

Review

Location, location, location: asset location data sources for nature-related financial risk analysis

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Nature, the services it provides and the threats it is exposed to are inherently location-specific. Therefore, financial institutions will need to apply geospatial analysis to accurately assess nature-related financial risks. As a minimum, this requires knowing where a counterparty's operations or supply chains are located. Asset location information is often cited by financial institutions as a major data gap for nature-related analysis. While granular supply chain data is notoriously hard to collect, location information about companies' direct operational assets is available for various industries. We review different sources of asset location data, analyse their availability per industry and provide recommendations to reduce the location data barrier and address the 'lack of data' excuse to delay nature action.

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Introduction

There is a growing awareness and understanding that the decline of nature and biodiversity poses significant risks to our economy [1]. Financial regulators responsible for the financial stability of our economy and financial system are acknowledging the detrimental impacts of nature decline and have started modelling its economy-wide implications [2,3]. Companies and financial institutions alike are starting to acknowledge their impacts on nature and are being encouraged to start reporting

their nature-related financial risks [4]. The Taskforce for Nature-related Financial Disclosures (TNFD) is the most widely known and adopted framework to streamline and standardise such reporting efforts. While TNFD and other frameworks are currently voluntary, it is expected that nature-related financial risk reporting requirements will eventually become mandatory, as we see happening for climate-related financial risks [5].

Ultimately, the idea is that better disclosure of nature-related risks and impacts across (all) companies will lead to more accurate pricing of these risks. Where companies with higher risk exposure would be valued less or receive less beneficial financing requirements (e.g. interest rates, insurance premia) [6]. In turn, this would incentivise businesses to invest in risk reduction measures, either by reducing their dependencies on natural assets and their ecosystem services or by reducing the impacts their operations are having on the environment. The concept of natural capital accounting, an approach to value natural resources and the ecosystem services they provide for economic decision-making, is another route to establish a 'business case' to invest in nature restoration or recovery [7].

The presence and condition of biodiversity, natural resources and the ecosystems they provide can vary strongly across locations. If we want to understand nature-related risks in any meaningful way that allows us to accurately price them, we need to analyse them in their spatial and socio-economic context, at the level of individual operations or supply chains [8–10]. This is not how many financial institutions would typically assess counterparties' risk. For instance, credit risk assessments by banks would be based on a company's aggregated financial statements. Sustainability or environmental, social and governance (ESG) risk assessment would be based on aggregate reported emission or other pollution numbers, as well as companywide (sustainability) policies. Finally, most 'biodiversity measurement' tools that are currently used by financial institutions follow a life cycle assessment approach, using industry averages rather than context-specific biodiversity indicators [11].

The concept of 'spatial finance' offers a high-level framework to better assess a wide range of sustainability risks, opportunities and impacts, leveraging geospatial

analysis and asset location data [12]. However, many financial institutions struggle to access asset location data, let alone supply chain location information [10,13,14]. Companies are not mandated to disclose asset location information, but in many cases and for many industries, it can be found even from public sources [15]. In this paper, we first outline why location information is fundamental for any nature and biodiversity risk assessments. We then review different sources of asset location data and the data availability per industry. Finally, we provide some recommendations for policymakers, financial institutions and researchers to advance the availability and quality of asset location information to raise the bar for all in assessing nature-related financial risks.

Location specificity of nature and biodiversity

The availability and state of nature and biodiversity are inherently location and time-specific, as are the availability and quality of ecosystem services provided [10,16,17]. For instance, the availability of water can vary significantly between (sub-)watersheds [18], the abundance and type of pollinators will differ between locations [19] or the diversity of genes, species and communities will differ between geographies based on ecosystem type, climate and human activity health [20,21]. This means that the reliance of businesses' operations on natural capital and ecosystem services and the impacts they have on those ecosystems are inherently location and time-specific as well.

As businesses and financial institutions start to assess the nature-related financial risks of their activities, they need to do so in a spatially explicit way [9,22,23]. While this approach is relatively new for many financial institutions, guidance from both scientific and civil society communities acknowledges the need to do so. For instance, Wassénus et al. [24] propose 15 essential environmental impact variables (EEIVs) to measure corporate impacts, 14 of which are specific to the operational asset and its location [24]. Similarly, methods developed by Crona et al. [25] and Rossi et al. [26] for quantifying corporate impacts on ecosystem services and biodiversity make use of spatially explicit ecosystem service modelling and high-resolution satellite imagery [25,26]. The Science Based Targets Network's guidance for setting nature targets starts with an 'Assess' step, which is focused on priority business and value chain locations [27]. Similarly, the TNFD's 'LEAP' approach to identify and assess nature-related issues starts with a 'Locate' phase to understand a company's spatial interface with nature [8], before entering into phases to 'Evaluate' and 'Assess' nature-related dependencies and impacts and 'Prepare' reporting [8]. However, financial institutions often report difficulties in accessing location information of their counterparties' operations and supply chains [14,28]. Even regulators, like the European Commission, are beginning to demand disaggregated reporting "by significant site or by

significant asset", although this requirement remains non-mandatory and applies only "when needed for a proper understanding of its material impacts, risks and opportunities" [29], for instance, any "anticipated financial effects from physical risks" as per article ESRS E1-9.

Sources of asset location data

There are three types of external sources for asset location data tied to ownership. The first one is company-reported data about the assets that they own and operate. This information is typically made available on company websites or within investment/sustainability reports. A small number of companies also report location information through their Carbon Disclosure Project (CDP) disclosures, for instance, for "facilities exposed to water risks that could have a substantive financial or strategic impact on your business" in the 2023 CDP water questionnaire or for the company's own or suppliers' processing sites as an optional attachment in the CDP 2023 forest disclosures.

A second source of information is public registers of high-impact facilities and their reported environmental pollution, for instance, through pollutant release and transfer registers (PRTRs), which catalogue releases and transfers of potentially harmful substances to the environment reported by companies in certain jurisdictions [30]. The Organisation for Economic Co-operation and Development has identified 44 PRTRs around the world. The European Pollutant Release and Transfer Register (E-PRTR) provides public access to its environmental data from some 35 000 industrial facilities across EU member states, Iceland, Liechtenstein, Norway, Switzerland, Serbia and the UK. This covers 65 economic activities and 91 key pollutants [31].

Finally, asset location information is increasingly available through third-party commercial and nonprofit organisations.

- For-profit providers range from industry specialists (focused on marketing use) such as Enverus, Global Cement or Glassgroup Global to generalists (focused on business intelligence or credit assessment use) such as Dun & Bradstreet, to finance specialists (focused on finance and sustainability risk uses) such as Asset Impact or S&P Global. They all offer asset database under different types of commercial licenses.
- Nonprofit organisations such as Global Energy Monitor (focus on energy sectors) [32] or projects such as GeoAsset (focus on heavy industry) [33] or Global Plastics Watch (focus on dumpsites) [34] offer open-source asset databases with location, and often ownership and other information.
- Some certification bodies, such as the Roundtable on Sustainable Palm Oil or the Marine Stewardship Council, provide datasets of certified processing

facilities with location and other information [35,36]. While public regulatory bodies such as the US Food and Drug Administration publish location and ownership data about registered facilities [37].

- Academics and researchers have also been creating asset location database for numerous industries based on a whole suite of novel methodologies. For instance, this covers mining [38,39], power [40,41], heavy industry [42] transport [43] or water [44] infrastructure facilities.

All of these data sources come with their own challenges and limitations. Company disclosures are patchy, as asset (location) disclosures are not mandatory. The voluntary nature of disclosures allows companies to cherry-pick ‘good’ examples or minimise the number of sites they report based on an internal assessment of risk materiality. Public registers’ scopes are typically limited to certain sectors and company sizes or struggle with data quality and validation issues in certain jurisdictions [45]. While third-party providers’ datasets have not necessarily been created for (nature-related) financial risk analyses, they are also not standardised across sectors, not necessarily updated frequently or not complete enough for holistic analyses [15]. Additionally, commercial datasets can be costly and come with considerable licensing constraints.

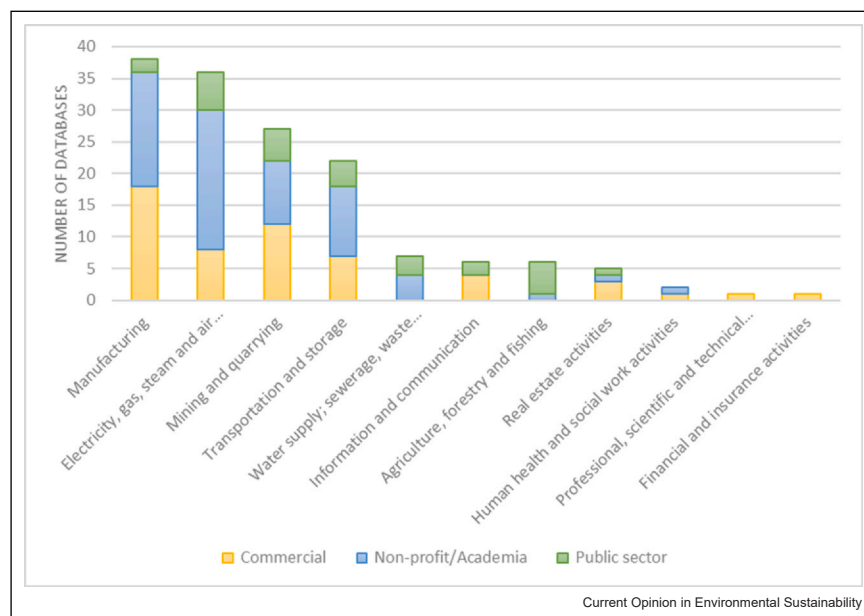
Availability of asset location data per sector

To understand the availability of asset location data across sectors, we have compiled an inventory of 173

asset databases. Covering databases that provide, as a minimum, location information about economic facilities, focusing on constructed assets (infrastructure, factories, etc.) rather than natural assets (farmland, forestry concessions, water bodies, etc.). We identified 141 databases for industries with fixed assets, 12 databases for industries with mobile assets and 20 databases that cover multiple industries. Forty-two percent of databases covered are from nonprofit providers, 34% from commercial providers and 25% from public sector providers. Databases from public and nonprofit sources are freely accessible, while databases from commercial providers typically require the payment of a license fee. For each database, we have captured information about the industry covered, asset type, geographic coverage, number of assets, asset features available, license type and most recent update year. Figure 1 shows the breakdown of all the sectoral databases in our inventory by sector and data source.

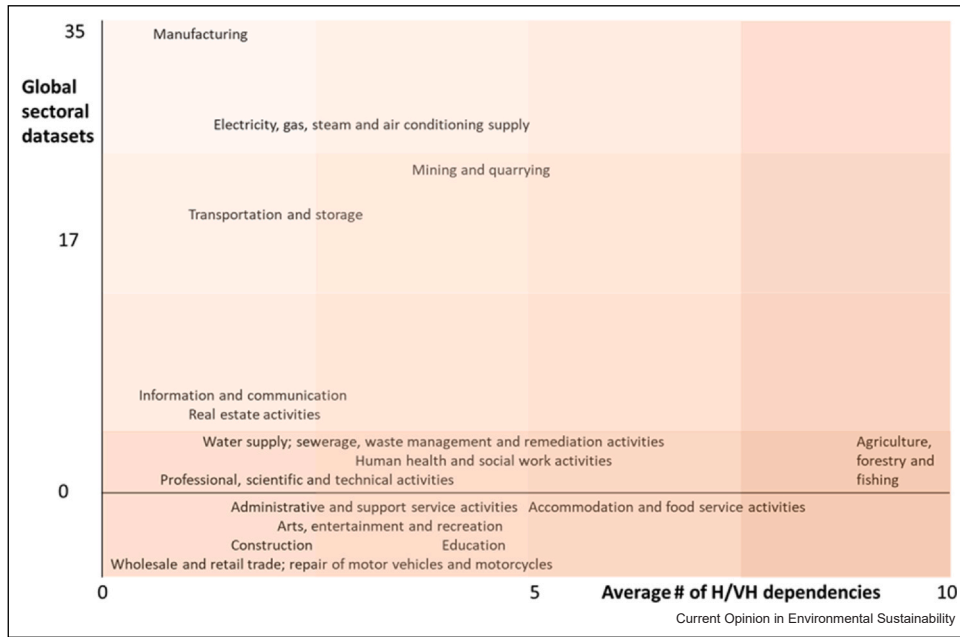
In Figure 2 and Figure 3, we plotted the number of asset databases in our inventory with global coverage (117/153) against the nature dependency and impact materiality assessments for 21 industries, classified as ‘sections’ under the International Standard Industrial Classification of All Economic Activities (ISIC) Revision 4. We used the databases from the Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE) tool to categorise the nature dependency and impact materiality for each sector as it is widely used by financial institutions to screen for potential nature-related financial risks

Figure 1



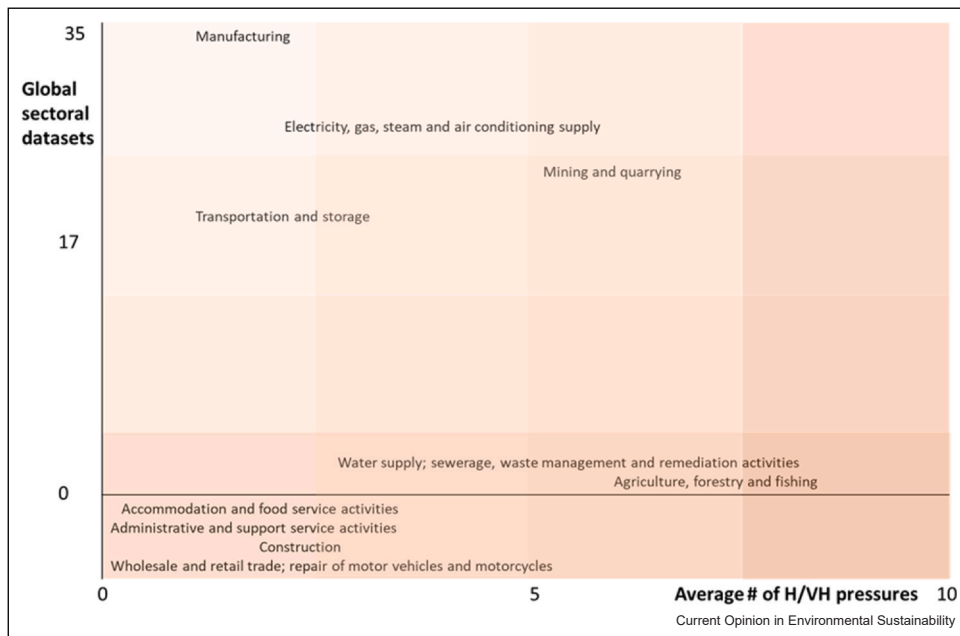
Number of databases in the inventory per sector and data source type.

Figure 2



Summary of global sectoral asset location data availability and material nature dependencies per economic sector, with the average number of high (H) and very high (VH) dependency materiality scores in ENCORE as a proxy for nature dependency materiality. The bivariate colour scheme highlights sectors with low data availability or high materiality in a darker shade of red.

Figure 3



Summary of global sectoral asset location data availability and material nature pressures per economic sector, with the average number of high (H) and very high (VH) pressure materiality scores in ENCORE as a proxy for nature pressure materiality. The bivariate colour scheme highlights sectors with low data availability or high materiality in a darker shade of red.

Table 1

Summary of database coverage per economic sector (categorised as 'sections' under ISIC Rev.4) within the inventory and the average H/VH dependency and pressure values used in Figures 2 and 3.

Sector	Sectoral databases	Sectoral databases with global coverage	Average # of H or VH dependencies	Average # of H or VH pressures
Manufacturing	38	33	0.6	1.2
Electricity, gas, steam and air conditioning supply	36	26	1.3	2.1
Mining and quarrying	27	22	3.7	5.3
Transportation and storage	22	20	1.0	1.1
Information and communication	7	5	0.4	0.0
Real estate activities	6	4	1.0	0.0
Water supply; sewerage, waste management and remediation activities	6	3	1.2	2.9
Human health and social work activities	5	2	3.0	0.0
Professional, scientific and technical activities	2	1	0.7	0.0
Agriculture, forestry and fishing	1	1	9.1	6.0
Financial and insurance activities	1	0	0.0	0.0
Construction	0	0	1.5	1.9
Wholesale and retail trade; repair of motor vehicles and motorcycles	0	0	0.1	0.1
Accommodation and food service activities	0	0	4.7	0.2
Administrative and support service activities	0	0	1.5	0.1
Public administration and defence; compulsory social security	0	0	0.0	0.0
Education	0	0	4.0	0.0
Arts, entertainment and recreation	0	0	2.0	0.0
Other service activities	0	0	0.0	0.0
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use (Households)	0	0	0.3	0.0
Activities of extraterritorial organisations and bodies (Int. bodies)	0	0	0.0	0.0

The database numbers in this table only provide an indication of availability, rather than quality or depth of scope of the underlying databases.

in portfolios [46]. ENCORE's materiality ratings indicate the significance of potential nature-related dependencies and pressures for economic activities, with 'material' meaning significant or important for decision-making. For each sector, we took the average number of high (H) or very high (VH) materiality ratings for ecosystem service dependencies or nature pressures within ENCORE, for direct operations. Table 1 shows the values used for this assessment. The inventory also includes 49 datasets that cover only a single country or countries in a single region. Europe (22) and North America (15) are best represented, with lower representation of Asia (6), Africa (3), South America (2) and Australasia (1). It is important to note that this does not necessarily represent lower data availability, as much as a lower familiarity of the authors with relevant sources in these regions. Additionally, with ENCORE being a globally average view of materiality based on a qualitative assessment of academic and grey literature, this means these numbers have more value in a relative rather than absolute sense.

Overall, we find a relatively high number of global databases for sectors such as mining and power or sub-sectors of manufacturing and transport. However, global location datasets for most other sectors are limited or

nonexistent. This is a bigger issue for financial institutions looking to screen their portfolios for nature dependencies compared to nature impacts, without easy access to location data for hospitality or recreation industries for instance. Additionally, these data gaps will be more or less problematic depending on the type of financial institution and/or portfolio; for example, global equity portfolios might have lower direct exposure to the agriculture, forestry and fishing sector compared to a commercial bank with a national (agriculture) loan book.

The bivariate colour scheme in Figures 2 and 3 indicates which sectors should be prioritised for data expansion, with darker hues of red for sectors with no/low data availability and sectors with higher dependencies/pressures. Overall, the most significant and important location data gap is for primary economic activities in agriculture, forestry and fishing, which is the industry with the highest dependencies and pressures on nature. This is a problem for financial institutions with direct exposure to these industries, for instance, through loans to farmers or equity investments in seafood companies, as well as indirect exposure through the supply chains of secondary and tertiary industries they are invested in. It is through supply chains that a lot of nature-related financial risk for financial institutions is expected to

originate [47]. However, data on processing facilities of raw natural inputs, such as oil palm mills, paper pulp mills or abattoirs, which are covered by different ‘manufacturing’ subsectors, are increasingly available and are being used to model supply chain risks [48,49].

Conclusion

Financial institutions struggle to access location information of counterparties’ operational assets and their supply chains. However, we show that asset location information tied to ownership can be found in company disclosures, public registers or third-party commercial and nonprofit datasets. We find databases for most industries that have medium or high dependency or impacts on nature, with good availability for power and mining sectors. Sectoral data gaps are most pronounced for industries with higher nature dependencies rather than industries with higher nature impacts. We have identified different types of data sources, typically covering individual sectors or specific geographies, and documented 173 individual databases. Rather than a complete ‘lack of’ location data for nature-related risk assessments, we find sectoral and regional data gaps. Additionally, challenges remain around the accessibility and usability of many of the location databases identified. More work needs to be done to define what good quality and good coverage location data look like for a variety of use cases.

Nonetheless, there are significant opportunities for the research, public and private sectors to improve those in a relatively short timeframe. The research community can identify minimum location data requirements to underpin a wide range of nature risk use cases. A harmonised approach to publishing ownership information will be key, building on formats that are used in corporate and financial analysis, such as Legal Entity Identifiers, International Securities Identification Numbers, national company registration numbers or others. The Global Legal Entity Identifier Foundation is a good example of ownership data harmonisation. Researchers can also develop new methodologies to compile asset location databases, combining a variety of alternative data sources from crowd sourced data in OpenStreetMap to news articles to satellite imagery, leveraging advances in artificial intelligence to process these at speed and scale. Examples include the GeoAsset project [33] and academic research presented in Refs. [38–42]. Public sector actors, such as environmental and industry regulators, can open up more of the location-specific data they are already collecting from companies today. This data should be published in a standardised way, across government departments and public bodies. Finally, private sector actors such as financial institutions, regulators and standards setters should advocate for the full disclosure of all companies’ operations, and preferably supply

chains, in a standardised way. A ‘principle of asset-level disclosure’ [50] could be integrated into existing mandatory and voluntary reporting standards and provide guidance on how to disclose a minimum level of location-specific asset characteristics based on insights from the research community. This principle should be comprehensive enough to cover all assets of an entity rather than only those deemed under material risk as determined by the companies itself, as is the case under the current European Sustainability Reporting Standards.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supporting information

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