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RESEARCH ARTICLE

Sustainability Evaluation in the Steel Industry: A Supply Chain Performance-Based Model

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Abstract

Environmental, Social, and Governance (ESG) performance is increasingly relevant for corporate sustainability, mainly in high-impact sectors. Building on a previously developed ESG evaluation model, this paper adapts it to the steel sector, considering its specific context and challenges. The model evaluates an Anchor Company (AC), the buyer and focal point, and their Supply Chain (SC), outputting scores for each and a consolidated score, acknowledging the responsibility and potential impact of the SC. This work uses empirical data from a Brazilian steel company, which showed strong ESG maturity, and their suppliers, which showed decent ESG results. However, after integrating the scores, the final ESG score of the AC was significantly influenced by the SC, with 61% of the consolidated result structurally driven by the model's supply chain weighting, reflecting the dominance of scope 3 dynamics in the sector. The findings highlight that to promote effective sustainability, companies must go beyond their boundaries and actively address ESG risks and opportunities across their SC. This study contributes to the sustainability literature by proposing and testing a sector-specific ESG evaluation model in the Brazilian steel industry context, with practical implications for corporate decision-making and potential for adaptation to other regions and sectors.

Keywords Steel Industry · Sustainability · Supply Chain · Evaluation Model

1. Introduction

Climate change is the most emblematic global challenge related to human activities (Sanson et al., 2019). GHG emissions have increased significantly, driven by industries (24%), energy generation (34%), transportation (15%), and agribusiness (22%) (IPCC, 2022). The GHG Protocol guides companies in estimating direct (scope 1) and indirect (scopes 2 and 3) emissions (WRI; WBCSD, 2004), with scope 3 supply chain emissions accounting for the majority in most sectors (Schmidt et al., 2022).

Environmental, Social, and Governance (ESG) considerations have become increasingly relevant for corporate sustainability. Sustainability is broadly defined as meeting present needs without compromising future generations (Brundtland, 1987), while ESG provides measurable criteria to assess organizational contributions to this goal (Bianchi et al., 2022; Tsalis et al., 2020). Several ESG reporting frameworks have been developed, including the Global Reporting Initiative (GRI, 2021), the Carbon Disclosure Project (CDP, 2021), and the International Integrated Reporting Framework (IIRC, 2021). However, these are primarily reporting systems and do not offer structured methodologies for integrating supply chain ESG performance into consolidated quantitative scores. A key concept underpinning ESG assessment is materiality, which

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encompasses identifying and reporting sustainability performance on topics considered material to the business (Pedersen et al., 2022; Khan et al., 2016).

The steel industry presents a compelling context for this study. Responsible for 7% of global GHG emissions and contributing approximately $2.9 trillion to global GDP (World Economic Forum, 2023; Godden et al., 2019), the sector faces intense pressure to decarbonize. Scope 3 emissions account for 68% of the industry's total (Schmidt et al., 2022), underscoring the critical role of supply chain management. Brazil, the 9th largest steel producer globally (World Steel Association, 2023), represents a particularly relevant case, given growing regulatory expectations around ESG disclosure and supply chain transparency (Chen, 2022; CDP, 2021).

This study is motivated by two key gaps in existing ESG evaluation approaches. First, most frameworks rely on relatively generic metrics that overlook sector-specific financial materiality (SASB, 2022). ESG issues affect industries differently: environmental impacts tend to be more material for extractive industries, while governance and data security may be more critical for financial institutions (SASB, 2022). Second, most ESG assessment approaches focus primarily on the focal company and do not quantitatively incorporate supply chain performance, despite the growing recognition that a significant share of a firm's ESG footprint originates beyond its direct operations (Koberg and Longoni, 2019; CDP, 2021).

While existing sustainability frameworks such as the GHG Protocol address supply chain emissions through scope 3 reporting (WRI; WBCSD, 2004), they focus primarily on the environmental dimension and do not generate a consolidated ESG score that integrates anchor company and supply chain performance across environmental, social, and governance dimensions simultaneously. Furthermore, most ESG assessment approaches focus on firm-level indicators and do not quantitatively incorporate supply chain sustainability performance into a weighted corporate score (Koberg and Longoni, 2019; CDP, 2021). This paper addresses this gap by developing and applying an ESG evaluation model tailored to the steel industry that combines sector-specific materiality, based on the SASB framework (SASB, 2022), with a structured mechanism to quantitatively integrate supply chain ESG performance into the consolidated corporate score. The resulting model supports benchmarking, ESG risk identification, and strategic decision-making across the value chain, contributing to the growing literature on supply chain sustainability management (Warmbier et al., 2022; Chen, 2022).

2. Methodology

The methodology is made up of five steps, starting with the definition of the material topics based on Sustainability Accounting Standards Board (SASB), followed by a quantitative method to calculate the material topics weight, which is applied to get a score for the AC and one for the SC. Finally, scores are combined into one consolidated score by considering the coefficient of impact on ESG factors.

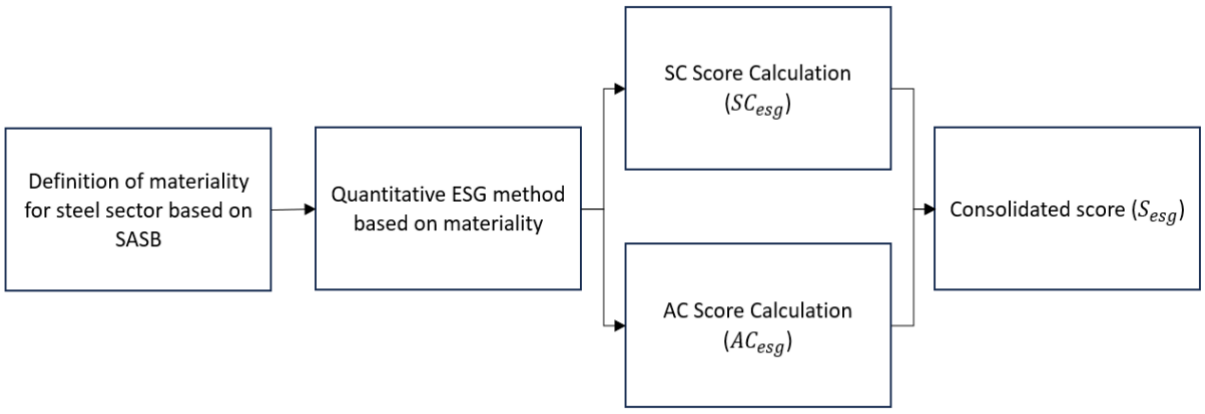

Figure 1. ESG Corporate Evaluation Model Methodology Flow

2.1. Material Topic Identification and Weighting

SASB provides industry-specific standards to identify financially material sustainability topics. In this study, the SASB framework was used to identify the most relevant sustainability topics to be incorporated into the proposed ESG evaluation model. SASB defines 11 economic sector groups divided into 77 subsectors and the material topics for each of them. There are 26 disclosure topics divided into 5 groups (Table 1). The steel industry has specific subsectors, 'Iron & Steel Producers' and 'Metals & Mining', under the sector 'Extractive & Mineral Processing', which guides the materiality definition.

Table 1. SASB Materiality Topics.

Environment	Social Capital	Human Capital	Business Model & Innovation	Leadership
GHG Emissions (GE) Air Quality (AQ) Energy Management (EM) Water & Wastewater Management (WM) Waste & Hazardous Materials Management (WH) Ecological Impacts (El)	Human Rights & Community Relations (HR) Customer Privacy (CP) Data Security (DS) Access & Affordability (AA) Product Quality & Safety (PQ) Customer Welfare (CW) Selling Practices & Product Labeling (SP)	Labor Practices (LP) Employee Health & Safety (EH) Employee Engagement, Diversity & Inclusion (EE)	Product Design & Lifecycle Management (PD) Business Model Resilience (BM) Supply Chain Management (SM) Materials Sourcing & Efficiency (MS) Physical Impacts of Climate Change (PI)	Business Ethics (BE) Competitive Behavior (CB) Management of the Legal & Regulatory Environment (ML) Critical Incident Risk Management (CI) Systemic Risk Management (SR)

Source: Adapted from SASB (2022)

The disclosure topics are classified into 3 categories: Environmental (E), Social (S), and Governance (G). "E" encompasses the first group called 'Environment' (6 disclosure topics), "S" aggregates the second and third groups called 'Social Capital' and 'Human Capital' (10 disclosure topics in total), and "G" combines the fourth and fifth groups called 'business model & innovation' and 'leadership and governance' (10 disclosure topics in total).

The material topics for 'Iron & Steel Producers' and 'Metals & Mining' are shown in Table 2. The material distribution among the groups is as follows: E = 64.7%; S = 23.5%; G = 11.8%, calculated by counting all the relevant material topics (17) and calculating the percentage for each area: environmental (11 material topics), social (4 material topics), and governance (2 material topics).

Table 2. Material Topics for Steel Industry

Subsector	Environmental (E)	Social (S)	Governance (G)
Iron & Steel Producers	• GHG Emissions • Air Quality • Energy Management • Water & Wastewater Management • Waste & Hazardous Materials Management	• Employee Health & Safety	• Supply Chain Management
Metals & Mining	• GHG Emissions • Air Quality • Energy Management • Water & Wastewater Management • Waste & Hazardous Materials Management • Ecological Impacts	• Human Rights & Community Relations • Labor Practices • Employee Health & Safety	• Business Ethics

Source: Adapted from SASB (2022)

The weights assigned to each ESG dimension were derived from the relative frequency of material disclosure topics identified for the sector based on the SASB framework. Although alternative weighting schemes could be adopted, the use of topic frequency was intentionally chosen to maintain methodological transparency. It should be noted that while this approach reduces arbitrary weighting, the choice to use topic frequency as a proxy for importance is itself a methodological assumption, one that is grounded in SASB's materiality framework but could be revisited in future applications (Savi et al., 2025).

The weights for individual material topics shown in Tables 3 and 4 follow a weighted occurrence approach. The base value assigned to each topic corresponds to the total number of material topics within that ESG dimension as defined by SASB: 6 for environmental topics and 10 for both social and governance topics. This design choice ensures that each occurrence of a topic carries a weight proportional to the size of its dimension, preserving the relative importance structure established by SASB.

To illustrate the procedure: in the environmental dimension, GHG Emissions (GE) is identified as material in both 'Iron & Steel Producers' and 'Metals & Mining' subsectors, accumulating 6 + 6 = 12 points. Ecological Impacts (EI), by contrast, is material only in 'Metals & Mining', accumulating 6 points. The total environmental score across all topics is 66 points. GHG Emissions therefore receives a weight of 12/66 = 18.2%, while Ecological Impacts receives 6/66 = 9.1%. The same normalization logic applies to social and governance topics, using a base value of 10. The resulting dimension-level weights (Environment – 64.7%; Social – 23.5%; Governance – 11.8%) emerge directly from counting the material topics identified for the steel sector across both subsectors.

In summary, the weighting procedure follows three steps: (1) identify material topics per subsector using SASB standards; (2) assign base values of 6 (environmental) or 10 (social and governance) to each topic occurrence; (3) normalize the accumulated points within each ESG dimension to obtain the final percentage weights.

Table 3. Material topics weights calculated for the steel industry AC score

Industry	Environment						Social										Governance									
	GE	AQ	EM	WW	WH	EI	HR	CP	DS	AA	PQ	CW	SP	LP	EH	EE	PD	BM	SM	MS	PI	BE	CB	ML	CI	SR
Steel Industry	18%	18%	18%	18%	18%	9%	21%	2%	2%	2%	2%	2%	2%	21%	43%	2%	4%	4%	36%	4%	4%	36%	4%	4%	4%	4%
	WE						WS										WG									
	65%						24%										12%									

2.2. Anchor Company ESG Score

Equation 1 shows the formula to define the score for each environmental (AC_e), social (AC_s), and governance (AC_g) material topics. Equation 2 combines the three categories following the weights calculated on previous paragraph to get the total AC ESG score (AC_{esg}).

$$AC^{E,S,G} = \Sigma_i^N t_i \, T_i^{E,S,G} \tag{1}$$

$$AC_{ESG} = \frac{(W_E \, \alpha_E + \, W_S \, \alpha_s + \, W_G \, \alpha_G)}{W_T} \tag{2}$$

where t_i is the weight of each material topic defined by the occurrence of each one of them as in Table 3; T_i is the score evaluated for each material topic. W_E is the weight of the environmental, W_S is the weight of the social, W_G is the weight of governance material topics, and W_T is the total weight, where $W_T = W_E + W_S + W_G$.

2.3. Supply Chain ESG Score

SC scores are calculated separately by environmental (SC_e), social (SC_s), and governance (SC_g) material topics, and then combined to get the total SC ESG score (SC_{esg}). Table 4 shows the weights considered for every sector, and Table 5 shows the total weight for ESG aspect by sector, both guiding the materiality assessment to calculate the SC score. The weights in Tables 4 and 5 represent counts of material topics, reflecting the distribution of material issues identified by the SASB framework.

Table 4. Material topics weight for ESG score calculation by sector

Industry	Environment (E)						Social (S)										Governance (G)									
	GE	AQ	EM	WW	WH	EI	HR	CP	DS	AA	PQ	CW	SP	LP	EH	EE	PD	BM	SM	MS	PI	BE	CB	ML	CI	SR
Consumer Goods	1	1	4	2	1	1	1	2	3	1	6	1	1	2	1	3	6	1	5	2	1	1	1	1	1	1
Extractive & Mineral Processing	9	7	4	8	7	7	4	1	1	1	1	1	1	3	8	1	3	3	2	1	1	4	4	4	7	1
Financials	1	1	1	1	1	1	1	2	3	2	1	1	5	1	1	3	6	1	1	1	3	5	1	1	1	5
Food & Beverage	5	1	8	7	3	2	1	1	2	1	6	7	6	3	3	1	5	1	8	6	1	1	1	1	1	1
Health Care	2	1	3	1	2	1	2	1	4	5	7	6	4	1	2	3	3	1	3	1	3	5	1	1	1	1
Infrastructure	3	3	3	4	3	3	1	1	1	4	3	1	1	2	5	1	5	6	1	2	3	3	1	1	3	2
Renewable Resources & Alternative Energy	2	3	4	4	2	3	2	1	1	1	1	1	1	1	3	1	5	1	3	4	2	1	1	2	2	1
Resource Transformation	3	3	6	3	5	1	2	1	2	1	4	1	1	1	3	1	6	1	2	4	1	3	1	2	2	1
Services	1	1	4	2	1	2	1	2	3	1	2	4	4	2	3	3	1	1	1	1	2	3	2	1	1	1
Technology & Communications	2	1	5	3	3	1	1	4	5	1	1	1	1	2	3	5	4	1	2	5	1	1	5	1	1	3
Transportation	7	6	2	1	2	3	1	1	1	1	5	1	1	5	6	1	4	1	2	3	1	2	4	1	7	1

Source: Adapted from Savi et al. (2025)

Table 5. Weight for ESG aspect by sector

Industry	Environment (WE)	Social (WS)	Governance (WG)	Total (WT)
Consumer Goods	10	21	20	51
Extractive & Mineral Processing	42	22	30	94
Financials	6	20	25	51
Food & Beverage	26	31	26	83
Health Care	10	35	20	65
Infrastructure	19	20	27	66
Renewable Resources & Alternative Energy	18	13	22	53
Resource Transformation	21	17	23	61
Services	11	25	14	50
Technology & Communications	15	24	24	63
Transportation	21	23	26	70

Source: Adapted from Savi et al. (2025)

Equation 3 shows the formula to generate the score for environmental (SC_e), social (SC_s), and governance (SC_g) score. Equation 4 calculates the individual score for each supplier (S_C). Moreover, Equation 5 shows the formula to calculate the SC ESG score (SC_{esg}). These equations are based on the weights of Table 4 and Table 5, and the score for each material topic should be inputted to obtain the weighted ESG scores for each SC dimension and the aggregated SC score.

$$SC^{e,s,g} = \frac{\Sigma_i^N t_i \, T_i^{E,S,G}}{\Sigma_i^N t_i} \quad (3)$$

$$S_C = \frac{(W_E \, SC_e + W_S \, SC_s + W_G \, SC_g)}{W_T} \quad (4)$$

$$SC_{esg} = \Sigma_i^N R_i S_{Ci} \quad (5)$$

Where t_i is the weight of each material topic by its occurrence as in Table 4; T_i is the score evaluated for each material topic; W_E , W_S, W_G are the weights of the environmental, social, and governance dimensions; where $W_T = W_E + W_S + W_G$. , $R_i = C, I, M, B$ is the relevance defined based on the contract with the anchor, divided into four categories. It should be noted that categorization by contract size captures economic exposure but may not fully reflect strategic criticality, as some suppliers may be highly critical to operations despite representing smaller contract values.

1. Critical (C) – 0-14% biggest contracts $C = 0.4$, 40% weight
2. Important (I) – 15-39% biggest contracts $I = 0.3$, 30% weight
3. Medium (M) – 40-69% biggest contracts $M = 0.2$, 20% weight
4. Basic (B) – 70-100% biggest contracts $B = 0.1$, 10% weight

2.4. Coefficients of Impact

The last step is to calculate the coefficients of impact for all ESG dimensions, to measure the real impact of the SC on the AC score, getting a consolidated score. Each dimension has its own particularities, requiring a specific approach.

The Environmental Coefficient of Impact (P_e) is shown on Equation 6. It is based on Schmidt et al. (2022), who presented a study where the steel industry emissions are distributed as 68% on scope 3, 13% scope 2, and 20% scope 1. Taking the assumption that the environmental aspects follow the same emissions pattern, 68% of the consolidated environmental score would come from the SC. This value is adopted as a fixed parameter based on sector-level emissions data, representing a methodological assumption that environmental impact from the SC follows the same distribution as GHG emissions. This simplification enables operationalization of the model but may not fully capture cases where a specific company's scope 3 profile deviates significantly from the industry average.

It should be noted that P_e differs from P_s and P_g in its computation approach: while P_e is fixed at the sector level based on published emissions data, P_s and P_g are computed dynamically from company and supplier-specific indexes. This asymmetry reflects the availability of sector-level environmental data in contrast to the more granular social and governance indexes and represents a deliberate methodological choice that could be revisited as more company-specific environmental data becomes available.

$$P_e = Scope\ 3\ emissions\ for\ economic\ sector = 68\% \quad (6)$$

The Social Coefficient of Impact (P_s) is calculated based on work accident indexes. This work uses the Work Accident Index (WAI) collected by the Brazilian Labor Ministry (MPT, 2022), shown on Table 6. The WAI represents the quantity of work accidents per 1,000 labor contracts in the state. The Governance Coefficient of Impact (P_g) is based on the Governance Transparency Index (GTI) from MBT (2020), which has a strong positive relationship with companies' value among financial markets and stakeholders (Liu et al., 2020). Both GTI and WAI are limited in this work to the Brazilian region, but the same indexes could easily be replicated using similar indexes from other areas. The use of WAI and GTI as proxies for social and governance impact, respectively, represents a deliberate methodological choice to operationalize dimensions that are otherwise difficult to quantify at the company level. However, it should be acknowledged that these are state-level indexes that aggregate performance across all industries and firms within a state, which may mask relevant company-specific variation. Alternative proxies could be considered in future adaptations of the model.

Table 6. WAI & GTI

State	Code	WAI	GTI
Acre	AC	6.52	6.53
Alagoas	AL	9.20	9.75
Amazonas	AM	11.92	8.67
Amapá	AP	7.04	9.83
Bahia	BA	7.76	8.60
Ceará	CE	8.13	10.00
Distrito Federal	DF	8.03	9.74
Espírito Santo	ES	13.53	10.00
Goiás	GO	11.56	8.85
Maranhão	MA	6.59	8.96
Minas Gerais	MG	12.32	10.00
Mato Grosso do Sul	MS	16.08	9.93
Mato Grosso	MT	13.19	9.74
Pará	PA	8.73	5.92
Paraíba	PB	6.10	9.83
Pernambuco	PE	8.96	9.60
Piauí	PI	6.68	7.18
Paraná	PR	14.21	9.96
Rio de Janeiro	RJ	10.11	7.80
Rio Grande do Norte	RN	8.37	9.10
Rondônia	RO	11.42	9.60
Roraima	RR	11.72	4.91
Rio Grande do Sul	RS	16.72	9.72
Santa Catarina	SC	17.50	9.21
Sergipe	SE	5.63	8.74
São Paulo	SP	13.95	9.60
Tocantins	TO	7.93	6.96

Source: Adapted from MPT (2022) and MBT (2020)

Equation 7 shows the formula to calculate the Social Coefficient of Impact (P_s), where WAI_{AC} represents the value from the state of the matrix of the AC, and WAI_{SC} is the value from the SC, calculated based on Equation 8, considering the relevance of the supplier (R). The same logic applies to the Governance Coefficient of Impact (P_g) in Equations 9 and 10.

$$P_s = \frac{WAI_{SC}}{(WAI_{SC}+WAI_{AC})} \quad (7)$$

$$WAI_{SC} = \Sigma_i^N R_i \, WAI_i \quad (8)$$

$$P_g = \frac{GTI_{SC}}{(GTI_{SC}+GTI_{AC})} \quad (9)$$

$$GTI_{SC} = \Sigma_i^N R_i \, GTI_i \quad (10)$$

2.5. Consolidated ESG Score and Empirical Application

Equation 11 presents the Consolidated ESG Score (S_esg), which integrates the AC and SC scores across all three dimensions, weighting each by the respective ESG dimension weight and Coefficient of Impact. Equation 12 reflects the consolidated ESG score already including the dimension weight values for the Steel Industry Sector based on the weights defined on Table 3.

$$S_{esg} = W_E(P_e SC_e + (1 - P_e)\, AC_e) + W_s\big(SC_s P_s + AC_s(1 - P_s)\big) + W_G\left(SC_g P_g + AC_g\big(1 - P_g\big)\right) \quad (11)$$

$$S_{esg} = 0.65(0.68SC_e + 0.32AC_e) + 0.24\big(SC_s P_s + AC_s(1 - P_s)\big) + 0.12\left(SC_g P_g + AC_g\big(1 - P_g\big)\right) \quad (12)$$

The model was applied using empirical data from a Brazilian steel company and their 20 most relevant suppliers. For confidentiality purposes, the companies' names are not shown and contract values are hidden. The AC is evaluated based on the sustainability report of 2023 and internal data on sustainability practices and policies. The SC is evaluated based on data collected during the AC's due diligence process, supported by the Protiviti Alliant platform (ICTS), which compiles information from media screening, regulatory lists, and other external databases. Based on this analysis, a sustainability score was assigned to each of the 26 sustainability topics included in the model, using a scale ranging from 0 to 10, where 10 represents the highest level of alignment with the sustainability practices considered in the model.

The complete scoring rubric used by the author is presented in Appendix 1A. In the assessments, a single evaluator (the lead author) selected the alternative that most accurately described the company's documented practices and policies at the time of assessment. Consistency across all 21 companies was ensured through the rubric itself, which anchored each score to predefined and observable criteria rather than open-ended judgment. The response alternatives for each topic follow a maturity progression structure, using capability levels through observable and verifiable criteria at each stage, from absence and initial adoption to full integration of sustainable practices, consistent with stage-based capability assessment frameworks established in the literature (Jamwal et al., 2025; Paulk et al., 1993; Wendler, 2012). In addition, the observable criteria defined at each level is consistent with the progressive disclosure practices in the SASB standard (SASB, 2022), reducing evaluator subjectivity across companies.

3. Results

3.1. Anchor Company

Table 7 summarizes the scores for each topic required to perform the evaluation. These values are input into the model, which calculates the Environmental, Social, and Governance scores according to Equation 1, and the AC ESG score according to Equation 2.

Table 7. Steel Industry Company Scores

Steel Industry Company		
Matrix State:		**São Paulo**
Environment	GE	10
	AQ	9
	EM	8
	WW	8
	WH	9
	EI	7

Table 7 (cont.). Steel Industry Company Scores

Steel Industry Company		
Matrix State:		**São Paulo**
Social	HR	9
	CP	9
	DS	9
	AA	4
	PQ	8
	CW	7
	SP	5
	LP	9
	EH	10
	EE	10
Governance	PD	9
	BM	6
	SM	9
	MS	9
	PI	9
	BE	9
	CB	8
	ML	9
	CI	9
	SR	7

$$AC_E = 8.6$$

$$AC_S = 9.2$$

$$AC_G = 8.8$$

$$AC_{ESG} = 8.8$$

The company presents a high maturity level in corporate sustainability. Even though it does not have a great score on every topic, it receives a high overall rating, especially because the specific topics with low grades (AA, SP, BM) are not material topics for the steel industry.

To assess the model's response to changes in the distribution of material topics, a scenario test was conducted in which the scores of AA, SP, and BM were replaced with the scores of EH, GE, and WH, respectively. This adjustment illustrates how changes in the relevance of specific sustainability topics affect the resulting ESG evaluation. Under this simulated scenario, the resulting values were $AC_E = 7.2$, $AC_S = 6.9$, $AC_G = 8.9$, and $AC_{ESG} = 7.3$.

3.2. Supply Chain

Table 8 shows the list of suppliers with their scores for each disclosure ESG topic. Table 9 shows the individual scores for each supplier focused on Environmental, Social, Governance, and ESG, along with their relevance level based on contract size (C, I, M, B), carrying weights of 40%, 30%, 20%, and 10% respectively when calculating the score of the entire SC.

Table 8. Supply Chain Scores per Topic

Suppliers	Industry	Enviroment						Social									Governance									
		GE	AQ	EM	WW	WH	EI	HR	CP	DS	AA	PQ	CW	SP	LP	EH	EE	PD	BM	SM	MS	PI	BE	CB	ML	CI	SR
Supplier A	Service	2	2	3	1	2	2	1	8	8	6	4	6	6	4	5	5	5	4	5	5	2	8	2	3	7	7
Supplier B	Technology & Communications	8	8	8	8	8	8	8	8	8	3	8	8	8	8	8	8	8	3	8	8	8	8	8	8	3	8
Supplier C	Extrative & Mineral Proccessing	8	8	8	8	8	3	4	8	8	3	8	8	8	8	8	8	8	3	8	8	8	1	8	2	3	8
Supplier D	Consumer Goods	8	8	8	8	8	8	8	8	8	3	8	8	8	8	8	8	8	3	8	8	8	8	8	8	3	8
Supplier E	Service	8	8	8	8	8	8	8	2	2	2	8	8	8	8	8	8	8	4	8	8	8	5	8	8	7	7
Supplier F	Service	8	8	7	8	7	8	8	8	8	8	8	8	8	7	8	8	8	4	8	8	8	3	8	8	4	8
Supplier G	Service	5	5	3	4	7	7	2	8	8	6	4	6	6	4	5	5	5	4	5	5	2	8	3	3	7	7
Supplier H	Insfrastructure	8	8	3	8	8	8	8	8	8	8	8	3	8	8	8	8	8	8	3	8	8	8	8	8	8	2
Supplier I	Insfrastructure	8	3	8	3	8	8	8	8	8	3	8	8	8	5	4	5	8	8	3	8	8	8	8	8	8	2
Supplier J	Resource Transformation	8	8	8	8	8	3	8	4	8	8	8	8	8	8	8	8	3	8	8	8	8	4	8	8	8	8
Supplier K	Insfrastructure	8	8	8	3	8	3	8	4	8	8	8	8	8	8	8	8	3	2	8	8	8	4	8	8	8	8
Supplier L	Insfrastructure	1	8	8	8	8	8	8	8	8	8	3	8	8	8	8	8	8	3	8	8	8	8	8	3	5	8
Supplier M	Insfrastructure	1	8	8	8	8	8	8	8	8	8	3	8	8	8	8	8	8	3	8	8	8	8	8	3	5	8
Supplier N	Consumer Goods	8	8	8	2	8	8	8	8	8	8	8	8	3	8	8	8	8	8	8	3	8	8	8	3	8	8
Supplier O	Extrative & Mineral Proccessing	8	3	8	8	8	8	3	3	8	8	8	8	3	4	5	4	3	3	8	8	8	3	3	3	8	8
Supplier P	Insfrastructure	8	8	3	3	7	7	3	3	9	8	8	3	8	8	8	8	3	3	8	8	8	3	3	8	8	3
Supplier Q	Service	1	2	8	8	2	8	2	8	8	1	8	8	1	2	8	8	8	1	8	8	8	8	8	8	1	1
Supplier R	Resource Transformation	8	8	8	5	5	5	2	8	8	2	8	2	2	3	3	3	2	2	8	8	8	2	2	8	2	1
Supplier S	Service	2	2	1	2	3	1	2	8	8	2	8	2	2	2	2	1	2	2	8	2	8	2	3	8	2	2
Supplier T	Consumer Goods	8	8	8	8	8	8	8	8	8	3	8	8	8	8	8	8	8	3	8	8	8	8	8	8	3	8

Table 9. Supply Chain Scores per Category

Suppliers	Relevance	E	S	G	ESG
Supplier A	C	2.2	5.6	4.9	4.7
Supplier B	C	8.0	7.8	7.6	7.8
Supplier C	C	7.2	7.0	4.6	6.3
Supplier D	I	8.0	7.8	7.5	7.7
Supplier E	I	8.0	6.6	6.9	7.0
Supplier F	I	7.5	7.9	6.4	7.4
Supplier G	I	4.6	5.7	5.0	5.3
Supplier H	I	7.2	7.8	7.4	7.4
Supplier I	M	6.2	5.6	7.4	6.5
Supplier J	M	7.8	7.8	6.2	7.2
Supplier K	M	6.2	7.8	5.3	6.3
Supplier L	M	6.9	7.3	6.4	6.8
Supplier M	M	6.9	7.3	6.4	6.8
Supplier N	M	6.8	7.8	7.3	7.4
Supplier O	B	7.2	4.8	5.0	5.9
Supplier P	B	5.8	7.3	4.9	5.9
Supplier Q	B	6.3	5.9	6.5	6.1
Supplier R	B	6.7	4.8	4.3	5.3
Supplier S	B	1.5	3.6	3.9	3.2
Supplier T	B	8.0	7.8	7.5	7.7

SC score results:

$$SC_E = 6.4$$

$$SC_S = 6.9$$

$$SC_G = 6.1$$

$$SC_{ESG} = 6.5$$

This suggests that, although the SC still has room for improvement in sustainability practices and policies, it demonstrates a noteworthy level of sustainability maturity. This happens because the company evaluated already has good ESG practices and a due diligence process when selecting suppliers, and suppliers with very low standards and high risks would not be acceptable to be part of the SC.

In this case study, critical suppliers (category C) presented ESG scores of 4.7, 7.8, and 6.3, with one supplier scoring notably below the SC average of 6.5. Given that critical suppliers carry a weight of 40% in the SC score calculation, their performance has an outsized influence on the consolidated result. Important suppliers (category I) showed a wider range of performance (5.3 to 7.7), while medium and basic suppliers generally clustered in lower score ranges, reflecting their reduced strategic weight in the model. From a management perspective, this highlights the importance of prioritizing ESG engagement with strategically critical suppliers.

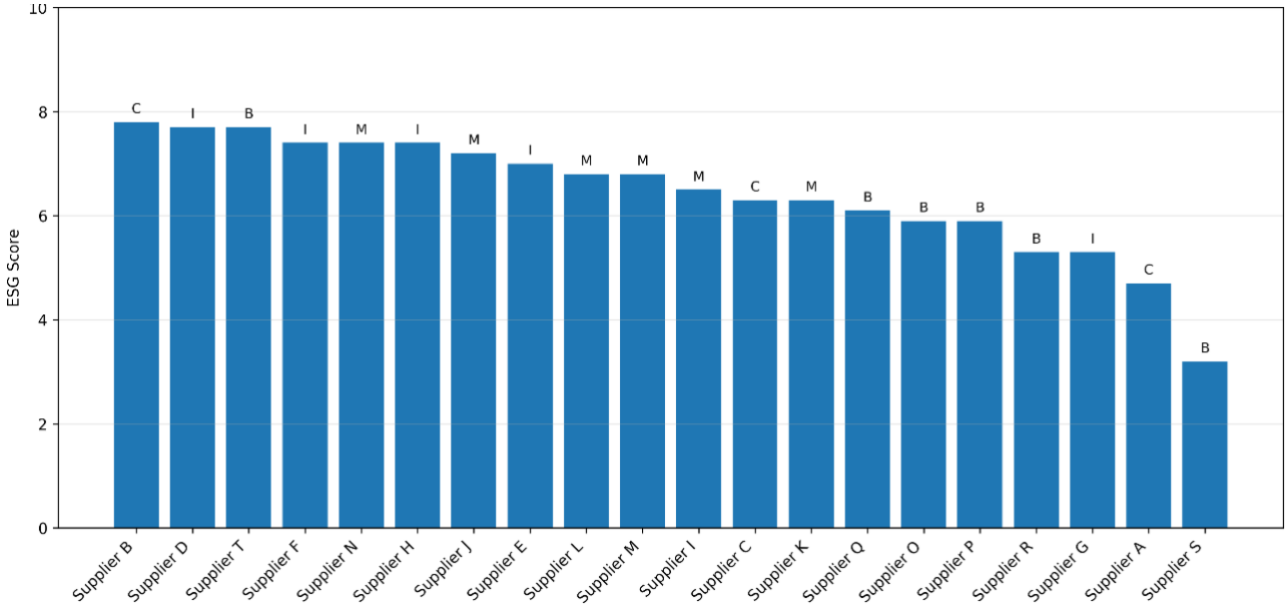

Figure 2. Supplier-Level ESG Score Distribution.

Letters above each bar indicate supplier relevance category: C = Critical, I = Important, M = Medium, B = Basic. As shown in Figure 2, the score distribution reveals big variability within categories. Critical suppliers show a range of 3.1 points (4.7 to 7.8), indicating heterogeneous ESG maturity among the suppliers with the greatest influence on the consolidated SC score, which may require attention. The concentration of most suppliers in the 6–8 range reflects a moderate sustainability maturity profile across the supply chain, with no extreme underperformers but limited evidence of best-in-class practices beyond the anchor company level.

3.3. Consolidated Sustainability Score

The Environmental Coefficient of Impact is P_e= 68%. The social and governance coefficients are calculated using Equations 7-10, based on the WAI and GTI data from Table 10.

Table 10. Companies' location, WAI, and GTI

Anchor	Location	WAI	GTI
AC	São Paulo	14.0	9.6
Suppliers	**Location**	**WAI**	**GTI**
Supplier A	Rio de Janeiro	10.1	7.8
Supplier B	São Paulo	14.0	9.6
Supplier C	São Paulo	14.0	9.6
Supplier D	Minas Gerais	12.3	10.0
Supplier E	São Paulo	14.0	9.6
Supplier F	Minas Gerais	12.3	10.0
Supplier G	Rio de Janeiro	10.1	7.8
Supplier H	São Paulo	14.0	9.6
Supplier I	São Paulo	14.0	9.6
Supplier J	São Paulo	14.0	9.6
Supplier K	São Paulo	14.0	9.6
Supplier L	São Paulo	14.0	9.6
Supplier M	São Paulo	14.0	9.6
Supplier N	Rio de Janeiro	10.1	7.8
Supplier O	Minas Gerais	12.3	10.0
Supplier P	Minas Gerais	12.3	10.0
Supplier Q	São Paulo	14.0	9.6
Supplier R	Minas Gerais	12.3	10.0
Supplier S	São Paulo	14.0	9.6
Supplier T	São Paulo	14.0	9.6

By inputting data on Table 10 on the model, the social and governance coefficients of impact are:

$$P_s = \frac{WAI_{SC}}{(WAI_{SC} + WAI_{AC})} = 47.86\%$$

$$WAI_{SC} = \Sigma_i^N R_i \, WAI_i = 12.8$$

$$P_g = \frac{GTI_{SC}}{(GTI_{SC} + GTI_{AC})} = 49.10\%$$

$$GTI_{SC} = \Sigma_i^N R_i \, GTI_i = 9.3$$

Using all the coefficients of impact, AC ESG score and SC ESG score as inputs for Equation 11, the ESG consolidated score, considering both AC and the SC is:

$$S_{esg} = 7.4$$

$$S_E = 7.1$$

$$S_S = 8.1$$

$$S_G = 7.5$$

The AC score of 8.8 ended up being a consolidated ESG score of 7.4 when considering the SC score (6.5). The environmental score combined 8.6 (AC) with 6.4 (SC), resulting in 7.1. The social score was 8.1, consolidating the AC (9.2) and the SC (6.9). The governance was 7.5, considering 8.8 (AC) and 6.1 (SC).

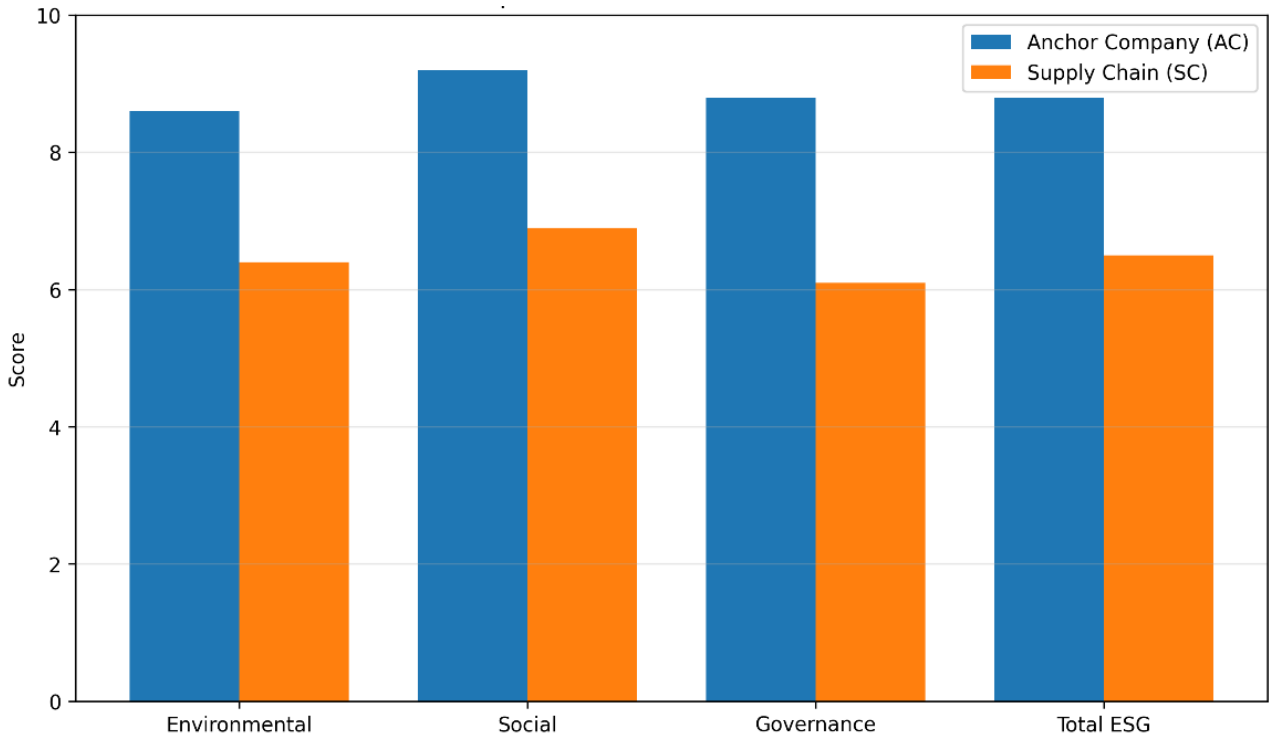

Figure 3. Comparison of AC and SC ESG Scores

Figure 3 highlights the gap between AC and SC performance across all three ESG dimensions, with the AC consistently outperforming the SC, particularly in the governance dimension. Which reinforces that the AC is high mature on ESG practices and the suppliers are still improving, and both will be considered and impact the ESG consolidated score

To clarify the impact of the SC score on the AC score, the same model was used with a score of 10 assigned to all topics for the AC, while scores of 0 were assigned to all suppliers. The result of this simulation is presented in Figure 4. Under this scenario, the final consolidated ESG score was 3.9, indicating that the consolidated score is composed of approximately 39% from the AC score and 61% from the SC component within the model. Figure 4 illustrates that under this extreme scenario, 61% of the consolidated score is driven by SC performance. It is important to note that this result is a structural consequence of the model's weighting parameters, particularly the Environmental Coefficient of Impact (P_e = 68%) adopted from Schmidt et al. (2022).

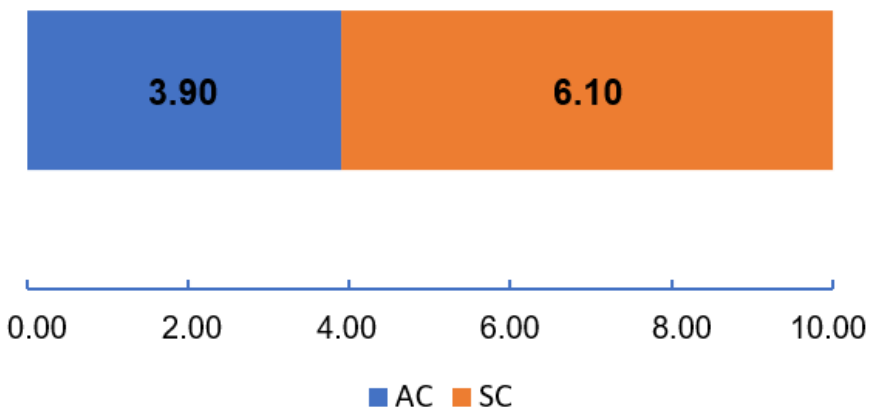

Figure 4. SC and AC score participation

This result indicates that 39% of the consolidated score is attributable to the AC's own performance, while 61% is driven by supply chain dynamics. This structural finding has direct implications for ESG strategy: companies that focus exclusively on their own operations risk overlooking the dominant driver of their consolidated sustainability performance. For steel companies, this suggests that ESG governance frameworks should explicitly integrate supply chain monitoring, supplier development programs, and contractual ESG requirements as core components of corporate sustainability strategy, rather than treating them as complementary measures.

After calculating the consolidated ESG score, it is important to contextualize the result within broader ESG performance ranges observed in the steel industry. ESG ratings provided by international agencies such as MSCI and Sustainalytics indicate that steel companies typically fall within intermediate ESG performance ranges due to the sector's high environmental intensity and transition challenges (MSCI, 2023). Sustainability assessments published by the World Steel Association similarly highlight structural decarbonization and supply chain management challenges as key factors influencing sector ESG outcomes (World Steel Association, 2023). However, direct numerical comparison between this model's output and external rating scores is constrained by methodological differences in how ESG performance is measured and aggregated across frameworks. In this context, the consolidated score of 7.4 (on a scale of 0 to 10) reflects the performance of this specific company and supply chain as measured by the model's parameters in this application. Cross-company benchmarking would require broader application of the model across multiple firms, which is identified as a direction for future research.

The findings of this study are consistent with and extend existing literature on supply chain sustainability. Schmidt et al. (2022) demonstrated that scope 3 emissions account for 68% of total emissions in the steel industry, highlighting the dominant role of supply chain activities in the sector's environmental footprint. The present study corroborates this finding from an ESG perspective: even when the anchor company presents strong sustainability performance (AC score of 8.8), the supply chain contribution accounts for 61% of the consolidated ESG score, reinforcing that supply chain dynamics extend well beyond the environmental dimension into social and governance outcomes. This alignment between emissions-based and ESG-based supply chain contributions strengthens the validity of the proposed model's weighting approach. Furthermore, the finding that strategically critical suppliers with lower ESG scores exert disproportionate influence on the consolidated result is consistent with Warmbier et al. (2022) and Koberg and Longoni (2019), who highlight the compounding effect of supplier sustainability performance on focal company outcomes.

This highlights the importance of collaborative engagement within the SC for effective ESG performance. Companies that engage suppliers in sustainability and ESG initiatives should achieve better results in both areas. This creates a win-win situation that improves ESG rating, reduces carbon costs, and builds stronger relationships with suppliers, enhancing both sustainability and financial resilience.

4. Limitations

Some limitations of this study should be acknowledged. First, the model was applied using empirical data from a Brazilian steel company and its supply chain, which limits the generalizability of the findings to other regions or industries. Given that the model was applied to a single anchor company, caution is warranted when extrapolating conclusions beyond this specific context. Although the model structure is based on internationally recognized frameworks such as SASB, the availability and consistency of ESG data may vary across companies and countries. In addition, part of the supplier information was obtained through the company's due diligence processes and internal evaluation platforms, which may introduce some degree of subjectivity or bias in the assessment of supplier sustainability performance.

Another limitation relates to the static nature of the analysis. The model evaluates ESG performance at a specific point in time and therefore does not capture how sustainability performance evolves over time. Future research could expand this approach by incorporating longitudinal data and dynamic tracking of ESG indicators. Furthermore, the model focuses primarily on upstream supply chain impacts and does not fully capture downstream activities, such as product use and end-of-life stages. Additionally, the scenario tests presented in this study illustrate the model's responsiveness to changes in inputs, but do not constitute a formal sensitivity analysis of model parameters. A systematic sensitivity analysis, testing robustness to variations in ESG dimension weights, supplier relevance weights, and impact coefficients, represents a relevant direction

for future research. Despite these limitations, the model provides a structured approach to integrate supply chain sustainability into corporate ESG evaluation, contributing to the growing literature on value chain accountability and sustainability management.

5. Conclusions

Corporate sustainability has become one of the most relevant topics in the modern era, and the supply chain plays a crucial role in that. The steel industry is one of the biggest contributors to GHG emissions and to the global economy. Due to that, the main objective of this work is to develop a sustainability evaluation model for the steel industry considering both the operations and the SC, aiming to assess sustainability performance and its impacts on industry emissions, particularly those related to scope 3.

Using empirical data from a steel industry company with strong ESG maturity (AC score of 8.8) and their supply chain (SC score of 6.5), the model produced a final consolidated ESG score of 7.4. The model's structure, anchored in sector-level scope 3 data (Schmidt et al., 2022), assigns 61% of the consolidated score to supply chain performance. This design reflects the empirical dominance of scope 3 emissions in the steel sector and highlights the critical role of suppliers in corporate sustainability and demonstrates that even companies with strong internal ESG practices may have their overall performance significantly influenced by supplier practices. Therefore, integrating ESG criteria into procurement policies, supplier evaluation, and monitoring processes becomes essential to mitigate sustainability risks and improve transparency across the value chain.

The influence of supply chain performance on the consolidated ESG score is consistent with prior research highlighting the importance of scope 3 emissions in corporate sustainability performance (Hertwich and Peters, 2009; CDP, 2021). In conclusion, this work highlights the critical importance of supply chain sustainability being part of the strategic planning of companies. By expanding the scope of corporate sustainability and exploring the gap between ESG performance across companies and their supply chains, this study proposes and tests a replicable ESG evaluation framework in the Brazilian steel industry context, offering structured guidance for companies addressing sustainability challenges and providing a foundation for future applications in other regions and sectors.

Authors' Contributions Antonio Savi: Conceptualization, methodology, validation, investigation, formal analysis, original draft preparation. Luan Santos: Conceptualization, methodology, validation, investigation, formal analysis, review and editing. Sofia Helena Zanella Carra: Conceptualization, methodology, validation, investigation, formal analysis, review and editing. Giovanna Tosto Franco: Final review and editing.

Data Availability The data supporting the findings of this study are not publicly available due to confidentiality constraints. The empirical application involves a Brazilian steel company and its suppliers, whose identities and contract values are protected. Data may be made available upon reasonable request to the corresponding author, subject to confidentiality and proprietary restrictions.

Declarations

Competing Interests The authors declare no competing interests.

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Appendix

1A – Reference for Scoring

This appendix presents the scoring rubric used to assess the sustainability performance of the Anchor Company and its 20 suppliers across the 26 material topics defined by the SASB. For each topic, five response alternatives are provided, corresponding to scores of 0, 2.5, 5, 7.5, and 10. Each alternative describes a distinct and observable level of sustainability practice, allowing the evaluator to select the option that best reflects the company's documented practices at the time of assessment.

Category 1: Environment

GHG Emissions (GE)

- 0: No GHG emissions monitoring or reporting in place.
- 2.5: Scope 1 emissions measured; no reduction targets or decarbonization plans formulated.
- 5: Scopes 1 and 2 monitored and reported; reduction targets defined; no structured decarbonization roadmap.
- 7.5: Full Scopes 1, 2, and 3 inventory; targets aligned with a recognized science-based or sector-specific decarbonization standard (e.g., SBTi); reduction projects underway.
- 10: Third-party verified inventory; net-zero targets with defined timeline; carbon capture and green hydrogen projects in implementation.

Air Quality (AQ)

- 0: No monitoring of atmospheric emissions (NOx, SOx, particulate matter).
- 2.5: Spot measurements conducted; no continuous monitoring or improvement targets established.
- 5: Continuous monitoring of key emissions; compliant with applicable legislation; improvement plans underway.
- 7.5: All atmospheric emissions monitored and publicly reported; investments in control technologies; consistent reduction trend documented.
- 10: Performance exceeds legal requirements; state-of-the-art technologies installed (bag filters, SCR); real-time monitoring in place.

Energy Management (EM)

- 0: No energy consumption monitoring or efficiency programs in place.
- 2.5: Energy consumption tracked; no efficiency targets or renewable energy use.
- 5: Energy efficiency program with defined targets; renewable sources present in the energy matrix.
- 7.5: Robust energy efficiency program with proven results; renewable energy share above 30%.
- 10: Continuous energy optimization through automation; roadmap to 100% renewables with defined timeline; energy management certification active (e.g., ISO 50001 or equivalent).

Water & Wastewater Management (WW)

- 0: No water consumption control or adequate effluent treatment.
- 2.5: Water consumption monitored; no reduction targets or reuse programs implemented.
- 5: Consumption controlled; effluents treated in accordance with legislation; basic water reuse program in place.

- 7.5: Reduction targets met with documented results; reuse rate above 70%; water quality of adjacent bodies monitored.
- 10: Near zero liquid discharge operation; water stewardship certification obtained; integrated watershed management and restoration projects in place.

Waste & Hazardous Materials Management (WH)

- 0: No adequate control or disposal of solid and hazardous waste.
- 2.5: Waste disposed of per minimum legal requirements; no reduction or valorization programs.
- 5: Formal waste management plan in place; legal targets met; co-processing or reuse of by-products (slag, mill scale) underway.
- 7.5: Waste valorization rate above 85%; by-products with high-value destinations; consistent generation reduction trend documented.
- 10: Zero waste target in implementation; 100% of by-products valorized internally or on the market; circular management recognized by independent audits.

Ecological Impacts (EI)

- 0: No assessment of biodiversity impacts in operations or value chain.
- 2.5: Basic flora and fauna surveys conducted only when required by environmental licensing.
- 5: Biodiversity management plan in place; legally required compensation for degraded areas; threatened species monitored in the area of influence.
- 7.5: Active conservation and ecological restoration program beyond legal requirements; partnerships with NGOs and research institutions.
- 10: Net positive biodiversity impact documented; reporting aligned with recognized biodiversity disclosure frameworks (e.g., TNFD or equivalent); significant forest restoration projects in implementation.

Category 2: Social

Human Rights & Community Relations (HR)

- 0: No human rights policy or community dialogue mechanism.
- 2.5: Formal human rights policy exists; no verifiable implementation or community communication channels.
- 5: Periodic community consultations conducted; active grievance mechanism; human rights policies implemented with training.
- 7.5: Structured human rights due diligence; effective grievance mechanism; community development programs with proven investment.
- 10: Robust FPIC process in place; reporting aligned with internationally recognized human rights principles (e.g., UN Guiding Principles — UNGP); social impact measured and published annually.

Customer Privacy (CP)

- 0: No customer data protection policy.
- 2.5: Basic privacy policy exists; inadequate technical controls; incomplete regulatory compliance.
- 5: Compliant with applicable data protection law; DPO appointed; basic data protection controls implemented.

- 7.5: Structured privacy program with regular risk assessments (DPIA); training in place; formal incident management process.
- 10: Mature privacy program with recognized certification (e.g., ISO 27701 or equivalent); independent audit conducted; privacy by design embedded in all systems.

Data Security (DS)

- 0: No cybersecurity controls or information security policy.
- 2.5: Basic IT controls in place; no cyber risk assessment or incident response plan.
- 5: Active information security policy; periodic vulnerability assessments; basic business continuity plan.
- 7.5: Cybersecurity framework implemented (e.g., NIST CSF or equivalent); dedicated SOC; regular penetration testing; incident response plan tested.
- 10: Information security certification active (e.g., ISO 27001 or equivalent); regular red team exercises conducted; OT security integrated with IT.

Access & Affordability (AA)

- 0: No consideration of product or service access for vulnerable populations or remote regions.
- 2.5: Isolated access initiatives exist; no formal structure or defined targets.
- 5: Structured access program with defined targets; social aspects considered in the product portfolio.
- 7.5: Partnerships with government and civil society to expand access; products developed for emerging markets; social impact monitored.
- 10: Access strategy aligned with sustainable development agenda; impact verified and published annually.

Product Quality & Safety (PQ)

- 0: No quality management system or product compliance controls.
- 2.5: Basic quality system implemented; recurring non-conformities on record.
- 5: Quality management certification active (e.g., ISO 9001 or equivalent); low non-conformity rate; formal traceability and recall management process.
- 7.5: Robust quality system with zero critical defects; full product traceability; sector-specific certifications in place (e.g., ABNT, API, or equivalent).
- 10: Multiple certifications active; end-to-end digital traceability; zero recalls in the past 3 years.

Customer Welfare (CW)

- 0: No assessment of product impacts on customer health and safety throughout the lifecycle.
- 2.5: Safety data sheets (SDS) provided; no proactive customer support programs.
- 5: Structured technical support program; complete product safety documentation; active complaint channels.
- 7.5: Customer partnership program for safe product applications; post-sale monitoring; NPS tracked and documented.
- 10: Full life cycle assessment (LCA) conducted for impact evaluation; collaboration with customers integrated into product development.

Selling Practices & Product Labeling (SP)

- 0: No compliance policies for commercial practices or product labeling.
- 2.5: Minimum legal labeling requirements met; no additional transparency to customers.

- 5: Transparent product information; basic Environmental Product Declarations (EPDs) available for key product lines; compliant with advertising standards.
- 7.5: Verified EPDs in place; responsible communication practices; low history of regulatory complaints.
- 10: Third-party verified EPDs available for the full product range; communication practices recognized for environmental and social transparency.

Labor Practices (LP)

- 0: Basic labor obligations not met; no diversity, equity, and inclusion (DEI) policies.
- 2.5: Compliant with labor legislation; no structured DEI or people management programs.
- 5: DEI policy implemented; professional development programs in place; stable labor relations with trade unions.
- 7.5: Robust DEI program with targets and tracked indicators; low turnover; positive climate survey results with action plans documented.
- 10: Parity targets achieved; recognized workplace certification active (e.g., Great Place to Work or equivalent); leading employee well-being programs in place.

Employee Health & Safety (EH)

- 0: No occupational health and safety (OHS) management system; high accident and fatality rates.
- 2.5: Basic OHS system in place; Total Recordable Incident Rate (TRIR) above sector average.
- 5: OHS management certification active (e.g., ISO 45001 or equivalent); TRIR within sector average; incident investigation process formalized.
- 7.5: TRIR below sector average; proactive behavioral safety program; zero fatalities over the past 3 years.
- 10: Vision Zero target in implementation; TRIR near zero; comprehensive health program (physical and mental) covering all employees.

Employee Engagement, Diversity & Inclusion (EE)

- 0: No workforce diversity monitoring or employee engagement surveys.
- 2.5: Basic diversity data collected; no inclusion targets or programs.
- 5: Diversity and inclusion program with representativeness targets; annual engagement survey with action plans.
- 7.5: Diversity targets progressively being met; mentoring programs for underrepresented groups; engagement above 75%.
- 10: Parity achieved at all organizational levels; engagement above 85% with continuous improvement documented.

Category 3: Governance

Product Design & Lifecycle Management (PD)

- 0: No sustainability considerations in new product development.
- 2.5: Environmental impacts assessed reactively and sporadically during product design.
- 5: Formal ecodesign process in place; carbon footprint calculated for key products via LCA; lower-impact product line available.
- 7.5: Sustainable product portfolio consolidated; third-party verified LCAs for main SKUs; low-carbon product roadmap defined.

- 10: Portfolio aligned with applicable sustainability classification frameworks; verified LCAs published for the full product range.

Business Model Resilience (BM)

- 0: No assessment of climate or energy transition risks to the business model.
- 2.5: Basic risk assessment conducted; no scenario analysis or structured adaptation plans.
- 5: Climate scenario analysis conducted aligned with recognized disclosure frameworks (e.g., TCFD or equivalent); risks and opportunities identified and integrated into strategic planning.
- 7.5: Climate risk report published; scenario analysis covers multiple time horizons; transition roadmap with defined investments.
- 10: Business strategy aligned with low-carbon economy transition; investments in DRI-H2 and carbon capture documented; climate risk reporting fully implemented.

Supply Chain Management (SM)

- 0: No ESG criteria assessed for suppliers.
- 2.5: Basic sustainability contractual clauses exist; no effective monitoring.
- 5: ESG assessment of critical suppliers conducted annually; supplier code of conduct published and communicated.
- 7.5: Supplier development program focused on sustainability; regular audits conducted; improvement plans formalized for critical suppliers.
- 10: Supply chain traceable and certified for critical inputs; complete verified Scope 3 report published.

Materials Sourcing & Efficiency (MS)

- 0: No monitoring of material use efficiency or waste reduction targets.
- 2.5: Raw material consumption tracked; no improvement targets or waste reduction programs.
- 5: Materials efficiency program with targets and documented results; substitution of virgin materials with recycled scrap underway.
- 7.5: Scrap recycling rate in metallic charge above 50%; yield indicators consistently improving; critical material traceability in place.
- 10: Scrap use above 70%; full circular economy in by-product management; zero raw material waste documented.

Physical Impacts of Climate Change (PI)

- 0: No assessment of facility vulnerabilities to extreme weather events.
- 2.5: Basic physical climate risk mapping conducted; no structured adaptation plans.
- 5: Physical climate risk assessment formalized; contingency plans for critical events (flooding, droughts) developed.
- 7.5: Climate adaptation investments made; infrastructure designed for 2050 scenarios; continuity plans tested.
- 10: All facilities assessed against 1.5°C and 2°C scenarios; adaptation plans implemented and reported under recognized climate disclosure frameworks (e.g., TCFD or equivalent).

Business Ethics (BE)

- 0: No code of conduct or anti-corruption policy.
- 2.5: Code of conduct exists; no training, whistleblower channel, or effective enforcement mechanisms.

- 5: Code of conduct with regular training; active whistleblower channel; anti-corruption policy aligned with applicable legislation.
- 7.5: Robust compliance program with dedicated committee; third-party due diligence conducted; clean regulatory sanction history.
- 10: Anti-corruption management certification active (e.g., ISO 37001 or equivalent); compliance report published; integrity culture verified by independent survey.

Competitive Behavior (CB)

- 0: No fair competition policies in place, or history of anticompetitive practices.
- 2.5: Basic antitrust policies exist; no training or compliance monitoring.
- 5: Fair competition policy implemented with periodic training; no recent history of sanctions for anticompetitive practices.
- 7.5: Structured competition compliance program; regular reviews of commercial practices; proactive collaboration with regulators.
- 10: Zero antitrust sanctions in the past 5 years; active participation in sector-wide fair practices initiatives.

Management of the Legal & Regulatory Environment (ML)

- 0: Reactive stance toward regulation; no proactive engagement with regulators or government bodies.
- 2.5: Regulatory changes monitored; no engagement strategy or transparent lobbying.
- 5: Participates in public consultations; lobbying disclosed per applicable law; formal regulatory strategy in place.
- 7.5: Proactive and constructive engagement with regulators; public positions aligned with sustainability agenda; advocacy transparent and documented.
- 10: Leadership roles in sector forums (e.g., worldsteel, national associations); lobbying fully disclosed and aligned with public interest.

Critical Incident Risk Management (CI)

- 0: No emergency response plans or critical operational risk management.
- 2.5: Basic emergency plans exist; not regularly tested or integrated with corporate risk management.
- 5: Emergency response plans updated and tested annually; formalized operational risk matrix; adequate insurance coverage.
- 7.5: Integrated critical risk management system; periodic simulation exercises conducted; crisis communication plans tested; lessons learned documented.
- 10: Business continuity certification active (e.g., ISO 22301 or equivalent); emergency response performance recognized by external audits; operational resilience demonstrated.

Systemic Risk Management (SR)

- 0: No assessment of systemic risks (macroeconomic, sectoral, climate) or integration into corporate strategy.
- 2.5: Basic systemic risk assessment conducted; no integration into strategic decision-making.
- 5: Systemic risks mapped and integrated into strategic planning; annual risk management report published.
- 7.5: Integrated ERM framework; scenario analysis covers climate, geopolitical, and market risks; board-level oversight established.
- 10: Systemic risks fully embedded in strategy and governance; reporting aligned with recognized sustainability and risk disclosure frameworks (e.g., TCFD, GRI, or equivalent); framework recognized by institutional investors.