Global Canopy AECOM nature-based insights

Nature risk screening for infrastructure projects across Asia:

Reflections from piloting TNFD's LEAP approach

Contents

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Citation: Nature-based Insights, AECOM, and Global Canopy (2023) Nature risk screening for infrastructure projects across Asia: Reflections from piloting TNFDs LEAP approach

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Name of participating organisations: AECOM piloted the TNFD LEAP approach in partnership with Nature-based Insights as lead consultant for the analyses, and Global Canopy responsible for commissioning, project management support and output review.

Overview

Scope

This case study outlines a high-level risk screening for a suite of projects on which AECOM consults across Asia. It uses multiple geospatial layers to score and rank projects with regards to potential impact, the dependencies of people on nature, physical risks from natural disasters and water-related stress variables, and opportunities for extinction-risk reduction. The analysis is structured around the Locate, Evaluate, and Assess phases of the TNFDs LEAP approach. The case study also conducts a deeper dive into a particular infrastructure project in Singapore to better understand the current nature-related data collected and any potential gaps based on information collected in Environmental Impact Assessments (EIAs).

- **Geography:** Assessed projects were located in multiple sub-national and national geographies in South Asia (India, Andaman and Nicobar Islands), South-East Asia (Singapore, Thailand, Malaysia, Philippines, Myanmar, Vietnam, Indonesia), and East Asia (Taiwan, Hong Kong).
- **Sector:** Infrastructure (multiple project types including transmission lines, railways, shoreline restoration, construction of recreational areas).
- **Biome:** Tropical and sub-tropical forests (T1); Temperate boreal forests and woodlands (T2); Shrublands and shrubby woodlands (T3), Savannas and grasslands (T4), Vegetated wetlands (TF1)
- **Impacts and dependencies:** Impacts: eg., pollution, disturbance, introduction and spread of invasive species, and changes in hydrological flows. Dependencies: eg., raw materials such as metal, timber, soil, and plant material, with potential consequences in the upstream value chain.

Pilot timeframe

March – September 2023

Business summary

AECOM is a multinational infrastructure consulting firm. They deliver professional services throughout the infrastructure project lifecycle: from advisory, planning, design and engineering, to programme construction and management. Projects span across sub-sectors, including transport, water, buildings and energy.

Key finding(s)

- AECOM's broad portfolios of infrastructure projects means that efficient resource allocation requires prioritisation towards impact and risk mitigation strategies.
- The data inputs used for the prioritisation process have a strong influence on the outcome, and some nature-related impacts and dependencies can be affected by positive or negative feedback loops.
- Supply chain activities are also an important consideration when assessing nature-related risks, as raw material sourcing can have significant upstream impacts.
- Overall, water and terrestrial ecosystem use were found as highly material impacts across infrastructure projects, presenting a strategic opportunity to mainstream nature-based solutions into project design and construction.

About this case study: This case study forms part of a series of six TNFD pilots run as part of Global Canopy's TNFD piloting program. The pilots tested the v0.4 beta TNFD recommendations and its accompanying 'LEAP' (Locate, Evaluate, Assess, Prepare) approach. Due to slight variations in the structure between v0.4 and the final recommendations, specific components of the LEAP approach have not been referenced in this case study. A comprehensive glossary is provided at the end of the document.

Business case

Infrastructure development and expansion is recognised as a significant driver of biodiversity loss. For example, transport infrastructure such as road and rail developments can catalyse deforestation by linking new deforestation frontiers to processing facilities and trade hubs. Noting that 95% of deforestation in the Brazilian Amazon is found within 5km of a road. The infrastructure sector also contributes to approximately 79% of global greenhouse emissions, particularly through energy infrastructure, buildings and transport (UNOPS, 2021).

Nature-related impacts and dependencies differ at different phases of an infrastructure project's life cycle. For example, during the construction and operation phase there may be pollution (of air, water and direct deposition on vegetation), disturbance (from movement noise and lights), introduction and spread of invasive species, and changes in hydrological flows. Infrastructure projects also require significant inputs of raw materials such as metal, timber, soil and plant material, with potential consequences in the upstream value chain. However, at the same time, project design can facilitate nature-related opportunities, such as habitat restoration.

Nature-related risks for the infrastructure sector

These nature-related impacts and dependencies can also generate nature-related risks. These typically include:

- **Physical:** Raw material production is vulnerable to shocks from climate, invasive species, and disease. Landscaping, drainage and failed mitigation actions can also reduce ecosystem service provision and cause design failure.
- **Transition:** A changing regulatory landscape for nature in infrastructure projects can adversely affect planning, construction and operations. The infrastructure sector needs to stay ahead of the curve in implementing nature-based solutions, sustainable materials and sustainable technologies in project design and development. Changes in subsidy structure, including in the agriculture sector, can influence the price of land. Biodiversity and carbon credits are likely to be highly relevant, especially over the development cycle of large infrastructure schemes.
- **Reputational:** Infrastructure developers are increasingly held accountable for damage to ecosystems, particularly where there are consequences for local communities.

A clearer understanding of the impacts and dependencies on nature across AECOM's infrastructure portfolio provides opportunities to mitigate joint climate and nature impacts and begin to shift towards nature positive infrastructure development. From AECOM's perspective, this process has the potential to positively alter existing protocols, procedures and assessments, such as Environmental Impact Assessments, by encouraging stakeholders to look at impacts from a more holistic perspective, moving away from siloed environmental workstreams. The TNFD process may also encourage impact assessments to look further afield, ensuring development projects consider more indirect landscape-scale issues, particularly by analysing high-level datasets at the pre-design, pre-construction and project initiation stages.

Furthermore, whilst processes are in place, across many global infrastructure development projects to assess procurement and sustainability issues across value chains, applying the TNFD LEAP approach to these projects will see, for the first time, development projects more robustly consider their nature-related impacts.

Implementation process

AECOM participated in the TNFD pilot with NbI as part of the expansion of their sustainability provisions beyond climate and carbon-focused reporting, including the TCFD, to include nature considerations and TNFD disclosures.

The internal pilot team was made up of AECOM's Global ESG Advisor for Nature and AECOM Asia's Nature Lead. Both team members have experience and expertise in advising infrastructure clients on their nature-related impacts, particularly through the Environmental Impact Assessment (EIA) process. AECOM has a wider team of 800 biodiversity specialists and 300 carbon ESG advisors.

Identifying infrastructure projects to be considered within the pilot study required engagement across AECOM Asia's environmental and design teams. In selected cases, AECOM engaged directly with the infrastructure client to obtain support for the pilot and gather project data. Consent to use project data, and limited access to supply chain data, were key challenges during the client engagement process.

AECOM worked with NbI to ensure the analysis during the pilot met AECOM's strategic objectives in furthering expertise and experience in applying the TNFD LEAP approach to help projects become nature positive, and to build their own internal capacity for technical risk assessment.

Analysis

Part 1: Determining sensitive locations

AECOM identified a portfolio of projects within key jurisdictions for their business activities across South, South-East and East Asia. Due to client engagement and confidentiality issues exact project location is not disclosed, and rather the sub-national districts (administrative level 2) in which the project resided. This approach is conservative, as it takes into account a broader landscape context that encompasses nature-related values extending beyond the specific project location, potentially affected by or influencing project implementation. Projects varied in geographical scope, from the construction of recreational areas within urban city centres to establishing power transmission lines across multiple districts within a single country. In several instances, the project crossed national boundaries (e.g., rail line connections between Malaysia and Singapore). The projects were located across nine Asian countries plus the Hong Kong Special Administrative Area and covered 65 districts. These districts were then taken forward for a more detailed analysis.

For each project, the impacted districts were merged into a single 'project landscape'. Where the project landscape included coastline, the project boundary was extended 20km from the coastline to capture coastal marine natural assets potentially being impacted. Although available tools for analysing marine impacts are limited compared to the land realm, coastal marine ecosystems deliver many ecosystem services including carbon sequestration, fishery production, coastal protection, recreation and intangible cultural services. A small number of datasets used here are representative of marine natural assets/risks, but a discussion of other potential data that could be used in the future is also provided below (see below).

Tools: R Programming; Microsoft Excel **Datasets:** Natural Earth shapefiles for administrative boundaries **Outputs:** Multiple project landscapes, of varying scale, in GIS shapefile format.

Part 2: Scoring and ranking impacts, risks, dependencies and opportunities

For each project landscape, we mapped and summarised multiple nature-related variables (datasets) grouped into eight categories aligned with the TNFD guidance:

- Biodiversity importance
- Ecological integrity
- Ecosystem extent
- Ecosystem change
- Physical risk
- Water stress
- Reputational risk
- Dependencies and impacts on nature

In Table 1 we provide a summary of the variables grouped according to each of the eight categories and linking to nature-related impacts, dependencies, risks and opportunities. A brief description of the datasets and the rationale is also provided.

Note that the selected variables reflect the potential risk of having impacts on nature or disrupting key ecosystem services, as well as the external risk posed by the physical environment; each project's footprint could not be assessed in this case study due to limitations in data sharing from external clients.

It is also important to note that risks can be bidirectional, where a project can exacerbate existing risk and/or be exposed to external risk. For example, water availability and quality are key dependencies for agriculture, so water stress represents an external risk. On the other hand, infrastructure builds are less dependent on water however they may contribute to water depletion. Coastal infrastructure may not directly impact mangrove ecosystems but depend upon the flood and erosion protection afforded by these ecosystems. The interactions between the project and nature need to be considered for each context.

Table 1. Summary of variables grouped according to the eight categories and linked to nature-related impacts, dependencies, risks and opportunities. A short description of each data set is also provided.

Variables (Datasets)	Impacts	Dependencies	Risks	Opportunities	Description
Biodiversity Importance					
Critical natural habitats (CNH)	●				CNH in the terrestrial (Brauneder et al. 2018) and marine (Martin et al. 2015) realms following the definitions of the International Finance Corporation's Performance Standard 6. Includes internationally and nationally recognised important biodiversity areas, the presence of threatened species and rare/unique ecosystems or those associated with key evolutionary processes (not shown)
Rarity-weighted species richness	●				An aggregate indicator representing an area's species richness and the endemism of its constituent species.
STAR metric				●	A spatially explicit data layer highlighting areas where investments in threat mitigation or restoration can reduce extinction risk (Mair et al. 2021). Available via subscription to the Integrated Biodiversity Assessment Tool (IBAT), a partnership of IUCN, BirdLife International, Conservation International, and UNEP-WCMC. This layer also represents nature-related opportunities
Ecological Integrity					
Forest landscape integrity index	●	●			A composite metric used to look at overall forest integrity (Grantham et al. 2020).
River fragmentation	●			●	Uses Connectivity Status Index to measure the current state of connectivity at a river reach scale considering five pressure factors representing the main human interferences within the four dimensions of fluvial or river connectivity (Grill et al. 2019).
Invasive species				●	Datasets published by the Invasive Species Specialist Group ISSG and GBIF occurrence data to assess risk in terms of promoting invasive species spread in the project area (Ries & Pagad, 2020)
Ecosystem extent					
Terrestrial habitat types	●	●			Extent natural or semi-natural ecosystems affects the probability that a project will impact them. We used a composite map of terrestrial habitat types (Jung et al. 2020) to assess the extent forests, grasslands, savannahs, wetlands and shrublands complemented with mangrove extent (Bunting et al. 2022)
Global mangrove extent	●	●			
Ecosystem Change					
Forest Loss Rate	●		●		Historical forest loss between 2000 and 2020 using the Global Forest Change dataset. (Hansen et al. 2013)
Changes in Mean species abundance	●				Historical forest loss between 2000 and 2020 using the Global Forest Change dataset (Hansen et al. 2013). Historical (1900-2015) and projected (2015-2050) change in mean species abundance (MSA) using the GLOBIO 4 model (Schipper et al. 2020)
Physical risk					
Flood risk (riverine)			●	●	
Flood risk (coastal)			●	●	
Drought risk			●	●	Physical risk focuses on natural disasters and uses multiple layers from the World Resources Institute's (www.wri.org) Aqueduct tool (floods and droughts) and the World Bank Data Catalog (wildfires, landslides and cyclones)
Landslide risk			●	●	
Cyclone risk			●		
Global wildfire hazard			●	●	

Variables (Datasets)	Impacts	Dependencies	Risks	Opportunities	Description
Water stress					
Baseline water stress	●			●	
Baseline water depletion	●			●	
Seasonal water availability			●		Data layers from Aqueduct tool (www.wri.org) 'physical risks - quantity' category reflecting water availability
Interannual water availability			●		
Reputational Risk					
Reputational risk			●		Overall ESG Reputational Risk from RepRisk data science company assessed through Aqueduct tool (www.wri.org)
Dependencies and impacts on nature					
Critical natural assets		●			Extent of critical natural assets (Chaplin-Kramer et al. 2022). These are natural or semi-natural ecosystems that provide one or more of the twelve ecosystem services termed nature's contribution to people.

For each variable, project landscapes were categorised into the top (3), middle (2) or bottom (1) third across the portfolio of projects. We scored the eight categories for each landscape by summing the values of the constituent variables and assigned nominal numeric scores (High = 3; Medium = 2; Low = 1; Box 1 for details). We used the same approach to rate each of the four categories of nature-related issues (impacts, risks, dependencies and opportunities). Table 2 shows an example of project scoring for 10 out of the 87 assessed projects.

Box 1: Details on the scoring method considering three generic projects and two categories (Biodiversity importance and Ecological integrity)

In each of the two categories, nature-related variables were assessed and assigned scores of top (3), middle (2), or bottom (1) thirds based on the raw values observed across the entire portfolio of projects. This means that when a raw value of a given variable falls in the top third, it will contribute significantly (●) to the overall score of that category. Conversely, when it falls in the bottom third, it will have a lower contribution (●) to the overall score of that category. For all variables, a higher raw value corresponds to a greater contribution, with the sole exception being river fragmentation. The underlying assumption is that if river fragmentation is already high, the project is less likely to increase it. In this case, a high raw value results in a lower score (●) while a low raw value receives a higher score (●).

Biodiversity Importance	CNH		STAR$_{TA}$		STAR$_{R}$		RWR		Total Score
	Raw	Score	Raw	Score	Raw	Value	Raw	Score	
Project 1	0.75	3	8.50	3	0.98	2	0.12	2	10
Project 2	0.08	1	0.00	1	0.04	1	0.27	3	6
Project 3	0.35	2	1.05	2	32.30	3	0.01	1	8

Ecological Integrity	FLII		River Fragmentation		MSA (2015)		Invasive species		Total Score
	Raw	Score	Raw	Score	Raw	Value	Raw	Score	
Project 1	0.00	1	0.70	1	0.58	2	0.00	1	5
Project 2	0.03	2	0.00	3	0.30	1	0.01	2	8
Project 3	0.12	3	0.48	2	0.76	3	32.87	3	11

High ● Medium ● and Low ● contribution to the category overall score

For illustration, taking CNH (Biodiversity Importance) as an example. Higher raw values in Project 1 result in a score of 3 (●), meaning a substantial contribution to the total score in the Biodiversity Importance category. Conversely, lower raw values in Project 2 yield a score of 1 (●), indicating a lesser contribution to the total score in the Biodiversity Importance category. As previously explained, it is worth noting that higher raw values in River Fragmentation result in a score of 1 (●), while low raw values score 3 (●), representing, respectively, low and high contributions to the total score of Ecological Integrity category.

Undertaking this approach, using this manner retrospectively, against undergoing or complete development projects enabled for a type of analysis that is not typically undertaken for large scale development projects. For example, if a project comes forward, typically an EIA is undertaken assessing the environment at the granular detail, and very rarely looks at landscape scale issues in a holistic way. In addition, unless for a masterplan or unique strategic assessment, concepts like water stress or physical risk are rarely assessed. If applied early in the consideration of site selection, such an approach has the potential to lead to better results relating to 'avoidance' of the worst environmental impacts, something which is difficult to ensure, as typically a site is already selected by the time an EIA is undertaken.

Tools: R Programming; IBAT; Aqueduct

Datasets: Potential Critical Natural Habitat layers (Brauneder et al. 2018; Martin et al. 2015); forest landscape integrity index (Grantham et al. 2020); mapping the world's free-flowing rivers (Grill et al. 2019);Global Register of Invasive and Introduced Species (Ries & Pagad, 2020); global map of terrestrial habitat types (Jung et al. 2020); global map of mangrove extent (Bunting et al. 2020); forest cover timeseries (Hansen et al. 2013); GLOBIO 4 (Schipper et al. 2020); Aqueduct (Kuzma et al. 2023); World Bank Data Catalog; map of Critical Natural Assets (Chaplin-Kramer et al. 2022); STAR metric (Mair et al. 2021); Global Biodiversity Information Facility.

Outputs: Scores for nature-related impacts, risks, dependencies and opportunities for each project landscape.

Table 2. Example of scoring for 10 projects out of the 87 that were assessed. Scores are grouped into the eight categories aligned with TNFD guidance and into nature-related Impacts, Dependencies, Risks and Opportunities. Colours represent High ●, Medium ● and Low ● scoring.

Project	Biodiversity Importance	Ecological Integrity	Ecosystem Extent	Ecosystem Change	Physical Risk	Water Stress	Reputational Risk	Dependencies and impacts on nature	Impacts	Dependencies	Risks	Opportunities
Biodiversity Action Plan - Power Transmission Lines	Low	Low	Medium	High	Medium	High	High	Low	High	Low	High	Medium
East Coast Rail Link	Medium	High	High	High	Medium	Medium	Medium	High	High	High	High	Medium
EIA for Solar Power Park in Gujarat, India	Low	Medium	High	Medium	Medium	High	High	Low	Medium	Medium	High	Low
EIA for Floating PV Power Plant in Java	Medium	High	High	High	High	Low	High	High	High	High	High	High
EIS for Onshore Wind Development in Taiwan	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Malaysia and Singapore Infrastructure Project	Low	High	High	High	Low	Low	Medium	High	Medium	High	Medium	Medium
Tengah Environmental Baseline Study	Low	Medium	High	Medium	Low	Low	Medium	Low	High	High	Medium	Low
Environmental Social Impact Assessment for Proposed Waste to Energy Plant in Bac Ninh Province	Low	Low	Low	Low	High	High	High	Low	Low	Low	High	High
EMP of Technology Industrial Park in Taiwan	High	Low	Medium	Low	High	Medium	Low	High	Low	Medium	Medium	High
Environmental Baseline Study for Singapore	Medium	Medium	High	Medium	Low	Low	Medium	Low	High	High	Medium	Low

Part 3: Exploring interactions in underlying datasets

The processes and/or underlying characteristics of nature represented by the multiple dimensions here do not operate in isolation, and there may be synergistic or antagonistic interactions. This way, it is likely that project scoring might change when considering these interactions. Table 3 highlights some potential interactions, sourced from peer-reviewed scientific literature, which may either magnify or mitigate risk.

Table 3. Potential interactions between characteristics, sourced from peer-reviewed scientific literature which may either magnify or mitigate risk

Interaction	Potential interaction type	Justification	Source(s)
Forest landscape integrity index and invasive species	Antagonistic/subtractive - lower FLII values increase invasive species risk	The FLII includes edge effects resulting from forest fragmentation. Invasive species' abundances may be greater in forest edges and/or biological invasions more likely.	Grantham et al. (2020); With (2002); Laurance et al. (2007)
Extent of critical natural habitat/ critical natural asset and the extent of natural/semi-natural ecosystems	Proportional - ratio of CNH/CNA coverage to total ecosystem coverage	When the proportion of existing ecosystems that is classified as CNA or potential CNH, the risk of impacting CNA/CNH is higher. Note that the CNH layers are expressed as 'potential/likely' and the authors highlight the need to validate the classification on the ground.	n/a
River fragmentation and water stress	Synergistic/additive - river fragmentation impacts water supply downstream from the point of fragmentation	The hydrological model used in Aqueduct to calculate baseline water stress only accounts for upstream consumption and the presence of dams as pressures on downstream water availability. By contrast, Grill et al. (2019) account for five factors, including flow regulation, road construction and urbanisation. Therefore their analysis counts for distinct pressures on downstream water flow, which may be synergistic or additive with the pressures accounted for by Aqueduct.	Kuzma et al. (2023); Grill et al. (2019); Jumani et al. (2020)
Mangrove extent and coastal flood risk	Antagonistic/subtractive - greater mangrove extent reduces coastal flood risk	The underlying FLOPROS model used in Aqueduct does not account for the effect of mangroves on reducing coastal flood risk, but these ecosystems are increasingly seen as a sustainable way of mitigating the impacts of coastal floods. Note that absolute mangrove extent would need to be weighted by the maximum possible extent according to biophysical suitability of the coastal regions in the landscape. This may be facilitated by using historical mangrove extent.	Bunting et al. (2020); Kuzma et al. (2023); Scussolini et al. (2016); Gijsman et al. (2021)
Wetland extent and riverine flood risk	Antagonistic/subtractive - greater wetland extent reduces riverine flood risk	As above Note historical wetland extent data is more difficult to source.	Kuzma et al., (2023); Tootchi et al. (2018); Wu et al. (2023)
Drought and riverine flood risk	Synergistic/additive - drought periods can exacerbate the impacts of subsequent heavy rainfall	There is evidence that drought periods can increase the impacts of heavy rainfall by reducing soil moisture, although the interactions are complex and context-dependent (e.g. saturated soils can also increase flood risk).	Kuzma et al., (2023); Scussolini et al., (2016); Qiu et al. (2021)
Untreated connected wastewater and coastal eutrophication potential (Aqueduct; not included in this analysis)	Synergistic/additive - lower levels of wastewater treatment increases the likelihood of excess nutrients causing harmful algal blooms	There is evidence that the treatment of wastewater can help mitigate the risk of harmful algal blooms; conversely, a lack of treatment increases their probability. The underlying nutrient model used in Aqueduct accounts for discrete nutrient sources (i.e., wastewater treatment plants) but not the level of treatment.	Ulloa et al. (2017); Beusen et al. (2015); Kuzma et al. (2023)

Incorporating these interactions into the present case study is not straightforward and may vary in complexity. Some instances would require precise project location information (those including critical natural habitats and assets), while others necessitate an extensive bibliography review and expert consultation (e.g., assessing mangroves' potential in reducing coastline flood risk).

As an illustrative example of how interactions may affect project ranking, we considered how invasiveness potential could be influenced by ecosystem integrity. While the FLII does not explicitly address the impact of invasive species, it recognises that this impact is likely greater in areas with higher human pressures and, consequently, lower integrity (Grantham et al., 2020). Our assumption is that among projects with the same invasive species score, the risk for forest landscapes will be higher in those with lower integrity. We acknowledge that this assumption is open to debate and should therefore be viewed solely as an illustrative example.

The use of data in relation to some interactions (e.g., invasive species) is dependent on how the data is interpreted in the context of the project. For example, high presence of invasive species within an area presents both an issue (i.e., development could cause spread and exacerbate the problem) and an opportunity (i.e., eradication could aid nature recovery). The interactions, once analysed, therefore aid enhanced decision-making, particularly when reconciled against the project context and aims. In addition to this, what constitutes an invasive species at different scales (e.g., local, national, international) can differ and is not always grounded in science nor reflects degraded impacts on biodiversity (i.e., poses cultural dilemmas or damage to physical infrastructure); therefore, local and national context is key for understanding how the data can be used more appropriately.

Based on the information provided above, out of the 26 projects with available data on invasive species, the scoring for 14 of them could potentially change. An example showing changes in score for four of these projects is shown in Table 4.

Table 4. Illustrative example using invasive species and FLII score showing how interactions between these datasets can potentially contribute to changes in project scoring. Colours represent High ● Medium ● and Low ● scoring.

Project	Invasive species score	FLII score	Invasive species * FLII
EIA for Solar Power Park in Gujarat, India	Low	High	Medium
Malaysia-Singapore Infrastructure Project	Medium	Low	Low
Tengah Environmental Baseline Study	Medium	High	High
Environmental Impact Study in Northern Singapore	High	Medium	Medium

Tools: R Programming; Microsoft Excel **Datasets:** forest landscape integrity index (Grantham et al. 2020); Global Register of Invasive and Introduced Species (Ries & Pagad, 2020) **Outputs:** Score changes for interacting variables/datasets.

Part 4: Mapping project and supply chain activities using ENCORE

Tools: Life-cycle analysis; ENCORE; SBTN Sector Materiality Tool.

In line with the requirements of the LEAP approach and to provide a fuller picture of nature-related risks and dependencies from within the project's sphere of influence, an analysis of the supply chain materials and processes used in the construction of infrastructure projects was undertaken.

To provide this high-level assessment of the key ecosystem services and natural capital assets that infrastructure projects depend on and impact, projects were categorised by infrastructure type (roads, buildings etc.) and compared to Global Industry Classification Standard (GICs) codes which are used in ENCORE[1] at sector, sub-industry, and production process level. The most frequently occurring GICs project types were infrastructure builds, highways and rail tracks and homebuilding.

1 ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure) is a free, online tool that helps organisations explore their exposure to nature-related risk and take the first steps to understand their dependencies and impacts on nature.

Subsequently, a brief literature search of life-cycle analysis studies[2] was undertaken to identify related production processes for each of these three high level GICs codes, which resulted in twelve further production processes to analyse in ENCORE.

Ten key materials that are often used in the fifteen production processes are classified as High Impact Commodities according to Science Based Targets for Nature (SBTN). These included: Cement, Coal, Copper, Iron, Oil (crude) Petroleum, Sand (Construction grade), Timber/roundwood, Bauxite/Aluminium, Gasoline and Steel.

It should also be noted that the Biodiversity Module relating to the mining sector in ENCORE was also investigated in terms of potential opportunities to reduce nature-related risks from a procurement perspective.

Outputs

Most impactful production processes
The most impactful production processes were identified by a simple count of their materiality scores. Of the fifteen production processes analysed, the most impactful were those at the raw material supply stage of the life cycle[3] and included: Oil & gas drilling, followed by Coal & consumable fuel mining, then Diversified metals and mining and Aluminium mining.

Impact drivers

The most material impact drivers[4] for all fifteen production processes analysed in ENCORE was water use (in terms of volume of groundwater consumed, volume of surface water consumed etc., by the production process). This was followed by terrestrial ecosystem use (e.g., area of land/habitat modification), and then greenhouse gas emissions (e.g., volume of carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), etc. as a non-product outputs of the production processes).

2 Focusing mostly on the Product stage (A1 Raw Materials Supply, A2 Transport, A3 Manufacturing), or 'Cradle to Gate' of the infrastructure life cycle, corresponding to tiers 2 and 3 of the upstream value chain

3 As defined in ISO 21930:2017(en) Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services

4 ENCORE defines impact drivers as: a measurable quantity of a natural resource that is used as an input to production or a measurable non-product output of business activity.

Key Dependencies - Ecosystem services and natural capital assets

ENCORE identified the infrastructure production processes analysed as being highly dependent upon the following ecosystem services and natural capital assets:

- Water flow maintenance - The hydrological cycle, also called water cycle, which is responsible for recharge of groundwater sources (i.e. aquifers) and maintenance of surface water flows. Water is abstracted for use in all the production processes identified and is a key input to raw materials extraction and processing. This ecosystem service is critical and irreplaceable in many of the production processes identified. Water flow maintenance is underpinned by the following natural capital assets: **atmosphere, habitats and water**.
- Climate regulation - provided by nature through the long-term storage of carbon dioxide in soils, vegetable biomass, and the oceans. At a regional level, the climate is regulated by ocean currents and winds while, at local and micro-levels, vegetation can modify temperatures, humidity, and wind speeds. Underpinned by the following natural capital assets: **atmosphere, habitats, soils and sediments and species**.
- Mass stabilisation and erosion control - which is delivered through vegetation cover, protecting and stabilising terrestrial, coastal and marine ecosystems, coastal wetlands and dunes. Vegetation on slopes also prevents avalanches and landslides, and mangroves, seagrass and macroalgae provide erosion protection of coasts and sediments. The natural capital assets underpinning this ecosystem service includes **habitats, land geomorphology, and soils and sediments**.

Opportunities and Conclusions

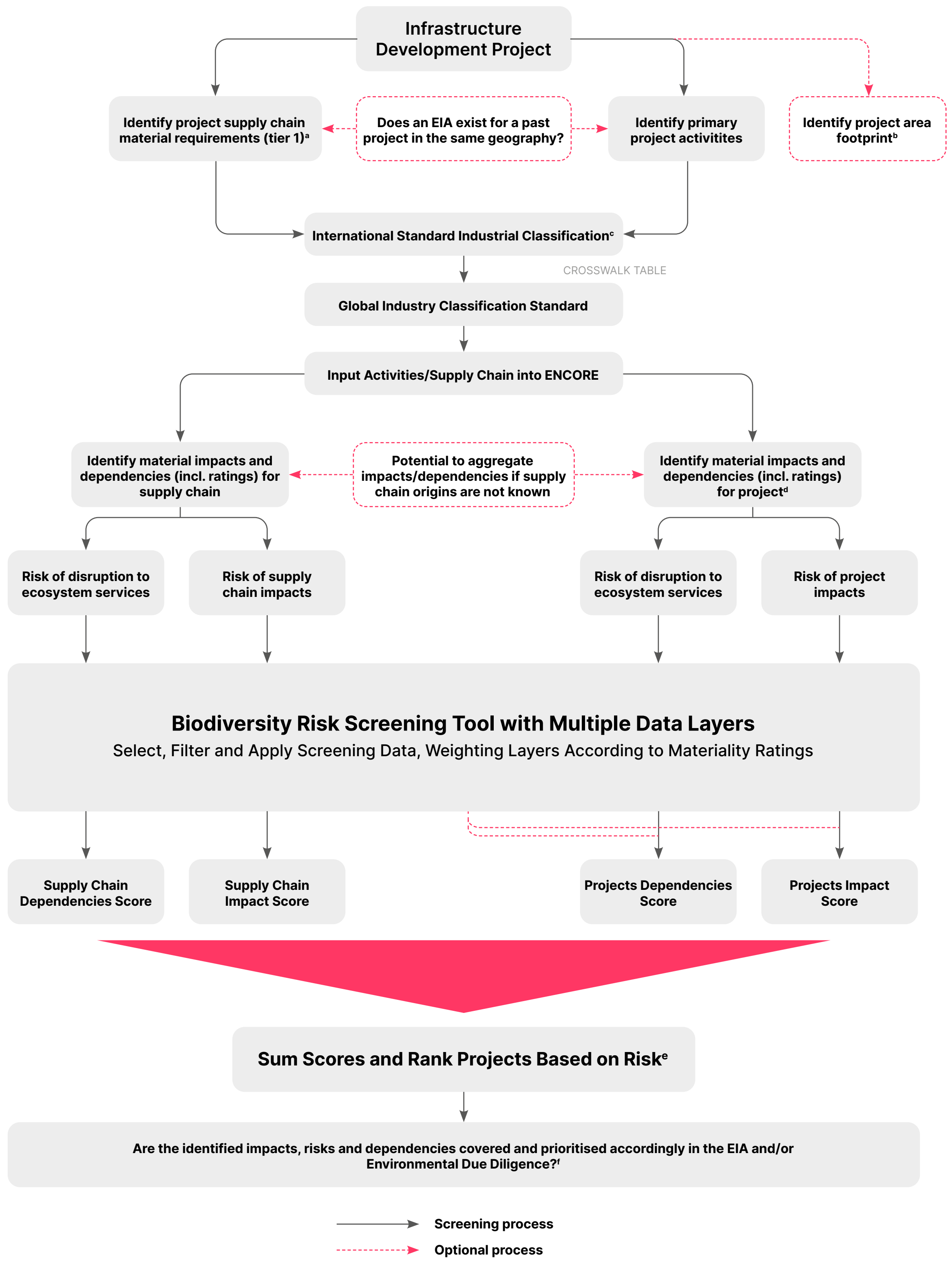
The upstream value chains of Infrastructure projects are highly dependent on the extractive industries, in particular the mining of iron, aluminium, sand, stone and other raw materials. ENCORE's Biodiversity Module (regarding the mining sector) can be used by procurement teams working on infrastructure projects to identify improvement opportunities with supply chain partners in specific eco-regions. In this case study, the tool highlighted the specific geographical regions that Infrastructure procurement teams could focus on with supply chain partners to reduce their nature-related impacts and risks (in terms of both the STAR metric and ecological integrity risk), as well as highlighting specific questions that supplier assessments could consider in order to better address nature and climate risks.

Incorporating nature-related assessments of materials used and upstream production process into project screening could present many opportunities to reduce wider nature-related impacts and risks. Ensuring decision-makers consider the nature-related impacts and dependencies of different project solutions at alternatives evaluation stage, and incorporating green and blue infrastructure and nature-based solutions at project design are two opportunities that can lead to transformative action. Additionally, working to support supply chain partners to align their operations to reduce impacts on nature will help shift the whole sector towards meeting global biodiversity and climate goals.

Part 5: An example framework for nature-related assessments in the infrastructure sector

As a result of the analysis and learnings in this case study, we have produced a theoretical framework that brings together the different workstreams undertaken (Figure 1). This framework can serve as guidance for infrastructure companies seeking to integrate multiple tools alongside primary project information, to tailor high-level assessments to both their geographical context and relevant activities. While these comparatively coarse tools cannot serve as a replacement for project-specific Environmental Impact Assessments often required for infrastructure builds, this might serve to highlight gaps in EIA regulation imposed by national bodies with regards to nature-related risk and/or inform risk prioritisation within EIAs.

Figure 1. A theoretical framework for how to integrate multiple tools and data sources to identify and evaluate potential project impacts on nature and the physical risks present in the project area.



[a]Identifying the main materials required for construction (e.g., sand, steel, rubber) helps understand upstream project impacts. Sourcing origins help further define potential impacts based on geographical location. If not available, aggregate upstream impacts using project location biodiversity features.

[b]Where possible, although this depends on the maturity of the project development.

[c]ISIC is used in the first instance as the higher granularity in activity classifications supports categorisation.

[d]The potential for impacts is equivalent to the reputational risk of causing such impacts.

[e]i.e. summarising scores within categories (impacts, dependencies, risks). A separate risk score category may be created for physical risks not directly linked to impact (i.e., exacerbating physical risk) or dependencies (i.e., risks not linked to the disruption of ecosystem services).

[f]This might include threatened/invasive species not assessed, water abstraction in a water stressed region, fragmentation of aquatic ecosystems with no mitigation strategy etc.

The process suggests that life cycle analyses, historical EIAs, or literature can be used to identify the key activities and required materials (Tier 1 supply chain). These activities can then be classified according to ISIC, and then GICS, after which ENCORE can be used to identify material nature-related impacts and dependencies. Identified impacts and dependencies can then be used to select relevant nature-related risk datasets, which can be weighted according to ENCORE materiality ratings. Finally, projects are then scored using these datasets, with scores normalised to account for potential differences in the number of underlying data layers, and normalised scores ranked to identify high and low risk projects. These scores can support the design of robust EIAs and/or due diligence assessments.

For example, such a process may reveal that a specific impact or dependency is not typically well covered in EIAs in the local jurisdiction, this can prompt discussions between infrastructure developers and environmental professionals, leading to the potential inclusion of additional assessments well in advance of the project's design phase. Such information can also help with project screening in terms of site location, noting that it may identify additional measures that new developments should incorporate to ensure biodiversity net gain in the area. Alternatively, assessments that cover these, may already be being done, but in silos. The TNFD guidance thus serves as a catalyst to ensure collaborative working. These complementary processes are useful, as the ability to influence nature related outcomes becomes more challenging beyond design phase, as such key environmental impacts and nature-related risks and opportunities may be insufficiently addressed.

Part 6: Testing the analysis against a key project in Singapore

The pilot project has provided AECOM with an opportunity to engage closely with the TNFD framework and particularly the LEAP approach, **developing our understanding and our confidence**. Exploring the various datasets and metrics that can be used to express the impacts of the infrastructure sector – and which are aligned with TNFD guidance - was interesting and valuable, and the engagement with tools, such as ENCORE, provided an additional opportunity to deepen our understanding.

Comparing this approach to the EIA approaches that AECOM typically undertakes in different regions of the world has been invaluable. Whilst current EIA approaches differ according to geography, at a minimum, most projects will follow IFC Performance Standards, so whilst many of the impacts assessed (direct and indirect) are typically similar to what is described as part of the TNFD guidance. However, the TNFD LEAP approach highlights some additional consideratios, which would typically require project assessments to go one-step further, looking at concepts such as water scarcity, which is not always assessed as part of a typical EIA. On the other hand, nature-related dependencies are also not a typical consideration as part of the EIA process; the TNFD is therefore likely to provide a more holistic, wide-ranging assessment compared with the standard EIA and has the potential to cause the EIA process to evolve over time.

Exploring how the **LEAP approach can be applied to projects** has been interesting – the focus is typically on applying the approach to organisations at a corporate level. The impacts of infrastructure projects on nature and biodiversity are explored using environmental impact assessment methodologies, which have been a statutory requirement of the planning and consenting stages of infrastructure projects in most jurisdictions for many years. The pilot has resulted in insight into how the approach advocated by TNFD (and potentially SBTN) could – and perhaps should - influence environmental impact assessment in the future. AECOM plans to explore this further, in its role as a thought leader in the environmental assessment of infrastructure projects and programmes.

AECOM's corporate sustainability clients are also focused in sectors outside the infrastructure sector and it has been valuable having the opportunity to explore the **nature-related dependencies of the infrastructure sector, primarily through its supply chain.**

Conclusion

Prioritisation of projects across broad portfolios is important for efficient resource allocation toward impact and risk mitigation strategies, and may inform the design of more granular Environmental Impact Analyses. Providing project level nature-related risks and dependencies analysis to decision makers at the 'alternatives evaluation' phases of infrastructure investment planning may improve decision-making at the siting and design stages of projects, which in turn will reduce cost and nature risk at the infrastructure design stage.

The selection of data used for prioritisation has a strong influence on the outcome, and the characteristics or processes represented by the different data layers can interact with each other synergistically or antagonistically. For example, biological invasions are more likely in fragmented, low integrity forests (Grantham et al., 2020). Conversely, large tracts of high integrity forests support resilience against riverine flood impacts. This highlights the need for screening protocols to account for these interdependencies within nature to understand how the risks and/or benefits associated with one characteristic of nature (e.g., forest integrity) propagate through the ecosystem.

By considering a diverse range of projects, we found the activities and supply chains associated with an infrastructure build are essential components of assessing risk. This allowed us to develop the screening protocol to reflect more than just geographical features. For example, shoreline restoration using dredged marine sediment or the construction of wind farms primarily risk impacting benthic marine ecosystems through seabed damage or increased turbidity. Conversely, the risks associated with power transmission line construction are more likely to be increased forest fragmentation, as well as the impacts from copper or aluminium mining required to produce the raw materials.

These differences need to be reflected in how projects are assessed for prioritisation to be most informative. The ENCORE tool and the ISIC/GICS classification systems can support the identification of core impacts and dependencies associated with a project's primary activities and the supply chain activities needed to produce the materials for the project. Further, the materiality rating can be used to weight data layers that represent the identified impacts and dependencies.

Applying elements of the TNFD LEAP process has highlighted the wider nature-related risks to infrastructure construction (aside from the large industry focus on carbon), and the sector's critical dependencies on ecosystem services and natural capital assets. Water and terrestrial ecosystem use are both highly impacted by the sector's activities, which they are also highly dependent upon. This presents many opportunities to the sector including:

- Re-aligning its strategic focus to include nature to the same extent as greenhouse gases,
- Working cross-industry to support supply chain partners to align with nature and climate targets,
- Ensuring decision-makers consider the nature-related impacts and dependencies of different project solutions when deciding on infrastructure solutions to community needs,
- The incorporation of green and blue infrastructure and nature-based solutions at project design, and
- Widening the breadth of traditional construction educational courses to include sustainable design and construction methods such as sustainable drainage systems as a standard part of the curriculum.

Glossary

Important Biodiversity Areas: Legally protected areas as defined by IUCN, areas proposed by governments that have not been designated yet, as well as 'internationally recognized areas' (IRAs). The latter include: UNESCO natural World Heritage sites, UNESCO Man and the Biosphere Reserves (MAB reserves), Key Biodiversity Areas (KBAs), and wetlands designated under the Convention on Wetlands of International Importance (i.e. Ramsar sites).

Threatened Species: Species classified as either critically endangered, endangered or vulnerable according to the IUCN

Rare/unique ecosystems: Follows the definition of the IUCN Red List of Ecosystems (RLE) which provides quantitative guidelines to assess the threatened status of ecosystems. Includes mangroves, saltmarshes, ever-wet tropical forests, tropical dry forest, and tropical montane cloud forest.

Key evolutionary processes: Physical or spatial landscape features promoting evolution (e.g. islands, mountains, ecotones), or groups of species with distinct evolutionary history.

Species richness: The number of species within a defined region.

Species endemism: Expressed as a percentage or the absolute number of taxa that are restricted to an area of interest.

Habitat fragmentation: A process by which large and contiguous habitats get divided into smaller, isolated patches of habitats.

Invasive species: Species known to negatively impact biodiversity, and including species that are widespread, spreading rapidly or present in high abundance.

Natural ecosystem: An ecosystem with intact processes and biodiversity

Semi-natural ecosystems: An ecosystem with most of its processes and biodiversity intact, though altered by human activity in strength or abundance relative to the natural state.

Synergistic interactions: When the combined scoring of two or more variables is greater than would be expected if the individual scores were added together.

Antagonistic interactions: When the combined scoring of two or more variables is less than would be expected if the individual scores were added together.

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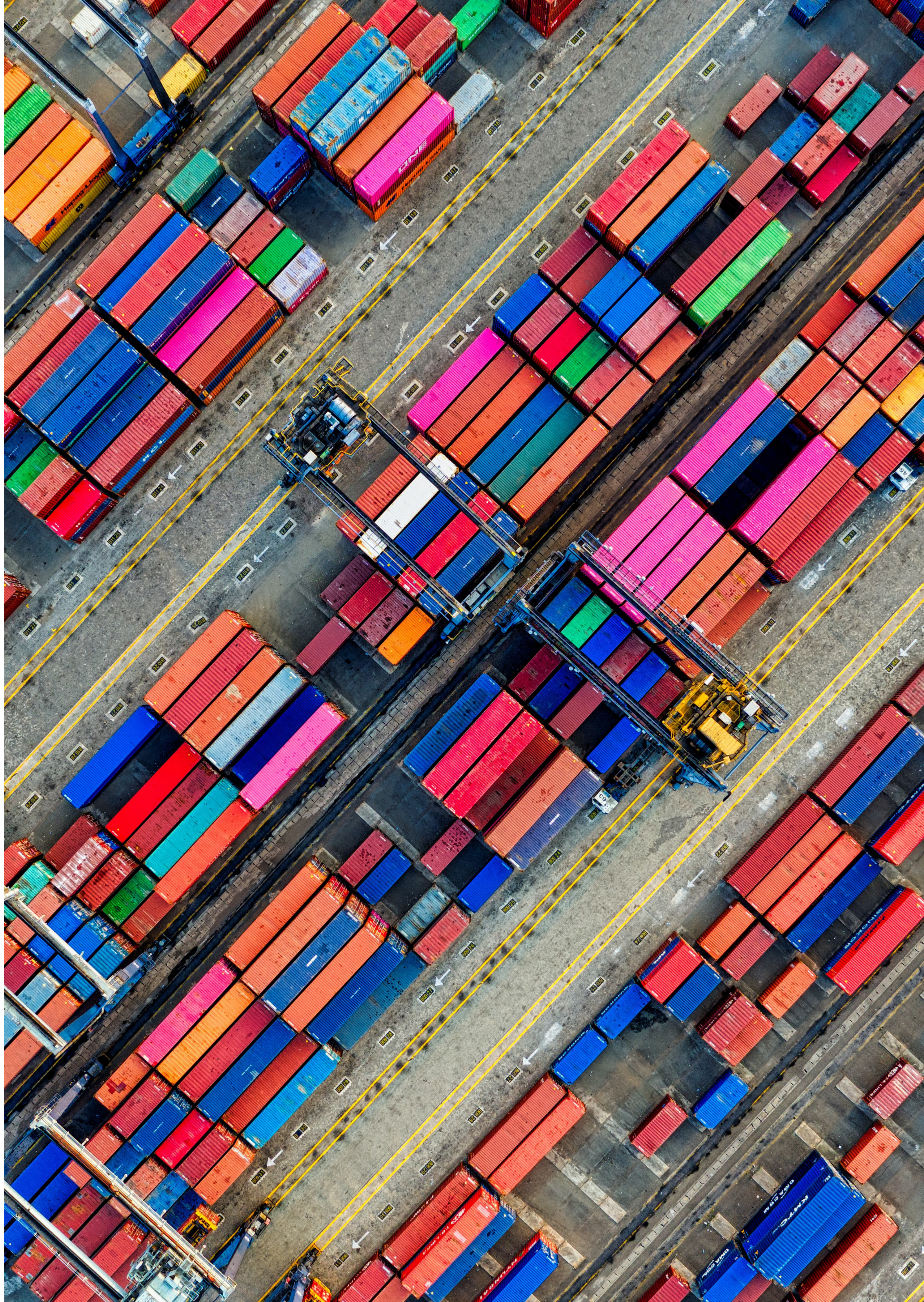

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