THE GLOBAL BIODIVERSITY SCORE

GBS Review: Core concepts

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CDC BIODIVERSITÉ

Caisse des Dépôts GROUPE

Content

Note to the reader

Global Biodiversity Score (GBS) review reports are not completely independent from each other. Readers of this report are advised to read the reports dedicated to **Terrestrial pressures on biodiversity** (CDC Biodiversité 2020d) and **Aquatic pressures on biodiversity** (CDC Biodiversité 2020b) to ensure a good overall comprehension of the tool and the present report. The sections describing default assessment as well as the limitation sections are especially recommended.

The following colour code is used in the report to highlight:

- Assumptions

- Important sections

- Developments of the GBS planned in the future

The GBS review reports are aimed at technical experts looking for an in-depth understanding of the tool and contribute to the transparency that CDC Biodiversité considers key in the development of such a tool. They focus on technical assumptions and principles. Readers looking for a short and easy-to-understand explanation of the GBS or for an overview of existing metrics and tools should instead read the general audience reports published by CDC Biodiversité (CDC Biodiversité 2017; CDC Biodiversité, ASN Bank, and ACTIAM 2018; CDC Biodiversité 2019b).

Introduction

This document aims at introducing and explaining the main concepts that will be called upon by the next reports. Therefore, it constitutes a preliminary document and should be read first and foremost. The first part of this document details the general principles on which the GBS was built upon. Then, the functioning of GLOBIO pressure-impact relationships and the choice of both this model and its associated metric: the Mean Species Abundance (MSA) are clarified. Finally, the third section goes through the GBS methodology, providing an overview of its step-by-step approach, the use of the EXIOBASE input-output model, and the essential concepts applied when delivering assessment results.

Eleven reports were delivered throughout the review of the GBS, which can be regrouped in the following three groups depending on where they intervene in the step-by-step GBS methodology (see section 3.2):

1. Input Output Modelling: will integrate the eponymous report (1).

2. CommoTools: Crops (4), Livestock, including grazing and livestock husbandry (5), Wood logs (6), Mining (7) and Oil & Gas (8) reports.

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3. Pressure-impact relationships: Terrestrial (2), Freshwater (3) and Ecotoxicity (9) pressures on biodiversity reports.

4. Core concepts (10, this report) and Quality assurance (11), two standalone transversal reports.

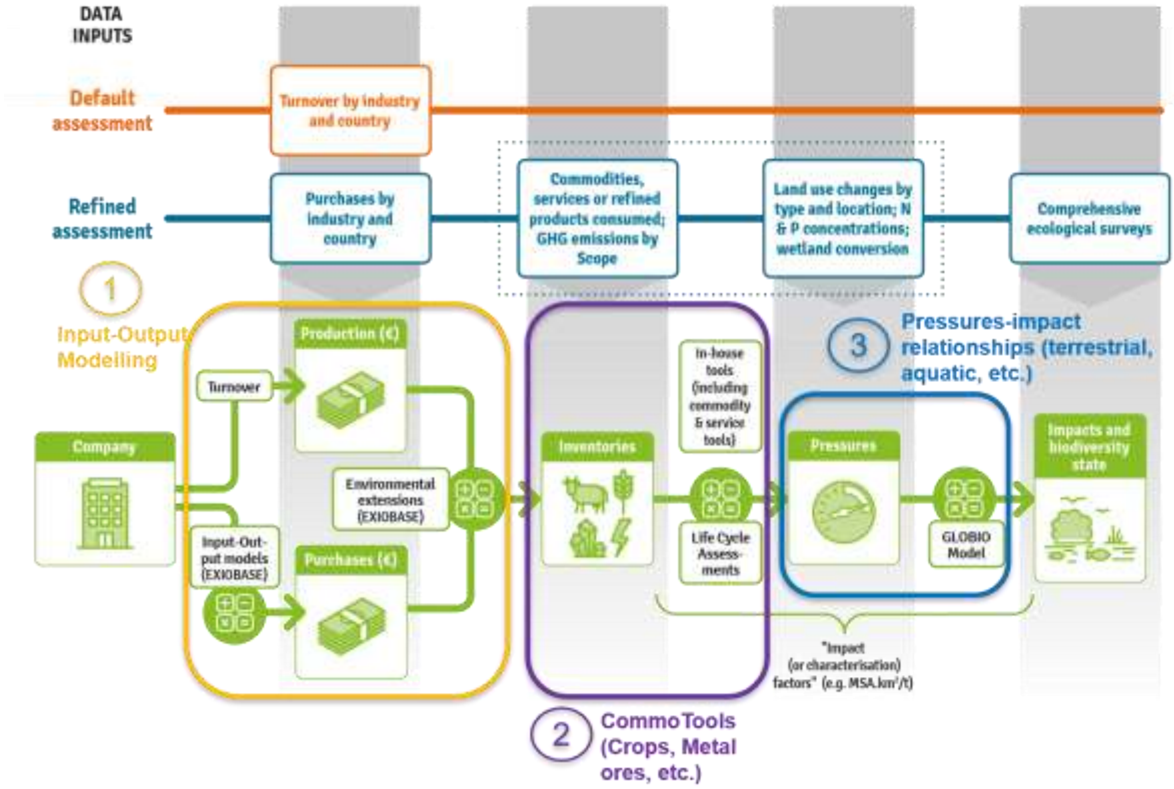

Figure 1: Types of reports and their place in the GBS methodology

Before diving into technical considerations, it is worth briefly mentioning where the GBS sits in terms of biodiversity covered. The main aggregate metrics currently in use focus on ecosystem and ecological integrity (*Biodiversity Intactness Index*, *MSA*), species and conservation status (*Red List Index)*, or population trends (*Living Planet Index)* (Mace et al. 2018). Aggregate metrics for genes diversity are still lacking. The GBS uses the MSA metric and focuses on ecological integrity. Readers interested in learning more about these metrics can refer to previous reports by CDC Biodiversité and the EU B@B platform (CDC Biodiversité 2019b; Lammerant 2019).

1 Foundations of the GBS and general principles

1.1 Desired features of the GBS

At the beginning of the GBS development, general principles were established to ensure that the tool was both useful for its end users, *i.e.* companies and financial institutions, and reflected the state of biodiversity itself. Therefore, it was settled that the GBS must (1) be quantitative, as businesses cannot manage what they do not measure; (2) cover the entire value chain, to involve all economic sectors and not just those with a direct and visible impact; (3) produce concise results, to facilitate in-house and out-of-house communication; (4) be focused on the biodiversity itself, as biodiversity should not be limited to the services it provides; (5) produce results responsive to changes, as it must reflect changes due to pro-biodiversity iniatives or additional impacts; (6) be scientifically consensual and transparent.

1.2 Desired specifications for biodiversity input data

To meet the methodology's needs, the input data must:

- **reflect the declining abundance of species**. Indeed, focusing only on species extinction risk has shortcomings. First, the risk is difficult to estimate and whether a species has become completely extinct can be complicated to assess. Second, the extinction risk may tend to underestimate the decline of a species (Gerardo Ceballos, 2017). For example, if the population of a very common bird such as the house sparrow declines sharply while still remaining within sustainability thresholds, the extinction risk does not increase even though there is a huge impact on the population dynamic.

- **factor in ordinary biodiversity and not just remarkable biodiversity**. Data should include information on both the decline in the populations of orangutans in Borneo and house sparrows in France as both play key roles in the functioning of ecosystems.

- **make it possible to quantitatively link pressures and impacts on biodiversity**. Biodiversity data must allow to establish a clear and intrinsic quantitative link with one or several drivers of biodiversity loss (*i.e.* pressures) and their impacts. Referring to pressures allows a dynamic management of the company's footprint since changes in the contribution to different pressures may be observed in a short time period, and therefore be reflected by a change in the footprint.

1.3 GBS end-users target and positioning with other tools

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

- **Businesses**: corporate assessment for internal communication and external disclosure, at the scale of the entire value chain.
- **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 specialised tools more specifically tailored to these uses.

Other tools end-users target and the scale at which they are best applied are specified in Figure 2 below. Work is under way to build bridges between them. In particular, the *Aligning Biodiversity Measures for Businesses* (ABMB) initiative was launched in 2018 to increase cooperation and "form a common view" between initiatives working on corporate biodiversity impacts and dependencies. It also aims to feed the discussions on corporate indicators through the biodiversity global policy frameworks.

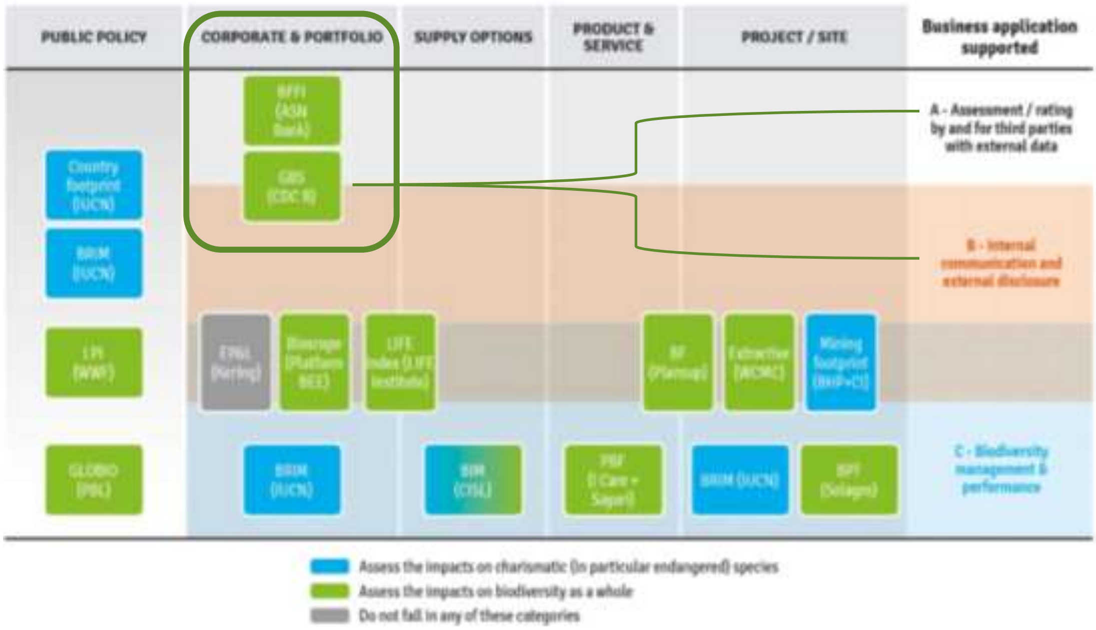

Figure 2: GBS positionning with other biodiversity assessment tools

2 Mean Species Abundance and the two components of GLOBIO

2.1 Justification for choosing GLOBIO and the Mean Species Abundance

The GLOBIO model was developed by a consortium formed in 2003 consisting of the PBL, UNEP GRID-Arendal[1] and UNEP-WCMC. It has two main components with very different uses.

First, it provides **pressure-impact relationships** (also called cause-effect or dose-response relationships) for a number of pressures on biodiversity, referred to as the "GLOBIO cause-effect relationships". It draws on pressure-impact relationships found in scientific literature. The pressures covered include land conversion, fragmentation, encroachment, eutrophication and climate change for terrestrial biodiversity (Alkemade et al. 2009; Schipper et al. 2016), and wetlands conversion, local and network land-use in catchment of wetlands, hydrological disturbance of wetlands and rivers, land-use in catchment of rivers and eutrophication of lakes for aquatic biodiversity (J. H. Janse et al. 2015; Jan H. Janse, Bakkenes, and Meijer 2016).

Second, it provides **scenarios of future global biodiversity loss**. In particular, it provides the scenario used in a technical background paper to the Global Biodiversity Outlook 4 or GBO4 (Kok et al. 2014). This part of GLOBIO is what we refer to as the "GLOBIO-IMAGE scenario". It produces spatialized results for land and aquatic (freshwater) biodiversity at a resolution of 0.5° by 0.5°, *i.e.* 55 km by 55 km at the Equator. These are expressed in MSA. GLOBIO combines spatialized data on various pressures – and not field data on species – to the cause-effect relationships to estimate impacts on biodiversity. These drivers are taken mainly from the Integrated Model to Assess the Global Environment (IMAGE) (Stehfest et al. 2014).

As explained in the Terrestrial module review document (CDC Biodiversité 2020d), the first component is essential to the GBS (though GLOBIO cause-effect relationships could be replaced by other cause-effect relationships in the future) while the second is not but is currently used as a proxy of pressures due to a lack of better global data. The terrestrial biodiversity of GLOBIO was updated from version 3.6 to version 4 (Schipper et al. 2020) in late 2019. This update happened too late to be considered for integration in the GBS 1.0. The fact that aquatic biodiversity is not yet covered by GLOBIO4 is also an obstacle. In the rest of this document, when GLOBIO is mentioned, we are thus referring to GLOBIO3.6.

[1] GRID-Arendal is a government-funded research centre located in Arendal (Norway). It works with the UNEP on questions relating to environmental data and evaluation and is part of the GRID network that produces consolidated accurate environmental data in support of research and public policy.

Table 1 details the characteristics of the main sources of biodiversity pressure-impact relationships that were considered as input data for the GBS, and whether or not they fit with the desired specifications of the GBS. Table 2 provides similar information for two additional noteworthy data sources.

Table 1: Characteristics of the main pressure-impact relationships that were considered as input for the GBS

Characteristics	GLOBIO cause-effect relationships	IUCN Red List[2]	Ecological Footprint[3]	LBII cause-effect relationships[4]	LCA methods[5]
Quantitative	Yes	Yes	Yes	Yes	Yes
Global and spatialized		Yes	Yes	Yes	
Consensual	Yes	Yes	Yes	Yes	Yes
Used by the CBD and IPBES[6]		Yes		Yes	
One aggregate metric	Yes		Yes	Yes	Yes
Comprehensible for non-experts	Yes	Yes	Yes	Yes	
Focused on biodiversity itself	Yes	Yes		Yes	Yes
Takes abundance into account	Yes			Yes	
Ordinary biodiversity	Yes			Yes	Yes
Pressures covered by “cause-effect relationships”	Many	Many	Few	Few	Many

Table 2: Characteristics of the main data sources that were considered as input for the GBS

Characteristics	GLOBIO-IMAGE scenario	LPI WWF[7]
Quantitative	Yes	Yes
Global and spatialized	Yes	
Consensual	Yes	Yes
Used by the CBD and IPBES[8]	Yes	Yes
One aggregate metric	Yes	Yes
Comprehensible for non-experts	Yes	Yes
Focused on biodiversity itself	Yes	Yes
Takes abundance into account	Yes	Yes
Ordinary biodiversity	Yes	Yes
Coverage cause-effect relationships		

[2] IUCN: International Union for the Conservation of Nature. The Red List includes quantifications of the impacts of a dozen pressures (IUCN 2020).
[3] https://www.footprintnetwork.org/our-work/ecological-footprint
[4] Local Biodiversity Intactness Index (Newbold et al. 2016; Purvis et al. 2018).
[5] Life cycle assessment methods include ReCiPe (Huijbregts et al. 2016), LC Impact (https://lc-impact.eu/) and Impact World+ (http://www.impactworldplus.org/en).
[6] (Kok et al. 2014; Díaz et al. 2019; CBD 2020)
[7] Living Planet Index: https://wwf.panda.org/knowledge_hub/all_publications/living_planet_report_2018
[8] See above.

It was therefore decided to use GLOBIO cause-effect relationships in the GBS methodology as they best fit the specifications. In particular, compared to the LBII cause-effect relationships, the coverage of pressures is higher. Combined with the spatialized and quantitative GLOBIO-IMAGE scenario, GLOBIO cause-effect relationships allow to build regional impact factors. Besides, the scientific worth of the model is confirmed by its use as part of the CBD and the IPBES. The data produced by GLOBIO are open access and transparent. The MSA metric, presented in detail hereinafter, displays interesting features. In a nutshell, the MSA measures biodiversity intactness relative to its abundance in undisturbed ecosystems. A 100% ratio indicates an intact ecosystem while damages caused by an increase of pressures bring the MSA progressively to 0% when all originally occurring species are extinct in the ecosystem. The gradual deterioration from a pristine ecosystem to a completely artificialized space is easily understandable for non-experts, which is a central requirement for a tool intended to support internal and external corporate communications with all types of public. Also, MSA complies with our ecological specifications as it captures changes in ordinary biodiversity by focusing on species abundance and richness and displays clear pressure–impact relationships. However, GLOBIO data carries weaknesses such as the absence of species-related field data, and the absence of cause-effect relationships for certain biodiversity loss drivers (invasive alien species, direct exploitation) and the total absence of cause-effect relationships regarding marine biodiversity.

2.2 The Mean Species Abundance

The Mean Species Abundance (MSA) is the metric used in GLOBIO cause-effect relationships . It describes biodiversity changes with reference to the undisturbed state of ecosystems. It is defined as the average abundances of originally occurring species relative to their abundance in the undisturbed ecosystem. Undisturbed ecosystem is understood here as equivalent to a pristine state, intact and undisturbed by human activity. The MSA is defined as (Schipper et al. 2016):

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

Where

MSA = mean abundance of native species,

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

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

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

MSA is applicable to both land and aquatic ecosystems. MSA varies between 0% and 100%[9]. The abundance of invasive alien species is not included in the calculation of MSA (they are not “native species” present in the undisturbed ecosystem): if the growth of their population is detrimental to native species, then

[9] The ceiling at 100% is caused by the “minimum” function in the MSA formula.

it will result in a decline of the MSA of the ecosystem. Similarly, if some species (temporarily) grow above their undisturbed abundance (their abundance would still be 100% as it is capped) in a way that is detrimental to other species (*e.g.* ungulates overgrazing vascular plants), the overall abundance of the ecosystem declines. Other cases exist where one species temporarily overshoots the undisturbed abundance (*e.g.* saplings with a higher density per hectare than mature trees) without negatively impacting other species, thus not negatively impacting MSA.

The question of what is the "undisturbed ecosystem" is non-trivial. In most cases of applications of the GBS, this does not raise any practical issue because GLOBIO cause-effect relationships are used without the need to define precisely the reference undisturbed ecosystem against which abundance is assessed. However, if MSA needs to be measured based on field data, more detailed guidelines would need to be developed to describe in which cases a forest ecosystem should be considered, in which cases a grassland ecosystem should instead be the reference, etc. In general, forest land uses should be assessed against a natural forest and pasture ecosystems should be assessed against a natural grassland.

Through the spatial integration of MSA % over a surface area, impacts can be expressed in MSA.km^2. The latter is the product of MSA (in %) multiplied by the area to which it applies (expressed in km^2). For example, for a surface area of 1 km^2 of intensely cultivated fields (MSA = 10 %), the value is 1x10% = 0.1 MSA. km^2. Similarly, a change in MSA from 100% to 75% over a surface area of 1 km^2 corresponds to a loss of (100%-75%)*1 = 0.25 MSA.km^2. Equivalently, MSA remaining at 100% across 75% of the surface area (0.75 km^2) and droping to 0% in the remaining 25% (0.25 km^2) also generates a loss of 0.25 km^{2}MSA, as shown in Figure 3:

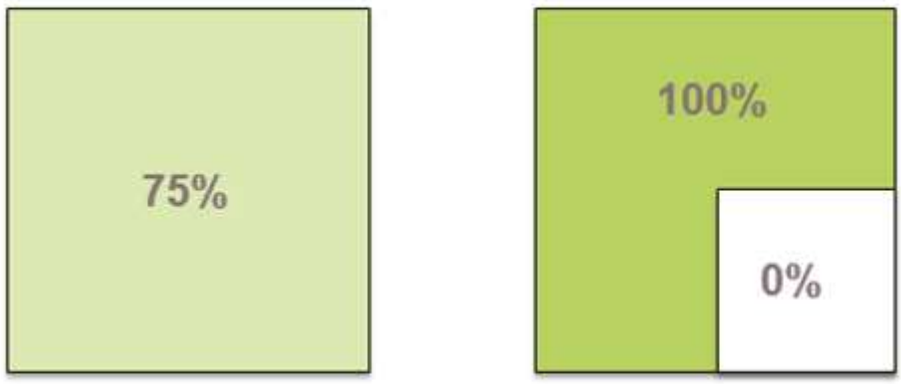

Figure 3: Illustration of the equivalence between a decline in MSA and partial artificialization

Interpreting a loss of x MSA.km^2 as the conversion of x km^2 of undisturbed ecosystem into a completely artificialized one has advantages for communication purposes. A MSA of 0% could however also correspond to an ecosystem populated solely with exotic species.

As illustrated by Figure 3 and the paragraphs above though, a loss of 0.25 MSA.km^2 can correspond to two (and actually a lot more) very different situations and it is not possible to go back from such a figure to the actual situation which caused it. As detailed in the Qualty assurance review document (CDC Biodiversité 2020c), we suggest to report impacts on biodiversity in line with the Biological Diversity Protocol (EWT -

NBBN 2019) or equivalent accounting framework. Under such a framework, impacts should be reported by ecosystem asset, which means the area to which the impact applies is known and the two situations in Figure 3 can be distinguished. The use of such a framework would also allow to distinguish between the loss of 1% MSA from 100% to 99%, from the loss of 1% MSA from 72% to 71%. In the second case, the loss could arguably be considered more problematic, as the threshold of the safe operating space for biodiversity (as it is currently known at a global level) is crossed (Lucas and Wilting 2018; CDC Biodiversité 2019b).

3 The GBS methodology

3.1 Step-by-step approach: use of the best data available

Depending on their economic sector and environmental policies, companies'data is heterogenous in content and in quality. In order to adapt to these data gaps, and because we consider that biodiversity footprint assessment should not be a closed door for companies that did not collect the most accurate data, the GBS runs up to four steps in order to retrieve the entity's biodiversity footprint. Each of these steps are presented below, starting from the case where the least accurate type of data is available (*i.e.* the company's turnover by industry and country/region) to the most accurate one (*i.e.* ecological surveys):

- Activity data: 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.
    - When available, Purchases by industry and country or region are directly used instead.

- Inventories[10]: production and purchases data are translated into amounts of commodities, refined products[11], water consumption and emissions thanks to EXIOBASE environmental extensions[12].
    - When available, actual quantity of Commodities, refined products consumed, water consumption or, Greenhouse gas emissions by Scope are used instead.

Emissions and water consumption 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

[10] To simplify, we call "inventories" all the items inputted between activity data and pressure data (defined here as data which can directly be used in pressure-impact equations).
[11] Refined products include for instance ferulic acid 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).
[12] 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.

databases) instead of relying directly on figures from the **Environmental extensions**, which can be less accurate.
Service consumption data will be used in future developments 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).

- **Pressures: terrestrial** and **freshwater** (or aquatic) **pressures**[13] are derived from inventories using a range of **in-house tools**, which can be completed by **Life Cycle Assessments**. In particular, **Commodity Tools** are used to link quantities of commodity to pressures. Simple coefficients are also used, for instance to translate greenhouse gas emissions into temperature increases.
  - When available, data expressed in units and perimeters compatible with GLOBIO cause-effect relationships is used directly instead of relying on approximations from inventories. This is the case for Land use changes by type and location, and freshwater pressures such as Nutrient emissions, nitrogen and phosphorous concentrations and Wetland conversion.

- **Biodiversity state and impacts**: the **state of biodiversity,** and thus **impacts on biodiversity**, are assessed using GLOBIO pressure-impact relationships (equations).
  - When available, comprehensive ecological surveys are 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.

Figure 4 below summarizes the steps followed during an impact assessment in the case where no data other than the turnover by industry and country is available, which is called a **"Financial default assessment**". To conduct this "Financial default assessment" data in orange italics are used to compensate for the company's lack of data: environmental extensions data and predicted scenarios by the GLOBIO-IMAGE scenario (see the two upper-right boxes). The boxes displayed as the Data Inputs of "**Refined Assessment**" are data which can be used to replace intermediary values calculated in the Financial default assessment. The steps are decomposed below[14], blue text representing how better data can be integrated in refined assessments.

[13] Marine pressures are currently not covered by the GBS.
[14] The boundary between the inventories and pressures steps in Figure 4 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.

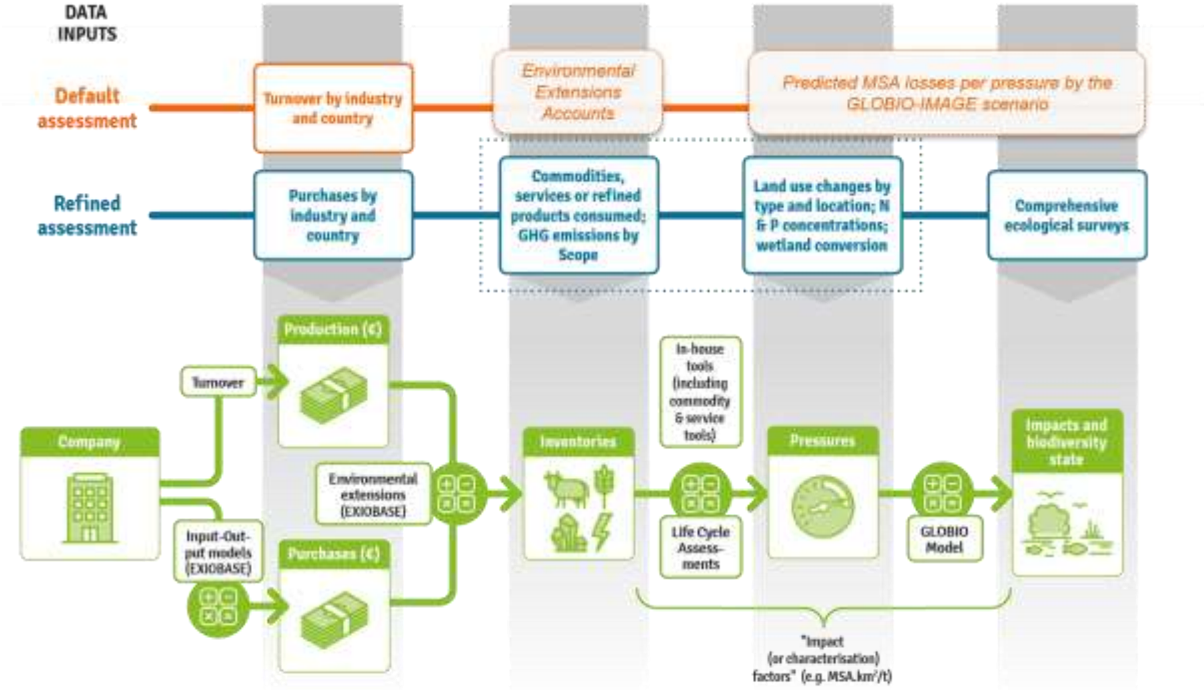

Figure 4. The GBS: a step-by-step approach making best use of data available at each step of the impact assessment

The GBS can also be seen from a LCA perspective, as illustrated by Figure 5. LCA practioners use the term "characterisation factor" (CF) to describe coefficients used in calculation. For instance, the Global Warming Potential of methane is a characterisation factor which allows to calculate how much kg CO_2-eq. is worth a kg of methane (ABMB 2019) [15]. We introduce two additional terms to facilitate understanding by non-expert and make explanations easy to follow in our review documents: impact intensities are midpoint to endpoint CF built in the terrestrial (CDC Biodiversité 2020d) and aquatic (CDC Biodiversité 2020b) modules of the GBS. Impact factors are basically inventory to endpoint CF which, in the GBS, combine commodity-specific data and assumption from individual CommoTools to impact intensities from the terrestrial and aquatic modules to come up with factors usually expressed in MSA.km^2/t of commodity.

Figure 4 and Figure 5 do not match directly: midpoints are not directly visible in Figure 4 because the terrestrial and aquatic modules sit in between inventories and pressures. The "pressures" listed in the figure are those directly expressed in the right units and perimeters compatible with GLOBIO cause-effect relationships, and thus do not match the midpoints (except for the land occupation for the land use pressure).

[15] The actual ISO definition Is: Factor derived from a characterization model which is applied to convert an assigned life cycle inventory analysis result to the common unit of the category indicator (ISO, n.d.).

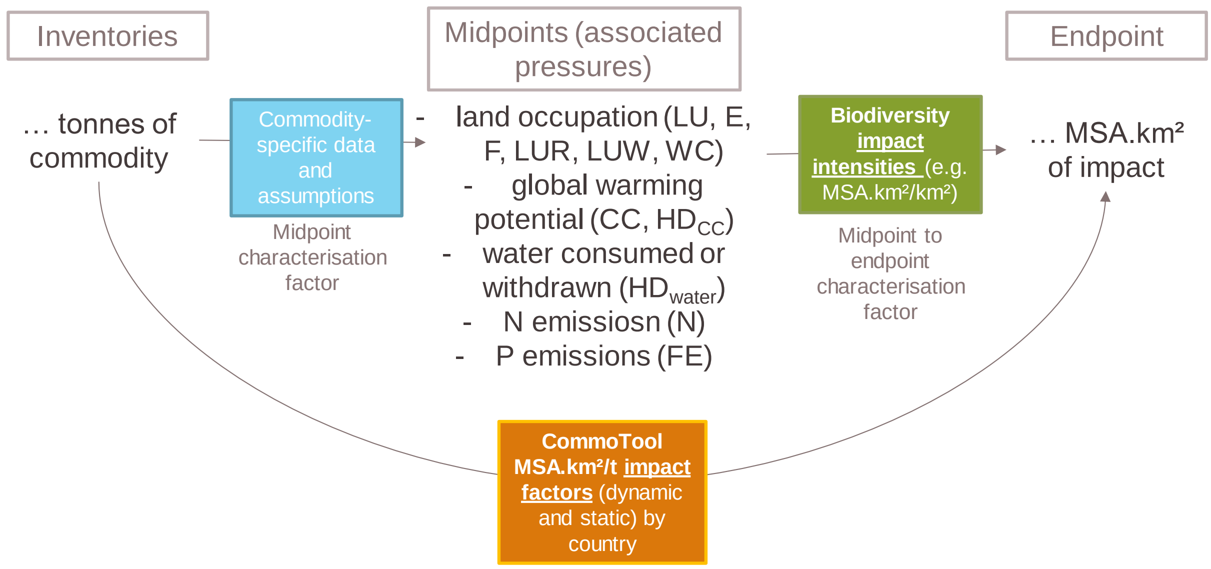

Figure 5: Linkages of the GBS to the LCA concepts of inventories, midpoints and endpoints and concepts of impact intensities and impact factors[16]

3.2 Important concepts used in GBS biodiversity footprint asessments

A DEFINING THE PERIMETER UNDER CONTROL

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 and 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 and 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.

[16] Please refer to the terrestrial and aquatic module for more details on the pressures and impact intensities. The acronyms are: Land use (LU), Fragmentation (F), Encroachment (E), Atmospheric nitrogen deposition (N), Climate change (CC), Land use in catchment of rivers (LUR) and wetlands (LUW), Hydrological disturbance due to climate change (HD_{CC}), Hydrological disturbance due to direct water consumption and withdrawal (HD_{water}), Wetland conversion (WC), 7 Nutrient emissions (FE).

- **Operational control**: the entity has "the full authority to introduce and implement its operating policies" (World Business Council for Sustainable Development and 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 owned or enterprise value (sum of debt and equity).

B DYNAMIC AND STATIC FOOTPRINTS AND TIME INTEGRATION

3.2.B.1 Description and relative strengths of the two accounting frameworks

The impacts are broken down into 'dynamic footprint' and 'static footprint'. *'Dynamic footprint'* is the footprint caused by changes, consumptions or restorations during the period assessed. '*Static footprint*' or '*ecological opportunity cost'*[17] includes all the '*persistent' or 'long-lasting' effects* which remain over time. Static footprints can result from the spatial pressures (land use, fragmentation, encroachment) linked to existing facilities and also the persistent (and constant) effect of past emissions still impacting biodiversity today, for instance greenhouse gas emissions emitted years ago but still keeping the atmosphere warm. They also include the persistent effects of past pollutions, for instance in freshwaters. Static footprints should be accounted for separately and, unlike dynamic footprints, should not be summed up over time to avoid double-counting. Static impacts are stocks of (past) impacts and fall into the "statement of position" in the Biological Diversity Protocol (EWT - NBBN 2019), while dynamic impacts are flows of impacts (during the period assessed) and fall into the "statement of performance" in the Protocol.

LCA-based approaches tend to use a different system to deal with persistent impacts: they integrate impacts over time (Lammerant 2019). The dynamic/static approach and the time integrated approach both have advantages and drawbacks and they answer different questions. They can thus be seen as complementary, as illustrated by Table 3.

Table 3: Comparison of dynamic/static vs time integration in the context of biodiversity footprint

Item	Dynamic/static	Time integration
Questions answered	What is the current state of remaining biodiversity and how much damage is being caused during the period assessed?	What impacts on the state of biodiversity will the pressures applied during the assessment period cause over their "lifetime"?
Capacity to link to trajectories of biodiversity state?	Yes. The dynamic impacts for instance equates the changes in the "Bending the curve" or the +20% ecosystem integrity in the CBD Zero Draft (CBD 2020).	No, except if those trajectories are also time-integrated (*e.g.* "the biodiversity loss should be reduced by 30%.Earth.yr by 2030").

[17] 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.

Capacity to set no biodiversity loss targets (including no net loss)	Yes: no net loss means the sum of variations of dynamic impacts equal zero.	Yes.
Incentive for companies to limit today pressures with persistent impacts	The dynamic/static framework alone does not provide strong incentives because the impacts of pollutants emitted today in 10 years' time will be accounted for in the company books only in 10 years. The incentive can be corrected through the introduction of the concept of "FutureFuture impacts" (see below). Such a multi-year accounting system is however complex to implement and currently not implemented in the GBS.	Yes: time integration by definition accounts for future impacts caused by today's pressures.
Capacity of non-expert stakeholders to understand the results	Relatively easier.	Difficult as time integration and ".yr" units are complex to grasp.

Conceptually, the dynamic/static accounting framework requires an accounting of impacts over multiple-time periods. In the GBS, we usually use the year as the accounting period (though impacts can be assessed over periods longer than one year). Pressures originating in year 0 and causing long-lasting impacts varying over several years should in theory be accounted for by dynamic impacts matching those gains or losses year after year. The theoretical approach to assessing impacts is thus to repeat the following two steps for every year over which impacts might occur:

- **Step 1**: apply the GLOBIO cause-effect relationship associated to the pressure to "plot" the impacts over time (*e.g.* by applying the cause-effect relationship to the "impulse curve", such as the one in Figure 9);

- **Step 2**: assess the level of impact at the end of year n and thus calculate the dynamic impact associated to year n: the variation (gain or loss) of biodiversity between the beginning and end of year n;

- **Step 3**: repeat Step 1 with year n+1. Dynamic impacts from year n are added to the static impacts of year n.

The sections below illustrate the practical differences between static/dynamic and time integration with two fictitious examples and calculate impacts with the GBS (dynamic/static, using the MSA.m^2 unit) and the Biodiversity Footprint for Financial Institutions (BFFI, time integrated, using the PDF.m^2.yr unit).

3.2.B.2 Illustration for land use

The first example focuses on a natural forest (PDF = 0%, MSA = 100%) converted to intensive agriculture (PDF = 89%; MSA = 10%[18]), with 1 m^2 converted every year during 3 years between 2014 and 2017 (Figure 6). The assessment is conducted **for the 2014-2017 period**.

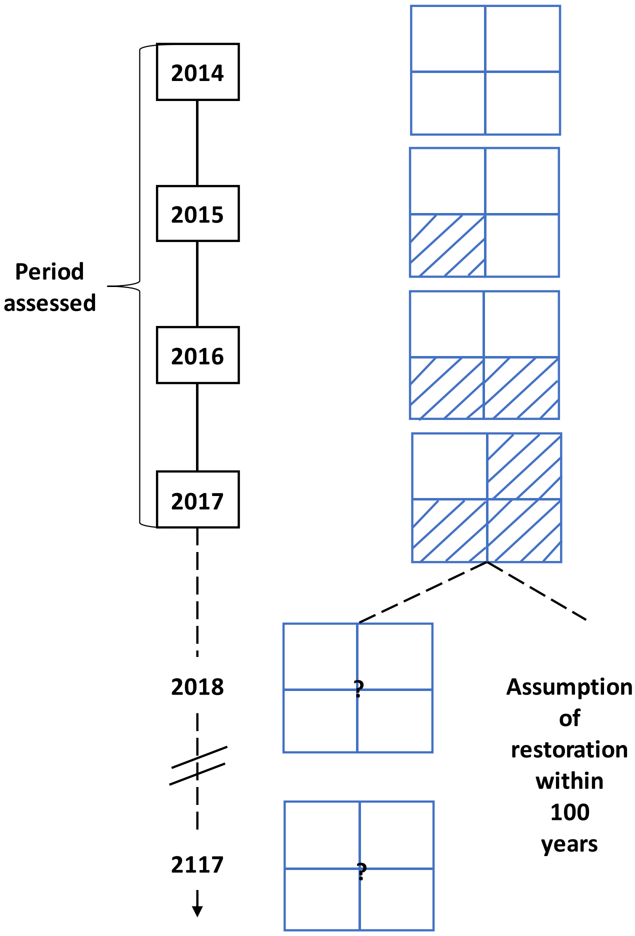

Figure 6: Fictitious example of a 4 m^2 natural forest being partly converted to intensive agriculture within the period assessed from 2014 to 2017 and potential situation after the period assessed.

White squares represent 1 m^2 of natural forest and stripped squares represent 1 m^2 of intensive agriculture. A description of the two paths after 2017 is provided below.

The **time-integrated assessment** with the **BFFI** would rely on the following elements: the time-integrated surface occupied is 6 squares: 1 square in 2015, 2 squares in 2016 and 3 squares in 2017. 0.89 is the PDF value of intensive agriculture. 1 is the integration over 1 year of occupation. The land-use change during the period is 3 squares converted from forest to intensive agriculture. 0 is the PDF value of natural forest. 100/2 is the restoration time estimated to be 100 years, divided by 2 because it is assumed the species

[18] Figures come from GLOBIO (Schipper et al. 2016)s and ReCiPe 2008, as used in the BFFI (CREM and PRé Consultants 2016).

richness does not recover immediately but rather recover slowly, as explained in the BFFI report (CREM and PRé Consultants 2016). The impacts attributed to the 2014-2017 period would amount to:

- impacts from land occupation: 6 x 0.89 x 1 = 5.34 PDF.m^2.yr

- impacts from land use change[19]: 3 x (0.89-0) x (100/2) = 133.5 PDF.m^2.yr

It is interesting to note here that the time integration is limited to one year for the land occupation but occurs over the period required to restore the land to its original state for land use change (100 years). This is the path on the right on Figure 6. Time-integrated approach usually takes a time horizon of 100 years in what is called “hierarchist” perspectives. To be in line with the approach taken for climate change for instance (see second example below), it might have made sense to integrate the land occupation impact over 100 years but it would require to make assumptions on the persistence of impacts due to land occupation, and possibly on the evolution of the land use from 2017 to 2117, which is unknown, as illustrated with the left path on Figure 6.

The **dynamic/static assessment** with the **GBS** would rely on the following elements: 4 squares are covered by natural forest with MSA = 100% in 2014 at the beginning of the period assessed (biodiversity remaining at the beginning of the period assessed: 4 MSA.m^2) and the pristine state is 100% MSA. 3 squares are converted from natural forest to intensive agriculture and the MSA of intensive agriculture is 10%. The impacts over the 2014-2017 period would amount to:

- land occupation: static impact of 4*(100%-100%) = 0 MSA.m^2 at the beginning of the assessment in 2014.

At the end of the period, the new static impact becomes (1 x (100%-100%) + 3 x (100%-10%)=2.7 MSA.m^2.

- land use change: 3 x (100%-10%) = 2.7 MSA.m^2.

This example shows that the dynamic/static calculations give a view of how much biodiversity was actually lost: 2.7 MSA.m^2 (and thus how much is remaining: 4 – 2.7 = 1.3 MSA.m^2).

This example illustrates that the time-integrated approach and the dynamic/static approach highlight different aspects: the former focuses on the impacts occurring over the lifetime of the impact, while the latter provides insights on the biodiversity actually lost during the period (and thus the biodiversity remaining).

3.2.B.3 Illustration for climate change

The following paragraphs focus on climate change but the conceptual frameworks would apply similarly to other pressures. If a pressure was described by an impulse response curve such as the one in Figure 7 for instance (such a case has not yet been met or used in the GBS), the same logic would apply and the three steps described in this section would be applied as much as possible: assessment of the level of the driver of biodiversity loss at the end of each year, application of the GLOBIO cause-effect relationship and calculation of the dynamic and static impacts.

[19] **NB**: the calculation of land use change impacts is currently not implemented in the BFFI (for ASN Bank’s calculations) as EXIOBASE data on land use change are missing. The calculation here is thus theoretical.

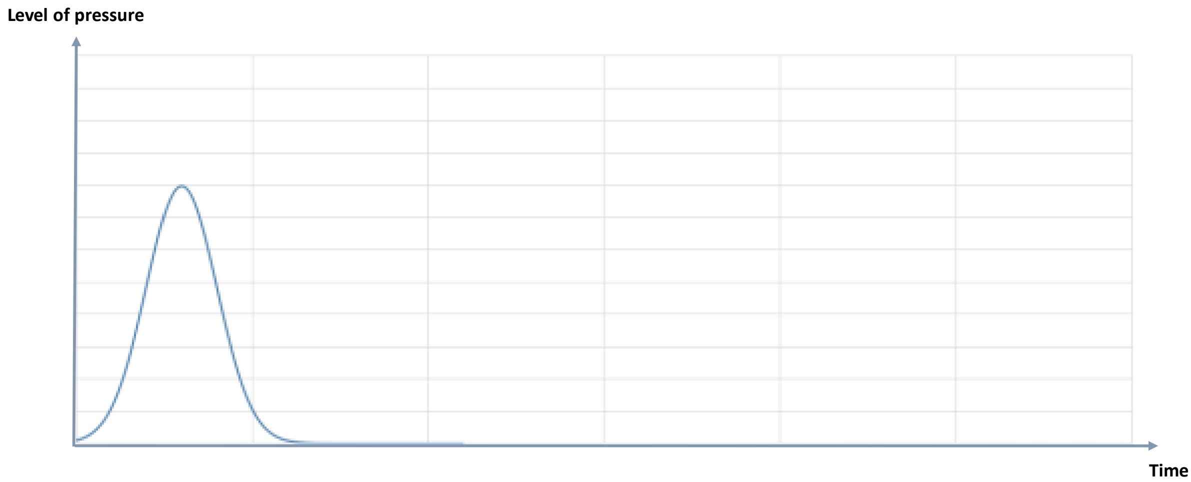

Figure 7: General case: potential shape of an impulse response curve

This example looks at the impact of 1 kg of CO_2-eq. emitted in 2014.

The time-integrated absolute global temperature change potential (IAGTP) of 1 kg of CO_2 is $4.76.10^{-14}$ °C.yr.kg CO_2^{-1} (Joos et al. 2013). For the sake of illustration and simplicity, we consider that the increase in surface air temperature following a pulse emission is $5.72.10^{-18}$ °C. kg CO_2^{-1} over 100 years (0.21°C at year 100 for a pulse of 100 GtC, order of magnitude of the average increase observed through multiple climate models (Joos et al. 2013)). This figure and the others used in this example are fictitious and provided only to illustrate the difference between time-integration and dynamic/static approaches. In particular, the pace at which the temperature increases between 2014 and 2018 (1.10^{-18} °C every year) is fictitious and not based on real figures.

Figure 8 illustrates the temperature increase over time following the emission of 1 kg CO_2-eq. Darker circles indicate a higher temperature, figures inside the circles are the temperature increase compared to the year of the emission (in 10^{-18}°C). After 2114, the temperature increase caused by the emission in 2014 will slowly recede (Joos et al. 2013) but this will take several centuries: this is illustrated by the stable temperature for 2115's "actual impact" on the left of Figure 8. The IPCC however recommends considering a 100-year time-horizon, equivalent to considering that the temperature drops down directly back to its initial level at year 101. Both BFFI and the GBS thus basically consider that the impact on biodiversity drops down to 0 in 2115, as illustrated on the right of Figure 8.

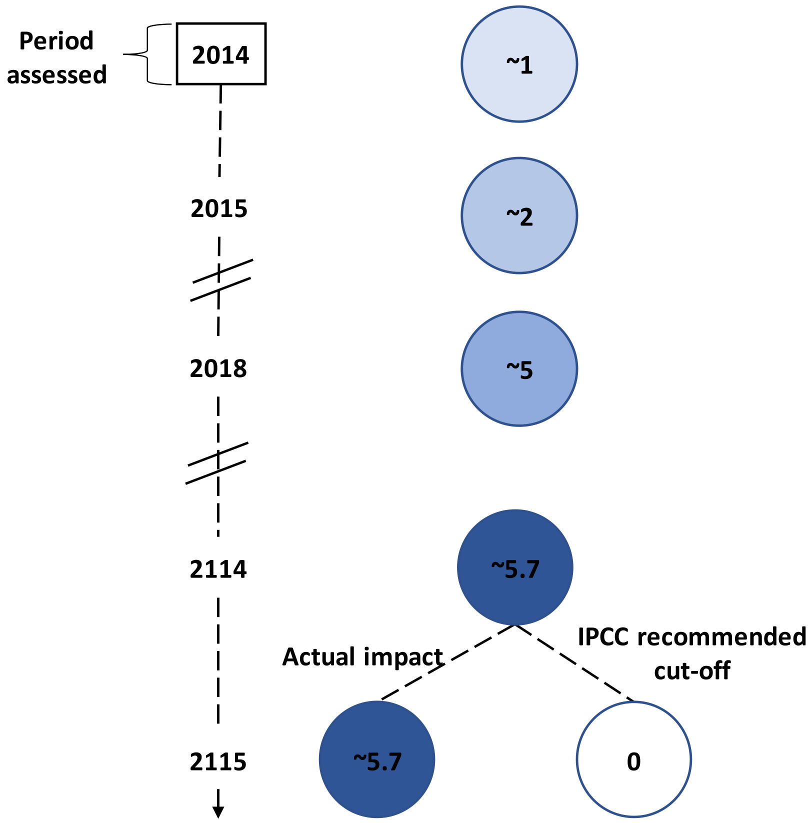

Figure 8: Global mean temperature increase (GMTI) in 10^{-18} °C in the years following the emission of 1 kg CO_2-eq. in 2014 (fictitious example).

Currently, as described in the Terrestrial module review document (CDC Biodiversité 2020d), the GBS:

1. Approximates the shape of the impulse response function of surface air temperature to a pulse of GHG emissions by a rectangular shape;
2. Assesses the associated impacts over time through the GLOBIO climate change cause-effect relationship (Step 1 in the conceptual framework described above). Since the relationship is proportional in this case, the shape of the “impact curve” is also rectangular;
3. Calculates the impact reached at the end of year 0 and caused by the emission based on this rectangular shape and assesses the associated dynamic impact to year 0 (Step 2 in the the conceptual framework described above).

A multi-year accounting framework is not yet implemented in the GBS (but will be in the future): only the impacts attributed to year 0 are accounted for. Therefore, the static impacts related GHG emissions in year 0 are currently not attributed to the company in year 1 (Step 3 of the conceptual framework described above). Also, contrary to the recommendation when using a multi-year accounting framework, the process is not repeated in year 1. If the process was repeated, the (additional) dynamic impact in year 1, and in subsequent years, would be equal to 0 because the impulse response function is approximated to be a rectangle (so all the impacts occur in year 0). The lack of multi-year accounting is thus less problematic for rectangular shaped impulse functions.

Furthermore, the GMTI caused by the pulse is assumed to not recede within the 100-year time-horizon, so the negative impacts on biodiversity never revert back to zero.

Based on the current approach, the dynamic impact related to the emission of 1 kg CO_2-eq in 2014 is $4.37.10^{-9}$ MSA.km^2.

In reality, the impulse response function is not rectangular: the GMTI does not immediately rise to its maximum value but rather increases progressively over several years, so that the impact also increases progressively until the maximum GMTI is reached. Thus, the approach described above over-estimates the dynamic impact in year 0 and under-estimates the maximum GMTI, as illustrated by Figure 9. To deal with this issue, it is necessary to introduce the concept of "FutureFuture" impacts as explained in section 3.2.B.4. It should however be stressed that the current approach does not ignore the impacts occurring between year 1 and year 100: they are all accounted for in year 0. For climate change, the approach does however under-estimates the maximum GMTI and thus the maximum level of impacts.

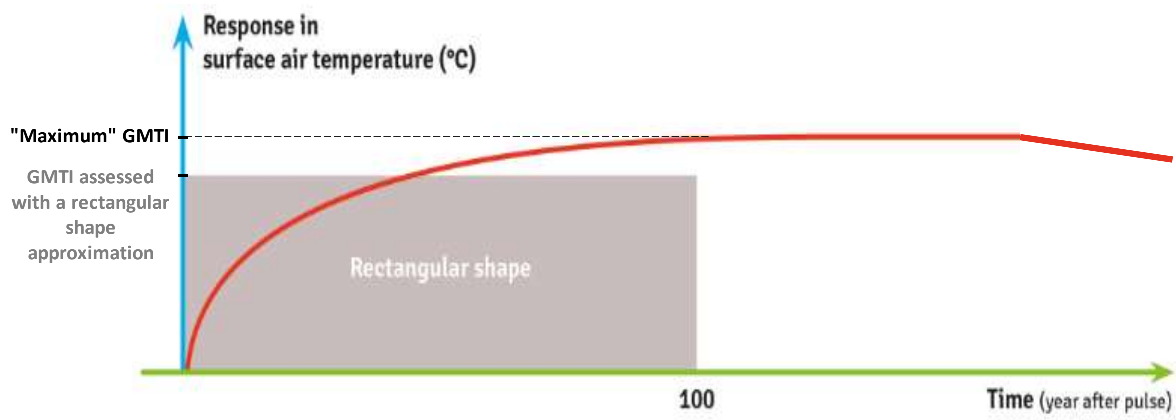

Figure 9: Consequences of the approximation of the impulse response by a rectangular shape in the GBS for the estimation of the GMTI.

In the BFFI, the time-integrated temperature increase over a time horizon of 100 years[20] is combined to an impact factor in PDF/°C to assess the time-integrated impact: $2.8.10^{-9}$ species.yr.

A fundamental difference between the GBS and the BFFI is that the GBS aims to assess the impact actually occurring in 2014, while BFFI seeks to assess the time-integrated impact over 100 years.

3.2.B.4 Towards a multi-year accounting framework introducing future impacts

The paragraphs above presented how the GBS currently works. The current approach is however not entirely satisfactory as noted in Table 3 and Figure 9: the maximum impact may be underestimated. In the future, the GBS thus plans to improve its accounting framework to better cope with persistent impacts. The following paragraphs present the envisaged multi-year accounting framework. It is not yet implemented due to multiple practical issues, including the need to know the shape of the "impulse response curve" or equivalent for each persistent impact to assess them (or at least to know the lifespan of the impacts). If these elements were known for each pressure, accounting for the persistent impacts due to ecotoxicity,

[20] BFFI uses a different IAGTP value : $6.5.10^{-14}$ °C.yr.kg CO_2^{-1} (CDC Biodiversité 2019b).

eutrophication, climate change or any other pressure could follow this improved accounting framework[21]. Please note that this framework is not currently used in the GBS and some questions it raises may remain unexplored.

Using the improved accounting framework, requires introducing an additional concept: **Future impacts.** Future impacts are impacts which have not yet occurred – and thus have not yet been accounted as dynamic or static impacts – but will occur in the future[22]. This concept modifies the steps described in section 3.2.B.1:

- **Step 1P**: apply the GLOBIO cause-effect relationship the pressure to "plot" the impacts over time (*e.g.* by applying the cause-effect relationship to the "impulse curve", such as the one in Figure 9);

- **Step 2P**: assess the highest level of impact, I_{max}, the driver of biodiversity loss will cause over its "lifespan". Initialize the future impact for year n-1 as equal to I_{max};

- **Step 3P**: assess the level of impact at the end of year n and thus calculate the dynamic impact associated to year n: the variation (gain or loss) of biodiversity between the beginning and end of year n;

- **Step 4P**: update the future impact: it is equal to the future impact of year n-1 minus the dynamic impact of year n;

- **Step 5P**: repeat Steps 3P to 4P with year n+1. Dynamic impacts from year n are added to the static impacts of year n.

3.2.B.5 Illustration of the multi-year accounting framework with the climate change example

Following the example of climate change, if 1 kg CO2-eq emitted in 2014 raises temperature by only 10^{-18}°C in 2014 and the temperature keeps rising in the following years, the impact of future increases in temperature are future impacts in the 2014 accounting books. Table 4 and Figure 10 illustrate this concept by breaking down the dynamic, future and static impacts of the 2014 emission from Figure 8. GMTI are converted into MSA.km^2 through the use of the GBS impact factor (derived from (Wilting et al. 2017)): $9.30.10^9$ MSA.km^2.°C^{-1}.

As mentioned above, relying on IPCC's recommended 100-year time horizon implies that the GHG emission no longer impacts the surface air temperature after 2115. Thus, Table 4 registers an immediate biodiversity gain in 2115, somehow assuming an immediate recovery. Similar biodiversity gains would be accounted at the end of the lifespan of any other kind of substance. If such an improved accounting framework is implemented in a future version of the GBS, more thoughts will be put in the accounting of those "end of lifespan gains".

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[21] In such an improved accounting framework, the impact of methane would differ from the impact of carbon dioxide for instance: methane's warming potential is concentrated in a shorter period. For illustrative purpose, let's consider its warming mainly occurs in the first 20 years: it would cause (dynamic, provision and static) impacts only during the first 20 years and then it would cause a gain of biodiversity in the 21st year (assuming recovery occurs).

[22] The concept and wording are inspired by the notion of "Provisions" used in corporate accounting, to which they are similar.

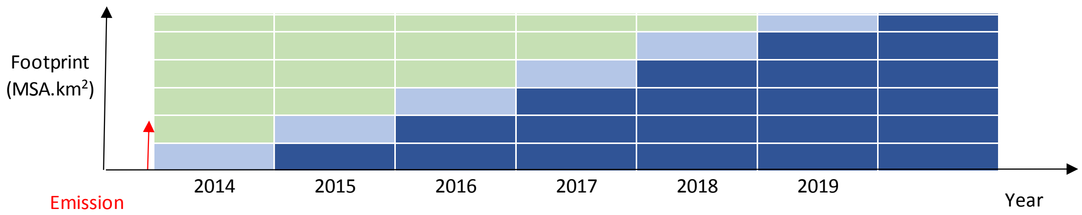

Figure 10: Impact of the 2014 emission over the first following years

Light blue represents dynamic impacts, dark blue static impacts and green future impacts.

Table 4: Impact of the emission of 1 kg CO_2-eq. in 2014 (10^{-11} MSA.km^2)

	Year assessed							
Impacts from the 2014 emission (10^{-11} MSA.km^2)	2014	2015	…	2018	…	2114	2115	2116
Dynamic	0.9	0.9	…	0.9	…	0	-5.3	0
Future	4.4	3.5	…	0.7	…	0	0	0
Static	0	0.9	…	3.7[23]	…	5.3	5.3	0

To fully illustrate how the accounting framework works, Table 5 provides the impacts of an emission of 1 kg CO_2-eq. occurring in 2015, and Table 6 details how the impacts of the company responsible for these two emissions should be accounted for (assuming the company did not emit any other GHG outside the 2 kg emitted in 2014 and 2015).

Table 5: Impact of the emission of 1 kg CO_2-eq. in 2015 (10^{-11} MSA.km^2)

	Year assessed							
Impacts from the 2015 emission (10^{-11} MSA.km^2)	2014	2015	…	2018	…	2114	2115	2116
Dynamic	0	0.9	…	0.9	…	0	0	-5.3
Future	0	4.4	…	1.6	…	0	0	0
Static	0	0	…	2.8	…	5.3	5.3	5.3

[23] Due to rounding, the static impact in 2019 is equal to 3.7 and not 0.9x4 = 3.6.

Table 6 provides an overview of all the impacts the company should account for.

Table 6: Total impacts of the company from 2014 to 2116 assuming the only pressure it is responsible for are 1 kg CO_2-eq emitted in 2014 and 1 kg CO_2-eq emitted in 2015 (10^{-11} MSA.km^2)

	Year assessed							
Impacts (10^{-11} MSA.km^2)	2014	2015	…	2018	…	2114	2115	2116
Dynamic	0.9	1.8	…	1.8	…	0	-5.3	-5.3
Future	4.4	7.9	…	2.3	…	0	0	0
Static	0	0.9	…	6.5	…	10.6	10.6	5.3

3.2.B.6 Aggregation of impacts caused by different pressures

Time integrated impacts are routinely summed up (Wilting et al. 2017; CREM and PRé Consultants 2016). Non-time-integrated impacts are also summed up, for instance the PBL sums up MSA% (implictely static) impacts at the global level when using GLOBIO model to describe biodiversity loss in different scenarios (Alkemade et al. 2009; Netherlands Environmental Agency (PBL) 2010; 2012; Kok et al. 2014; Lucas and Wilting 2018). This global sum of pressures is equivalent to summing impacts integrated over the whole terrestrial area of the Earth. The constraint which needs to be fulfilled to sum up non-time-integrated impacts is that the period considered must be of the same duration for all impacts. In the GBS, this period is implicitely one year (though it can be longer, as illustrated y the land-use example where the period assessed is 4 years).

For instance, if we combine the two examples above and consider that the same company is responsible for the conversion of 3 m^2 of natural forest to intensive agriculture from 2014 to 2017 and emitted 1 kg CO_2-eq. in 2014 and again in 2015, then the world has indeed lost biodiversity both due to land use change and climate change effects on biodiversity. This loss corresponds to the dynamic impacts during the 2014-2017 period. We can consider that its overall impact during the period 2014-2017 is $2.7 + 2 \times 4.37.10^{-3} = 2.708$ MSA.m^2 (in the current implementation of the GBS, ignoring the improved accounting framework described above).

C SCOPES 1, 2 AND 3

GHG emissions accounting distinguishes three Scopes. These Scopes can be adapted to biodiversity assessments 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.

The GBS seeks to assess impacts across all three Scopes and the entire value chain, though the GBS 1.0 does not cover downstream impacts yet.

The dinstinctions between dynamic and static impacts, combined to the Scopes, are illustrated in Figure 11 below:

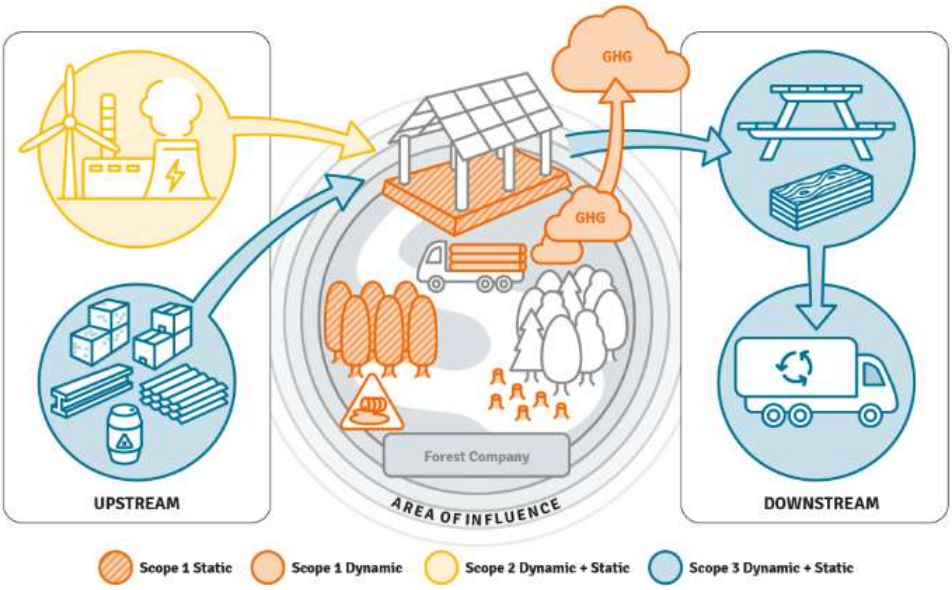

Figure 11: Scopes. Distinction and differenciation between Upstream and Downstream Impacts

Figure 12 illustrates how the figures obtained with the GBS and expressed per Scope fit with the broader global figures by breaking down the MSA of the Earth.

- The global average terrestrial MSA of the Earth was about 65% in 2010 (Lucas and 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 and Wilting 2018). If we consider that all this loss is entirely due to economic activities, it means that the sum of all the dynamic Scope 1 impact of economic activities on the planet is equal to 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)[24].

- 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.

- 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%.

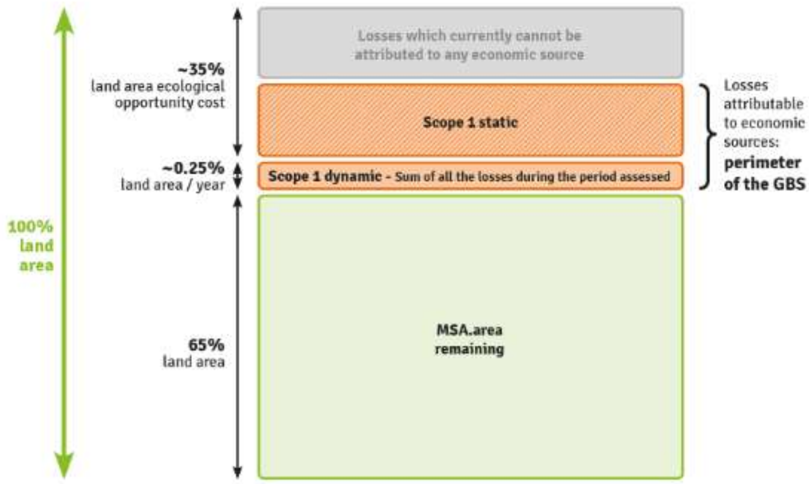

Figure 12. Link between the GBS and the total MSA of Earth

D ASSESSING UNCERTAINTY: DATA QUALITY TIERS

In order to quickly **qualify data accuracy**, we use a quality tier system similar to that of the IPCC to describe the quality of impact factors. The five data quality tiers are described in Table 7.

Table 7: Data Quality Tiers

Real or *modelled*	Data quality tier	Description	Example for characterisation factors
Modelled	1	Simple linear approach. Tier 1 characterisation factors are international defaults.	*Average agricultural yield of wheat across the world.*

[24] This is not completely true, as Scope 3 downstream linked to end-users can not always be considered as a company's Scope 1 impact but, for instance, as an individual own impact. We made this simplification for pedagogical purposes.

	2	Region (country)-specific linear factors or more refined empirical estimation methodologies[25].	*Average agricultural yield of wheat in Brazil.*
	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 relationships to biodiversity used does not include "permeable areas". In such a case, "impervious areas" and "permeable areas" need to be translated into one of the habitat types used in the dose-response relationships through simple attribution rules.	*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).*
	4	Impact factors derived from the use of direct relationships (equations) to biodiversity	*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, characterisation factors for each of the 13 habitat types used in GLOBIO.*
Real	5	Direct measurements of biodiversity state.	

Each step requiring the application of an impact factor (or characterisation factor), lowers the data quality tier down by one level, from 5 to 2. Additionally, if the precision of the data is global (*e.g.* world average yield of wheat), or regional (*e.g.* Europe' average wheat yield), the data quality tier will be capped respectively at 1 and 2. For instance, direct measurement of biodiversity state requires the use of no impact factor: it fall into data quality tier 5. Using directly the cause-effect relationship of GLOBIO for land use requires the use

[25] 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.

of one model, GLOBIO, it falls into data quality tier 4. Using impact factors based on GLOBIO but requiring a translation (*e.g.* of custom land use classes into GLOBIO land use classes) involve two "models", the "translation model" (*e.g.* artificial area means 50% urban and 50% intensive agriculture in GLOBIO) and GLOBIO, it falls into data quality tier 3. And so on for data quality tier 2 with the use of three models.

The data 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 will be used in the GBS step-by-step approach. 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.

Data quality tiers allow to assess the "amount or number of layers of modelling" involved, but it does not assess the entire uncertainty of the results. In some cases, applying two models (usually tier 3) can be more accurate than applying only one model, if that latter model is very inaccurate. As described in the Quality assurance review document (CDC Biodiversité 2020c) and in the section below, the management of uncertainties in the GBS will thus include other elements such as calculation modes. In general though, the more models involved (and thus the lower the data quality tier), the higher the risk of significant inaccuracies. Companies should thus in general seek to use higher data quality tier data and impact factors. The GBS data collection guidelines provide further guidance (CDC Biodiversité 2019a).

To illustrate how using higher data quality tier can lead to more accurate results, we can consider the land use dynamic impact of the production of 1 tonne of soybean in Paraguay (ignoring impacts from other pressures in this simplified example). If the company only provides the production information, a tier 2 impact factor has to be used and an implicit assumption is made on the land use change involved in the production of this tonne: the land use dynamic impact assessed is 32.9 MSA.m^2 (CDC Biodiversité 2020a). If instead, the company is able to provide the actual land use change (*e.g.* intensification, deforestation, etc.) and reports that 10 m^2 was converted from natural forest to intensive agriculture, then a tier 4 impact factor can be used and applied to the actual land use change instead of using Paraguay's average trends. The impact assessed is then 10 x (100%-10%) = 9 MSA.m^2.

Finally, it should be noted that using tier 5 impact factors, *i.e.* no modelling and direct measurement of biodiversity state, has its own drawbacks: while it is easier to attribute the responsibility of pressures to companies, assessing who is responsible for observed gains or losses of species richness and abundance may be tricky and requires specific attribution rules.

E CALCULATION MODES

In order to keep track of the uncertainity in the data at all levels, "calculations modes" are used to capture the range of each value. By default, three calculation modes are used, but more can be used when relevant. The three modes are "Central" for the "best estimate" of the actual value, "Optimist" which will lead to the lower impacts on biodiversity, and "Conservative" which will lead to the higher impacts on biodiversity.

These modes apply to input data provided by companies and to impact factors. For corporate input data, companies are allowed to enter three values if they have doubts about the accuracy of their measurement. Central should always be the best estimate of what the actual value is. Optimist should be the maximum (respectively minimum) of the range within which the actual value of the input indicator lies, depending on whether a high (respectively low) value leads to a lower impact. And vice-versa for conservative: minimum (or maximum) value depending on which value yields the highest impact. For instance, if a company knows that the yield of its wheat production lies within [4; 10] t/ha and the average is 7 t/ha, then central = 7 t/ha, optimist = 10 t/ha and conservative = 4 t/ha because, *ceteris paribus*, a higher yield leads to lower land occupation and thus lower impacts.

For impact factors, the overaching principle is that the standard error should be used to build the optimist and conservative values. The central value should be the mean, and the optimist and conservative should be the mean +/- one standard error.

F CODE DESCRIPTION NOMENCLATURE

In the technical reports, code architecture overview will be described in figures using the following nomenclature:

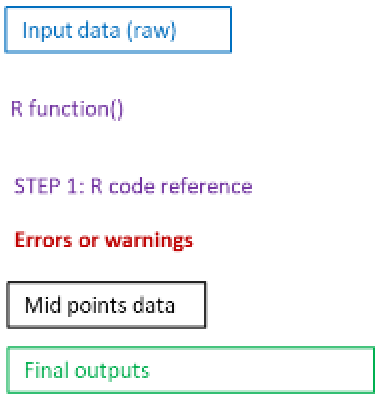

Figure 13: Caption of code overview in the review documents

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