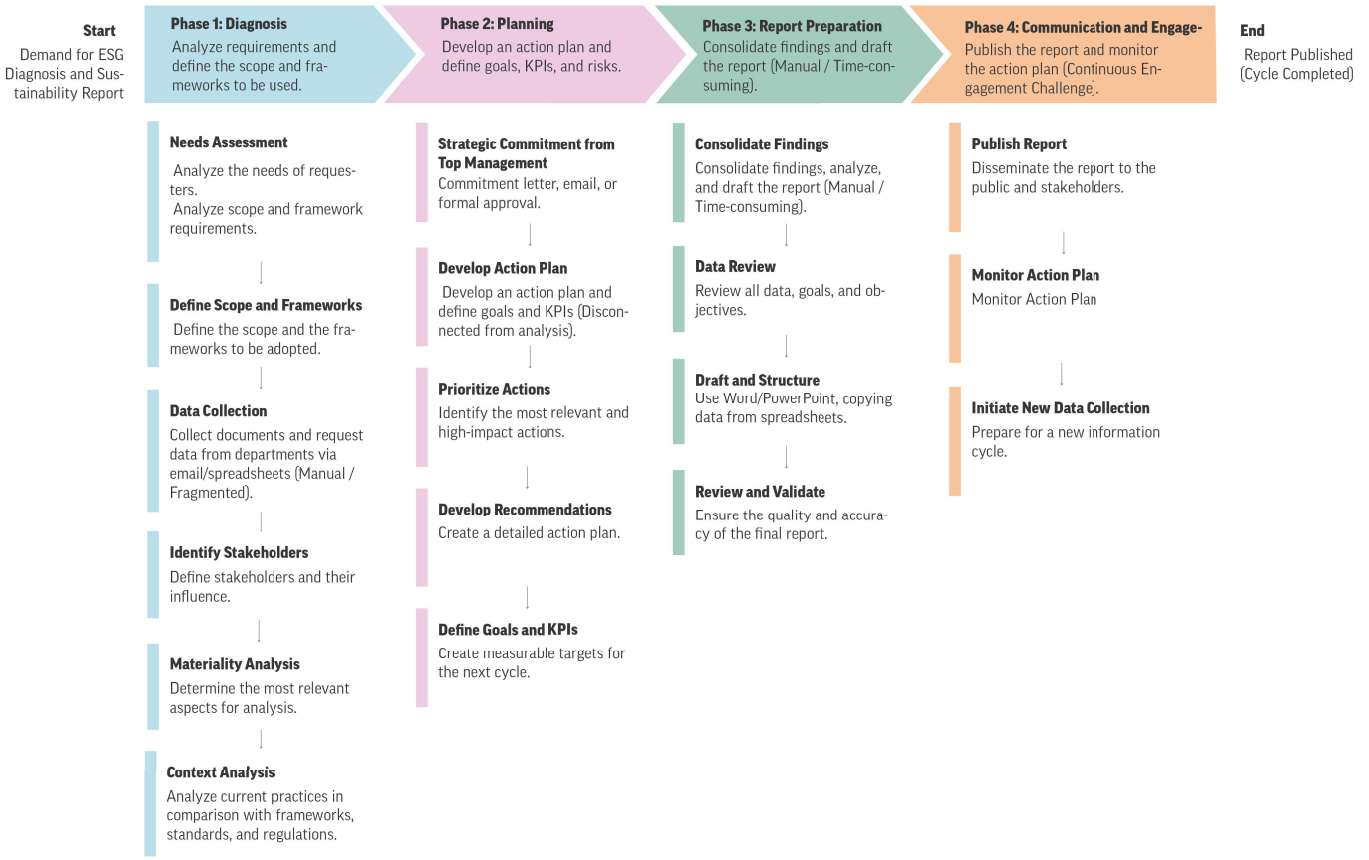
At the Operational level (Behavioral and Interface Design), it focuses on the end-user (the employee), applying behavioral nudges and clear information architectures within software interfaces to encourage accurate data entry, continuous engagement, and transparent communication, echoing the need for stakeholder integration highlighted by Franco et al. (2021).

To understand how these interventions become necessary in practice, it is essential to analyze the 'user journey' in current ESG management practices. Figure 1 illustrates the typical workflow observed in the market, synthesizing the stages of a reporting cycle (Diagnosis, Planning, Development, and Communication). Although this flow follows the management logic recommended by the ABNT PR 2030 standard (ABNT, 2022), its execution faces severe instrumental limitations, as corroborated by global reports on sustainability tools (BARC, 2023).

A detailed analysis of this flow reveals specific friction points at each stage, which not only delay the process but also compromise information integrity, thereby justifying the intervention of Design:

In the Diagnostic Phase (Data Collection): The flowchart highlights that data collection is carried out

Figure 1 – Current ESG Manager Workflow



Source: Authors.

predominantly via “email and spreadsheets,” characterizing it as a “manual and fragmented” process. In the context of the Manaus Free Trade Zone , where data integration has historically been low (Alves, 2025), this generates a high risk of human error and loss of traceability at the source of the information. ESG staff often fill out bureaucratic forms without understanding the real impact of that data on the company’s strategy, resulting in low-quality information or entries completed merely to comply with protocol, without the necessary technical rigor.

In the Planning Phase: The transition from diagnosis to target-setting presents a critical gap. The current flow reveals that ESG goals are often defined in isolation by top management or external consultancies, reaching operations as abstract impositions. This disconnect generates what Almeida (2024) classifies as "purpose asymmetry": employees fail to see how their daily tasks impact global goals. Without participatory design in this stage, the strategy lacks the necessary cultural adherence to be effective.

In the Development Phase: Consequently, the consolidation of findings becomes "manual and time-consuming," requiring the transcription and copying of data across different, disconnected software tools (Word, Excel, and PowerPoint). This disconnection between the analytical database and the final action plan creates the "lack of transparency" and opacity criticized by Almeida (2024), as it makes it extremely difficult to audit the origin of the final figures presented in the report. Without a direct line of evidence, management

loses the ability to make agile decisions based on real scenarios.

In the Communication and Engagement Phase: The workflow indicates that "continuous engagement is difficult," revealing a critical failure in closing the cycle. After the publication of the annual report, the maintenance of daily practices quickly loses momentum due to the lack of immediate feedback to operational teams. As workers do not see the results of their efforts returning in the form of recognition or progress indicators, the sustainability culture fails to take hold, turning ESG into a one-off initiative rather than an organizational habit.

Table 2 proposes and details how specific design tools address each of these operational bottlenecks, transforming points of friction into opportunities for engagement.

Table 2 – Design Intervention Matrix in the ESG Workflow

Critical Point in the Workflow	**Identified Problem (Diagnosis)**	**Design Intervention (Practical Solution)**
Data Collection (Phase 1)	Manual, fragmented process based on spreadsheets and dependent on human input, which is prone to errors.	**Interface Design (UI) and Explainable Artificial Intelligence (XAI):** Development of intuitive and simplified data-collection interfaces for operators, using XAI to validate data consistency at the point of entry and to explain errors in real time, thereby reducing cognitive load.
Strategic Planning (Phase 2)	Disconnect between top management strategy and operational reality; goals are defined abstractly and lack stakeholder engagement.	**Strategic Design and Co-creation (Workshops):** Use of Design Thinking tools to facilitate the collaborative definition of materiality and KPIs, creating Visual Roadmaps that translate complex strategy into tactical steps understandable at all levels.
Consolidation and Analysis (Phase 3)	Lack of transparency and difficulty in tracing the origin of information across disconnected systems.	**Data Visualization (Information Design):** Creation of integrated dashboards that replace static reports, enabling a clear visualization of data flows and facilitating auditing and agile decision-making by managers.
Continuous Engagement (Phase 4)	Low perceived value among employees and disengagement after the reporting cycle.	**Gamification and Behavioral Design:** Implementation of continuous visual feedback systems (e.g., progress bars, team achievements), transforming abstract sustainability goals into tangible and motivating objectives in everyday work.
Supply Chain Integration (Cross-cutting)	Disconnect between the company's strategy and the reality of local suppliers and recyclers.	**Service Design:** Mapping the waste and supplier journey to identify communication "blind spots," and designing new touchpoints that facilitate reverse logistics and information exchange across the value chain.

Source: Authors.

The effectiveness of this approach is corroborated by Campos et al. (2025), who demonstrate how the mapping of experience journeys ("Sustainable Journey") acts as a catalyst for innovation in environmental

communication and for engaging participants in behavioral change.

It is this ability to orchestrate complex systems that positions Design not merely as a support tool, but as the strategic intelligence necessary to overcome the paradoxes of the ZFM (Manaus Free Trade Zone) model, as synthesized in the following considerations.

5 FINAL CONSIDERATIONS

This study analyzed the implementation of ESG in the Manaus Free Trade Zone not merely as a technical adjustment, but also as a systemic challenge of organizational design. The investigation confirmed the premise that the ZFM model is undergoing a critical moment of transition: the historical justification of "extrafiscality" (Benchimol, 2010; Sandrini, 2024) must now be substantiated through auditable and transparent metrics in order to ensure the legitimacy of the industrial pole before the global market and society.

The analysis of the results revealed that the main barrier to this transition is not the lack of technology or financial resources, but rather the disconnect between strategy and operations. It was identified that the "materiality" of risks in the PIM lies in the physical management of waste (environmental liability) and in the management of human capital and information (social and governance liabilities). The persistence of "enclave" practices and data opacity (Almeida, 2024) create a scenario in which advanced tools such as Artificial Intelligence and Big Data remain underutilized or generate fragmented information.

It is therefore concluded that technology is a necessary but not sufficient condition. The effectiveness of the ESG agenda in factories depends on overcoming cultural barriers related to engagement and qualification (Alves, 2025; Torchia & Torchia, 2022). At this point, Human-Centered Design establishes itself as the decisive strategic competence. Based on the diagnosis conducted, this study proposes three design-driven fronts of action to enable the effective implementation of ESG in PIM companies:

Information and Interface Design (UI/UX) for Governance:

To combat data opacity, the development of management interfaces is proposed that translate the complexity of global standards (IFRS) into accessible visual indicators. Design should act to simplify the cognitive load of control dashboards, allowing managers and operators to visualize the impact of their actions in real time, transforming the bureaucratic completion of spreadsheets into evidence-based management.

Service Design for the Circular Economy:

To mitigate environmental liabilities, Design should map the complete journey of industrial waste, identifying communication bottlenecks between generators and local recyclers. The systemic approach of Service Design enables the projection of touchpoints and logistical flows necessary to integrate the value chain, facilitating the operationalization of reverse logistics and industrial symbiosis.

Behavioral Design and Gamification for Social Engagement:

To overcome cultural resistance, the application of gamification strategies in training and data collection processes is suggested. By designing systems of positive feedback and non-monetary rewards, Design transforms compliance obligations into a participatory experience, fostering a culture of sustainability that engages

employees from the factory floor to top management.

This study indicates that the path toward consolidating ESG in the PIM requires Design to go beyond products and act in the mediation of complex systems. For future research, it is suggested to further investigate how these tools can be applied to improve the usability and transparency of corporate data systems and to develop cultural engagement strategies that connect workers to the purpose of sustainability. Only through this integration between technical solutions and the human factor will it be possible to transform regulatory obligations into a genuine competitive advantage for the region, validating the vocation of the Manaus Free Trade Zone as a hub of bioeconomy and actual sustainability.

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