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Biodiversity and the mining Environmental Impact Statements of the state of São Paulo - Brazil

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Abstract: The state of São Paulo has a history of habitat loss and fragmentation in endemic areas with projects that threaten its biodiversity. Therefore, this study analyzed how the Environmental Impact Statements (EISs) of mining activities of the state of São Paulo (2005-2016) considered the biodiversity theme in different chapters. To analyze the ten selected EISs, we used the Index of Biodiversity Inclusion (IBI), which reflects the analysis of environmental indicators (from 0 to 1), depending on the commitment presented in each of the indicators. The IBI values ranged from 0.25 to 0.67 with significant variation among EISs. Most of them partially met the criteria, which was a profile similar to other countries, representing information gaps in most of the chapters covering biodiversity. The shortcomings were data limitation, impact analysis, and inadequate mitigation measures, in which the study highlights the need for a better scoping definition previous to Environmental Impact Assessment.

Keywords: Biological Diversity, Environmental Impact Assessment, Land Use.

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Introduction

In Brazil, some political plans and economic projects, such as mining activities, may not consider that biodiversity loss has exceeded the planetary boundaries and may pose a threat to conservation biology, including biological groups that are not known yet (FAHRIG, 2003; ROCKSTRÖM, 2009; BOCKMANN et al., 2018). This scenario reinforced the need to improve the effectiveness of environmental policy tools, such as the Environmental Impact Assessment (EIA) in order to support biodiversity maintenance.

Although mining is not considered the main cause of biodiversity loss on a large scale, this activity is a pressure or may intensify the existing pressures on biological diversity (BRUMMIT; BACHMAN, 2010). Among the direct and indirect threats of mining on biodiversity, we can cite the vegetation suppression and its regeneration impediment, ecosystems alteration, and habitat fragmentation. Furthermore, there is noise, water, and air pollution by the activity itself and influenced by road construction, waste disposal, and electricity production (MECHI; SANCHEZ, 2010; ASHE, 2012; CABALLERO ESPEJO et al., 2018; RANJAN, 2019). Recently, the ruptures of Mariana and Brumadinho dams in the state of Minas Gerais - two major environmental disasters involving mining activities - have intensified the debates on mining, EIA, and environmental licensing in Brazil.

The state of São Paulo is the largest consumer of minerals for civil construction and the fourth in mineral production in Brazil. In total, the Financial Compensation for Mineral Resources Exploration in the state of São Paulo (CFEM, an acronym in Portuguese) was around R$56 million in 2017, out of R$1,837 million from Brazilian collection (SEM, 2018). Moreover, the state of São Paulo has few remnant forest patches from two biomes (Cerrado and Atlantic Forest), both considered global hotspots due to exceptional concentration of endemic species and few natural habitats (MYERS et al., 2000).

Regarding the expected environmental effects from mining activity, public authority decisions must consider the Principles of Precaution and Prevention using environmental policy tools. For instance, EIA is a tool for environmental management (MORGAN, 2012) required for projects likely to cause significant environmental degradation (JAY et al., 2007), which is the case of most mining projects. Hence, the proponents of the projects need to submit an Environmental Impact Statement (EIS) to the competent environmental authority, responsible for the environmental licensing. In Brazil, EISs are documents of the environmental licensing. The process should support the decision-making regarding the environmental feasibility of the project (JAY et al., 2007), considering the relationship between typology and location (MONTAÑO et al., 2012).

International studies have associated biodiversity with EIA procedures, aiming to contribute to conservation biology. However, some problems in the elaboration of EISs are discussed, such as vague and descriptive environmental analyses; few quantitative indicators; location alternatives rarely based on ecological issues; lack of analyses for the ecosystem level and for the spatial and temporal scales of ecosystem processes (ATKINSON et al., 2000; BYRON et al., 2000; MANDELIK; DAYAN; FEITELSON, 2005; SODERMAN, 2005; NASER; BYTHELL; THOMASON, 2008; KHERA; KUMAR, 2010; MORGAN, 2012; DRAYSON; WOOD; THOMPSON, 2015; BIGARD; PIOCH;

THOMPSON, 2017).

Therefore, based on the shortcomings in EIA and the intense impacts of mining activities on biodiversity, we analyzed how EISs associated with mineral extraction and treatment of the state of São Paulo between 2005 and 2016 considered the biodiversity theme.

Material and Methods

Ten EISs of mineral extraction and treatment were analyzed (Table 1 - letters A to J), an amount similar of a mining study in the state of Minas Gerais – Brazil (PRADO-FILHO; SOUZA, 2004). Such EISs were selected randomly on the website Sorteador (https://sorteador.com.br/), in which every EIS received a number from 1 to 295. The final number of EISs (10) represents 30% of the mining EISs of the state of São Paulo, maintaining the same proportion of the total mining EISs carried out from 2005 to 2016, which is 11% (1) of the total amount of EISs (295).

$$\mathbf{295 \times 11\% \times 30\% = 9{,}7} \qquad \mathbf{(1)}$$

295: the total amount of EISs of the state of São Paulo from 2005 to 2016.

11%: percentage of EISs of the state of São Paulo from 2005 to 2016 regarding mining activities (32/295).

30%: percentage of the analyzed EISs.

The sample comprises three implantation projects (letters A to C in Table 1) and seven expansion ones (letters D to J in Table 1). The ores of the projects involved sandstone (sand, gravel, and clay), basalt (gravel), limestone, cement, phyllite, and granite (Table 1). The EISs with the letters A and D to J were accessed on CETESB[1] online collection, while EISs B and C were consulted in person in the same environmental agency.

1 - Available at: <http://licenciamentoambiental.cetesb.sp.gov.br/eia-rima>

Table 1 – Ten Environmental Impact Statements of the state of São Paulo selected for the analysis of the inclusion of biodiversity information, based on a stratified sample

Code	Process Year	Process number/ Finder	Project title
A	2005	13500/0677	Limestone mining - Serrinha Area
B	2007	13534/0607	Project of granite mining and beneficiation for gravel production
C	2008	00552/0818	Mineral limestone extraction
D	2009	00089/0816	Phyllite, sand, clay, and gravel mine expansion
E	2009	08447/0236	Basalt mining area expansion
F	2010	00022/0793	Ponte Alta and Salto mines expansion
G	2013	00299/0857	Serrinha mine activities expansion
H	2013	00416/0843	Expansion of the mining area Olho D'Água - Bom Sucesso de Itararé
I	2014	00056/0860	Granite extraction activity expansion in the municipality of Caieiras
J	2015	00190/0864	Granite and gravel mining expansion and Waste deposits implantation

Source: preparation of the authors.

For the analysis of the inclusion of biodiversity in EISs, we used indicators adapted from Khera and Kumar (2010), which are based on article 14 (Impact Assessment and Minimizing Adverse Impacts) of the Convention on Biological Diversity (CBD) and other fundamental components of biodiversity and its conservation (Tab. 2). The goal is to avoid and to minimize impacts on biodiversity, and to promote its conservation. As Khera and Kumar (2010) list is originally from India, some categories and indicators make sense in both contexts (India and Brazil), but others do not. For instance, the category about the effort made to effectively involve stakeholders in decision making was excluded. In indicator 8, the parameter associated with the Ministry of Environment, Forest and Climate Change of India was replaced for a comprehensive characterization. Moreover, in order to reproduce the study, the scores attribution was detailed on Table 2. Despite that, bias in the results is still possible.

All the EISs were analyzed in the same way, and one of those scores (0, 0.5, and 1) was assigned, according to the following classification (e.g., ATKINSON et al., 2000):

1.0 – when the indicator was totally met;

0.5 – when the indicator was partially met; and

0.0 – when the indicator was not met (i.e., nothing about biodiversity).

Subsequently, we calculated the Index of Biodiversity Inclusion (IBI) and the Index of Biodiversity Inclusion for indicators (IBIi), which are quantitative indexes that facilitate the comparison of the status of biodiversity inclusion between the EISs (2) (ATKINSON et al., 2000) and the indicators (3) respectively. The closer to 1, the more the EIS (in the case of IBI) and indicator (in the case of IBIi) addressed topics about biological diversity.

$$\text{IBI of each EIS} = \frac{\text{sum of assigned scores}}{\text{sum of indicators}} = \frac{(P)}{26} \quad (2)$$

Obs1: é necessário que o número 26 esteja logo abaixo de (P), pois 26 é o denominador de (P).

Obs2: é preciso sublinhar a expressão "(P)", de modo que seja o numerador de "26".

Obs3: é preciso sublinhar a expressão "sum of assigned scores", de modo que ele seja o numerador de "sum of indicators"

$$\text{IBIi of each indicator} = \frac{\text{sum of assigned scores of the ten EISs}}{\text{sum of the analyzed EISs}} = \frac{(S)}{10} \quad (3)$$

Obs1: é necessário que o número 10 esteja logo abaixo de (S), pois 10 é o denominador de (S).

Obs2: é preciso sublinhar a expressão "(S)", de modo que seja o numerador de "10".

Obs3: é preciso sublinhar a expressão "sum of assigned scores of the ten EISs", de modo que ele seja o numerador de "sum of the analyzed EISs".

To visualize the frequency of IBI and IBIi intervals, we made a histogram, and to analyze the frequency of values assigned to the sufficiency groups of the indicators, a vertical bar graph. In order to compare the results of the EISs of the state of São Paulo, the Kruskal-Wallis test (nonparametric data) was applied, in which the null hypothesis designated ten EISs with significantly equal IBIs, while the alternative hypothesis represented at least one EIS with significantly different IBI from others. When this difference was identified, the post-test Dunn was applied to verify, pair by pair, which data series were different from each other.

Table 2 – Analysis of the Environmental Impact Statements of the extraction and treatment of minerals of the state of São Paulo

Category	Indicator	Assigned score		
		1.0	0.5	0.0
Enough information on the impact area vis-à-vis biodiversity has been gathered	1- Is the location map showing known biodiversity area, urban area, other industrial establishments and projects and distance from coastal area/surface water bodies/ecologically sensitive areas, etc. available?	Map with all items	Map with part of the items	NA
	2- Has the impact area been described keeping in mind the biodiversity impacts, wherever biodiversity impacts are likely to occur over a larger area?	Consider biodiversity in ADA, AID e AII[1*] For instance: APP[2*], ecological corridors, priority areas for conservation	Consider biodiversity in ADA and/or AID and/or AII[1*]	NA

Baseline study is comprehensive enough to provide a basis for correct impact prediction*	3- Have the components of the biodiversity likely to be affected by the project been identified and described sufficiently for the prediction of impacts[3*]?	Relationship between identified impacts and baseline	Partial relationship between identified impacts and baseline	NA
	4- Does the information include listings of endemic and endangered species present within the proposed project area?	Endemic and threatened	Endemic or threatened	NA
	5- Where applicable, does the baseline data identify and enumerate flora and fauna including seasonal variables, e.g. species, migration routes, spawning and breeding grounds?	Addresses all the items	Addresses part of the items, e.g., identifies and lists only flora or fauna; evaluates flora and fauna, without analyzing seasonal variables	NA
	6- Has the importance of biodiversity elements present in the impact area been assessed and described, e.g., Importance Value Index?	Always evaluates and describes it	Always or sometimes evaluates or describes it. Or evaluates and describes it in part of the cases	NA
	7- Were biodiversity experts involved in conducting the study?	Experts in herpetofauna, avifauna, mastofauna, and flora	Lack of one or more of the cited experts	NA

Baseline study is comprehensive enough to provide a basis for correct impact prediction	8- Is the method of collection of primary biodiversity data described in detail? [Checked points, collection days, period of the year, equipment, identification bibliography, and parameters]	Methods fully described for all flora and fauna groups	Methods described for some biological groups. Or partial description of the methods	NA
	9- Have sources of secondary data been referred to?	All	Some	NA
	10- Are gaps and limitations of the baseline biodiversity data indicated and means to deal with them explained?	In all cases	In some cases	NA
All the possible impacts on all components of biodiversity are predicted	11- In order to effectively address biodiversity impacts, it is imperative that biodiversity impacts are not merged within the broader category of ecological impacts, or merely as impact on flora and fauna. Therefore, it was a matter of concern if the biodiversity impacts were described in a separate section.	Chapter entirely dedicated to biodiversity	Chapter on the biotic environment without a biodiversity focus	NA
	12- Are direct biodiversity impacts described appropriately?	Classification and description of direct impacts	Classification or description of direct impacts	NA
	13- Are indirect, secondary and cumulative biodiversity impacts described appropriately?	Classification and description of indirect, secondary and cumulative impacts	Classification and/or description of one of the cited impacts	NA

All the possible impacts on all components of biodiversity are predicted	14- Are short-term/ long-term impacts on biodiversity due to air, noise or water pollution described?	Description of short-term and long-term impacts of the three types of pollution	Description of short-term and/ or long-term impacts of 1 or 2 types of pollution. Or description of short-term or long-term impacts of one or more types of pollution	NA
	15- Has the significance of the impacts been assessed?	Evaluates with explicit parameters	Evaluates without explicit parameters	NA
	16- Does the impact on biodiversity cover all the three levels, viz. ecosystem, species and genetic level?	Addresses the three levels	Addresses one or two levels, e.g., mentions the genetic level slightly	NA
All the possible impacts on all components of biodiversity are predicted	17- Are the biodiversity impacts predicted in quantitative terms?	Using explicit indicators	Without explicit indicators	NA
	18- Are the biodiversity impacts predicted in qualitative terms?	Qualitative analysis with clear parameters	Qualitative analysis without clear parameters	NA
	19- Are the methods /approaches used to identify the impacts and the rationale for using them described[4*]?	Description of the methods and justification	Methods partially described and / or justified	NA
Alternatives with least biodiversity damage are available	20- Have biodiversity impacts of the alternative solutions/ sites been described and compared with the proposed development and with the likely future conditions in zero-option development?	Biodiversity considered in the alternative and in the comparison with the scenario without the project	Biodiversity considered in the alternative or in the comparison with the scenario without the project	NA

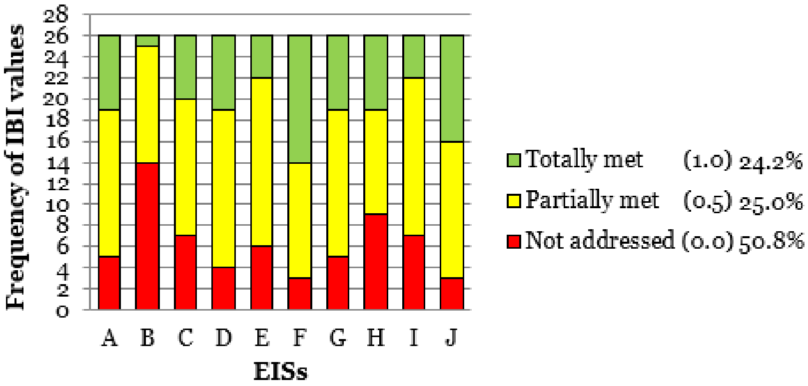
Effective mitigation measures for the predicted impacts are proposed	21- Is mitigation a part of the project design from the start of the development of the project?	For all impacts	For some impacts	NA
	22- Are mitigation measures proposed to address the biodiversity impacts at all levels, i.e. genetic/ species/ landscape and all structures trees/shrubs/herbs as well as temporal biodiversity?	Levels, structures, and temporal variation	Absence of mitigation proposals for levels and/or structures and/ or temporal variation	NA
	23- Is effectiveness of the mitigation measures addressed and gaps identified?	For all impacts	For some impacts	NA
An effective biodiversity monitoring plan is in place	24- Is a monitoring plan for biodiversity impact proposed?	For all impacts	For some impacts	NA
An effective biodiversity monitoring plan is in place	25- Are details of the criteria and indicators to be used during the monitoring available in the report?	For all impacts	For some impacts	NA
	26- Have the limitations in monitoring biodiversity been identified and addressed?	For all impacts	For some impacts	NA

Source: Adapted from Khera and Kumar (2010).
NA: Not addressed.
1* Directly Affected Area (ADA), Direct Influence Area (AID), and Indirect Influence Area (AII)
2* Permanent Preservation Area (APP)
3* Analyze the topics “Final consideration”, “Discussion”, “Considerations on the biotic environment”, “Results evaluation and discussion”, “Synthesis of environmental conditions” and/or the biotic environment of Environmental Assessment.
4* Description of the environmental aspects/generating actions and environmental factors/ components, and presentation of the identified impacts on a table, matrix or flowchart, relating them with the mentioned items.

Results and Discussion

IBI values ranged from 0.25 to 0.67, with a median of 0.51, a regular index, according to Naser, Bythell and Thomason (2008) and Khera and Kumar (2010). Considering all indicators and all EISs (n=260), 50.8% of them were partially met (n=131), 24.2% were totally met (n=64), and 25% were not addressed (n=65) (Fig. 1). The results represented information gaps in most of the EISs chapters.

Figure 1 - Scores regarding the Index of Biodiversity Inclusion (IBI) for each mining Environmental Impact Statement (EIS) of the state of São Paulo. In parentheses and in bold, there are the raw frequencies of each score



Source: preparation of the authors.

The Kruskal Wallis test showed statistical differences between the results obtained for the analyzed EISs ($p < 0.05$). The lowest IBI was obtained by the EIS of project B and the highest IBI for EIS F (Table 3). This result was corroborated by the Dunn test, in which EIS B had a performance significantly lower than other EISs. Instead, the highest IBI (EIS F) was only significant in relation to the EISs with IBI lower than the median of 0.51 (B, C, E, H, and I), but not for those with IBI higher than the median (A, D, G, and J). A statistical difference was observed between the most recent EISs (I- 2014 and J- 2015).

Table 3 - Scores assigned to ten Environmental Impact Statements (A to J) associated with mineral activities in the state of São Paulo

Ind	A	B	C	D	E	F	G	H	I	J	IBIi
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**0.50**
2	0.5	0.0	0.0	0.5	0.5	0.5	0.5	0.0	0.5	0.0	**0.30**
3	0.5	0.5	0.5	1.0	1.0	1.0	0.5	0.5	0.5	1.0	**0.65**
4	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**0.55**
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**0.50**

6	0.5	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**0.40**
7	0.5	0.0	0.5	0.0	0.5	0.5	0.5	1.0	0.0	1.0	**0.45**
8	1.0	0.5	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**0.60**
9	0.5	1.0	1.0	1.0	1.0	1.0	0.5	1.0	0.5	0.5	**0.80**
10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**0.50**
11	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**0.40**
12	0.0	0.5	0.5	0.5	0.5	1.0	1.0	0.5	1.0	0.5	**0.60**
13	0.5	0.0	0.5	0.5	0.0	0.5	0.5	0.0	0.5	0.5	**0.35**
14	0.5	0.5	0.5	0.5	0.0	1.0	0.5	0.0	0.5	0.0	**0.40**
15	0.5	0.0	0.0	1.0	0.0	1.0	1.0	0.0	0.5	1.0	**0.50**
16	0.0	0.5	0.5	0.5	0.5	1.0	1.0	1.0	0.5	1.0	**0.65**
17	0.5	0.0	1.0	0.5	0.0	0.0	0.0	0.0	0.0	1.0	**0.30**
18	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**0.95**
19	1.0	0.5	1.0	1.0	0.5	1.0	0.0	0.0	1.0	0.5	**0.65**
20	0.5	0.0	0.5	0.0	0.5	1.0	0.0	0.0	0.0	0.5	**0.30**
21	1.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**0.80**
22	0.5	0.0	0.0	0.5	0.5	1.0	0.5	0.5	0.5	1.0	**0.50**
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.00**
24	1.0	0.0	1.0	1.0	0.5	1.0	1.0	1.0	0.0	1.0	**0.75**
25	1.0	0.0	0.5	0.5	0.5	0.5	1.0	1.0	0.0	1.0	**0.60**
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	**0.05**
IBI	**0.54**	**0.25**	**0.48**	**0.56**	**0.46**	**0.67**	**0.54**	**0.46**	**0.44**	**0.63**	

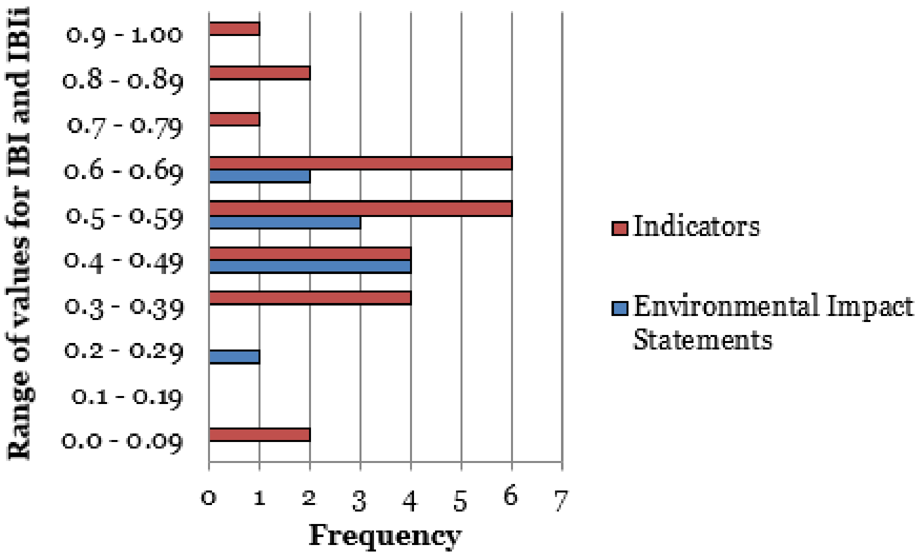
Source: preparation of the authors.

Ind: Indicator. Index of Biodiversity Inclusion (IBI) for each indicator (IBIi).

Comparing the 26 indicators, the one with the highest index was 18 (IBIi: 0.95), in which only one EIS did not meet it (Table 3). However, the lowest results were for indicators 23 (IBIi zero) and 26 (IBIi: 0.05), showing that the effectiveness or limitation of mitigation and monitoring measures were addressed unsatisfactorily. In addition, seven IBIis (indicators 1, 4, 5, 7, 10, 15, and 22) were in the range 0.5 +/- 0.05 and another seven (indicators 3, 4, 8, 12, 16, 19, and 25) between 0.51 and 0.69 (Fig. 2), similar to India (KHERA; KUMAR, 2010).

The indicators results were described in the following topics.

Figure 2 - Distribution of the values for the Index of Biodiversity Inclusion (IBI) and the Index of Biodiversity Inclusion for indicators (IBIi) for Environmental Impact Statements (red bars) and indicators (blue bars) respectively.



Source: preparation of the authors.

Areas of impact and baseline regarding biodiversity

All EISs had a baseline, a description of biodiversity components to be affected by the project, the inclusion of endangered species for flora and fauna, and the indication of endemism for some biological groups (indicator 4 - IBIi: 0.55), all of them relevant items to biodiversity conservation (PEARSON, 2016). In the last case, the indication of endemism was less frequent for flora, which hinders the subsequent inclusion of endemic plant species in reforestation projects or in the Program of Degraded Areas Recovery. The relevance of including endemic species increases as the state of São Paulo has two biodiversity hotspots and because endemic species are characterized by occurring only in specific areas (MYERS et al., 2000).

Another limitation in indicator 4 was the presence of a sub-topic called “Endemic and endangered species”, which did not show any information about endemism in the text, as observed in EIS H. Only EIS A analyzed endemic and threatened species for flora and fauna, and EIS D did not only obtain 1.0 index because the EIS just analyzed the endemism for some groups of fauna.

All EISs showed the identification and enumeration of flora and fauna at least for a biological group (indicator 5). Furthermore, all EISs had material collections in different seasons (dry or rainy one) for fauna, and only EIS J for flora and fauna. It is worth mentioning that there was no mention of migration routes, as well as spawning and reproduction land. Therefore, all EISs had a 0.5 index in indicator 5. Such shortcoming may pose a threat to migratory species, which move seasonally looking for food, weather, or resting/breeding areas in native habitats (LACK, 1968; SOMENZAR et al., 2018). Thus, the consideration of temporal variation is relevant to the sustainability of species, and should be considered in the EIA and mitigation, compensation, and monitoring measures. Similarly, in France and India, although almost all statements had fieldwork, problems regarding different seasons were reported (KHERA; KHUMAR, 2010; BIGARD et al., 2017).

In indicator 6 (IBIi: 0.40), most of EISs scored 0.5, similar to the Indian results (KHERA; KHUMAR, 2010). All EISs had the Importance Value Index for flora, but there was not a similar index for fauna, only a description of the importance of some groups, such as composition, wealth, abundance, frequency, diversity, habit, and ecological interactions. However, the interpretation of those descriptions rarely addressed the implications for the biotic environment and biological conservation, although this interpretation could turn the baseline more analytical and indicative, supporting impacts identification and assessment.

In addition, 40% of the EISs associated the baseline main results with the impacts of the project under analysis in indicator 3 (IBIi: 0.70). The other EISs did it partially. It is worth mentioning a summary table, in baseline, about the conditions of the biotic environment in EIS E, which analyzed the scenarios with and without the developing project.

In the delimitation of the Areas of Influence, the parameters were hydrological, considering the basins and/or micro hydrographic basins, mainly for the Area of Indirect Influence (AII), following the guidelines of the environmental agency of the state of São Paulo (CETESB, 2014). For the Area of Direct Influence (AID, acronym in Portuguese), a buffer with different values was used to justify the area delimitation. Among the criteria regarding biodiversity, there were the presence of Permanent Preservation Areas (APP, acronym in Portuguese), area for animal movement, fragmented populations, and predominant ecosystems. In the case of the Directly Affected Area (ADA, acronym in Portuguese), the area was that of the project itself. However, the use of biodiversity as a criterion for the establishment of those areas (AII, AID, and ADA) would be relevant to integrate mainly areas and species critical to conservation, supporting impacts prediction, mitigation, compensation and monitoring measures, and consequently, decision-making (BRASIL, 1986).

All EISs scored 0.5 in indicator 1 (IBIi: 0.50), i.e., no EIS showed a location map with known biodiversity (e.g., protected areas and species), urban area, other projects, and industrial establishments, as well as the distance from sensitive areas, water bodies, coastal areas. Only some of those items were addressed. This result was similar to India, in which only 9% of the EISs (total of 22 EISs) included biodiversity in location maps (KHERA; KHUMAR, 2010). However, this information would support the decision-making of environmental agencies and inform the surrounding population of the developing project about the influences on local/regional biodiversity. For instance, there could be an overlap of maps on biodiversity and its surround such as zoning and the critical areas for biotic environment.

All EISs had fieldwork and quoted secondary sources in the baseline, mainly to describe the AII (indicator 9 - IBIi: 0.80), supporting detailed impact assessment. Also, a baseline elaborated considering primary and secondary sources is relevant for analyzing alternatives for the project, e.g., the option without the project. In Finland and France, most of the documents also quoted those sources, however, in India, the rate was lower (52%) (SODERMAN, 2005; KHERA; KHUMAR, 2010; BIGARD; PIOCH; THOMPSON, 2017).

In the present study, 60% of the EISs quoted the secondary data appropriately, while the other 40% showed inadequacies regarding regional fauna. Also, in some cases, there was a description of the references used in the beginning of the methodology section, without specifying them throughout the text. Only EISs A and C described the methods completely, while the others included them partially (indicator 8 - IBIi: 0.60). In general, the parameters with the lowest indexes were about the used equipment, period of the day and bibliography used for species identification, which are important to understand data limitations and reproducibility. Furthermore, the period of the day is relevant to address the varying fauna, such as nocturnal animals (SOMENZAR et al., 2018).

Moreover, we analyzed whether people involved in the environmental baseline were experts in biodiversity (indicator 7 - IBIi: 0.45), since they could improve the quality of the analyses with their knowledge and contribute to biological conservation (MANDELIK; DAYAN; FEITELSON, 2005). Two EISs of the state of São Paulo fully met the indicator, with experts in herpetofauna, avifauna, mastofauna, and flora. Half of the EISs indicated some type of expert, such as in ichthyofauna (C) and aquatic macrobiota (F), or for each group of fauna without specifying (A, E, and G). In France, more than half of the EISs (57.1%) had experts (BIGARD; PIOCH; THOMPSON, 2017), while in Finland, the rate was almost 80% (SODERMAN, 2005), different from India, in which no EIS mentioned experts involvement (KHERA; KHUMAR, 2010). A limitation in the analysis is that scoping in the state of São Paulo does not require the description of the experts (BRASIL, 1986). Therefore, the experts in biodiversity were maybe involved in the baseline, but that information was not reported.

The limitations regarding the baseline of biodiversity must be addressed in such a way to indicate the shortcomings of the study, i.e., the gaps that may affect conservation biology if the project is approved. Although all EISs of the state of São Paulo showed some limitations, the implications, or ways to deal with them were not always addressed. Thus, all EISs scored 0.5 in indicator 10 (IBIi: 0.5). An example is the collector's curve: in some cases, when the plateau of the curve was not reached, this information was rarely discussed. However, there were also satisfactory results, with discussion and ways to deal with this limitation. Other examples include the difficulty to identify species outside the flowering period and the non-convergence between data from interviews and the observations in the field, pointing out the need for environmental monitoring. However, the lack of baseline limitations is against the Precautionary Principle, according to which risks, and uncertainties must be considered when making decisions (JAY et al., 2007). Similarly, in Finland and India, the most recurrent result was the partial approach of the indicator (SODERMAN, 2005; KHERA; KUMAR, 2010).

Impacts on biodiversity components

A separate section called biotic environment (*meio biótico* in Portuguese), regarding impacts on biodiversity, was observed in 90% of the EISs of the state of São Paulo, as reported in Finland and India, without distinguishing the name of the chapter in those cases (SODERMAN, 2005; KHERA; KUMAR, 2010). The only exception to the state of São Paulo was EIS A, which did not have this separation in indicator 11. According to the literature and government guidelines, such topic aims to identify and analyze the biotic characteristics of the affected area in the EIS for the effective conservation of biodiversity (SODERMAN, 2005; KHERA; KUMAR, 2010).

Regarding the description of the impacts associated with direct effects on biodiversity, most of the EISs (60%) showed a partial description, mainly due to the lack of association with the baseline (indicator 12 - IBIi: 0.60). Nonetheless, 30% of the EISs reported that relationship, in which only EIS A did not describe such impacts. Similarly, in India and Finland, less than 10% of the EISs did not describe the direct impacts properly (SODERMAN, 2005; KHERA; KUMAR, 2010). In the USA and France, the indicator evaluated the identification of direct and indirect impacts, in which around 70% the EISs included the indicator (ATKINSON et al., 2000; BIGARD; PIOCH; THOMPSON, 2017).

None of the EISs described the secondary effects of the project, however 30% of the EISs did so only for the indirect effects (D, G, and I), and 40% for the indirect and cumulative effects (A, C, F, and J) (IBIi: 0.35). Note that the analyses were superficial, such as the simple classification of the effect as cumulative or not, without quantifying it, or even, without describing the impacts that are added/accumulated to each other. A similar scenario has been reported in India and Finland (SODERMAN, 2005; KHERA; KUMAR, 2010). Thus, indicator 13 was considered unsatisfactory because it indicated that few EISs addressed likely effects caused by human actions.

Half of the EISs showed the identified impacts and described the environmental aspects/generating actions, and environmental factors/ components in a table, matrix, or flow chart, linking the mentioned items. This association is relevant since it indicates how the impacts were identified, which is the first step for establishing mitigation, compensation, recovery, and monitoring measures. In addition, three EISs met the indicator partially and two EISs scored zero, resulting in an IBIi of 0.65. That value was similar to the rates of Finland and France, i.e., around 45% (SODERMAN, 2005; BIGARD; PIOCH; THOMPSON, 2017). In India, the IBIi value was lower: only 2/22 of the EISs detailed the methods (KHERA; KUMAR, 2010).

The indicator 14 had a 0.4 IBIi, in which only EIS F associated atmospheric, noise, and water pollution with short and long-term impacts on biodiversity. However, half of the EISs encompassed the likely impacts on the biotic environment due to the resulting noise. That is a worrying result, since mining activities result in these three types of pollution by leachate substances, carried or contained in their effluents, by machine noise emissions, burning fuel, or suspended particles released by mining, processing, and transport activities (MECHI; SANCHEZ, 2010; RANJAN, 2019).

Despite all the EISs showed the magnitude degree, only 40% of them had a significance evaluation for each impact in indicator 15 without a clear interpretation of the indexes (IBIi: 0.50). However, such evaluation would be important to synthesize the EIS data, facilitating the analysis of the decision maker. In India, half of the EISs fully included the indicator, and the other part partially did it (KHERA; KUMAR, 2010). Nonetheless, studies conducted in Finland and France showed values lower than in Brazil (SODERMAN, 2005; BIGARD; PIOCH; THOMPSON, 2017).

Atkinson et al. (2000) suggested that it is essential to reasonably forecast the effects of the project considering the three levels of biodiversity to better reduce biodiversity loss. In this study, all EISs, except A, included the ecosystem and species levels in impacts assessment (indicator 16 - IBIi: 0.65). However, issues regarding genetic variability, which are important for the sustainability of the ecosystems, were addressed in 40% of the EISs superficially. This result is a challenge shared with other countries (ATKINSON et al., 2000; SLOOTWEG; KOLHOFF, 2003; KHERA; KUMAR, 2010).

All EISs had qualitative analyses, as in Finland (SODERMAN, 2005) but project B did not show the description of criteria scale. Among the qualitative parameters were duration, range, nature, source, reversibility, and magnitude.

On one hand, 20% of the EISs analyzed the impacts in quantitative terms with clear parameters; on the other hand, 20% of the EISs had quantitative analyses without clear indicators, resulting in a 0.5 index in indicator 17. This low rate was also observed in Israel and Finland (MANDELIK; DAYAN; FEITELSON, 2005; SODERMAN, 2005), while in India, the index was higher: 60% of the EISs scored 0.5 or 1.0. The predictions of impacts on biodiversity in quantitative and qualitative terms (indicators 17 and 18) had the lowest (0.30) and the highest IBIi (0.95), respectively for the category.

Alternatives, mitigation, and monitoring

The principles of good practice in EIA recommend the identification of regulatory measures for each group of impacts in an ordering of actions, distinguishing their level of relevance, which is called mitigation hierarchy[2]. The major priority is given to measures that avoid impacts on the environment, e.g., including location and technological alternatives for the project. In this context, 80% of the EISs addressed preventive activities before vegetation suppression, however, this indicator was fully considered for India (KHERA; KUMAR, 2010).

Despite the legal requirement and relevance of the location alternatives and the zero-option (i.e., comparison with the likely future without the developing project)

2 - Mitigation hierarchy scheme by BBOP, which is available at: https://www.forest-trends.org/bbop/bbop-key-concepts/mitigation-hierarchy/

(BRASIL, 1986), only EIS F integrated those two topics, while half of the EISs (Table 3) did not do it (IBIi: 0.30). Out of the 4 EISs which had a 0.5 index, biodiversity was only considered in location alternatives. In general, the justifications were about the socio-economic benefits of mining, considering the activity as a public utility and essential for the development of the country. In addition, the EISs about mining expansion justified the continuity of the existing deposits due to a better economic use of the area as well as the lower environmental impacts and liabilities compared to new areas.

Other studies have also pointed out flaws in the search and in the comparison of alternatives (e.g., BENSON, 2003). In France, the index was 2%, however, the scenario was more satisfactory in Finland, India, and USA, with 92%, 70% and 58% respectively (ATKINSON et al., 2000; SODERMAN, 2005; KHERA; KUMAR, 2010; BIGARD; PIOCH; THOMPSON, 2017).

According to the mitigation hierarchy, when it is not possible to avoid impacts on biological diversity, measures must be proposed to minimize the effects of the developing project (see more in BBOP[2]). Eighty percent of the EISs addressed measures to mitigate impacts on biodiversity. Hence, two of them encompassed all biodiversity levels, phyto-physiognomies, and the temporal variable (index 1). The other six addressed them partially (indicator 22 - IBIi: 0.50), pointing out the species and ecosystem levels, while the genetic level was approached superficially. Temporality was normally included, prioritizing dry periods for vegetation suppression. The vegetation was addressed in the selection of the specimens for rescue (bromeliads, orchids, seedlings, epiphytes, and litter). As in India, most of the EISs had a 0.5 index. One of the reasons of this result may be the extensive list of items in the indicator.

Although the inclusion of biodiversity monitoring programs is considered essential to ensure a more consistent environmental management, some authors pointed out the lack of monitoring measures or even vague proposals in relation to biological diversity (SODERMAN, 2005; NASER; BYTHELL; THOMASON, 2008; BIGARD; PIOCH; THOMPSON, 2017; DIAS; FONSECA; PAGLIA, 2019). However, the result was different for the state of São Paulo (indicator 24 - IBIi: 0.75): 80% of the EISs had monitoring programs for biodiversity, mostly for fauna. Four of them established, in detail, criteria and indicators on biodiversity, and the other four made it superficially (indicator 25 - IBIi: 0.58). In France, the rate was lower (12%) (BIGARD; PIOCH; THOMPSON, 2017).

Both feasibility and sustainability of mitigation measures (indicator 22) and the monitoring limitations (indicator 26) proposed in the EISs had unsatisfactory results. No EIS identified the limitations and effectiveness of the monitoring and mitigation programs. Likewise, this result has been criticized internationally (MANDELIK; DAYAN; FEITELSON, 2005; SODERMAN, 2005; NASER; BYTHELL; THOMASON, 2008; KHERA; KUMAR, 2010; BIGARD; PIOCH; THOMPSON, 2017). In Brazil, specifically in the state of Minas Gerais, a similar result was observed, since the mitigation proposals were more frequent and detailed in items about physical environment compared with biotic and anthropic ones (PRADO-FILHO; SOUZA, 2004).

Analysis of the tool used and limitations

Some indicators in the list elaborated by Khera and Kumar (2010) do not have clear parameters, such as indicators number 1, 5, 8, 13, and 26, requiring the establishment of clear criteria (Table 2). For instance, in indicator 8 by Khera and Kumar (2010), the authors used the expression "described in detail" but it was not explained what this represented. Thus, the parameters for identifying impacts were proposed (Table 2). Similarly, the expression "from the start of the development" for mitigation (indicator 21) was detailed in Table 2.

In addition, we noted the need to delineate which section of the EIS was under analysis (indicator 3) and to exemplify which indexes could be considered for assessing the importance of fauna (indicator 6). Thus, despite the description of the indicators in Table 2, the proposed criteria may be different from Khera and Kumar (2010), representing limitations when comparing the results between Brazil and India.

Furthermore, when applying the list of India, we noted that some indicators could be added to future lists in order to complement the analyses about biodiversity and EISs, such as: indicators dealing with compensation measures and surrogate species, adding more items regarding the elements and components of biodiversity throughout the categories, mainly for monitoring, mitigation measures, and technical alternatives. In addition, the score "0.5" of Khera and Kumar (2010) can indicate the contemplation from 1% to 99% of the items analyzed by the indicator, as well as in indicators number 3, 10, and 21. However, there could be a subdivision of the assigned value "0.5", in 0.2, 0.4, 0.6 and 0.8, similar to that proposed by Lee and Dancey (1993) but these authors used letters.

Finally, indicators 1 and 2 could be subdivided into two since the large number of items to be analyzed, which makes it difficult and confused to interpret the results and scenarios represented by the assigned scores. For instance, in indicator 2, 0.5 score was assigned when biodiversity considerations are made in at least one of these areas: ADA, AID and AII, as well as APP, ecological corridors, and priority areas for conservation.

Conclusion

The evaluation of the 26 indicators applied for the EISs of the state of São Paulo showed that 75.8% of the indicators were not considered or were partially addressed. Thus, it was shown that there are gaps in the inclusion of conservation biology issues in the process of preparing mining EISs, which is a challenge shared with other countries that are signatory to CBD.

Evidence has shown that, despite the qualitative identification of impacts on biodiversity (indicator 18), there is low commitment in the implementation of mitigation measures (indicator 23) and in their analyses of effectiveness and monitoring (indicator 26). Therefore, EISs indicate impacts, however, there are few efforts to understand the quality of measures to mitigate or monitor them.

Another relevant result is that EISs show few analyses about temporal variation, genetic variability, short and long-term polluting agents, and ecological aspects in the location alternatives. These are aspects to be observed by environmental agencies to foster better information, and then, to increase mitigation measures and their effectiveness and monitoring on biodiversity loss.

Finally, we understand that it is possible to overcome the main limitations mentioned here by requesting them in the scoping of the EISs (mandatory measures), mainly by the Term of Reference, aiming to improve the inclusion of biodiversity conservation issues in the EISs. Environmental agencies, society and the proponents of mining projects are jointly responsible for the advancement of this important topic: the inclusion of the maintenance of biodiversity in the decision-making process of EISs and consequent environmental licensing.

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SciELO

A biodiversidade e os Estudos de Impacto Ambiental de mineração do estado de São Paulo – Brasil

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Artigo Original

Resumo: O estado de São Paulo apresenta histórico de perda e fragmentação de habitats, com empreendimentos que ameaçam sua biodiversidade. Assim, este trabalho buscou analisar como os Estudos de Impacto Ambiental (EIAs) paulistas das atividades de mineração (2005-2016) consideraram o tema biodiversidade em seus diferentes capítulos. Para avaliar os dez EIAs selecionados, foi utilizado o Índice de Inclusão da Biodiversidade (IIB), que reflete a análise dos indicadores ambientais (0 a 1), dependendo do compromisso apresentado em cada um dos indicadores. Os valores de IIB foram de 0,25 a 0,67, com uma variação significativa entre os EIAs. A maioria contemplou parcialmente os critérios, perfil similar ao de outros países, representando lacunas de informações em grande parte dos capítulos que contemplavam a biodiversidade. As maiores deficiências referiram-se à limitação dos dados, análise dos impactos e insuficiência das medidas mitigadoras, apontando a necessidade de uma melhor definição previamente à elaboração do EIA.

***Palavras-chave*:** Avaliação de Impacto Ambiental, Diversidade Biológica, Uso da terra.

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Biodiversidad y los Estudios de Impacto Ambiental de minería en el estado de São Paulo - Brazil

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São Paulo. Vol. 24, 2021
Artículo original

Resumen: El estado de São Paulo tiene una historia de pérdida y fragmentación del hábitat, con proyectos que amenazan su biodiversidad. Así, este estudio analizó cómo los Estudios de Impacto Ambiental (EIAs) de las actividades minerales del estado de São Paulo (2005-2016) consideraron el tema de la biodiversidad en sus diferentes capítulos. Para analizar los diez EIAs seleccionadas, se utilizó el Índice de Inclusión de la Biodiversidad (IIB), que consideró los indicadores ambientales (0 a 1), dependiendo del compromiso presentado en cada indicador. Los valores del IIB varió de 0.25 a 0.67, con variación significativa entre ellos. La mayoría de ellos cumplieron parcialmente los criterios, perfil similar al de otros países, representando lagunas de información en la mayoría de los capítulos. Las principales deficiencias apuntan a la limitación de datos, análisis de impacto y medidas de mitigación inadecuadas, apuntando a la necesidad de una mejor definición en la fase previa al EIA.

Palabras-clave: Diversidad Biológica, Evaluación de Impacto Ambiental, Uso de la Tierra.

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