Journal of Management and Sustainability; Vol. 14, No. 2; 2024
ISSN 1925-4725 E-ISSN 1925-4733
Published by Canadian Center of Science and Education

Sustainability Indicators in the Integrated Management of Industries with Galvanic Activities

Sheilla da S. M. Figueirêdo[1], José G. de Araujo Filho[2], Thiago J. M. Rocha[3], Francisco J. de Paula Filho[4] & Marilia G. dos S. Cavalcanti[1]

[1] Center for Exact and Nature Sciences, Federal University of Paraiba, João Pessoa, Paraíba, Brazil

[2] Regional University of Cariri, Department of Production Engineering, Science and Technology Center, Juazeiro do Norte, Ceará, Brazil

[3] Alagoas State University of Health Sciences (UNCISAL), Medicine Course, Maceió, Alagoas, Brazil

[4] Federal University of Cariri, Science and Technology Center, Juazeiro do Norte, Ceará, Brazil

Correspondence: Sheilla Figueirêdo, Federal University of Paraiba, João Pessoa, Paraíba, Brazil.

Received: June 20, 2024   Accepted: August 18, 2024   Online Published: September 8, 2024

doi:10.5539/jms.v14n2p53   URL: https://doi.org/10.5539/jms.v14n2p53

Abstract

Growing concern for sustainability has driven industries, including the galvanic sector, to adopt more responsible practices due to their significant environmental and occupational impacts. This article discusses the importance of integrating quality, environmental, and occupational safety management (ISO 9001, 14001, and 45001) and highlights the need for specific indicators to measure sustainability in this sector. Using the Delphi technique, experts and workers from the galvanic industry identified and validated relevant performance indicators. The results improve management and performance, promoting the competitiveness and sustainability of the galvanic industry. The research identified 39 key indicators covering resource consumption, waste generation, occupational safety, governance, and quality. These indicators help companies monitor and enhance their socio-environmental performance, aligning with the Sustainable Development Goals (SDGs) and ESG (Environmental, Social, and Governance) practices.

Keywords: sustainable development, indicators, Galvanic Industry, Integrated Management

1. Introduction

The growing concern about the global environmental crisis has driven the search for more sustainable development, prompting companies to integrate socio-environmental factors into their management (Klein, 2014). Despite its economic importance, the galvanic industry poses significant environmental and occupational hazards (Innocenzi et al., 2020; Figueirêdo et al., 2021; Oliveira et al., 2019; Lositska, 2018), requiring an integrated management system that addresses quality, environment, and occupational safety, in line with the Sustainable Development Goals (SDGs) (UN, 2015).

ISO standards 9001, 14001, and 45001 offer guidelines for implementing this integrated management system, promoting process optimization, cost reduction, and improving the company's image (Bertolino & Couto, 2018). However, measuring sustainability in the galvanic industry remains challenging due to the lack of specific and relevant indicators for the sector (Mengistu & Panizzolo, 2023).

Currently, companies use generic indicators that do not reflect the specific characteristics and needs of the galvanic industry. However, this practice hinders strategic decision-making and implementing improvements, leading to inefficient management and difficulties in identifying bottlenecks, opportunities for improvement, and monitoring progress in sustainability (Ahmad & Wong, 2019).

Investors and consumers increasingly value companies that adopt ESG (Environmental, Social, and Governance) practices, emphasizing the importance of integrating these practices into organizational processes to meet the growing demands for sustainability. This demand reflects a growing awareness of the importance of considering environmental, social, and governance impacts in investment and consumption decisions (Vanham & Schwab, 2021; Henderson, 2020; Khan, Serafeim, & Yoon, 2016).

By incorporating ESG principles into their operations, companies demonstrate a commitment to sustainable development, which can generate benefits such as increased attractiveness to investors, strengthened reputation, and customer loyalty. Moreover, adopting these practices directly enhances corporate sustainability, positively impacting organizational processes and business performance. Additionally, risk management improves as ESG companies are better prepared to handle socio-environmental issues that may affect their business (Eccles & Serafeim, 2014).

In this context, creating sustainable alternatives for the industrial sector is crucial. Implementing an Integrated Management System (IMS) serves as a primary instrument for the sustainable development of companies and industries (Tachizawa & Pozo, 2010).

The IMS combines processes, procedures, and practices to implement policies and achieve objectives more efficiently than separate systems. Management has evolved from focusing solely on accounting and finance to including quality, environmental, and occupational health and safety aspects, which are essential for competitiveness. Systems that centralize customers, production, and labor significantly increase company value (Bertolino & Couto, 2018).

Therefore, identifying and validating a set of specific, relevant, and effective performance indicators for the galvanic industry is crucial. These indicators should enable companies to assess and improve performance, considering their particularities, challenges, and management needs.

The Delphi technique, involving a panel of experts, is a promising methodology for identifying and validating these indicators (Rozados, 2015; Munaretto, Corrêa, & Cunha, 2013). The expertise and diversity of perspectives from the specialists in the Delphi panel will help construct a comprehensive system of indicators that address the sector's needs, including ISO 9001, ISO 14001, ISO 45001 standards, and ESG aspects.

From this perspective, this study aims to identify and validate specific performance indicators for the galvanic industry using the Delphi technique. The research results are expected to improve management and performance in the sector, promoting competitiveness and sustainability.

2. Research Methods

This descriptive and exploratory investigation involved experts and workers in the galvanic industry. Due to the nature of the findings, we used a quantitative approach in all three research stages and a qualitative approach for the data obtained in the first stage (Munaretto et al., 2013).

Qualitative and quantitative approaches complement each other, providing a better understanding of the sector's sustainability issues and contributing to effective analysis and solutions (Lakatos & Marconi, 2010). The Delphi technique was used to achieve the general objective of defining sustainability indicators for the management of galvanic industries (Tachizawa & Pozo, 2010; Veiga, 2014).].

The Delphi technique gathers experts' experience and knowledge in a specific field, using a multidisciplinary approach to gain a deeper understanding of the study's focus (Rozados, 2015; Munaretto et al., 2013). This method also aims to achieve expert consensus on sustainability indicators for the galvanic industry. Additionally, it maintains participants' anonymity and eliminates biases related to academic or professional status, encouraging more active and unbiased participation (Munaretto et al., 2013; Dalkey, 2018).

This study was submitted to and approved by the Research Ethics Committee of the Federal University of Paraíba, under Protocol no. 5.722.746 (CE/CCS/UFPB), through Platform Brazil, CAAE no. 63118022.4.0000.5188.

2.1 Study Area

The study area involved the municipality of Juazeiro do Norte-CE, part of the Cariri Metropolitan Region (RMC), one of the most important regions of the State of Ceará, northeastern Brazil. The municipality occupies an area of 249 km² and has a population of 270,383 inhabitants, according to estimates from the Brazilian Institute of Geography and Statistics (IBGE, 2017).

A study with the Municipal Environmental Authority of Juazeiro do Norte (AMAJU) identified 19 licensed veneer semi-jewelry industries in the municipality. Managers and workers from these industries participated in the research.

2.2 Selection of Subjects for Participation in the Validation of Indicators

The original Delphi interviewees were not chosen randomly but were carefully selected from all areas related to the research topic: galvanic industry processes, administration, quality management, environmental management, occupational safety management, and sustainable development. The Delphi technique emphasizes the importance of diversity and expertise among participants to ensure the quality and validity of the resulting forecasts and decisions, but it does not set fixed rules regarding the number of specialists involved (Nutt, 2002; Rowe & Wright, 1999).

Participants were chosen based on the following inclusion criteria: being from the scientific field with research related to the study topics (electroplating, sustainable development, quality management, environmental management, occupational safety management), being a manager or worker in the galvanic industry, or being an environmental inspection professional. The exclusion criteria used in this study were: not being from the study topic area (electroplating, sustainable development, quality management, environmental management, occupational safety management) or not being an environmental inspection professional. A total of 70 invitations were sent for participation in the research.

2.3 Research Steps

The Delphi technique involves several well-defined stages designed to systematically and iteratively collect and refine expert opinions. The main stages of this process are described below:

- First stage: Initial collection and suggestions. In this stage, experts evaluate a preliminary set of indicators. They can suggest new indicators or alter the text of the proposed ones if necessary. To facilitate suggestions, a space is provided at the end of the instrument for participants to record their contributions descriptively.

- Second Stage: Analysis and Resubmission. The data collected in the first stage are analyzed to identify trends and areas of consensus or divergence. Based on this analysis, a second instrument (Instrument 2) is developed and sent to participants via Google Forms. This instrument, along with the consolidated feedback from the first stage, allows experts to reassess their responses considering contributions from others.

- Third Stage: Refinement and New Feedback. After analyzing the responses from the second stage, a third round of data collection is conducted. Instrument 3, accompanied by the tabulated results from the second stage, is sent to participants. This comprehensive feedback enables experts to adjust their responses based on the consolidated opinions of the group. This stage continues refining the responses and aims to further reduce divergences.

- Final Stage: Consolidation and Consensus. At the end of multiple rounds, the experts' opinions are consolidated to achieve a final consensus. The resulting list contains validated sustainability indicators for the galvanic industry, representing the convergence of the experts' opinions and ensuring that the indicators are robust and reflective of collective perspectives.

2.4 Bibliographic Survey

- Literature review and document survey: The goal was to identify models used for developing sustainability indicators. This review gathered information on the process of constructing the concept of sustainable development, its historical context, and its interrelationships with socio-environmental impacts caused by Industries with galvanic activities. It also covered the Brazilian legal foundations under which this concept has developed. The review, combined with document research on specific legislation, data, and reports related to indicators in Brazilian business management, formed the basis for developing the first data collection instrument.

- Comparative Analysis of Management System Standards: A comparative analysis of the Quality Management System ISO 9001 (NBR ISO 9001, 2015), the Environmental Management System ISO 14001 (NBR ISO 14001, 2015), and the Occupational Health and Safety Management System ISO 45001 (NBR ISO 45001, 2018) was conducted. This analysis combined the covered requirements, resulting in the Integrated Management System as the first step toward structuring the indicator system.

2.5 Elaboration of the Instrument

The initial indicators for the instrument were based on the Ethos Indicators for Sustainable and Responsible Businesses (Instituto Ethos, 2013). These indicators focus on evaluating the integration of sustainability and social responsibility into business practices, helping define strategies, policies, and processes (Pescador, Briere, & Novak, 2016). They enable self-assessment of management regarding the incorporation of social responsibility into strategic planning and overall monitoring (Penteado & Duarte, 2014).

Indicators meeting the requirements of ISO 9001 (quality management), ISO 14001 (environmental management), and ISO 45001 (occupational health and safety management) standards were added, along with ESG aspects. The ESG (Environmental, Social, and Governance) aspects emphasize integrating sustainable and socially responsible practices into business strategies, demonstrating that business prosperity and social progress can, and should, coexist (Porter & Kramer, 2011).

In this context, the proposed **environmental** indicators cover resource consumption (water, energy, raw materials, packaging materials, and fossil fuels), waste generation and treatment (hazardous waste, galvanic sludge, liquid and gaseous effluents), and atmospheric emissions, aiming to reduce the sector's environmental impact. The **social** indicators address workers' health and safety, including accident and illness rates, exposure to chemicals, training, awareness campaigns, and workplace improvement programs. Indicators like job quality, additional payments and benefits, and monitoring the health and safety of third parties demonstrate the company's concern for employee well-being and social responsibility.

Governance indicators evaluate investment in infrastructure and services for public benefit, methods for monitoring quality, efficiency, and productivity, customer impact, and the performance of products, services, and teams. These indicators reflect the pursuit of transparent, efficient, and responsible management.

Additionally, the Sustainable Development Goals (SDGs) (UN, 2015) were considered. The relevant SDGs for the galvanic industry address water consumption and pollution (SDG 6), energy use and greenhouse gas emissions (SDG 7), health and safety risks for workers (SDG 8), innovation and cleaner technologies (SDG 9), hazardous waste generation (SDG 12), and contribution to climate change (SDG 13).

The responses were classified using the Likert scale (Linstone & Turoff, 2002), allowing participants to express the importance of each indicator (5—Very important; 4—Important; 3—Desirable; 2—Not a priority; 1—Dispensable). Indicators were selected if 75% of evaluations rated them as "important" or "very important." Data collection was conducted via Google Forms due to its ease of use, remote access, and anonymity. These features encourage participation and honesty, which are crucial for the success of the Delphi technique (Greener & Martelli, 2015; Gordon, 1994; Linstone & Turoff, 2002). Figure 1 presents the content of the instruments applied in the three stages of the Delphi Technique.

Instrument 1

- Preliminary sustainability indicators in the social, environmental, and economic dimensions, each containing a Likert scale classification (5 - Very important; 4 - Important; 3 - Desirable; 2 - Not a priority; and 1 - Dispensable) for each indicator;
- Space at the end of the questionnaire for suggestions.

Instrument 2

- Sustainability indicators in the social, environmental, and economic dimensions, with evaluations above 75% in the relevance levels 4 "important" and 5 "very important" in the first stage of the Delphi Technique;
- Insertion of new sustainability indicators suggested by experts in the previous stage;
- Change in the text of indicators suggested by experts in the previous stage and approved by the authors;
- A Likert scale classification (5 - Very important; 4 - Important; 3 - Desirable; 2 - Not a priority; and 1 - Dispensable) for each indicator.

Instrument 3

- Sustainability indicators in the social, environmental, and economic dimensions, with an evaluation above 75% in relevance grades 4 "important" and 5 "very important" in the 2nd stage of the Delphi Technique;
- A Likert scale classification (5 - Very important; 4 - Important; 3 - Desirable; 2 - Not a priority; and 1 - Dispensable) for each indicator;
- For each indicator, a space was added to provide a justification if the participant evaluates the indicator as "3-desirable".

Figure 1. Content of the Instruments applied in the 3 stages of the Delphi Technique

Source: The authors, 2024.

2.6 Data Analysis

2.6.1 Data Organization

The collected data were systematically organized into tables and graphs, facilitating analysis and comparison across different rounds. This structuring allowed for clear visualization of the responses and changes in opinions throughout the process. Descriptive statistics and Spearman's correlation coefficient were used to analyze the data, providing a comprehensive view of the experts' opinions. Measures of central tendency, dispersion, position, and graphical representation facilitated data interpretation, while Spearman's coefficient assessed the consistency and relationship between responses across rounds, contributing to the robustness and validity of the research results.

- Data organization was done in Microsoft Excel spreadsheets and then imported into the Statistical Package for the Social Sciences (SPSS) and Statistica 12 for descriptive analysis and calculation of measures of central tendency. This process demonstrated the reference values that established the degree of consensus among the respondents.

2.6.2 Descriptive Statistics

To summarize and interpret the data from the experts, various descriptive statistical measures were employed. The general linear model (Ostertagova & Ostertag, 2013) with post-hoc tests (Nogueira, 2004) identified where differences occurred. Welch's correction was used to infer the F statistic for non-homogeneous variances among groups (Hajji & Leyrat, 2018), and Dunnett's post-hoc test was applied for heterogeneous variances (Sauder & DeMars, 2019).

Analyses were conducted in two stages: first, determining if there was a significant difference in at least one variable. If so, post-hoc tests identified which variables differed and in which profiles.

2.6.3 Spearman Correlation Coefficient

Spearman's correlation coefficient was used to analyze the relationship between experts' responses and evaluate the consistency of opinions across rounds (Genest, Nešlehová, & Rémillard, 2013), including the coefficient of determination and the regression line (Altman & Krzywinski, 2015). This non-parametric measure was chosen for its suitability for ordinal data and its lack of assumption about normal data distribution.

Descriptive statistical analysis combined with Spearman's correlation provided a detailed understanding of the patterns and trends in the experts' responses. Comparing rounds revealed the degree of consensus achieved and identified areas of greater or lesser agreement. This analytical approach was essential for synthesizing the experts' opinions and supporting decisions based on collective evaluations.

- Calculation of Spearman's Coefficient: Spearman's Coefficient was calculated for each pair of questionnaire rounds by measuring the strength and direction of the association between experts' response rankings.

- Interpretation of Results: Coefficient values close to "+1" indicated a strong positive correlation, suggesting high consistency in experts' responses between rounds. Values close to -1 indicated a negative correlation, while values close to 0 suggested little or no correlation.

The research methodology combined measures of central tendency (mean, median, mode), measures of dispersion (range, standard deviation, variance), and measures of position (quartiles, percentiles) to analyze experts' responses. Measures of central tendency provided an overview of the opinions, while measures of dispersion and position allowed for a detailed analysis of variability and distribution. These statistical measures were essential for interpreting the results of the Delphi technique, providing a robust and detailed analysis of the experts' opinions.

3. Results

The researchers participated significantly throughout the three stages of the Delphi Technique, representing an average of 50% of the respondents. Employees of industries with galvanic activities also had a relevant participation, averaging 27.4%, followed by industry managers at 14.5% and environmental inspectors at 4.8%.

The participating researchers had diverse academic backgrounds, including production engineering, industrial chemistry, environmental sciences, and economics. Many held postgraduate degrees in Sustainable Regional Development (Master's), Development and Environment (Doctorate), and Occupational Safety.

This diversity of profiles is desirable, as the proposed instrument encompasses indicators related to different areas of knowledge and is relevant to various stakeholders in the galvanic industry, such as environmental inspectors, managers, and employees. In the initial phase of the research, 62 individuals participated, as detailed in Table 1, however, 18 participants withdrew in the second stage and 12 in the third resulting in 32 participants in the final stage of the Delphi Technique.

Table 1. Profile of the interviewee for the 3 stages of the Delphi Technique

INSTRUMENT 1				
Profile of the interviewee	Frequency	Percentage	Valid percentage	Cumulative percentage
Environmental Inspector	3	4.8	4.8	4.8
Employee of the Galvanic Industry	17	27.4	27.4	32.2
Manager of the Galvanic Industry	9	14.5	14.5	46.7
Researcher	31	50.0	50.0	96.7
Unidentified	02	3.3	3.3	100.0
Total	62	100.0	100.0	
INSTRUMENT 2				
Profile of the interviewee	Frequency	Percentage	Valid percentage	Cumulative percentage
Environmental Inspector	2	4,5	4,5	4,5
Employee of the Galvanic Industry	9	20,5	20,5	25,0
Manager of the Galvanic Industry	8	18,2	18,2	43,2
Researcher	25	56,8	56,8	100,0
Unidentified	44	100,0	100,0	
INSTRUMENT 3				
Profile of the interviewee	Frequency	Percentage	Valid percentage	Cumulative percentage
Environmental Inspector	2	6.3	6.3	6.3
Employee of the Galvanic Industry	10	31.3	31.3	37.6
Manager of the Galvanic Industry	4	12.5	12.5	50.1
Researcher	16	50.0	50.0	100.0
Unidentified	32	100.0	100.0	

Source: The authors, 2024.

3.1 First stage of Delphi Method

Among the 62 participants in the first stage, only 50 evaluated all the indicators in Instrument 1. Incomplete responses were more frequent for the indicators related to occupational safety, possibly due to the participants' lack of specific knowledge in this area. Additionally, these topics are complex and specific, which may have led participants to ignore them or respond to them partially, depending on their prior knowledge in the area (Table 2).

Table 2. Descriptive statistics—Instrument 1

Indicators	N	Minimum	Maximum	Mean	Standard Deviation
A1 - Energy consumption	62	3	5	4.68	0.621
A2 - Water consumption	62	3	5	4.74	0.599
A3 - Water reuse	62	1	5	4.73	0.728
A4 - Consumption of packaging materials	62	2	5	4.15	0.973
A5 - Consumption of raw materials	62	3	5	4.4	0.735
A6 - Generation of hazardous waste - Class I	62	1	5	4.39	1.077
A7 - Generation of galvanic sludge	62	1	5	4.26	1.115
A8 - Generation of liquid effluents	61	1	5	4.26	1.063
A9 - Generation of gaseous effluents	60	1	5	4.17	1.122
A10 - Recycling of solid waste	62	3	5	4.55	0.670
A11 - Effluent recycling	62	1	5	4.65	0.726
A12 - Consumption of fossil fuels	60	1	5	3.75	1.244
A13 - Physicochemical standards of effluents	62	1	5	4.53	0.762
A14 - Atmospheric emissions	61	1	5	4.38	0.969
S1 - Lost workdays by employees	60	1	5	4.13	0.929
S2 - Specific incidence rate for occupational diseases	61	2	5	4.62	0.610
S3 - Incidence rate of typical work accidents	60	2	5	4.58	0.645
S4 - Level of exposure to chemical agents in the plating sector	62	3	5	4.77	0.493
S5 - Legal documentation related to occupational health and safety	62	3	5	4.69	0.561
S6 - Compliance with regulatory labor standards regarding emergencies and fire hazards	62	3	5	4.74	0.571
S7 - Monitoring of indicators and rates related to occupational health and safety	61	2	5	4.66	0.602
S8 - Collective and personal protective equipment	61	3	5	4.77	0.529
S9 - Training in occupational health and safety for employees	62	3	5	4.77	0.525
S10 - Awareness campaigns on the topic and/or campaigns aimed at employee well-being	62	3	5	4.35	0.704
S11 - Programs for risk reduction and promotion of workplace improvements	62	2	5	4.56	0.692
S12 - Monitoring of third-party occupational health and safety performance	62	2	5	4.29	0.876
E1 - Direct economic value generated: revenues, operating costs, remuneration, employees, donations, other community investments, retained earnings, and payments to capital providers and governments	60	2	5	4.17	0.806
E2 - Risk and opportunity rate for activitie due to environmental changes (climate)	62	2	5	4.39	0.710
E3 - Value and description of benefits paid to employees	62	2	5	4.26	0.700
E4 - Value of financial assistance received from the government	62	2	5	3.85	0.865
E5 - Proportion of spending on local suppliers in significant operational units	62	2	5	4	0.830
E6 - Proportion of senior management members recruited to work in significant operational units	62	2	5	3.87	0.799
E7 - Value of investment in infrastructure and services for public benefit (health, education, safety, and related areas)	62	2	5	4.26	0.808
Q1 - Efficiency and productivity	62	3	5	4.74	0.477
Q2 - Impact (customer satisfaction levels regarding the quality of sold products)	62	3	5	4.74	0.477
Q3 - Effectiveness (number of product defects over time)	62	1	5	4.34	0.848
Q4 - Customer service (number of complaints)	62	3	5	4.42	0.666
Q5 - Production safety	62	3	5	4.79	0.449
Q6 - Completion of requirements on time	61	3	5	4.49	0.698
Q7 - Product/service/team performance	62	3	5	4.5	0.695
Evaluated all indicators	50				

Source: The authors, 2024.

Most indicators received evaluations ranging from 3 to 5, with some ranging from 2 to 5. The response “dispensable” was rarely considered by the panel of experts, highlighting the relevance of the listed indicators.

The indicator with the greatest variation in evaluation was A12—Consumption of Fossil Fuels, showing the highest standard deviation. This indicator received 66.2% in evaluations rated as 4 and 5 on the relevance scale (Figure 1). This low score can be partly attributed to a lack of awareness about the consequences of fossil fuel consumption, a topic frequently discussed in academic literature.

In “Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming” (2010), Naomi Oreskes and Erik Conway expose obfuscation strategies adopted by political and economic interests regarding fossil fuel consumption. Bill McKibben’s “The End of Nature” (1989) warned about the dangers of fossil fuels and the urgent need for renewable energy. David Wallace-Wells’ “The Uninhabitable Earth: Life After Warming” (2019) presents a grim vision of the future if climate change is not addressed. These authors highlight the adverse impacts of fossil fuel consumption and the urgency of mitigating climate change effects.

3.1.1 Assessment by Degree of Relevance—First Stage of the Delphi Method:

Of the seven quality management indicators proposed, three received the highest evaluations (above 98% for relevance levels 4 and 5). These were Q1—Efficiency and productivity, Q2—Customer satisfaction levels regarding product quality (both with 98% evaluations), and Q5—Production safety (98.3%). The best-evaluated indicators are related to quality management. Figure 2 presents the assessment by degree of relevance for the indicators in Instrument 1.

Except for A12—Consumption of Fossil Fuels, the other environmental indicators received evaluations above 75% for relevance levels 4 and 5. Listed in order of relevance, these are: A11—Effluent recycling (93.6%), A2—Water consumption and A3—Water reuse (both 92%), A13—Physicochemical standards of effluents and A1—Energy consumption (both 91.9%), A10—Solid waste recycling (90.3%), A14—Atmospheric emissions (87.1%), A6—Generation of hazardous waste—Class I (85.5%), A5—Raw material consumption (85.4%), A8—Generation of liquid effluents (83.8%), A7—Generation of galvanic sludge (82.3%), A9—Generation of gaseous effluents (79%), and A4—Consumption of packaging materials (75.8%). There were no suggestions for new indicators in this category.

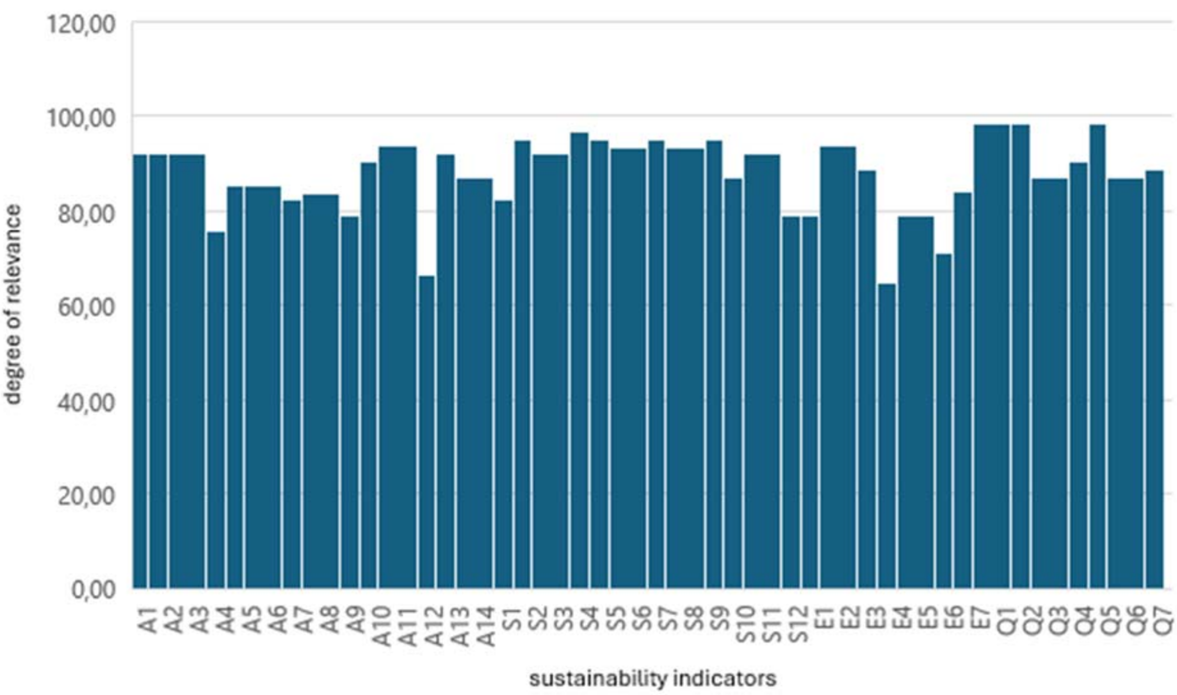

Figure 2. Assessment by degree of relevance—Indicators of Instrument 1

Source: The authors, 2024.

With regard to economic indicators, the analysis of relevance levels showed the greatest divergence and was judged most critically. Only 5 of the 7 proposed indicators received ratings of 4 or 5 above 75%. These were E2—Risk and opportunity rate due to environmental (climate) changes (93.6%), E3—Value and description of benefits paid to employees (88.7%), E7—Value of investment in infrastructure and services for public benefit (83.9%), and E5—Proportion of spending on local suppliers in significant operational units (79.0%).

Indicators E4—Value of financial assistance received from the government and E6—Proportion of senior management members recruited for significant operational units did not reach 75% consensus for relevance levels 4 and 5, scoring 64.0% and 71.0%, respectively.

For social indicators, all proposed indicators were deemed important. The highest scores were for S4—Level of exposure to chemical agents in the plating sector (96.7%); S7—Monitoring of indicators and rates related to occupational health and safety, S5—Legal documentation related to occupational health and safety, and S9—Training in occupational health and safety for employees (all 95.2%). S2—Specific incidence rate for occupational diseases and S6—Compliance with regulatory labor standards regarding emergencies and fire hazards scored 93.5% and 95.2%, respectively.

Three new indicators were suggested for this category: SN1—Quality of work from the worker's perspective, SN2—Payments of additional benefits as stipulated by law or collective agreement, and SN3—Adequacy of Personal Protective Equipment (PPE) for the work performed. Participants provided their evaluations for the proposed indicators, except for SN3, which did not receive a prior evaluation. Table 3 presents the suggested and evaluated indicators from the first stage.

Table 3. Indicators suggested and evaluated in the first stage.

Suggested Indicators	Degree of relevance				
	5	4	3	2	1
SN1 - Quality of work from the worker's perspective		X			
SN2 - Payments of additional benefits as stipulated by law or collective agreement		X			
SN3 - Adequacy of Personal Protective Equipment (PPE) for the work performed					
QN1 - Use of methods to monitor quality levels			X		
EN1 - Amount allocated to R&D activities		X			
EN2 - Amount allocated to employee professional training projects		X			

Source: The authors, 2024.

3.2 Second Stage of the Delphi Method

In the second stage of the Delphi method, Instrument 2 was sent out. It contained indicators that received over 75% ratings for relevance levels 4 and 5 in the first stage, along with the indicators suggested by participants, totaling 41 indicators. The instrument was sent to all previous participants via a Google Forms link through email and WhatsApp. This stage had 44 respondents, as shown in Table 4.

Statistical analysis revealed that the indicator with the greatest variation in evaluation was S1—Workdays lost by employees, which had the highest standard deviation. Indicators with the least variation, meaning the lowest standard deviation, were those related to water consumption and collective and personal protective equipment, as presented in Table 4.

Table 4. Descriptive statistics for Instrument 2

Indicators	N	Minimum	Maximum	Mean	Standard Deviation
A1 - Energy consumption	44	3	5	4.8	0.509
A2 - Water consumption	44	3	5	4.86	0.409
A3 - Water reuse	44	3	5	4.82	0.446
A4 - Packaging material consumption	44	2	5	4.16	0.861
A5 - Raw material consumption	43	3	5	4.44	0.700
A6 - Generation of hazardous waste - Class I	44	1	5	4.43	0.998
A7 - Generation of galvanic sludge	44	1	5	4.52	0.902
A8 - Generation of liquid effluents	44	1	5	4.52	1.023
A9 - Generation of gaseous effluents	44	1	5	4.36	1.059
A10 - Recycling of solid waste	44	2	5	4.59	0.757
A11 - Effluent recycling	44	2	5	4.64	0.650
A13 - Physical-chemical standards of effluents	44	3	5	4.66	0.608
A14 - Atmospheric emissions	44	1	5	4.34	1.077
SN1 - Quality of work from the worker's perspective	44	3	5	4.55	0.627
SN2 - Payments of additional benefits as stipulated by law or collective agreement	43	3	5	4.49	0.668
SN3 - Adequacy of Personal Protective Equipment (PPE) for the work performed	44	3	5	4.8	0.462
S1 - Workdays lost by employees	43	1	5	3.93	1.242
S2 - Specific incidence rate of occupational diseases	44	3	5	4.52	0.698
S3 - Incidence rate of typical work accidents	44	3	5	4.5	0.665
S4 - Level of exposure to chemical agents in the plating sector	43	3	5	4.72	0.549
S5 - Legal documentation related to Occupational Health and Safety	44	3	5	4.64	0.532
S6 - Compliance with regulatory labor standards concerning emergencies and fire risks	44	3	5	4.75	0.488
S7 - Monitoring of indicators and rates related to occupational health and safety	44	2	5	4.68	0.674
S8 - Collective and personal protective equipment	44	3	5	4.86	0.409
S9 - Occupational health and safety training for employees	44	3	5	4.59	0.583
S10 - Awareness campaigns on the topic and/or campaigns aimed at employee well-being	44	3	5	4.34	0.776
S11 - Programs to reduce risks and promote improvements in the work environment	44	3	5	4.57	0.625
S12 - Monitoring the performance of third parties in occupational health and safety	44	2	5	4.16	0.939
EN1 - Amount allocated to R&D activities	42	3	5	4.19	0.740
EN2 - Amount allocated to employee professional training projects	44	2	5	4.07	0.846
E1 - Direct economic value generated	43	2	5	4.09	0.971
E2 - Risk and opportunity rates for activities due to environmental (climate) changes	44	2	5	4.25	0.811
E3 - Amount and description of benefits paid to employees	44	2	5	4.18	0.843
E5 - Proportion of spending on local suppliers in important operational units	44	1	5	3.93	1.087
E7 - Amount of investment in infrastructure and services for public benefit (health, education, security, etc.)	42	2	5	4.02	1.024
QN1 - Use of methods to monitor quality levels	44	2	5	4.45	0.730
Q1 - Efficiency and productivity	44	3	5	4.43	0.728
Q2 - Impact (customer satisfaction levels regarding the quality of products sold)	44	1	5	4.45	0.951
Q3 - Effectiveness (number of product defects over time)	44	1	5	4.34	0.963
Q4 - Customer service (number of complaints)	44	1	5	4.16	1.010
Q5 - Production safety	44	3	5	4.75	0.576
Q6 - Completion of requirements within the deadline	44	1	5	4.41	0.897
Q7 - Performance of the product/service/team	44	1	5	4.41	0.871
Answered all	39				

Source: The authors, 2024.

In this stage, out of the 44 participants, only 39 evaluated all the indicators in Instrument 2. Incomplete responses occurred mainly in indicators related to occupational safety and economic indicators.

3.2.1 Assessment by Degree of Relevance—Second Stage of the Delphi Method

The results from Instrument 2 (Figure 2) show the best-evaluated indicators were: S6—Compliance with regulatory labor standards concerning emergencies and fire risks (97.8%); SN3—Adequacy of Personal Protective Equipment (PPE) for the work performed; S5—Legal documentation related to Occupational Health and Safety; A2—Water consumption; A3—Water reuse; and S8—Collective and personal protective equipment, all with 97.7% consensus. Figure 3 presents the assessment by degree of relevance for the indicators in Instrument 2.

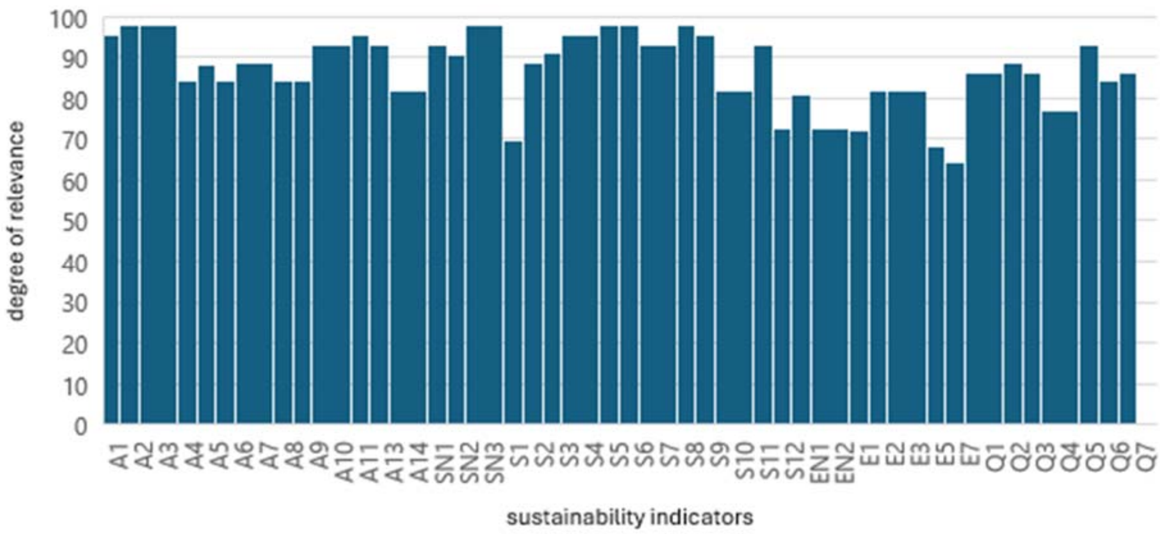

Figure 3. Assessment by degree of relevance – Indicators of Instrument 2

Source: The authors, 2024.

Indicators not achieving over 75% for relevance levels 4 and 5 were excluded from the final list of sustainability indicators for the galvanic industry. These included EN2—Amount allocated to employee professional training projects (72.8%), S12—Monitoring the performance of third parties in occupational health and safety (72.7%), E1—Direct economic value generated (72.1%), S1—Workdays lost by employees (69.8%), E5—Proportion of spending on local suppliers in important operational units (68.1%), and E7—Amount of investment in infrastructure and services for public benefit (64.2%).

3.3 Third Stage of the Delphi Method

In the third and final stage, the instrument included only three relevance levels: 5 for "Very important," 4 for "Important," and 3 for "Desirable," aiming to validate and determine the final importance of the selected indicators. A space was provided for participants to justify their evaluation if they rated an indicator as "Desirable." This allowed participants to highlight relevant factors not addressed by others. After returning the questionnaires, data were organized and tabulated using descriptive statistics. Table 5 presents the statistical analysis for Instrument 3.

Table 5. Statistical analysis—Instrument 3

Sustainability indicators for the galvanic industry		% Important	% Very Important
A1	Energy consumption	15.6	84.4
A2	Water consumption	9.4	90.6
A3	Water reuse	15.6	84.4
A4	Consumption of packaging materials	31.3	59.4
A5	Raw material consumption	25.0	71.9
A6	Generation of Hazardous Waste - Class I	34.4	59.4
A7	Generation of Galvanic Sludge	25.0	71.9
A8	Generation of Liquid Effluents	25.0	68.8
A9	Generation of Gaseous Effluents	37.5	56.3
A10	Recycling of Solid Waste	18.8	81.3
A11	Effluent Recycling	18.8	78.1
A13	Physicochemical Standards of Effluents	25.0	75.0
A14	Atmospheric Emissions	18.8	75.0
SN1	Job quality from the worker's perspective	31.3	68.8
SN2	Payments of legal or collective agreement bonuses	12.5	84.4
SN3	Adequacy of Personal Protective Equipment for the work performed	28.1	71.9
S2	Specific incidence rate for occupational diseases	28.9	78.1
S3	Incidence rate of typical work accidents	34.4	74.6
S4	Level of exposure to chemical agents in the plating sector	25.0	75.0
S5	Legal documentation related to Occupational Health and Safety	37.5	62.5
S6	Compliance with Labor Regulatory Standards regarding emergencies and fire hazards	21.9	78.1
S7	Monitoring of health and safety indicators and rates	37.5	62.5
S8	Collective and Personal Protective Equipment	15.6	84.4
S9	Training in occupational health and safety with employees	25.0	75.0
S10	Awareness campaigns on the topic and/or campaigns aimed at employee well-being	34.4	62.5
S11	Programs for risk reduction and workplace improvement	31.3	61.6
S12	Monitoring the health and safety performance of third parties	50.0	46.9
EN1	Amount allocated to R&D activities	62.5	34.4
EN2	Amount allocated to employee professional training projects	56.3	43.8
E2	Rate of risks and opportunities for activities due to environmental (climatic) changes	50.0	50.0
E3	Value and description of benefits paid to employees	43.8	53.3
QN1	Use of methods for monitoring quality levels	40.6	59.4
Q1	Efficiency and productivity	31.3	68.8
Q2	Impact (customer satisfaction levels regarding product quality)	40.6	59.4
Q3	Effectiveness (number of product defects over time)	43.8	56.3
Q4	Customer service (number of complaints)	56.3	43.8
Q5	Production safety	9.4	90.6
Q6	Completion of requirements within the deadline	40.6	59.4
Q7	Performance of the product / or service / or team	37.5	62.5

Source: The authors, 2024.

Figure 4 highlights sustainability indicators in the galvanic industry, classified by their degree of relevance and including only those rated as "very important" by experts. Two indicators achieved over 90% agreement: water consumption and production safety, both with 90.6% of evaluations rated as "very important."

Four indicators received 84.4% of evaluations: energy consumption, water reuse, collective and personal protective equipment, and payments of bonuses as stipulated by law or collective agreements. The indicator related to solid waste recycling received 81.3% of evaluations rated as "very important." The remaining indicators received less than 80% of evaluations rated as "very important" and are listed in Table 6 below, in order of relevance.

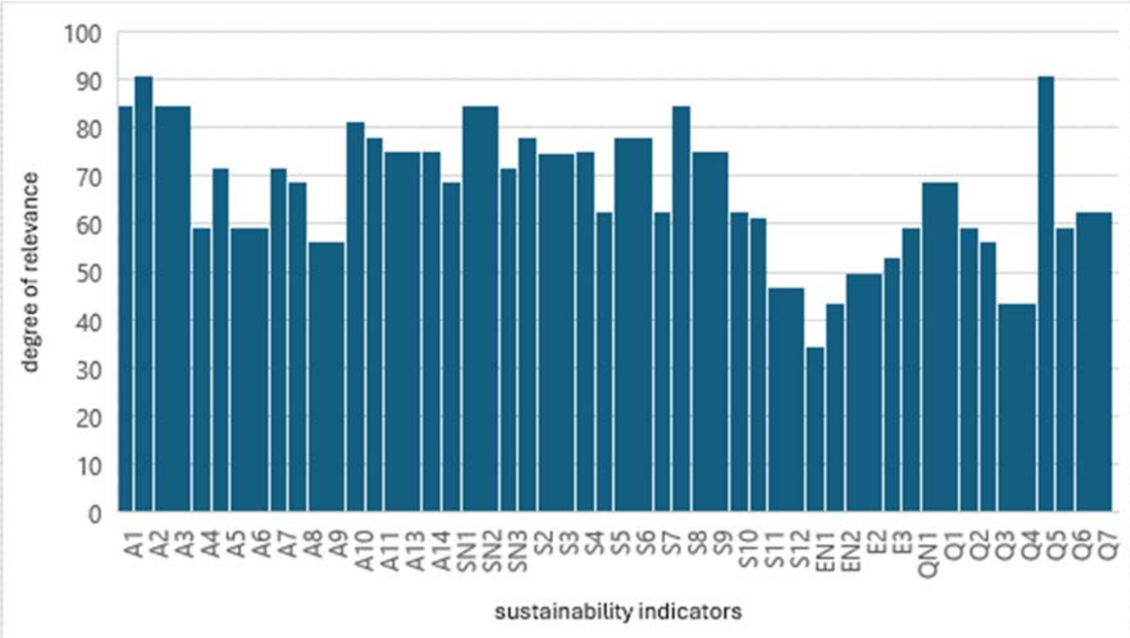

Figure 4. Assessment by degree of relevance – Indicators of Instrument 3

Source: The authors, 2024.

The remaining indicators, receiving less than 80% of evaluations rated as "very important," are listed in Table 6 below, in order of relevance. The final list contains 39 sustainability indicators agreed upon by participants, as shown in Table 6. These chosen indicators aim to measure sustainable management specific to the galvanic industry, directing it towards integrated management of quality, environment, and occupational health and safety.

Table 6. Final list of sustainability indicators for the galvanic industry

Sustainability indicators for the galvanic industry by degree of relevance		% Very Important
A2	Water consumption	90.6
Q5	Production safety	90.6
A1	Energy consumption	84.4
A3	Water reuse	84.4
SN2	Payments of bonuses as stipulated by law or collective agreement	84.4
S8	Collective and Personal Protective Equipment	84.4
A10	Recycling of Solid Waste	81.3
A11	Effluent Recycling	78.1
S2	Specific incidence rate for occupational diseases	78.1
S6	Compliance with Labor Regulatory Standards regarding emergencies and fire hazards	78.1
A13	Physicochemical Standards of Effluents	75.0
A14	Atmospheric Emissions	75.0
S4	Level of exposure to chemical agents in the plating sector	75.0
S9	Training in occupational health and safety for employees	75.0
S3	Incidence rate of typical work accidents	74.6
A5	Raw material consumption	71.9
A7	Generation of Galvanic Sludge	71.9
SN3	Adequacy of Personal Protective Equipment for the work performed	71.9
A8	Generation of Liquid Effluents	68.8
SN1	Job quality from the worker's perspective	68.8
Q1	Efficiency and productivity	68.8
S5	Legal documentation related to Occupational Health and Safety	62.5
S7	Monitoring of health and safety indicators and rates	62.5
S10	Awareness campaigns on the topic and/or campaigns aimed at employee well-being	62.5
Q7	Performance of the product / or service / or team	62.5
S11	Programs for risk reduction and workplace improvement	61.6

A4	Consumption of packaging materials	59.4
A6	Generation of Hazardous Waste - Class I	59.4
QN1	Use of methods for monitoring quality levels	59.4
Q2	Impact (customer satisfaction levels regarding product quality)	59.4
Q6	Completion of requirements within the deadline	59.4
A9	Generation of Gaseous Effluents	56.3
Q3	Effectiveness (number of product defects over time)	56.3
E3	Value and description of benefits paid to employees	53.3
E2	Rate of risks and opportunities for activities due to environmental (climatic) changes	50.0
S12	Monitoring the health and safety performance of third parties	46.9
EN2	Amount allocated to employee professional training projects	43.8
Q4	Customer service (number of complaints)	43.8
EN1	Amount allocated to R&D activities	34.4

Source: The authors, 2024.

4. Discussion

The indicators considered most relevant in this study were "Water Consumption" and "Production Safety," both with 90.6% consensus for the "very important" relevance level.

The "Water Consumption" indicator is crucial for assessing sustainability and operational efficiency in industries with galvanic activities. It encompasses environmental, economic, and regulatory aspects. Environmentally, it measures the water footprint and efficient resource management, essential in the context of increasing water scarcity (Hoekstra et al., 2011). From a regulatory standpoint, it ensures compliance with environmental standards, avoiding fines and sanctions. Thus, monitoring and reducing water consumption is vital for the sustainability, efficiency, economy, and compliance of industries with galvanic activities, enhancing overall business performance.

Similarly, the "Production Safety" indicator is essential due to the various risks associated with galvanization processes, including handling hazardous chemicals, operating heavy equipment, and exposure to dangerous environments. Worker protection is a priority given the toxicity of substances such as chromium, zinc, and nickel (NIOSH, 2018). Additionally, compliance with government regulations is crucial to ensure the sustainability and social responsibility of operations (ABNT NBR ISO, 2018). In summary, production safety directly influences various aspects of industries with galvanic activities, making the implementation and monitoring of safe practices necessary for sustainable and responsible operations.

The indicator with the lowest percentage of consensus among experts was "Amount Allocated to R&D Activities," with 34.4% consensus for the "very important" relevance level. This lower consensus is due to differing views among experts on the role of research and development in an organization's success. Some consider it crucial for long-term innovation and growth, while others prioritize investments in areas such as marketing or production.

4.1 Valorization of Galvanic Sludge Waste: A Sustainable Approach for the Galvanic Industry

Galvanic sludge, a byproduct of the electroplating industry, contains various heavy metals. Its specific composition varies depending on the processes and chemicals used in plating. Several studies identify zinc (Zn) and copper (Cu) as the predominant metals in galvanic sludge (Alves & Seo, 2014; Rodrigues et al., 2020). While nickel (Ni), cadmium (Cd), manganese (Mn), iron (Fe), chromium (Cr), and cobalt (Co) are also present, they typically appear in lower concentrations. The presence of these metals, even in trace amounts, raises concerns due to their potential toxicity and environmental impact (Alves & Seo, 2014; Costalonga, Lelis, & Pertel, 2011; Rodrigues et al., 2020).

The Brazilian standard NBR10004/04 classifies and characterizes waste as hazardous based on certain chemical elements. Cadmium (Cd) and chromium (Cr) are the primary constituents responsible for this classification. Known for their toxicity, these elements can cause significant harm to the environment and human health. Therefore, the presence of Cd and Cr in galvanic sludge requires special attention and appropriate treatment to prevent environmental and health risks.

Valorizing galvanic sludge waste (GSW) is a feasible and realistic approach for the galvanic industry to avoid the negative impacts associated with landfill disposal. This method mitigates environmental hazards and promotes the sustainable reuse of materials. Transforming GSW into valuable resources offers significant environmental and economic benefits (Nasyrov et al., 2019; Cubas et al., 2014). The technological domain of Integrated Management in industries with galvanic activities plays a crucial role in achieving sustainability goals (Lositska, 2018). By incorporating technological advancements, industries can optimize processes, reduce waste, and minimize environmental impact (Innocenzi et al., 2020). Implementing cleaner production technologies, such as advanced filtration systems, recycling units, and automation, significantly decreases resource consumption, particularly water and energy (Oliveira et al., 2019). Additionally, adopting innovative treatment methods for effluents and waste mitigates pollution and promotes a circular economy (Figueirêdo et al., 2021).

4.2 Technological Integration for Sustainable Galvanic Industry Management

Technological advancements can enhance occupational safety in industries with galvanic activities. Sensors, monitoring systems, and personal protective equipment help identify and mitigate potential hazards, ensuring a safer working environment for employees (NIOSH, 2018). Investing in research and development allows industries to continuously improve their technologies, leading to more sustainable and efficient practices.

Integrating technology into the management systems of industries with galvanic activities is essential for achieving long-term sustainability. Embracing technological solutions enables industries to comply with environmental regulations, reduce costs, improve efficiency, and meet the growing demand for sustainable products and services. This integration provides a competitive advantage and supports overall sustainability goals.

4.3 Contribution to SGDs

SDG 6 (Clean Water and Sanitation): The industries with galvanic activities consumes considerable amounts of water and generates potentially polluting effluents. Indicators that measure water consumption per produced piece, water reuse rate, and effluent quality help monitor and reduce environmental impact, promoting sustainable water use.

SDG 7 (Clean and Affordable Energy): The industries with galvanic activities can reduce energy consumption by optimizing processes, using more efficient equipment, and adopting renewable energy sources such as solar and wind. Evaluating the possibility of generating clean energy for consumption contributes to the renewable energy matrix.

SDG 8 (Decent Work and Economic Growth): The industries with galvanic activities exposes workers to chemical and physical risks. Indicators related to occupational health and safety, such as accident rates, number of occupational diseases, and absenteeism index, promote safer and healthier work environments, enhancing worker well-being and sustainable economic growth.

SDG 9 (Industry, Innovation, and Infrastructure): Research encourages innovation and the development of cleaner, more efficient technologies in the galvanic sector by proposing indicators like investment in research and development and the adoption of clean technologies. This modernizes the industry and reduces environmental impacts.

SDG 12 (Responsible Consumption and Production): The generation of hazardous waste is a challenge for the industries with galvanic activities. Indicators measuring waste quantity, recycling rate, and proper disposal encourage more responsible consumption and production practices, promoting a circular economy.

SDG 13 (Climate Action): The galvanic industry contributes to greenhouse gas emissions. Indicators such as the carbon footprint and emissions per produced piece encourage the adoption of mitigation and adaptation measures to climate change, aligning the sector with global emission reduction commitments.

4.4 Contribution to ESG in Industries with galvanic activities

Environmental (E): The proposed indicators help industries with galvanic activities monitor and reduce environmental impacts such as water consumption, waste generation, and greenhouse gas emissions. This strengthens the company's image as environmentally responsible and improves stakeholder relationships;

Social (S): Including occupational health and safety indicators shows a commitment to employee well-being, enhancing the organizational climate and the industry's reputation as an employer;

Governance (G): The research promotes transparent and responsible management practices, such as disclosing social and environmental performance information and implementing integrated management systems. This strengthens corporate governance and increases investor and stakeholder trust.

5. Conclusion

The research resulted in expert consensus on 39 sustainability indicators specific to the industries with galvanic activities through the Delphi Technique. Besides indicators related to the sustainability tripod (environmental, economic, and social), the instrument also included indicators for integrated management of quality, environment, and occupational safety.

Adopting an Integrated Management System (IMS) with an effective system of indicators is crucial for the sustainability of the galvanic sector. By integrating the dimensions of quality, environment, and occupational safety, companies can achieve significant economic and socio-environmental results.

Indus

This research provides a sustainability framework adaptable to other environmentally burdened industries beyond galvanic operations. The IMS, encompassing quality (ISO 9001), environmental (ISO 14001), and occupational safety (ISO 45001) standards, offers a holistic approach to addressing sustainability challenges. This approach can be tailored to other sectors like mining, textiles, or chemical manufacturing by incorporating relevant indicators.

Aligning with SDGs and ESG principles ensures sustainability efforts are environmentally sound, socially responsible, and economically viable. The SDGs offer a universal framework for global challenges, while ESG principles guide businesses towards responsible practices. By adapting these research findings, other industries can develop comprehensive sustainability strategies for a more sustainable future.

These indicators are part of a primary study for subsequent implementation in the industries with galvanic activities to verify their applicability. This approach aims to contribute significantly to comprehensive sustainability analyses of the sector, both nationally and internationally, ensuring clear and unbiased results.

References

Ahmad, S., & Wong, K. Y. (2019). Development of weighted triple-bottom line sustainability indicators for the Malaysian food manufacturing industry using the Delphi method. *Journal of Cleaner Production*, *229*, 1167–1182. https://doi.org/10.1016/j.jclepro.2019.04.399

Altman, N., & Krzywinski, M. (2015). Simple linear regression. *Nature Methods*, *12*, 999–1000. https://doi.org/10.1038/nmeth.3627

Alves, L. C., & Seo, E. S. M. (2014). Characterization of solid waste from the galvanic process for environmental economic valuation. *Sanitary and Environmental Engineering*, *19*(4), 423–434.

Associação Brasileira de Normas Técnicas. (2015a). *NBR ISO9001: 2015—Quality management systems—requirements*.

Associação Brasileira de Normas Técnicas. (2015b). *NBR ISO14001: 2015—Environmental management systems—requirements with guidance for use*.

Associação Brasileira de Normas Técnicas. (2018). *NBR ISO 45001: 2018 Occupational health and safety management systems—Requirements with guidance for use*.

Bertolino, M. T., & Couto, M. (2018). *Integrated Management Systems: ISO 9001, ISO 14001 and ISO 45001, Quality, Environmental and Occupational Health and Safety Management with Focus on Results* (1st ed.). Qualitymark Editora.

Costalonga, L. E. O., Lelis, M. F. F., & Pertel, M. (2011). *III-139—Assessment of the toxic load of galvanic sludge from the cyanide-free effluent treatment process*. 26th Brazilian Congress of Sanitary and Environmental Engineering.

Cubas, A. L. V., Machado, M. de M., Machado, M. de M., Gross, F., Magnago, R. F., Moecke, E. H. S., & Souza, I. G. de. (2014). Inertization of Heavy Metals Present in Galvanic Sludge by DC Thermal Plasma. *Environmental Science & Technology*, *48*(5), 2853–2861. https://doi.org/10.1021/es404296x

Dalkey, N. C. (2018). Delphi. In *An Introduction to Technological Forecasting* (pp. 25–30). https://doi.org/10.4324/9781351106450-3

Eccles, R. G., & Serafeim, G. (2014). The Impact of Corporate Sustainability on Organizational Processes and Performance. *Management Science*, *60*(11), 2835–2857. https://doi.org/10.1287/mnsc.2014.1984

Figueirêdo, S. S. M., Pinto, L. A., Oliveira, L. S., Menezes, J. M. C., & de Paula Filho, F. J. (2021). Overview of industrie with galvanic activitie in Juazeiro do Norte, Brazil: emphasis on trace metal content in effluents and solid waste. *Sanitary and Environmental Engineering*, *26*(6), 1111–1121. https://doi.org/10.1590/s1413-415220190063

Genest, C., Nešlehová, J. G., & Rémillard, B. (2013). On the estimation of Spearman's rho and related tests of independence for possibly discontinuous multivariate data. *Journal of Multivariate Analysis*, *117*, 214–228. https://doi.org/10.1016/j.jmva.2013.02.007

Gordon, T. J. (1994). *The Delphi Method: Techniques and Applications*. Addison-Wesley.

Greener, S., & Martelli, J. (2015). *An Introduction to Business Research Methods*. Bookboon.

Hajji, Y., & Leyrat, C. (2018). *ANOVA, Welch correction, Satterthwaite correction and Kruskal-Wallis test comparison of type I error rate and power*.

Henderson, R. (2020). *Reimagining Capitalism in a World on Fire*. Public Affairs.

Hoekstra, A. Y., Chapagain, A. K., Aldaya, M. M., & Mekonnen, M. M. (2011). *The Water Footprint Assessment Manual: Setting the Global Standard*. Earthscan.

Innocenzi, V., Cantarini, F., Amato, A., Morico, B., Ippolito, N. M., Beolchini, F., … Vegliò, F. (2020). Case study on technical feasibility of galvanic wastewater treatment plant based on life cycle assessment and costing approach. *Journal of Environmental Chemical Engineering*, *8*(6), 104535. https://doi.org/10.1016/j.jece.2020.104535

Instituto Ethos. (2013). *Ethos Indicators for Sustainable and Responsible Business*.

Khan, M., Serafeim, G., & Yoon, A. (2016). Corporate Sustainability: First Evidence on Materiality. *The Accounting Review*, *91*(6), 1697–1724. SSRN. https://doi.org/10.2308/accr-51383

Klein, N. (2014). *This Changes Everything: Capitalism vs. The Climate*. Simon & Schuster.

Lakatos, E. M., & Marconi, M. A. (2010). *Fundamentals of scientific methodology*. Atlas.

Linstone, H., & Turoff, M. (2002). *The Delphi Method*.

Lositska, T. (2018). Innovative Technologies: Essence and Importance of Galvanic Production Development. *Technology Transfer: Innovative Solutions in Social Sciences and Humanities*, *1*, 7–9. https://doi.org/10.21303/2613-5647.2018.00618

McKibben, B. (1989). *The End of Nature*. Random House.

Mengistu, A. T., & Panizzolo, R. (2023). Analysis of indicators used for measuring industrial sustainability: a systematic review. *Environment, Development and Sustainability*, *25*, 1979–2005. https://doi.org/10.1007/s10668-021-02053-0

Munaretto, L. F., Corrêa, H. L., & Cunha, J. A. C. (2013). A study on the characteristics of the Delphi Method and Focus Group as techniques to obtain data in exploratory research. *Revista de Administração da UFSM*, *6*(1), 9–24. https://doi.org/10.5902/198346596243

Nasyrov, I. A., Lukina, K. S., Mavrin, G. V., & Kharlyamov, D. A. (2019). Emission of heavy metals from galvanic production sludge in water objects and soil. *International Journal of Psychosocial Rehabilitation*, *23*(3), 734–745. https://doi.org/10.37200/IJPR/V23I3/PR190362

National Institute for Occupational Safety and Health (NIOSH). (2018). *Preventing Occupational Exposures to Lead and Other Metals in the Industrial Sector*.

Nutt, P. C. (2002). *Making Tough Decisions: Tactics for Improving Managerial Decision Making*. Jossey-Bass.

Oliveira, L. S., Pinto, L. A., Figueiredo, S. S. M., Menezes, J. M. C., & Filho, F. J. P. (2019). *Analysis of effluents generated by industrie with galvanic activitie in the production of plated jewelry*. SBRNS Brazilian Semiarid Natural Resources Symposium.

Oreskes, N., & Conway, E. M. (2010). *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. Bloomsbury Press.

Ostertagova, E., & Ostertag, O. (2013). Methodology and Application of One-way ANOVA. *American Journal of Mechanical Engineering*, *1*(7), 256–261.

Penteado, E. J. S., & Duarte, C. G. (2014). An evaluation of the Ethos Indicators based on the Bellagio Principles. In *International Meeting on Business Management and the Environment* (Vol. 16). FEA USP. Retrieved from https://www.engema.org.br/XVIENGEMA/76.pdf

Pescador, S. V. B., Briere, F., & Novak, P. (2016). The impact of the results of the assessment of corporate social responsibility using the ethos sebrae-2013 indicators on the actions of the companies investigated. *Social Sciences in Perspective Magazine*, *15*(29), 115–138. https://doi.org/10.5935/1981-4747.20160006

Porter, M. E., & Kramer, M. R. (2011). Creating Shared Value. *Harvard Business Review*, *89*(1/2), 62–77.

Rodrigues, M. F. S., Veldhuis, R., Gomes, L. K. M., Menezes, J. M. C., Teixeira, R. N. P., & Silva, J. H. (2020). Evaluation of the retentive capacity of toxic metals from galvanoplasty industries using ceramic matrices. *Research, Society and Development*, *9*(7).

Rozados, H. B. F. (2015). The use of the Delphi technique as a methodological alternative for the field of

Information Science. *Em Questão*, *21*(3), 64–86. https://doi.org/10.19132/1808-5245213.64-86

Rowe, G., & Wright, G. (1999). The Delphi technique as a forecasting tool: questions and analysis. *International Journal of Forecasting*, *15*(4), 353–375. https://doi.org/10.1016/s0169-2070(99)00018-7

Sauder, D. C., & DeMars, C. E. (2019). An Updated Recommendation for Multiple Comparisons. *Advances in Methods and Practices in Psychological Science*, *2*(1), 26–44. https://doi.org/10.1177/2515245918808784

Vanham, P., & Schwab, K. (2021). *Stakeholder Capitalism: A Global Economy that Works for Progress, People and Planet*. Wiley. ISBN: 978-1-119-75614-9

Copyrights