Furthering the understanding of a mine's area of influence in Amazon

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ABSTRACT

The area of influence (AoI) of a project encompasses the spatial extent where direct and indirect impacts are observable or likely to occur, including the project site, associated facilities, and surrounding areas. Monitoring is a critical tool for reducing uncertainties inherent to any impact prediction due to various reasons, including biodiversity complexity. It also contributes to validating and refining initial forecasts, including the AoI delineation. Despite its importance, the concept of AoI and its methodological guidance remain underexplored within the scientific literature on impact assessment. In mining projects, characterized by dynamic operational changes, as extraction progresses and the ongoing rehabilitation of mined areas, the AoI may change over time. In this context, this study aimed to reflect upon the current AoI of a bauxite mining operation since 2009 in the Brazilian Amazon, by examining AoI polygons and data from selected monitoring programs of flora and fauna components. The findings suggest that current field-based monitoring could be complemented by incorporating landscape metrics to enhance the assessment of ecological processes such as habitat fragmentation, degradation, and connectivity loss. This integrated approach would provide a more comprehensive understanding of landscape configuration changes and their effects on biodiversity, facilitating the identification of direct and indirect impacts. Consequently, it would support more precise refinements of the AoI.

Keywords: Monitoring grid, biodiversity, bauxite mining, environmental impacts

Introduction

The area of influence (AoI) of a project encompasses the spatial extent where direct and indirect impacts are observable or likely to occur, including the project site, associated facilities, and beyond (Sánchez, 2020). AoI depends on the expected impacts, it can only be delimited after impact assessment ex-ante studies (Peeters et al., 2018; Sánchez, 2020). Due to the predictive nature of the EIA process, there is a certain degree of uncertainty inherent to the process and the difficulty of predicting ecological responses (Treweek, 1999; Lees et al., 2016) may make the area of influence delimited in previous studies obsolete and should be reassessed over time (Santos; Fonseca, 2016). Monitoring in impact assessment follow-up is a critical tool for reducing such uncertainties (Morrison-Saunders et al., 2021). It also contributes to validating and refining initial forecasts, including the delineation of the AoI. Despite its importance, the concept of AoI and its methodological guidance remains underexplored within the scientific literature on impact assessment (Menin et al., 2017; Emberton, Wenning, Treweek, 2018; Sánchez, 2020; Antonaccio et al., 2020).

In mining projects, characterized by dynamic operational changes such as progression of extraction and the continuous rehabilitation of mined areas, the AoI may change over time, requiring periodic updates of the monitoring plan to ensure that mitigation measures are accurately targeted. In this context, the present study aimed to reflect upon the current AoI of a bauxite mining operation active since 2009 in the Brazilian Amazon by examining AoI polygons and data from selected monitoring programs of flora and fauna components.

Material and Methods

The study area is the Juruti Bauxite Mine, located in the western of the State of Pará, in the Brazilian Amazon. The mine installation began in 2006, and the operations started in 2009 by Alcoa World Alumina Brazil (Alcoa, 2022). It includes several structures, such as the mine, a processing plant, and respective auxiliary facilities, including thickening and disposal ponds, a railroad for the flow of production to the port, also owned and used by Alcoa, in addition to having road access through a state highway.

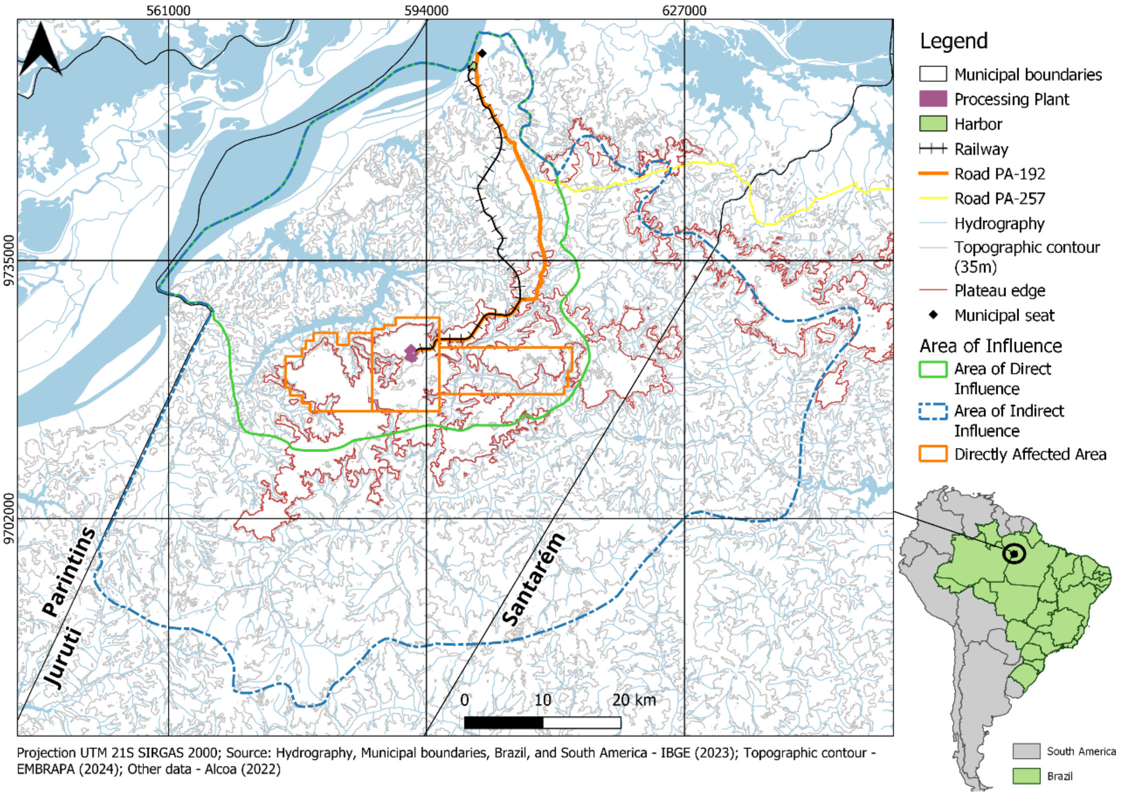
In Brazil, the Environmental Impact Assessment is a mandatory requirement for the environmental licensing of projects, with the delimitation of the AoI governed by CONAMA Resolution No. 01 of 1986. The AoI is typically divided into three according to the extent of the potential impacts: the Directly Affected Area, the Area of Direct Influence, and the Area of Indirect Influence. The Directly Affected Area refers to the area where project activities, such as implementation, operation, and closure, occur and directly interact with the environment. The Area of Direct Influence, which includes the Directly Affected Area, is defined as the area where project impacts are observed, and the delimitation must be based on the characteristics of the surrounding environmental components. The Area of Indirect Influence includes both the Directly Affected Area and Area of Direct Influence and represents the area where indirect impacts of the project can potentially occur due to changes in adjacent regions (IBAMA, 2006).

The document review primarily focused on the Environmental Impact Statement (EIS) presented in 2004 to understand how the AoI was initially delineated. In addition, annual monitoring reports submitted to the environmental agency from 2016 to 2023 were analyzed to gather information on the sampling grid and results related to biodiversity. This information has been organized through GIS-based maps to support discussions about AoI.

Results and Discussion

The EIS of the Juruti Project introduces the AoI at the beginning of the document, outlining the Area of Direct Influence and Area of Indirect Influence for both the physical-biotic and socioeconomic environments. However, the present study focuses exclusively on the physical-biotic components. The Area of Direct Influence corresponds to the area directly affected by the projects's operation, including the concession areas for research on the plateaus to be mined, the processing plant, and ore transportation structures. The Area of Indirect Influence was delimited based on the set of hydrographic basins within the project region. It is important to highlight that the EIS indicates the AoI was delimited for the development of the project's environmental studies and the area indicated as being considered as the study area, a common source of confusion to the delimitation of the AoI (Sánchez, 2020). While the EIS is not explicitly a Directly Affected Area, subsequent documents, such as the annual reports, refer to this area as the mining concession granted by the Brazilian National Mining Agency (Figure 1).

Figure 1 – Area of Influence of the Juruti Bauxite Mine (Pará).



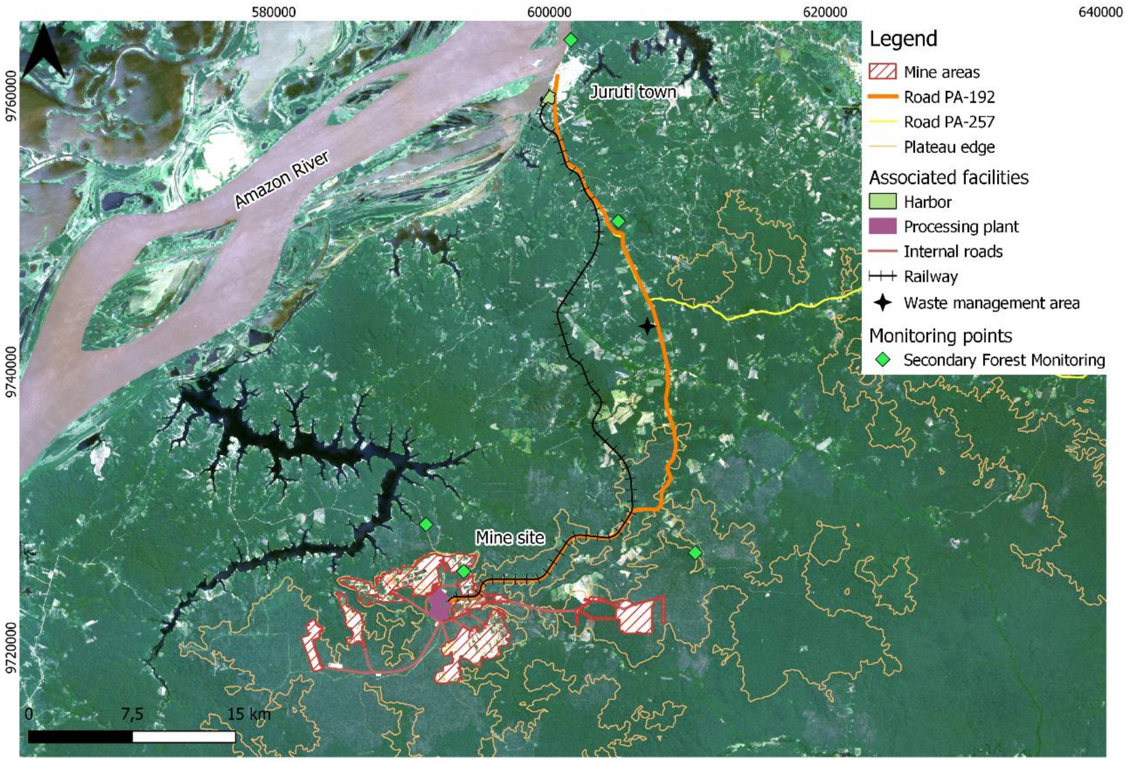
Although the limits of the hydrographic basins were considered for delimitation the AoI of the physical-biotic environment, as recommended by CONAMA Resolution, it is important to note that this criterion was not fully applied. Specifically, the western boundary of the AoI was defined by the municipal and state administrative limits - political boundaries that do not constitute physical barriers to biodiversity. This choice of delimitation may be attributed to guidance provided by the state environmental agency.

To delineate the AoI, monitoring should be conducted to identify the area affected by the project, the project footprint, and the area that could be affected by direct or indirect impacts (Gullison et al., 2015). In the case studied, the main activity that induces environmental impacts on biodiversity is vegetation clearance for mining (Nascimento, 2023), and the flora and fauna components will be impacted mainly within these areas and along their edges, which, for the Amazon Forest, can extend up to 300 meters.

The potential impacts on flora and fauna in the Juruti Bauxite Mine are addressed through ongoing monitoring programs – Flora Conservation Program: Monitoring of Secondary Forest and Fauna Monitoring Program, which is encompasses all faunal groups. These programs have monitoring points distributed according to the AoI and are expected to provide insights for confirming or refinement of this delineation.

The Secondary Forest Monitoring is conducted in five permanent plots, implemented in 2015, representing different vegetation formations present in the AoI, to provide subsidies to the forest restoration process (Figure 2). Although the program seeks to monitor the impact of 'Modification of floristic composition' as a result of the edge effect (Nascimento, 2023), the current allocation of monitoring points may not be optimal for detecting this impact, since only one plot is in the vicinity of the extraction area, where such effects are most likely to occur (Emberton; Wenning; Treweek, 2018).

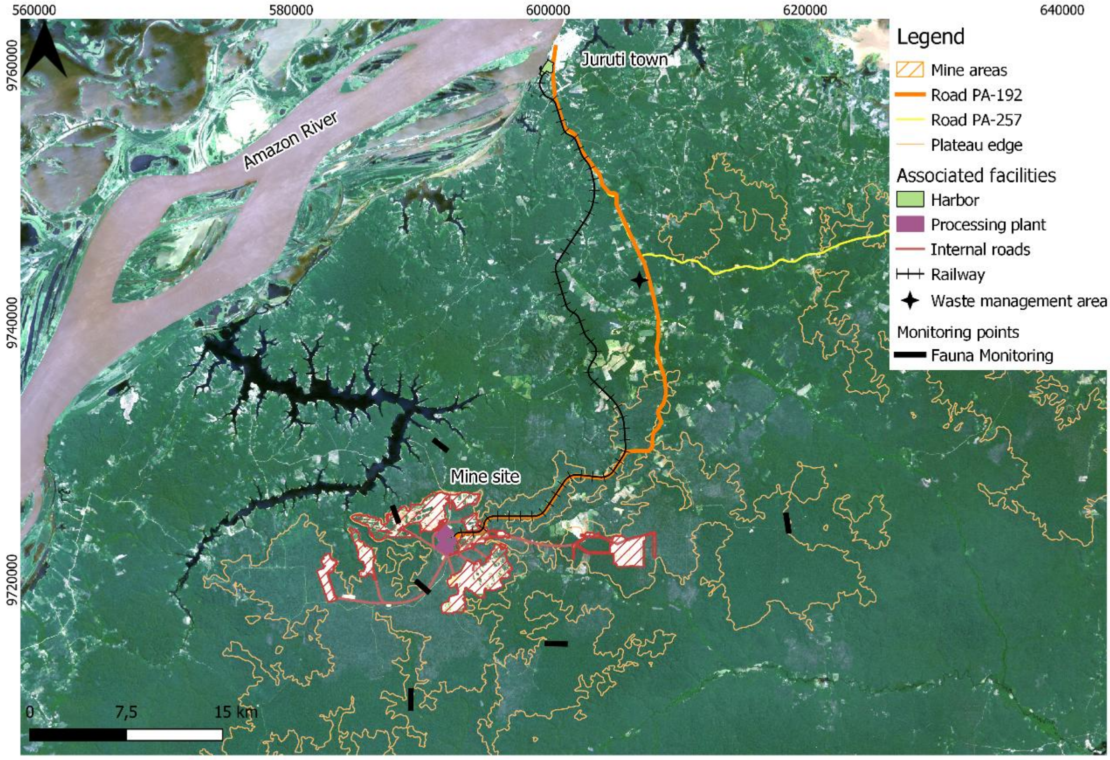
Figure 2 - Location of flora monitoring points at Juruti Bauxite Mine (Pará).



Projection UTM 21S SIRGAS 2000;
Source: Landsat image - USGS (2024); Mine areas - PRODES (2025); Other data - Alcoa (2022);

The Fauna Monitoring Program is conducted along six transects of 1 kilometer each to cover the vegetation formations present in the AoI (Figure 4). These transects are positioned to track the progress of mining and the effectiveness of the restoration in previously mined areas, as well as to monitor a designated control area. The inclusion of a control area for biodiversity monitoring is important for a better understanding of the impacts, but if allocated outside the limits of the AoI, it can provide information about trends external to the influence of the project (Gullison et al., 2015).

Figure 3 - Location of fauna monitoring transects at Juruti Bauxite Mine (Pará).



Projection UTM 21S SIRGAS 2000;
Source: Landsat image - USGS (2024); Mine areas - PRODES (2025); Other data - Alcoa (2022);

Monitoring is necessary to understand and confirm the occurrence of biodiversity impacts. At Juruti Bauxite Mine, both biodiversity monitoring programs within the AoI involve data collection at a local scale. However, to gain a broader understanding of long-term changes in biodiversity, it is possible to adopt a multi-scale approach, also adopting landscape-scale monitoring to assess habitat fragmentation, degradation, and loss of connectivity (Watkins et al., 2015). Changes in spatial patterns within AoI can corroborate the understanding of the ecological processes, as certain ecological phenomena cannot be fully explained at a single scale (Koblitz et al., 2011). Additionally, some indirect impacts, often more complex to detect, can extend far from the mine area (Sonter et al., 2017).

In this context, it is recommended that the current biodiversity monitoring programs at the Juruti Bauxite Mine be complemented with landscape patterns monitoring. This would support the identification of indirect and cumulative impacts within the AoI, following the recommendation of the International Finance Corporation (IFC, 2012), and contribute to the coherence of its delimitation.

Conclusion

According to the literature, the absence of technical guidelines and appropriate spatial scales for the AoI of projects raises concerns regarding the accuracy of their delimitation. This delineation is based on the prediction of impacts, and monitoring plays a crucial role in validating or indicating the need for revision.

Based on the analysis of the Juruti Bauxite Mine case, we observed that the AoI adopted conceptually corresponds to the study area. The biodiversity monitoring is conducted through field-based parameters. There is an opportunity for improvement in biodiversity monitoring by adopting landscape pattern measures, such as remote sensing, to better understand changes in the landscape configuration and their interference on biodiversity components. This approach can help identify the occurrence and extent of direct and indirect impacts and point out to refining the AoI.

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