BIODIV'2050 **OUTLOOK:**

CLUB B4B

Global Biodiversity Score: a tool to establish and measure corporate and financial commitments for biodiversity

2018 technical update

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FOREWORD

In 2018, the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) released four regional and subregional assessments of biodiversity and ecosystem services and a thematic assessment of land degradation and restoration. These assessments highlighted that biodiversity continues to decline in every region of the world, and that land continues to be degraded, thus endangering economies, livelihoods, food security and the general quality of life of people everywhere on the Planet. Land degradation negatively impacts 3.2 billion people and represents an economic loss in the order of 10% of annual global gross product.

Major direct drivers of such declines include land-use change, such as agriculture intensification, followed by human-induced climate change. Other drivers of biodiversity loss include invasive alien species, pollution and overexploitation of resources. The IPBES global assessment, to be released in May 2019, will provide additional evidence of these trends at the global level and is expected to inform discussions regarding the post-2020 global biodiversity framework under the Convention on Biological Diversity, as well as action on implementing the 2030 Agenda for Sustainable Development and the Sustainable Development Goals.

Projected trends in indirect drivers, including increased population growth and consumption, and a more globalised economy will lead to failure to achieve the Sustainable Development Goals, the Aichi Biodiversity Targets and the Paris Agreement on climate change, unless concerted action is urgently taken.

The IPBES assessments have identified a mix of governance options, policies and management practices that are currently available to reduce the loss of biodiversity and nature's contributions to people but recognize that a major commitment is needed to put them into practice. One key solution is to include the conservation and sustainable use of biodiversity, and the provision of nature's contributions to people, into all sectoral policies (e.g. agriculture, energy, health, industry, transportation), plans, programmes, strategies and practices - an objective known as "mainstreaming biodiversity".

Tools like the Global Biodiversity Score (GBS) are necessary to actively consider, or "mainstream" biodiversity across sectors, and to involve business and industry, in particular. By measuring the impacts of businesses and financial assets across value chains, such tools can highlight actions to effectively reduce pressures on biodiversity. Their use of synthetic metrics can also facilitate the assessment of the contribution of businesses to the achievement of global targets such as the Aichi Biodiversity Targets.

I would like to congratulate the authors of this document for their role in providing concrete solutions towards a more robust corporate biodiversity impact assessment tool. It is through such initiatives that business and industry will become able to embrace the cause of biodiversity, as they have done for climate change, and thus become part of the solution to the loss of biodiversity and nature's contributions to people.

ANNE LARIGAUDERIE
Executive Secretary of IPBES

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Science and Policy
for People and Nature

Context

1 Context

1.1 Brief history and introduction

What tools do business need to move towards net positive impacts on biodiversity? This question has been a key focus of the Biodiversity Economics Mission (*Mission Économie de la Biodiversité* or MEB), an initiative of Caisse des Dépôts, spearheaded and run by CDC Biodiversité, since its inception. Over several years and a number of reports (CDC Biodiversité, 2015b, 2015a), the works conducted by the MEB identified the need for a tool to complement existing approaches and bring a comprehensive and synthetic view to businesses about their biodiversity impacts. In 2015, the idea of the Global Biodiversity Score (GBS) was born.

The GBS seeks to fill gaps left by existing tools and to assess the biodiversity impacts of economic activities across their value chain, in a robust and synthetic way. It aims to answer questions such as:

- What are the options to reduce the biodiversity impacts of a business on its sites and across its value chain?
- How can financial institutions (FIs) assess the risks related to the biodiversity impacts of their activity and that of the businesses they finance? How can such information be incorporated into their risk management policy?
- Can businesses set quantitative targets to reduce their impact on biodiversity as they do for climate (*e.g.* decrease biodiversity footprint by x% by 2030)?

The development of the GBS started in **2015**. At the end of **2016**, the Club of Positive Biodiversity Businesses (B4B+ Club, cf. section 1.3) held its first meeting, providing the support and feedback of businesses, financial institutions and technical partners to the development of the GBS. In **2017**, a first report described the objectives, founding choices and methodologies of the GBS and its first applications on crop commodities (CDC Biodiversité, 2017). **2018** was a year of technical development and conceptual maturing: this new 2018 report provides an update on the 2017 report. It was also a year of partnership building during which we started converging with other corporate impact assessment methodologies (CDC Biodiversité, ASN Bank, & ACTIAM, 2018). In **2019**, further technical developments will be conducted, a few full-scale corporate biodiversity audit pilots will be conducted and a Review Committee including experts from academia, NGOs and auditing will provide feedback to strengthen and operationalize the tool. The GBS will be operational by **2020**.

Transparency is critical to the development approach of the GBS and these annual reports provide a detailed and transparent description of the methodological choices and the data underpinning the GBS. A similar report will be published in 2019 to cover the technical developments and methodological choices that will occur in the coming year. Taken together, the technical sections of these reports will form the backbone of a "technical guide" for the GBS.

The report starts with a **Context** section. Section 2 deals with the **Role of the Global Biodiversity Score in the biodiversity footprint landscape.** A summary of the **Update on methodological developments** is provided in section 3, which also includes **Technical notes**, inserted in the middle of the report. Targeted at experts interested by the details of the methodology, these notes are distinguished from the rest of the report by their blue border. Section 4 is dedicated to **Case studies** and provides insights from three road-testing of the GBS with three members of the B4B+ Club. A standalone **FAQ** section answers some common questions about the GBS. The final **Conclusion and prospects** section discusses the road ahead.

BOX 1

The GBS in short

This box aims to remind the GBS's main features to readers already somehow familiar with it. For a more comprehensive introduction, readers are invited to refer to the 2017 report (CDC Biodiversité, 2017) and the FAQ section of this report.

Some definitions and clarifications

The GBS is a corporate biodiversity footprint assessment tool: it can be used to evaluate the impact or footprint of companies and investments on biodiversity. The results of assessments conducted with the GBS are expressed in the MSA.km² unit where MSA is the Mean Species Abundance, a metric expressed in % characterising the intactness of ecosystems. MSA values range from 0% to 100%, where 100% represents an undisturbed pristine ecosystem (cf. section 5.1).

Stakeholders can then build indicators based on GBS assessment results, for instance Key Performance Indicators (KPI) against which to measure corporate performance[1]. Such a KPI could for instance be the total biodiversity impact of a business, and it could for example be associated to a reduction target by 2030.

Key figures regarding global biodiversity loss

In 2010, the global average terrestrial MSA was about 65%. In other words, about 35% of global terrestrial MSA had been lost. It is as if an area the size of North America, Europe and Oceania combined[2] had been entirely covered with a pure asphalt parking, with no single living being left breathing on over 47 million km² (Figure 1). The use of this parking image does not mean that only land conversion or occupation are taken into account: the 35% figure includes all the terrestrial pressures covered by GLOBIO: land use, climate change, encroachment, fragmentation and atmospheric nitrogen deposition.

By 2050, global average MSA may reach 57% (Lucas & Wilting, 2018). This would amount to further converting about 11 million km² into that same asphalt parking, i.e. an area almost the size of China and Mongolia combined[3] (Figure 2).

Methodology

In order to assess corporate biodiversity footprint, the main approach of the GBS is to link data on economic activity to pressures on biodiversity, and to translate these pressures into biodiversity impacts. A hybrid approach is used, to take advantage of data available at each step of the assessment. Data on purchases or related to pressures (such as land use changes or greenhouse gas emissions) can thus be used to refine the evaluations. In the absence of precise data, a default calculation assesses impacts based on financial turnover data.

The GBS uses peer-reviewed tools such as EXIOBASE, an environmentally extended multi-regional input-output model, or GLOBIO, to link activity, pressures and impacts. Its underlying assumptions are transparent.

In the long run, the aim of the GBS is to cover all biodiversity impacts across the value chain (including both upstream and downstream impacts). It currently covers only terrestrial pressures on biodiversity and upstream impacts, though freshwater (aquatic) pressures will be included shortly (see Appendix a). The terrestrial impacts covered are:

- Land use
- Fragmentation of natural ecosystems
- Human encroachment
- Infrastructure[4]
- Atmospheric nitrogen deposition
- Climate change

Section 3.2 (and in particular Figure 7) provides more details on the sequence of methodological steps and Appendix a describes the pressures on freshwater biodiversity which will be integrated into the GBS in 2019.

(1) The term "indicator" can also be used to describe specific data required by the GBS to conduct assessments. Such "input indicator" include for instance yearly corporate turnover by industry or region (EUR), area of natural forest converted into intensive agriculture every year (ha), etc.

(2) The total land area excluding Antarctica and Greenland is about 133 million km² (GLOBIO 3.5 data). 35% x 133 = 47 million km². The area of North America, Europe and Oceania are about 24.3 million km², 9.9 million km², 7.7 million km² respectively (https://fr.wikipedia.org/wiki/Continent), for a total of 41.9 million km², which is close to 47 million km².

(3) (65% - 57%) x 133 = 11 million km². The area of China and Mongolia are 9.6 million km² and 1.6 million km² respectively, for a total of 11 million km². https://en.wikipedia.org/wiki/List_of_countries_and_dependencies_by_area

(4) Work is still ongoing to fully link the pressures caused by infrastructure to activity data.

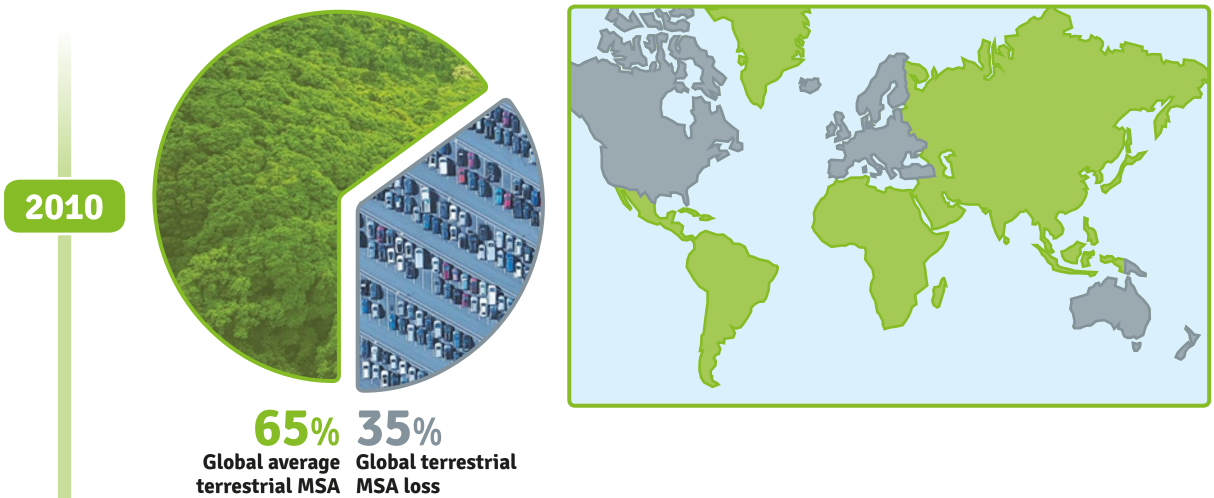


Figure 1: Global MSA loss in 2010 amounted to converting an area which would be equivalent to the size of North America, Europe and Oceania combined into a giant lifeless parking

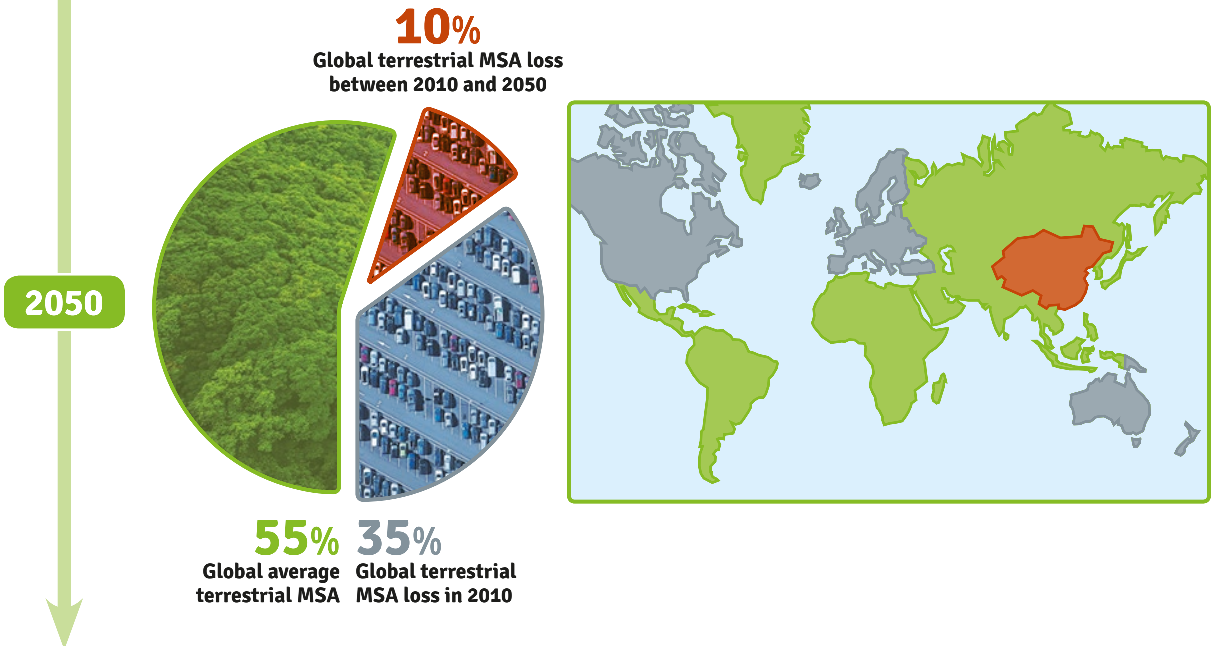


Figure 2: Global MSA loss between 2010 and 2050 may amount to converting an additional area which would be equivalent to the size of China and Mongolia combined into the giant lifeless parking

- Area equivalent to the remaining global terrestrial MSA (86 million km² in 2010 and 75 million km² in 2050)
- Area equivalent to the global terrestrial MSA loss (47 million km²)
- Area equivalent to the global terrestrial MSA loss between 2010 and 2050 (11 million km²)

1.2 The stars are aligned for the mainstreaming of biodiversity footprinting

Thanks to a **combination of a favourable international political agenda** (Figure 3) and a **growing pressure from the finance world**, the sequence leading to 2020 is **very conducive to the emergence and mainstreaming of biodiversity footprint assessments** across countries and sectors. A number of **recent technical developments** support such a shift, which would have been unthinkable a few years ago. These technical developments range from the launch of several initiatives aiming at assessing the impacts of economic activities on biodiversity to the improvement of global biodiversity modelling, along with new datasets, for instance derived from satellite imaging.

The next two sub-sections detail the two main drivers which will lead companies to measure, reduce and report their biodiversity footprint: the political agenda and financial pressure.

1.2.1 The strong 2018-2020 international biodiversity agenda

The 2018-2020 sequence promises to be an important turning point for the global biodiversity crisis. A series of events leading up to the Conference of the Parties 15 (COP15) of the Convention on Biological Diversity (CBD) in Kunming, China, in 2020 should move biodiversity to the same level as climate change on the agenda of global decision-makers. The previous international objectives for biodiversity, the Aichi targets, all expire in 2020. COP15 will thus be a major event, where new targets for the 2020-2030 period and beyond will be set.

From 17 to 29 November 2018, **COP14 of the CBD** was held in Sharm El-Sheikh, Egypt. A High-Level Segment and the Global Business & Biodiversity Forum were held shortly ahead of the COP, on November 14th and 15th. It led to agreements on the process to decide the post-2020 global biodiversity framework and to the launch of the Sharm El-Sheikh to Beijing (now Kunming) Action Agenda for Nature and People, which aims to map and catalyse actions from all sectors and stakeholders in support of biodiversity conservation.

From 26 to 30 November 2018, Paris hosted the Biodiversity and Natural Capital Week[5], gathering several major international initiatives to spread knowledge and facilitate the sharing of best practices among businesses and policy makers. The week included events by the **Policy Forum on Natural Capital Accounting**, the **Natural Capital Coalition Day**, the **Business @ Biodiversity platform of the European Union**, and the **Business and Biodiversity Offsets Programme (BBOP)**. France had also hosted another event on 10 July 2018: the **act4nature summit**. Business leaders were mobilised by *Entreprise pour l'environnement*, the French equivalent of the World Business Council on Sustainable Development. About 70 large international companies have committed to 10 common pledges and a number of specific individual pledges for biodiversity[6]. One of these commitments is to "**Assess** the various components of biodiversity of concern to us, using **direct and indirect impacts** indicators".

(5) https://naturalcapitalcoalition.org/natural-capital-week-2018/
(6) http://www.act4nature.com/wp-content/uploads/2018/11/act4nature_version-en.pdf

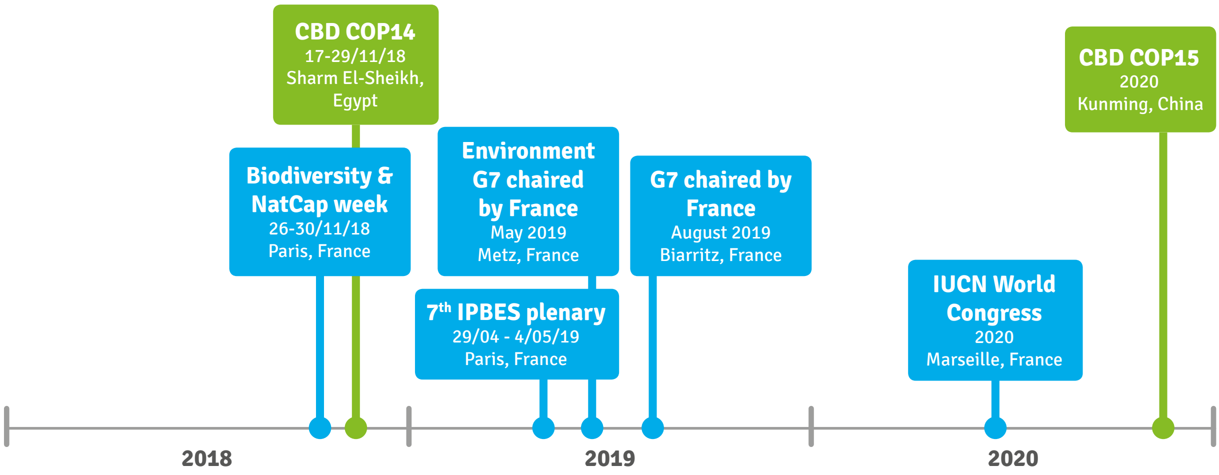


Figure 3: Key events of the 2018-2020 political agenda for biodiversity

From 29 April to 4 May 2019, biodiversity will again be highlighted thanks to the **7th plenary session of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)** to be held in Paris. The plenary will validate the first Global Assessment of Biodiversity and Ecosystem Services since 2005.

In May and then in August 2019, in the wake of the IPBES plenary, France will hold the presidency of the **G7 Environment** and the **G7** respectively. Biodiversity will be on the agenda, at the same level as global warming.

Building on the momentum generated by these 2019 events, 2020 will be a pivotal year.

The **International Union for the Conservation of Nature (IUCN)** will host its **World Congress** in Marseille, France. The World Congress is an event where major decisions for conservation are taken and it is held only every four years.

Finally, **COP15** itself will be hosted in Kunming, China in late 2020. Drawing lessons from the global implementation of the 2020 objectives, it will define new ambitions for biodiversity. Scientific research and civil society support allow the definition of ambitious global and regional quantified targets which can catch the imagination of the general public and drive change among businesses and countries, as the 2°C target does for climate change (**Box 2**).

As a result of this favourable political timeline, biodiversity is moving up the corporate social responsibility agenda.

As a result of this favourable political timeline, biodiversity is moving up the corporate social responsibility agenda. In France in particular, the new National Biodiversity Plan[7] published in July 2018 states in its Action 30:

"Starting in 2018, we will launch work to encourage companies to qualify their biodiversity footprint. In this context, we will support works seeking to define a biodiversity impact indicator comparable to the CO_2 equivalent ton for the climate impact. When this biodiversity footprint is qualified, we will generalize its use and we will bring to the European level the mandatory publication of this indicator as part of the Corporate Social Responsibility (CSR) review planned for 2020. The French platform for CSR will be mobilised as early as 2018 to make proposals in this area."

France sets itself a high level of ambition with the generalization of the evaluation of the biodiversity footprint for companies, in France but also in Europe. Such an objective was still unthinkable a few years ago, but with the development of quantification tools such as the GBS, regulators want to make mandatory what is now technically possible. The regular publication of company biodiversity footprints at the same level as their carbon footprint will invite them to think about the levers to reduce this footprint, and will allow civil society to monitor the evolution of their performance.

1.2.2 Pressure is building up from finance to fund biodiversity-friendly activities

From the Business & Biodiversity Forum held at the start of COP14 in Sharm-el-Sheikh, Egypt, to the Global Roundtable of the United Nations Environment Programme's Finance Initiative (UNEP-FI), there is a broad agreement that large amounts of money seek sustainable projects to be invested in but finding appropriate opportunities is a struggle. Hence, money is not missing but large and replicable environmentally-friendly projects with limited risks and appropriate returns on investment are.

"Socially responsible investments" are expanding fast[8]. Among the strategies followed by socially responsible investments, **negative screening** (simply excluding assets deemed not responsible) has the greatest share of assets under management. **Environment Social Governance (ESG) integration** (taking ESG factors into account in the investment process) is the second-largest by assets. **Green bonds** issuance has rocketed to over USD 160 billion in 2017.

(7) Available in French: https://www.ecologique-solidaire.gouv.fr/sites/default/files/2018.07.04_PlanBiodiversite.pdf This 2018-2024 Plan proposes 90 actions defining the priorities and vision of the government for biodiversity.

(8) http://www.gsi-alliance.org/wp-content/uploads/2017/03/GSIR_Review2016.F.pdf and https://www.economist.com/blogs/economist-explains/2018/04/economist-explains-13

ESG investment is going mainstream and is for example offered by BlackRock, the world's largest asset manager, and the asset-management division of Goldman Sachs, a bank. Even **impact investment**, the most ambitious form of socially responsible investment, includes funds by two of America's largest private-equity firms, Bain Capital and TPG Capital.

This rapid expansion shows the interest of a number of investors and their clients for socially and environmentally sound investments. Some investors are ready to withdraw from entire sectors as shown by the fossil fuel divestment initiatives which started gathering pace in the early 2010s. For environmentally-minded investors, up to recently the main focus has been climate but demands to take into account other parameters such as biodiversity are rising. Divestment initiatives such as the one related to fossil fuels might at some point be replicated for sectors with very high biodiversity impacts.

Consistent measures and ratings that allow for comparison across investments are still a work in progress, and this used to be especially true for biodiversity.

The **European Union** wants to support the development of such measures and has **launched an Action plan** on financing sustainable growth in March 2018[9]. It includes plans for an EU labelling scheme for green bonds, low-carbon benchmarks, and a strengthening of sustainability disclosure and accounting. A first package of legislative proposals was issued in May 2018[10]. This package includes a proposal for a regulation establishing a taxonomy for sustainable investments and a requirement for all asset managers to consider ESG factors when giving advice to their investors, and to explain how they are doing so. The implementing acts should be released **between December 2019 and December 2022**.

The GBS is designed to provide the missing indicator to measure the biodiversity impact across investments.

1.3 A tool connected to business realities thanks to the B4B+ Club

The B4B+ Club gathers businesses and financial institutions seeking to move towards net gains for biodiversity, meaning that their positive impacts are higher than their negative ones, through the measurement of their impacts and the implementation of impact reduction actions. The Club actively supports the development of the GBS. As explained in our 2017 report, businesses, financial institutions and technical and institutional partners taking part in three to four annual working group meetings provide feedback on methodological developments and participate in various road-testing of the tool under real-world conditions (CDC Biodiversité, 2017). This feedback and experience are very precious as they allow significant redesigning and fine-tuning to adapt to data availability and actual business decision-making processes.

In 2018, B4B+ members raised a number of questions which steered the work of the development team, and in some cases remain areas under work for 2019:

- What perimeters of the value chain should be considered? Members mentioned the applicability of different "Scopes" (Figure 10).
- When assessing an entire value chain, how should the responsibility of impacts be attributed between upstream and downstream businesses?
- How can plastics and other pollutions (in particular pesticides) be taken into account by the GBS?

Members also highlighted the need for the GBS to cover all sectors, and the need to be able to assess asset portfolio, but also large-scale projects.

(9) https://ec.europa.eu/info/publications/180308-action-plan-sustainable-growth_en

(10) https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance_fr#implementing

As of December 2018, the B4B+ Club included the following members:

VALUE CHAIN WORKSTREAM

- 3F
- Compagnie des Alpes
- GRTgaz
- Michelin
- AccorHotels – Feel Welcome
- EDF
- Habitat Réunion – La force du logement social
- Solvay – asking more from chemistry®
- Air France
- egis
- Icade
- storengy
- CIVB Bordeaux
- Eiffage
- Kering
- transdev – Inventons votre mobilité
- cdc habitat – Groupe Caisse des Dépôts
- Engie
- L'Oréal
- Veolia

FINANCE WORKSTREAM

- AFD – Agence Française de Développement
- Groupe BPCE
- BNP Paribas
- bpifrance
- Groupe Caisse des Dépôts
- Crédit Agricole
- CNP assurances
- La Banque Postale Asset Management
- mirova – Responsible Investing
- Société Générale

PARTNERS

- epe – entreprises pour l'environnement
- icare & consult
- Noé
- orée – Entreprises, territoires et environnement

BOX 2

From planetary boundaries to global, regional and corporate quantified biodiversity footprint targets

The planetary boundaries framework defines a "safe operating space" in which social and economic development can take place while maintaining the resilience of the Earth system as a whole. Based on the intrinsic biophysical processes that regulate the stability of the Earth system, they deal with climate change, novel entities, stratospheric ozone depletion, atmospheric aerosol loading, ocean acidification, biochemical flows (phosphorus and nitrogen), freshwater use, biosphere integrity (functional and genetic biodiversity) and , land-system change (Steffen et al., 2015). This framework has been developed for about a decade (Rockström, 2009) and has attracted great interest within the scientific community as well as from the policy, governance and business sectors and is recognised as a relevant approach to inform efforts towards global sustainability. The framework also helps setting quantitative targets identifying limits to environmental modification, habitat degradation, resource use and biodiversity loss (T. Häyhä, Cornell, Hoff, Lucas, & Van Vuuren, 2018; Tiina Häyhä, Lucas, van Vuuren, Cornell, & Hoff, 2016; Hoff, Häyhä, Cornell, & Lucas, 2017; Hoff & LOBOS, 2017; Lucas & Wilting, 2018).

In this context, there is a growing interest from various counterparts to quantify the biodiversity boundary in the same way as a climate boundary is quantified. The climate boundary is expressed as the need to limit the global temperature increase to 1.5 degrees Celsius and the Intergovernmental Panel on Climate Change (IPCC) evaluated a carbon emission budget that should not be overpassed to stay within this boundary.

In 2015, Steffen et al. (2015) used the Biodiversity Intactness Index (BII) to analyse the biodiversity planetary boundary. There was no clear-cut evidence on the relationship between BII boundary values and irreversible Earth system responses that lead to undesired ecosystem statuses and significant impacts on the provisioning of goods and services to society. As a starting point for further research and discussion, Steffen et al. (2015) proposed a preliminary boundary of maintaining the BII at 90% or above, with a 90% to 30% uncertainty zone. This approach serves as an intermediate solution, to be used until more appropriate indicators are developed. Further work analysed the extent to which this planetary boundary of 90% BII had been crossed (Newbold et al., 2016) or sought to downscale it to regional levels (T. Häyhä et al., 2018).

Lucas & Wilting (2018) used the GLOBIO simulation model (Alkemade et al., 2009; Schipper, Meijer, Alkemade, & Huijbregts, 2016) to translate the BII-based proposal for a boundary value into Mean Species Abundance (MSA) terms, a biodiversity intactness indicator very similar to the BII. It is a relative index that compares the observed biodiversity in an ecosystem to that of the pristine state (Alkemade et al., 2009). Combined with areas of ecosystems under consideration, it can be expressed in an area unit ($MSA.km^2$) and this is the unit used in the Global Biodiversity Score. Lucas & Wilting (2018) used BII values per land-use type and land-use intensity data from Newbold et al. (2016), and calculated the corresponding global MSA boundaries values. A regression analysis of the simulation outcomes resulted in a global planetary boundary of maintaining the MSA at 72% or above (100% global MSA translates into an Earth covered by intact ecosystems with healthy populations of all non-invasive species, cf. Figure 27 and FAQ 5.1), and this value was subsequently used to derive national targets by using allocation procedures based on different equity principles.

The global safe operating space for biodiversity integrity, as defined by Steffen et al. (2015), has unfortunately already been overshot as the global average terrestrial MSA stood at around 65% in 2010 and 63% in 2018. If it was decided to move back towards the safe zone, it would mean that the global average terrestrial MSA would have to raise from 63% to 72%. Such an increase cannot be achieved only by reducing the current rate of loss, as illustrated by the "20% reduction of impact every four years" scenario in Figure 4. It is necessary to achieve positive biodiversity impacts on a global scale to get back to the "safe zone".

These figures are preliminary and need to be refined with further research. It should also be noted that the biosphere is currently in the "zone of uncertainty (increasing risk)" and it is unclear whether the "beyond zone of uncertainty (high risk)" area has already been reached (Steffen et al., 2015).

Furthermore, several political and technical options remain open regarding the target and pace of implementation that should be set to move towards the safe zone. Kok et al. (2018), provide a model-based analysis of three alternative pathways dedicated to biodiversity conservation.

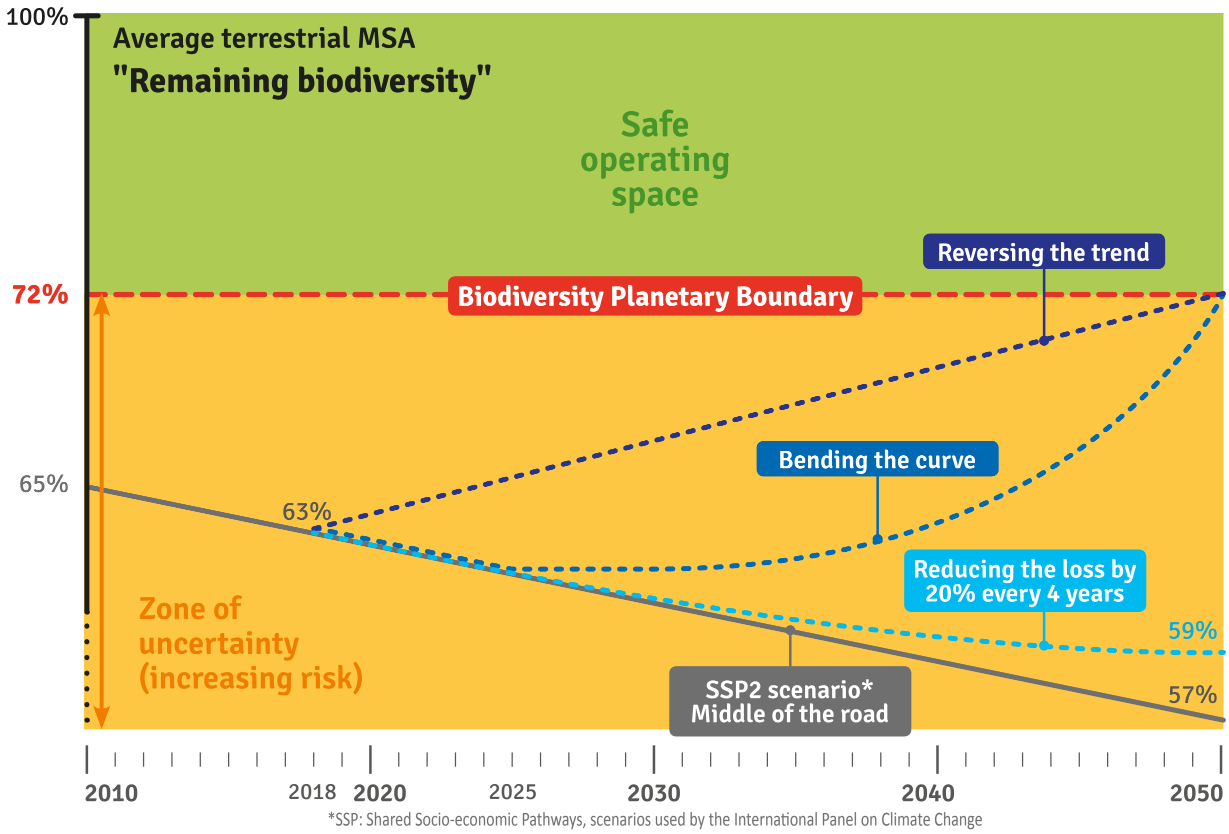


Figure 4: Scenarios to get back into the biosphere integrity planetary boundary (adapted from Lucas & Wilting, 2018)

The different combinations of bio-physical measures (e.g. yield increase), ecosystem management changes (e.g. limited conversion of natural areas) and behavioural changes (e.g. dietary change towards less meat consumption) can reduce the expected global biodiversity loss to 4.4 - 4.8% MSA points between 2010 and 2050. That would amount to about half the expected global biodiversity loss in the trend scenario (see Figure 4), which stands at 9.5% points MSA predicted. This would not bring MSA back within the proposed/preliminary safe zone above 72% MSA, but other options which have not been assessed by Kok et al. (2018), such as expanding the network of protected areas or more in-depth mainstreaming of biodiversity into economic models, might provide additional biodiversity gains.

Of course, translating global planetary boundaries into national or subnational targets requires taking into account socio-economic and ethical dimensions and is thus a political choice that cannot be limited to biophysical considerations. Lucas & Wilting (2018) analysed the consequences of different allocations of the required efforts based on several ethical approaches. The approaches display various equity principles including equality, responsibility, capability, right to development, sovereignty and cost effectiveness and the principles distinguished put different weights on indicators such as population, economic growth (GDP), resource efficiency and environmental pressures. However, such quantitative targets provide useful insights as to what is required to get back to the "safe operating space" and which actions and policies could be implemented to do so.

Such scientific work can help in the target setting process for overarching biodiversity loss reduction targets in the like of the IPCC's 1.5°C and 2°C climate change limits for 2100. They can also contribute to deriving national biodiversity loss reduction targets similar to the climate Nationally Determined Contributions (NDCs), which can then be linked to sectoral reduction targets by some form of political negotiation or other burden-sharing processes. CDC Biodiversité strongly advocates for such considerations to be at the core of the post-2020 global biodiversity framework, especially in the form of a simple, communicable and quantifiable overarching "apex goal" underpinning other objectives, associated actions and enabling conditions (WWF, 2018). Once such an apex goal is set and translated into regional targets, tools like the Global Biodiversity Score can assess the contribution of businesses towards their achievement. The ability to track the progress of companies and investments will support the shift towards thriving sustainable societies.

Role of the Global Biodiversity Score in the biodiversity footprint landscape

2 Role of the Global Biodiversity Score in the biodiversity footprint landscape

2.1 The needs to measure the state of and impacts on biodiversity

In general, biodiversity footprints apply to **five broad perimeters or "use categories"** covering different application areas and answering different questions (CDC Biodiversité, ASN Bank & ACTIAM, 2018):

Public policy

- How can quantified targets for countries/sectors be set and monitored to reduce biodiversity loss; *e.g.* by the Convention on Biological Diversity (CBD), national governments and other actors?
- How can trends in biodiversity decline be expressed and how can the contribution of each industry be assessed at a national level?
- What does the biodiversity footprint per capita look like?
- What % of the total biodiversity impact of a country is 'imported' through dependencies on foreign resources?

Corporate / (Financial asset) portfolio

- What is the biodiversity footprint of a financial institution or company and what is the footprint it induces across its value chain? What is the footprint of different asset classes and investments?
- How do the investments in companies compare to each other regarding their biodiversity impact?

Supply options

- How do different suppliers and supply chain options compare with regard to their impact on biodiversity?[11]

Product or service

- What design and composition of products or services guarantee the lowest biodiversity footprint? How do different commodities compare with regard to their impact on biodiversity?

Project or site

- How can operational impacts on biodiversity be minimised at the site or project level and how can positive impacts be measured and compared?
- How can the impacts of sites be summed up to come up with aggregated figures?

An overview of biodiversity indicators in business usefully distinguishes categories among a spectrum of **business applications** (Addison, Carbone, & McCormick, 2018). We narrowed down these categories to:

A - Assessment / rating by and for third parties with external data[12]: assessment of corporate biodiversity performance by third party (e.g. rating agencies) for their own use and based on external (and often public) data. Typically, the assessment conducted by financial institutions (FIs) of the footprints of businesses they fund falls within this business application (FIs act as third party here).

B - Internal communication and external disclosure: reporting by companies of information on their corporate biodiversity performance based on internal data, to demonstrate effective management of impacts, risks and opportunities. Tools fulfilling this business application could for instance be used for future regulatory external reporting of corporate biodiversity footprint;

C - Biodiversity management & performance: monitoring and evaluation by companies of the effectiveness of their own management interventions such as actions taken to mitigate impacts. This feeds into companies' internal decision-making on topics such as the concrete actions which could be implemented to move towards bio-

(11) Assessing the impact of the commodities produced by one specific raw material producer without comparing different sourcing options falls under Product or service use.

(12) Unlike Addison, Carbone, & McCormick (2018), we exclude external audits to obtain certifications from this business application. Instead in our typology, this business application focuses on the need to have third parties auditing businesses for their own third party uses, with limited or no contact with the business itself. Certification audits fall within the "Biodiversity management & performance" application. It should also be clear that this category is not about who technically conducts the assessment but about who commissions it.

diversity net gains, for instance should one supplier be encouraged to switch to more biodiversity-friendly practices, or should agricultural practice *X* or agricultural practice *Y* be implemented on farmlands operated by the company;

Third party rating and external disclosure of biodiversity impacts require a synthetic metric which can communicate efficiently the performance of businesses. Summarizing complex information into a single metric helps making the message understandable for non-experts. It also allows governments to take commitments with this synthetic metric. Companies can then position themselves with regards to these commitments and set their own targets to contribute to national or international targets.

Tackling biodiversity loss at a macro level with synthetic metrics such as the MSA is necessary. It reveals massive impacts across the value chains of many industries (Lenzen et al., 2012; Wilting & van Oorschot, 2017), and those industries are currently often not covered by any regulatory obligation to deal with their biodiversity impacts.

However, evaluating biodiversity footprint **at a macro level**, with metrics such as the MSA **is not sufficient** in itself. A business might have reduced its score but still have impacted endangered species or critical habitats. **It is thus necessary to apply the mitigation hierarchy at the site level** and ensure it appropriately avoids, reduces and offsets impacts on biodiversity (especially on endangered species, protected areas or critical habitats).

The "macro" and "micro" approaches are complementary and both necessary.

The “macro” and “micro” approaches are complementary and both necessary.

2.2 Mapping of biodiversity footprint assessment tools

Figure 5 provides an update on the mapping CDC Biodiversité presented with ASN Bank, ACTIAM and Finance in Motion in our common ground on biodiversity footprint report (CDC Biodiversité, ASN Bank & ACTIAM, 2018). As for the previous mapping, Figure 5 does not seek to assess the initiatives listed against any criteria. Instead, it seeks to provide a non-exhaustive overview of existing tools to measure biodiversity impacts and illustrate that most of them fulfil different needs and thus are complementary to each other. Figure 5 focuses on the core (or primary) business applications and perimeters of each tool. However, most of the tools are not limited to their core applications: tools focused on biodiversity management & performance can for instance sometimes be used to report externally on the biodiversity performance they contribute to achieve.

The perimeter of the mapping was determined following the same rule as the assessment conducted by the EU Business and Biodiversity Platform in 2018: “*biodiversity accounting approaches for businesses and financial institutions (FIs) which rely on quantitative indicators that provide information on the significance of impacts on biodiversity, and which are not case-specific*” (Lammerant, Müller, & Kisielewicz, 2018).

The selection of mapped international initiatives is briefly characterised below:

- **Country biodiversity footprint**[13] (IUCN): the IUCN is conducting an assessment of the biodiversity footprint of countries and their balance of trade.
- **GLOBIO** (PBL): developed by the PBL, UNEP GRID-Arendal and UNEP-WCMC, the GLOBIO model evaluates the impact of environmental drivers on biodiversity in the past, present and future. It is used to support and coordinate global or national public biodiversity policies[14].
- **LPI** (WWF): the Living Planet Index measures the global state of biodiversity based on changes in the populations of over 16 700 populations covering over 4 000 vertebrate species throughout the planet[15].
- **EP&L** (Kering): Kering assesses its land use (among other indicators) impact through its Environmental Profit & Loss methodology[16].
- **BFFI** (ASN Bank): PRé and CREM assess the biodiversity footprint of the assets of ASN Bank through the Biodiversity Footprint for Financial Institutions, combining data from EXIOBASE, the ReCiPe methodology and a qualitative analysis.
- **GBS** (CDC B): CDC Biodiversité is developing the Global Biodiversity Score, a tool to assess the biodiversity footprint of economic and financial activities.
- **BioScope** (Platform BEE): developed by PRé Sustainability, Arcadis and CODE, BioScope assesses the most important corporate impacts on biodiversity arising from their supply chain[17].

(13) Provisional name as the project does not currently have an official name.
(14) https://www.globio.info/
(15) https://wwf.panda.org/knowledge_hub/all_publications/living_planet_report_2018/
(16) http://www.kering.com/en/sustainability/epl
(17) https://www.bioscope.info/uploads/bioscope.info/bee_downloads/9/file/Methodology_Report_v1.compressed.pdf

- **BRIM** (IUCN): the IUCN is developing the Biodiversity Return on Investment Metric to assess the gains of investing in biodiversity conservation[18].
- **LIFE Index** (LIFE Institute): Lasting Initiative for Earth (LIFE) Institute has been developing and applying for over 8 years a Biodiversity Impact Index in South America to assess businesses biodiversity performance and their eligibility to the LIFE certification. The Index is part of a broader Methodology that guides companies to an ecological transition towards concrete positive impacts[19].
- **BIM** (CISL): Cambridge Institute for Sustainable Leadership is developing the Biodiversity Impact Metric to compare the impacts of different commodities and supply chains[20].
- **PBF** (I Care + Sayari): I Care and Sayari assess the impact of products and services through their Product Biodiversity Footprint[21].
- **BF** (Plansup): Plansup assesses the Biodiversity Footprint of a range of businesses, *e.g.* to compare biodiversity improvement options[22].

(18) https://www.iucn.org/regions/washington-dc-office/our-work/biodiversity-return-investment-metric

(19) http://institutolife.org/o-que-fazemos/desenvolvimento-de-metodologias/documentos-que-dao-suporte-tecnico-a-metodologia/?lang=en

(20) https://www.cisl.cam.ac.uk/resources/working-papers-folder/healthy-ecosystem-metric-framework

(21) http://www.productbiodiversityfootprint.com/

(22) http://www.plansup.nl/models/biodiversity-footprint-model/

- **Mining footprint**[23] (BHP + CI): the extractive company BHP is "developing a framework to evaluate and verify the [biodiversity related] benefits of its actions" through a seven-year partnership with Conservation International. It involves pressure-state-response indicators at the site level.
- **Extractive** (WCMC): UNEP-WCMC is developing biodiversity indicators for extractive companies under its Proteus Partnership with the industry. It is focused on tracking pressure-state-response at the site level, with the possibility to aggregate results at the corporate level.
- **BPT** (Solagro): Solagro has developed Biodiversity Performance Tool (BPT) under the European LIFE Food & Biodiversity project. It qualitatively assesses farm-level biodiversity and recommends actions to implement in a biodiversity management plan[24].

More in depth comparisons of biodiversity footprint methodologies can be found in the following two reports:

- Lammerant, J., Müller, L., & Kisielewicz, J. (2018). Assessment of biodiversity accounting approaches for businesses and financial institutions - Update report 1 (Discussion paper for EU Business @ Biodiversity Platform).
- Core initiative on BiodiversityOne Planet Program on Sustainable Food Systems. (2018). Technical report on existing methodologies & tools for biodiversity metrics. Zurich

(23) Name suggested by the authors as the project does not currently have an official name.

(24) https://www.business-biodiversity.eu/en/biodiversity-performance-tool

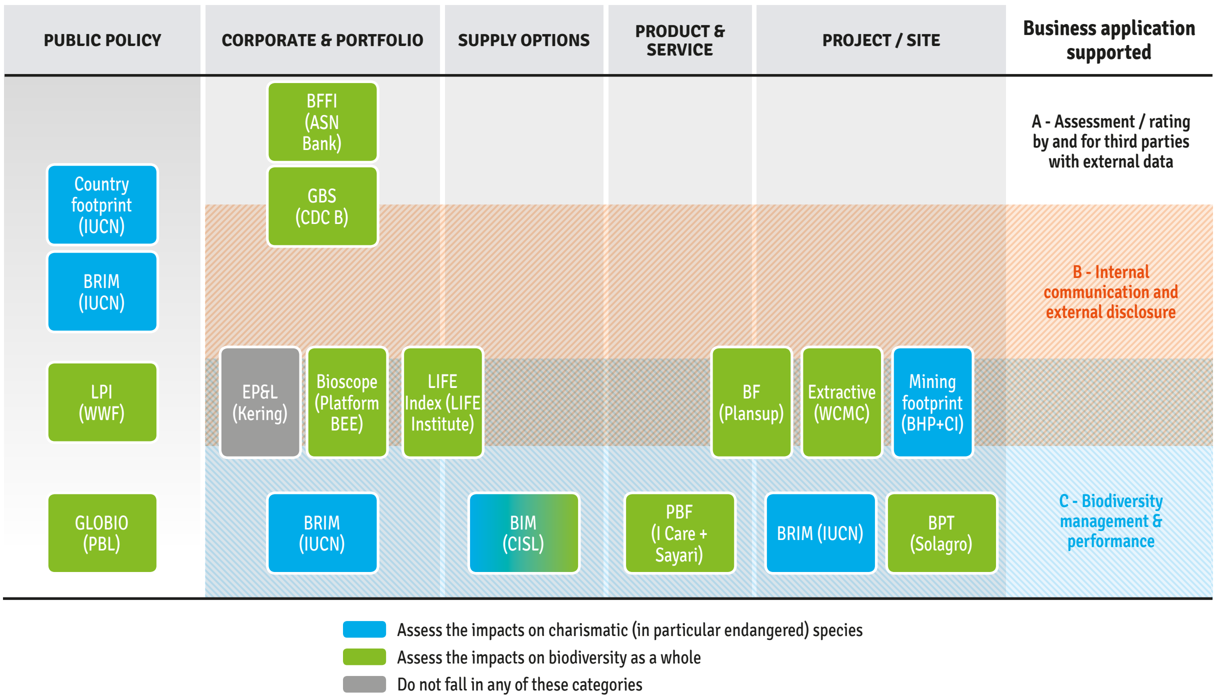


Figure 5: Mapping of the core business applications and perimeters of biodiversity footprint initiatives

2.3 Focus of the Global Biodiversity Score and relationships with other tools

The GBS focuses primarily on two target user groups and their needs:

- **Businesses**: corporate assessment for internal communication and external disclosure;
- **Financial institutions**: financial asset portfolio assessment / rating by third parties (*i.e.* assessment of the footprint of companies or projects a FI funds by the FI itself and not by the companies or project owners themselves).

The data collection, impact assessment and result visualization tools we develop are better fitted to these twin focuses. The GBS can however help for *Biodiversity management & performance* business applications and for *Supply chain*, *Product & service* or *Project / site* perimeters but it is best combined with other more specialised tools more specifically tailored to these uses.

GLOBIO, the Biodiversity Impact Metric (BIM), the Biodiversity Footprint of Plansup and the LIFE Index (for the assessment of habitat change) all use the same metric as the GBS, the MSA. As illustrated in Figure 6, **together with the GBS, these four "MSA-based" tools cover all business applications as well as public policy**. Work is under way to build bridges between them.

In particular, an initiative was launched in 2018 to increase cooperation and "form a common view" between initiatives working on corporate biodiversity impacts and dependencies: the Aligning Biodiversity Measures for Business project. It also aims to feed the discussions on corporate indicators through the biodiversity global policy frameworks.

This initiative gathers most of the teams working on biodiversity footprint assessment tools and should contribute to the emergence of common grounds regarding methodologies, concepts and metrics.

In addition to this more comprehensive cooperation between initiatives, CDC Biodiversité seeks to work more closely with some development teams through more-focused partnerships:

- **CDC Biodiversité, ASN Bank, ACTIAM (supported by Finance in Motion)** teamed up to work on a solid basis (common ground) for a methodology on biodiversity footprinting for financials and seek convergences between the GBS and the BFFI tools. This led to a first common ground report in 2018 (CDC Biodiversité, ASN Bank & ACTIAM, 2018). In 2019, the partnership might be extended to other FIs with high ambition levels on biodiversity footprinting and should provide more detailed guidance per asset class.
- **Product Biodiversity Footprint (PBF)**: CDC Biodiversité and I Care are discussing the articulations of the PBF and GBS approaches which focus primarily on product and corporate & portfolio respectively.

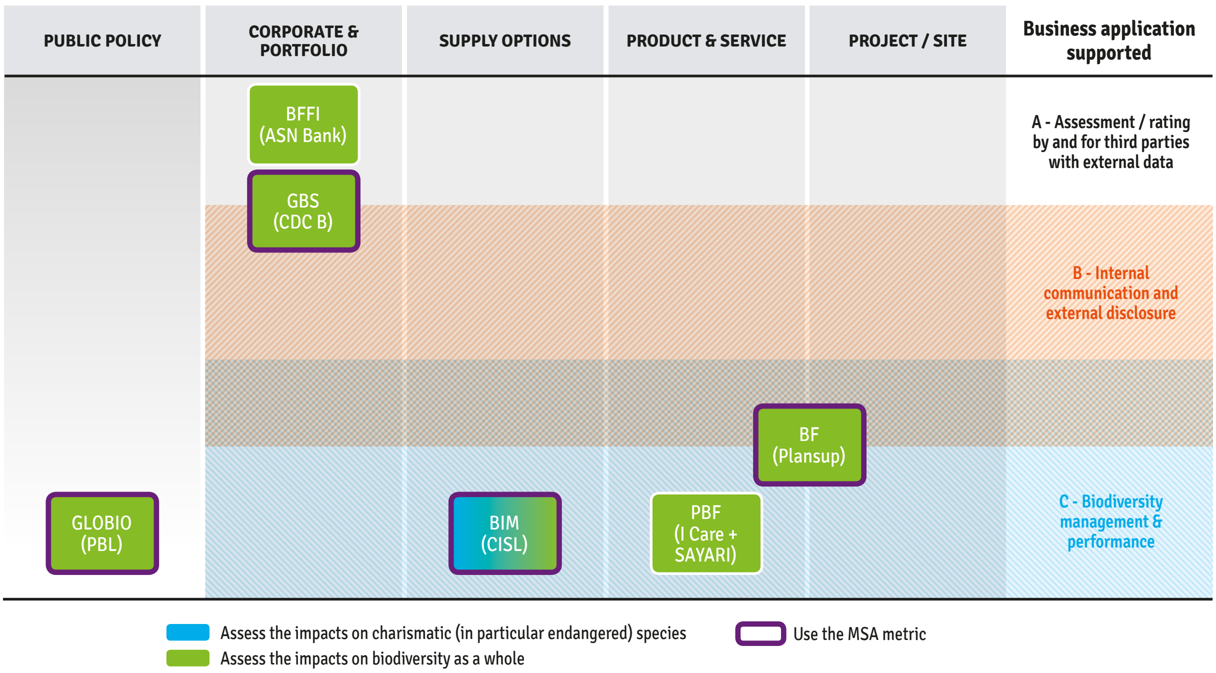


Figure 6: Linkages between the GBS and other tools

Update on methodological developments

3 Update on methodological developments

3.1 Summary of methodological developments

The rest of **section 3** is a technical section which deals in-depth with the progress since November 2017 and the previous GBS report (CDC Biodiversité, 2017). This progress is summarised here to readers who do not need all the technical details.

Conceptual innovation

To make the GBS more flexible and nimble, a **hybrid approach** has been chosen. Footprint assessments will seek to use the best data available at every step of calculations, in what can be called a **stepwise approach**. In the absence of data, the default approach evaluates companies based on turnover figures and industry and regional averages. Fed with more specific data, the assessment is refined to take into account company-specific pressures, etc.

To describe the perimeter and the impacts assessed throughout the value chain, the GBS adapted concepts from the climate world. The **perimeter under control** of a company is defined through one of three options: financial control, operational control, or share of assets owned. **Scopes** are used to describe the impacts assessed: Scope 1 corresponds to (direct) impacts of the perimeter under control, Scope 2 to impacts of the generation of purchased electricity, steam, heat and cold, and Scope 3 to the other (indirect) impacts along the value chain. A new distinction is introduced: '*dynamic footprints*' are caused by changes, consumptions or restorations. '*Static footprints*' represent the '*ecological opportunity costs*' of persistent pressures, which prevent the return to an undisturbed state, even without new dynamic impacts.

New areas

One new module has been added to the GBS: an **environmentally extended input-output model** named EXIOBASE. It makes it possible to translate turnover figures into emissions and raw material consumptions. Linked to the Commodity Tools developed or under development, it is the key module of the default assessment, allowing to assess the footprint of any business, as long as its turnover split by industry and region is known.

Freshwater pressures are also being integrated into the GBS, and they are described in **Appendix a**.

Updates on previous approaches

Following further technical developments, some approaches described in our previous BIODIV'2050 OUTLOOK (CDC Biodiversité, 2017) have been updated.

A convergence work has been undertaken to align the BFFI tool, the GBS and other tools regarding the way **climate change** is taken into account. A time horizon of 100 years was agreed on and we sought to use the same impact factor to translate greenhouse gas emissions into global temperature increases.

For **spatial pressures**, calculations have been updated to better assess dynamic and static footprints with the default assessments. A cap has also been introduced so that, in the default assessment, agricultural decline in some regions (like the USA) do not translate any more into biodiversity gains for companies operating in them.

3.2 Stepwise approach: use of the best data available

The GBS follows a hybrid approach to assess the footprint of economic activities.

When data is limited, it conducts a **default assessment** based on average industry and region values. This default assessment is quick to conduct and the quantity and quality of data required is limited. But two companies from the same industry operating in the same country will have the same "impact intensity" (*e.g.* impacts in MSA.km^2/EUR of turnover).

Such a default approach is not satisfactory when the objective is to distinguish companies of the same industry based on their actual practices. A **refined assessment** thus takes over when better data is available. This refined approach makes it possible to assess the effects of sourcing policies and of actions on a number of biodiversity pressures.

What datasets are needed to conduct an assessment as refined as possible? One rule of thumb is that the higher the spatial resolution, the better. Another is that data closely related to pressures on biodiversity (*e.g.* areas of land use changes, which are directly related to habitat degradation) will yield more refined results than monetary flow data. Similarly, physical flow data (*e.g.* production or purchases of rice in tons) should be preferred to monetary data (*e.g.* production or purchases in euros).

Figure 7 summarizes the steps followed during a default assessment. The boxes displayed as the "data inputs" of a "refined assessment" are data which can be used to replace intermediary values calculated in the default assessment. The steps are decomposed below[25], with arrows and text in blue representing how better data can be integrated in refined assessments.

1. Activity

- The **turnover by industry and country or region** is input to assess the **Production** of the activity assessed. In the case of the assessment of financial assets such as a portfolio of listed equities, this can include the turnover of multiple companies.
- The **Purchases** associated to this turnover are assessed thanks to the **EXIOBASE Input-output model**.
  - ➔ If **Purchases by industry and country or region** are known, they can be used directly instead.

2. Inventories[26]

- **Production** and **Purchases** data are translated into **Commodities and refined products**[27] and **Emissions** thanks to **EXIOBASE environmental extensions**[28].
  - ➔ If the actual quantity of **Commodities or refined products consumed** or the actual **Greenhouse gas emissions by Scope** are known, they can be used instead.
- **Service** consumption is another data used to assess the pressures which are not linked to commodity and product consumption (*e.g.* encroachment or land use changes caused by nature tourism and offices).
  - ➔ Similarly, actual **Service consumption** can replace the quantity assessed by the **Environmental extensions**.
- **Emissions** are in some cases re-assessed using **Commodity or refined product consumptions** (*e.g.* by applying impact factors originating from life cycle assessments or reference databases) instead of relying directly on figures from the **Environmental extensions**, which can be less accurate.

3. Pressures

- **Terrestrial** and **Freshwater** (or aquatic) **pressures**[29] are derived from inventories by using a range of **in-house tools**, which can be completed by **Life Cycle Assessments**. In particular, **Commodity or Service Tools** developed by CDC Biodiversité are used to link quantities of commodity or service consumption to pressures. The Crop Commodity Tool is for instance described in our previous technical report (CDC Biodiversité, 2017). Simple coefficients can also be used, for instance to translate greenhouse gas emissions into temperature increases.
  - ➔ Data expressed in units and perimeters compatible with the pressure-impact equations can be used directly instead of relying on approximations from inventories. This is the case for **Land use changes by type and location** and should also be the case for freshwater pressures such as **Nutrient emissions (nitrogen and phosphorous concentrations)** and **Wetland conversion**.

4. Biodiversity state and impacts

- The **state of biodiversity**, and thus **impacts on biodiversity**, are assessed using GLOBIO pressure-impact relationships (equations).
  - ➔ **Comprehensive ecological surveys** could in theory be used to directly extrapolate the MSA based on field data. In practice, collecting comprehensive-enough data is not practical nor economical in a majority of cases.

The term "**impact factor**" could be used to describe the coefficients that can be derived from the GBS to directly calculate the impact in MSA.km^2 of any quantity of any inventory or any pressure.

(25) The boundary between the inventories and pressures steps in Figure 7 is in fact blurry. A separation is artificially set in the figure, to simplify explanations. But in reality, there is a number of interactions between the two and the process is not purely linear with calculations moving from inventories to pressures.

(26) To simplify, we call "inventories" all the items between activity data and pressure data (defined here as data which can directly be used in pressure-impact equations).

(27) Refined products include for instance ferulic acid (see Solvay case study in section 4.2), which can be obtained from a co-product of rice. The impact of refined products can be assessed by using processing factors to return to quantity of commodities (we know how many tons of rice are necessary to produce one ton of ferulic acid for instance).

(28) EXIOBASE environmental extensions also include data on land use consumptions but these are limited to agricultural land use conversions and the level of details is lower than in the Crop Commodity Tool developed by CDC Biodiversité. This data is therefore currently not used in the GBS.

(29) Marine pressures are currently not covered by the GBS (cf. FAQ 6.7).

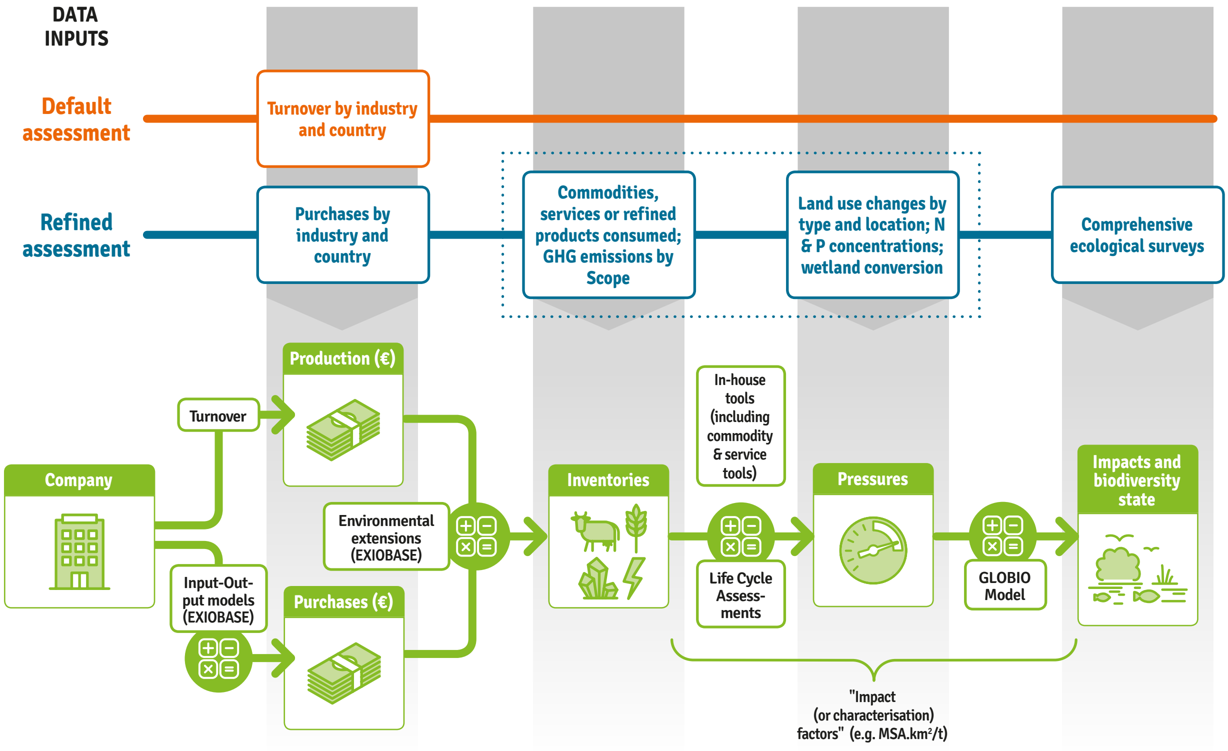


Figure 7: The GBS: an hybrid approach making best use of data available at each step of the impact assessment

In default assessments, the GLOBIO model is used at two levels. The first one is to provide the pressure-impact relationships as explained above. The second one is to provide expected biodiversity losses across the globe derived from the bio-physical and economic IMAGE integrated assessment model. The Commodity and Service Tools developed by CDC Biodiversité attribute these expected biodiversity losses to economic activities which are considered as sources for a number of pressures. If data on actual biodiversity losses were available at equivalent or better spatial resolutions, they could potentially be used instead of the expected biodiversity losses provided by GLOBIO and IMAGE.

In refined assessments, if data on pressures are directly available, the second use of GLOBIO (providing expected biodiversity losses) is not required.

Figure 8 illustrates how the GBS proceeds through a stepwise approach. A less accurate default value is calculated first through the default assessment, then the parts of the footprints which can be recalculated through refined assessments are replaced.

Accurate and **precise** data and impact factors have to be used to limit uncertainties in results. Accuracy refers to how close an assessed value is to the actual (true) value. Precision refers to how close the assessed values are to each other (Figure 9). A precise assessment will for instance be able to claim that the assessed value is "15.126" and not just "15".

In order to quickly **estimate data accuracy**, we use a quality tier system similar to the IPCC's tier system to describe the quality of impact factors. Tier 1 is generally the least accurate:

Data quality tier 1: simple linear approach. Tier 1 impact factors are international defaults.

Example: average agricultural yield of wheat across the world.

Data quality tier 2: region (country)-specific linear factors or more refined empirical estimation methodologies[30].

Example: average agricultural yield of wheat in France.

Data quality tier 3: impact factors derived from the use of relationships (equations) linking the impact source (for instance a land use change) to biodiversity impacts, with inputs requiring a translation into the appropriate typology. For instance, this covers cases where inputs are "impervious areas" and "permeable areas" and the

(30) Data quality tier 1 and 2 are actually associated with similar accuracy (they are both linear factors) but data quality tier 2 displays a higher precision. For instance, the (data quality tier 1) global yield of rice has a wide distribution around its average, whereas the yield of rice in a specific rice paddy has a narrower distribution around its mean.

relationships to biodiversity used is GLOBIO's MSA per land use type. In such a case, "impervious areas" and "permeable areas" need to be translated into one of the 13 habitat types used in GLOBIO through simple attribution rules to enable the application of GLOBIO pressure/impact relationships.

*Example: impact factors for **data in formats requiring transformation** to be fed to dynamic bio-geophysical simulation models using multi-year time series and context-specific parameterization (such as GLOBIO).*

Data quality tier 4: impact factors derived from the use of direct relationships (equations) to biodiversity.

*Example: impact factors for **data which can be directly** fed to dynamic bio-geophysical simulation models using multi-year time series and context-specific parameterization (such as GLOBIO). For instance, impact factors for each of the 13 habitat types used in GLOBIO.*

Data quality tier 5: direct measurements.

The quality tiers apply to impact factors, but, by extension, can be used to describe the quality of datasets based on the quality of the best impact factors which can be used with these datasets. For instance, if a dataset contains changes from impervious to permeable land uses (and vice-versa), at best, only **tier 3** impact factors can be used by approximating impervious and permeable land uses with habitats among the 13 types used by GLOBIO. Conversely, if the datasets contained directly land use changes from, for example, natural forest to cultivated grazing area (both GLOBIO land uses), a **tier 4** impact factor of 0.4 MSA.ha/ha could be used.

The format and quality of data which can be used by the GBS is further described in a regularly updated document: *Data collection guidelines for GBS assessments*.

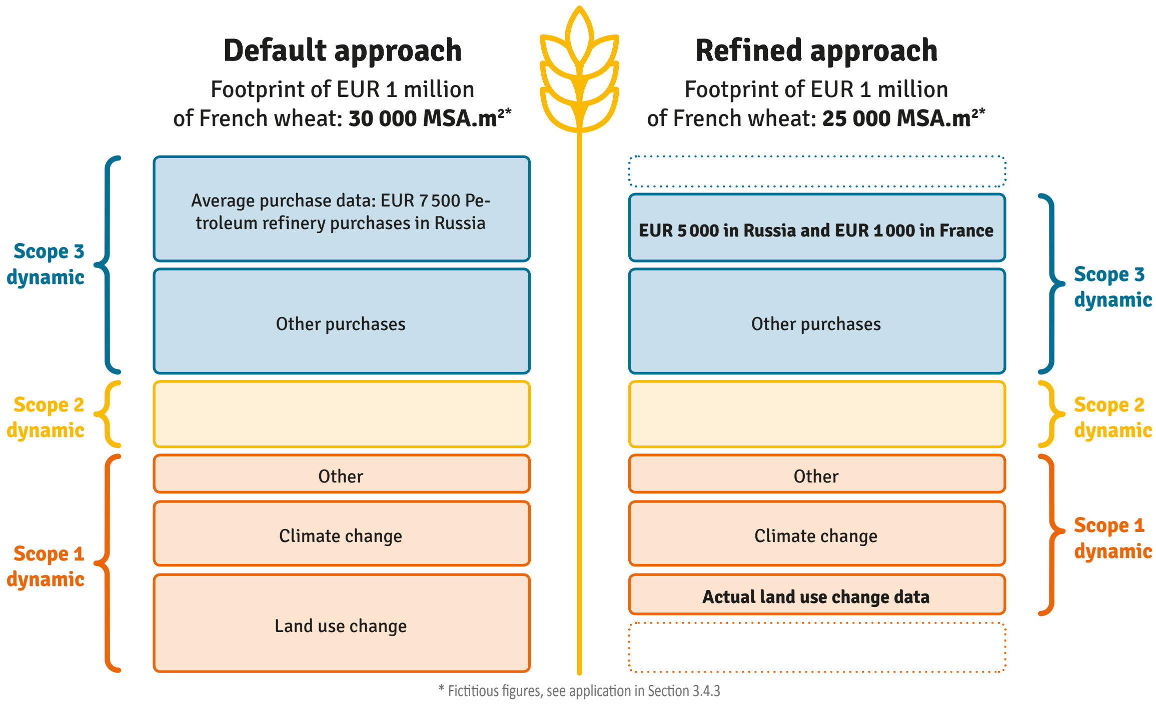


Figure 8: Illustration of the stepwise approach: less accurate footprints are replaced by more accurate ones if and when better data becomes available

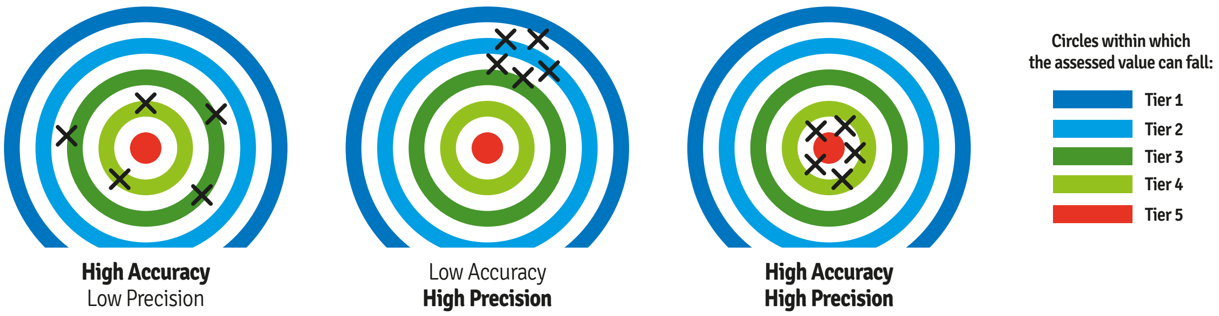


Figure 9: Use of data quality tiers to describe data accuracy

3.3 Perimeter and impacts throughout the value chain

3.3.1 Defining the perimeter under control

As noted in our common ground working paper (CDC Biodiversité, ASN Bank & ACTIAM, 2018), when assessing impacts throughout the value chain, clear rules are necessary to define the perimeter under the direct control of each entity. Impact attribution rules have been developed for carbon footprinting, *e.g.* by the Greenhouse Gas Protocol (World Business Council for Sustainable Development & World Resources Institute, 2004). These rules could also be used for biodiversity footprinting.

In general, three approaches can be considered, and the choice of one method over the other must be consistent with the (financial) accounting choices of the entity assessed:

- **Financial control**: the entity assessed "retains the majority risks and rewards of ownership of the operation's assets" (World Business Council for Sustainable Development & World Resources Institute, 2004), which usually means it controls more than 50% of the voting right of the considered operation. 100% of the impact of the operation is then considered to be "under the control" of, or attributed to, the entity.
- **Operational control**: the entity has "the full authority to introduce and implement its operating policies" (World Business Council for Sustainable Development & World Resources Institute, 2004). Similarly, 100% of the impact of the operation is then attributed to the entity.
- **Share of the assets owned**: the entity accounts for biodiversity impact according to its share (*pro rata*) of the assets or enterprise value (sum of debt and equity) owned.

3.3.2 Describing impacts across the value chain: the Scope concept

As also noted in our common ground working paper (CDC Biodiversité, ASN Bank & ACTIAM, 2018), a key concept developed by the Greenhouse Gas Protocol for climate footprinting to describe the impacts and their attribution through the value chain is **Scopes**. When considering the impact caused by a business, Scopes allow to distinguish between the impacts of a company's own operations and impacts occurring along its value chain; in particular those of its suppliers but also downstream impacts, *e.g.* due to products' use and end-of-life phases.

For carbon emissions, three Scopes are distinguished, which can be adapted for biodiversity as follows:

- **Scope 1**: impacts generated on the area controlled by the entity and other impacts directly caused by the entity during the period assessed.
- **Scope 2**: impacts resulting from non-fuel energy (electricity, steam, heat and cold) generation, including impacts resulting from land use changes, fragmentation, etc.
- **Scope 3**: impacts which are a consequence of the activities of the company but occur from sources not owned or controlled by the company, both upstream and downstream of its activities.

These three Scopes could also be grouped into **direct** (resulting from the organization's own activity) and **indirect** (resulting from activities in the value chain) impacts (GRI, 2007). With this definition, Scope 1 is equivalent to direct impacts. Scopes 2 and 3 are indirect impacts.

The three Scopes can be broken down into 'dynamic footprint' and 'static footprint'. *'Dynamic footprint'* is **the footprint caused by changes, consumptions or restorations**. However, existing pressures can limit the ability of biodiversity to thrive even without any change in pressures. For instance, the very existence of a palm oil plantation prevents the area it occupies from growing back into a natural tropical forest and thus prevents biodiversity from reaching 100% MSA. **This *'static footprint'* or *'ecological opportunity cost'*[31] is not used in climate footprinting but is very important for biodiversity** (see Figure 10). This static footprint includes all the '*persistent effects*' which remain over time. They can range from the spatial footprint (land use, fragmentation, encroachment) of existing facilities (excluding any consumption/expansion or restoration during the assessment period, which will be captured in dynamic Scope 1) but also the past emissions still impacting biodiversity today, for instance greenhouse gas emissions emitted years ago but still warming the atmosphere. They also include the persistent effects of past pollutions, for instance in freshwaters. Due to its holistic nature, today, part of the global static footprint cannot be attributed to any economic activity.

Also, static footprints should be accounted for separately and, unlike dynamic footprints should not be summed up over time to avoid double-counting.

The concept of dynamic and static footprints is useful for all impact assessment methodologies to describe clearly and more comprehensively what impacts are assessed and what causes these impacts. It is not specific to the GBS.

Figure 10 is a simplified illustration, with only three pressure types represented and not all Scopes represented for each pressure, but the Scope concept applies to all pressure types. On top of purchased goods and services and use and end-of-life treatment of sold products, Scope 3 also includes other impacts which are not represented for simplicity sake. Upstream Scope 3 also includes capital goods, fuel and energy related activities, upstream trans-

(31) In microeconomic theory, the opportunity cost is the 'cost' incurred by not enjoying the benefit that would have been if an alternative scenario had occurred. It is not necessarily a monetary or financial cost. Here we use the term 'ecological opportunity cost' to address the biodiversity lost due to the existence of an economic activity, compared to a scenario where the activity would not exist.

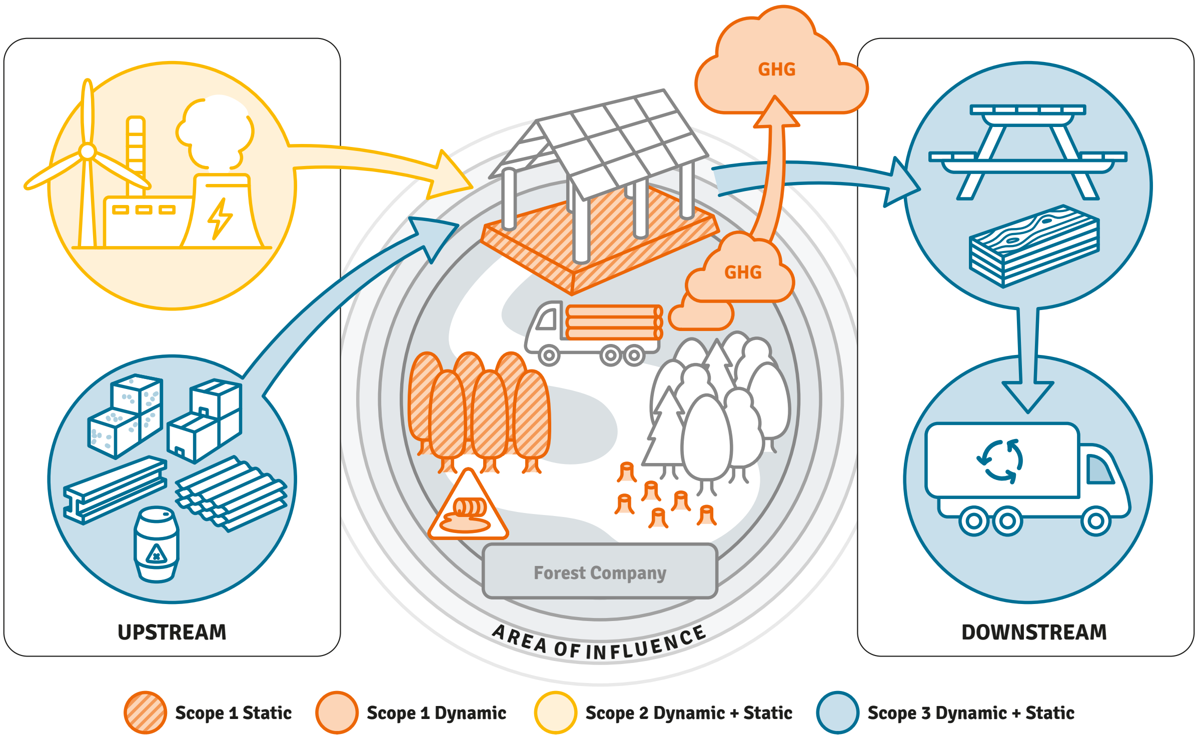


Figure 10: Graphical presentation for the three Scopes (simplified, with only three pressures)*

*In our common ground working paper, the *static footprint* was also called the "*Scope 0*".

portation and distribution, waste generated in operations, business travel, employee commuting and operation of assets leased by the reporting company. Downstream Scope 3 includes downstream transportation and distribution, processing of sold products (by downstream companies buying them), operations of assets leased to other entities, franchises and investments.

In Figure 10, the harvested plantation expands over natural forest during the period assessed, and the associated land use change causes a Scope 1 dynamic habitat change impact. Forestry activities, such as fertilization, harvesting and log transport also cause Scope 1 dynamic impacts, in terms of climate change and pollution. In addition to these Scope 1 *dynamic* impacts, the log storage facility and the plantation trees generate a Scope 1 *static* footprint by occupying an area that is thus unavailable for intact natural habitats (this can be considered an "ecological opportunity cost"). The impacts caused by the generation of the energy purchased to power the storage facility (in particular electricity) belong to the dynamic and static Scope 2 of the forestry company. Finally, all the upstream inputs and downstream use and end-of-life of the forestry products generate dynamic and static Scope 3 impacts.

The concept of Scopes makes it possible to avoid double counting at the corporate level by reporting Scope 1, 2 and 3 and dynamic and static impacts separately and not adding them at the company level.

Figure 11 illustrates how the figures obtained with the GBS and expressed in Scopes fit with the broader global figures (as detailed in **Box 2**). It represents the MSA of our planet. Earth had a global average terrestrial MSA of about 65% in 2010 (Lucas & Wilting, 2018). In other words, the remaining global terrestrial biodiversity was about 86 million MSA.km^2 or 65% of the total land area (excluding Antarctica and Greenland).

We are losing about 0.25% global terrestrial MSA per year (Lucas & Wilting, 2018). If we consider that all this loss is due to economic activities, it means that the sum of all the dynamic Scope 1 of all economic activities on the planet is equal to 330 000 MSA.km^2/year or 0.25% of the total land area. As impacts are summed across all companies, Scope 2 and 3 must not be summed to avoid double-counting (as the Scope 2 or 3 of one company is the Scope 1 of others).

The difference between an intact and undisturbed Earth and the current situation is about 35% of the total land area. It corresponds to the sum of all the static Scope 1 associated to economic activities and to other static impacts which might not currently be attributed to any economic source, such as past greenhouse gas emissions lingering in the atmosphere.

Every year, the remaining global average terrestrial MSA shrinks, eaten up by new losses (the annual dynamic Scope 1). Meanwhile the static Scope 1 expands, absorbing the losses from the previous year. For example, in 2011, the remaining global average terrestrial MSA would be 64.75% and the sum of all static Scope 1 and unattributable losses would reach 35.25%.

In principle, Scope 1, Scope 2 and Scope 3, dynamic and static should all be included in assessments (Figure 12). When deviating from this, it should be made clear why. The inclusion of Scope 3 is particularly important for biodiversity, especially the upstream part since most impacts on biodiversity take place during raw material production.

Ideally, downstream Scope 3 should also be included in assessments. In practice, appropriate methodologies are currently lacking to properly take downstream impacts into account. The GBS does not yet account for downstream impacts but aims to include them in the future.

3.4 Default assessments

3.4.1 The EXIOBASE environmentally extended input-output model, foundation of the default assessments

Input-output models are constructed from observed economic data and provide information about the activity of industries that both produce and consume goods. Those interindustry relationships are derived from interindustry transaction tables in which the rows describe the composition of inputs required by a particular industry to produce

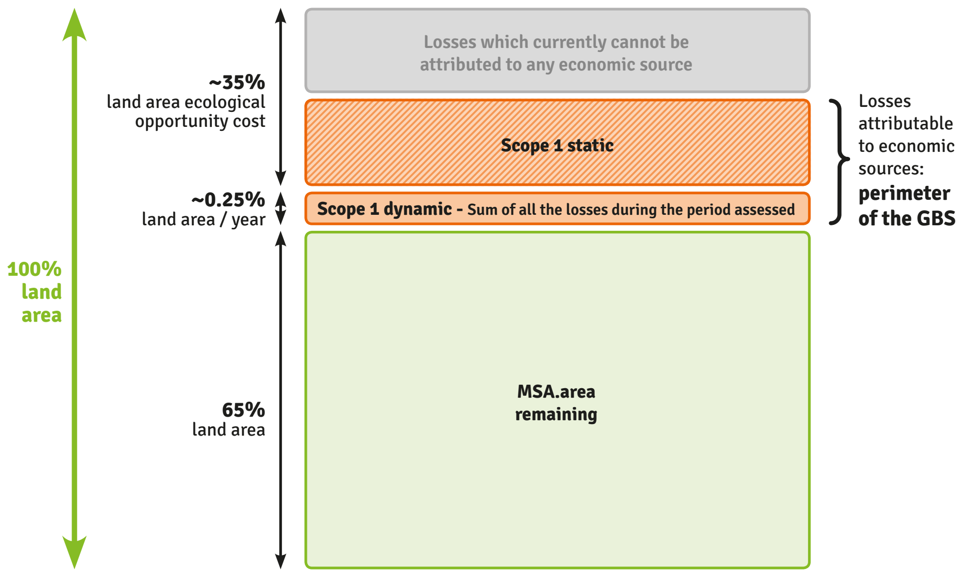


Figure 11: MSA of the Earth - the static Scope: the link between the GBS and the total MSA of Earth

	Impacts generated by				
	Raw material energy supplier	**Raw material producer**	**Manufacturer energy supplier**	**Manufacturer**	**User**
Raw material energy supplier inventory	S1D & S1S	Downstream S3D & S3S			
Raw material producer inventory	S2D & S2S	S1D & S1S	Downstream S3D & S3S	Downstream S3D & S3S	Downstream S3D & S3S
Manufacturer energy producer inventory			S1D & S1S	Downstream S3D & S3S	
Manufacturer inventory	Upstream S3D & S3S	Upstream S3D & S3S	S2D & S2S	S1D & S1S	Downstream S3D & S3S
User inventory	Upstream S3D & S3S	Upstream S3D & S3S	Upstream S3D & S3S	Upstream S3D & S3S	S1D & S1S

Figure 12: Accounting for biodiversity impacts throughout a simplified value chain (S1, S2, S3: Scope 1, Scope 2, Scope 3; D: dynamic; S: static)

its output. In multi-regional input-output (MRIO), data are spatialised and flows between geographical regions are detailed. As illustrated by Figure 13, additional columns represent final demand, *i.e.* the sales to final markets (consumers, government, exports), and additional lines deal with value added, *i.e.* account for non-industrial production inputs (labour, capital, etc.)[32].

The input-output framework seems particularly suited to the analysis of global supply-chain-related environmental pressures. Indeed, it has been extended to account for pollution generation and abatement associated to economic activity since the late 1960s. Environmental – and social – "extensions" allow the comprehensive examination of a wide variety of factors – employment, pollution, water, capital expenditures, etc. – associated to economic activities and policies. Environmentally extended multi-regional input-output (EEMRIO) models are used today to assess climate, water and material resources footprints of production and consumption at national or regional levels. In short, while MRIO models provide a mathematical representation of the flows of goods and services between industries all over the world by documenting the monetary transactions involved in production and consumption, EEMRIO models are appropriate for analysing the supply-chain-related environmental pressures due to production and consumption activities.

EEMRIO models provide data on material, water and land-use consumptions and emissions of substances related to the economic activities of a detailed list of industries all over the world (the "Environmental extensions" in Figure 13). They are recognised as key frameworks to provide a comprehensive description of the global economy and analyse its effect on the environment and are thus interesting tools to support biodiversity footprint methodologies. In fact, Wilting, Schipper, Bakkenes, Meijer, & Huijbregts (2017) and Wilting & van Oorschot (2017) use such a framework to quantify biodiversity losses due to, respectively, consumption and production activities in the Netherlands. EEMRIO models display several advantages in the development of GBS compared to, for instance, the life-cycle analysis framework:

1. They allow the evaluation of companies based solely on the distribution of their turnover across regions and industries;
2. Conceptually, all industries of all countries can be evaluated simultaneously;
3. They are self-contained and guarantee internal consistency between and within monetary as well as physical amounts.

Those models are based on a sectoral approach and face limits when analysing companies within the same industry. Indeed, in an EEMRIO framework, two companies operating in the same industries and the same regions cannot be distinguished otherwise than by the monetary value of their production. Thus, three main applications of EEMRIO tools in the GBS are envisaged:

- Providing **benchmark industry footprints at the national level**;
- Calculating a **generic corporate footprint** for companies with limited information. The footprint obtained would be considered as a "default footprint" with room for improvement if the company choses to disclose more specific data. As explained below, computing the footprint of a company using EEMRIO data only requires the knowledge of the breakdown of its activity by country and industry. The main industry and the location of the headquarter of each company is usually known. The distribution of turnover by country and industry can sometimes be deduced from the company's annual reports but is not always available.
- Calculating the **footprint of financial assets**. The footprint of the companies financed is first assessed ("dimensioning" of the impact), then attribution rules specific

(32) Within a country, the sum of value added is equal to the Gross Domestic Product (GDP).

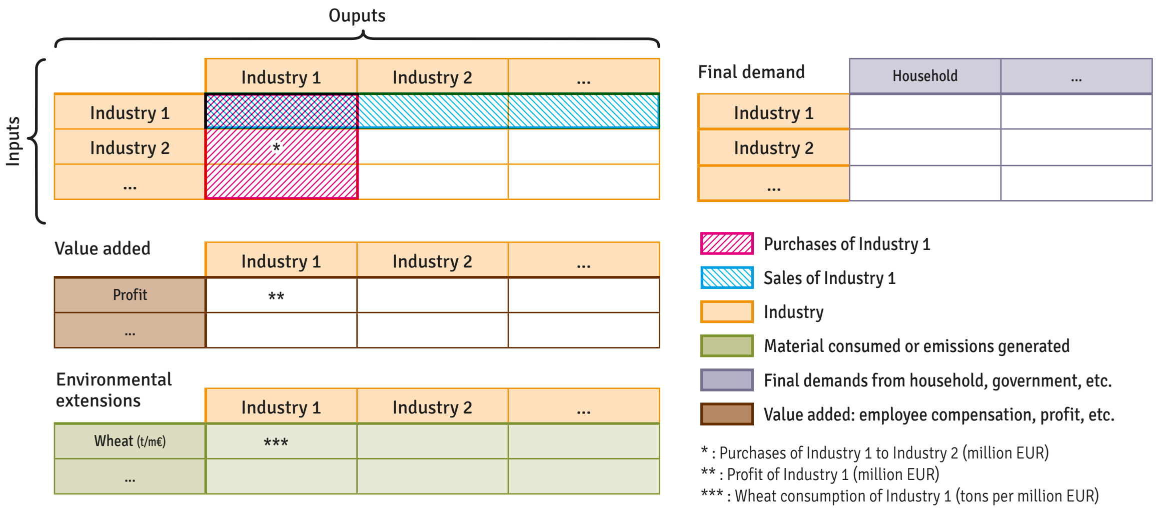


Figure 13: Components of an Environmentally extended multi-regional input-output (EEMRIO) **model.**

BOX 3

The EXIOBASE EEMRIO model

The EEMRIO model used in the GBS is EXIOBASE version 3.4 (Stadler et al., 2018), noted "EXIOBASE 3" in the rest of the report. It is a time series of EEMRIO tables ranging from 1995 to 2011 for 49 regions (44 countries and 5 rest of the world regions) and 163 industries. Though the time series provide information for analysing the dynamics of environmental pressures of economic activities over time, only the data for year 2011 are used in the GBS. Data related to environmental impacts are grouped into 4 accounts:

- The **emission account** provides quantitative data on industry-specific emissions of 27 pollutants, including GHGs, nitrogen and phosphate;
- The **water account** documents water consumption (blue and green) and water withdrawal of agricultural, manufacturing and energy production activities;
- The **material account** documents the extraction of 222 raw materials, including biomass items, metal ores, minerals and fossil fuels;
- The **land account** lists the area consumption related to agricultural and settlement activities for 15 types of land use.

to the asset class are applied to evaluate the impact which can be attributed to the funding source ("attribution" of the impact). The monetary framework of EEMRIO proves especially appropriate in this context.

The remainder of this section provides a detailed description of the approach used to assess default corporate and portfolio footprints and an example of application.

3.4.2 Default assessment computation

A OVERALL APPROACH

The **first step** of the corporate default assessment is to link the production of EUR 1 million of any industry and any region to direct (Scope 1) biodiversity impacts. This analysis can be broken down in two sub-steps:

1. The assessment of the inventory data of the production of EUR 1 million worth of output of any industry in any region.

This component gives information on the contributions of the activity to drivers of biodiversity loss, mostly the emission of GHGs and the consumption of raw materials and water. It is calculated based on the environmental extensions of the EEMRIO model EXIOBASE 3. These "direct environmental impacts" include pollutant emissions and material consumptions, among others. They are gathered in what we call the "D matrix", following Wilting & van Oorschot (2017). In the life-cycle analysis world, they would be called "inventory data", as in Figure 7.

2. The assessment of the "biodiversity impacts" of the drivers.

This component gives information on the loss of biodiversity caused per unit of driver (kg CO_2-eq, ton of raw material) in MSA.km². We call it the "M matrix", following Wilting & van Oorschot (2017). It is spatially explicit and calculated based on the combination of the GLOBIO model and several commodity-specific tools developed by CDC Biodiversité.

At each sub-step, computation is conducted simultaneously for all industries and regions using dedicated matrices.

The **second step** of the analysis is to combine these data with the multi-regional input-output part of EXIOBASE 3 to assess the purchases of each sector across its entire value chain and thus its upstream biodiversity impacts. The result is the direct and supply chain related biodiversity impacts of EUR 1 million worth of output of any industry in any region in MSA.km².

It can be used at various levels of the GBS methodology, either for default corporate assessments or in refined assessments when a company directly provides financial data about its purchases (see Figure 7). The IO framework also enables the distinction of the various tiers[33] of the supply chain (direct suppliers, suppliers of the direct suppliers, direct users and so forth).

B DEALING WITH DATA GAPS

The computation of a default corporate footprint requires very limited data, namely the **turnover of the company broken down by region and industry of operation**. Ideally, those data should be provided in the **EXIOBASE nomenclature**, *i.e.* using EXIOBASE 3 region and industry terminologies, and **grouped by {region; industry} pairs**, *i.e.* splitting the turnover made in industry X between {region A; industry X} and {region B; industry X}. We learnt from the case studies (see **section 4.3**, BNP Paribas Asset Management case study) that such detailed data is however seldom available. Most often, the data provided either

(33) "Tier" here refers to supplier tier (tier 1 are direct suppliers, tier 2 are the direct suppliers of one's tier 1 suppliers, etc.). This is a totally different concept from the "data quality tiers" introduced in section 3.2.

do not fit the EXIOBASE nomenclature or document the region and industry mix separately instead of by {region; industry} pair. We thus apply data transformation rules so that the data format fits the required GBS input. Two guiding assumptions shape these rules. The first is that getting industry figures right matters more than getting regional figures right because we assume that in most cases, difference between industries are more significant than regional differences (*e.g.* Cultivation of wheat is more different from Petroleum refinery than Cultivation of wheat in France is different from Cultivation of wheat in Germany). The second is that the best hypothesis when data on turnover breakdown are lacking is to consider the average region or industry breakdown. In some situations, these assumptions may be clearly misleading, the assessors should then either take more appropriate assumptions, or avoid assessing the problematic entity altogether, if no satisfying assumptions can be made. Overall, assumptions should ensure assessments are fit for purpose, rigorous and consistent.

The cases most commonly encountered so far and the corresponding rules are presented below.

The data is in a nomenclature other than EXIOBASE 3.

We established correspondence tables between the European NACE rev 2 nomenclature of industries and EXIOBASE 3. Industry-related data can thus be provided in NACE rev 2 nomenclature, as well as in the French INSEE nomenclature. If the data is provided in another nomenclature, we convert it manually to the most appropriate EXIOBASE category.

The level of detail of the region or industry documented is different from that of EXIOBASE categories.

As presented, EXIOBASE region categories are at the country or group of country level. Three sub-cases can occur.

First, data can be provided at a lower geographical level than EXIOBASE (*e.g.* infra-national state or county). They are then allocated to the corresponding country.

Second, data related to countries not individually listed in EXIOBASE are allocated to one of the corresponding "Rest of" regions (for instance "Rest of Asia").

Third, data related to wider geographical areas than the EXIOBASE 49 "regions" (*e.g.* a turnover reported for the entire European Union and not separately for each Member State) are allocated to one of EXIOBASE 3's 11 region groups that fit the most commonly used regional entities (*e.g.* European Union, Asia, South America). If none of the 11 region groups fit, it is associated to the "World" region group, specific to GBS analyses.

In this third case where turnover is specified at the region group level, data undergoes a second step during which the associated turnover is split between the regions of the group based on the share of the production of the group in each region. For instance, if the company operates in the industry "Cultivation of wheat" but turnover data – say EUR 100 million – is documented for the European Union as a whole, the turnover will be split between the countries of the European Union according to their share in the production of the industry "Cultivation of wheat" in the total industry production in the European Union as reported in EXIOBASE 3. Thus, we will assume that only 5% of the "Cultivation of wheat" turnover of the company is made in Belgium if the Belgian production of wheat represents 5% of the European Union's production of wheat. In short, when data is documented at the group level, we assume that the company's mix fits EXIOBASE mix.

In all three cases, the rules applied to regions are similarly applied to industries.

The region mix and industry mix of turnover are documented separately instead of by {region; industry} pair.

Three cases are distinguished.

First, if the company operates in only one industry and several regions, the turnover is split between the regions documented based on the share of turnover made in each region.

Second, if the company operates in only one industry and one or more region groups, the turnover is first split by region group based on the share of turnover made in each region group to obtain {region group; industry} pairs. Then, it is split between the regions of each group based on the share of the region in the region group production for the industry to obtain {region; industry} pairs.

Third, if the company operates in several industries or industry groups and one or more regions or region groups, maintaining both the documented region and industry mixes while using average turnover breakdown (in line with the second guiding assumption listed above) would lead to inconsistencies. Considering the first guiding assumption that industry level data are more discriminating than region level data, we only use the company's industry level mix data and rely on EXIOBASE data to split the turnover between the regions listed.

The turnover split per region or region group is not available.

We use EXIOBASE region mix for the industry of interest. For each industry, the turnover is split between the 49 regions according to the share of each region in the world production of the industry in EXIOBASE data and the rules described above are applied.

The turnover split per industry or industry group is not available.

We manually classify the company into the most relevant EXIOBASE industry and consider that 100% of its turnover is made in this industry. If this assumption is not satisfactory, it might be preferable to keep the company out of the assessment altogether. The rules described above are applied.

C DISTINGUISHING SCOPES

Impacts assessed through the direct environmental impacts and biodiversity impacts matrices are broken down between Scope 1, Scope 2 and Scope 3.

Scope 1 impacts correspond to the impacts related to the company's production, *i.e.* its own turnover in the various {region; industry} pairs where it operates, not considering the related purchases.

Scope 2 impacts refer to the biodiversity impacts of the generation of the electricity, steam, heat and cold purchased. By definition, it includes only tier 1 suppliers, *i.e.* the ones selling directly to the company, and not those generating energy for the companies' other suppliers. These purchases in the various {region; industry} pairs are identified thanks to the IO tables which display the purchases to the non-fuel energy generation industries(34) and the part related to generation is then isolated. For now, only the climate change impacts of Scope 2 are considered, defined as the impacts due to combustion-related GHG emissions (EXIOBASE distinguishes combustion and non-combustion emissions).

Upstream Scope 3 impacts refer to all the remaining upstream impacts. They are computed based on the purchases related to the company's activity in the various {region; industry} pairs and the different suppliers' tiers (tier 1, tier 2, etc. suppliers) are distinguished thanks to the IO tables.

D FINANCIAL ASSET FOCUS: LISTED EQUITIES AND CORPORATE DEBT

This section deals with one of the three applications of the EEMRIO framework in the GBS: financial asset footprint assessment.

An equity portfolio can be seen as a bundle of business activities. Corporate loans can be seen in a similar light, with debt replacing equity. In both cases, the funding source can be considered to own part of the businesses it finances. Consequently, a part of the impacts generated by the businesses financed can be attributed to the funding source.

As explained above, assessing the **footprint of financial assets** involves two steps.

First, in the **dimensioning step**, the biodiversity impact of the business activities financed are assessed. If no specific data is available, this involves the default corporate assessment methodology described above. This approach can be applied only to listed equity and the debt of large corporations. For private equity, data are usually too scarce to conduct default assessment with the methodology described above. For small and medium enterprise corporate loans, data will be similarly lacking.

Then, in the **attribution step**, a fraction of the footprint of the companies financed is attributed to the funding source. To do so, attribution factors are computed for each company and are defined as the share of the company's enterprise value owned by the funding source, *i.e.*

$$attribution\ factor_{company,portfolio} = \frac{financed\ value_{company,portfolio}}{enterprise\ value_{company}}$$

The attribution factor is the same for listed equity and corporate loan. It is in line with the attribution factors used by the Platform for Carbon Accounting for Financials (PCAF, 2017).

The total footprint is thus:

$$Footprint_{portfolio} = \Sigma_{company \in portfolio} Footprint_{company} \times attribution\,factor_{company,portfolio}$$

Although the conceptual definition of the attribution factors is straightforward, practical issues occur when computing them in practice. Indeed, the value and the number of shares of the companies fluctuate over time, so that the attribution factors described above as $\frac{investment\ value}{enterprise\ value}$ also fluctuate. For instance, let's consider the example we took in our Common ground working paper (CDC Biodiversité, ASN Bank & ACTIAM, 2018): a company Z with a debt of EUR 1000 and 10 shares with an initial value of EUR 100 per share and thus a market capitalization of EUR 1000. If the shares' valuation moves from EUR 100 per share to EUR 50 per share, the attribution factor changes:

Initial attribution factor for owner of 1 share:

$$\frac{100}{10 \times 100 + 1000} = 5\%$$

Attribution factor for owner of 1 share after the price change:

- If the value invested (EUR 100) is used:

$$\frac{100}{10 \times 50 + 1000} = 6.6\%$$

- If the current value of the investment is used (EUR 50):

$$\frac{50}{10 \times 50 + 1000} = 3.3\%$$

Also, the attribution factor changes if there is a share buyback or a share emission, or if the ratio of the investment over the market capitalization evolves. Hence, assessing the attribution factors on a particular date, *e.g.* December 31st, may lead to biases. Computing attribution factors more frequently and averaging them over the period considered is a possible solution to this issue, though more data intensive.

Defining the most appropriate methodology to compute the biodiversity footprint of other financial products (loans, governments bonds) could be at the agenda of the work of the Platform Biodiversity Accounting for Financials (PBAF) for 2019.

(34) The energy production industries are: production of electricity by coal, production of electricity by gas, production of electricity by nuclear, production of electricity by hydro, production of electricity by wind, production of electricity by petroleum and other oil derivatives, production of electricity by biomass and waste, production of electricity by solar photovoltaic, production of electricity by solar thermal, production of electricity by tide, wave, ocean, production of electricity by geothermal, steam and hot water supply.

3.4.3 Application: Scope 1 and tier 1 biodiversity footprint of the production of EUR 1 million of French wheat

We illustrate the methodology using the example of the computation of part of the biodiversity footprint of the production of EUR 1 million worth of French wheat. The pressures assessed are listed in Figure 14. The impact beyond direct suppliers (tier 1) is not assessed and the impact related to non-crop raw materials is also not assessed. Both will be assessed in 2019.

The Wheat production industry in France purchases from many other industries and listing the impacts associated with all of them would make the example barely readable. In order to keep explanations simple and reader-friendly, the example thus highlights the impacts caused by two specific purchases, which represent only a small fraction of the total impacts.

The two steps of the default assessment computation described above are followed.

The **first step** links the production assessed to its direct biodiversity impacts. As explained, it is divided into two sub-steps. In the **first sub-step**, “direct environmental impacts” related to {France; Cultivation of wheat} are extracted from EXIOBASE environmental extensions. Here, the GHG emissions documented in the emission accounts is 842 593 kg CO_2-eq. The raw material quantity documented in the material accounts is 5 289 t of wheat.

In the **second sub-step**, biodiversity impacts are computed based on the inventories obtained through the first sub-step. For raw materials, the crop commodity tool is used. This tool is presented in details in the previous publication (CDC Biodiversité, 2017) and its update is detailed in **section 3.5**. The Scope 1 impact of the production of 5 289 t of wheat is assessed at 2 000 MSA.m^2.

GHG emissions related impacts are computed using the “climate change” factor (described in **section 3.5.2**). The Scope 1 impact related to GHG emissions amounts to 3 700 MSA.m^2.

The **second step** repeats the analysis for suppliers. In this example, the perimeter is limited to direct (*i.e.* tier 1) suppliers. The amounts purchased for the production of EUR 1 million worth of French wheat are documented in the IO table. Among many other purchases, the purchase of EUR 7 500 from {Russia; Petroleum refinery} is required. In the rest of the text, we focus only on the impact related to {Russia; Petroleum refinery} (but Table 1 includes the impacts generated by all purchases). In the first sub-step, the GHG emissions are identified from the emission account (the raw material extraction induced could also be read from the material account but it is excluded from the perimeter of this example). The amount of refined petrol purchased causes the emissions of 4 226 kg CO_2-eq.

Concerning the Scope 2 impacts (impacts related to the generation of the electricity, steam, heat and cold purchased), IO tables provide all the non-fuel energy purchases. We focus on purchases from {France; Production of electricity by coal} (though Table 1 also includes impacts from other purchases). Only EUR 65 are purchased from {France; Production of electricity by coal}, inducing the emission of 736 kg CO_2-eq.

In the second sub-step, the biodiversity impacts for the two specific purchases we focus on are evaluated. For petrol purchases, they amount to 18 MSA.m^2 and for the Scope 2 impact of purchases from {France; Production of electricity by coal}, they amount to 3 MSA.m^2. These impacts are very limited due to the perimeter of the study. In general though, Scope 2 and 3 represent a significant share of the total impacts of businesses, especially when impacts across the entire upstream value chain are considered.

The output of the assessment for French wheat is presented on Table 1 and Figure 15.

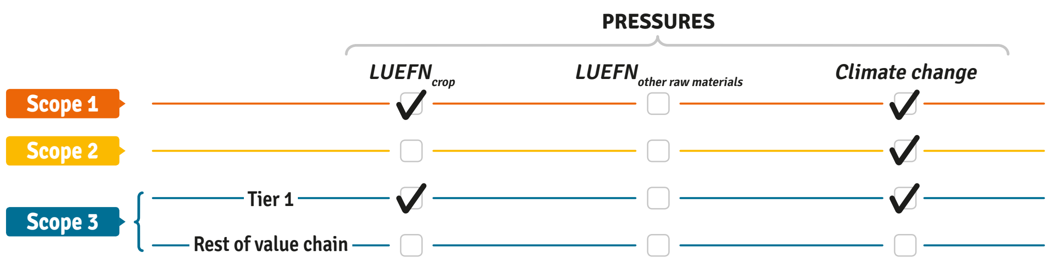


Figure 14: Perimeter of the pressures assessed in this application
(LUEFN: land use, encroachment, fragmentation and atmospheric nitrogen deposition)

Perimeter	Scope 1		Scope 2		Scope 3, tier 1		Rest of Scope 3	
Pressure	*CC*	*LUEFN*	*CC*	*LUEFN*	*CC*	*LUEFN*	*CC*	*LUEFN*
Impact (MSA.m²)	3 700	19 000	7	TBA in 2019	7 300	TBA in 2019	TBA in 2019	TBA in 2019

Table 1: GBS output for the production of EUR 1 million worth of French wheat. CC: Climate change, LU: Land use, E: Encroachment, F: Fragmentation, N: Nitrogen deposition, TBA in 2019: To be added in 2019

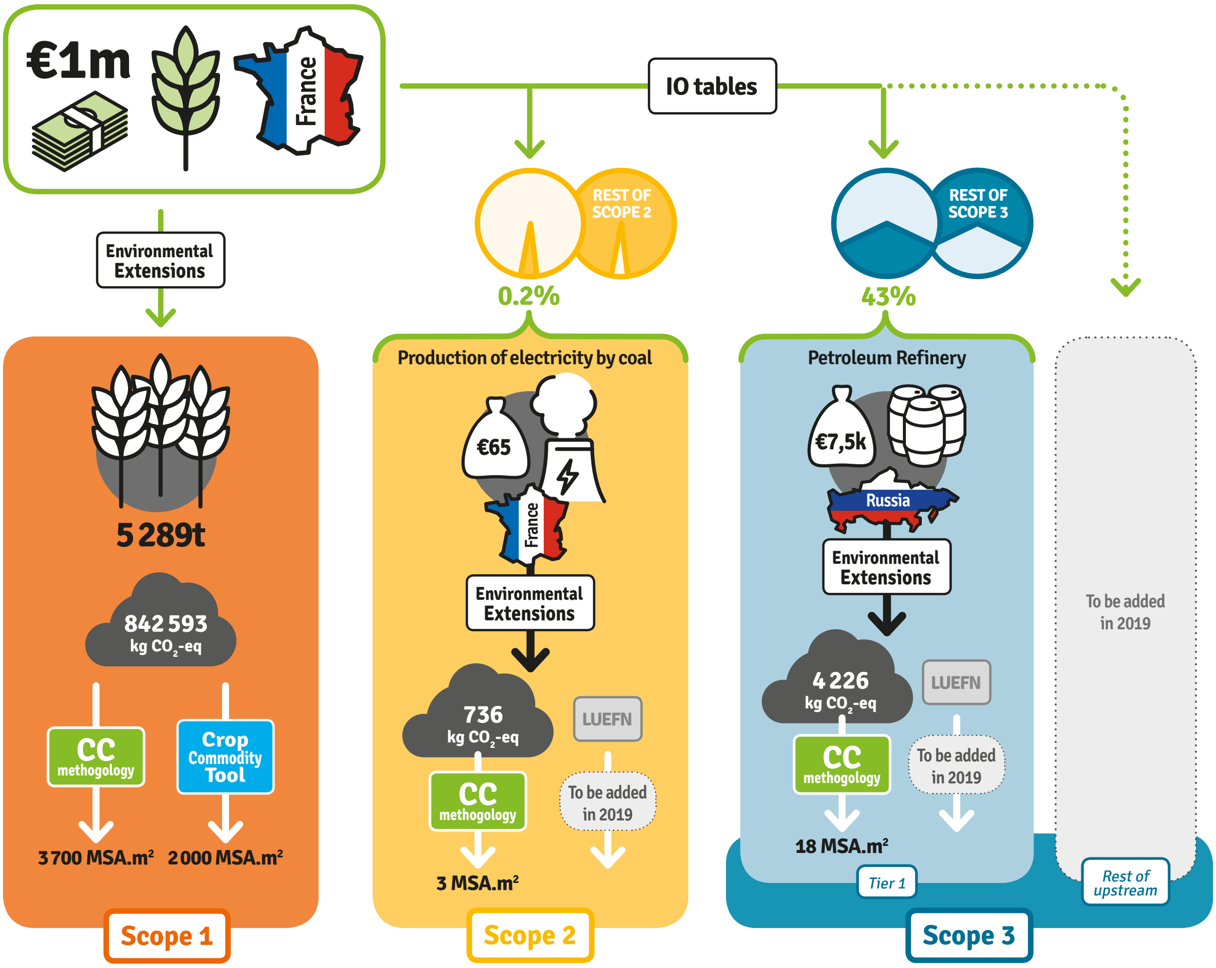


Figure 15: Illustration of the assessment of some of the impacts of EUR 1 million of Wheat cultivation in France with the EEMRIO framework (caption: see Table 1)

3.5 From pressures to impacts – updates

3.5.1 Spatial pressures

For terrestrial biodiversity, the GLOBIO model considers three spatial pressures: land use, encroachment and habitat fragmentation. This section focuses on how the concepts of dynamic and static footprints apply for the spatial pressures. Elements presented here concerning the dynamic footprint are an update of what was presented in GBS's last technical paper (CDC Biodiversité, 2017). Indeed, the GBS methodology was then focusing only on the dynamic footprint. Only land conversion is presented here, the methodology used for fragmentation and encroachment follows the same principles.

Land conversion dynamic footprint

In GLOBIO, 13 land-use categories and their associated MSA (in percentage, hereafter designated as MSA%) are considered. Let's consider a fixed perimeter *P*. This perimeter can be a GLOBIO cell, a country, a region, etc. From year *n* to year *n+1*, the land uses on this perimeter *P* changed, some of them extended and, as the total surface remains constant, some of them shrank. In other word, land conversion happened leading to a change in the state of biodiversity ("biodiversity variation") which can be a loss or a gain. The question here is how to allocate this biodiversity variation to the different types of land uses. First, we define the restricted perimeter *RP* which sums up land use differences between year *n* and year *n+1*. Areas where the land use did not change between year *n* and *n+1* are excluded from *RP* (step 1 in Figure 16). The change in biodiversity is then allocated to the final land uses of *RP* (year *n+1*), as we consider that responsibility for the biodiversity variation falls on land uses that remain at the end of the period. Since the exact conversion process is unknown – land use repartition in years *n* and *n+1* is known but no data on the evolution of each specific land use is available, *e.g.* which land use replaced which one – we assume that the conversion started from an average land use reflecting the average biodiversity value of *RP* in year *n* (step 2 in Figure 16). Biodiversity loss due to land conversion allocated to each land use LU is computed as follow:

$$MSA\ conv.dynamic_{LU}^{n \to n+1} = S_{LU}^{n+1} \times (MSA_{RP}^{n} - MSA_{LU})$$

With $MSA\ conv.dynamic_{LU}^{n \to n+1}$: biodiversity variation due land use conversion attributed to land use LU (MSA.m²)

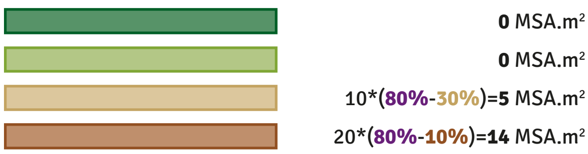
S_{LU}^{n+1} : surface in RP at year n+1 for land use LU

MSA_{RP}^{n} : average MSA in year n of all land uses within RP (in %)

MSA_{LU} : MSA for land use LU (in %)

Figure 16 gives a simplified example with only 4 land uses distributed on a perimeter *P* of surface 100 m² to illustrate the methodology.

The biodiversity loss for each land use is finally computed as follows:



In default assessments, *i.e.* assessments based on modelled data only, if the sum of biodiversity loss generated by the three spatial pressures is negative (*i.e.* they generate biodiversity gains) then it is capped at 0. This reflects the conservative stance adopted by the GBS in default assessments: if no data is available to demonstrate that farmers are actually reducing their area of agricultural land use (leading to less biodiversity being lost to spatial pressures), we consider that the reduction in agricultural area is due to some farmers stopping their activity, while the remaining farmers maintain their existing areas.

It does not mean that GBS methodology cannot account for potential gains for spatial pressures, it is still possible in the refined assessment with appropriate and robust data justifying it.

Static footprint for spatial pressures

As a reminder, static footprint for a given pressure is the opportunity cost or the potential gain that could be achieved over the long run if that pressure disappeared. Here, to simplify, there is no other pressure than land occupation (so the area is not subject to climate change, nitrogen deposition, fragmentation nor encroachment). The static footprint for land occupation only is then computed as follows for each land use:

$$Static\ occupation\ loss_{LU}^{n} = S_{LU}^{n} \times (100\% - MSA_{LU})$$

With $Static\ occupation\ loss_{LU}^{n}$: static footprint for land occupation for land use LU in year *n* (in MSA.m²)

S_{LU}^{n} : surface of land use LU in year n (in m²)

MSA_{LU} : MSA for land use LU (in %)

Using the previous simplified example (Figure 16), we obtain:

$$Static\ occupation\ loss_{P}^{n} = 30 \times (1-1) + 30 \times (1-0.7) + 20 \times (1-0.3) + 20 \times (1-0.1) = 41\ MSA.m^2$$

$$Static\ occupation\ loss_{P}^{n+1} = 20 \times (1-1) + 10 \times (1-0.7) + 30 \times (1-0.3) + 40 \times (1-0.1) = 60\ MSA.m^2$$

Note that, on a fixed perimeter and when only land use pressures apply, the following equation is verified:

$$Static\ land\ use\ loss_{P}^{n+1} = Static\ occupation\ loss_{P}^{n} + \sum_{LU} dynamic\ conversion\ loss_{LU}^{n \to n+1}$$

In reality, other pressures than land use will apply and the static footprint will be the difference between 100% and the current MSA (resulting from the combination of all the pressures), integrated over the area considered.

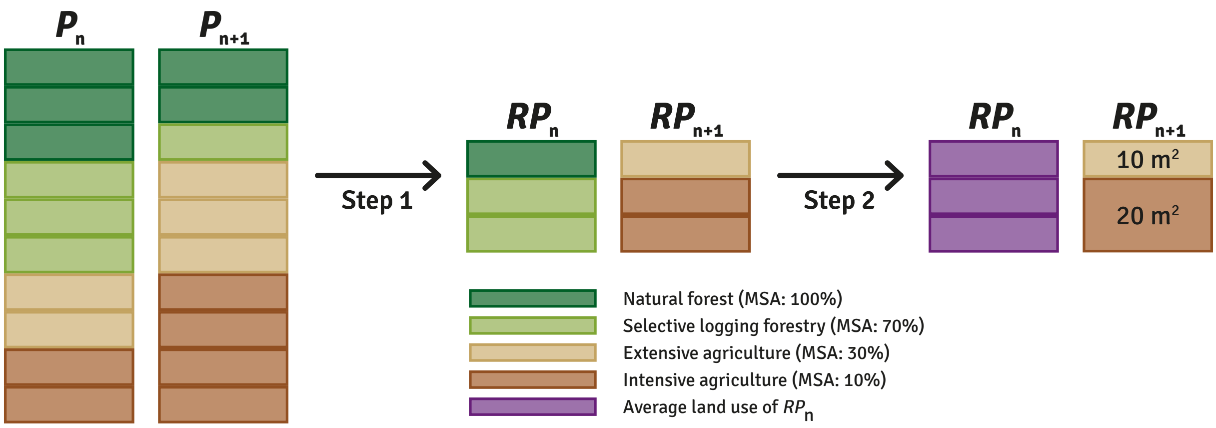


Figure 16: Illustration of the calculation of the dynamic footprint for land use conversion with a simplified example

3.5.2 Greenhouse gas emissions

The methodology used to assess the impact of climate change on biodiversity has evolved since our last publication (CDC Biodiversité, 2017) for we have been working towards the convergence of the GBS methodology with other existing approaches. We use a three-step approach consisting in 1) assessing the total GHG emissions related to the activity studied, 2) identifying the global mean temperature increase (GMTI) generated by these emissions and 3) linking the temperature increase to impacts on biodiversity using GLOBIO dose-response relationships.

We consider emissions of the six gases covered by the Kyoto Protocol, *i.e.* carbon dioxide (CO_2), fossil and biogenic methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). Depending on the context and use, GHG emissions can be taken from various sources: from company data (refined assessment), from the environmental extensions of the input-output model EXIOBASE version 3.4 (default assessment, see **section 3.4** for more details on the input-output methodology in GBS), from FAO emission data (for crop commodities, see Michelin or Solvay case studies), from LCA databases (*e.g.* for transformed products), etc. All GHG emissions are expressed in CO_2-equivalents using Global Warming Potentials (GWPs) taken from the GHG Protocol (Table 2). For the GWP, we consider a time horizon of 100 years in the calculations, consistent with the IPCC (Stocker, 2014). The biodiversity loss factor per kg of CO_2-equivalent is calculated according to steps 2 and 3 of the methodology described above, namely using the time-integrated absolute global temperature potential of 1 kg CO_2 (in °C.year.kg CO_2^{-1}) combined with the area-integrated global loss in MSA due to the corresponding global mean temperature increase (in MSA.km².°C^{-1}).

The temperature change caused by GHG emissions depends on how long they are supposed to remain in the atmosphere. The integrated absolute global mean temperature potential (IAGTP) of CO_2 for the 100-year time horizon considered is $4.76.10^{-14}$ °C.yr.kg CO_2^{-1} (Joos et al., 2013).

GLOBIO's dose-response relationship expresses the biodiversity loss relative to the absolute increase of the temperature in degrees (the GMTI). Arets, Verwer, & Alkemade (2014) report losses in MSA per degree of global mean temperature increase for 14 terrestrial biomes. We thus define the loss in MSA due to climate change across the globe as the weighted aggregation across the biomes using biome areas[35] reported by IMAGE for the year 2010, following Wilting & van Oorschot (2017).

Combining the IAGTP and the dose-response relationship provided by GLOBIO, a "*time-integrated footprint*" expressed in MSA.km².yr could be calculated[36]. It would amount to evaluate the current and future impacts caused by the GHG emissions (up to time horizon of 100 years considered here). Though arguably useful, such a time-integrated footprint would not be consistent with the GBS approach, which seeks to relate the footprints assessed with biodiversity richness on the field and with the global average terrestrial biodiversity. These are usually not integrated over time (the GLOBIO model for instance does not integrate its results over time) and are best understood by non-specialists when expressed as their value at a given time (for instance global average terrestrial biodiversity stood at about 65% MSA in 2010, see **Box 2**). Accounting for the duration of impacts is however undoubtedly necessary and the dynamic and static footprints framework allows to do so. Whenever additional impacts occur, they are accounted for as dynamic impacts. By definition, if these impacts persist beyond the period assessed, they are accounted for as static impacts (see Figure 17).

In order to assess the non-time integrated impacts, the IAGTP (integrated over time) needs to be translated into an actual rise in temperature. A rectangular shape is assumed for the impulse response function for CO_2, *i.e.* an almost immediate increase of global mean temperatures in response to the CO_2 emission pulse, which then remains stable for 100 years (and beyond, see Figure 18)[37]. Under this hypothesis, the average increase in temperature caused by the GHG emission during the emission year (and the subsequent 99 years for a time horizon of 100 years) is equal to the IAGTP divided by the number of years considered. An IAGTP of $4.76.10^{-14}$ °C.yr.kg CO_2^{-1} over 100 years is equivalent to a global temperature increase of $4.76.10^{-16}$ °C.kg CO_2^{-1}.

Table 3 provides an overview of the approaches used by several initiatives to assess the biodiversity impact of climate change.

(35) Biome area refers to the total terrestrial area of that biome excluding cropland and urban areas. Ice: 2 269 549 km², Tundra: 6 416 065 km², Wooded tundra: 2 394 095 km², Boreal forest: 17 147 840 km², Cool coniferous forest: 2 676 959 km², Temperate mixed forest: 4 147 544 km², Temperate deciduous forest: 3 408 164 km², Warm mixed forest: 4 764 378 km², Grassland and steppe: 16 043 172 km², Hot desert: 21 623 633 km², Scrubland: 6 452 856 km², Savanna: 13 427 554 km², Tropical woodland: 7 323 116 km², Tropical forest: 8 185 654 km², Mediterranean shrub: 1 269 787 km².

(36) Such a time-integrated footprint is the classical approach taken by LCA methodologies.

(37) This is consistent with the impact observed in the MAGICC model on which IMAGE and GLOBIO rely. Indeed, in this model, the emission of 1 kg CO_2 leads to a rapid temperature increase in the first 5 years and a stabilization over the next 95 years (Joos et al., 2013).

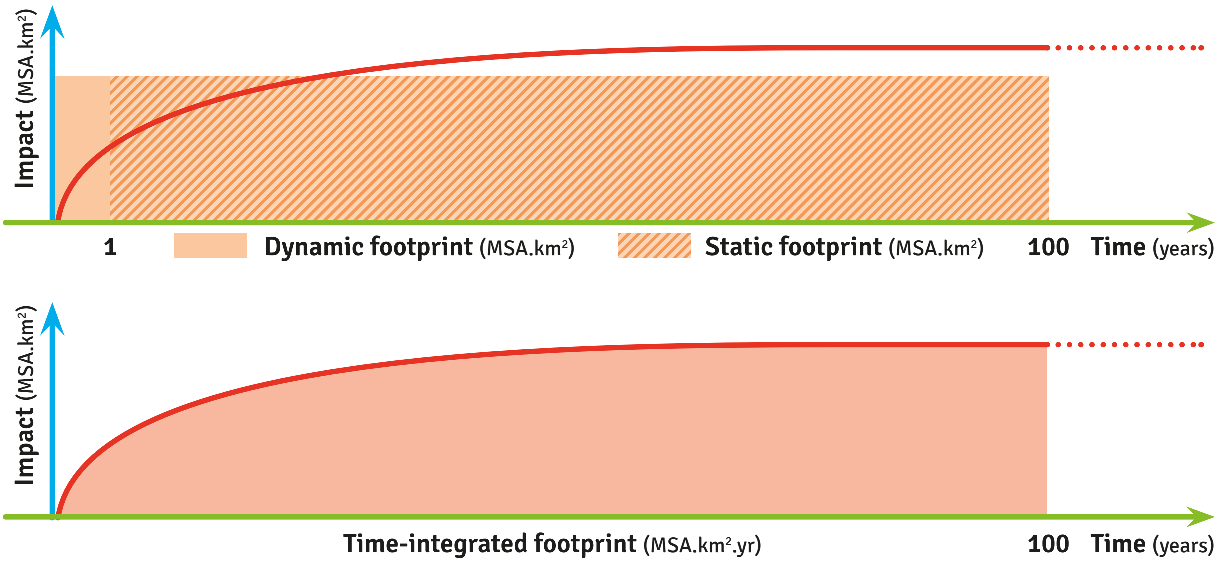


Figure 17: Illustration of the difference between the dynamic + static footprints approach and the time-integrated footprint approach

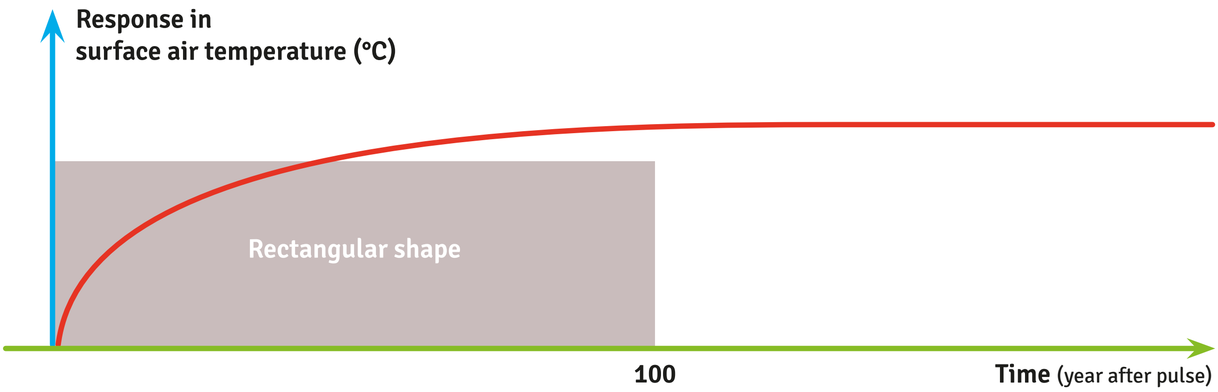


Figure 18: Illustration of the approximation of the impulse response of surface air temperature to a pulse of GHG emissions by a rectangular shape (schematic)

Greenhouse gas	GWP (kg CO_2-eq/kg) for 100 years
CO_2	1
CH_4	28
N_2O	265
SF_6	23 500

Table 2: Global Warming Potential of the main GHGs for a time horizon of 100 years*, source: (Stocker, 2014)

* No GWP for HFCs and PFCs since they are already documented in kg CO_2-eq in EXIOBASE data.

Methodology	Time horizon	IAGTP (°C.yr/kg CO_2-eq)	Biodiversity impact (per kg CO_2-eq)
GBS	100 years	$4.76.10^{-14}$	$4.37.10^{-9}$ MSA.km²
Wilting & van Oorschot (2017)	100 years	$4.76.10^{-14}$	$4.37.10^{-7}$ MSA.km².yr
BFFI	100 years	$6.5.10^{-14}$	$2.8.10^{-9}$ species.yr
Biodiversity Footprint Tool	100 years	$4.76.10^{-14}$	$3.29.10^{-7}$ MSA.km²

Table 3: Summary of existing approaches to assess the biodiversity impact of climate change

4 Case studies

Case study Summary sheet

Context

CASE STUDY

Footprint use category: Supply option **Assessment time:** Sample 2017

Business application: Biodiversity management & performance

Perimeter

		LUEFN Pressures	CC Pressure	Aquatic Pressures
Scope 1		☐ (✓ biodiversity icon)	☐	☐
Scope 2		☐ (✓ biodiversity icon)	☐	☐
Scope 3	Natural rubber purchases	✓	✓	☐
	Downstream	☐	☐	☐

COMPANY'S IDENTITY

MICHELIN

Industry
Manufacturing

Sub-industry
Auto and truck parts

2017 turnover
EUR 21.96 billion

Listed
Euronext, CAC40

Why?

EXPLORE THE DIFFERENCE OF IMPACTS OF A RANDOM SAMPLE OF **NATURAL RUBBER SUPPLY SOURCES**

When?

COMPUTATION IS DONE FOR A RANDOM SUPPLY SPLIT PER COUNTRY OBSERVED IN 2017

How often?

ONE OFF (TESTING PHASE)

What?

AVERAGE TERRESTRIAL BIODIVERSITY FOOTPRINTS PER COUNTRY ARE EVALUATED PER TON OF RUBBER

For who?

INTERNAL USE
STRATEGY, SOURCING

How detailed?

SOURCING OPTIONS ARE EVALUATED AT THE COUNTRY LEVEL

DATA COLLECTED

Item	Details
Sourcing locations	List of countries
Sourcing split	% per country
Production yield	Average yield (t/ha) for 5 countries accounting for 96% of supply

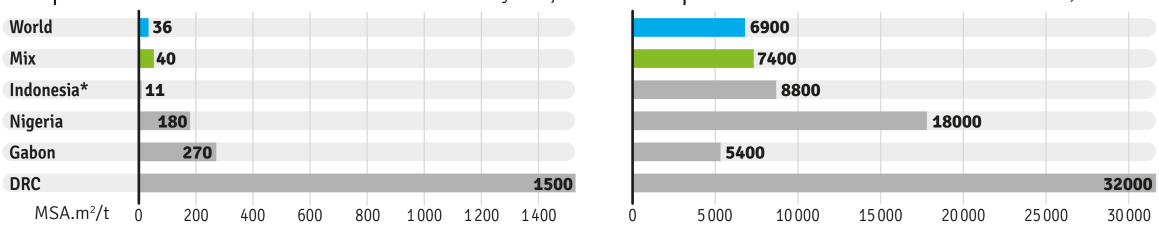
Footprint analysis

RESULTS

For a fictive supply of 1 million tons of natural rubber, based on the sample's mix per country

Dynamic footprint — **Total footprint 40 MSA.km²** or the area of the French city of Dijon

Static footprint — **Total footprint 7 400 MSA.km²** close to the area of Corsica, 8 680 km²



(source: GBS calculations, December 2018)

KEY MESSAGES

➔ Land use change is the key driver of dynamic biodiversity footprint

➔ Additional information from suppliers certifying that land conversion is broadly contained within their business perimeter would improve significantly the precision of the assessment of their dynamic footprint

➔ Yield is the main explanatory factor of static biodiversity loss

➔ Additional information from suppliers on their yield performance would significantly improve the accuracy of the static footprint

IMPROVEMENTS

➔ Integration of additional pressures such as air and water pollutants or water use in the GBS methodology in the future should put into perspective the significant share of impact of spatial pressures

4.1 Michelin

A CONTEXT AND OBJECTIVES

Michelin is involved in various initiatives in order to better assess and reduce the socio-environmental impacts related to the upstream part of its value chain. Being the world's second largest tyre manufacturer, Michelin is an important buyer of natural rubber which accounts for about a quarter of a tyre's composition (source: Michelin). Natural rubber production takes place in plantations located in tropical or sub-tropical regions and can potentially have a significant impact on biodiversity.

In this case study, the "Supply option" use of the GBS tool is explored. The tool is used to compute the average biodiversity footprint of the production of 1 ton of natural rubber depending on its country of origin. The objective is to provide Michelin with preliminary information on the risks of biodiversity impacts of different supply options and identify potential impact hotspots requiring further attention (and additional data collection to refine results). As rubber is a purchase of Michelin, it falls within its Scope 3 (see Figure 10).

The GBS is still under development, so only the impacts caused by the five terrestrial pressures listed in GLOBIO (land use changes, encroachment, fragmentation, climate change, atmospheric nitrogen deposition) on terrestrial biodiversity are assessed.

B METHODOLOGY

Michelin provided a 2017 non-representative sample of its natural rubber supply split among ten countries. For five countries (Indonesia, Brazil, Thailand, Côte d'Ivoire, Malaysia) accounting for most of this supply by weight, Michelin also provided a production yield based on the LMC - *Outlook for Natural & Synthetic Rubbers – 2018 Report*. For each country, the GBS tool computed the terrestrial biodiversity footprint of 1 ton of natural rubber. When production yield was not provided by Michelin, the latest average yield documented by the FAO for the country was used. The methodology used to assess the biodiversity impact of crop commodities detailed in the GBS's first technical paper (CDC Biodiversité, 2017) was then applied.

C RESULTS AND DISCUSSION

Dynamic footprint varies significantly from one country to another (Figure 19). For instance, the dynamic footprint of rubber cultivation is **136 times higher in the Democratic Republic of Congo** (1 500 MSA.m²/t) **than in Indonesia** (11 MSA.m²/t).

This is explained by very different land use dynamics. As illustrated in Figure 20, in countries which are still at an early stage of their economic development such

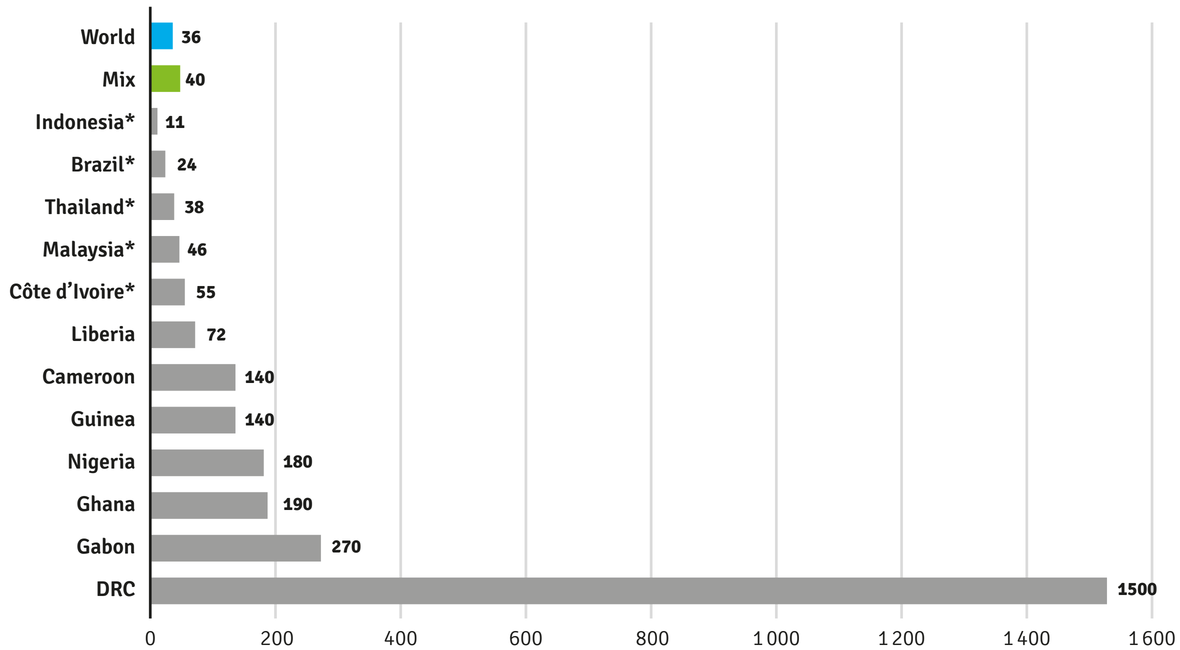


Figure 19: Dynamic footprint of natural rubber cultivation (MSA.m2/t) **per country in the study's sample purchase** (source: GBS calculations, December 2018). ***: country where the yield from the LMC report was used.**

Figure 20: Land use evolutions expected in GLOBIO's central scenario for the Democratic Republic of Congo and Indonesia from 2010 to 2050

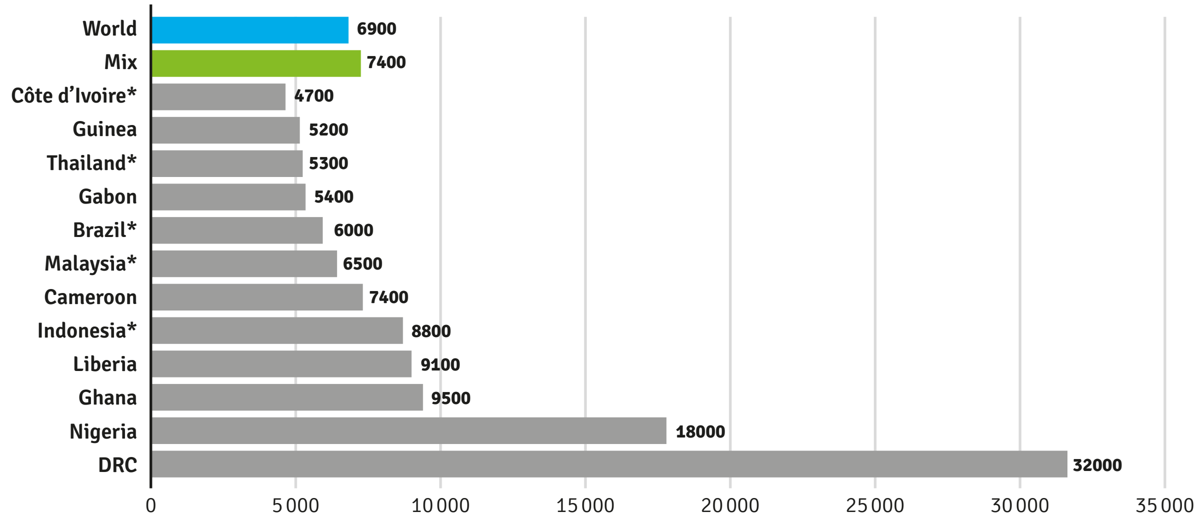


Figure 21: Static footprint of natural rubber (MSA.m2/t) **per country in the study's sample purchase** (source: GBS calculations, December 2018)

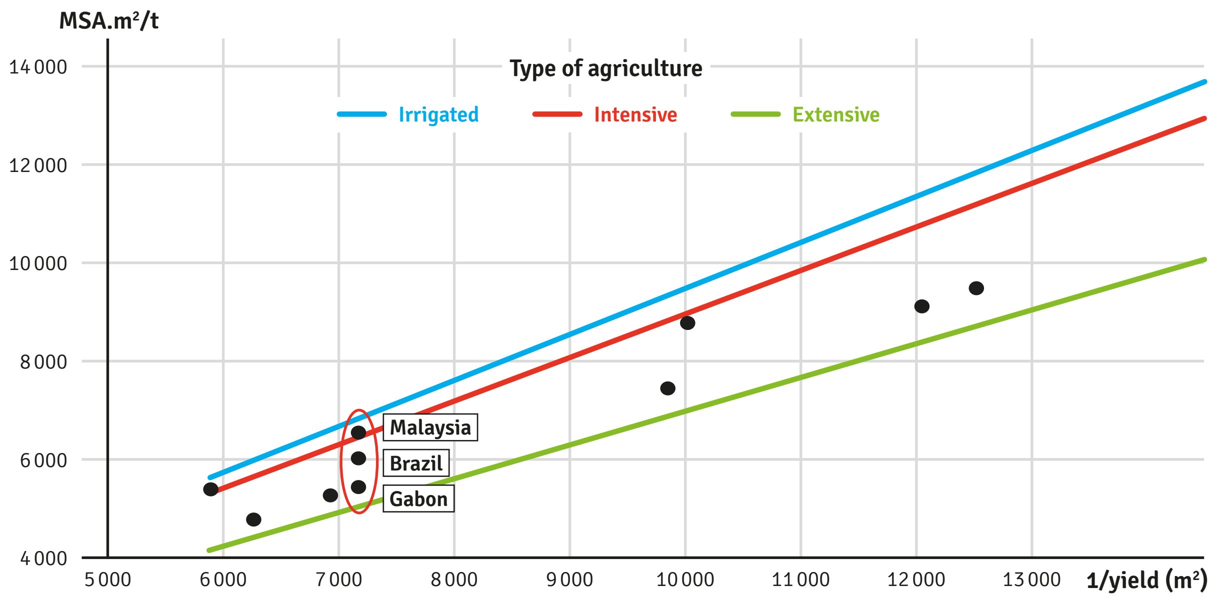


Figure 22: Static footprint (MSA.m²/t) **as a function of the inverse of yield for 1 ton of natural rubber**

as the Democratic Republic of Congo (DRC), land uses are expected to change in sizeable proportion in the coming years with natural lands being converted to support economic activities, mainly agriculture (including both farmland and cultivated grassland) and forestry. Conversely, in countries more advanced in their economic development such as Indonesia, the conversion dynamic will be subdued and therefore associated biodiversity losses are much lower. If additional pressures such as air and water pollutants or water use were also assessed (they will be integrated in the GBS assessments in the future), the overwhelming share of the land use impacts in the total biodiversity footprint would be relatively smaller.

Static footprint also varies significantly from one country to another (Figure 21).

Currently, the static footprint is only computed for spatial pressures and is thus structurally highly correlated to production yield (see formula in **section 3.5.1**). The other driver for default static footprint is the average intensity of the agriculture in a given country. In Figure 22 for instance we see that Malaysia, Brazil, and Gabon have the same yield (1.4 t/ha) but their static footprints are significantly different (respectively 6 500, 6 000 and 5 400 MSA.m²/t). This is due to the fact that their agriculture intensities differ which is reflected in the average MSA% for agricultural lands which are respectively 9%, 16% and 24%.

D LESSONS LEARNT

This case study is an important step in the development of the GBS tool regarding its “supply chain comparison” use. It could help to better understand what the drivers of biodiversity loss are and how they interact. Testing the tool on this case also quickly showed to the GBS and Michelin teams that in-depth understanding of supply chains was a key element in order to refine the footprint. Indeed, suppliers’ additional information on yield performance would significantly improve the accuracy of the static footprint. Also, suppliers’ information on their actual land use changes would allow to significantly refine the assessments of the dynamic footprint, especially for countries where this pressure is expected to be high such as DRC. Suppliers identification is a challenge for most of the commodities today, hence this study comforts Michelin in pursuing their effort on having a better knowledge about their natural rubber supply with a target of risks mapped for 80% of the volume purchased by the end of 2020. For the time being, these figures could help to assess countries where risks to impact biodiversity are too high. But they can also be used to engage specific suppliers and work with them to ensure that their actual footprint is much lower than the average impact calculated with this approach. The assessment can thus support cooperation with suppliers to move towards more sustainable rubber plantations in high risk countries.

Case study Summary sheet

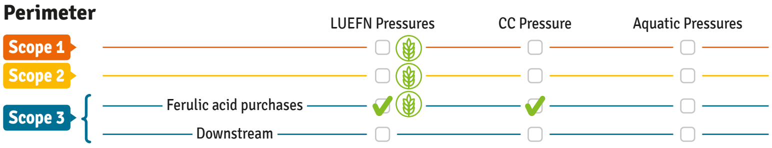
Context

CASE STUDY

Footprint use category: Supply option **Assessment time:** 2018

Business application: Biodiversity management & performance

Perimeter



COMPANY'S IDENTITY

SOLVAY
asking more from chemistry

Industry	Manufacturing
Sub-industry	Chemistry
2017 turnover	EUR 10.9 billion
Listed	Euronext, BEL 20, CAC40

Why?

COMPUTE THE BIODIVERSITY FOOTPRINT OF SOLVAY'S FERULIC ACID SUPPLY, A SUB-PRODUCT OF RICE AND UNDER-STAND SOURCING IMPLICATIONS

When?

COMPUTATION IN NOVEMBER 2018 TO REFLECT CURRENT OPERATIONS

How often?

ONE OFF
TO BE RENEWED IF SOURCING CHANGES

What?

AVERAGE TERRESTRIAL BIODIVERSITY FOOTPRINTS PER COUNTRY ARE EVALUATED PER TON OF FERULIC ACID

For who?

INTERNAL USE
STRATEGY, SOURCING

How detailed?

SOURCING OPTIONS ARE EVALUATED AT THE COUNTRY LEVEL

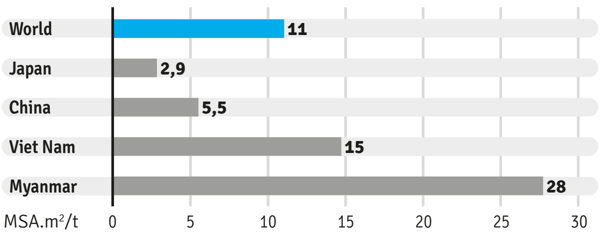
DATA COLLECTED

Item	Details	Source
Rice sourcing location	List of countries	Solvay
Transformation process	Detailed processes from rice to ferulic acid	Solvay / LCA
Transformation ratios	Mass ratio and allocation method for each process	Solvay / LCA

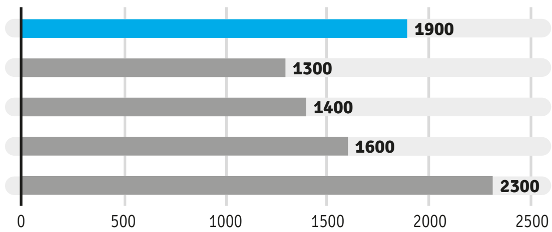
Footprint analysis

RESULTS

Dynamic footprint



Static footprint



(source: GBS calculations, December 2018)

KEY MESSAGES

- Dynamic and static footprints vary strongly depending on the origin of the rice purchased
- Pressure breakdown varies significantly among countries depending on the land conversion dynamic leading to very different situations.

IMPROVEMENTS

- Taking into account **aquatic biodiversity** which should play an important role for rice production
- Solvay is looking for additional information from its rice suppliers (location, fertilizer and chemical inputs , water consumption) which could be used to refine the results

4.2 Solvay

A CONTEXT AND OBJECTIVES

Solvay has already various ESG criteria in place to mitigate CSR risks in its upstream and downstream supply chains. Risk mapping is the cornerstone of a sustainable supply chain, enabling Solvay to be aware of the main CSR stakes outside its direct operations. Solvay aims to create sustainable value, particularly through partnerships with its suppliers for the joint development of solutions that address environmental and social issues. With this case study, Solvay is aiming to understand if it is technically possible and relevant for biodiversity to be one of them. In that context and since the GBS tool was most appropriate to assess crop commodities at its 2018 stage of development, Solvay chose ferulic acid whose production is based on rice. This compound is used to produce vanilla natural aroma. Solvay has different sourcing options and would like to evaluate the biodiversity footprint related to each of them.

In this case study, the GBS tool evaluates the footprint of rice production. The objectives are very similar to the Michelin case study (cf. section 4.1) and it is also a typical "supply option" application of the GBS. As ferulic acid and rice are purchases of Solvay, they fall within its Scope 3 (*cf.* Figure 10).

The footprint of the pressures generated by the transformation processes of rice into ferulic acid (land use of processing factories, greenhouse gas emissions, etc.) are not included in this study. The GBS is still under development, so only the impacts caused by the five terrestrial pressures listed in GLOBIO (land use changes, encroachment, fragmentation, climate change, atmospheric nitrogen deposition) on terrestrial biodiversity are assessed.

B METHODOLOGY

Solvay provided data relative to the transformation processes of rice into ferulic acid. This dataset comes from ecoinvent, a life-cycle analysis database, and describes all the intermediary steps to obtain ferulic acid from rice. For each transformation step, the information specified is:

- the initial product,
- an exhaustive list of sub-products obtained by transforming the initial product,
- the mass ratio of each sub-product, which is the quantity produced for 1 unit of initial product,
- the allocation ratio of each sub-product which reflects the share of initial product's biodiversity footprint which is allocated to the sub-product. In some cases, the share is equal to the mass ratio. In other cases, the allocation ratio reflects the relative economic value of the sub-product relative to the initial product. Economic value is a fair reflection of business incentives, but it is sometimes hard to evaluate as prices for the different compounds can be very volatile and are not always officially available. The share of the biodiversity footprint allocated to ferulic acid is low, respectively $1{,}5.10^{-3}$ % and $5{,}0.10^{-4}$ % if calculated on mass or on economic value.

In this case study, FAO's average country production yields are used. GHG emissions for rice production are also directly extracted from the FAO database. A precise GHG emissions assessment is particularly important for rice production as it is one of the most GHG intensive crop production due to significant methane emissions in the flooded rice paddies.

The GBS tool is used to compute the impacts on terrestrial biodiversity of the production of rice for different countries of origin. The methodology developed by CDC Biodiversité to compute biodiversity footprint for crop commodities is described in details in the first GBS technical paper (CDC Biodiversité, 2017).

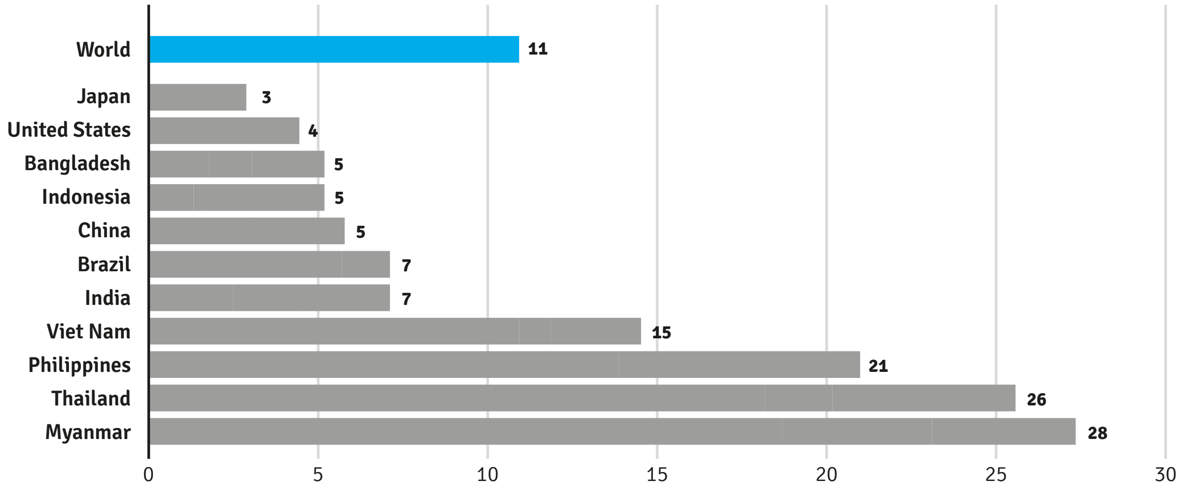


Figure 23: Dynamic footprint of rice (MSA.m²/t)
sourced from different countries (source: GBS calculations, December 2018)

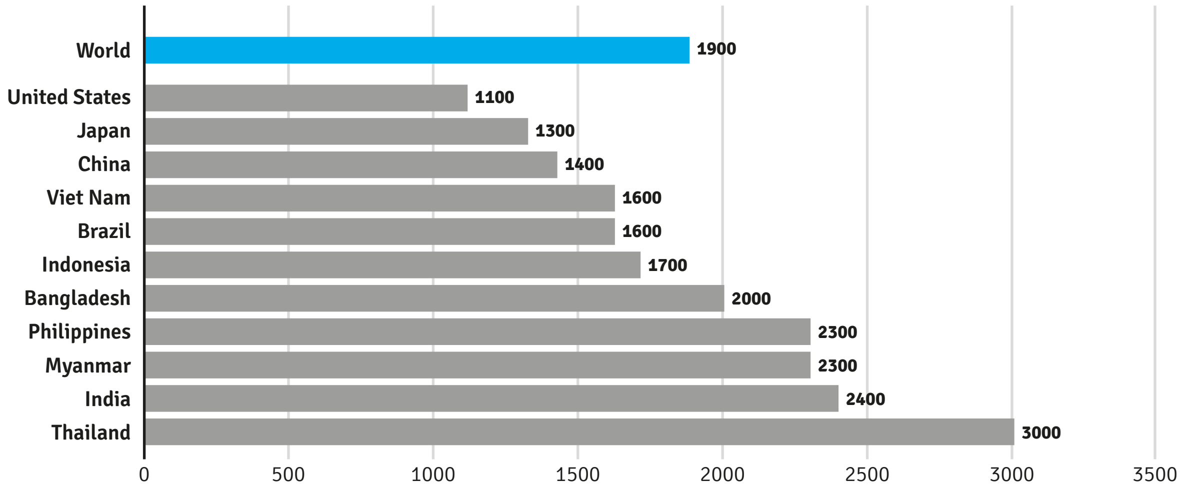


Figure 24: Static footprint of rice (MSA.m²/t) **sourced from different countries** (source: GBS calculations, December 2018)

Step	Product In	Products Out
1	Rice	Rice bran
		Rice husk
		White rice
		Rice brokens
2	Rice bran	Crude rice bran oil
		Rice bran meal
3	Crude rice bran oil	Soap stock
		Refined rice bran oil
4	Soap stock	Oryzanol
		By-products (1)
		Wastes
5	Oryzanol	Ferulic acid
		Cycloartenol

Table 4: Steps from rice to ferulic acid (source: Solvay, based on ecoinvent)

C RESULTS AND DISCUSSIONS

Dynamic footprint and its pressure split vary significantly from one country to another (Figure 23 and Figure 24). Dynamic footprint for Japan is the smallest with 2.9 MSA.m², almost 4 times less than the world average mix (11 MSA.m²) and almost 10 times less than Myanmar (28 MSA.m²). For countries where pressures from land conversions are expected to remain low (Japan or USA), the main driver of biodiversity loss is climate change. For countries where pressures from land conversions are expected to be high (Vietnam, Myanmar, etc.), spatial pressures (sum of land use change, fragmentation and encroachment) is a key driver.

Static footprint also varies significantly from one country to another (Figure 25), yield being by construction the main driver (see formula section 3.5.1 and Michelin case study). It is interesting to note that **static footprint values are consistent with ecoinvent "land use transformation" values**. For instance, for China, land use transformation is evaluated at 1 482 m² in ecoinvent: when applied an average MSA% of 8.1% for croplands, the static footprint would be about 1 362 m² (1482x0.919) which is exactly the same as the static footprint calculated with the GBS for China.

D LESSONS LEARNT

Results could be refined thanks to additional data from Solvay's suppliers, such as yield and land use dynamics. Further methodological developments will allow to evaluate the impacts on freshwater biodiversity. For a water intensive culture such as rice, these impacts could potentially be significant. This study was very interesting regarding GBS development as it allowed to tackle the methodological issues around transformed products, how to deal with the transformation process in terms of data and allocation between the studied product and its associated sub-products. Although results could be improved, this case study showed to Solvay that the differences between sourcing locations are significant, therefore it makes it relevant for them to add biodiversity to their ESG sourcing criteria list.

Case study Summary sheet

Context

CASE STUDY

Footprint use category: Corporate and portfolio **Assessment time:** 2018

Business application: Assessment / rating by and for third parties with external data

Perimeter

		LUEFN Pressures	CC Pressure	Aquatic Pressures
Scope 1		✓ (Evaluated companies)	✓ (Evaluated companies)	☐
Scope 2		✓ (Evaluated companies)	✓ (Evaluated companies)	☐
Scope 3	Tier 1	✓ (Evaluated companies)	✓ (Evaluated companies)	☐
	Rest of value chain	☐	☐	☐
	Downstream	✓ (Asset owner)	✓ (Asset owner)	☐

✓ Asset owner ✓ Evaluated companies

COMPANY'S IDENTITY

BNP PARIBAS

Industry
Financial institution

Asset under management 2018
EUR 416 billion

Why?

ASSESS THE BIODIVERSITY IMPACT OF A PORTFOLIO OF LISTED COMPANIES

When?

THE FOOTPRINT IS COMPUTED BASED ON THE STATE OF THE PORTFOLIO IN 2018

How often?

ONE-OFF FOR THE PILOT BUT THE ASSESSMENT OF PORTFOLIO'S BIODIVERSITY FOOTPRINT COULD BE CONDUCTED YEARLY

What?

TOTAL IMPACT OF THE PORTFOLIO AND BIODIVERSITY INTENSITY OF INVESTMENTS IS EVALUATED

For who?

INTERNAL USE AT THIS STAGE. IN THE FUTURE, COULD BE USED FOR DECISION MAKING, RISK MONITOR-ING AND DISCLOSURE

How detailed?

CORPORATE LEVEL, TAKING INTO ACCOUNT SPECIFICITIES PER REGION AND INDUSTRY

DATA COLLECTED

➔ List of the companies in the portfolio with turnover per region and industry of operation, amount of BNPP AM's investments, share of each company owned

KEY FIGURES

➔ Portfolio of 10 food and agro-business companies with a total turnover of EUR 467.6 billion

➔ Total investment: EUR 20.1 million

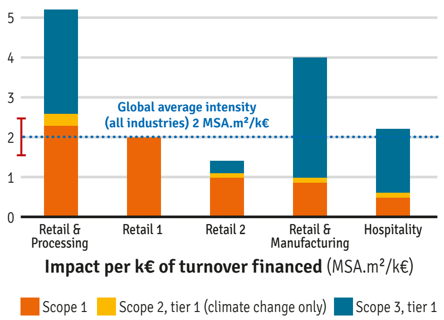
Footprint analysis

RESULTS

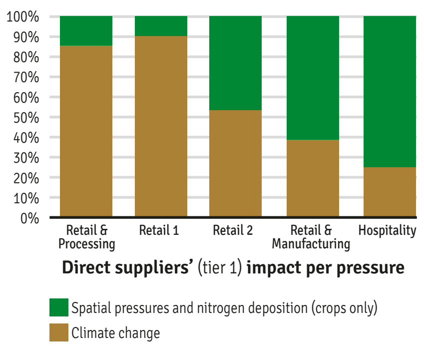
Results for the whole portfolio and for the five most impacting companies

Total Dynamic footprint
0.057 MSA.km²
or about 8 soccer fields

Total Static footprint
4.8 MSA.km²
or about the first ten "arrondissements" of Paris



Impact per k€ of turnover financed (MSA.m²/k€)



Direct suppliers' (tier 1) **impact per pressure**

(source: GBS calculations, November 2018)

KEY MESSAGES

➔ The overall impact of the portfolio is limited, which is consistent with the limited investments involved

➔ Considering the impacts due to companies' value chains is key to properly estimate the impact of their activities

➔ Climate change makes up the majority of the footprint of the companies due to the fact that spatial pressures are accounted for only for crop commodities. This result is likely to change when the impact of other raw materials is accounted for. The share of spatial pressures in the footprint is already higher for companies most reliant on crop commodities (*e.g.* Hospitality)

IMPROVEMENTS

➔ The results could be improved with more specific data on the industrial and regional distribution of companies' turnover

4.3 BNP Paribas Asset Management

A CONTEXT AND OBJECTIVES

CDC Biodiversité worked on a case study with the French financial institution BNP Paribas Asset Management (BNPP AM) to compute the biodiversity footprint of one of their portfolios of listed equities. The portfolio assessed gathers 10 companies operating in the agri-food industry (food processing, retail, catering). This pilot aims at computing the biodiversity footprint of this portfolio. As the GBS is still under development, the assessment of four of the five terrestrial pressures is limited to the impacts caused by crop commodities, while the assessment of the climate change pressure covers all industries. Similarly, only terrestrial pressures are considered at this stage of development of the tool. The evaluation focuses on the **Scope 1, 2 and 3 impacts (both static and dynamic) of the portfolio's companies. The Scope 3 impacts presented here are limited to the upstream part of the value chain for direct suppliers (tier 1)**. These impacts actually belong to the downstream Scope 3 (investment) of the asset owners. For the sake of simplicity, they are described as Scope 1, 2 and 3 (of the portfolio's companies) in the following paragraphs.

B METHODOLOGY

A data collection file (Excel spreadsheets and fill-in instructions) was sent to BNPP AM and completed by its ESG analysts using public (annual reports of companies), private (Bloomberg) and internal data. The collected data were pre-treated and analysed following the method described in **section 3.4.2**.

Pre-treatment was especially important since the nomenclature used was most often the one used by companies in their annual report. Very few observations were provided in the {region; industry} format needed to use the EXIOBASE tables. Turnover data were mainly provided as the total for region and industry groups, and not split by {region; industry} pair (see Figure 23). For instance, while the initial dataset contained 62 lines, the pre-treated dataset contained 989 lines. Each line of the pre-treated dataset corresponds to the turnover financed by BNPP AM's investment for a company in a {region; industry} pair. Each company thus spans on several lines, the number of which depends on the number of regions and industries it operates in.

The portfolio is relatively small and represented EUR 20.1 million of turnover financed (2017 data) in total. The data collected did not allow to determine precisely the countries where turnover was generated for around 66% of the turnover financed. This turnover was thus associated to region groups instead of specific EXIOBASE regions, EU, USA, North America and France being the most important ones. As for the industries, according to the data collected, Retail trade, Hotels and Restaurants (hereafter Hospitality) and Manufacture of food products represented almost 75% of the turnover financed. This is consistent with the agri-food focus of the study.

The biodiversity footprint related to each line was computed using the "direct environmental impacts" (inventory data) and "biodiversity impacts" matrices (cf. section 3.4.2). The main results are presented below.

Figure 23 displays the region mix and industry mix of the portfolio in terms of the turnover financed. The turnover financed is defined as the amount (in euros) that the portfolio's investment finances, *i.e.*

$$\textit{total turnover of the company} \times \textit{share of the enterprise value owned}$$

For instance, if a company has a turnover of EUR 100 million and BNPP AM owns 1% of its shares and debt (*i.e.* of its enterprise value), then the turnover financed is EUR 1 million.

C RESULTS AND DISCUSSION

The main results of the assessment are presented in Table 5. The impact of the portfolio is split between the dynamic impact and the static impact. The latter amounts to 4.8 $MSA.km^2$, approximately the surface area of the first three "arrondissements" of Paris. As a comparison, the dynamic impact covers an area equivalent to that of 8 soccer fields (0.06 $MSA.km^2$). Since the case study focuses on agricultural commodities, it is logical that the static impact be much higher than the dynamic impact as the former is caused by the occupation of cultivated land required for the companies' purchases, while the latter only accounts for induced land conversions which apply to much more limited surface areas.

Figure 24 and Figure 25 provide more detailed information on the portfolio's impact per company, notably detailing it along the value chain. The biodiversity impact of the five companies with the highest Scope 1 impact per thousand euros is displayed on Figure 24. The companies operate in Retail, Processing and Hospitality and their Scope 1 impact ranges from 0.5 to 2.2 $MSA.m^2$ per thousand euros of turnover, close to or below the global average intensity of all industries. This global intensity is computed by simply dividing the total annual biodiversity loss predicted by GLOBIO by the total monetary value of the world production computed on EXIOBASE data in 2011.

Yet, considering value chain impacts changes the results quite dramatically. Scope 3 impacts are indeed equivalent or higher than Scope 1 impacts for three companies out of the five, Scope 3 impacts of the company “Hospitality” is three times higher than its Scope 1. On the contrary, Scope 3 impacts are limited for the two companies operating only in Retail (“Retail 1” and “Retail 2”), and Scope 2 impacts are limited for all companies. Accounting for Scope 3 impacts is thus key to properly assess the biodiversity impacts of an activity, all the more than only Scope 3 impacts of crop cultivation are considered here. Accounting for the Scope 3 impacts of other raw materials (metals, minerals, oil products) and of suppliers further up the supply chain would drive the results up even more.

Figure 25 displays a detailed distribution of the biodiversity impacts of the five companies along 10 compartments of the value chain: raw material production, raw material processing, manufacture, retail, waste management, energy, transport, construction, financial services and non-financial services and other activities (horizontal axis). To each of the company correspond two lines, the upper one being the impact of their own operations (Scope 1) and the lower one their value chain impact (Scopes 2 and 3 of direct suppliers). The size of the "cast iron weight" is proportional to the size of the impact (in MSA.km²). The percentages displayed refer to their respective line, for instance the Scope 1 impacts caused by the "Retail & processing" company are split at 15% in "Raw & secondary material processing" and 85% in "Retail". The Scope 1 impact of the companies lies, logically, in the compartment corresponding to their industries of operation. A significant share of the impact of their direct suppliers lies in upstream compartments of the value chain, especially “raw material production”, energy and transport accounting for the rest of the impacts. Figure 26 presents the split of companies’ direct suppliers’ impact between the two major types of pressures, climate change and spatial pressures. Climate change makes up a very different share of the companies’ direct suppliers’ footprint according to the industry in which they operate. Indeed, spatial pressures account for a higher share of the impact for the companies which suppliers are closer to raw material production (Hospitality). The share of spatial pressures in the footprint may increase as the impacts of other raw materials are taken into account.

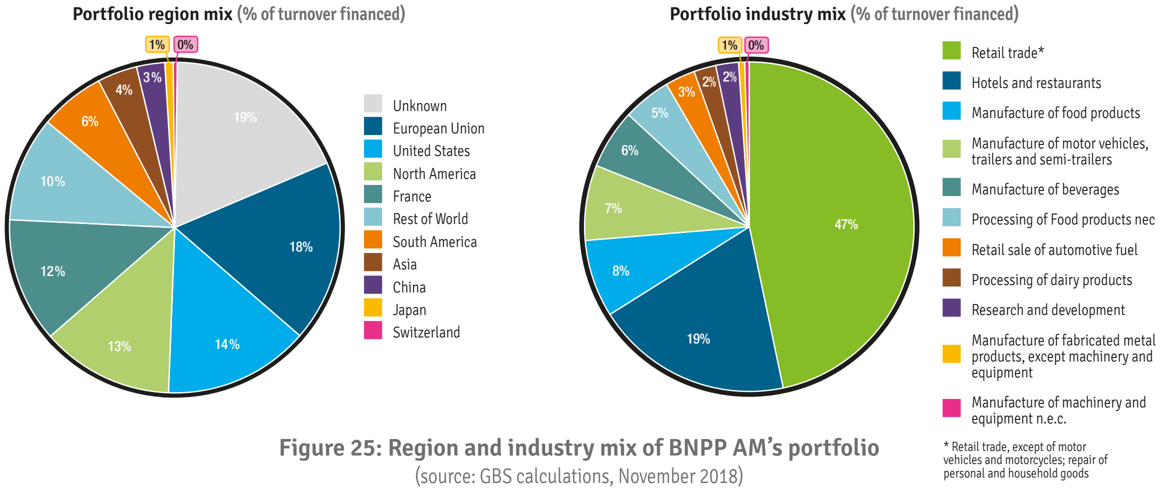


Figure 25: Region and industry mix of BNPP AM’s portfolio
(source: GBS calculations, November 2018)

	Portfolio dynamic footprint (MSA.km²)	Portfolio static footprint (MSA.km²)
Scope 1	0.021	0.008
Scope 2 + Scope 3 tier 1	0.036	4.8
Total	**0.057 MSA.km²**	**4.8 MSA.km²**
Equivalent	8 soccer fields	First three arrondissements of Paris

Table 5: Overall biodiversity footprint of the portfolio (source: GBS calculations, November 2018)

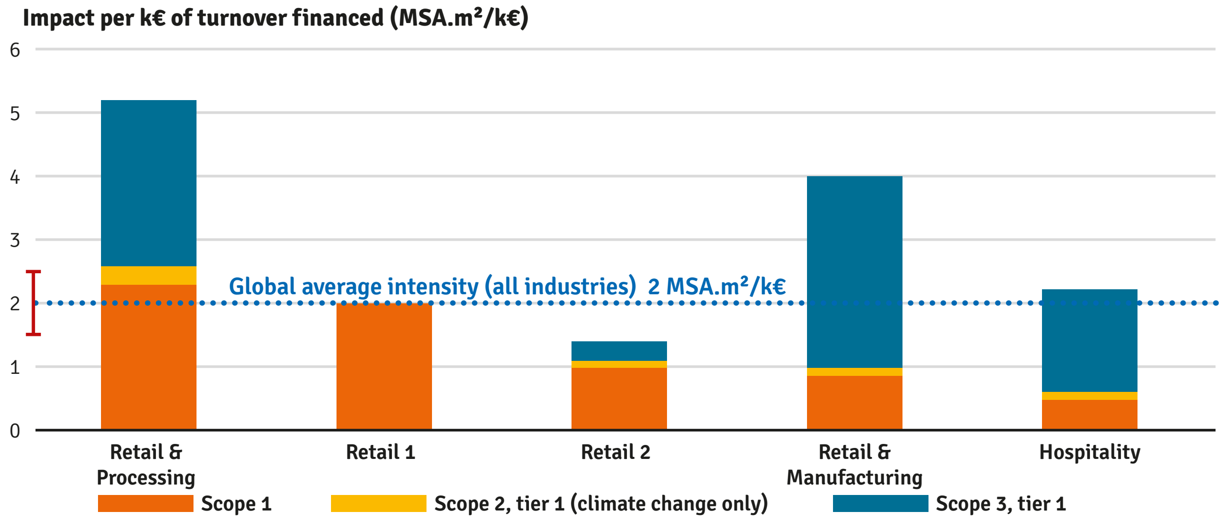


Figure 26: Impact per thousand euros of turnover financed for five companies of the portfolio
(source: GBS calculations, November 2018)

		Raw material production	Raw and secondary material processing	Manufacturing	Retail	Waste and wastewater management	Energy	Transport	Construction	Financial services	Non-financial services and other activities
Retail & Processing	Scope 1		15%		85%						
	Tier 1 of Scope 3	83%					10%				
Retail 1	Scope 1				100%						
	Tier 1 of Scope 3	14%			31%		15%	31%			
Retail 2	Scope 1				100%						
	Tier 1 of Scope 3	56%		5%	6%		21%	5%			
Retail & Manufacturing	Scope 1		8%		87%						
	Tier 1 of Scope 3	89%					5%				
Hospitality	Scope 1										100%
	Tier 1 of Scope 3	89%					5%				

Figure 27: Distribution of companies' impacts along the value chain
(source: GBS calculations, November 2018)

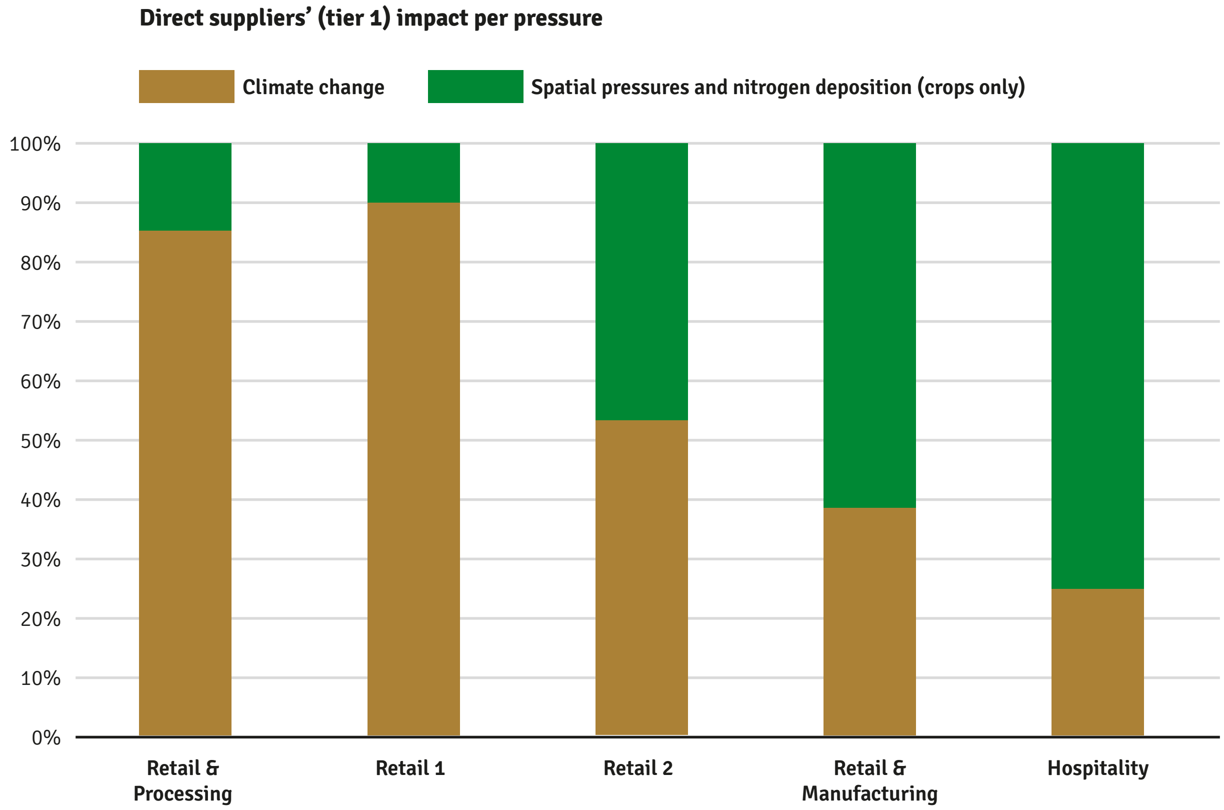


Figure 28: Decomposition of the most intensive companies' direct suppliers' impact per type of pressure (source: GBS calculations, November 2018)

D LESSONS LEARNT

The goal of the case study was to help us develop the GBS methodology by providing the opportunity to road-test the input-output based "default assessment" for listed equity portfolios. Additionally, it enabled to establish and improve the data collection file dedicated to the assessment of financial institutions' funding and investment. It also informed us on the typical data available in companies' annual reports and ESG analysts' private databases like Bloomberg.

In a nutshell, data is most often insufficient (industry and region level of detail) and in varying formats. We thus realised that quite heavy data pre-treatments were needed, which led us to elaborate the guidelines and tools to conduct such pre-treatments.

The case study was also fruitful for BNPP AM which is among the first movers in the field of natural capital. For them, it was the opportunity to better apprehend the biodiversity issue in their activity, to experiment what future biodiversity disclosure processes could be like and to get a head start on the reflection on how biodiversity impact information could be useful to their business in the future.

Concerning the results, the key finding is that the impacts of activities directly under the control of companies (*e.g.* their stores, etc.) often account for only a small fraction of their footprint. It is thus very important to assess their Scope 2 and 3 (upstream) impacts. The GBS allows to do such assessment, as illustrated with the case of these five companies.

FAQ

5. FAQ

5.1 What is the reference used by the GBS for the biodiversity state?

The GBS uses the Mean Species Abundance (MSA) metric, defined as *"The mean abundance of original species relative to their abundance in undisturbed ecosystems (MSA)"* (Alkemade et al., 2009; Schipper et al., 2016), which can be expressed as (CDC Biodiversité, 2017):

$$MSA = \frac{1}{N_{reference\ species}} \sum_{i=1}^{N_{reference\ species}} Min\left(\frac{A_{observed}(i)}{A_{intact}(i)}, 100\%\right),$$

Where

MSA = mean abundance of original species (those found in undisturbed ecosystems, thus excluding invasive species),

$N_{reference\ species}$ = total number of species in an undisturbed ecosystem,

$A_{degraded}(i)$ = abundance of species *i* in the observed ecosystem,

$A_{intact}(i)$ = abundance of species *i* in an undisturbed ecosystem,

By definition, the MSA compares the abundance of original species at the time of assessment to their expected abundance if the ecosystem had been undisturbed. In practice, the expected abundance for undisturbed ecosystems (which corresponds to MSA = 100%) can rarely be observed directly. BirdLife suggests assessing the optimum population for the site, which is very similar to an abundance of 100%, by looking at "*the estimated extent of potential habitat and population density in undisturbed conditions*" (BirdLife International, 2006). In any case, the concept of abundance for undisturbed ecosystems is different from the concept of a historical baseline abundance: it does not match the abundance of populations in 1970 for instance[38].

The GBS is a measurement tool: it measures the MSA variation (gain or loss) caused by economic activities. It does not favour the use of specific baseline scenarios (or "references") over others. The GBS can be used to conduct *ex ante* scenario comparisons (*e.g.* impacts of business as usual vs impacts of shifting to zero-deforestation sourcing). The choice of scenarios or baselines is independent from the assessment tool.

To measure MSA variations, the GBS does not compare actual biodiversity to a reference situation site by site, but instead uses pressure-impact relationships from the GLOBIO model to evaluate the dynamic and static footprint caused by economic activities. The GLOBIO model derives pressure-impact relationships expressed in MSA from a database with impact values taken from peer-reviewed literature on field-based impact studies. The global assessment of biodiversity decline with the GLOBIO model directly uses these mathematical relationships to assess biodiversity losses, to be able to perform future scenario studies.

(38) 1970 is the reference year for the Living Planet Index of WWF.

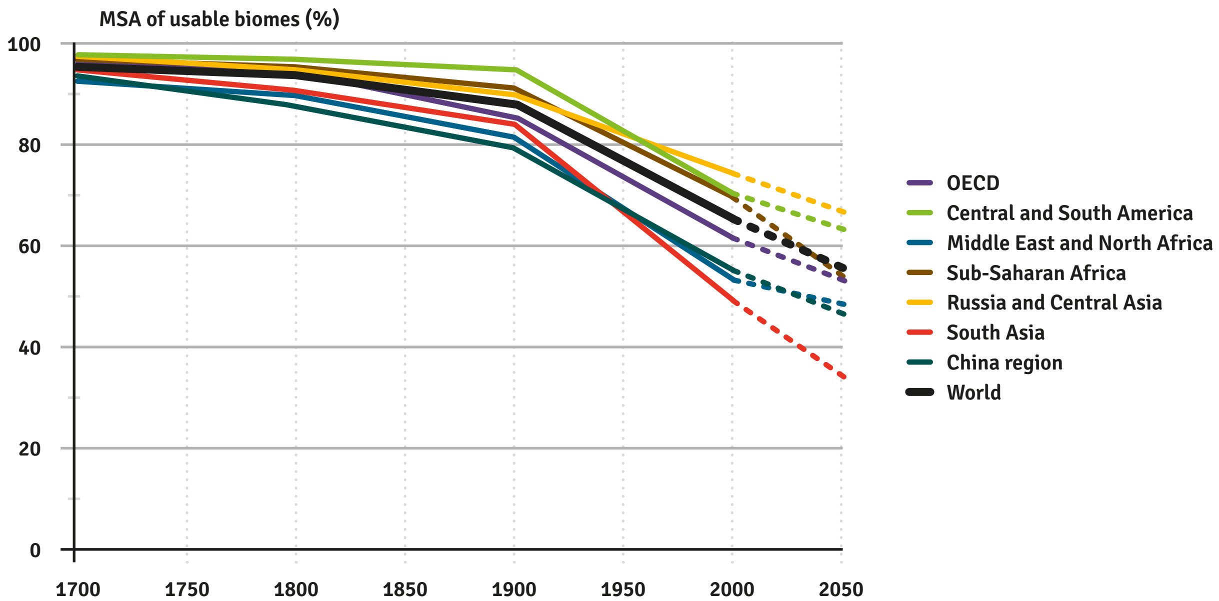


Figure 29: Historic and projected MSA for different world regions under the baseline scenario (Netherlands Environmental Agency (PBL), 2010)

5.2 Can a desert and a tropical forest both reach a MSA of 100%?

The MSA metric compares the abundance of species in the ecosystem assessed with the expected abundance if the ecosystem had been intact and undisturbed (cf. previous question). As such, any ecosystem can reach an ecosystem integrity of 100% MSA, even with limited species richness such as deserts (which are not devoid of plants and animals unlike what can be commonly thought). Undisturbed deserts and undisturbed tropical forests both have, by definition, an ecosystem integrity of 100% MSA, even if the former may host only a few hundred vascular plants and the latter a few thousands.

The difference of "quality" (number of species, threat status, etc.) of biodiversity across ecosystems can be dealt with during the complementary qualitative analysis that should accompany any quantitative footprint assessments (see the description of step 4 "Interpretation of results" in our common ground paper CDC Biodiversité et al., 2018). In the future, the GBS could include weights to reflect these differences.

5.3 Does the GBS consider that transforming a natural forest into intensive agriculture has the same impact in Cambridge and in an Atlantic forest?

As explained for the previous question, undisturbed ecosystems such as natural forests indeed all have a MSA of 100%, whether they are in Cambridge, United Kingdom, or in an Atlantic Forest in Brazil for instance. Transforming such natural forests into intensive agriculture (MSA = 10%) will thus result in the same MSA loss, regardless of the difference of species richness (lower in the temperate oceanic climate than in the tropical rainforest climate of the Atlantic Forest).

As for the previous question, the difference of "quality" of biodiversity across ecosystems can be dealt with in the qualitative analysis and weights could be included in the future to reflect this "biodiversity quality". An ongoing research work of the PBL to explore complementary indicators to the MSA could feed analyses to further refine impact assessments.

5.4 Does the GBS take into account upstream and downstream impacts?

Section 3.3 describes how the GBS currently deals with impacts which occur upstream and downstream of the perimeter of control of the business assessed.

The GBS currently assesses the impacts from cradle to gate, *i.e.* from raw material production to the delivery of the products or services of the business assessed. By 2020, it will assess most of these upstream and Scope 1 (perimeter under control) impacts.

In the long term, the objective is also to seek the best way to include downstream impacts.

5.5 Has MSA been measured through ecological surveys?

The pressure-impact relationships were derived by the PBL from a meta-analysis of peer-reviewed literature. The primary research articles from this meta-analysis are all actual field-based ecological surveys. The quantitative results on species abundances in these surveys were translated into uniform MSA values by the PBL (Alkemade et al., 2009; Schipper et al., 2016).

5.6 Are the models and data underlying the GBS regularly updated?

Yes, the building blocks of the GBS are updated as knowledge improves and better data become available. CDC Biodiversité seeks to use the most up to date reliable data and will regularly update the GBS to include them.

GLOBIO reached its version 3.0 in 2009 and its version 3.5 in 2016 (Alkemade et al., 2009; Schipper et al., 2016). Work is ongoing on its version 4.0, which should include data from the PREDICTS database, among other improvements.

EXIOBASE was launched in 2013, its second version was released in 2015 and its third in 2018 (Stadler et al., 2018; Wood et al., 2015).

Data underlying the Commodity Tools developed by CDC Biodiversité are also updated at varying frequency.

5.7 Does the GBS take into account marine biodiversity and invasive species?

The GLOBIO model currently does not take into account marine biodiversity and the terrestrial GLOBIO model does not explicitly distinguish the effects of invasive species. Thus, the GBS currently does not cover them. Unfortunately, there is no plan to integrate them in GLOBIO in the near future[39]. As soon as reliable data are available, the GBS will include impacts on marine biodiversity and impacts from invasive species in its assessments.

Also, the GBS does not currently assess the impact of overexploitation of natural resources.

(39) A 2010 global biodiversity strategy analysis by the PBL (Netherlands Environmental Agency (PBL), 2010) combined GLOBIO with analyses of fish populations derived from other models (Pauly et al., 2003; Pauly, Watson, & Alder, 2005).

Conclusion and prospects

CONCLUSION AND PROSPECTS

In 2018, we built the connections between the different modules of the GBS (EXIOBASE, in-house tools such as our CommoTools, and GLOBIO), which means we can now launch default assessments for any industry or region and that we will be able to run complete assessments as soon as all the CommoTools and Service Tools are completed. We made great progress in our vision of future GBS (internal and external) audits, introducing concepts such as Scopes and moving towards a stepwise approach. We refined our data collection process and tested different components of the GBS through three case studies covering agricultural raw material supply comparisons and financial portfolio assessment. We also launched work on minerals (extractive industries) and on freshwater biodiversity.

2018 was also a fruitful year in terms of cooperation: we collaborated with ASN Bank, ACTIAM and Finance in Motion to agree on common concepts and methodological issues related to the biodiversity footprint of financial institutions (CDC Biodiversité, ASN Bank & ACTIAM, 2018). The Aligning Biodiversity Measures for Business project was also launched to gather and facilitate convergence between most of the existing impact assessment initiatives. Following these technical exchanges, we harmonised several methodological elements and in particular the way the GBS accounts for the impact of climate change. This harmonization effort seeks to foster business confidence in the consistency and mutual compatibility of existing tools. We also had in-depth discussions with public policy-makers and environmental NGOs and the GBS is clearly identified as a useful and legitimate tool to support the post-2020 global biodiversity framework and corporate biodiversity footprint reporting (which should become mandatory in France and then in the EU under the extra-financial performance reporting framework).

Looking ahead, three major events will shape the biodiversity agenda, and thus the GBS agenda, in 2019 and 2020. First, the IPBES plenary in April-May 2019 in Paris should build momentum for biodiversity among civil society and decision-makers. Then, in 2020, the IUCN World Congress in Marseille will focus minds just before COP15 of the CBD in Kunming where the post-2020 global biodiversity targets will be decided.

In order to build on the momentum created by the IPBES plenary and the IUCN World Congress and feed COP15, we plan to step up our partnerships and technical development. On the **partnership** side, we plan to work towards convergence of concepts and methodologies with other initiatives through the Aligning Biodiversity Measures for Business project. We will also monitor closely how work on the biodiversity planetary boundary expressed in MSA (Lucas & Wilting, 2018) will feed into the post-2020 targets discussion and how the GBS can be used to assess the contribution of businesses to the achievement of such targets. We believe the post-2020 global biodiversity framework should include global and shared targets and in particular a simple, communicable and quantifiable overarching "apex goal" which underpins a set of objectives, actions and enabling conditions. This raises the question of a common metric to set and monitor such a goal.

On the **technical development** side, in 2019, the GBS team will complete the minerals CommoTool and the connection of existing CommoTools to freshwater pressures. It will launch work on a number of CommoTools and Service Tools: fossil fuels, livestock husbandry, forestry, and other products and services. Work will also be launched on the diffuse pressure generated by pesticides. The new methodological developments completed in 2019 will be described in a new BIODIV'2050 OUTLOOK release around the end of 2019.

A first audit pilot is already planned in 2019 with a member of the B4B+ Club. More audit pilots should be launched in the second half of 2019.

The GBS' Review Committee will also be launched in 2019. Gathering representatives from academia and civil society, it will conduct a peer-review of the GBS and its comments will be integrated into the tool, to reinforce its reliability and legitimacy.

The release of an operational GBS is planned in 2020. The capacity of auditors and rating agencies to conduct corporate footprint assessment with the GBS will be ensured through training by CDC Biodiversité and partnerships.

REFERENCES

Addison, P., Carbone, G., & McCormick, N. (2018). *The development and use of biodiversity indicators in business: an overview* (p. vi + 16pp). Gland, Switzerland: IUCN.

Alkemade, R., van Oorschot, M., Miles, L., Nellemann, C., Bakkenes, M., & ten Brink, B. (2009). GLOBIO3: A Framework to Investigate Options for Reducing Global Terrestrial Biodiversity Loss. *Ecosystems*, *12*(3), 374–390. https://doi.org/10.1007/s10021-009-9229-5

Arets, E. J. M. M., Verwer, C., & Alkemade, R. (2014). Meta-analysis of the effect of global warming on local species richness.

Beusen, A. (2014). Transport of Nutrients from land to sea; Global Modeling Approaches and Uncertainty Analyses. Utrecht Studies in Earth Sciences, No. 58.

Biemans, H., Haddeland, I., Kabat, P., Ludwig, F., Hutjes, R. W. A., Heinke, J., Gerten, D. (2011). Impact of reservoirs on river discharge and irrigation water supply during the 20th century. *Water Resources Research*, *47*(3).

BirdLife International. (2006). *Monitoring Important Bird Areas: a global framework*. (No. Version 1.2). Cambridge, UK.

CDC Biodiversité. (2015a). *Entreprises et biodiversité : quels outils pour quelles décisions ? Analyse comparative et outils opérationnels pour l'action* (Les Cahiers de BIODIV'2050 No. 7).

CDC Biodiversité. (2015b). *Entreprises et biodiversité : risques et opportunités* (BIODIV'2050 No. 7). Retrieved from http://www.mission-economie-biodiversite.com/publication/entreprises-et-biodiversite-risques-et-opportunites

CDC Biodiversité. (2017). *Global Biodiversity Score: measuring a company's biodiversity footprint* (Biodiv'2050 Outlook No. 11).

CDC Biodiversité, ASN Bank, & ACTIAM. (2018). *Common ground in biodiversity footprint methodologies for the financial sector*. Paris: ACTIAM, ASN Bank, CDC Biodiversité. Supported by Finance in Motion. Retrieved from https://www.asnbank.nl/web/file?uuid=b71cf717-b0a6-47b0-8b96-47b6aefd2a07&owner=6916ad14-918d-4ea8-80ac-f71f0ff1928e&contentid=2412

Davidson, N. C. (2014). How much wetland has the world lost? Long-term and recent trends in global wetland area. *Marine and Freshwater Research*, *65*(10), 934–941.

Fekete, B. M., Wisser, D., Kroeze, C., Mayorga, E., Bouwman, L., Wollheim, W. M., & Vörösmarty, C. (2010). Millennium ecosystem assessment scenario drivers (1970–2050): climate and hydrological alterations. *Global Biogeochemical Cycles*, *24*(4).

GRI. (2007). *Biodiversity: a GRI reporting resource*. Retrieved from https://www.globalreporting.org/resourcelibrary/Biodiversity-A-GRI-Resource-Document.pdf

Häyhä, T., Cornell, S., Hoff, H., Lucas, P. L., & Van Vuuren, D. P. (2018). Operationalizing the concept of a safe operating space at the EU level–first steps and explorations. *Stockholm Resilience Centre Technical Report, Prepared in Collaboration with Stockholm Environment Institute (SEI) and PBL Netherlands Environmental Assessment Agency. Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden.*

Häyhä, Tiina, Lucas, P. L., van Vuuren, D. P., Cornell, S. E., & Hoff, H. (2016). From Planetary Boundaries to national fair shares of the global safe operating space—How can the scales be bridged? *Global Environmental Change*, *40*, 60–72.

Hoff, H., Häyhä, T., Cornell, S., & Lucas, P. (2017). Bringing EU policy into line with the Planetary Boundaries. *SEI Discussion Brief. Stockholm Environment Institute (SEI), Stockholm Resilience Centre (SRC) and PBL Netherlands Environmental Assessment Agency, Stockholm/The Hague.*

Hoff, H., & LOBOS, A. I. (2017). How the planetary boundaries framework can support national implementation of the 2030 Agenda. *SEI Policy Brief*. Retrieved from http://www.seiinternational.org/mediamanager/documents/Publications/SEI-2017-PB-Hoff-Howthe-Planetary.pdf

Janse, J. H., Kuiper, J. J., Weijters, M. J., Westerbeek, E. P., Jeuken, M., Bakkenes, M., Verhoeven, J. T. A. (2015). GLOBIO-Aquatic, a global model of human impact on the biodiversity of inland aquatic ecosystems. *Environmental Science & Policy*, *48*, 99–114.

Janse, Jan H., Bakkenes, M., & Meijer, J. (2016). Globio-Aquatic. *Technical Model Description*, *1*.

Joos, F., Roth, R., Fuglestvedt, J. S., Peters, G. P., Enting, I. G., von Bloh, W., Weaver, A. J. (2013). Carbon dioxide and climate impulse response functions for the computation of greenhouse gas metrics: a multi-model analysis. *Atmospheric Chemistry and Physics*, *13*(5), 2793–2825. https://doi.org/10.5194/acp-13-2793-2013

Kok, M. T. J., Alkemade, R., Bakkenes, M., van Eerdt, M., Janse, J., Mandryk, M., van Vuuren, D. P. (2018). Pathways for agriculture and forestry to contribute to terrestrial biodiversity conservation: A global scenario-study. *Biological Conservation*, *221*, 137–150. https://doi.org/10.1016/j.biocon.2018.03.003

Ladson, A. R., White, L. J., Doolan, J. A., Finlayson, B. L., Hart, B. T., Lake, P. S., & Tilleard, J. W. (1999). Development and testing of an Index of Stream Condition for waterway management in Australia. *Freshwater Biology*, *41*(2), 453–468.

Lammerant, J., Müller, L., & Kisielewicz, J. (2018). *Assessment of biodiversity accounting approaches for businesses and financial institutions - Update report 1* (Discussion paper for EU Business @ Biodiversity Platform).

Lehner, B., & Döll, P. (2004). Development and validation of a global database of lakes, reservoirs and wetlands. *Journal of Hydrology*, *296*(1–4), 1–22.

Lehner, B., Liermann, C. R., Revenga, C., Vörösmarty, C., Fekete, B., Crouzet, P., Magome, J. (2011). High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management. *Frontiers in Ecology and the Environment*, *9*(9), 494–502.

Lenzen, M., Moran, D., Kanemoto, K., Foran, B., Lobefaro, L., & Geschke, A. (2012). International trade drives biodiversity threats in developing nations. *Nature*, *486*(7401), 109.

Lucas, P., & Wilting, H. (2018). Towards a safe operating space for the Netherlands.

Netherlands Environmental Agency (PBL). (2010). *Rethinking Global Biodiversity Strategies: Exploring structural changes in production and consumption to reduce biodiversity loss*. The Hague. Retrieved from https://www.rivm.nl/bibliotheek/rapporten/500197001.pdf

Newbold, T., Hudson, L. N., Arnell, A. P., Contu, S., De Palma, A., Ferrier, S., others. (2016). Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. *Science*, *353*(6296), 288–291.

Pauly, D., Alder, J., Bennett, E., Christensen, V., Tyedmers, P., & Watson, R. (2003). The future for fisheries. *Science*, *302*(5649), 1359–1361.

Pauly, D., Watson, R., & Alder, J. (2005). Global trends in world fisheries: impacts on marine ecosystems and food security. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *360*(1453), 5–12.

PCAF. (2017). *Paving the way towards a harmonised Carbon Accounting Approach for the Financial Sector*. The Netherlands: Platform Carbon Accounting Financials.

Rockström, J. (2009). A safe operating space for humanity. *Nature*, *461*(7263), 472.

Schipper, A. M., Meijer, J. R., Alkemade, R., & Huijbregts, M. A. J. (2016). *The GLOBIO model: a technical description of version 3.5*. The Hague: Netherlands Environmental Agency (PBL). Retrieved from http://www.pbl.nl/sites/default/files/cms/publicaties/pbl_publication_2369.pdf

Stadler, K., Wood, R., Bulavskaya, T., Södersten, C.-J., Simas, M., Schmidt, S., Bruckner, M. (2018). EXIOBASE 3: Developing a time series of detailed environmentally extended multi-regional input-output tables. *Journal of Industrial Ecology*, *22*(3), 502–515.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., others. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, *347*(6223), 1259855.

Stehfest, E., van Vuuren, D., Bouwman, L., & Kram, T. (2014). *Integrated assessment of global environmental change with IMAGE 3.0: Model description and policy applications*. Netherlands Environmental Assessment Agency (PBL).

Stocker, T. (2014). *Climate change 2013: the physical science basis: Working Group I contribution to the Fifth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Van Asselen, S., Verburg, P. H., Vermaat, J. E., & Janse, J. H. (2013). Drivers of wetland conversion: a global meta-analysis. *PloS One*, *8*(11), e81292.

Van Beek, L. P. H., & Bierkens, M. F. P. (2009). *The Global Hydrological Model PCR-GLOBWB: Conceptualization, Parameterization and Verification, Report Department of Physical Geography, Utrecht University, Utrecht, The Netherlands.*

Wilting, H. C., Schipper, A. M., Bakkenes, M., Meijer, J. R., & Huijbregts, M. A. J. (2017). Quantifying Biodiversity Losses Due to Human Consumption: A Global-Scale Footprint Analysis. *Environmental Science & Technology*, *51*(6), 3298–3306. https://doi.org/10.1021/acs.est.6b05296

Wilting, H. C., & van Oorschot, M. M. P. (2017). Quantifying biodiversity footprints of Dutch economic sectors: A global supply-chain analysis. *Journal of Cleaner Production*, *156*, 194–202. https://doi.org/10.1016/j.jclepro.2017.04.066

Wood, R., Stadler, K., Bulavskaya, T., Lutter, S., Giljum, S., de Koning, A., Usubiaga, A. (2015). Global sustainability accounting—developing EXIOBASE for multi-regional footprint analysis. *Sustainability*, *7*(1), 138–163.

World Business Council for Sustainable Development, & World Resources Institute (Eds.). (2004). *The greenhouse gas protocol: a corporate accounting and reporting standard* (Rev. ed). Geneva, Switzerland : Washington, DC: World Business Council for Sustainable Development ; World Resources Institute.

WWF. (2018). *WWF views on the post-2020 global biodiversity framework.*

APPENDIX

a. EXIOBASE 3

The exhaustive list of regions and industries in EXIOBASE 3 are displayed *Table 6* and *Table 7*. To facilitate the interpretation and discussion of results, we classified the industries of the Input-Output model into broad categories or "macro industries" corresponding to the main steps of the value chain.

- **Raw material production** refers to the primary production of raw materials (*e.g.* agriculture, mining, extraction of fossil fuels)
- **Raw and secondary material processing** refers to the transformation of materials into products that are used as inputs in the making of finished products (*e.g.* processing of dairy products, petroleum refinery, pulp processing)
- **Manufacturing** refers to the industries producing finished products (*e.g.* manufacture of textiles, manufacture of fabricated metal products, manufacture of furniture)
- **Retail** refers to industries mostly involved in sale and trade (wholesale trade, retail trade)
- **Waste and wastewater management** refers to the industries dealing with waste and wastewater management, waste disposal, incineration and recycling (*e.g.* incineration of waste, biogasification of food waste, composting of paper)

Industries which occupy a more transversal place in the value chain are grouped into:

- **Energy**, referring to the production and supply of electricity (*e.g.* production of electricity from various sources, steam and hot water supply)
- **Transport** (inland, coastal, sea, air)
- **Construction**
- **Financial services** (*e.g.* financial intermediation, insurance and pension funding)
- **Non-financial services and other activities** (*e.g.* computer and related activities, research and development, education).

Table 6: EXIOBASE 3 regions and corresponding region groups

EXIOBASE 3 region	EXIOBASE 3 region group
Austria	European Union
Belgium	European Union
Bulgaria	European Union
Cyprus	European Union
Czech Republic	European Union
Germany	European Union
Denmark	European Union
Estonia	European Union
Spain	European Union
Finland	European Union
France	European Union
Greece	European Union
Croatia	European Union
Hungary	European Union
Ireland	European Union
Italy	European Union
Lithuania	European Union

EXIOBASE 3 region	EXIOBASE 3 region group
Luxembourg	European Union
Latvia	European Union
Malta	European Union
Netherlands	European Union
Poland	European Union
Portugal	European Union
Romania	European Union
Sweden	European Union
Slovenia	European Union
Slovak Republic	European Union
United Kingdom	European Union
United States	North America
Japan	Asia
China	Asia
Canada	North America
South Korea	Asia
Brazil	South America

EXIOBASE 3 region	EXIOBASE 3 region group
India	Asia
Mexico	South America
Russian Federation	Russia
Australia	Australia
Switzerland	Switzerland
Turkey	Turkey
Taiwan	Asia
Norway	Norway
Indonesia	Asia
South Africa	Africa
RoW Asia and Pacific	Rest of World
RoW America	Rest of World
RoW Europe	Rest of World
RoW Africa	Rest of World
RoW Middle East	Rest of World

Table 7: EXIOBASE 3 industries and corresponding industry groups and value chain categories

EXIOBASE 3 industry	EXIOBASE 3 industry group	Value_chain_ category
Cultivation of paddy rice	Crop and animal production, hunting and related service activities	Raw material production
Cultivation of wheat	Crop and animal production, hunting and related service activities	Raw material production
Cultivation of cereal grains nec	Crop and animal production, hunting and related service activities	Raw material production
Cultivation of vegetables, fruit, nuts	Crop and animal production, hunting and related service activities	Raw material production
Cultivation of oil seeds	Crop and animal production, hunting and related service activities	Raw material production
Cultivation of sugar cane, sugar beet	Crop and animal production, hunting and related service activities	Raw material production
Cultivation of plant-based fibers	Crop and animal production, hunting and related service activities	Raw material production
Cultivation of crops nec	Crop and animal production, hunting and related service activities	Raw material production
Cattle farming	Crop and animal production, hunting and related service activities	Raw material production
Pigs farming	Crop and animal production, hunting and related service activities	Raw material production
Poultry farming	Crop and animal production, hunting and related service activities	Raw material production
Meat animals nec	Crop and animal production, hunting and related service activities	Raw material production
Animal products nec	Crop and animal production, hunting and related service activities	Raw material production
Raw milk	Crop and animal production, hunting and related service activities	Raw material production
Wool, silk-worm cocoons	Crop and animal production, hunting and related service activities	Raw material production
Manure treatment (conventional), storage and land application	Crop and animal production, hunting and related service activities	Raw material production
Manure treatment (biogas), storage and land application	Crop and animal production, hunting and related service activities	Raw material production
Forestry, logging and related service activities (02)	Forestry and logging	Raw material production
Fishing, operating of fish hatcheries and fish farms; service activities incidental to fishing (05)	Fishing and aquaculture	Raw material production
Mining of coal and lignite; extraction of peat (10)	Mining of coal and lignite	Raw material production
Extraction of crude petroleum and services related to crude oil extraction, excluding surveying	Extraction of crude petroleum and natural gas	Raw material production
Extraction of natural gas and services related to natural gas extraction, excluding surveying	Extraction of crude petroleum and natural gas	Raw material production
Extraction, liquefaction, and regasification of other petroleum and gaseous materials	Extraction of crude petroleum and natural gas	Raw material production
Mining of uranium and thorium ores (12)	Mining of metal ores	Raw material production
Mining of iron ores	Mining of metal ores	Raw material production
Mining of copper ores and concentrates	Mining of metal ores	Raw material production
Mining of nickel ores and concentrates	Mining of metal ores	Raw material production
Mining of aluminium ores and concentrates	Mining of metal ores	Raw material production
Mining of precious metal ores and concentrates	Mining of metal ores	Raw material production
Mining of lead, zinc and tin ores and concentrates	Mining of metal ores	Raw material production
Mining of other non-ferrous metal ores and concentrates	Mining of metal ores	Raw material production

EXIOBASE 3 industry	EXIOBASE 3 industry group	Value_chain_ category
Quarrying of stone	Other mining and quarrying	Raw material production
Quarrying of sand and clay	Other mining and quarrying	Raw material production
Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	Other mining and quarrying	Raw material production
Processing of meat cattle	Manufacture of food products	Raw and secondary material processing
Processing of meat pigs	Manufacture of food products	Raw and secondary material processing
Processing of meat poultry	Manufacture of food products	Raw and secondary material processing
Production of meat products nec	Manufacture of food products	Raw and secondary material processing
Processing vegetable oils and fats	Manufacture of food products	Raw and secondary material processing
Processing of dairy products	Manufacture of food products	Raw and secondary material processing
Processed rice	Manufacture of food products	Raw and secondary material processing
Sugar refining	Manufacture of food products	Raw and secondary material processing
Processing of Food products nec	Manufacture of food products	Raw and secondary material processing
Manufacture of beverages	Manufacture of beverages	Manufacturing
Manufacture of fish products	Manufacture of food products	Manufacturing
Manufacture of tobacco products (16)	Manufacture of tobacco products	Manufacturing
Manufacture of textiles (17)	Manufacture of textiles	Manufacturing
Manufacture of wearing apparel; dressing and dyeing of fur (18)	Manufacture of wearing apparel	Manufacturing
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear (19)	Manufacture of leather and related products	Manufacturing
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (20)	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Manufacturing

EXIOBASE 3 industry	EXIOBASE 3 industry group	Value_chain_ category
Re-processing of secondary wood material into new wood material	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Raw and secondary material processing
Pulp	Manufacture of paper and paper products	Raw and secondary material processing
Re-processing of secondary paper into new pulp	Manufacture of paper and paper products	Raw and secondary material processing
Paper	Manufacture of paper and paper products	Manufacturing
Publishing, printing and reproduction of recorded media (22)	Printing and reproduction of recorded media	Manufacturing
Manufacture of coke oven products	Manufacture of coke and refined petroleum products	Manufacturing
Petroleum Refinery	Manufacture of coke and refined petroleum products	Raw and secondary material processing
Processing of nuclear fuel	Electricity, gas, steam and air conditioning supply	Raw and secondary material processing
Plastics, basic	Manufacture of chemicals and chemical products	Raw and secondary material processing
Re-processing of secondary plastic into new plastic	Manufacture of coke and refined petroleum products	Raw and secondary material processing
N-fertiliser	Manufacture of chemicals and chemical products	Manufacturing
P- and other fertiliser	Manufacture of chemicals and chemical products	Manufacturing
Chemicals nec	Manufacture of chemicals and chemical products	Manufacturing
Manufacture of rubber and plastic products (25)	Manufacture of rubber and plastic products	Manufacturing
Manufacture of glass and glass products	Manufacture of other non-metallic mineral products	Manufacturing
Re-processing of secondary glass into new glass	Manufacture of other non-metallic mineral products	Raw and secondary material processing
Manufacture of ceramic goods	Manufacture of other non-metallic mineral products	Manufacturing

EXIOBASE 3 industry	EXIOBASE 3 industry group	Value_chain_ category
Manufacture of bricks, tiles and construction products, in baked clay	Manufacture of other non-metallic mineral products	Manufacturing
Manufacture of cement, lime and plaster	Manufacture of other non-metallic mineral products	Manufacturing
Re-processing of ash into clinker	Manufacture of other non-metallic mineral products	Raw and secondary material processing
Manufacture of other non-metallic mineral products n.e.c.	Manufacture of other non-metallic mineral products	Manufacturing
Manufacture of basic iron and steel and of ferro-alloys and first products thereof	Manufacture of basic metals	Manufacturing
Re-processing of secondary steel into new steel	Manufacture of basic metals	Raw and secondary material processing
Precious metals production	Manufacture of basic metals	Raw and secondary material processing
Re-processing of secondary preciuos metals into new preciuos metals	Manufacture of basic metals	Raw and secondary material processing
Aluminium production	Manufacture of basic metals	Raw and secondary material processing
Re-processing of secondary aluminium into new aluminium	Manufacture of basic metals	Raw and secondary material processing
Lead, zinc and tin production	Manufacture of basic metals	Raw and secondary material processing
Re-processing of secondary lead into new lead, zinc and tin	Manufacture of basic metals	Raw and secondary material processing
Copper production	Manufacture of basic metals	Raw and secondary material processing
Re-processing of secondary copper into new copper	Manufacture of basic metals	Raw and secondary material processing
Other non-ferrous metal production	Manufacture of basic metals	Raw and secondary material processing
Re-processing of secondary other non-ferrous metals into new other non-ferrous metals	Manufacture of basic metals	Raw and secondary material processing
Casting of metals	Manufacture of basic metals	Raw and secondary material processing
Manufacture of fabricated metal products, except machinery and equipment (28)	Manufacture of fabricated metal products, except machinery and equipment	Manufacturing

EXIOBASE 3 industry	EXIOBASE 3 industry group	Value_chain_ category
Manufacture of machinery and equipment n.e.c. (29)	Manufacture of machinery and equipment n.e.c.	Manufacturing
Manufacture of office machinery and computers (30)	Manufacture of computer, electronic and optical products	Manufacturing
Manufacture of electrical machinery and apparatus n.e.c. (31)	Manufacture of electrical equipment	Manufacturing
Manufacture of radio, television and communication equipment and apparatus (32)	Manufacture of electrical equipment	Manufacturing
Manufacture of medical, precision and optical instruments, watches and clocks (33)	Manufacture of computer, electronic and optical products	Manufacturing
Manufacture of motor vehicles, trailers and semi-trailers (34)	Manufacture of motor vehicles, trailers and semi-trailers	Manufacturing
Manufacture of other transport equipment (35)	Manufacture of other transport equipment	Manufacturing
Manufacture of furniture; manufacturing n.e.c. (36)	Manufacture of furniture	Manufacturing
Recycling of waste and scrap	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Recycling of bottles by direct reuse	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Production of electricity by coal	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by gas	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by nuclear	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by hydro	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by wind	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by petroleum and other oil derivatives	Electricity, gas, steam and air conditioning supply	Energy

EXIOBASE 3 industry	EXIOBASE 3 industry group	Value_chain_ category
Production of electricity by biomass and waste	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by solar photovoltaic	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by solar thermal	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by tide, wave, ocean	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by Geothermal	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity nec	Electricity, gas, steam and air conditioning supply	Energy
Transmission of electricity	Electricity, gas, steam and air conditioning supply	Energy
Distribution and trade of electricity	Electricity, gas, steam and air conditioning supply	Energy
Manufacture of gas; distribution of gaseous fuels through mains	Electricity, gas, steam and air conditioning supply	Energy
Steam and hot water supply	Electricity, gas, steam and air conditioning supply	Energy
Collection, purification and distribution of water (41)	Water collection, treatment and supply	Non-financial services and other activities
Construction (45)	Construction	Construction
Re-processing of secondary construction material into aggregates	Waste collection, treatment and disposal activities; materials recovery	Raw and secondary material processing
Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessoiries	Wholesale and retail trade and repair of motor vehicles and motorcycles	Retail
Retail sale of automotive fuel	Wholesale and retail trade and repair of motor vehicles and motorcycles	Retail
Wholesale trade and commission trade, except of motor vehicles and motorcycles (51)	Wholesale trade, except of motor vehicles and motorcycles	Retail

EXIOBASE 3 industry	EXIOBASE 3 industry group	Value_chain_ category
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52)	Retail trade, except of motor vehicles and motorcycles	Retail
Hotels and restaurants (55)	Accommodation and food service activities	Non-financial services and other activities
Transport via railways	Land transport and transport via pipelines	Transport
Other land transport	Land transport and transport via pipelines	Transport
Transport via pipelines	Land transport and transport via pipelines	Transport
Sea and coastal water transport	Water transport	Transport
Inland water transport	Water transport	Transport
Air transport (62)	Air transport	Transport
Supporting and auxiliary transport activities; activities of travel agencies (63)	Travel agency, tour operator and other reservation service and related activities	Non-financial services and other activities
Post and telecom-munications (64)	Post and telecom-munications	Non-financial services and other activities
Financial intermediation, except insurance and pension funding (65)	Financial service activities, except insurance and pension funding	Financial services
Insurance and pension funding, except compulsory social security (66)	Insurance, reinsurance and pension funding, except compulsory social security	Financial services
Activities auxiliary to financial intermediation (67)	Activities auxiliary to financial services and insurance activities	Financial services
Real estate activities (70)	Real estate activities	Non-financial services and other activities
Renting of machinery and equipment without operator and of personal and household goods (71)	Other personal service activities	Non-financial services and other activities
Computer and related activities (72)	Computer and related activities	Non-financial services and other activities
Research and development (73)	Scientific research and development	Non-financial services and other activities

EXIOBASE 3 industry	EXIOBASE 3 industry group	Value_chain_ category
Other business activities (74)	Other business activities	Non-financial services and other activities
Public administration and defence; compulsory social security (75)	Public administration and defence; compulsory social security	Non-financial services and other activities
Education (80)	Education	Non-financial services and other activities
Health and social work (85)	Human health and social work activities	Non-financial services and other activities
Incineration of waste: Food	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Incineration of waste: Paper	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Incineration of waste: Plastic	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Incineration of waste: Metals and Inert materials	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Incineration of waste: Textiles	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Incineration of waste: Wood	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Incineration of waste: Oil/ Hazardous waste	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Biogasification of food waste, incl. land application	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Biogasification of paper, incl. land application	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Biogasification of sewage slugde, incl. land application	Waste collection, treatment and disposal activities; materials recovery	End-of-life

EXIOBASE 3 industry	EXIOBASE 3 industry group	Value_chain_ category
Composting of food waste, incl. land application	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Composting of paper and wood, incl. land application	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Waste water treatment, food	Water collection, treatment and supply	End-of-life
Waste water treatment, other	Water collection, treatment and supply	End-of-life
Landfill of waste: Food	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Landfill of waste: Paper	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Landfill of waste: Plastic	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Landfill of waste: Inert/metal/ hazardous	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Landfill of waste: Textiles	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Landfill of waste: Wood	Waste collection, treatment and disposal activities; materials recovery	End-of-life
Activities of membership organisation n.e.c. (91)	Activities of membership organisation n.e.c.	Non-financial services and other activities
Recreational, cultural and sporting activities (92)	Arts, entertainment and recreation	Non-financial services and other activities
Other service activities (93)	Other service activities	Non-financial services and other activities
Private households with employed persons (95)	Activities of households as employers of domestic personnel	Non-financial services and other activities
Extra-territorial organizations and bodies	Activities of extraterritorial organisations and bodies	Non-financial services and other activities

b. Surface freshwater biodiversity

Inland aquatic ecosystems – rivers, lakes, and wetlands – represent 11-13 million km², or 8-9% of the Earth's continental surface (Lehner & Döll, 2004). They host a high and unique biodiversity delivering important ecosystem services. Figure 28 presents a map of freshwater bodies in the world.

Biodiversity in freshwater ecosystems is undergoing a rapid and global decline. Hence the need for adequate policies, regulations and tools to understand and halt this decline. PBL scientists recently developed the GLOBIO-Aquatic model (J. H. Janse et al., 2015), counterpart of the GLOBIO terrestrial model, focusing on the biodiversity of inland surface aquatic ecosystems. Thus, we are currently developing the GBS methodology to include aquatic biodiversity based on the GLOBIO-Aquatic model. According to the model's results and as illustrated by Figure 29, the world average aquatic mean species abundance has decreased to 76% in 2000 and is predicted to drop to 72% by 2050 in the OECD baseline scenario (the same scenario as for GLOBIO Terrestrial, it is also called "SSP2" for Shared Socioeconomic Pathway, a middle-of-the-road scenario in terms of socioeconomic predictions). The highest losses are occurring in Central Africa (Figure 30). Assessing the impact of economic activities on freshwater ecosystems with the GBS is therefore crucial to complete the assessment on terrestrial ecosystems and provide a comprehensive analysis of companies' biodiversity footprint.

Overview of the GLOBIO-Aquatic model

As with the terrestrial model, GLOBIO-Aquatic provides both pressure-impact relationships and projections of global aquatic biodiversity evolution up to 2050.

Three types of freshwater ecosystems – lakes, rivers and wetlands[40] – and four pressures – drainage of wetlands, catchment land use changes, nutrient loading and hydrological disturbance – are considered in the pressure-impact relationships. A description of the drivers is provided below and we refer readers interested into a more detailed description of GLOBIO-Aquatic to the scientific paper (J. H. Janse et al., 2015) and the technical description of the model (Jan H. Janse, Bakkenes, & Meijer, 2016).

(40) The GWLD "largely [refers] to lakes as permanent still water bodies (lentic water bodies) without direct connection to the sea". It also includes "saline lakes and lagoons (but not 'lagoon areas') as lakes, while excluding intermittent or ephemeral water bodies". It includes both natural and manmade reservoirs as lakes. The definition of wetlands generally follows the Ramsar Convention definition of wetlands, which basically includes non-lake, non-river water bodies with a depth lower than 6m. Large rivers are also considered "lotic wetlands" (Lehner & Döll, 2004). Wetlands include classes 4 to 12 of the GWLD, *i.e.* freshwater marshes, floodplains, swamp forests, flooded forests, coastal wetlands (mangroves, estuaries, deltas, lagoons), pans, brackish/saline wetlands, bogs, fens, mires, intermittent wetlands/lakes.

The projections up to 2050 benefit from the linkages with the IMAGE model framework, which provides information on the evolution of biodiversity intactness in freshwater ecosystems at the same spatial scale as the GLOBIO terrestrial model (0.5° by 0.5° grid cells). The environmental drivers are evaluated through a chain of global models and maps involving the IMAGE model for land use and climate change (Stehfest, van Vuuren, Bouwman, & Kram, 2014), the PCR-GLOBWB hydrological model (Van Beek & Bierkens, 2009), the Global Nutrient Model , (Beusen, 2014) and the Global Lakes and Wetlands Database, GLWD, a map of water bodies (Lehner & Döll, 2004). The catchment approach is applied by including upstream-downstream spatial relationships between grid cells based on flow direction. The biodiversity impacts on a waterbody depends on the intensity of drivers on all upstream cells. A schematic representation of the model chain is provided by Figure 31.

Description of the drivers of aquatic biodiversity loss

The indicator for biodiversity intactness (MSA) is based on the same principles as in the terrestrial model, dose-response (pressure-impact) relationships being described by a set of empirical functions based on meta-analyses of literature data for each driver and water body type. Table 8 summarizes the drivers considered and the water body types impacted.

➨ Direct land use change: wetland conversion

This driver deals with the direct impacts of conversion and draining of wetlands for human purposes. Global wetland area has indeed decreased by over 60% since 1900 (Davidson, 2014), due mainly to agricultural expansion (Van Asselen, Verburg, Vermaat, & Janse, 2013). As no historical wetland map is available, conversions are derived indirectly in GLOBIO-Aquatic based on a conservative guess of the minimal wetland area required to meet the projected increase in agricultural demand if all non-wetland natural areas have been used. The two hypotheses underlying the methodology are thus: 1) wetlands are converted solely into agricultural land and 2) they are converted only after all other natural areas in the cell have been converted. This method likely underestimates the biodiversity loss due to wetland conversion. The biodiversity impact of conversion is straightforward, the MSA dropping from its current value to 10% (MSA of croplands) on the area converted.

Figure 30: Global Lakes and Wetlands map (GLWD)**.** Source (Lehner and Döll, 2004)

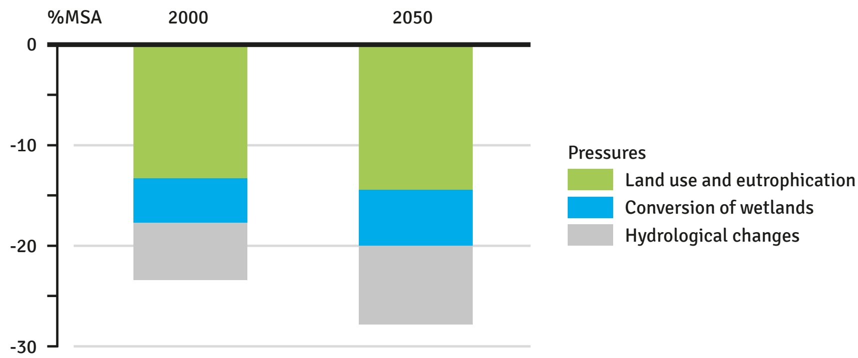


Figure 31: World-averaged aquatic MSA loss in 2000 and 2050 according to the OECD baseline scenario and contribution of the main pressures included in the model. Source (J.H. Janse et al., 2015)

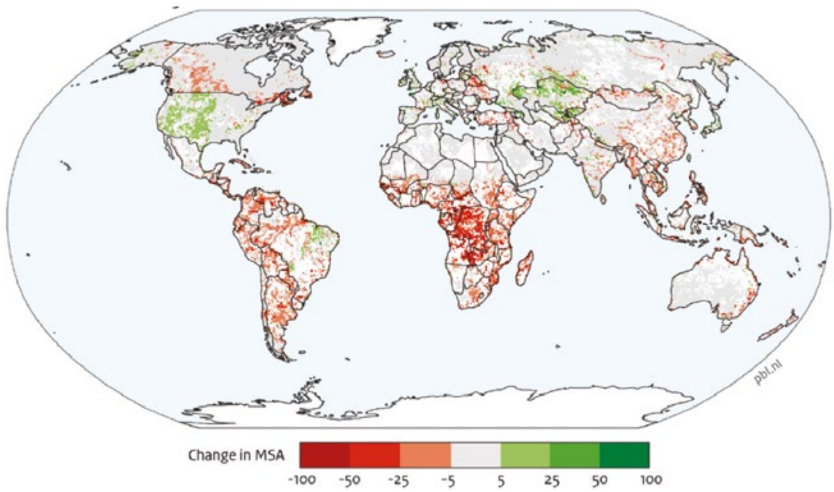


Figure 32: Map of the difference between mean freshwater MSA between 2000 and 2050 (J.H. Janse et al., 2015)**. The change is expressed in absolute MSA, so a +50 increase can signify a rise from 10% to 60% or from 25% to 75% for instance.**

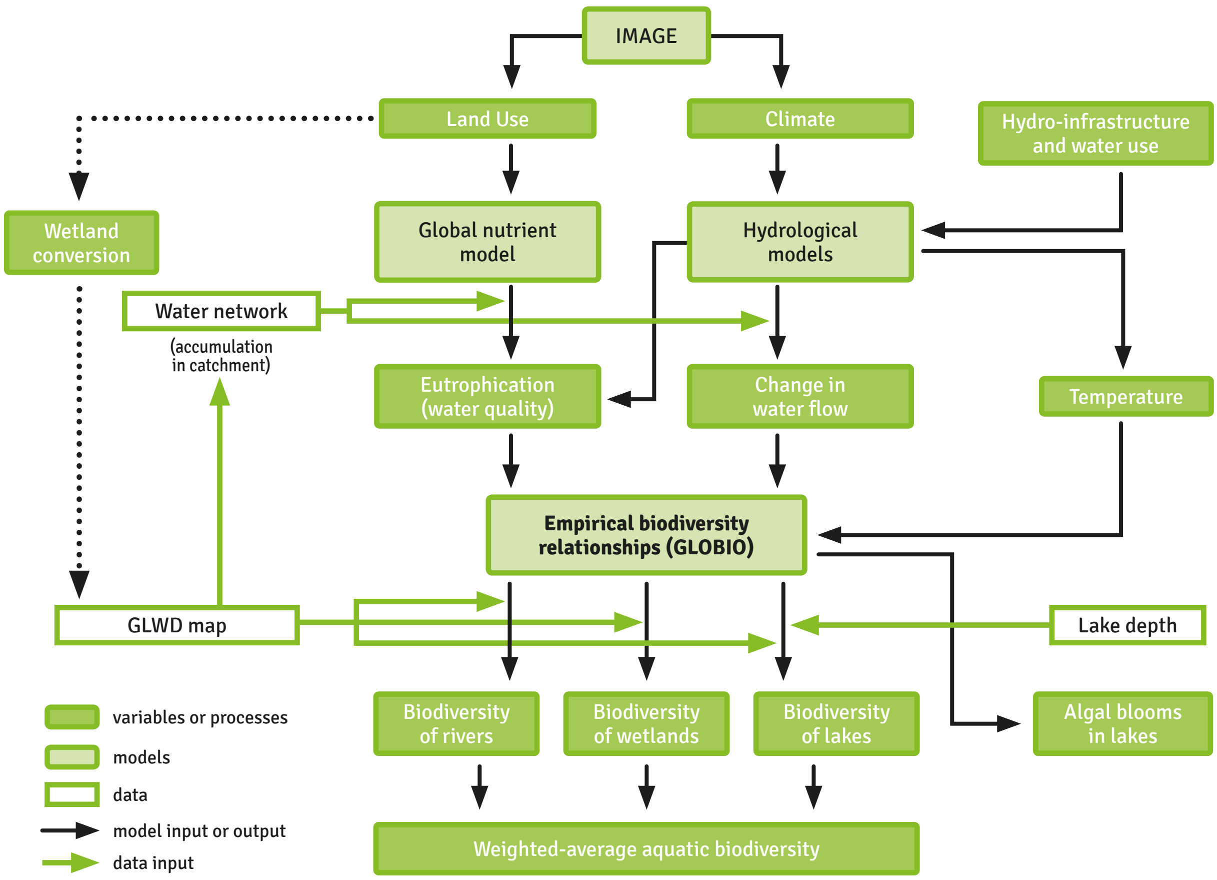


Figure 33: Model chain for freshwater biodiversity.
Source: J.H. Janse et al. 2015

Driver	Water body type			
	Lakes	Rivers	Wetlands in network[1]	Isolated wetlands[2]
Wetland conversion			+	+
Land use in catchment or in current cell		+	+	+
Nutrient emissions	+	+		
Hydrological disturbance		+	+	

[1] Include floodplain wetlands, swamps and coastal wetlands.
[2] All other wetland types.

Table 8: Driver - water body type combination in GLOBIO-Aquatic model (J.H. Janse et al., 2015)

Land use change in catchment

This driver accounts for the indirect impact of upstream land use changes on downstream water bodies, considering that land use type is a proxy for the nutrient emissions leaching to the ecosystems. Projections of land use change in each grid cell are derived from the terrestrial GLOBIO model (and thus indirectly from the IMAGE model). The proportion of anthropic vs natural land uses in the catchment area rather than the type of land use is considered to be the main source of pressure on aquatic biodiversity in downstream cells. The sum of all human land use categories (croplands, pastures, urban areas) is thus computed for each cell and combined with the catchment delineation to calculate the human land use fraction in the upstream part of the catchment. The catchment delineation is derived from the local drain direction (LDD) map[41], itself based on the DDM30 map digital elevation model. GLOBIO Aquatic lists more than 6000 basin connected to GLOBIO Terrestrial cells.

For lakes, rivers and wetlands connected to rivers the catchment is defined as the current cell plus all upstream cells in the hydrological model, whereas for "isolated" wetlands the catchment is confined to the cell in which they are located.

For rivers, the MSA due to land use change in catchment is 1 - 0.7 × F where F is the fraction of cropland, pasture and urban areas land use categories.

For wetlands, the equation is MSA = 1 - 0.87 × F.

Nutrient emissions

The Global Nutrient Model (Beusen, 2014) models nitrogen (N) and phosphorus (P) leaching and runoff to surface water based on agricultural area, the application of fertilizers and manure, precipitations and spatial characteristics of slope, soil texture and groundwater characteristics. To these emissions are added the modelled urban nutrient emissions based on population, GDP, sanitation and the use of detergents. The GLOBIO-Aquatic model uses the accumulated total N and P concentrations as drivers of biodiversity loss in lakes with a differentiated impact between shallow (average depth inferior to 3 meters) and deep lakes and in rivers. The impact on wetlands is not included due to data limitations. Figure 32 shows the results obtained for phosphorus concentrations.

Hydrological disturbance

Hydrological disturbance is defined as the deviation of the current river flow from the natural one. Causes of deviation include climate change (changes in rainfall or evaporation), anthropic water abstraction and river dams used for hydropower, water storage and/or other purposes. Data on existing river dams are taken from the Global Rivers and Dams (GRanD) database (Lehner et al., 2011) documenting the location and use of over 7 000 dams in the world and the projection of future dams is taken from Fekete et al. (2010).

The deviation between natural and current (impacted) flow patterns is determined by the models PCR-GLOBWB (Van Beek & Bierkens, 2009) and LPJmL (Biemans et al., 2011) and calculated as the "amended annual proportional flow deviation" or AAPFD, expressed in cubic meters (Ladson et al., 1999)[42]. The biodiversity impact of flow deviation in rivers and wetlands connected to rivers (*i.e.* floodplain wetlands) is represented in Figure 33 and Figure 34.

(41) Each GLOBIO cell has a drainage direction (north, north east, east, etc.) which makes it possible to know the upstream or downstream position of cells relative to each other.

(42) $AAPDF = \left[\Sigma_{i=1}^{12} \left(\frac{Q_i - Q_{i0}}{\overline{Q_{i0}}} \right)^2 \right]^{\frac{1}{2}}$ with Q_i the runoff in month i, Q_{i0} the natural runoff in month i and $\overline{Q_{i0}}$ the year-averaged natural runoff.

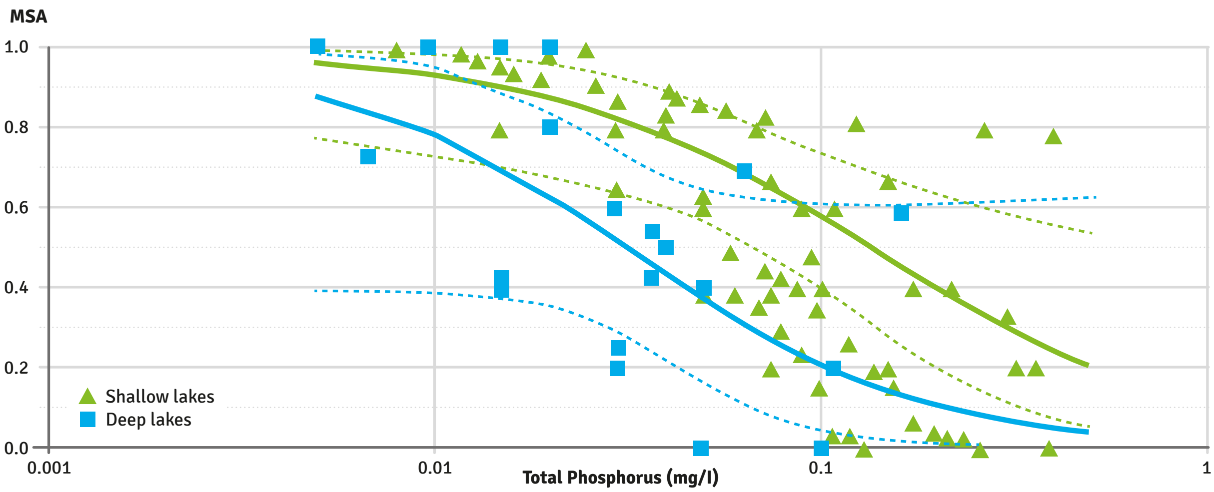


Figure 34: MSA in deep and shallow lakes in relation to nutrient concentrations: regression lines (solid lines) **and 95% intervals** (dashed lines)**.** Source (J.H. Janse et al., 2015)

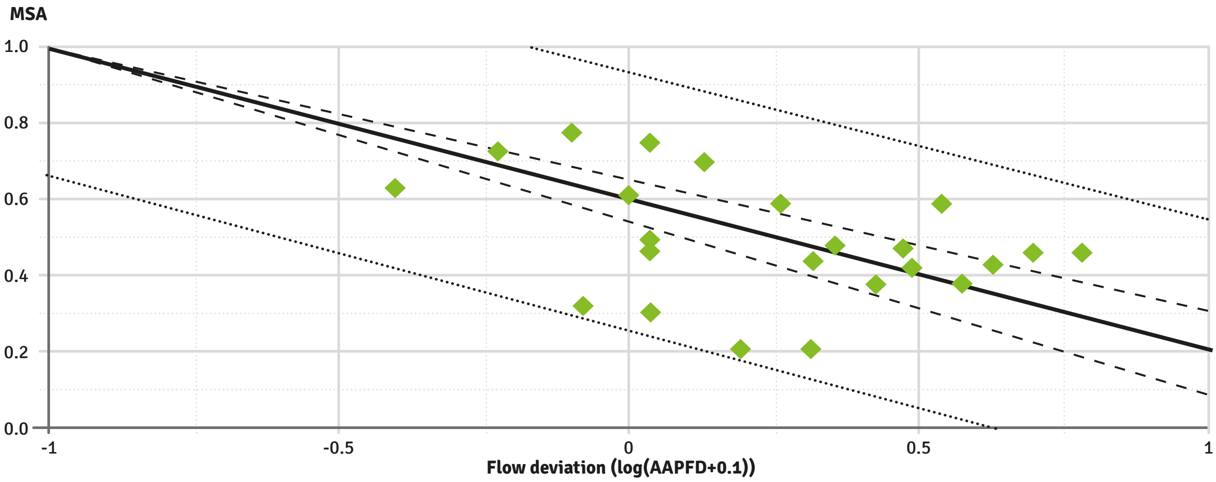


Figure 35: MSA in rivers and streams in relation to flow disturbance including regression line (black line)**, confidence interval** (dashed lines) **and prediction interval** (dotted lines)**.** Source (J.H. Janse et al., 2015)

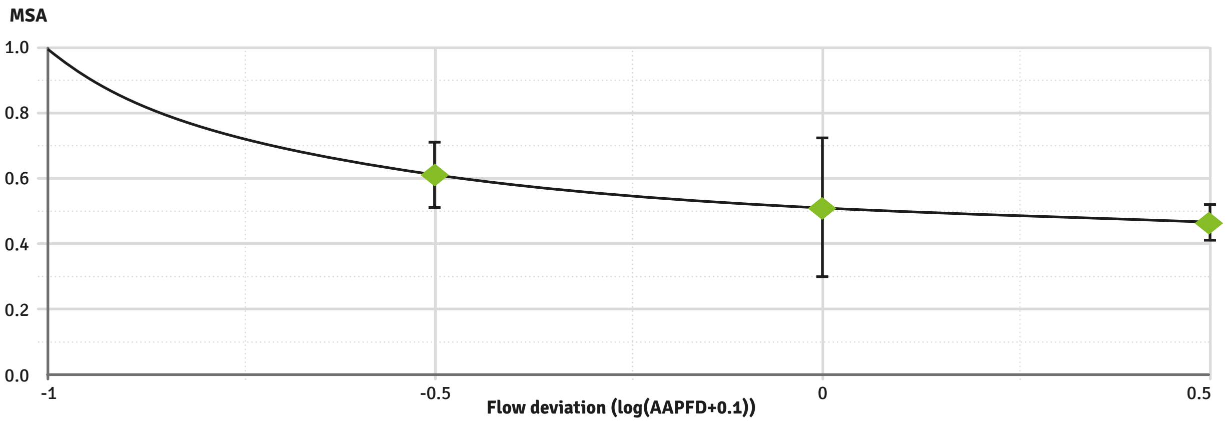


Figure 36: MSA in floodplain wetlands in relation to flow disturbance for three intensities of hydrological alteration, mean effect and standard error. Source (J.H. Janse et al., 2015)

What are the options to reduce the on-site and value chain-related biodiversity impacts of a business? How can financial institutions assess the risks related to the biodiversity impacts of their activity and that of the businesses they finance? How can such information be incorporated into their risk management policy? Can businesses set quantitative targets to reduce their impact on biodiversity as they do for climate? The Global Biodiversity Score (GBS) is a corporate biodiversity footprint assessment tool which seeks to answer these questions. It assesses the biodiversity impacts of economic activities across their value chain, in a robust and synthetic way. It is developed with the support of about 30 businesses and financial institutions gathered in the Business for Positive Biodiversity Club (B4B+ Club) and through collaborations with academics, NGOs and other corporate biodiversity footprint initiatives. This 2018 update clarifies the role of the GBS compared to other tools under development, transparently describes the latest technical developments, shares preliminary results of road testing of the tool with businesses and provides a FAQ answering the most common questions about the GBS.

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