Analysis of the Sustainable Water Management Impact in Business Performance in the Mining Industry

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Abstract--**The mining activity is essential in the economic context. However, there are several potential impacts caused by this activity, from the environmental and social perspective. In this regard, it is worth noting the relationship of this industry with the management of water use, a strategic resource for the business activity. This study aims to identify the relationship between the management of water use and the business performance in industries in the Brazilian mining sector. To that end, we conducted a survey with managers from industries in the sector. The results of the survey lead to the acceptance of the central hypothesis of the study, where there is a positive relationship between the management of water use and business performance, corroborating the significant importance of this resource to the competitiveness of industries in the mining sector.**

I. INTRODUCTION

The mining activity is the basis for several key supply chains to modern life. This industry is an important source of energy and has a significant share in the Brazilian economy and in the Brazilian trade balance [16]. Due to its importance, the environmental impacts and social issues involved in this activity are well known. Discussions about the extraction of non-renewable resources, changes in environmental landscape and issues involving the health and working conditions of workers are some of the aspects covered. In environmental terms, as examples of potential impacts on soils, with changes in their composition and erosion; on the amount of water consumed and wastewater discharged in rivers and in the air; on the pollution caused by the processing of minerals [2, 14, 18].

According to studies by the National Water Agency - ANA and the Brazilian Mining Institute - IBRAM [1], that the mining industry is among the largest users of water in Brazil and has the greatest peculiarities. These activities comprise large projects with high environmental impact, that rely on modern and efficient management and small miners, who explore small mines with poor controls and environmental planning. Also according to ANA and IBRAM [1], the technical and economic feasibility of a mine is subject to the proper knowledge on the hydrological context in which it is located and the outlining of the hydrological-mineral performances, highlighting the need for a proper management of water use in this sector [1]

Considering the increasing need for reducing the social and environmental impacts, as well as the competitiveness in the industrial sector, we highlight, therefore, the importance of assessing the business performance in an integrated manner with the sustainability prospects, noting aspects that go beyond the economic indicators, optimizing the environmental and social performance of organizations [4, 20, 9]. Above all, it should be noted that the management of water use is an important factor related to the business success in the mining sector, in view of the high dependence on water and the impacts of its operations [18]. In this context, this study aims at identify the relationship between the management of water use and the business performance in industries in the Brazilian mining sector. Initially, we describe in this study the aspects related to the management of water use and the prospects of sustainable development to the mining sector. Subsequently, we describe the research method and the technical procedures used. Finally, we present the results of the field research, its findings and the strategic implications for the management of the companies.

II. PERSPECTIVES OF THE MANAGEMENT OF WATER USE AND SUSTAINABLE DEVELOPMENT IN THE MINING SECTOR

Conceptually, sustainable development is defined as the way to "meet the needs of the present without compromising the ability of future generations to meet their own needs", as defined in the Brundtland Report, in 1987 [7]. From the organizational standpoint, the core concept of sustainable development is associated with a term coined by John Elkington: the triple bottom line. In this approach, business success is not evaluated only in terms of profit, but also considers the economic, environmental and social perspectives [9, 20].

We highlight the importance of measuring business performance through aspects that go beyond profit, considering also the environmental and social indicators. The need to develop sustainable development indicators is explicit in Agenda 21, created in the International Conference of the United Nations on Environment and Development [5]. Among some of the indicators used in the business environment, are those developed by the Global Reporting Initiative (GRI), and broadly disseminated throughout the business world. The GRI aims to develop and disseminate globally the guidelines for the preparation of sustainability reports, organized in the economic, environmental and social categories. Although the GRI was created to be used by organizations of any size, sector and location, specific sector supplements were also developed. Among them are the sector supplement, intended for the metal and mining sector [12, 13].

According to Azapagic [2], the model developed by the GRI has been consolidated as one of the communication standards used by companies in the mining sector. In addition, it is also worth noting that the mining industry is embedded in the context of integration of sustainability into its operations, as the sustainable development represents a major challenge to this sector, in social and environmental terms, due to the nature of its activities. McLellan et al.[18] corroborate this argument by stating that there are advances in relation to the alignment of the mining industry with regard to its commitment to sustainable development, through the reduction of the impact caused by the production process.

According to Hilson and Murck [14], such integration requires a commitment to the continuous environmental and socioeconomic improvement, from mineral exploration, going through operation, to the end of the chain [14]. The authors offer recommendations for companies that wish to target their operations toward sustainability, improve planning and environmental management, implement cleaner technology, generate greater engagement with stakeholders, build partnerships, and invest in training [14].

The management of water use has been debated since the Stockholm Conference, in 1972. In Brazil, the management of water resources is anchored in Law No. 9433, as of January 1997, which established the National Water Resources Policy-PNRH. According to Art. 1, water is considered a public good, and a limited natural resource with economic value. The Law does not regulate the instruments of collection, but promotes the operation of river basin committees, the participation of the government, users and the community, in a decentralized manner, and the creation of the National System of Water Resources Management-SINGREH [21].

There are several drivers that justify and lead companies to reduce water use, as well as develop policies for sustainable use. Among these drivers are cost reduction, generating benefits for the company; the availability of water; the reputation of the company in view of a society increasingly aware of the environmental impacts; the risk associated with community pressures facing local authorities and the high investments for water management [17]. Corroborating this argument, Ceres [6] states that companies should care about their "social license to operate", especially in areas of water stress caused by the scarcity of this resource.

In this sense, Lambooy [17] presents several tools, guidelines and initiatives developed worldwide involving the reduction of water use in the corporate environment and its sustainable management. It can be mentioned the CEO Water Mandate, the Water Footprint, the Global Water Tool and GEMI Water Sustainability Planner/Tool.

Ceres [6] aims to understand how companies present in critical and vulnerable sectors, have been assessing, managing and communicating their risks in relation to water use to their operations, supply chain and products. The corporate disclosure practices were evaluated through a framework that covers the following dimensions: (1) Water accounting, (2) Risk Assessment, (3) Direct Operations, (4) Supply Chain and, (5) Stakeholder Engagement. Among the main results presented, it can be mentioned the low performance in relation to corporate disclosure practices about the risks associated with water use and the performance of companies. It was also noted that among the sectors studied, the mining sector was the one that with the best performance [6].

The reliance on water in the industry means that it is a significant source of its costs and many of its problems. These problems occur in both groundwater and surface water, leading to the need to drain water and imposing important the need to drain the areas of mines, thus producing important hydrological, environmental and economic effects, which require the proper handling and management of these waters [1].

According to Fennel [10], the management of water use is one of the biggest challenges for the safe and economic development of the mining activity, thus requiring an integrated and holistic approach to water management, taking into account scientific, engineering and regulatory aspects to ensure the sustainable development and utilization of opportunities for innovation in the management of water use.

Based on the theoretical considerations, below we present the central hypothesis that guides the development of this study:

***H1**: The management of water use impacts positively the business performance of industries in the Brazilian mining sector.*

Considering the importance of the management of water use to the mining activity and the performance evaluation for the corporate competitiveness, we intend to confirm the direct relationship existing between the constructs in the industries surveyed. Business performance is understood here beyond profit, but also evaluating the environmental and social performance of companies.

The following section describes the method of study outlined for achieving the objectives proposed.

III. METHOD

In order to achieve our objectives, we employ a survey, with quantitative approach and descriptive nature.

The research base comprises mining industries associated with the Brazilian Mining Institute – IBRAM, the largest organization representing companies and institutions working in the Brazilian mining industry. For the composition of the target population, we included companies that:

1) Participate in the boards of members of IBRAM or a trade association associated with this institute.
2) Focus on the development of extraction, transformation or processing activities of any mineral commodity.

All companies in the target population were contacted. We collected 50 questionnaires from a sample of 260 companies, which produced a return rate of 19%, an acceptable index for surveys of this nature.

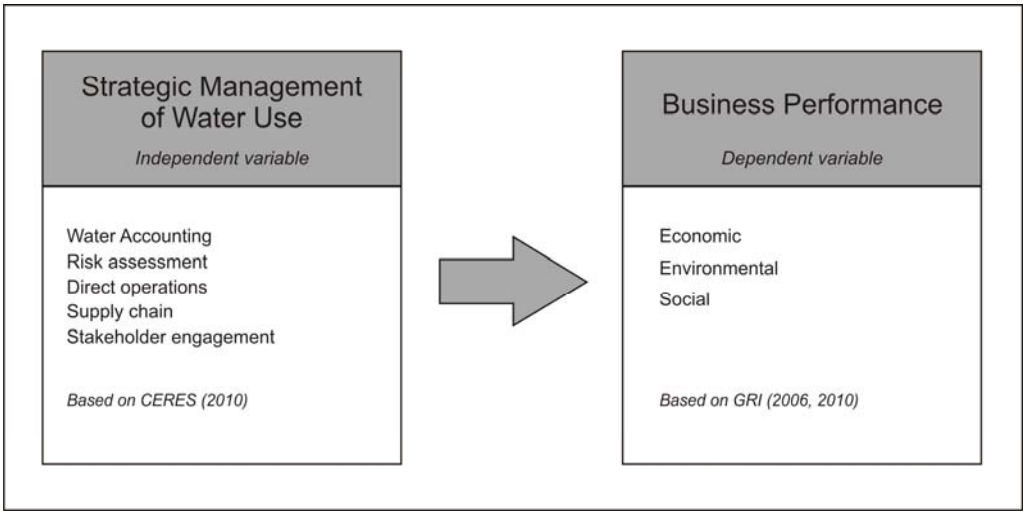

Figure 1 – Conceptual model

Data were collected through email by using a questionnaire based on the conceptual model, as shown in Figure 1.

As can be seen in Figure 1, the independent variables of the model allow the identification of the management practices of water use, based on the study conducted by Ceres (2010), that defines 19 indicators relating to the following aspects: (1) water accounting, (2) risk assessment, (3) direct operations, (4) supply chain, and (5) stakeholder engagement.

The dependent variables that identify the business performance are based on the model developed by the Global Reporting Initiative – GRI [12] and its supplement focused on the mining sector [13]. The business performance, understood here as the results of companies in economic, social and environmental terms, is assessed through 31 indicators, as (1) economic, (2) environmental and (3) social.

To measure the independent and dependent variables described above, we used a 10-point interval scale, in which the respondent indicates the degree of agreement with company practces, where '0.1' represents the lowest degree of agreement and '1.0' the highest degree of agreement. The respondent could also indicate '0' for the option 'not applicable'. The questionnaire was reviewed by experts in the field and subsequently a pilot test was developed and conducted with three companies in the Brazilian mining sector.

Data analysis was conducted through the observation of descriptive statistics, using univariate and multivariate techniques, with the support of the SPSS v.17 software. Data normality was tested using the Kolmogorov-Smirnov and Shapiro-Wilk tests [11], and both tests indicated that the collected data are not normally distributed. The multivariate data analysis consisted of an exploratory factor technique has as its primary purpose to define the inherent structure between the variables in the analysis. For the extraction of the factors, we used the principal component analysis technique, with the varimax rotation method, which maximizes the sum of the variances of the required loads, thus providing a clear association between the variables and the factor. For the selection of the factors, we used the Kaiser criterion with eigenvalues of significance greater than 1.0. The adhesion of the variables took into account their commonalities, the correlation matrix, the anti-image matrix and the matrix of components, as indicated by Pestana and Gageiro [19]. The quality of the correlation between variables is identified by the Kaiser-Meyer-Olkin (KMO) index and Bartlett's test of sphericity. Finally, we verified the internal consistency of the groups of variables, through the analysis of the Cronbach's Alpha [19]. To verify the impact of the management of water use in business performance, we used the multiple regression analysis that, according to Pestana and Gageiro [19], refer to a multivariate, descriptive and inferential statistical technique. We adopted stepwise method.

IV. RESULTS

We present the characteristics of companies and then descriptions of their water management and business performance. Finally, we present the evidence of the relationship between the management of water use and business performance in the industries surveyed, through the multiple regression analysis.

A. Profile of companies

The companies have been operating for 37 years on average, though there is a huge variation in the range, with the shortest period of operation being three years and the longest being 130 years. Most of the firms are located in the South and Southeast of the country. According to DNPM [8], most Brazilian production is concentrated in the Southeastern states, especially Minas Gerais and Sao Paulo.

In order to identify the size of the companies, Table 1 shows figures related to the gross operating revenue in a classification adapted from BNDES [3].

TABLE 1 – SIZE OF COMPANIES – GROSS OPERATING REVENUE (2010)

Company Size - Gross operating revenue (2010)	Frequency	(%)
Micro and Small enterprise (up to 16 million reais)	21	42.00
Medium enterprise (from 16 to 300 million reais)	16	32.00
Large enterprise (over 300 million reais)	11	22.00
No Answer	2	4.00
Total	**50**	**100**

TABLE 2 – MINERAL PRODUCTS EXTRACTED

Mineral Product	Frequency	(%)	Mineral Product	Frequency	(%)
Mineral Aggregates	13	26.0	Bauxite	1	2.0
Mineral Coal	9	18.0	Calcium Carbonate	1	2.0
Limestone	8	16.0	Copper	1	2.0
Iron	4	8.0	Niobium	1	2.0
Dolomite	3	6.0	Nickel	1	2.0
Kaolin	2	4.0	Gold	1	2.0
Steel	1	2.0	Oil	1	2.0
Aluminum	1	2.0	Serpentine	1	2.0
Asbestos	1	2.0	**Total**	**50**	**100**

There is a predominance of micro and small enterprises, in accordance with the this distribution is once again in accordance with the profile of the Brazilian mining sector, which consists mostly of small enterprises [8].

Table 2 demonstrates the diversity of the companies, which extract 17 different types of minerals, as well as mineral aggregates. According to IBRAM [16], the market for mineral aggregates primarily consists of sand and crushed stone, especially intended for the construction sector. Also noteworthy is the production of coal, which accounts for 15% of Brazilian mineral imports [8].

B. Management of water use

The analysis of water management aims to present key business practices adopted by the mining industries surveyed. The discussions in this section is based on the model proposed by Ceres (2010), which includes five dimensions of analysis: (i) water accounting; (ii) risk assessment; (iii) direct operations; (iv) supply chain, and (v) stakeholder engagement. Table 3 shows the activities of the survey respondents.

TABLE 3 – MANAGEMENT OF WATER USE – DESCRIPTIVE STATISTICS

Variables	Mean	Median
1 Water accounting	0.56	0,67
Control of the amount of water withdrawn/consumed	0.68	0,80
Control of the discharge of wastewater	0.70	0,80
Control of the amount of water used by its suppliers	0.31	0,10
2 Risk assessment	0.77	0,89
Awareness of its exposure to physical risks	0.79	0,90
Awareness of its exposure to reputation risks	0.80	0,90
Awareness of its exposure to regulatory risks	0.76	0,90
Awareness of its exposure to litigation risks	0.72	0,85
3 Direct operations	0.67	0,70
Policies and management systems in relation to water	0.70	0,85
Information about non-conformity, violations or penalties in water use or waste discharges	0.73	0,95
Effort to reduce water use at the corporate level	0.78	0,90
Effort to reduce the discharge of waste water	0.75	0,90
Targets to reduce water use at corporate and local level	0.55	0,65
Targets to reduce the discharge of waste water	0.54	0,65
4 Supply Chain	0.32	0,20
Effort in assessing, training or helping its suppliers	0.35	0,15
Effort in collecting data and monitoring the impacts of its suppliers	0.29	0,10
Targets to reduce impacts in the supply chain	0.33	0,10
5 Stakeholder engagement	0.48	0,50
Collaboration with stakeholders on issues involving drinking water and sanitation	0.52	0,55
Collaboration with stakeholders in the management and restoration of watersheds	0.47	0,50
Consultation with communities and NGOs to implement or expand operations.	0.44	0,40

[1] The average figures refer to the level of agreement of the companies on the implementation of such practices on a scale ranging from 0 to 1, where 1 is the highest level of agreement.

[2] The average figures of each dimension were calculated from the arithmetic mean of its variables.

The practices relating to the 'assessment of the risks' involved in relation to use of water had the highest averages in the study and the lowest coefficients of variation. The high rates in this category corroborate the study of Ceres [6], in which companies in the mining sector stand out in evaluating and disseminating risks of water use. This is because mining has a high dependency on the availability of water and is subject to increasing pressure from legislation. The high average in the variable associated with reputation risks is in line with the study of Lambooy [17], and makes sense because of society's increasing awareness of environmental impacts.

The high average of the "direct operations" dimension corroborates with studies that points to the increasing use of operational tools and practices in the mining industry, aimed at the control of water use at the operational level [10, 14, 1, 16].

Finally, there are two dimensions with smaller results: 'stakeholder engagement' and 'supply chain'. Our results support the contention of Hilson and Murck [14] that there needs to be greater integration of the mining industries and their stakeholders. At the same time, data shows that the integration industry-supply chain with regard to the management of water use is still incipient in the companies surveyed. Based on these results, it is possible to move toward the business performance of these industries.

C. Business performance.

An assessment of the business performance of the companies surveyed, measured based on the GRI model [12, 13] considered three dimensions: economic, social and environmental, wich are shown in Table 4

TABLE 4 – BUSINESS PERFORMANCE (IMPACTS) – DESCRIPTIVE STATISTICS

Variables	Mean	Median
Economic dimension	0.56	0,64
Increase of the generated and distributed direct economic value	0.63	0,70
Presence of policies, practices and proportion of expenses with local suppliers.	0.58	0,70
Higher proportion of senior management hired from the local community.	0.48	0,50
Investment in infrastructure and services offered especially for public benefit	0.54	0,60
Environmental dimension	0.64	0,69
Increased use of materials derived from recycling.	0.58	0,70
Reduction of direct and indirect energy consumption	0.66	0,80
Reduction of water consumption	0.66	0,80
Increase in the percentage of land rehabilitation	0.70	0,80
Reductions in emissions of greenhouse gases, effluents and waste	0.64	0,80
Reduction of the total values of overload, rocks, tailings, and sludges and their associated risks.	0.68	0,80
Initiatives to reduce environmental impacts of products and services	0.77	0,90
Percentage of recovered products and packaging in relation to total goods sold	0.42	0,40
Reduction of environmental impacts related to the transportation of products, materials and workers.	0.65	0,75
Social dimension	0.59	0,58
Reduction of the rate of employee turnover	0.77	0,80
Reduction of rates of injury, occupational diseases, lost days, absenteeism and work-related deaths	0.87	0,90
Occupational health and safety programs	0.86	1,00
Investment in training	0.79	0,80
Percentage of suppliers and contractors submitted to assessments relating to human rights	0.59	0,60
Measures to reduce discrimination	0.67	0,80
Measures to abolish child labor and/or slavery	0.70	1,00
Reduction of operations conducted within or near indigenous territories	0.29	0,00
Programs and practices to reduce the impact of operations on communities	0.63	0,80
Reduction of conflicts related to land use	0.37	0,05
Promotion of resettlement and rehabilitation of resettled individuals	0.22	0,00
Increase of the percentage of operations with closure plans	0.41	0,30
Investment in anti-corruption mechanisms.	0.42	0,25
Reduction of fines and non-monetary sanctions resulting from the noncompliance with laws and regulations	0.64	0,90
Reduction of impacts on the health and safety of customers from the assessment of the life cycle of products and services	0.56	0,70
Adequacy to labeling requirements for products and services	0.52	0,55
Programs and progress relating to the management of materials aiming at sustainability.	0.63	0,75
Increase of stakeholder involvement	0.65	0,80

[1] The average figures refer to the level of agreement of the companies on the implementation of such practices on a scale ranging from 0 to 1, where 1 is the highest level of agreement.

[2] The average figures of each dimension were calculated from the arithmetic mean of its variables.

Although there is a relative balance in the assessment of the impacts generated in the three dimensions analyzed, the environmental dimension obtained the highest average figures among the companies surveyed. This result is in line with findings of previous studies, which point to the increasing alignment of the mining sector with the prospects of sustainable development, evidencing concerns with business performance not only from an economic standpoint, but also from the environmental and social standpoint. [2, 14, 16, 18].

D. Factors that influence the management of water use and business performance

In view of the large number of variables that make up the conceptual model - 19 indicators related to the management of water use and 31 relating to business performance, we chose to conduct a factor analysis. We obtained a KMO index above 0.70, Barllet's test with significance lower than 0.001 and total explained variance greater than 70% in both constructs. The reliability of the scales, using the Cronbach's Alpha, shows its suitability, as proposed by Pestana and Gageiro [19]. Table 5 shows the factor analysis related to the management of water use.

The results presented indicate the construction of four factors that explain 78.56% of the total variance of the figures. The total Cronbach's Alpha greater than 0.90 indicates the internal consistency of this construct. The factor analysis of the variables related to the business performance is described in Table 6.

The results of the factor analysis suggest the construction of five factors that explain 74.49% of the total variance of the figures. The total Cronbach's Alpha is greater than 0.90, indicating the reliability of the scale. Due to the low correlations, 10 indicators have not joined the factors extracted, after the initial rotation, and were excluded from the analysis, thus improving the results.

Based on the factor analysis presented, we identify the four factors related to the construct of management of water use and the five factors associated with business performance. Based on these dimensions, it is possible to move towards the analysis of the relationship between the management of water use and business performance.

TABLE 5 – FACTOR ANALYSIS RELATED TO THE MANAGEMENT OF WATER USE

Factors	Variables	Factor Loads	Eigenvalues	Total Explained Variance
Corporate and operational control	Effort to reduce water use at the corporate level	0.890	4.415	24.53%
	Effort to reduce the discharge of waste water	0.828		
	Control of the amount of water withdrawn/consumed	0.719		
	Control of the discharge of wastewater	0.700		
	Policies and management systems in relation to water	0.637		
	Information about non-conformity, violations or penalties in water use or waste discharges	0.598		
	Targets to reduce water use at corporate and local level	0.579		
Risk assessment	Awareness of its exposure to litigation risks	0.940	3.809	21.16%
	Awareness of its exposure to regulatory risks	0.921		
	Awareness of its exposure to physical risks	0.812		
	Awareness of its exposure to reputation risks	0.764		
Stakeholder engagement	Collaboration with stakeholders in the management and restoration of watersheds	0.905	3.268	18.16%
	Consultation with communities and NGOs to implement or expand operations.	0.840		
	Collaboration with stakeholders on issues involving drinking water and sanitation	0.766		
	Targets to reduce the discharge of waste water	0.556		
Supply chain	Effort in collecting data and monitoring the impacts of its suppliers	0.874	2.653	14.74%
	Effort in assessing, training or helping its suppliers	0.829		
	Targets to reduce impacts in the supply chain	0.794		

[1] Method of extraction: Principal component analysis.
Rotation method: Varimax with Kaiser normalization, with conversion in 5 iterations.
KMO = 0.729, Bartlett's test with significance p = 0.000.
Total Cronbach's Alpha: 0,934

TABLE 6 – FACTOR ANALYSIS RELATED TO BUSINESS PERFORMANCE

Factors	Variables	Factor Loads	Eigenvalues	Total Explained Variance
Economic and community impacts	Increase of the generated and distributed direct economic value	0.803	3.859	18.37%
	Investments in infrastructure and services offered especially for public benefit	0.747		
	Increased presence of policies, practices and proportion of expenses with local suppliers.	0.741		
	Higher proportion of senior management hired from the local community.	0.730		
	Programs and practices to reduce the impact of operations on communities	0.580		
Environmental impacts.	Reduction of environmental impacts related to the transportation of products, materials and workers.	0.808	3.623	17.25%
	Initiatives to reduce environmental impacts of products and services	0.765		
	Reduction of water consumption	0.634		
	Reduction of direct and indirect energy consumption	0.634		
	Reduction of the total values of overload, rocks, tailings, and sludges and their associated risks.	0.558		
	Reductions in emissions of greenhouse gases, effluents and waste	0.526		
Social impacts on human rights and stakeholder engagement	Increase in the percentage of suppliers and contractors submitted to assessments relating to human rights	0.712	2.840	13.52%
	Measures to reduce discrimination	0.690		
	Increase of stakeholder involvement	0.684		
	Measures to abolish child labor and/or slavery	0.684		
Social impacts on labor practices	Occupational health and safety programs	0.854	2.798	13.33%
	Reduction of rates of injury, occupational diseases, lost days, absenteeism and work-related deaths	0.772		
	Investment in training	0.634		
	Increase in the percentage of land rehabilitation	0.541		
Social impacts on product liability	Adequacy to labeling requirements for products and services	0.874	2.523	12.02%
	Programs and progress relating to the management of materials aiming at sustainability.	0.688		

[1] Method of extraction: Principal component analysis. Varimax rotation with Kaiser normalization, with conversion in 10 iterations; KMO = 0.804, Barlett sig p = 0.000; Cronbach's Alpha: 0.934

E. Analysis of the impact from the management of water use in business performance

This section aims to assess the impact from the management of water use in business performance, by using the multiple regression technique. In this case, it is possible to check whether the factors related to the management of water use significantly impact the increase in business performance, identifying the degree of this relationship.

The independent variables that initially comprise the model are the four factors of water use management extracted in the exploratory factor analysis, namely: 'corporative and operational control', 'risk assessment', 'engagement with stakeholders' and 'supply chain'.

The dependent variable is represented by the business performance index, calculated based on the weighted average of the business performance factors, extracted in the exploratory factor analysis, taking into account the weights of their respective explained variances.

We used the stepwise method of entry, which allows the analysis of the additional contribution of each independent variable to the model before its insertion. Table 7 below shows the coefficients obtained in the regression analysis in each one of its stages.

TABLE 7 – COEFFICIENTS OF THE REGRESSION MODEL

Model	Non-standardized coefficients		Standardized coefficients	t test	Sig.	VIF
	Coef. B	Standard error	*Beta*			
Step 1						
Constant	0.000	0.055		0.000	1.000	
Stakeholder engagement	0.239	0.056	0.528	4.307	0.000**	1.000
Step 2						
Constant	0.000	0.049		0.000	1.000	
Stakeholder engagement	0.239	0.050	0.528	4.797	0.000**	1.000
Corporate and operational control	0.177	0.050	0.390	3.543	0.001**	1.000

Dependent Variable: Business Performance Index

TABLE 8 – SUMMARY STATISTICS OF THE REGRESSION MODEL

Model	R	R²	Adjusted R²	Standard Error of the Estimate	Statistics of Change					Durbin-Watson
					Change in R²	Change in F	gl1	gl2	Change, in F-Sig	
1	0.528[a]	0.279	0.264	0.38913	0.279	18.550	1	48	0.000	
2	0.656[b]	0.431	0.407	0.34935	0.152	12.552	1	47	0.001	1.764

a. Predictors: (Constant), 'Stakeholder engagement'
b. Predictors: (Constant), 'Stakeholder engagement', 'Corporate and operational control'
c. Dependent variable: Business Performance Index

TABLE 9 - ANOVA F-TEST OF THE REGRESSION MODEL

	Sum of Squares	Gl	Mean of Squares	F	Sig.
Regression – Step 1	2.809	1	2.809	18.550	0.000[a]
Residuals	7.268	48	0.151		
Total	10.077	49			
Regression – Step 1	4.341	2	2.170	17.783	0.000[b]
Residuals	5.736	47	0.122		
Total	10.077	49			

a. Predictors: (Constant), 'Stakeholder engagement'
b. Predictors: (Constant), 'Stakeholder engagement', 'Corporate and operational control'
c. Dependent variable: Business Performance Index

The set of summary statistics of the regression model is presented in Table 8, which shows the coefficients R, R² and adjusted R², in addition the Durbin-Watson test.

The factors 'stakeholder engagement' and 'corporate and operational control' explain a variation of 43.1% of the business performance Index (R² = 0.431). In this sense, the model can be described by Equation 1 below. The factors 'risk assessment' and 'supply chain', did not reach significant levels and, therefore, are not part of the model of analysis.

$$Y = 0{,}526\,X_1 + 0{,}390\,X_2 + \varepsilon \quad (1)$$

Where: Y = index of business performance; X1 = 'Stakeholder engagement'; X2 = 'Corporate and operational control'; ε Error of the model

Note the set of assumptions of the regression analysis that grant validity to the model. The significance of the ANOVA F-test, as shown in Table 9, suggests the rejection of the null hypothesis and that the regression coefficients are zero. The value of VIF (VIF=1.000) and the tolerance strongly indicate the absence of multicollinearity in the model. The Durbin-Watson test (1.764) indicates that the hypothesis of independence of errors is met, showing that there is no autocorrelation. It is also worth noting that it is not possible to reject the hypothesis of homoscedasticity of residuals, granting validity to the model. Finally, we address the hypothesis of normality of the residuals, which is tested by means of Kolmogorov-Smirnov and Shapiro-Wilk tests. Both tests allow the acceptance of the hypothesis that the residuals follow a normal distribution. Thus, the regression model meets the assumption of normality.

Since it meets all the desirable assumptions of regression analysis, the model is valid and we conclude that the factors 'stakeholder engagement' and 'corporate and operational control', related to the management of water use, are the main elements that impact the business performance of the industries analyzed. These factors together explain a variation of 43% of the business performance index as shown in Figure 2.

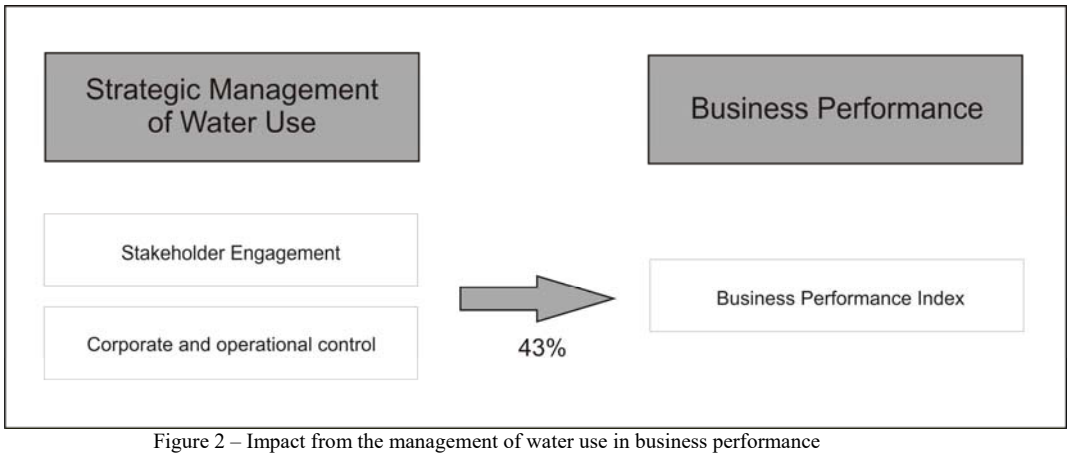

Figure 2 – Impact from the management of water use in business performance

The model of multiple regression analysis suggests the importance of the factors 'stakeholder engagement' and 'corporate and operational control' for the management of water use, positively impacting the business performance in the companies analyzed.

While 'stakeholder engagement' is among the dimensions that reported lowest rates in the descriptive analysis, its high impact on business performance shows the importance of investing in aspects related to the integration of the company with stakeholders, thus corroborating previous studies [6, 14, 1]. Therefore, the investment in stakeholder engagement is an opportunity for performance gains for mining companies.

It is evident also that controlling the amount of water used by the company is equally important on the impact on business performance. The quantitative management of this resource, from the corporate and operational standpoint, has a positive impact on performance, which corroborates Lambooy [17].

Thus, the results of the regression model, which point to the relationship between two factors associated with the management of water use, indicate the relationship existing between the management of water use and business performance in the industries surveyed and confirm hypothesis H1 of this study:

H1: The management of water use impacts the business performance of industries in the Brazilian mining sector.

V. FINAL CONSIDERATIONS

The mining industry is important in Brazil: it is a key supplier for several supply chains, has a large share of Brazilian production, and is a significant source of job creation. However, there are several potential impacts caused by this activity, from the environmental and social perspective. In particular, mining uses a large amount of water and affects its quality.

The results initially allowed us to understand the behavior of the companies participating in the survey with regard to the management of water use and business performance. The highlights were the practices associated with the assessment of the risks involved and the direct operations in the management of water use. We also show the need for a greater integration of the companies with the supply chain and the engagement of stakeholders on issues related to water.

Based on the factors extracted in the exploratory factor analysis, we used multiple regression analysis to find the impact of water use on business performance. The results of this technique allowed us to state that the factors associated with 'stakeholder engagement' and 'corporate and operational control' significantly impact the business performance index of the industries surveyed. Thus we confirm our hypothesis water use management impacts - H1: *The management of water use impacts positively the business performance of industries in the Brazilian mining sector.*

Finally, we conclude that the objectives proposed have been achieved, as we have verified the relationship between the management of water use and the business performance in the industries surveyed, results that are in-line to other researches [17, 10, 1, 18].

The study results increased the discussion on the theme management of water use combined with the business performance, considering that there are few studies that address these issues together. The study also contributes with applied analyzes that show the reality of the companies in the Brazilian mining industry with regard to management of water use.

However, there are some limitations to the study. First, survey firms that are included are those who responded to the survey and so may be different from the norm in the mining industry. Second, we cannot evaluate the impact of Brazilian policies; we would like to see the results compared to those in other countries so that the effects of different policies and social contexts can be evaluated.

Through a holistic and integrated perception of the aspects related to water use, we find that the efficient use of water increases business performance in the Brazilian mining industry. The result is likely to extend beyond the mining industry and to other sectors in which water is essential, so that companies can enhance their business performance and simultaneously minimize environmental costs, seeking a more sustainable industrial activity, in economic, social and environmental terms.

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