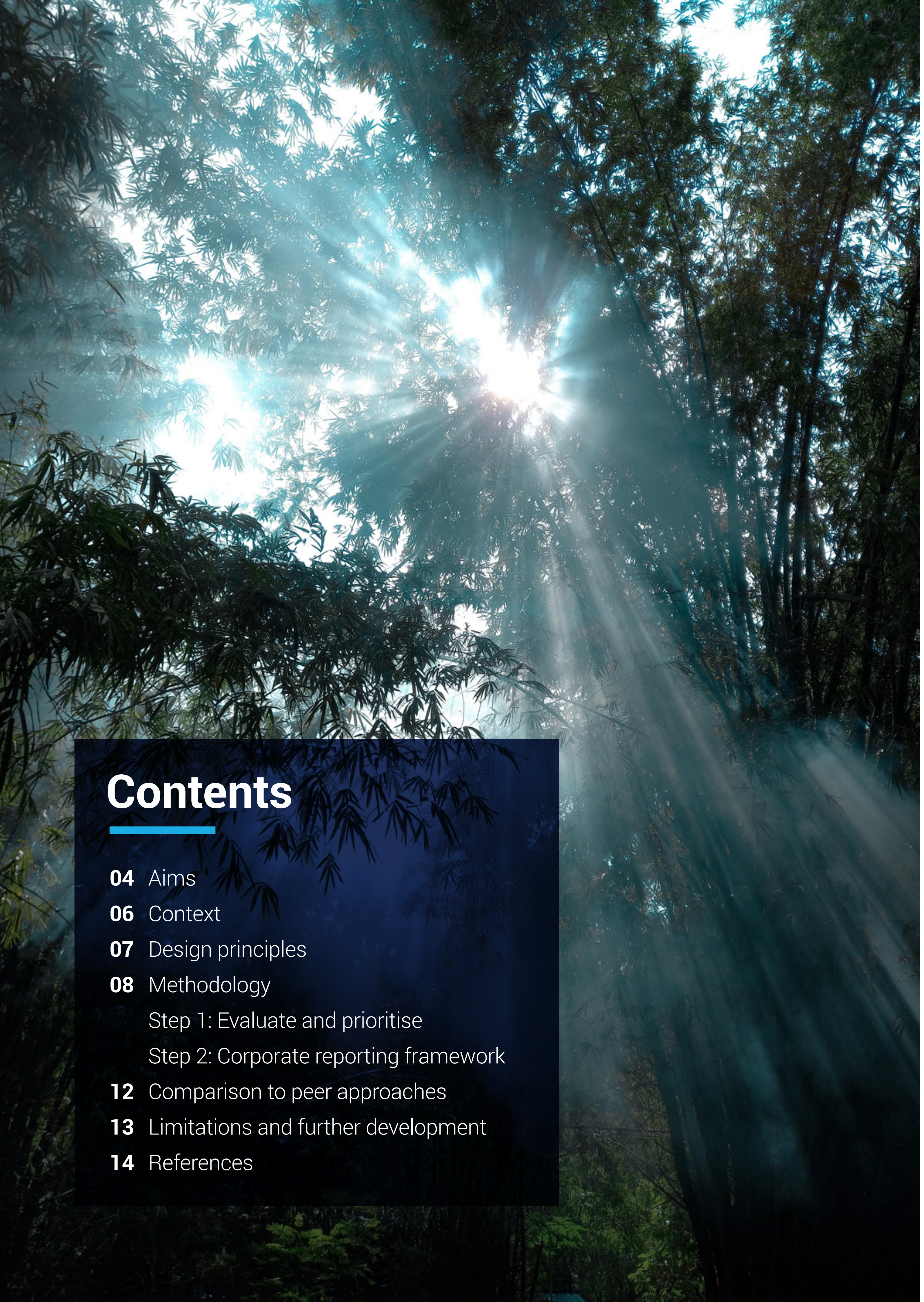
Biodiversity Footprint Indicator for Sites (BFIS)

THE BIODIVERSITY CONSULTANCY

TotalEnergies



Contents

Executive Summary

Land use for infrastructure is a major pressure on global biodiversity. This pressure is expected to intensify due to rising population, wealth, and energy demand. Global policy frameworks increasingly require businesses to report annually on material biodiversity impacts across their site portfolios and to demonstrate progress toward improved biodiversity outcomes at priority sites. Achieving this can be technically challenging, especially for companies that operate thousands of sites worldwide and lack the capacity for intensive biodiversity monitoring at each location.

Biodiversity Footprint Indicator for Sites (BFIS) is a standardised framework designed to evaluate, manage, monitor, and report biodiversity impacts across a company's site-based operations portfolio (Box 1, Figures 1-2). Developed to support businesses in meeting emerging policy expectations, BFIS guides users through a stepwise process to cost-effectively generate quantitative estimates of site-level impacts, to screen sites for biodiversity risks, and to validate these findings using site-level (primary) data. This enables users to prioritise and implement proportionate mitigation actions and monitoring efforts. BFIS also supports annual reporting of portfolio-level quantitative impacts and site-specific outcomes.

BFIS goes beyond generic impact and biodiversity risk screening. It can easily incorporate company data to enable more granular assessments that do not require specialised expertise or inordinate resourcing. It was designed to utilise existing datasets on how much different pressures impact biodiversity and on where important biodiversity is located. Where a necessary dataset was not available—e.g. for bird and bat collision risk at windfarms or spatially explicit marine extinction risk—BFIS has developed them and made them accessible to the public. It goes beyond impact and risk assessment and enables users to prioritise actions and monitoring. It does not replace Environmental Impact Assessments for new projects, but enables users to pragmatically and effectively screen, manage, and report on large portfolios of sites. The methodology, supporting expert-verified data, and software package are freely available to use.

The BFIS was co-developed through a collaboration between The Biodiversity Consultancy (TBC) and TotalEnergies and is jointly owned by both parties. This partnership has resulted in a standardised methodology for assessing biodiversity impacts across site-based operations, enabling scalable, portfolio-level reporting and prioritisation of mitigation actions.

What does the BFIS framework include?

- A methodology for assessing and reporting on site-level impacts of land use on biodiversity that can be aggregated at company level
- Supporting expert-verified data, including data layers on location-based opportunities to reduce marine species extinction risk and collision risks for birds and bats at windfarms
- A software package in R that enables non-specialist users to implement the methodology after appropriate training

THE BIODIVERSITY CONSULTANCY

TotalEnergies

Figure 1: Overview of BFIS steps

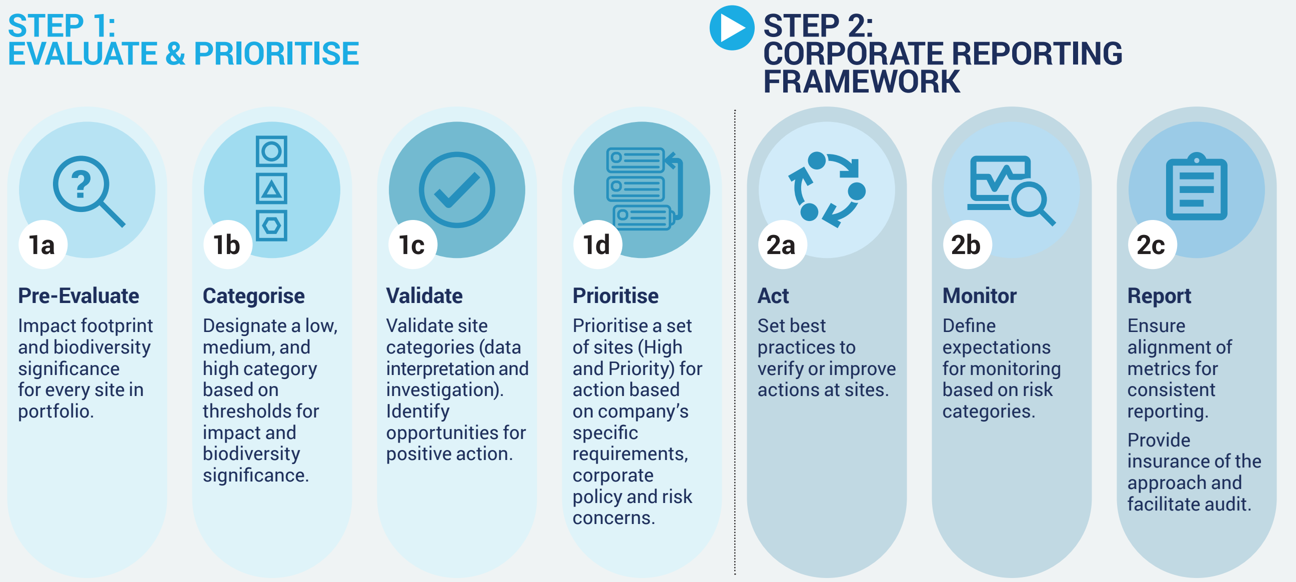
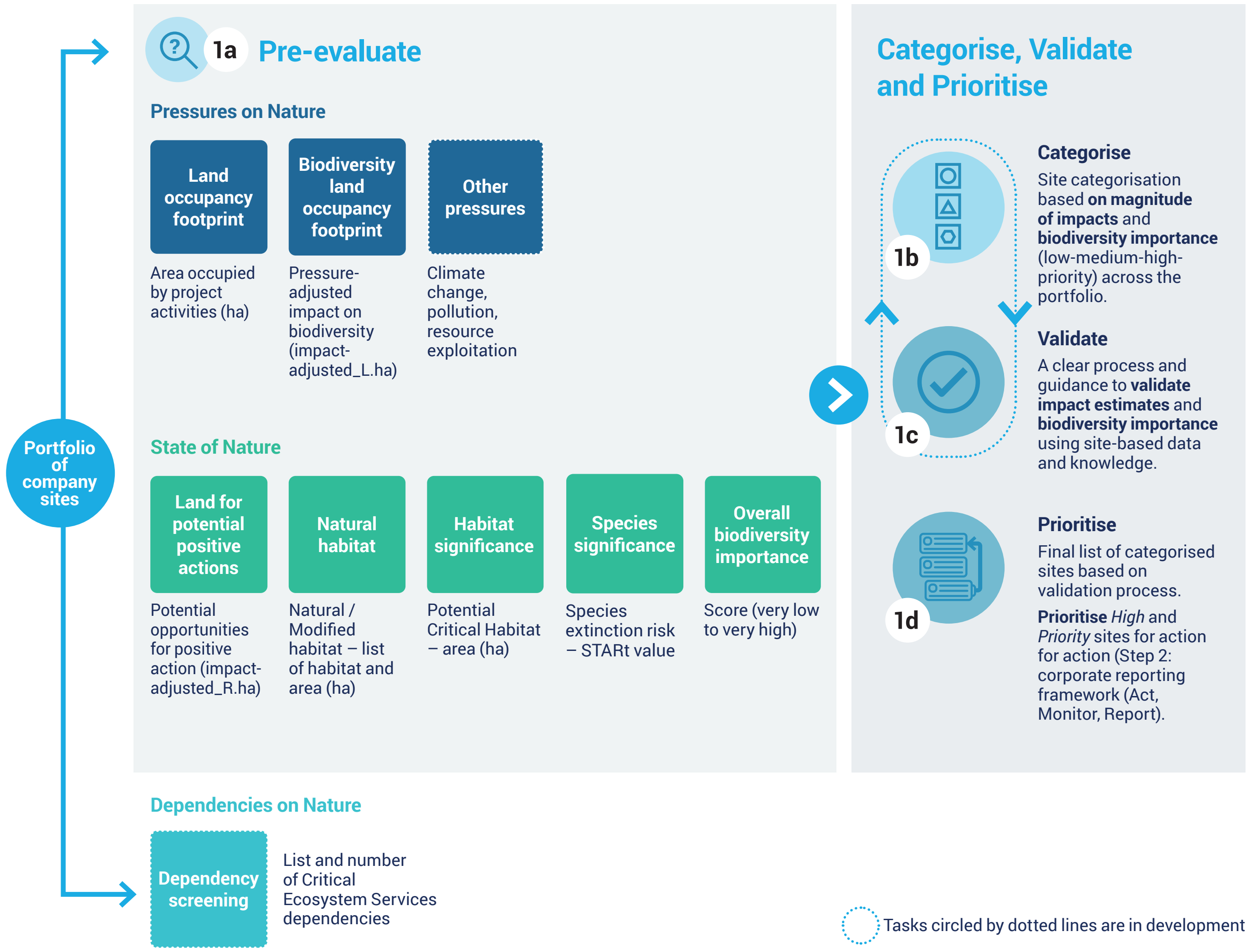


Figure 2: Output for BFIS step 1



Aims

This white paper answers the following questions:

- Why was BFIS developed?
- What challenges is BFIS designed to solve?
- What are the key design principles?
- How does it work?
- How does it compare with peer approaches?
- What are the known limitations?
- What is under further development?

Context

Human activities have transformed the surface of the Earth. Over half of the world's ice-free surface is used for crops, grazing, or urban areas (Ritchie & Roser 2019) and biotic intactness has declined past the safe limit (in a planetary boundaries context) on over 65% of the world's terrestrial surface (Newbold *et al*. 2016). The associated land-use change, climate change, overexploitation, pollution and the spread of invasive and alien species have significantly elevated the rate of species extinctions above the geological baseline rate (Barnosky *et al*. 2011; IPBES 2019; McElwee *et al*. 2024). Land-use change, which includes the ongoing occupancy of land for human activities as well as its transformation, is the largest overall driver of terrestrial biodiversity loss (Jaureguiberry *et al*. 2022).

While most of the land-use change pressure on biodiversity is associated with agriculture (Tilman *et al*. 2017), the rapid expansion in anthropogenic infrastructure is a rapidly accelerating threat to biodiversity (Laurance *et al*. 2015; Simkins *et al*. 2023). Drivers of infrastructure demand include urbanisation (nearly 70 million people move to cities every year), transport, minerals, and energy (Smil 2021). Infrastructure construction affects biodiversity not only at the site level, but also far beyond through transport and energy connections, each creating further land-use change and habitat fragmentation (Laurance et al. 2009; Sonter *et al*. 2017). The materials needed to build infrastructure must be unearthed from other locations. Mining of aggregates and metals to meet this demand creates site-based impacts in those areas, contributing to growing pressures on biodiversity (Torres *et al*. 2021; Giljum *et al*. 2025).

Energy demand is forecasted to increase 16-57% between 2022-2050 (EIA 2025). While decarbonisation of the world's energy supply to produce solar, wind, and hydro infrastructure will help mitigate climate change—the second largest pressure on biodiversity—it will also drive increased demand for minerals. This, in turn, introduces new pressures on biodiversity through resource extraction and associated land-use impacts (Sonter *et al*. 2020).

The need to manage the biodiversity impacts of human pressures on the environment, including those driven by the expansion of site-based infrastructure, has driven the development of global policy frameworks. The Kunming–Montreal Global Biodiversity Framework (GBF) sets out ambitious biodiversity goals. Parties to the Convention on Biological Diversity that have adopted the GBF have committed to achieving these goals, including increasing or maintaining the integrity, connectivity and resilience of natural ecosystems and halting the human-induced extinction of known threatened species. The GBF specifically outlines a role for businesses via Target 15, which includes a sub-target on monitoring, assessing and disclosing impacts on biodiversity across portfolios. These goals are echoed in a wide range of mandatory and voluntary frameworks for corporate sustainability including the Corporate Sustainability Reporting Directive (CSRD), the Taskforce on Nature-related Financial Disclosures (TNFD), the Global Reporting Initiative (GRI), and the Science Based Targets Network (SBTN).

This global context requires the developers and managers of sites to assess pressures on biodiversity, implement appropriate actions, monitor changes in pressures and biodiversity, and report on biodiversity pressures and outcomes. There is a long history of Environmental Impact Assessments, dating formally at least as far back as 1970 in the US following the National Environmental Protection Act (1971) and they are now legally mandated for many project types in many jurisdictions (Burdge 1991). Additionally, a large body of policy and best-practice guidance has been developed to guide impact assessment, biodiversity management plans (BMPs) and biodiversity action plans (BAPs) for high risk sites (IFC 2006; BBOP 2012). While businesses have long needed to assess the impacts and manage at sites, and already have risk screening tools to do high-level risk assessment (e.g., WWF Risk Filter), the new global policy context, requires businesses to:

- **Consistently report on and demonstrate material impacts across their portfolio;**
- **Demonstrate that appropriate actions and monitoring are in place to manage biodiversity risk, in line with legal requirements or higher ambitions; and,**
- **To report on progress annually.**

The BFIS framework was developed to meet this need.

Design principles

BFIS was designed with the following design principles in mind, to meet the needs of companies who need to rapidly but effectively identify potential risks in a portfolio of sites. It can also be used as a tool to support investment decision-making:

To consistently report on and demonstrate material impacts across a portfolio of site-based operations, a framework should:

- Be applicable anywhere in the world, across terrestrial, freshwater, and marine contexts to account for the global scope of many businesses' operational footprint
- Cover all relevant pressures on biodiversity
- Cover indirect as well as direct impacts (e.g. in-migration and resettlement)
- Include information on biodiversity significance
- Be cost-effective to run across a portfolio that may include thousands of sites
- Be feasible to run by non-experts (after some initial training and support with implementation)
- Be possible to validate with real-world data from sites to account for inaccuracies in any global datasets or models used
- Complement, but not replace, Environmental Impact Assessments (EIAs), as these assessments are usually legal requirements and cover all environment components

To enable businesses to demonstrate that appropriate actions and monitoring are in place to manage biodiversity risk, and meet legal requirements or higher ambitions, a framework should:

- Enable categorisation/classification by relative risks to allow strategic allocation of resources to sites where biodiversity monitoring and action plans are most likely to create significant positive outcomes for biodiversity
- Enable site-level gains and losses to be calculated

To enable businesses to report on their progress annually, a framework should:

- Act as a bridge between top-down corporate strategy and bottom-up site level management and monitoring
- Provide results that are can be aggregated across a portfolio to enable transparent disclosure and progress tracking

Method

This section provides an overview of how BFIS works, and how it meets the design criteria outlined above. For further details, consult the methodology report.

Step 1: Evaluate and prioritise

In Step 1a (pre-evaluate), sites are assessed based on the level of pressures–primarily land occupancy–and the state of nature, which includes habitat availability for positive actions, global significance of habitats, and global significance of species (see Table 1). In Step 1b (categorise), sites are categorised according to the magnitude of impact and potential biodiversity risk. These assessments rely on global databases and remotely sensed data (i.e., secondary data), which will be sufficient for many prioritisation and reporting use cases. However, some users may wish to validate the results using site-level insights and primary data in Step 1c (validate). Finally, Step 1d (prioritise) involves prioritising sites for action, as illustrated in Figures 1-2.

To ensure global applicability, the BFIS is structured around an Extent, Condition, and Significance framework. Impact assessment is based on both the area affected and the estimated biodiversity impact per hectare, resulting in an *impact-adjusted hectare* metric. This approach allows BFIS to be applied to any ecosystem worldwide and aligns with established environmental accounting practices, such as the Align framework, TNFD guidance on measuring changes to the state of nature, Biodiversity Net Gain methodologies, and the Verra Nature Framework for biodiversity credits.

To account for both direct and indirect impacts, the framework also includes those associated with site operations, such as transport infrastructure (e.g., access roads, pipelines, transmission lines) and population dynamics (e.g., resettlement and project-induced in-migration).

Table 1: Summary of pressure and state of nature indicators used in Step 1

	Indicator	Metric
Pressures on Nature	Overall land occupancy footprint (area impacted)	*ha*
	Overall biodiversity land occupancy footprint	*Impact-adjusted_L.ha* (where L=loss)
	Other pressures[1]	
State of Nature	Land for potential positive actions	*Impact-adjusted_R.ha* (where R= Retained)
	Natural Habitat (presence of NH/MH)	*Natural/Non-natural – area (ha) and percent of overall footprint*
	Habitat significance (potential presence of Critical Habitat)	*Potential/ unlikely*
	Species significance (species extinction risk)	*Sum of STAR threat abatement values*
	Overall biodiversity importance	*Score: Very Low – Low – Medium – High – Very High*
Dependencies on Nature	Dependencies[2]	

[1]The effects of other pressures are included via the impacts on biodiversity condition of certain activities; other pressures will be more explicitly included in future developments of the framework.
[2]Dependencies may be included in future developments of the framework.

To incorporate relative biodiversity significance into a scalable and universal impact assessment approach, it is essential to avoid the assumption that impacts across different regions are equally comparable in their potential to support ecosystem conservation and reduce species extinction risk. To address this, the BFIS integrates a range of State of Nature indicators that help assess relative risk to global biodiversity goals. These include the Species Threat Abatement and Restoration (STAR) metric (Mair et al. 2021) and internationally recognised areas (BirdLife International 2022; UNEP-WCMC 2024).

BFIS is designed to be **cost-effective and feasible** to scale up to large portfolios of sites while **covering all relevant pressures** that could be included. Estimates of extent and condition can be drawn from existing literature on biodiversity impacts. The BFIS therefore leverages the following sources to estimate impacts on ecological condition:

- Where available, from databases based on the literature, such as GLOBIO (Schipper *et al.* 2020)
- Where not included in a database, from a literature review or peer-reviewed study on the effects of certain pressures
- Where not available in the scientific literature, from grey literature and consultation with subject-matter experts

Using general patterns to estimate impacts allows for cost-effective screening to identify sites with higher potential risks, which can then be validated using site-specific (primary) data. A stepwise prioritisation process thus ensures that resource-intensive validation efforts are strategically focused on high-risk sites. Step 1c facilitates dialogue between the entity responsible for screening and site managers—who possess critical insights into site-level impacts—to validate and refine the results of Steps 1a and 1b. This collaborative process supports informed decision-making in Step 1d, helping to prioritise sites for action including identification of opportunities for conservation and restoration.

Biodiversity Action and Monitoring Plans require both technical expertise and financial investment. **To ensure resources are allocated effectively, a method for categorising sites by relative risk is needed**. These categorisations are also informed by company-specific biodiversity policies (e.g. No Net Loss), standards, and requirements (e.g. IFC PS6), particularly relating to high-priority biodiversity features. The Priority category enables companies to highlight sites that trigger criteria in addition to impact magnitude or the presence of important biodiversity features. For example, a company may want to flag sites that potentially affect World Heritage Sites, Alliance for Zero Extinction sites, and sites with complex stakeholder relationships and nature-based stakeholder risk. Step 1d offers a framework for this classification, enabling prioritisation of sites that have been validated with site-specific data. These sites should be targeted for higher levels of mitigation and monitoring efforts (see Table 2).

Step 2: Corporate reporting framework

Step 2 provides the opportunity to translate the desktop-based estimations and prioritisations from Step 1 into concrete actions and site-level monitoring. It ensures that the outcomes of these actions are incorporated into overall reporting. **This step enables the measurement and assessment of biodiversity losses—and potential gains—at individual sites**.

Step 1d provides a logical framework for applying varying levels of effort across sites, based on the significance of biodiversity features and the scale of potential impacts, as outlined in the Site Category (Table 2). At a minimum—and in line with best practice recommendations—all sites should adhere to general environmental good practices. In cases where significant impacts are identified (Medium, High, or Priority), the mitigation hierarchy should be applied. Furthermore, sites with biodiversity features of concern (High and Priority) should implement Biodiversity Action Plans to safeguard these features. This triaging framework enables users to identify and prioritise investment into on-the-ground actions for sites in different risk categories.

Both Step 1 and Step 2 **provide results that can be aggregated across a portfolio to enable transparent disclosure and progress tracking**. Step 1 enables estimated and validated impacts to be assessed, disclosed and reported annually. Step 2 builds on the previous stage by enabling the monitoring, assessment, and—where necessary—annual disclosure of site-level biodiversity losses and potential gains, based on measured site data. This allows businesses to evaluate and report on the effectiveness of the mitigation measures prioritised in Step 1.

Table 2: Expectations for action, monitoring, and reporting at different levels of biodiversity risk

Site category	Characterisation	Expectation in terms of mitigation measures	Expectation in terms of tracking performance and reporting
Low	• Low impact • No specific biodiversity features of concern	• General environmental good practice	• BFIS tool results sufficient • No ground monitoring specific to biodiversity requested
Medium	• Some impact on nature • No specific biodiversity features of concern	• General environmental good practice • Follow the mitigation hierarchy	• Measured data based on cost-efficient technologies (remote sensing for ecosystem + bioacoustics for species)
High	• Presence of specific biodiversity features of concern • High impact on nature	• General environmental good practice • Follow the mitigation hierarchy • Biodiversity specific mitigation measures	• Measured data based on cost-efficient technologies (remote sensing for ecosystem + bioacoustics for species) • Measured ground data for ecosystem
Priority	• Sites categorised as "High", but which have additional reputational risk, impacts to several important biodiversity features, or require specific standards	• Same as High but may aim to align with specific commitment	• Monitoring and evaluation plan • Same as High

Comparison to peer approaches

Table 3: Other approaches that are used in similar contexts to BFIS.

Note that tools which are suited to screening portfolios of sites are equally applicable to corporations, value-chain actors, investors, and financial institutions, although they might use the results in different ways tailored to their needs.

Framework	Organisation	What is this approach used for, and how does it differ from BFIS?
Portfolio screening tools		
Biodiversity Indicators for Site-Based Impacts (BISI)	UNEP-WCMC	Designed for portfolio screening but uses categorical scoring and is more focused on tracking responses.
Biodiversity Impact Assessment Framework (BIAF)	WWF CH, TBC	Used to compare the likely magnitude (also in an ecosystem x condition and significance framework) of different response options across a portfolio. Designed for Development Finance Institutions and other impact investors.
Biodiversity Indicator and Reporting System (BIRS)	Holcim, IUCN	Designed for site-based impact assessment for the mining sector, requires field sampling at all sites. Condition based on classes rather than scored 0-1.
Nature Risk Profile	S&P Global Sustainable 1	Designed for portfolio screening with S&P asset data, not for updating with site-based data.
LCA based tools		
Life Cycle Assessment (LCA, e.g. ReCiPe)	Various	Used to estimate the biodiversity impacts of a wide range of pressures across a portfolio, based on activities and commodities. These approaches do not require or use site-location data.
Global Biodiversity Score (GBS)	CDC Biodiversité	
Corporate Biodiversity Footprint (CBF)	Iceberg Data Labs	
Biodiversity accounting approaches		
Ramboll Biodiversity Metric	Ramboll	These are site-based gain and accounting frameworks, typically for biodiversity offsetting or crediting purposes. They were not designed for portfolio screening, but include some components that make them compatible for offsetting and crediting purposes (e.g. comparison to intact reference values and counterfactuals).
Nature Framework	Verra	
Biodiversity Net Gain	UK government	
Séquence Eviter, Réduire, Compenser (ERC)	French government	
Accounting for Nature (AfN) Econd metric	Accounting or Nature	
Nature Positive Initiative (NPI) state of nature metrics	Nature Positive Initiative	
Biodiversity Impact Credits (BIC)	QMU, BGCI	
Habitat Hectare Assessment	Australian government	
Natural Asset Recovery Investment Analytics (NARIA)	Credit Nature	
IUCN Nature Positive – measurement component	IUCN	
Guidance documents		
Rapid High-Integrity Nature-positive Outcomes (RHINO)	IUCN	These provide guidance on management actions that can be used to help implement Step 2 of BFIS.
IUCN guidance for the renewable sector	IUCN	

Limitations, constraints and further development

One of the key constraints of this approach is that it was developed to quantitatively assess the impacts of site operations in a way that allows aggregation across portfolios. While indirect impacts in the immediate vicinity of sites are included, supply chain impacts are intentionally excluded from scope. As outlined in the introduction, these impacts may be substantial and, in some cases, even greater than those at individual sites. BFIS was specifically designed to support reporting on 'direct operations', a category distinguished and prioritised in many reporting and target-setting frameworks (e.g., CSRD, SBTN). However, this does not remove the need to assess supply chain impacts, which can be addressed through Life Cycle Assessment (LCA) or by extending the extent × condition framework to estimate land occupancy, combined with an evaluation of the biodiversity significance of sourcing locations.

The development of BFIS has focused primarily on land use, because this is the most significant pressure on biodiversity. While other pressures are partially included in the assessment—for example, in the inclusion of noise pollution and other disturbances from operations in assessing the impact on condition—further technical development is underway to include climate change, water use and pollution.

While Step 2 enables the losses and potential gains at site level to be calculated to enable reporting, it was designed to enable reporting on changes to the state of nature in response to site level actions. It was not designed to feed into voluntary or national biodiversity offsetting or credit schemes and therefore lacks some of the technical safeguards—e.g., the calculation of sophisticated natural reference sites and counterfactual impacts—that would be necessary for use in an offsetting and crediting context. It should not be used for those purposes in its current state.

A final consideration is that while this has been developed to be as accessible as possible, including through the development of an R package, there are minimum expectations in data readiness and technical capacity. First, users need to have GIS polygons of their operational sites. Users without this data readiness should instead use location-agnostic portfolio screening tools (Table 3). Second, the users will need to be comfortable with GIS and R and will require training before using the tool. Further development of a more accessible web-based tool has been considered and is possible, depending on feedback from potential users.

References

Barnosky, A.D., Matzke, N., Tomiya, S., Wogan, G.O.U., Swartz, B., Quental, T.B., Marshall, C., McGuire, J.L., Lindsey, E.L., Maguire, K.C., Mersey, B. & Ferrer, E.A. (2011) Has the Earth's sixth mass extinction already arrived? Nature 471: 51–57.

BBOP (2012) Business and Biodiversity Offsets Programme (BBOP) Glossary. Business and Biodiversity Offsets Programme, Washington, D.C. http://www.forest-trends.org/documents/files/doc_3100.pdf

BirdLife International (2022) Digital boundaries of Key Biodiversity Areas from the World Database of Key Biodiversity Areas. Developed by the KBA Partnership: BirdLife International, International Union for the Conservation of Nature, American Bird Conservancy, Amphibian Survival Alliance, Conservation International, Critical Ecosystem Partnership Fund, Global Environment Facility, Global Wildlife Conservation, NatureServe, Rainforest Trust, Royal Society for the Protection of Birds, Wildlife Conservation Society and World Wildlife Fund. April 2022 Version. Available at http://www.keybiodiversityareas.org/kba-data/request. http://www.keybiodiversityareas.org/site/requestgis

Burdge, R.J. (1991) A Brief History and Major Trends in the Field of Impact Assessment. Impact Assessment 9: 93–104.

Giljum, S., Maus, V., Sonter, L., Luckeneder, S., Werner, T., Lutter, S., Gershenzon, J., Cole, M.J., Siqueira-Gay, J. & Bebbington, A. (2025) Metal mining is a global driver of environmental change. Nature Reviews Earth & Environment 6: 441–455.

IFC (2006) Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Resources. International Finance Corporation, Washington DC, USA.

IPBES (2019) Summary for policymakers of the global assessment report on biodiversity and ecosystem services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES. https://zenodo.org/record/3553579

Jaureguiberry, P., Titeux, N., Wiemers, M., Bowler, D.E., Coscieme, L., Golden, A.S., Guerra, C.A., Jacob, U., Takahashi, Y., Settele, J., Díaz, S., Molnár, Z. & Purvis, A. (2022) The direct drivers of recent global anthropogenic biodiversity loss. Science Advances 8: eabm9982.

Laurance, W.F., Goosem, M. & Laurance, S.G. (2009) Impacts of roads and linear clearings on tropical forests. Trends in Ecology & Evolution 24: 659–669.

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.

Mair, L., Bennun, L.A., Brooks, T.M., Butchart, S.H.M., Bolam, F.C., Burgess, N.D., Ekstrom, J.M.M., Milner-Gulland, E.J., Hoffmann, M., Ma, K., Macfarlane, N.B.W., Raimondo, D.C., Rodrigues, A.S.L., Shen, X., Strassburg, B.B.N., Beatty, C.R., Gómez-Creutzberg, C., Iribarrem, A., Irmadhiany, M., Lacerda, E., Mattos, B.C., Parakkasi, K., Tognelli, M.F., Bennett, E.L., Bryan, C., Carbone, G., Chaudhary, A., Eiselin, M., da Fonseca, G.A.B., Galt, R., Geschke, A., Glew, L., Goedicke, R., Green, J.M.H., Gregory, R.D., Hill, S.L.L., Hole, D.G., Hughes, J., Hutton, J., Keijzer, M.P.W., Navarro, L.M., Nic Lughadha, E., Plumptre, A.J., Puydarrieux, P., Possingham, H.P., Rankovic, A., Regan, E.C., Rondinini, C., Schneck, J.D., Siikamäki, J., Sendashonga, C., Seutin, G., Sinclair, S., Skowno, A.L., Soto-Navarro, C.A., Stuart, S.N., Temple, H.J., Vallier, A., Verones, F., Viana, L.R., Watson, J., Bezeng, S., Böhm, M., Burfield, I.J., Clausnitzer, V., Clubbe, C., Cox, N.A., Freyhof, J., Gerber, L.R., Hilton-Taylor, C., Jenkins, R., Joolia, A., Joppa, L.N., Koh, L.P., Lacher, T.E., Langhammer, P.F., Long, B., Mallon, D., Pacifici, M., Polidoro, B.A., Pollock, C.M., Rivers, M.C., Roach, N.S., Rodríguez, J.P., Smart, J., Young, B.E., Hawkins, F. & McGowan, P.J.K. (2021) A metric for spatially explicit contributions to science-based species targets. Nature Ecology & Evolution 1–8.

McElwee, P.D., Harrison, P.A., van Huysen, T.L., Alonso Roldán, V., Barrios, E., Dasgupta, P., DeClerck, F., Harmáčková, Z., Hayman, D.T.S., Herrero, M., Kumar, R., Ley, D., Mangalagiu, D., McFarlane, R.A., Paukert, C., Pengue, W.A., Prist, P.R., Ricketts, T.H., Rounsevell, M.D.A., Saito, O., Selomane, O., Seppelt, R., Singh, P.K., Sitas, N., Smith, P., Vause, J., Molua, E.L., Zambrana-Torrelio, C. & Obura, D. (2024) IPBES Nexus Assessment: Summary for Policymakers. Zenodo. https://zenodo.org/records/13850290

Newbold, T., Hudson, L.N., Arnell, A.P., Contu, S., De Palma, A., Ferrier, S., Hill, S.L.L., Hoskins, A.J., Lysenko, I., Phillips, H.R.P., Burton, V.J., Chng, C.W.T., Emerson, S., Gao, D., Pask-Hale, G., Hutton, J., Jung, M., Sanchez-Ortiz, K., Simmons, B.I., Whitmee, S., Zhang, H., Scharlemann, J.P.W. & Purvis, A. (2016) Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. Science 353: 288–291.

Ritchie, H. & Roser, M. (2019) Half of the world's habitable land is used for agriculture. Our World in Data.

Schipper, A.M., Hilbers, J.P., Meijer, J.R., Antão, L.H., Benítez-López, A., de Jonge, M.M.J., Leemans, L.H., Scheper, E., Alkemade, R., Doelman, J.C., Mylius, S., Stehfest, E., van Vuuren, D.P., van Zeist, W.-J. & Huijbregts, M.A.J. (2020) Projecting terrestrial biodiversity intactness with GLOBIO 4. Global Change Biology 26: 760–771.

Simkins, A.T., Beresford, A.E., Buchanan, G.M., Crowe, O., Elliott, W., Izquierdo, P., Patterson, D.J. & Butchart, S.H.M. (2023) A global assessment of the prevalence of current and potential future infrastructure in Key Biodiversity Areas. Biological Conservation 281: 109953.

Smil, V. (2021) Grand Transitions: How the Modern World was Made. Oxford University Press.

Sonter, L.J., Dade, M.C., Watson, J.E.M. & Valenta, R.K. (2020) Renewable energy production will exacerbate mining threats to biodiversity. Nature Communications 11: 4174.

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.

Tilman, D., Clark, M., Williams, D.R., Kimmel, K., Polasky, S. & Packer, C. (2017) Future threats to biodiversity and pathways to their prevention. Nature 546: 73–81.

Torres, A., Simoni, M.U., Keiding, J.K., Müller, D.B., Ermgassen, S.O.S.E. zu, Liu, J., Jaeger, J.A.G., Winter, M. & Lambin, E.F. (2021) Sustainability of the global sand system in the Anthropocene. One Earth 4: 639–650.

UNEP-WCMC (2024) The World Database on Protected Areas (WDPA).

THE
BIODIVERSITY
CONSULTANCY

TotalEnergies