proteus

The Area of Influence of site-based operations – Indirect Impacts

A Framework for Capturing Indirect Impacts in site-level Biodiversity Risk Screening

Opening Pandora's Box: Aerial view of a bauxite mine exploitation and aluminium production in Ciudad Guayana, Venezuela.
Source: apomares /E+ via Getty Images

Key Messages

- An adequate and effective biodiversity risk screening process should account for the full range of project impacts - indirect as well as direct when determining area of influence (AoI).
- Indirect impacts are elusive and hard to capture in risk assessments. They are also more far-reaching both temporally and spatially than direct impacts.
- Indirect impacts can be defined and triggered by the wider socio-economic and demographic changes associated with the project and not directly by project operations.
- Indirect impacts follow three main pathways 1) increased access to habitats 2) population influx 3) increased viability of other economic activity.
- Available literature on the exact spatial extent to which indirect impacts have been observed is sparse.
- A range of socio-economic and demographic factors can act as high-level predictors of the likelihood and intensity of indirect impacts and form the basis of a decision-making framework to select appropriate buffers for different assets.
- Applying this decision-making framework will allow a more complete and accurate screening of potential biodiversity risks.

Introduction

Site-based industrial operations such as those within the extractive, energy and infrastructure sectors can result in a whole host of direct and indirect impacts on biodiversity within their Area of Influence (AoI). Effective biodiversity risk screening requires consideration of the full range of these impacts when deciding on buffers to apply. Unlike direct impacts, which are more obvious and therefore better studied and documented, indirect impacts are harder to capture in risk screening as they are a step removed from project operations. While direct impacts are triggered by the pressures created by project operations (such as collisions, avoidance, pollution and land clearing), indirect impacts result from the wider socio-economic and demographic changes caused by the operations, and often involve third-party actors such workers, migrants and other businesses.

Some industrial projects are growth-inducing by design i.e., they are meant to stimulate spin-off economic growth. Such 'keystone projects' catalyse population influx and an increase in disposable incomes and consumption, which in turn change the extent and intensity to which local actors access, use and impact natural ecosystems (Johnson et al., 2020) - in the process, pressures such as induced or intensified bushmeat hunting, poaching, logging and land clearing get triggered beyond the project boundary, resulting in species and habitat loss that is far-reaching (Jones et al., 2014). These indirect impacts, also termed as induced, secondary or off-site impacts, are often more profound and enduring as compared to the direct ones (Laurance et al., 2015, Lenzen et al., 2003). It is therefore important to adequately assess and mitigate them.

The elusive and complex nature of indirect impacts makes them difficult to identify and quantify – which is the key reason they are undercounted in Environmental Impact Assessment (EIA) practice. This is despite the fact they feature in the impact assessment requirements of several multilateral development banks (e.g., IFC Guidance Note 6 (IFC, 2018)) and regulatory frameworks (e.g., European Commission's EIA Directive of 1985 (Commission, 1985)). This briefing provides a decision-making framework for incorporating indirect impacts in biodiversity risk screening, with applicability at both project level (for businesses) and portfolio-level (for financial institutions). Note that the briefing does not focus on projects where the main objective is development of linear transport infrastructure or infrastructure corridors.

This briefing:

- highlights the key pathways through which indirect impacts manifest, supported by evidence from scholarly literature to form an adequate definition of indirect impacts
- outlines the wider socio-economic and demographic factors that determine indirect impacts
- presents a decision-making framework to capture potential for indirect impacts when selecting appropriate buffers.

Indirect Impact Pathways

Underlying the indirect impacts of industrial projects such as mining, oil & gas, and renewable energy is the linear infrastructure (i.e., roads, railway lines, powerlines) deployed to connect the hub infrastructure (i.e., mine, dam, powerplant) with raw material sources, population centres and markets. While the footprint of the hub infrastructure itself is usually small, ancillary linear infrastructure often runs for kilometres, applying pressures on biodiversity across large spatial scales (Teo et al., 2019, Jones et al., 2014). Linked to the development of ancillary linear infrastructure, indirect impacts can be defined through three mutually-reinforcing pathways (Figure 1).

1. Increased access to habitats

Ancillary linear infrastructure induces new or deeper access of third-party actors such as bushmeat hunters, poachers and loggers into intact habitats, facilitating increased exploitation that is often unregulated or illegal. For example, increased access of poachers along oil exploration roads led to a collapse in Guanaco (a camelid native to South America) populations up to a distance of 20 km from three surveyed sites in northern Patagonia over a period of twenty years (Radovani et al., 2015).

2. In-migration and settlement

The employment opportunities provided by the project and the new access into ecosystems trigger population influx and settlement into previously-uninhabited areas leading to pressures such as land clearing. For example, the opening of the Geita Mine, Tanzania's largest open-pit gold mine, led to quadrupling of the population of the Geita township (Lange, 2006). An additional risk is that when contracts end, lack of alternative livelihoods and adequate skills transfer (Lesutis 2021) leads workers to engage in exploitative activities.

3. Increased viability of other economic activity

The increased access to raw materials and markets facilitated by the ancillary infrastructure of the industrial project makes other economic activity viable, triggering further exploitation of nearby ecosystems. For instance, improved infrastructure in the form of roads and powerlines

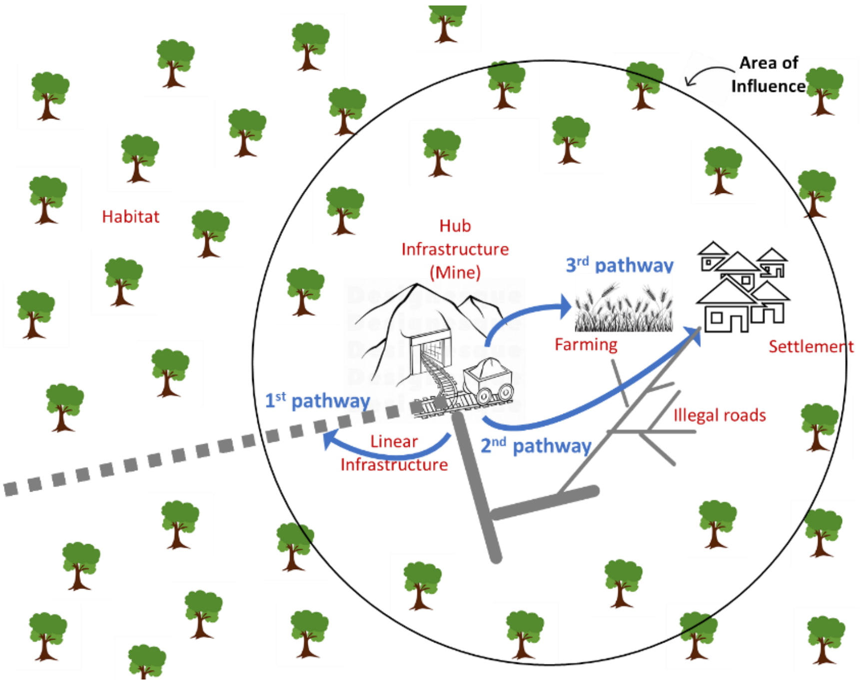


Figure 1: Indirect Impact Pathways and Area of Influence

makes marginal agricultural lands more profitable (Lees et al., 2016). Communities around Tanzania's Geita gold mine have reported an increased market for their agricultural products due to population influx at the mine site (Kitula, 2006). Development of 'keystone' infrastructure also facilitates/subsidises growth of upstream and downstream operations. The cheap electricity from Canada's Northwest Transmission Line, for example is expected to result in a boom in metal mining in the mineral-rich region of north-western British Columbia (Pollon, 2011).

Figure 2 presents the three impact pathways (with pressures induced and resultant indirect impacts) for various industrial project asset types. Annex Table 1 lists real-life examples from scholarly literature of how each impact pathway plays out. Bushmeat hunting, poaching, logging and increased dispersal of exotic species are the key pressures associated with the first pathway, while land clearing is the main pressure associated with the second and third pathways. In case of offshore energy (oil & gas and wind), dispersal of invasive species was seen as the key pressure. Evidence on indirect impacts of solar energy is sparse, as is that on mineral processing, refining and storage facilities.

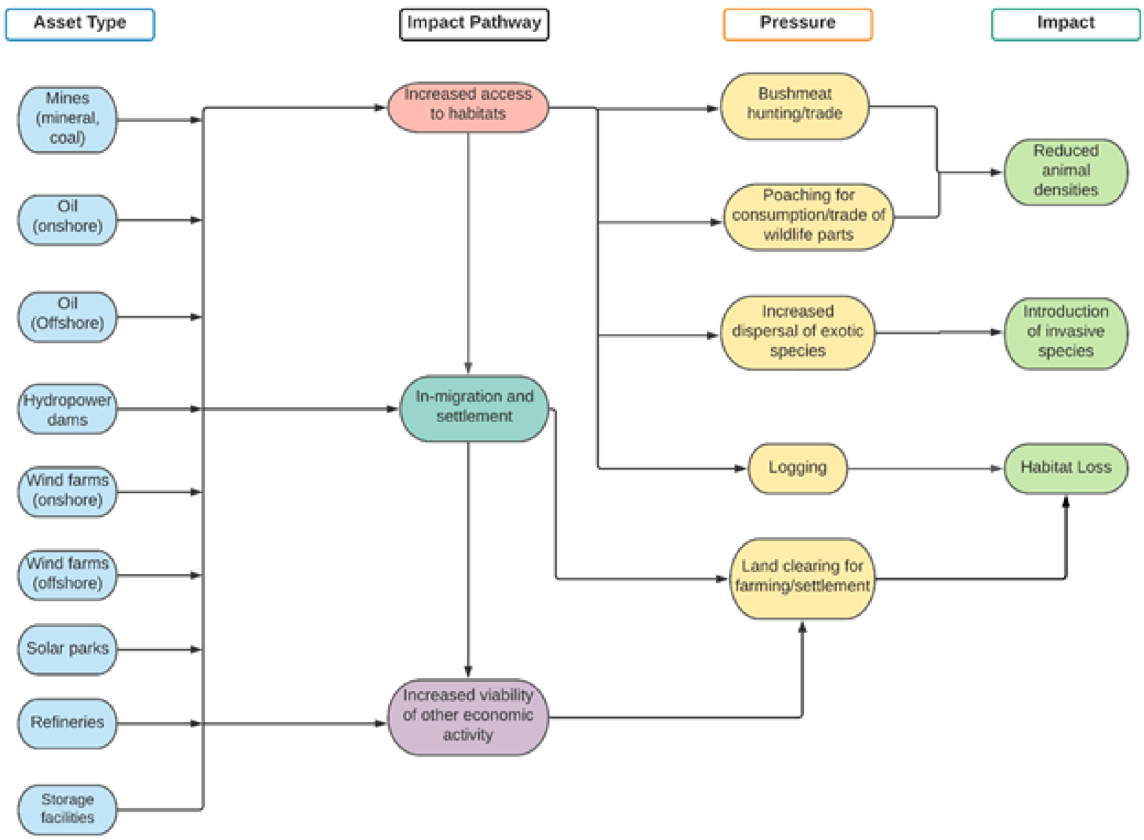


Figure 2: Indirect Impact Pathways of Site-based industrial operations

Factors Influencing Indirect Impacts

Available scientific literature provides limited information (e.g., Radovani et al., (2015) and Sonter et al., (2017)) on the exact spatial extent to which indirect impacts of site-based industrial operations occur. There is however, evidence on how wider socio-economic and demographic factors such as population density, prior development etc. determine the degree to which projects trigger indirect impacts (such as deforestation). Although the relationships between these factors and deforestation are often complex, an overall positive or negative correlation can be interpreted. And even though the occurrence of indirect impacts is highly context specific, these factors can act as high-level predictors of the likelihood of occurrence and severity of indirect impacts. This is especially true when the various factors act in tandem. Annex Table 2 lists the various determining factors that influence indirect impacts and the predictors they translate into. Each of these are spatially explicit (others such as commodity prices which are not, have not been included). Global spatial datasets exist that can be used to ascertain these predictors for each project or portfolio of projects under consideration (Annex Table 2).

Decision-making Framework for AoI Selection

In the absence of exact kilometre figures of the spatial extent to which indirect impacts manifest, broader predictors (listed in Annex Table 2) can be used to decide whether the decision-maker (project developer or investor) should apply a precautionary buffer (AoI) to capture indirect impacts or a more moderate one that only captures direct impacts stemming from the site. Figure 3 presents the decision-making framework. The thresholds of the predictors are discretionary.

Following are two hypothetical cases that demonstrate how the decision tree can be applied:

Case 1: Bauxite mine A is sited in a tropical dry forest, with a few forest villages in the vicinity, inhabited by Indigenous communities. The nearest paved road is located 20 km away. The key economic activity of the local communities is collection of Non-timber Forest Products (NTFP). It takes two days to travel to the nearest city. The site is located within 25 km distance of the boundary of an IUCN Category Ia Protected Area.

Overlaying the coordinates of the project on the spatial maps corresponding to each of the predictors in the decision tree, yields a 'Yes' in all the cases. It is likely that the Protected Area may be impacted by the site through indirect impacts. A precautionary buffer to capture the indirect impacts should therefore be applied for risk screening.

Case 2: Bauxite mine B is sited near an Aluminium industrial cluster with another mine and several ancillary and downstream facilities such as smelters. The habitats within 1 km of the mine are not classified as critical habitat. The cluster is strategically well connected by roads and railways. A major port is also located at a distance of about 175 km. People from the nearby township are employed within the cluster. The mine site is also 25 km from the boundary of an IUCN Category Ia Protected Area.

Overlaying the coordinates of the project on the spatial maps corresponding to each of the predictors in the decision tree, yields a 'No' in all the cases. This may mean that the protected area is assessed as not at risk of being impacted by the site. While indirect impacts should not be ignored, a moderate buffer that captures direct impacts can be applied for the purposes of risk screening.

Application of the decision tree may not always yield all no's or all yes', in which case 'yes' answers should be weighted higher than 'no' answers to ensure a precautionary approach is taken to ensure all risks are captured.

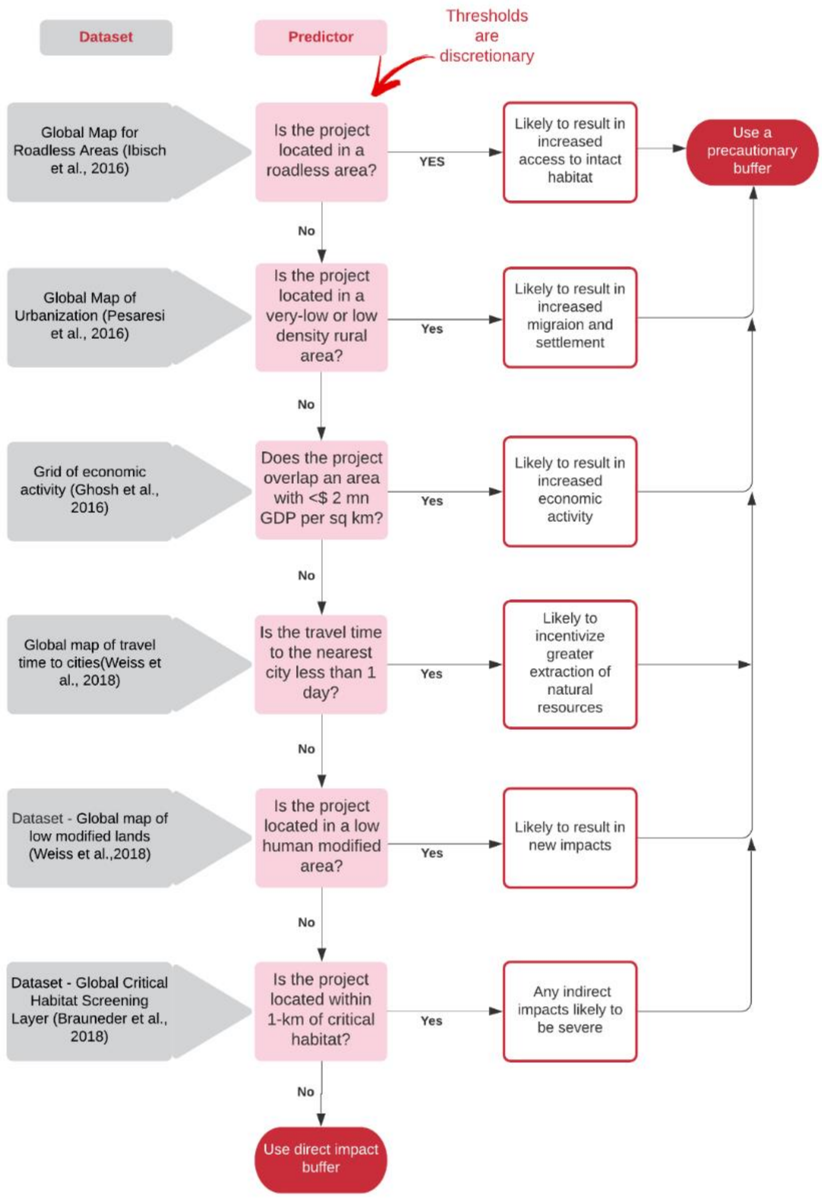


Figure 3: Decision-making Framework for buffer selection: Capturing Indirect Impacts

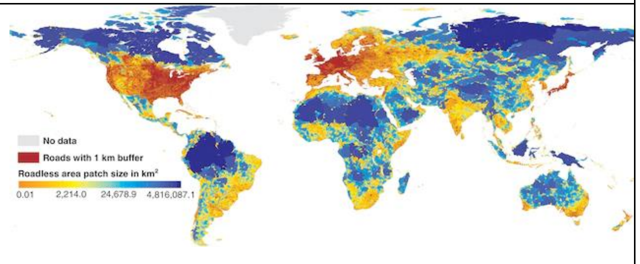
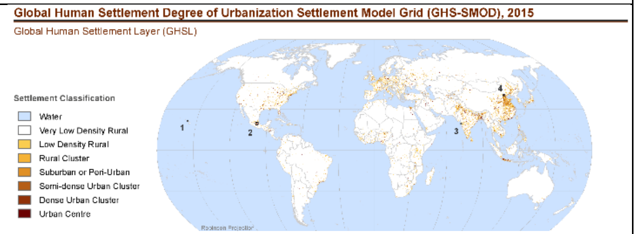
Summary

Indirect impacts of industrial development have remained a grey area in terms of how they are defined, identified and captured in biodiversity risk assessment and management. This leads to the possibility of impacts on important biodiversity features to be missed during screening processes, but also mistrust in the use of more precautionary buffers due to unclear justifications. Greater clarity on the pathways these indirect impacts follow and the factors that determine their extent can therefore help ensure more comprehensive screening, a more trusted assessment of risks from indirect impacts and thereby more robust decision-making on project development, financing and impact mitigation.

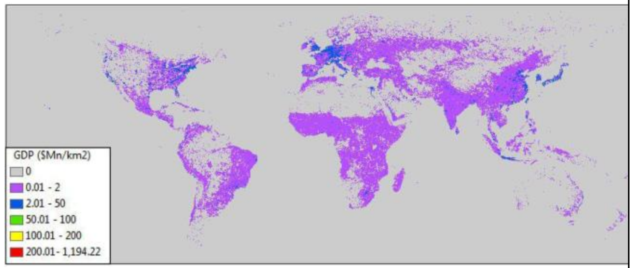
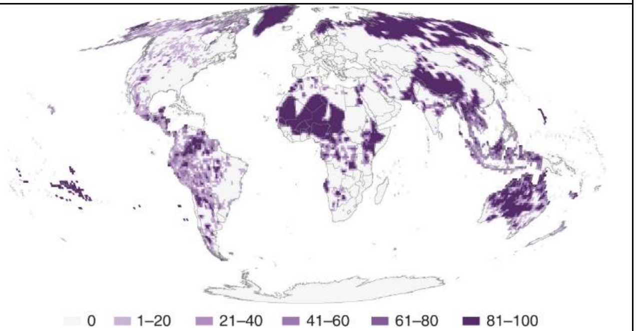
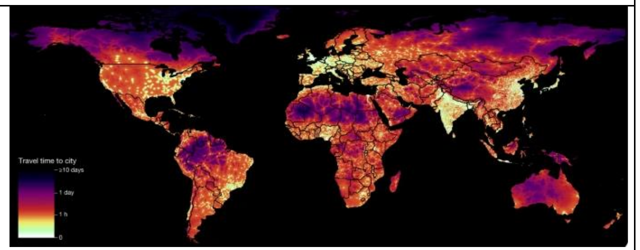
Annex Table 1: Indirect Impact Pathways: Evidence from Literature

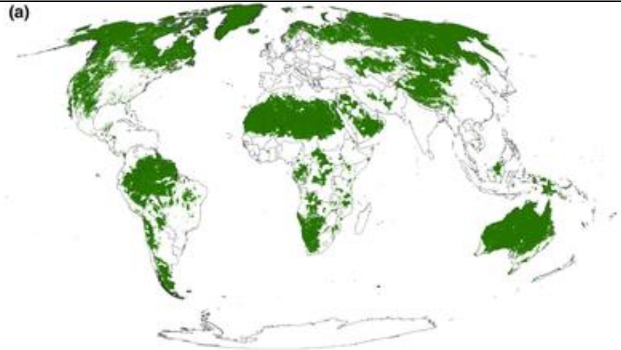
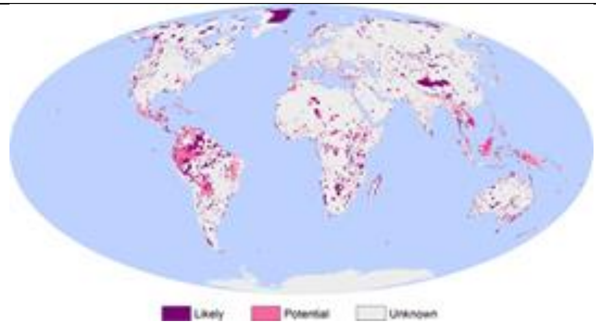
Impact Pathways	Asset Type	Pressure	Impact	AoI (km)	Citation
Induced/increased access to habitats	Mines (mineral, coal)	Bushmeat hunting/trade	Reduced animal densities		Suarez et al., 2009; Owusu et al., 2018
	Mines (mineral, coal)	Logging	Reduced animal densities		Owusu et al., 2018
	Mines (mineral, coal)	Bushmeat hunting/trade	Reduced animal densities		Thibault and Blaney, 2003
	Mines (mineral, coal)	Increased dispersal of exotic species	Introduction of invasive exotic species		Adesipo et al., 2020
	Oil (onshore)	Poaching for consumption/trade of wildlife parts	Reduced animal densities	20 km	Radovani et al., 2015
	Oil (onshore)	Increased dispersal of exotic species	Introduction of invasive exotic species		Numbere, 2018
	Oil (onshore)	Increased dispersal of exotic species	Introduction of invasive exotic species		Page et al., 2006
	Wind farms (onshore)	Increased dispersal of exotic species	Introduction of invasive exotic species		Keehn and Feldman, 2018
	Wind farms (offshore)	Increased dispersal of exotic species	Introduction of invasive exotic species		Kerckhof et al., 2016
In-migration and settlement	Mines (mineral, coal)	Land-clearing for farming and settlement	Habitat Loss	70 km	Sonter et al., 2017
	Hydropower dams	Land-clearing for farming and settlement	Habitat Loss		Finer and Jenkins, 2012
Increased viability of other economic activity	Mines (mineral, coal)	Land-clearing for farming and settlement	Habitat Loss		Kitula, 2006

Annex Table 2: Predictor variables for the likelihood of indirect impacts and associated potential data sources

Factors influencing indirect impacts	Correlation with indirect impacts	Supporting Evidence	Predictor	Example Dataset	Map
Existing roads (1st pathway)	Negative	Ibisch et al., (2016)	Degree of roadlessness of the site	Global map of roadless areas (Ibisch et al., 2016) Data Download Link	
Existing settlement (2nd pathway)	Negative	Chomitz and Gray, (1996), Laurance et al.,(2002)	Settlement classification of the site	Global Human Settlement Degree of Urbanization Settlement Model Grid (GHS-SMOD), 2015 (Florczyk et al., 2019)[1] Data Download Link	

[1] Alternate Dataset: Global Map of Population Density

Existing economic development (3rd pathway)	Negative	Pfaff et al.,(2018), Chomitz and Gray (1996), Faria and Almeida (2016), Jaffe et al.,(2021)	GDP per km² of the site	Grid of total economic activity in millions of dollars per km² pixel (Ghosh et al., 2010) Data Download Link	
Presence of indigenous lands	Negative	Nepstad et al., (2006), Jaffe et al., (2021)	Overlap with indigenous lands	Global map of lands managed and/or controlled by Indigenous Peoples (Garnett et al., 2018) Available upon request from author.	 Percentage of each degree square mapped as Indigenous
Accessibility to markets/ urban areas	Negative	Rideout et al., (2013)	Travel time to cities from the site	Global map of travel time to cities (Weiss et al., 2018) Data Download Link	

Current human modification (Habitat state)	Negative		Overlap of site with low modified land	Global map of low modified lands (Kennedy et al., 2019)[2] Data Download Link	 13 pressures (human population density, built-up area, cropland, livestock, major roads, minor roads, two-tracks, railroads, mines, oil wells, wind turbines, power lines, night-time lights)
Biodiversity value (habitat sensitivity)	Positive		Overlap or proximity of site to critical habitat	Global Critical Habitat Screening layer Brauneder et al., (2018) Data Download Link	

[2] Alternate Datasets – Global Screening Layer for Modified Habitat, Global Human Footprint Map, Global Map of Low Impact Areas, Anthropogenic Biomes of the World

References

ADESIPO, A. A., AKINBIOLA, S., AWOTOYE, O. O., SALAMI, A. T. & FREESE, D. 2020. Impact of mining on the floristic association of gold mined sites in Southwest Nigeria. *BMC ecology,* 20, 1-13.

BRAUNEDER, K. M., MONTES, C., BLYTH, S., BENNUN, L., BUTCHART, S. H., HOFFMANN, M., BURGESS, N. D., CUTTELOD, A., JONES, M. I. & KAPOS, V. 2018. Global screening for Critical Habitat in the terrestrial realm. *Plos One,* 13, e0193102.

CHOMITZ, K. M. & GRAY, D. A. 1996. Roads, land use, and deforestation: a spatial model applied to Belize. *The World Bank Economic Review,* 10, 487-512.

COMMISSION, E. 1985. EIA Directive. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31985L0337.

FARIA, W. R. & ALMEIDA, A. N. 2016. Relationship between openness to trade and deforestation: Empirical evidence from the Brazilian Amazon. *Ecological Economics,* 121, 85-97.

FINER, M. & JENKINS, C. N. 2012. Proliferation of hydroelectric dams in the Andean Amazon and implications for Andes-Amazon connectivity. *Plos one,* 7, e35126.

FLORCZYK, A. J., EHRLICH, D., FREIRE, S., KEMPER, T., MAFFENINI, L., MELCHIORRI, M., MELCHIORRI, M., PESARESI, M., POLITIS, P., SCHIAVINA, M., SABO, F. & ZANCHETTA, L. 2019. GHSL Data Package 2019, EUR 29788 EN. Luxembourg: Publications Office of the European Union.

GARNETT, S. T., BURGESS, N. D., FA, J. E., FERNÁNDEZ-LLAMAZARES, Á., MOLNÁR, Z., ROBINSON, C. J., WATSON, J. E., ZANDER, K. K., AUSTIN, B. & BRONDIZIO, E. S. 2018. A spatial overview of the global importance of Indigenous lands for conservation. *Nature Sustainability,* 1, 369-374.

GHOSH, T., L POWELL, R., D ELVIDGE, C., E BAUGH, K., C SUTTON, P. & ANDERSON, S. 2010. Shedding light on the global distribution of economic activity. *The Open Geography Journal,* 3.

IBISCH, P. L., HOFFMANN, M. T., KREFT, S., PE'ER, G., KATI, V., BIBER-FREUDENBERGER, L., DELLASALA, D. A., VALE, M. M., HOBSON, P. R. & SELVA, N. 2016. A global map of roadless areas and their conservation status. *Science,* 354, 1423-1427.

IFC. 2018. Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. Available: https://www.ifc.org/wps/wcm/connect/a359a380498007e9a1b7f3336b93d75f/Updated_GN6-2012.pdf?MOD=AJPERES.

JAFFÉ, R., NUNES, S., DOS SANTOS, J. F., GASTAUER, M., GIANNINI, T. C., NASCIMENTO JR, W., SALES, M., SOUZA, C. M., SOUZA-FILHO, P. W. & FLETCHER, R. J. 2021. Forecasting deforestation in the Brazilian Amazon to prioritize conservation efforts. *Environmental Research Letters,* 16, 084034.

JOHNSON, C. J., VENTER, O., RAY, J. C. & WATSON, J. E. 2020. Growth-inducing infrastructure represents transformative yet ignored keystone environmental decisions. *Conservation Letters,* 13, e12696.

JONES, I. L., BULL, J. W., MILNER-GULLAND, E. J., ESIPOV, A. V. & SUTTLE, K. B. 2014. Quantifying habitat impacts of natural gas infrastructure to facilitate biodiversity offsetting. *Ecology and evolution,* 4, 79-90.

KEEHN, J. E. & FELDMAN, C. R. 2018. Disturbance affects biotic community composition at desert wind farms. *Wildlife Research,* 45, 383-396.

KENNEDY, C. M., OAKLEAF, J. R., THEOBALD, D. M., BARUCH-MORDO, S. & KIESECKER, J. 2019. Managing the middle: A shift in conservation priorities based on the global human modification gradient. *Global Change Biology,* 25, 811-826.

KERCKHOF, F., DE MESEL, I. & DEGRAER, S. 2016. Do wind farms favour introduced hard substrata species. *Environmental impacts of offshore wind farms in the Belgian part of the North Sea: Environmental impact monitoring reloaded*, 61-75.

KITULA, A. 2006. The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study of Geita District. *Journal of cleaner production,* 14, 405-414.
LANGE, S. 2006. *Benefit streams from mining in Tanzania: Case studies from Geita and Mererani*, Chr. Michelsen Institute.
LAURANCE, W. F., ALBERNAZ, A. K., SCHROTH, G., FEARNSIDE, P. M., BERGEN, S., VENTICINQUE, E. M. & DA COSTA, C. J. J. O. B. 2002. Predictors of deforestation in the Brazilian Amazon. 29, 737-748.
LAURANCE, W. F., PELETIER-JELLEMA, A., GEENEN, B., KOSTER, H., VERWEIJ, P., VAN DIJCK, P., LOVEJOY, T. E., SCHLEICHER, J. & VAN KUIJK, M. 2015. Reducing the global environmental impacts of rapid infrastructure expansion. *Current Biology,* 25, R259-R262.
LEES, A. C., PERES, C. A., FEARNSIDE, P. M., SCHNEIDER, M., ZUANON, J. A. J. B. & CONSERVATION 2016. Hydropower and the future of Amazonian biodiversity. 25, 451-466.
LESUTIS, G. 2021. Infrastructure as techno-politics of differentiation: socio-political effects of mega-infrastructures in Kenya." *Transactions of the Institute of British Geographers*.1-13
LENZEN, M., MURRAY, S. A., KORTE, B. & DEY, C. J. 2003. Environmental impact assessment including indirect effects—a case study using input–output analysis. *Environmental Impact Assessment Review,* 23, 263-282.
NEPSTAD, D., SCHWARTZMAN, S., BAMBERGER, B., SANTILLI, M., RAY, D., SCHLESINGER, P., LEFEBVRE, P., ALENCAR, A., PRINZ, E. & FISKE, G. 2006. Inhibition of Amazon deforestation and fire by parks and indigenous lands. *Conservation biology,* 20, 65-73.
NUMBERE, A. O. 2018. The impact of oil and gas exploration: invasive nypa palm species and urbanization on mangroves in the Niger River Delta, Nigeria. *Threats to mangrove forests.* Springer.
OWUSU, E. H., OFORI, B. Y. & ATTUQUAYEFIO, D. K. 2018. The secondary impact of mining on primates and other medium to large mammals in forest reserves in southwestern Ghana. *The Extractive Industries and Society,* 5, 114-121.
PAGE, H. M., DUGAN, J. E., CULVER, C. S. & HOESTEREY, J. C. 2006. Exotic invertebrate species on offshore oil platforms. *Marine Ecology Progress Series,* 325, 101-107.
PFAFF, A., ROBALINO, J., REIS, E. J., WALKER, R., PERZ, S., LAURANCE, W., BOHRER, C., ALDRICH, S., ARIMA, E. & CALDAS, M. 2018. Roads & SDGs, tradeoffs and synergies: learning from Brazil's Amazon in distinguishing frontiers. *Economics,* 12.
POLLON, C. 2011. Who Will Clean Up Our Mining Mess?| The Tyee.
RADOVANI, N. I., FUNES, M. C., WALKER, R. S., GADER, R. & NOVARO, A. J. 2015. Guanaco Lama guanicoe numbers plummet in an area subject to poaching from oil-exploration trails in Patagonia. *Oryx,* 49, 42-50.
RIDEOUT, A. J., JOSHI, N. P., VIERGEVER, K. M., HUXHAM, M. & BRIERS, R. A. 2013. Making predictions of mangrove deforestation: a comparison of two methods in Kenya. *Global change biology,* 19, 3493-3501.
SONTER, L. J., HERRERA, D., BARRETT, D. J., GALFORD, G. L., MORAN, C. J. & SOARES-FILHO, B. S. 2017. Mining drives extensive deforestation in the Brazilian Amazon. *Nature Communications,* 8, 1013.
SUAREZ, E., MORALES, M., CUEVA, R., UTRERAS BUCHELI, V., ZAPATA-RÍOS, G., TORAL, E., TORRES, J., PRADO, W. & VARGAS OLALLA, J. 2009. Oil industry, wild meat trade and roads: indirect effects of oil extraction activities in a protected area in north-eastern Ecuador. *Animal Conservation,* 12, 364-373.
TEO, H. C., LECHNER, A. M., WALTON, G. W., CHAN, F. K. S., CHESHMEHZANGI, A., TAN-MULLINS, M., CHAN, H. K., STERNBERG, T. & CAMPOS-ARCEIZ, A. 2019. Environmental Impacts of Infrastructure Development under the Belt and Road Initiative. *Environments,* 6, 72.
THIBAULT, M. & BLANEY, S. 2003. The oil industry as an underlying factor in the bushmeat crisis in Central Africa. *Conservation biology,* 17, 1807-1813.
WEISS, D. J., NELSON, A., GIBSON, H., TEMPERLEY, W., PEEDELL, S., LIEBER, A., HANCHER, M., POYART, E., BELCHIOR, S. & FULLMAN, N. 2018. A global map of travel time to cities to assess inequalities in accessibility in 2015. *Nature,* 553, 333-336.

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