Mining causes direct and indirect loss of tropical forests

Stefan Giljum[1], Victor Maus[1], Nikolas Kuschnig[1], Sebastian Luckeneder[1], Michael Tost[2], Laura J. Sonter[3], Anthony J. Bebbington[4]

[1] Vienna University of Economics and Business, Austria
[2] Montanuniversität Leoben, Austria
[3] The University of Queensland, Australia
[4] Clark University, United States of America

FINEPRINT Brief No. 17, March 2023

The growing demand for minerals continues to drive deforestation worldwide. Tropical forests are particularly vulnerable to the environmental impacts of mining and mineral processing. In this study, we present the first biome-wide assessment to show where industrial mine expansion has caused the most deforestation over the past two decades. We find that 3,264 km² of forest was directly lost due to industrial mining, with 80% occurring in only four countries: Indonesia, Brazil, Ghana, and Suriname. Additionally, controlling for other non-mining determinants of deforestation, such as agriculture, we find that mining caused indirect forest loss in two-thirds of the investigated countries. Our results call for impact assessments and mitigation plans of industrial mining to address both direct and indirect impacts in order to support conservation of the world's tropical forests.

This FINEPRINT Brief builds on the paper 'A pantropical assessment of deforestation caused by industrial mining' published by Giljum and colleagues in PNAS. The datasets used for the analysis are available for download from PANGAEA.

Driven by rising affluence and surging demand for minerals for consumer products, infrastructure, and energy transition technologies, global mining activities expanded at an unprecedented pace in the past 20 years [1]. Today, mines worldwide extract double the amount of raw materials com-

pared to the year 2000, with the trend expected to continue in the coming decades [2]. Resource-extracting regions face extensive land-use changes due to the expansion of mining activities and related infrastructure, often accompanied by deforestation [3].

Compared to other causes of tropical deforestation, such as crop production or livestock farming, mining is so far often considered a minor driver. However, its growing importance has been emphasised in various case studies and our work suggests that the overall deforestation caused by mining is underestimated, as indirect effects are often not considered. In our study, we provide an investigation of deforestation impacts induced by industrial mining operations across 26 countries located in tropical wet and dry forests. To quantify deforestation we intersect mining polygons of an earlier study [4] with areas of tropical forest loss over the period from 2000 to 2019 using the Global Forest Change dataset [5].

Our assessment framework considers both direct and indirect deforestation impacts of industrial mining. Direct deforestation occurs within the mining area itself through establishing or expanding extraction sites, tailing storage facilities, waste rock dumps, and on-site processing facilities and roads. In addition to quantifying direct deforestation within mining areas, we set up a statistical model to assess whether mining induces indirect deforestation in its surroundings. Indirect deforestation occurs outside areas designated for mining and emerges through various pathways. For example, mineral extraction and processing require large amounts of energy, demanding infrastructure for energy generation. Building up infrastructure for mineral processing, storage, and transport is another pathway leading to indirect deforestation. Expansion of mining sites may also lead to in-migration and growth of settlements in the surrounding areas, creating new agricultural land and pastureland with impacts on forest loss.

Direct deforestation within mining areas

The investigated mining areas covered 11,467 km² of land that included 7,019 km² of tropical forest in 2000. By 2019, 3,264 km² (46.5%) of these forest areas were directly lost to industrial mine expansion. With 1,901 km² of deforested area, Indonesia was by far the most affected country, accounting for almost 60% of direct forest loss by mining across all 26 investigated countries (Figure 1). Mine expansion in East Kalimantan on the island of Borneo for coal production was the main factor behind this development in Indonesia. Deforestation within Brazil's mining areas located in tropical forest biomes extended over 327 km² since 2000. Ghana (213 km²), Suriname (203 km²), and Côte d'Ivoire (99 km²) follow as the countries with the highest direct forest loss. All other countries together made up 16% of tropical forest loss by mining observed across the 26 countries.

While for most countries the direct deforestation effects of mining (on-site) are rather small compared to other land-intensive activities, such as the production of soybeans and palm oil or cattle farming, some countries show considerably higher shares in total forest loss, e.g. Suriname with 11% and Guyana with 4%.

Indirect deforestation induced by mining

We find strong evidence that mining also induces indirect deforestation outside areas designated for mining activities. In 18 of the 26 investigated countries, deforestation rates are higher close to the actual mining areas than areas farther away than 50 km, even when controlling for other known

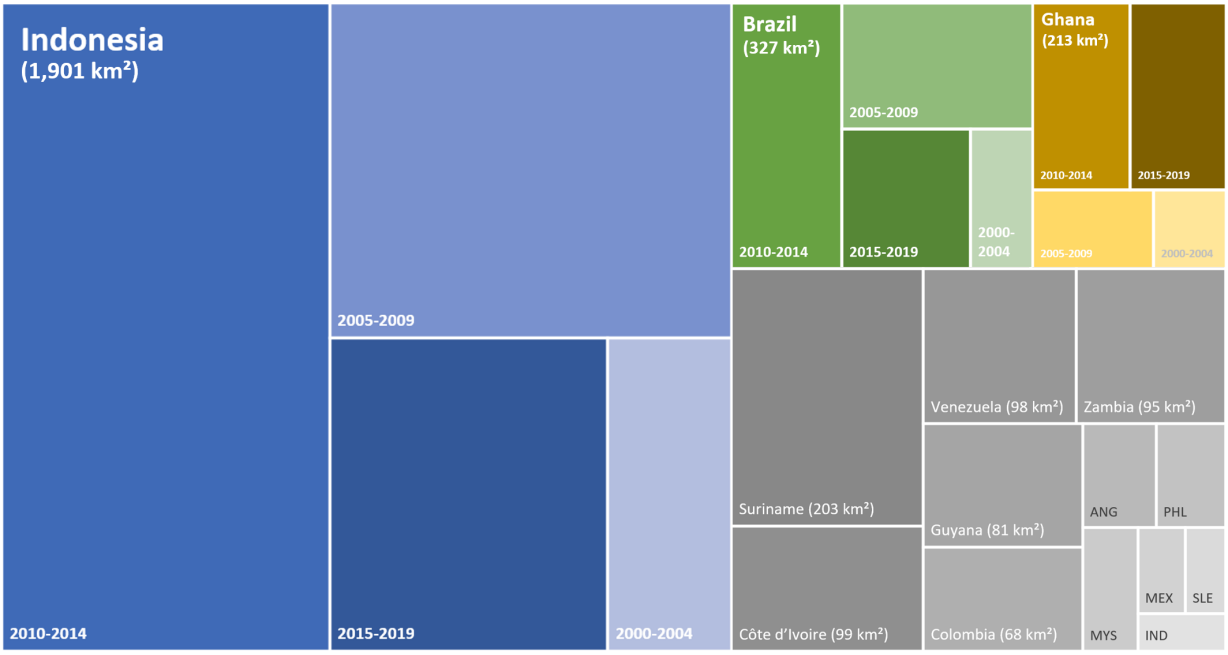

Figure 1: Direct tropical forest loss due to industrial mining from 2000 to 2019 in the top 15 countries with the highest absolute deforestation by industrial mining, together accounting for 98 percent of direct deforestation across all 26 investigated countries.

determinants of tropical deforestation, such as proximity to agriculture or roads. These indirect impacts are estimated using the distance to the closest mine in a spatial statistical model. Thus, if deforestation increases with higher proximity to the mines, we expect this to indicate indirect deforestation effects of the corresponding mines.

In Brazil and Indonesia, we find high statistical significance for higher deforestation 50 km around the actual mining sites. On average, and holding all other parameters fixed, reducing the distance to a mine in Brazil by 10% (e.g. from 10 to 9 km) leads to a 3% increase in deforestation. For Indonesia, this value is 2.3%. The absolute effects of these results can be illustrated with a scenario simulation: For instance, if all mines in Indonesia were to expand their borders by 100 m, this would induce an additional deforestation between 194 and 215 km². In Brazil, the same 100-m expansion would lead to 147 to 154 km² of additional forest loss. Apart from Indonesia and Brazil, the statistical relation of mines causing indirect deforestation can also be observed for many other tropical countries, including Guyana, Colombia, the Philippines, Papua New Guinea and the Democratic Republic of the Congo (DRC).

Figure 2 provides a visualisation of the statistical results. Map (a) shows the coefficients for mining-induced deforestation in all 26 investigated mining countries with tropical forests. A negative coefficient indicates that mining drives off-site deforestation. The impacts of industrial mining on forest loss can also be illustrated on a spatially explicit level by considering the distance of each grid cell to the nearest mine (b). These three maps for mining regions in Brazil, the DRC, and Indonesia thus illustrate the importance of mining-induced deforestation in total forest loss in each grid cell. White areas indicate that no forest loss has been observed since 2000. The importance of forest loss due to industrial mining is clearly visible in the state of Minas Gerais in Brazil, where iron ore

and gold are particularly mined in the "Iron Quadrangle" in the south. The indirect deforestation induced by mining in the Central African Copperbelt, stretching between Zambia and the DRC, is illustrated in the second example. As a third case, we show the Indonesian mining regions on the island of Borneo, where coal, nickel, and tin mining significantly expanded since the year 2000.

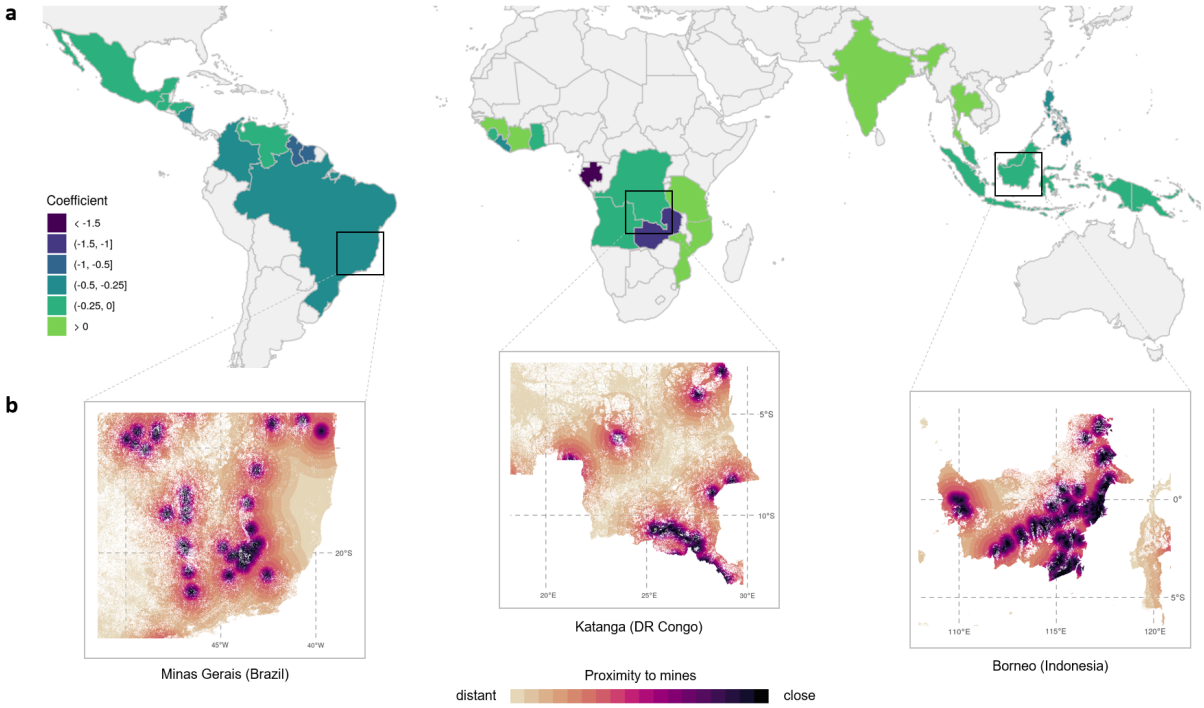

Figure 2: Visual representation of indirect deforestation induced by industrial mining outside mining areas. (a) The national coefficient of distance to mine across 26 investigated countries. (b) Granular representation of the national coefficient in three selected mining areas. The closer a grid cell is located near a mining site, the higher is the share of mining-induced deforestation.

Discussion

Our study has provided an assessment of deforestation caused by industrial mining in countries across the tropical biome. The results show that the direct impacts of mining on tropical forests have been concentrated in only a few countries, with Indonesia, Brazil, and Ghana being the most heavily affected. In Indonesia, the highest deforestation rates were observed for the years 2010 to 2014, a period that was marked by a doubling of coal production volumes, particularly driven by demand from China and India. A fragmented and opaque governance system for issuing new coal extraction licenses facilitated this development. Institutional reforms after 2014 implemented caps on coal extraction growth rates, which also slowed down direct deforestation. Also in Brazil, forest loss within mining areas decreased after 2014. Declining global commodity prices and an economic crisis in Brazil after 2014 are among the explanatory factors for that temporal pattern. We also found that mining played a large role in the deforestation trajectories in other countries with relatively less absolute forest loss (e.g., 11% of deforestation in Suriname between 2000 and 2019 was directly caused by mining). Further, we revealed that industrial mining indirectly drives deforestation in the surroundings outside mining areas. Indirect deforestation effects caused by industrial mining are most considerable for Brazil and Indonesia, but these effects can be observed in more than two-thirds of the investigated countries. Against the background of rapidly increasing

global demand for mineral resources, e.g., for housing and transport infrastructure or green energy technologies, our results emphasise important yet unevenly distributed and largely unmanaged future threats to tropical forests.

Implications for policy and industry

Our results suggest that Environmental Impact Assessments and licensing procedures for new mining projects should also consider potential impacts outside the actual mining extents. Applications for new mining concessions should also not be considered in isolation – in particular, if they include additional economic sectors, such as agriculture – but should take their potential cumulative impact on forest loss into account. Policy initiatives that aim at raising transparency and due diligence along global supply chains could also play an increasingly significant role in managing environmental impacts of mining.

Apart from policy measures, other actors, including conservation organisations, multilateral organisations, and industry groups, will play a key role in setting stricter environmental standards. Although companies in the extractive sectors have started to manage direct deforestation impacts of mining activities, only a few examples consider indirect impacts on deforestation.

Best-practice approaches to mitigate mining impacts on forests are promoted by private sector organisations, such as the International Council on Mining and Metals (ICMM). However, off-site impacts are not addressed appropriately yet. ICMM also has a requirement in place for its member companies not to explore or mine in World Heritage areas listed by the International Union for Conservation of Nature (IUCN). Opportunity exists to expand these commitments to avoid impacts on other biodiverse places.

One key requirement to limit losses of tropical forests due to mining is the development and implementation of monitoring programs. Satellite-based data systems on mining activities and deforestation, as employed in our study, could form the starting point for developing monitoring systems that allow for a regular and consistent identification of deforestation linked to the expansion of specific mines. Such information is also a precondition to set up supply chain initiatives in the private sector to reduce deforestation, following examples from the agriculture and food sectors. Such initiatives would increase the traceability and transparency of mining products and could thereby help slowing down mining-induced deforestation as part of national and global forest conservation efforts.

Citation

Giljum, S., Maus, V., Kuschnig, N., Luckeneder, S., Tost, M., Sonter, L.J., Bebbington, A.J., 2023. Mining causes direct and indirect loss of tropical forests. FINEPRINT Brief No. 17. Vienna University of Economics and Business (WU). Austria.

References

[1] Luckeneder S, Giljum S, Schaffartzik A, Maus V, Tost M. Surge in global metal mining threatens vulnerable ecosystems. Global Environmental Change 2021;69:102303. doi:10.1016/j.gloenvcha.2021.102303.

[2] OECD. Global material resources outlook to 2060: Economic drivers and environmental consequences. Paris. 2019.

[3] Bebbington AJ, Humphreys Bebbington D, Sauls LA, Rogan J, Agrawal S, Gamboa C, et al. Resource extraction and infrastructure threaten forest cover and community rights. PNAS 2018. doi:10.1073/pnas.1812505115.

[4] Maus V, Giljum S, Gutschlhofer J, da Silva DM, Probst M, Gass SLB, et al. A global-scale data set of mining areas. Nature Scientific Data 2020:289. doi:10.1038/s41597-020-00624-w.

[5] Hansen MC, Potapov PV, Moore R, Hancher M, Turubanova SA, Tyukavina A, et al. High-resolution global maps of 21st-century forest cover change. Science 2013;342:850–3. doi:10.1126/science.1244693.