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A PROSPECTIVE EVALUATION OF THE AMBITION OF THE KUNMING-MONTREAL GLOBAL BIODIVERSITY FRAMEWORK

A CONTRIBUTION TO THE CBD REVIEW PROCESS

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A prospective evaluation of the ambition of the Kunming-Montreal Global Biodiversity Framework: A contribution to the CBD review process

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Summary

At its 15th Conference of the Parties (COP) in 2022, Parties under the Convention on Biological Diversity (CBD) adopted the Kunming-Montreal Global Biodiversity Framework (GBF). Four goals for 2050 and twenty-three supporting action targets for 2030 were established, 'to take urgent action to halt and reverse biodiversity loss and to put nature on a path to recovery for the benefit of people and planet'. To enhance accountability and transparency, these goals and targets are supported by a mechanism for planning, monitoring, reporting, and reviewing of the implementation of the GBF. The review mechanism consists of multiple building blocks, including existing ones such as the National Biodiversity Strategies and Action Plans (NBSAPs), the Monitoring Framework, and the National Reports (NRs). The review mechanism will possibly be extended with a global analysis of progress, voluntary country peer review, an open-ended review forum, and a global review. Parties agreed to take the outcome of the global analysis and review into account in the future revisions and implementation of their NBSAPS, to improve actions and efforts. This is also known as the ratcheting effect of the review cycle.

In this policy brief, we intend to make a three-fold contribution to ongoing discussions and negotiations on the global review. First, we provide a scenario analysis of the potential contribution of the global implementation of the GBF for the realisation of Goals A: 'Protect and Restore' and B: 'Prosper with Nature'. Second, we explore if and how the national targets submitted to the CBD reporting tool can be used for a global scenario analysis and complementary analysis on policies and measures as employed by countries. Third, we argue for a purpose-oriented, multi-actor, and multiple-evidence base approach for the global review.

A new and crucial element in the review mechanism is the global analysis of the collective commitments of countries and non-state actors, which will inform the global review and aid in evaluating collective ambitions and intended contributions to the GBF. To assess the extent to which the collective ambitions of Parties and non-state actors are sufficient for achieving the 2050 GBF goals, it is necessary to understand to what extent the global implementation of the action targets for 2030 enables the realisation of the 2050 goals. So far, such information has been lacking. This policy brief contributes to filling this knowledge gap by providing the first quantitative prospective assessment of the expected contribution of the global implementation of the action targets to achieving the 2050 Goals A and B, compared to a business-as-usual scenario. In addition, we assess the effect of current climate policies and pledges submitted by countries in their Nationally Determined Contributions (NDCs) to contribute to the achievement of the Paris Agreement in order to evaluate synergies and trade-offs between biodiversity and climate mitigation policies. In the last scenario, we assess a situation where high environmental ambitions are realised through conservation of 50% of terrestrial land by 2050, keeping temperature increase well below 2°C, strong changes in diets, and decreases in waste. The scenarios were analysed with the PBL GLOBIO-IMAGE model framework.

Following a business-as-usual trajectory will place GBF goals further out of reach and will lead to a continuing deterioration of biodiversity. The global implementation of the GBF has the potential to increase the area of natural ecosystems by 2050, but achieving an overall increase in the state of biodiversity specifically will be harder to secure. Our results show that this can be achieved for Living Planet Index (LPI) for mammals, yet our Mean Species Abundance (MSA) trends for plants, birds, and mammals still show a slightly decreasing trend for biodiversity. Still, in both cases there

are nonetheless significant improvements in the state of biodiversity when compared to the baseline. The GBF+NDC scenario allowed us to determine that NDCs alone contribute to a climate change mitigation of 0.5 °C in 2100, whereas the GBF alone contributes to a climate mitigation of 0.2 °C. These results confirm that more ambitious NDCs are needed to reduce climate change impacts on ecosystems and biodiversity, and that the effect of biodiversity policy on climate mitigation is certainly not negligible. With respect to the achievement of the GBF goals, the GBF+NDC scenario shows small improvements in 2050 when compared to the GBF scenario. By the end of the century, the GBF+NDC does perform significantly better, also highlighting the long time frames before the impacts of climate change mitigation become visible. An effective bending of the curve of biodiversity loss above current levels, was only achieved in our high environmental ambition scenario.

The scenarios indicate that conservation policies alone will not be enough to put nature on the path to recovery. Addressing indirect and direct drivers of biodiversity loss and ensuring full integration of biodiversity in public and private decision-making will be necessary. Building on CBD Party submissions to the CBD online reporting tool, we made a preliminary assessment concerning to what extent Parties are formulating national targets in ways that are conducive to the mainstreaming of biodiversity across government and across society. We compiled five relevant mainstreaming considerations, including links to parts of government outside of nature conservation as well as putting finance into place. We then analysed if Parties include these in their national targets. For the targets analysed, only 30% to 45% of the Parties consider one or two elements of mainstreaming. Our assessment illustrates how scenario analyses can be combined with country information on policies and measures. We plan, in the next step of our research, to use the online reporting tool and NBSAPs to create a policy scenario to evaluate country ambitions that will be compared to the GBF fully implemented scenario. Analysis of the national targets aligned with the GBF targets included in the scenario-analysis also showed that, as of yet, many of them are not quantified or specific, making future evaluations of ambition a challenge.

CBD's mechanism for planning, monitoring, reporting, and reviewing need to create an ambition cycle that fosters learning and improves implementation to realise the goals and targets of the GBF towards 2030 and beyond. Parties should take the outcomes of the global review into account in future revisions and implementation of their NBSAPs, particularly with a view to improving actions and efforts. Based on ambition and implementation gaps that can be identified through the global review, future COPs need to take decisions to increase efforts to achieve the 2050 goals of the GBF. A purpose-oriented approach will ensure that the global review sends clear signals and recommendations to both Parties and non-state actors about the necessary actions to achieve the changes needed. This is particularly important given the complexity of biodiversity governance, where the success of the GBF depends on a dynamic and adaptive process that includes, for example, mainstreaming across all levels of government. By promoting an inclusive, multi-actor, and forward-looking process, the review can act as a facilitating tool, encouraging actors to revise and enhance their contributions and commitments. Furthermore, it should be based on a multiple-evidence approach and identify concrete pathways for improvement, barriers, and opportunities and foster a culture of learning, adaptation, and increased ambition where necessary.

1 Introduction

At its 15th Conference of the Parties (COP) in 2022, Parties under the Convention on Biological Diversity (CBD) adopted the Kunming-Montreal Global Biodiversity Framework (GBF). In this framework, countries agreed 'to take urgent action to halt and reverse biodiversity loss and to put nature on a path to recovery for the benefit of people and planet' as their mission towards 2030, in order to achieve the 2050 vision that 'biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential to people' (CBD 2022c). To operationalise this vision, four goals for 2050 and twenty-three supporting action targets for 2030 were established (see Box 1.1). These goals and targets are supported by a global monitoring framework that ensures consistent, standardised, and scalable tracking of progress towards the global objectives (CBD 2022b). In addition, parties agreed to a mechanism for planning, monitoring, reporting, and reviewing of the implementation of the GBF in order to enhance accountability and transparency (CBD 2022a). This was a response to one of the lessons learned for missing the 2020 Aichi targets, the predecessor of the GBF action targets. The lack of SMART targets and the lack of an accountability mechanism, alongside insufficient resources and insufficient policy coherence, are considered among the primary reasons for missing the earlier targets (Hughes 2023; Hughes & Grumbine 2023; Miller Smallwood et al. 2022). An effective accountability mechanism, for example, could help address these broader challenges for the GBF by supporting improved implementation and coherence across policies.

In October 2024, at the 16th CBD COP (COP-16) in Cali, Colombia, countries will further negotiate the mechanisms for planning, monitoring, reporting, and reviewing of the implementation of the GBF. This so-called multidimensional approach consists of various building blocks, including existing ones such as the National Biodiversity Strategies and Action Plans (NBSAPs) and National Reports (NRs). This will now possibly be extended with a global analysis of progress, a voluntary country peer review, an open-ended review forum, and a global review to strengthen the accountability and transparency mechanism of the GBF (Landry et al. 2024). One of the new elements is the global analysis of countries' commitments in their NBSAPs and non-state actors' commitments to inform the global review and evaluation of ambitions and intended contributions to the GBF. By COP-16, countries must submit a new or updated NBSAP and/or complete the online reporting tool to submit their national targets. This will provide a basis for the global analysis of the collective ambition of Parties. In 2026 and 2029, countries are required to submit their NRs, which will then form the primary basis for the global review of collective progress.

Important questions for these evaluations are whether collective ambition in NBSAPs and implementation by countries will be enough to achieve the global biodiversity goals, how 'to get a grip' on the extent to which the GBF is implemented at the national level (Maney et al. 2024), and what additional action by Parties (and non-state actors) is needed in order to achieve these goals. It is expected that Parties take the outcome of the global analysis and review into account in the future revisions and implementation of their NBSAPs with a view to improving actions and efforts, as appropriate. This is referred to as the GBF's ratcheting effect. With so many open questions regarding its design and modalities, the outcomes of the COP-16 negotiations are of crucial importance for the effectiveness of the CBD, not only for the period towards 2030, but also beyond.

This policy brief intends to contribute to the further development of the methodology and contents of the global analysis and the design and modalities for the global analysis and global review of the GBF. It provides three complementary contributions to the policy discussions and negotiations.

To make the global analysis and global review meaningful it is, first of all, necessary to have a quantitative reference point on what could be achieved with the GBF if all action targets are realised (see Chapter 2). Such an analysis gives insight into whether global implementation of the action targets will result in reaching the 2050 goals of the GBF and thus halt and reverse biodiversity loss and put nature on a path to recovery. Such insight and knowledge are currently lacking. Moreover, this analysis would also provide a baseline against which to compare ambitions and implementations of Parties, which is currently lacking as well. This policy brief addresses these knowledge gaps by providing the first quantitative, prospective evaluation of the global implementation of the GBF compared to a business-as-usual scenario, more specifically of the action targets contributing to its Goals A: 'Protect and Restore' and B: 'Prosper with Nature' (Box 1.1). In addition, as biodiversity loss is inextricably linked to climate change (Pörtner et al. 2021), we assess the implementation under tow different climate scenarios. We assess how the mitigation effect of the Nationally Determined Contributions to the Paris Agreement (UNEP 2023) contribute to halting and reversing biodiversity loss. We also present a scenario with high environmental ambitions that realises the goals of the Paris Agreements and other long-term environmental goals.

Secondly, bending the curve for biodiversity and realising the GBF's Goals A and B for 2050 requires addressing both direct and indirect drivers of biodiversity loss, many of which come from outside the conservation policy domain. For example, to put nature on a path to recovery and avoid trade-offs on, say, food security, it is necessary to combine ambitious area-based conservation and restoration measures with a portfolio of strong climate mitigation and sustainable production and consumption policies (Kok et al. 2023; Leadley et al. 2022; Leclère et al. 2020). To address both direct and indirect drivers of biodiversity loss, effective mainstreaming of biodiversity is required beyond traditional conservation policies (IPBES 2019), as addressed in several targets of the GBF. Additionally, mainstreaming itself calls for the inclusion of local government entities and stakeholders outside of the government in the policy process. We assess the extent to which new and revised national targets directly related to Goals A and B, and submitted to the CBD's online reporting tool, indeed take a such mainstreaming conditions into account (see Chapter 3). We do this by assessing if conditions that are conducive to mainstreaming are mentioned in the national targets. This assessment also illustrates how the quantitative analysis of ecological targets, as addressed in Chapter 2, can be complemented with the analysis of more governance-related targets in the GBF and to further develop policy scenarios.

Finally, we address the design of accountability and transparency mechanisms (see Chapter 4) that will be negotiated further during COP-16. The effectiveness of the CBD and potential impact of the global analysis will, ultimately, depend on the CBD's ability to implement a robust and effective global review mechanism. We reflect on possible ways forward, to be able to achieve a strong and credible multi-actor and multiple-evidence knowledge base. We also reflect on ways forward to strengthen the global review in support of the realisation of the GBF goals, as well as a potentially necessary increase of efforts towards and beyond 2030 (the ratcheting effect).

Box 1.1 - Global Goals for 2050 and Global Targets for 2030 in the Global Biodiversity Framework

(full text at https://www.cbd.int/gbf)

Global Goals for 2050:

Goal A Protect and Restore
The integrity, connectivity, and resilience of all ecosystems are maintained, enhanced, or restored, substantially increasing the area of natural ecosystems by 2050;

Human-induced extinction of known threatened species is halted, and, by 2050, the extinction rate and risk of all species are reduced tenfold, and the abundance of native wild species is increased to healthy and resilient levels;

The genetic diversity within populations of wild and domesticated species is maintained, safeguarding their adaptive potential.

Goal B Prosper with Nature
Biodiversity is sustainably used and managed and nature's contributions to people, including ecosystem functions and services, are valued, maintained, and enhanced, with those currently in decline being restored, supporting the achievement of sustainable development for the benefit of present and future generations by 2050.

Goal C Share Benefits Fairly
The monetary and non-monetary benefits from the utilisation of genetic resources and digital sequence information on genetic resources, and of traditional knowledge associated with genetic resources, as applicable, are shared fairly and equitably, including, as appropriate with indigenous peoples and local communities, and substantially increased by 2050, while ensuring traditional knowledge associated with genetic resources is appropriately protected, thereby contributing to the conservation and sustainable use of biodiversity, in accordance with internationally agreed access and benefit-sharing instruments.

Goal D Invest and Collaborate
Adequate means of implementation, including financial resources, capacity-building, technical, and scientific cooperation, and access to and transfer of technology to fully implement the Kunming-Montreal Global Biodiversity Framework are secured and equitably accessible to all Parties, especially developing country Parties, in particular the least developed countries and small island developing States, as well as countries with economies in transition, progressively closing the biodiversity finance gap of $700 billion per year, and aligning financial flows with the Kunming-Montreal Global Biodiversity Framework and the 2050 Vision for biodiversity.

Global targets for 2030:

Target 1: Plan and Manage all Areas To Reduce Biodiversity Loss

Target 2: Restore 30% of all Degraded Ecosystems
Target 3: Conserve 30% of Land, Waters and Seas
Target 4: Halt Species Extinction, Protect Genetic Diversity, and Manage Human-Wildlife Conflicts
Target 5: Ensure Sustainable, Safe and Legal Harvesting and Trade of Wild Species
Target 6: Reduce the Introduction of Invasive Alien Species by 50% and Minimize Their Impact
Target 7: Reduce Pollution to Levels That Are Not Harmful to Biodiversity
Target 8: Minimize the Impacts of Climate Change on Biodiversity and Build Resilience
Target 9: Manage Wild Species Sustainably To Benefit People
Target 10: Enhance Biodiversity and Sustainability in Agriculture, Aquaculture, Fisheries, and Forestry
Target 11: Restore, Maintain and Enhance Nature's Contributions to People
Target 12: Enhance Green Spaces and Urban Planning for Human Well-Being and Biodiversity
Target 13: Increase the Sharing of Benefits From Genetic Resources, Digital Sequence Information and Traditional Knowledge
Target 14: Integrate Biodiversity in Decision-Making at Every Level
Target 15: Businesses Assess, Disclose and Reduce Biodiversity-Related Risks and Negative Impacts
Target 16: Enable Sustainable Consumption Choices To Reduce Waste and Overconsumption
Target 17: Strengthen Biosafety and Distribute the Benefits of Biotechnology
Target 18: Reduce Harmful Incentives by at Least $500 Billion per Year, and Scale Up Positive Incentives for Biodiversity
Target 19: Mobilize $200 Billion per Year for Biodiversity From all Sources, Including $30 Billion Through International Finance
Target 20: Strengthen Capacity-Building, Technology Transfer, and Scientific and Technical Cooperation for Biodiversity
Target 21: Ensure That Knowledge Is Available and Accessible To Guide Biodiversity Action
Target 22: Ensure Participation in Decision-Making and Access to Justice and Information Related to Biodiversity for all
Target 23: Ensure Gender Equality and a Gender-Responsive Approach for Biodiversity Action

2 Can the global implementation of the GBF bend the curve of biodiversity loss?

To assess the extent to which the collective ambitions of Parties and non-state actors are sufficient for achieving the 2050 GBF goals, it is necessary to understand to what extent the global implementation of the action targets for 2030 enables the realisation of the 2050 goals. So far, such information has been lacking. Here we contribute to filling this knowledge gap by providing the first quantitative prospective assessment of the expected contribution of the full implementation of the action targets to achieving the 2050 goals, more specifically, Goals A and B. In addition, we assess the effect of current climate policies and pledges submitted by countries in their Nationally Determined Contributions (NDCs) to contribute to the achievement of the Paris Agreement in order to evaluate synergies and trade-offs between biodiversity and climate mitigation policies. Finally, we assess a scenario where high environmental ambitions are realised through the conservation of 50% of terrestrial land by 2050, keeping temperature increase well below 2°C, strong changes in diets, and decreases in waste.

2.1 Approach and scenario-set up

This quantitative assessment focuses on the realisation of Goals A and B (Box 1.1) as these state the desired ecological outcomes of the GBF by 2050, through the implementation of the action targets for 2030. Goals C and D and their related action targets provide for conditions, tools, and instruments for the realisation of the GBF. These are not included in the analysis, however we are aware that realisation of Goals A and B is dependent on national action and the necessary means being put in place, requiring the full implementation of Goal C and D.

For this quantitative assessment, we apply PBL's integrated assessment modelling framework IMAGE (Stehfest et al., 2014) in combination with PBL's global biodiversity model GLOBIO (Schipper et al. 2020) (see Appendix 1 for further description). The IMAGE-GLOBIO framework has been used to explore alternative futures for biodiversity and policy pathways towards the realisation of biodiversity targets (CBD Secretariat 2014, 2020; IPBES 2019; Kok et al. 2023; Leclère et al. 2020; Schipper et al. 2020). In this novel approach of prospective or ex ante evaluation of policy action, we implement CBD's 2030 action targets in our modelling framework (Box 1.1 and Table 2.1) following, as far as possible, the guidance provided by CBD.[1] In addition, as biodiversity loss is inextricably linked to climate change (Pörtner et al. 2021), we assess how the mitigation efforts stated in the Nationally Determined Contributions to the Paris Agreement (UNEP 2023) contribute to halting and reversing biodiversity loss. Finally, a scenario with high environmental ambitions is

[1] https://www.cbd.int/gbf/targets

presented that realises stronger conservation actions, including reaching the goals of the Paris Agreement, and incorporating other actions geared towards transformative change environmental sustainability. These last two scenarios position the GBF goals and targets in a broader perspective of sustainability policies.

Specifically, we analyse the following four scenarios:

(i) *Baseline*: this is a middle-of-the-road scenario, following the Shared Socioeconomic Pathway 2 (SSP2). In this scenario, global trends of population, economics, and technological development do not change much compared to historical patterns, implying continued population growth that levels off towards the end of the century, continued economic growth although large differences between countries remain, and some progress towards sustainable development but without significant breakthroughs. Specifically for climate, current policies in the energy and industry-system are included, and for biodiversity currently protected areas are included. The other scenarios build on the assumptions in the *Baseline*, notably with the same population and economic drivers;

(ii) *Global Biodiversity Framework (GBF)*: in this scenario we implement a selection of GBF's action targets (for more detail see Table 2.1);

(iii) *GBF + Nationally Determined Contributions (NDCs)*: this scenario is equal to the *GBF* scenario regarding the implementation of the GBF, but we additionally implement climate policies in line with the self-declared Nationally Determined Contributions (NDCs) as submitted to the UNFCCC;

(iv) *High Environmental Ambition (HEA)*: in this scenario the *GBF* scenario is further strengthened and complemented with policies geared towards transformative change and high sustainability ambitions. Notably, this includes the realisation of the goal of the Paris Agreement of keeping the increase in global temperature well below 2°C, additional measures to protect and restore biodiversity, and transformative change in the food system.

First and foremost, it is important to note that we only assessed the targets that could be evaluated based on the indicators available in the IMAGE-GLOBIO framework, therefore not all targets nor all dimensions of the targets could be assessed (Box 2.1 and Table 2.1). Furthermore, it is important to consider that some targets are not very specifically formulated, nor quantitative or time-bound, which required an extra interpretation from our side to translate the targets into the scenario (Table 2.1).

Compared to previous studies, we use an updated version of the SSP2 scenario. This builds on recently published datasets on demography and economics, including empirical data on historical developments up to 2020 (IIASA 2024). The conceptual framework and the narratives of the SSPs remain the same as in previous studies (see O'Neill et al. 2017 and Riahi et al. 2017). The IMAGE 3.4 model that is used to elaborate this SSP2 scenario is calibrated to historical data from FAO, IEA, and GTAP up to 2020 and includes various new features compared to the previous model version (see Appendix 1): among others, more detailed representation of irrigation systems and unsustainable groundwater use, policy measures for soil carbon management, and improved high-resolution assessment of land availability for agricultural expansion.

In our scenarios, we assess the period from 2020 to 2100. For results on biodiversity, carbon stocks, land, and the food system we focus on 2050 as these are the deadlines to achieve the GBF goals.

We go beyond 2050 because climate change dynamics have long time lags and mitigation targets are typically set for the end of the century, and we therefore also show biodiversity impacts for 2100.

Box 2.1 - Mean Species Abundance and Living Planet Index

Mean Species Abundance (MSA) for plants and for warm-blooded vertebrates (birds and mammals): MSA is an indicator of local biodiversity intactness, ranging 0 to 1, where 1 means that the species assemblage is fully intact, and 0 means that all original species are extirpated (locally extinct). MSA is calculated based on the abundance of individual species under influence of a given pressure, compared to their abundance in an undisturbed situation.

Living Planet Index (LPI) for mammals: the LPI measures the mean relative change in vertebrate population size compared to a reference year (1970). LPI values lower than 1 indicate that vertebrate populations have, on average, declined, whereas values higher than 1 indicate average increases in population size relative to the reference year.

Table 2.1 - Key assumptions in the four scenarios concerning the targets implemented in our modelling framework. All scenarios follow SSP2 population and GDP projections.

Target	Model implementation in the different scenarios			
	Baseline	Global Biodiversity Framework (GBF)	GBF + Nationally Determined Contributions	High Environmental Ambition (HEA)
Target 1 *Plan and Manage all Areas to Reduce Biodiversity Loss*	-	Total agricultural land is not allowed to increase after 2030.	Same as GBF scenario.	Same as GBF scenario.
Target 2 *Restore 30% of all Degraded Ecosystems*	-	Ecological restoration is achieved by (i) natural regeneration of abandoned agricultural areas and by (ii) reducing pressures (see Targets 7, 8, and 10).	Same as GBF scenario.	Same as GBF scenario.
Target 3 *Conserve 30% of Land, Waters, and Seas*	Current protected areas following World Database on Protected Areas (WDPA).	30% protection of terrestrial lands is achieved by 2030. The protection target is achieved at the ecoregion level to ensure ecological representation. The areas include currently protected areas, Key Biodiversity Areas, Intact Forest Landscapes, and areas with high Range Rarity index values.	Same as GBF scenario.	30% protection of terrestrial lands is achieved by 2030 and 50% by 2050. The protection target is achieved at the ecoregion level to ensure ecological representation. The areas include currently protected areas, Key Biodiversity Areas, Intact Forest Landscapes and areas with high Range Rarity index values.
Target 7 *Reduce Pollution to Levels that are Not Harmful to Biodiversity*	-	Increase nutrient use efficiency.	Same as GBF scenario.	Same as GBF scenario.
Target 8 *Minimise the Impacts of Climate Change on Biodiversity and Build Resilience*	Current policies in energy and industry sectors (NewClimate 2023).	Same as Baseline scenario.	Climate policies in line with Nationally Determined Contributions in energy, industry sectors, and forest protection in line with current policy.	Climate policies consistent with the Paris Agreement, i.e. limiting global warming to well below 2°C by the end of the century.
	Baseline	Global Biodiversity Framework (GBF)	GBF + Nationally Determined Contributions	High Environmental Ambition (HEA)

Target 10 *Enhance Biodiversity and Sustainability in Agriculture, Aquaculture, Fisheries, and Forestry*	-	Strong increase in irrigation efficiency to reduce freshwater withdrawals. Globally, strong increase in residues left on the fields on 30% of cropland in 2030 and 50% in 2050 to enhance soil carbon stocks. All forest management transitions to natural forest management with reduced impact logging, except for forest plantations that are maintained at baseline levels to limit pressure on natural forests.	Same as GBF scenario.	Same as GBF scenario.
Target 11 *Restore, Maintain, and Enhance Nature's Contributions to People*	-	High carbon forests, riparian zones, water retention areas, and peatlands are protected in order to ensure that NCPs are maintained and enhanced.	Same as GBF scenario.	Same as GBF scenario
Target 16 *Enable Sustainable Consumption Choices to Reduce Waste and Overconsumption*	-	By 2050, 50% of the global population adopts a healthy diet (Willett et al. 2019) with reduced intake of livestock products, higher intake of legumes, and a sufficient caloric intake (i.e. no undernutrition or overconsumption). Globally, food waste is reduced by 50% in 2050. Per capita timber demand is reduced following SSP1 (Doelman et al. 2018).	Same as GBF scenario.	By 2050, 100% of the global population adopts a healthy diet (Willett et al. 2019) with reduced intake of livestock products, higher intake of legumes, and a sufficient caloric intake (i.e. no undernutrition or overconsumption). Globally, food waste is reduced by 50% in 2050. Per capita timber demand is reduced following SSP1 (Doelman et al. 2018).

2.2 Results

We use the outcomes of the four scenarios to assess whether the implementation of the action targets puts nature on a path to recovery for a set of different indicators. By analysing this effort under different climate scenarios, we explore to what extent the realisation of the goals of the GBF is dependent on global climate mitigation efforts and where synergies and trade-offs between biodiversity and climate policies can occur.

Achieving Goal A of the GBF requires that the integrity, connectivity, and resilience of all ecosystems are maintained, enhanced, or restored, substantially increasing the area of natural ecosystems by 2050. According to our analysis, we see that by 2050 the area of forest and natural lands increases substantially in the GBF scenario with 300 Mha globally compared to 2020, i.e. a 3.8% increase (Figure 2.1 and 2.2). In the short term some deforestation still occurs, most notably in sub-Saharan Africa. This is due to strong population growth and strong increases in agricultural demand. If no action would be taken, as assessed in the Baseline scenario, forests and natural lands would strongly decline, with 350 Mha lost from 2020 to 2050 (-4.4%), in line with historical trends. In the GBF+NDC scenario, forest and natural areas are 16 Mha lower in 2050 compared to the GBF, partly due to higher area use for bioenergy production. The HEA scenario on the other hand results in increases in forests and natural areas that are substantially larger than the GBF scenarios (550 Mha between 2020-2050, i.e. a 6.9% increase). In the GBF, GBF+NDC, and HEA scenarios, the increases in forest and natural areas are a result of the implementation of Targets 1, 2, 3, 11, 12, and 16. This includes an expansion of protected areas and ecosystem restoration for the protection of biodiversity and ecosystem services, as well as an increase in demand-side measures on consumption and waste.

Achieving Goal A also requires that decreases in the state of biodiversity are halted by 2050 and that the abundance of native and wild species increases. Our analysis shows that in 2050 (and

onwards), compared to the baseline, all the scenarios with policy interventions result in improvements in the state of biodiversity for both indicators (Figure 2.3). The GBF and the GBF+NDC scenarios result in smaller improvements in biodiversity compared to the HEA scenario (Figure 2.3). For MSA, the GBF and GBF+NDC scenario can attenuate biodiversity loss, while the HEA scenario improves the state of biodiversity. For LPI, improvements in biodiversity are achieved in all policy scenarios with strong improvements up to 2050 compared to the baseline. From 2050 to 2070, the state of biodiversity slightly declines again as the beneficial impact of policy measures implemented from 2025-2050 starts to fade and some of the restored land is lost again to agriculture. While the state of biodiversity is still better than in the Baseline scenario, this does highlight the need for effective policy measures for the long term.

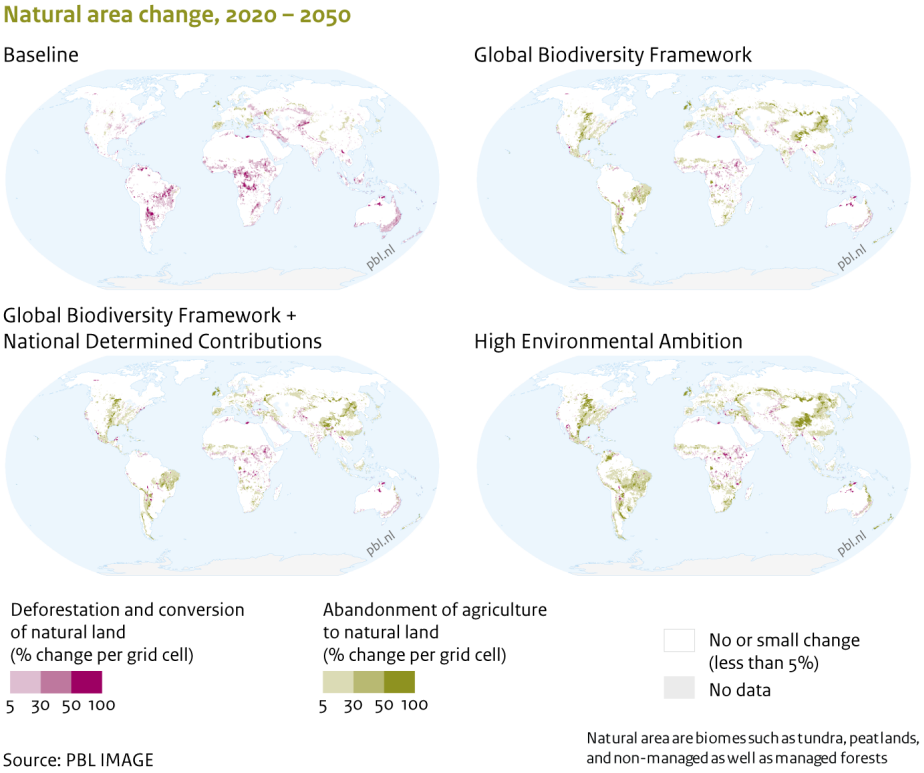
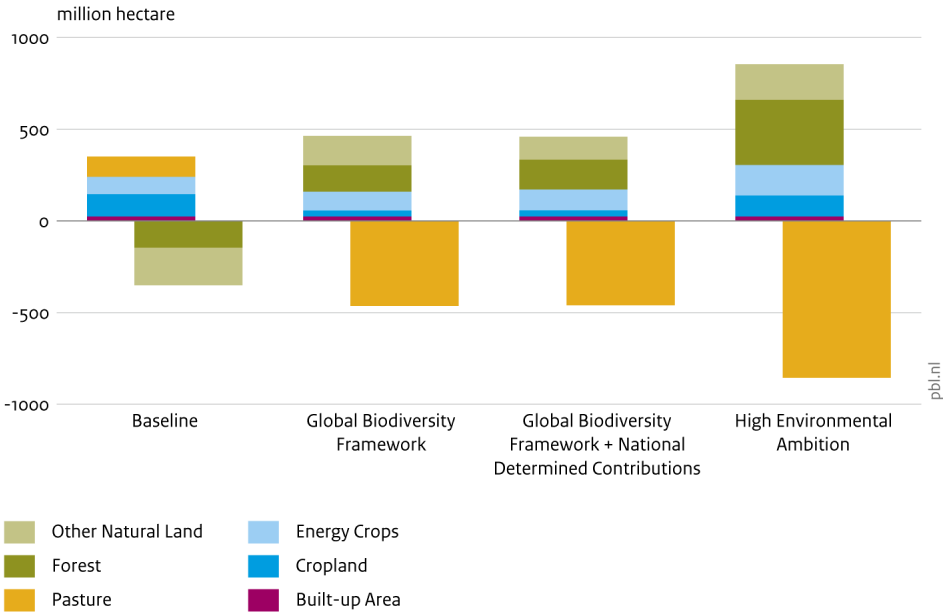


Figure 2.1 – Natural area changes from 2020 to 2050 for the four scenarios analysed. Change is expressed in % change.

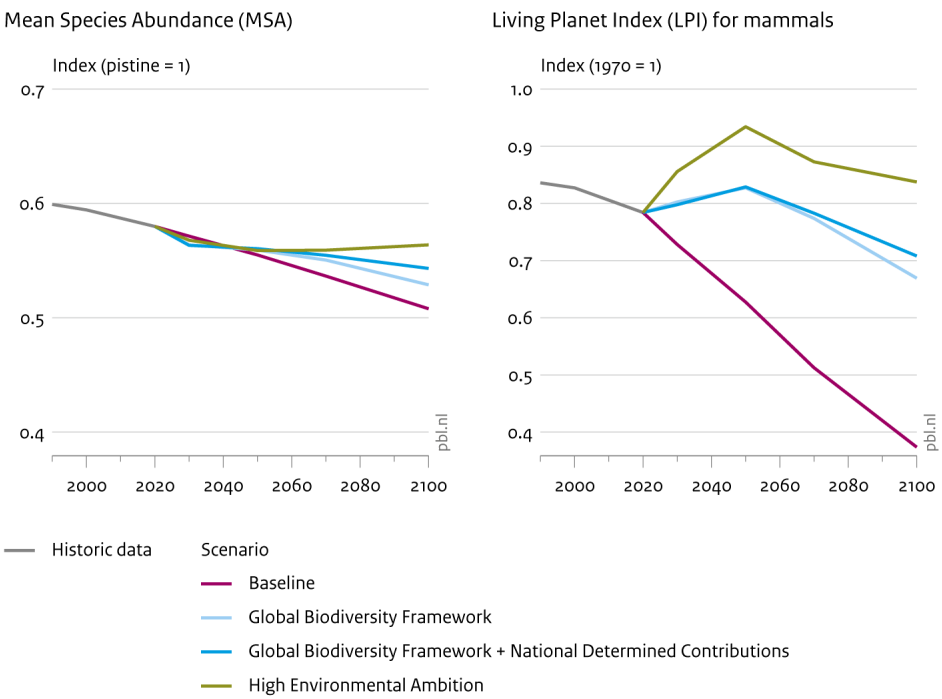
Land-use change, 2020 – 2050



Source: PBL IMAGE

Figure 2.2 – Change in land use area (Mha) between 2020 and 2050 for the different scenarios.

The difference between the GBF and GBF+NDC scenarios results from the implementation of climate policies currently pledged by countries in line with their Nationally Determined Contributions (NewClimate 2023). The scenarios and policies implemented therein result in different increases in global mean temperature and correspondingly different climate change levels (Figure 2.4). In the Baseline scenario, a global mean temperature increase of approximately 3.1°C in 2100 is projected, indicating that without climate policies in addition to what is currently implemented, climate change will continue to worsen. In the GBF+NDC scenario, the temperature increase reaches 2.4°C in 2100, while in the GBF scenario the temperature increase rises to approximately 2.9°C. These results show that the GBF alone contributes to climate change mitigation with about 0.2°C, highlighting that the non-climate oriented GBF goals contribute substantially to climate change mitigation. Implementing climate policies in line with the NDCs, which predominantly occurs in the energy and industry sectors (Figure 2.5), reduces global mean temperatures in 2100 by about 0.5 °C. The climate change mitigation level reached in the different scenarios has important implications for the state of biodiversity, especially in longer time frames (Figure 2.3). In 2050, the GBF+NDC scenario shows slightly better trends for biodiversity than the GBF scenario, but in 2100 the differences between scenarios increase, mostly because of the different climate change mitigation levels. In 2100, MSA increased from 0.51 in the Baseline scenario to 0.53 in the GBF scenario, and 0.54 in the GBF+NDC scenario. The LPI indicator is more sensitive; in 2100 LPI reaches 0.37 without climate and biodiversity policies, while in the GBF scenario it increases to 0.67 and to 0.70 in the GBF+NDC scenario.



Source: PBL GLOBIO

Figure 2.3 – Trends in the state of biodiversity expressed in Mean Species Abundance (MSA) and the Living Planet Index (LPI) under the four different scenarios.

The HEA scenario limits temperature increase to below 2 °C, in line with the objectives of the Paris Agreement. As expected, the differences in temperature between scenarios are larger for longer time horizons due to the cumulative effect of continuously higher emissions in the Baseline and GBF scenarios compared to the HEA scenario. The HEA scenario is the only scenario where, in the long run, lasting improvements in biodiversity are achieved when compared to the current situation (Figure 2.3). This is the result of effective and ambitious climate mitigation policy in combination with additional measures on nature protection, restoration, and demand-side measures.

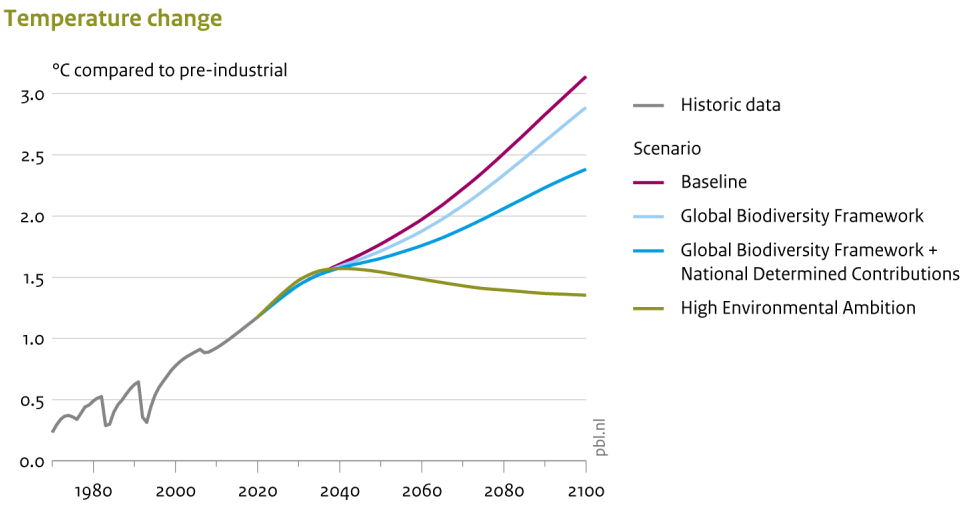


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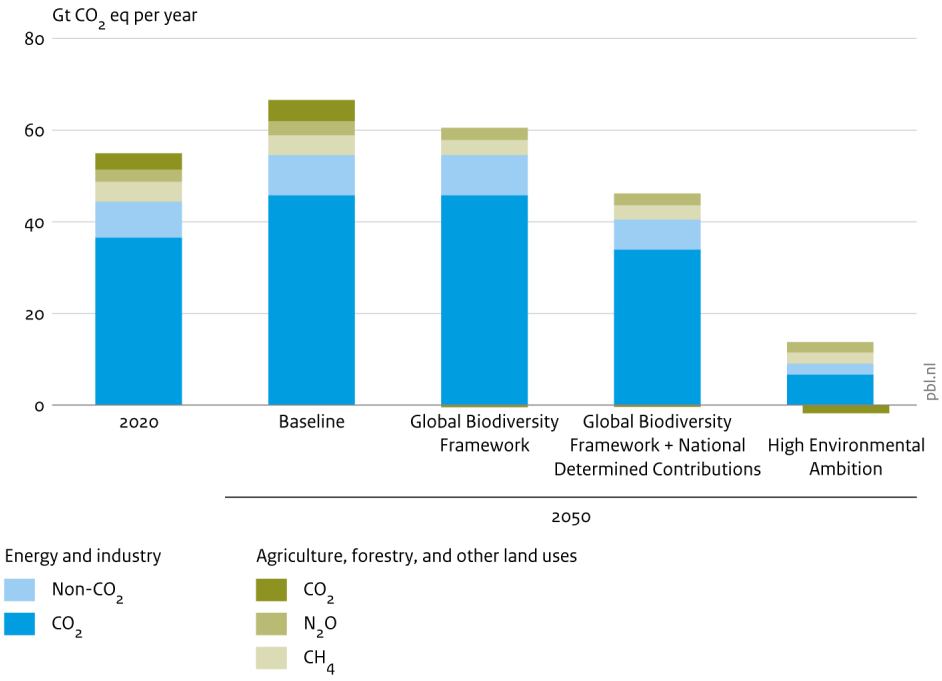
Figure 2.4 – Temperature change in degrees Celsius compared to pre-industrial times (1750-1850) from 1970 until 2100 for the four scenarios.



Source: PBL IMAGE

Figure 2.5 – Annual greenhouse gas (GHG) emissions (Mton CO2-eq/year) for 2020 and 2050 for the four scenarios for the agricultural sector (CO2, N2O and CH4) and for CO2 and non-CO2 GHGs for the energy and industry sectors.

Goal B of the GBF focuses on prospering with nature, meaning that biodiversity is sustainably used and managed and nature's contributions to people are valued, maintained, and enhanced. This goal is very broad in scope, so in this analysis we focus on two main aspects: the relationship with food systems and the contribution of biodiversity to climate mitigation through the provision of ecosystem services.

For agricultural production, the main impact of the implementation of the GBF compared to the Baseline, is a decrease in the production of livestock and, as a result, a substantial decrease in feed requirements (Figure 2.6). These changes are predominantly a consequence of the measures taken to implement Target 16, concerning diet changes and food waste reduction. The 50% reduction in food waste directly reduces the crop and livestock production requirements (Gustavsson et al. 2011). In addition, the adoption of healthy and equitable diets as proposed by Willet et al. (2019) results in strong reductions in meat production (from 290 Mt/yr in the Baseline to 220 Mt/yr in GBF to 160 Mt/yr in HEA). This diet includes much lower consumption of animal-based products and a reduction of overconsumption in the global north, higher intake of fruits, vegetables, legumes, and nuts everywhere, and an increase in food consumption to healthy levels most notably in the global south. Total crop production for food, feed, and other uses does not change much, but a larger share of crops is directly used as food for people while this was first used to feed livestock. On the other hand, additional crops are produced to fulfil the demand for bioenergy in order to achieve the targets of NDCs and the Paris Agreement in the GBF+NDC and HEA scenarios, respectively.

The strong reduction in meat and dairy production has a direct impact on land use, most notably through lower requirements for grazing. The GBF, GBF+NDC, and HEA scenarios all project strong decreases in pasture areas (Figure 2.2). Total cropland area does not increase as much in the GBF scenarios as in the Baseline due to protection measures (Target 3) and sustainable agricultural intensification (Target 10). Cropland area for bioenergy does increase relatively more in the HEA scenario due to the stringent climate target, but not at the cost of increases in natural land as former pasture areas are used for this purpose (Figure 2.2).

The different categories of GHG emissions shows the dominance of the energy and industry sectors in causing climate change (Figure 2.5). Nonetheless, agriculture and land use are responsible for a substantial share, too; around 20% in 2020. These emissions continue to increase in the Baseline scenario, in line with population growth and economic development. The implementation of the GBF has substantial benefits for climate mitigation (Figure 2.4 and 2.5), which is predominantly due to reductions in emissions of methane and nitrous oxide from livestock rearing (and natural vegetation turning from a source into a sink). The NDC measures have a strong effect on emissions, most notably in energy and industry, which is key to limiting climate change. Finally, the HEA scenario shows very strong emission declines that are near net-zero by 2050 and also substantial CO_2 sequestration from natural vegetation (Figure 2.5).

Agricultural production

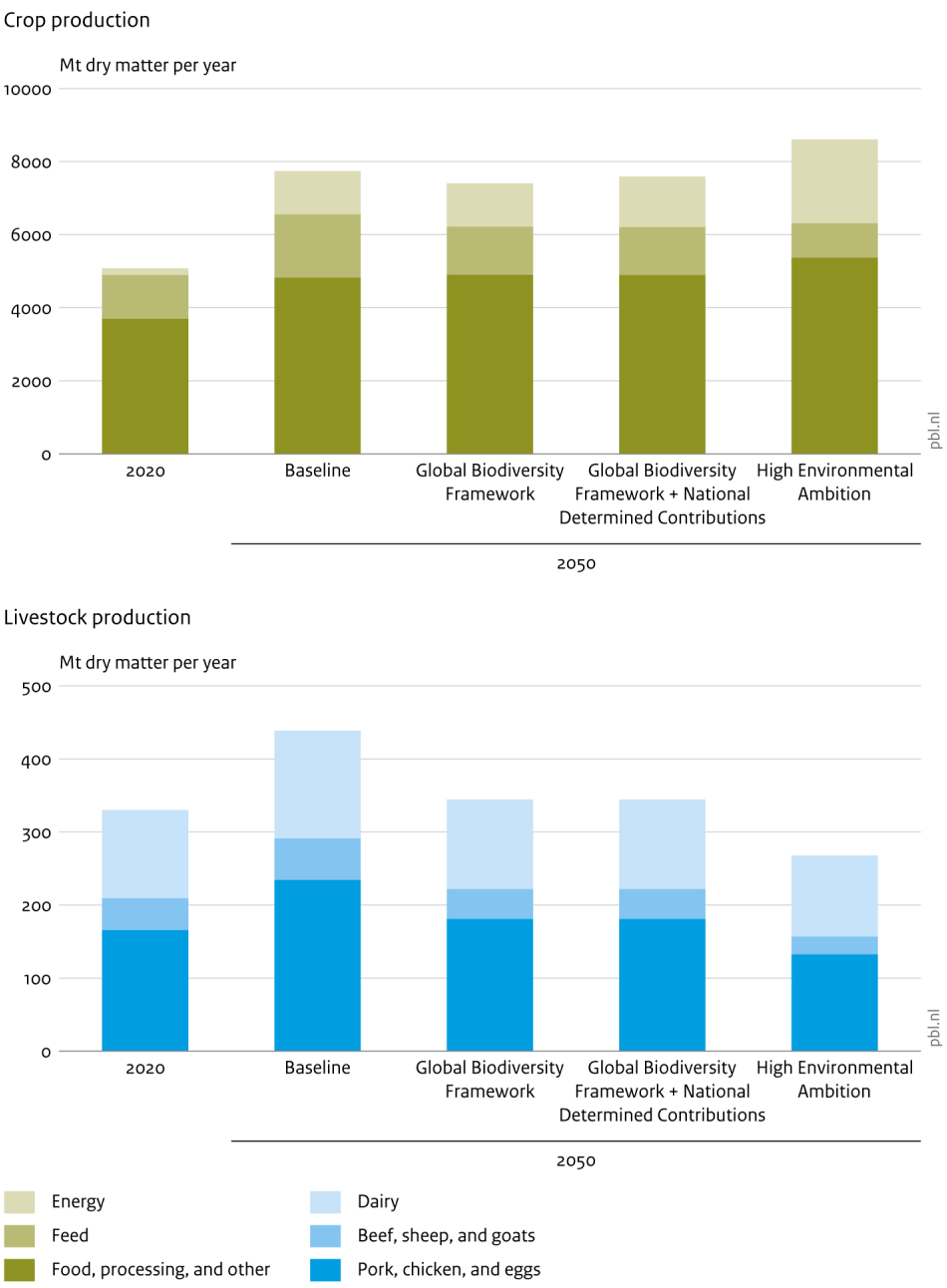


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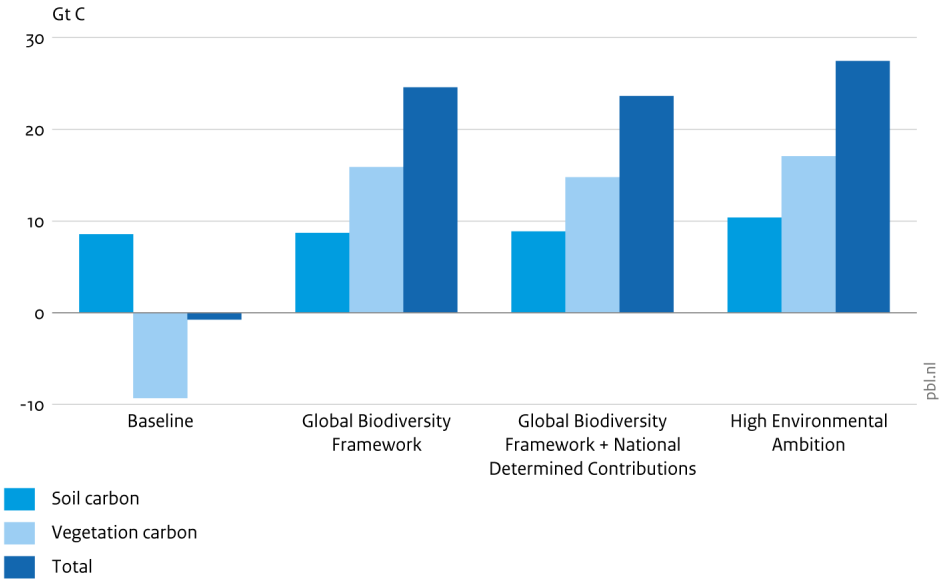
Figure 2.6 - Agricultural production in 2020 and 2050 for the scenarios in terms of megatonne dry matter per year. Crop production includes crops for food and other uses, feed, and bioenergy; production of animal-based products includes dairy, beef, sheep and goats (ruminants), and pork, chicken and eggs (non-ruminants).

The contribution of nature to climate change mitigation greatly increases in all scenarios when compared to the Baseline (Figure 2.7). In the Baseline, carbon stocks in living biomass decrease, reflecting the loss of forest areas and natural land (Figure 2.6). Overall, changes in carbon stocks in the GBF, GBF+NDC, and HEA scenarios are similar from 2020 to 2050. The highest level of carbon stocks, both in vegetation and soils, is achieved in the HEA scenario; this occurs mostly because of higher levels of protection of natural areas in this scenario (Table 2.1).

Global carbon stock changes, 2020 – 2050



Source: PBL IMAGE

Figure 2.7 – Changes in carbon stocks (GtC) in vegetation and soils between 2020 and 2050 for all scenarios.

2.3 Conclusions

In this chapter we provided the first quantitative prospective assessment of the contribution of a global implementation of GBF's action targets to achieve the 2050 goals, more specifically, Goals A and B. Following a business-as-usual trajectory will place GBF goals further out of reach and will lead to the continuing deterioration of biodiversity. The global implementation of the GBF has the potential to increase the area of natural ecosystems by 2050, but achieving an overall increase in the state of biodiversity will be harder to secure and will require additional measures. Our results show that this can be achieved for LPI for mammals, yet our MSA trends for plants, birds, and mammals still show a decreasing trend for biodiversity. However, in both cases there are significant improvements in the state of biodiversity when compared to the Baseline.

To understand the impacts of current climate policies on nature, we evaluated the GBF+NDC scenario. This allowed us to determine that NDCs alone contribute to a climate change mitigation of 0.5 °C, whereas the GBF alone contributed to a climate mitigation of 0.2 °C. On the one hand, these results confirm that more ambitious NDCs are needed to comply with the Paris Agreement and to also reduce impacts on ecosystems and biodiversity, and on the other hand they demonstrate that the effect of biodiversity policy on climate mitigation is not negligible. With respect to the achievement of the GBF goals on biodiversity, the GBF+NDC scenario shows small improvements compared to the GBF scenario by the year 2050. By the end of the century, however, the GBF+NDC does perform significantly better on biodiversity compared to the GBF scenario, highlighting the importance of climate change mitigation for the goals of the GBF and indicating the length of time needed before the impacts of these measures become visible.

An effective bending of the curve of biodiversity loss above current levels, was only achieved in our

high environmental ambition scenario where conservation targets are increased, the Paris Agreement is reached, and strong measures regarding diet change and waste reduction are put in place. These option imply a large implementation challenge for countries. For example, demand-side measures have large potential for biodiversity restoration and climate change mitigation, and also have important co-benefits for other sustainability goals such as food security and pollution. However, a full global transition to healthy diets is a very optimistic scenario and its feasibility is highly uncertain. Moreover, it is uncertain how the agro-economic system will respond to such a transition and to what extent agricultural land will indeed become available for other purposes such as nature restoration.

It is important to note that the analysis presented here is a first attempt at understanding the potential outcomes of a global implementation of the GBF. It therefore has an exploratory nature. Another aspect to consider is that we only explored a limited set of indicators which reflects a narrow view on all the potential outcomes and implications of the measures implemented in our scenario analysis. Furthermore, it is important to highlight that global models are inherently uncertain and reflect the assumptions and choices made during their development as well as assumptions regarding the implementation of the GBF targets.

3 Mainstreaming global biodiversity goals: assessing national targets

Conservation policies alone will not be enough to put nature on the path to recovery. Addressing indirect and direct drivers of biodiversity loss and ensuring full integration of biodiversity in public and private decision-making will be necessary. Building on country submissions to the CBD online reporting tool[2], in this chapter we make a first attempt to assess to what extent countries are formulating national targets in ways that are conducive to the mainstreaming of biodiversity across government and across society.

3.1 The importance of mainstreaming

The scenario analysis in Chapter 2 has demonstrated the need to address direct and indirect drivers of biodiversity loss in order to halt the loss of biodiversity and restore nature. It also illustrated that the effectiveness of the GBF will increase when simultaneously implementing NDCs. An integrated approach for biodiversity and climate is therefore needed to realise synergies and deal with trade-offs. Biodiversity mainstreaming, which intends to promote coherence between biodiversity policy and other policy domains (OECD 2018), is crucial for the implementation of the GBF biodiversity targets, as biodiversity loss is driven by activities in policy areas outside of conservation (Cardona Santos et al. 2023). This means that, to achieve the GBF's goals, national target setting should actively include mainstreaming considerations and address both indirect and direct drivers of biodiversity loss (IPBES 2019).

The GBF consists of action targets that are relevant to mainstreaming in two ways. A number of targets related to Goal A and B are relevant to mainstreaming in the sense that they address sectors outside of nature conservation, for example agriculture (Target 10) and spatial planning (Target 1). Targets related to Goal C and D are equally relevant to mainstreaming because they focus on actors, tools, and solutions for a just and effective implementation of the GBF. Specific mainstreaming targets are Target 14 which aims to 'Ensure full integration of biodiversity and its multiple values into policies, regulations, planning and development processes'; Target 15 that aims to encourage businesses to assess, disclose, and reduce biodiversity-related risks and negative impacts; Target 16 on enabling sustainable consumption choices; and Target 22 on ensuring 'full, equitable, inclusive, effective and gender-responsive representation and participation in decision-making'.

The implementation of the GBF targets is dependent on the CBD's Parties and the plans laid out in their Nationally Biodiversity Strategies and Action Plans (NBSAPs). The development of NBSAPs and national targets is a crucial step in the process of moving from the ambitions stated in the GBF to its actual implementation. It is also an opportunity to embed biodiversity policy into national

[2] https://ort.cbd.int.

development strategies and to prioritise biodiversity in decision-making across governmental institutions in all sectors (CBD Secretariat 2011).

However, broadening biodiversity policy to other policy domains is a big and complicated task for countries to achieve. The literature shows that although mainstreaming has been on the biodiversity agenda for a long time now, little progress has been made in practice. A significant barrier to biodiversity mainstreaming is the fact that governments operate in silos (hindering horizontal policy coherence) and that it is challenging to implement international policies at the national and sub-national level, where they can contradict other, established policies (hindering vertical policy coherence) (Karlsson-Vinkhuyzen et al. 2017). Resultingly, mainstreaming is more often being established through non-governmental actors and soft laws, but within those contexts multiple other challenges can arise (Karlsson-Vinkhuyzen et al. 2018). Mainstreaming actions brings stakeholders together that otherwise would not cooperate, which can lead to institutional challenges. Additionally, motivational differences, in interests and values for example, and a lack of means, such as knowledge and resources, can hinder mainstreaming efforts.

The GBF is a new attempt to underline the importance of and to push Parties towards effective mainstreaming. A preliminary analysis by the CBD Secretariat of national targets, as submitted by 53 countries by 5 August 2024 through the CBD online reporting tool, concludes that almost all Parties have mapped at least one national target on each of the mainstreaming targets 14, 15, 16 and 22 (see above). Half to three-quarter of these national targets were reported by countries as being highly aligned with the related GBF action-target (CBD 2024). However, no analysis has been made to what extent national targets that require action from public or private actors outside the biodiversity domain are addressed in ways that are conducive to mainstreaming. In the following sections, we provide an exploratory analysis, to see if and how Parties are incorporating conditions in their national targets that will be conducive to the further mainstreaming of these targets. With this analysis we aim to get a better understanding of how the reporting tool can be used for a policy scenario analysis of country targets.

3.2 Approach

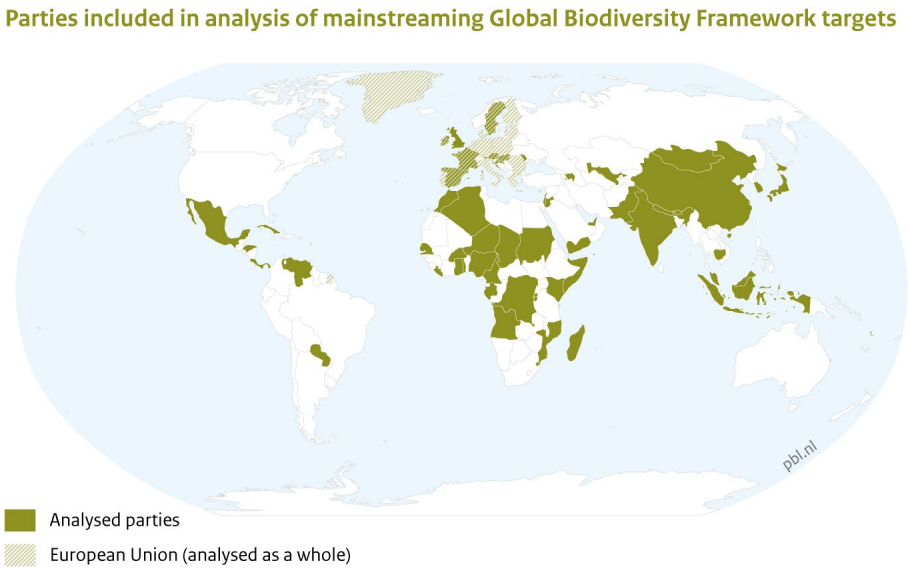
To assess how the national targets, submitted by Parties to the CBD to support the implementation of the GBF, are conducive to mainstreaming, we extracted information from CBD's online reporting tool. In the online reporting tool, Parties submit their national targets and map them to the GBF goals and action targets, indicate how closely they are aligned, and provide a description of the main policy measures that will be taken to achieve them. This information was evaluated and scored against six criteria (Table 3.1) that follow conditions that were identified as important in the CBD's *Action plan for the long-term strategic approach to mainstreaming biodiversity* (CBD 2020). If a criterion is met a score of 1 is attributed; otherwise the score is 0.

Table 3.1 - Set of questions used to review national targets aligned with the Global Biodiversity Framework on mainstreaming criteria, including an explanation on their relevance for mainstreaming.

	Criteria	**Explanation**
1.	Is there a national target, directly linked to the GBF target, that is specific and quantified?	Specificity and quantifiability of targets promote implementation, as it clarifies what policy measures are required to reach the targets. Additionally, it makes targets measurable and it therefore enables the review of the level of implementation (Hughes & Grumbine 2023).
2.	Are multiple entities of the national government addressed (e.g. ministries outside of environment)?	Mainstreaming requires coherence between different policy areas and efforts of ministries such as agriculture, economy, and finance (OECD 2018).
3.	Are local governments addressed?	Addressing local governments is crucial in complying to decisions made at the (inter)national level. Local governments refer to, for example, provinces or municipalities (Bulkeley et al 2023).
4.	Are fiscal, budgetary, or financial instruments put into place?	It is not possible to achieve mainstreaming without the allocation of monetary resources towards biodiversity policy (OECD 2018).
5.	Are stakeholders outside of the government considered or addressed?	Biodiversity actions directly or indirectly affect many types of stakeholders. Simultaneously, stakeholders can provide the necessary knowledge and the means to achieve biodiversity targets. Therefore, it is necessary to address stakeholders including the private sector, local communities, and NGOs in national strategies to achieve mainstreaming and deliver on implementation (Karlsson-Vinkhuyzen et al. 2017).
6.	Is there capacity for people to have knowledge on and awareness of biodiversity, as well the ability to act?	To reach biodiversity targets, a change in consumption patterns is crucial. Creating capacity for citizens to gain knowledge on biodiversity creates awareness and political will. Additionally, national governments can support local participatory processes (Cardona Santos et al. 2023).

The information used in this analysis was retrieved from CBD's online reporting tool up until the 14th of September 2024 and included information from 61 countries (Figure 3.1). In this assessment we included only GBF targets 1, 7, 8, 10, 11, and 16; each target is analysed separately. These targets are the same as the ones used in the scenario analysis in Chapter 2, except for targets 2 and 3, which are left out of this assessment; they are very specifically related to conservation and thus not directly related to mainstreaming. Per GBF target, we included the national targets that are aligned with it and extracted from CBD's online reporting tool the information provided under the fields 'Target title', 'Description', and 'Main policy measures' to perform the evaluation and scoring against the established criteria.

For criteria 2-6 we summed up the scores achieved per target to have an insight into the overall level of mainstreaming. If the overall score was 0, no criteria was achieved and therefore the target would have a low potential for mainstreaming; if the score was 5 that meant all criteria were achieved and therefore a high potential for mainstreaming.



Source: CBD online reporting tool, 14 Sep 2024

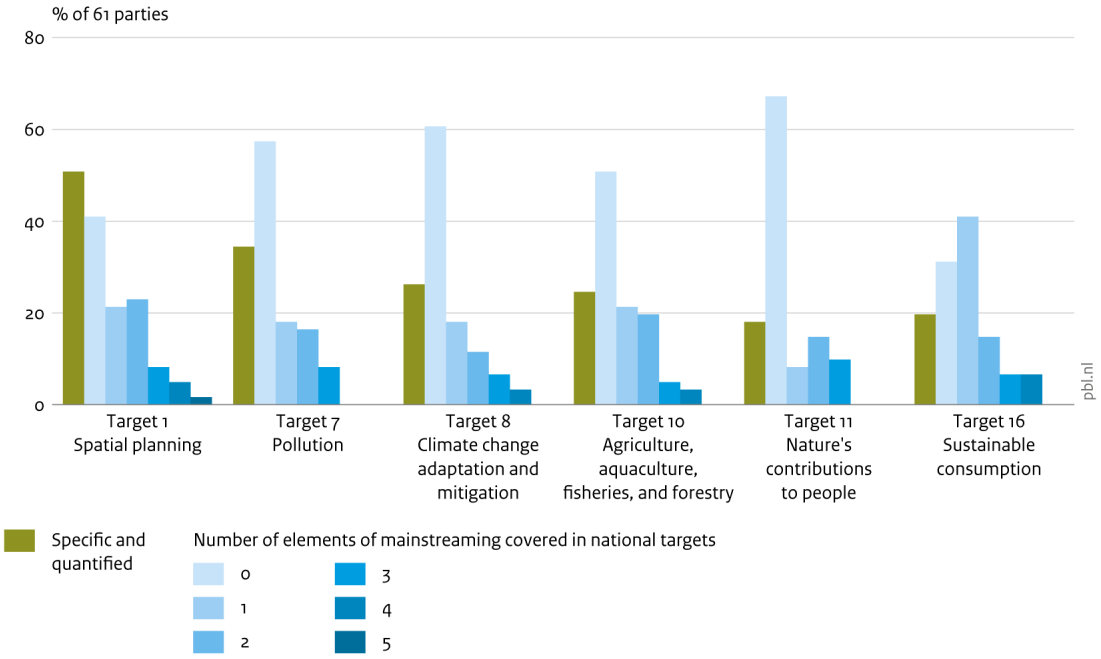
Figure 3.1 - World map showing which CBD Parties are included in analysis, 61 in total.

3.3 Results

We use the national targets submitted to the CBD online reporting tool to evaluate whether Parties are creating specific and quantified targets and whether they incorporate mainstreaming considerations into their biodiversity strategies. Additionally, we explore whether and how the online reporting tool can be used for taking stock of country ambitions to create a policy scenario, to be able to compare ambitions of Parties to the GBF scenario as presented in Chapter 2.

First, figure 3.2 shows per GBF target analysed what percentage of Parties uploaded a national target that is aligned with the GBF target and is, moreover, specific and quantified. Overall, not many Parties created specific and quantified targets. Target 1 on spatial planning and Target 7 on pollution perform best with 51% and 34%, respectively, of the total number of Parties. As GBF target 1 aims for all surface area to be under spatial planning, when a national target aligns with the GBF target, the amount of surface area under spatial planning accounts for 100% and thus is counted as quantified. An example is the following national target: "*By 2030, 25% of areas of environmental importance should be under spatial planning and effective management. By 2050, all land (...) should be under spatial planning to prevent land use changes in biodiversity-rich ecosystems*". Regarding pollution Target 7, most national targets that are specific and quantified are related to plastic or excess nutrients lost to the environment. Regarding the other targets, 26% or less of the Parties created a national target that aligns with the GBF target and is quantified. This may reflect the way in which the GBF targets are formulated; Targets 1 and 7 are formulated relatively SMART, while there is less specific guidance provided in the other targets.

Quantification and mainstreaming in national targets aligned with Global Biodiversity Framework, 2024



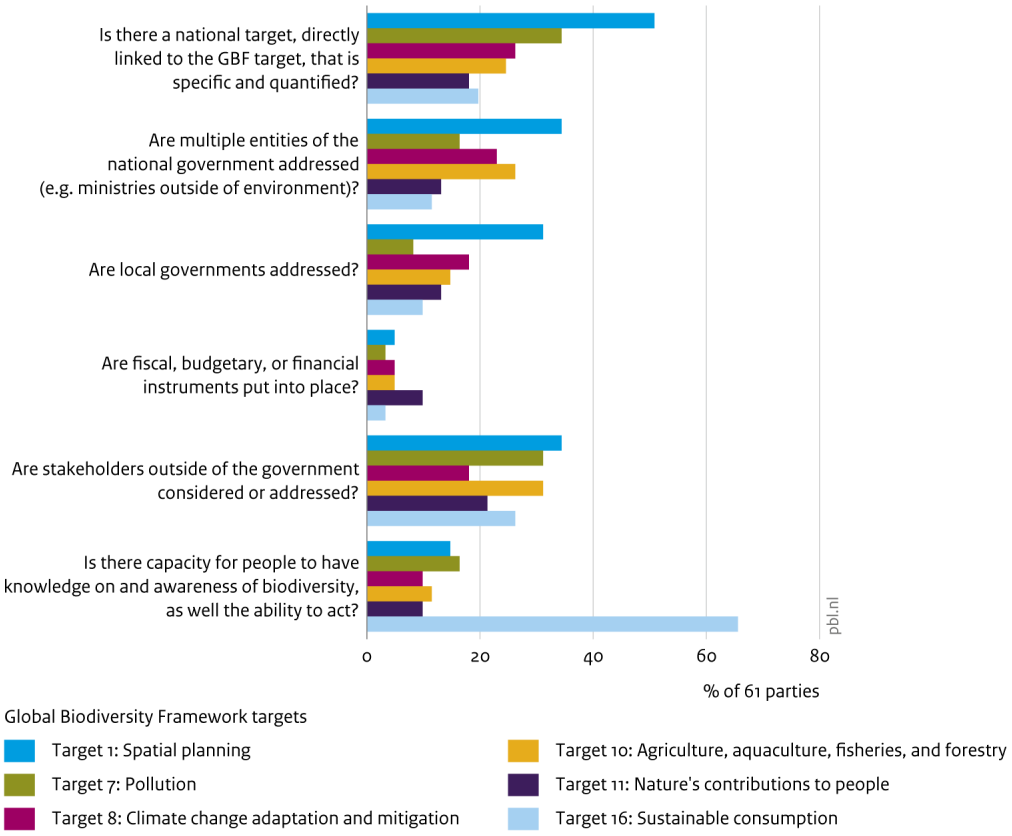
Source: CBD online reporting tool, 14 Sep 2024; analysis PBL

Figure 3.2 – Percentage of CBD Parties that formulated a specific and quantified target and scores in percentages on mainstreaming criteria covered in their national targets related to GBF targets.

Figure 3.2 also shows the scoring of Parties on mainstreaming elements. For all GBF targets, more than half of the analysed Parties score 0 or 1 on mainstreaming considerations. This means that either mainstreaming is not yet considered in national target setting, or policy measures are still too vague. Overall, an analysis of the targets shows that 30% to 45% of the Parties consider one or two elements of mainstreaming, except for Target 11, which performs worse with 23%, and Target 16, which performs better with 56%. It is not the same Parties that score higher regarding mainstreaming considerations across the different GBF targets. Five Parties scored a 3 or higher on at least three GBF targets. It differs per topic which Parties consider multiple mainstreaming elements. There is only one case in which a Party gained a score of 5, which was for GBF Target 1 on spatial planning. Noticeable is that the majority of Parties assessed consider none of the mainstreaming elements in how their national targets are operationalised.

GBF Target 11, on nature's contributions to people, scores the lowest on both specificity and mainstreaming considerations. Analysing the national targets aligned with this GBF target, it seemed as if it is difficult for Parties to specify what ecosystem services are most relevant in what context and to tie this to a quantifiable target. As a result, most Parties rephrase the target in a similar way as phrased in the GBF, without going into further detail. An example of a national target aligned with GBF Target 11 (and Target 8) that does provide further detail, and that aims at mainstreaming conservation with climate, mentions as a policy measure that *"Nature-based solutions will be identified and promoted as an important part of climate change adaptation and mitigation measures"*. Additionally, extra attention is given to the restoration of carbon-rich ecosystems.

Parties considering mainstreaming elements in national targets aligned with Global Biodiversity Framework, 2024



Source: CBD online reporting tool, 14 Sep 2024; analysis PBL

Figure 3.3 - Percentage of CBD Parties for which mainstreaming criteria are considered, based on national targets aligned with GBF target.

Figure 3.3 shows, per GBF Target, per question, for what percentage of analysed Parties the question could be answered with 'yes'. Target 16, on sustainable consumption, scores relatively high on the question on capacity creation for people to have knowledge on and awareness of biodiversity, and to support their ability to act. This applies to the fact that this question covers a big part of the GBF target. Still, 34% of the analysed Parties did not include this aspect in their national targets; some focused on food waste reduction only, others hinted at raised awareness among citizens, but without mentioning if or how capacity would be created to get to that point.

Overall, addressing entities of the national government outside of nature and biodiversity policy, and addressing stakeholders outside of government, are the two mainstreaming elements which receive the most attention within the national targets. For example, the target that "*By 2030, land under organic farming is increased to 10%*", supported a policy measure in which the department for agriculture "*and other stakeholders will support farmers to transition to organic farming*". However, for GBF Target 10 on agriculture, aquaculture, fisheries, and forestry, only 31% of the observed Parties describe how or what stakeholders will be addressed in policy. Since questions around agricultural reform are highly sensitive and politicised, it is especially important to actively include stakeholders in the policy process to achieve meaningful implementation.

Additionally, there is little reference to involving local government within the national targets. Target 1, on spatial planning, scores a bit higher on addressing local government (31%). This is to be expected, as local authorities have a role to play in spatial planning. However, local government also plays a crucial role in complying to the other (inter)national policy goals, though on average only 13% of the analysed Parties refers to local authorities in their policy actions for the other targets.

Finally, the establishment of fiscal, budgetary, or financial instruments was considered the least by Parties, for every GBF target. This can partially be explained because the finance plans corresponding with NBSAPs will only be created after COP-16. Still, it is important to note that there is almost no mention of these types of instruments, while they form a crucial part of creating policy actions and designing concrete measures for implementation. Some examples of national targets that do address financial policy measures are "*By 2030, 1.2 million hectares will be incorporated into the Payment for Environmental Services (PSA) program*" in relation to GBF Targets 10 and 11, and to "*Implement carbon pricing mechanisms such as carbon taxes or cap-and-trade systems*" in relation to GBF Targets 8 and 11

3.4 Conclusions

This assessment moves beyond the coverage of the GBF in national targets by asking the question whether CBD Parties are incorporating elements in national biodiversity targets that will be conducive to the further mainstreaming of these targets. We can conclude that overall, specifically related to targets 1, 7, 8, 10, 11, and 16, not many targets are phrased in ways that will enhance mainstreaming. Additionally, not many Parties created targets that are specific and quantifiable.

The phrasing of GBF targets is reflected in national target setting. This is not surprising, but it is important to emphasise that countries will have to make that extra step towards mainstreaming in their national planning processes. Parties score relatively high on target specificity and quantifiability regarding spatial planning Target 1 and Target 7 on pollution. Similarly, Parties score relatively high on the mainstreaming element on the capacity for people to have knowledge on biodiversity and to support their availability to act regarding Target 16 on sustainable consumption. This last target specifically aims to "Ensure that people are encouraged and enabled to make sustainable consumption choices". On the other hand, Target 11 on nature's contributions to people is phrased more broadly, resulting in less specific national targets. Though specific target setting at the global level does not automatically result in specific targets at the national level, we do observe a positive relation between the two.

CBD's online reporting tool is created with the aim to make it easier for countries to upload their national targets according to the requested reporting template. Additionally, it should make it easier for the Secretariat, as well as other stakeholders, to analyse Party ambitions and implementation and to provide information for the global reporting to review progress. We observed big differences between Parties regarding the type and amount of information uploaded to the online reporting tool. The online reporting tool has the potential to support the review mechanism and can be used as a methodological tool for future stocktake analyses of national target development and implementation. However, for the quantitative information needed for policy scenario analyses of the collective ambition and implementation by Parties, information from the global reporting tool needs to be complemented with information from the NBSAPs.

Ultimately, the creation of specific national targets is only the first step to actually reach biodiversity goals. As drivers of biodiversity loss come from policy areas outside of nature conservation, it is crucial to address and mobilise those other policy areas and create a broad approach to realise biodiversity targets. This can realise synergies and help deal with trade-offs. An effective mainstreaming approach will have to address all relevant actors, within government and non-governmental. However, this analysis shows that criteria for mainstreaming are not considered widely in national targets set so far. A majority of the Parties that uploaded national targets to the online reporting tool included none of these mainstreaming elements. Per target, more than half of the Parties included zero or one element. This shows that more specific attention is needed by Parties on effective ways to realise mainstreaming in national target setting. If mainstreaming is considered more explicitly and concretely, the global review can be more specific regarding progress in mainstreaming, lessons learned, and ways forward.

4 Towards a multi-actor, multiple-evidence approach for CBD global analysis and review

COP-16 will decide on the modalities of the mechanisms for planning, monitoring, reporting, and reviewing. In the previous chapters we have provided analyses that could potentially inform CBD's global review process. We now turn to some considerations about the need and opportunities arising from including non-state actors commitments and actions in the global analysis and review, as well as the need for a multiple-evidence approach to provide a diverse knowledge base. Finally, we draw some conclusions, focusing on ways forward to help the global review in sending clear signals and recommendations to both Parties and non-state actors in support of the realisation of the GBF goals, as well as a potentially necessary stepping up of efforts (the so-called ratcheting effect) towards and beyond 2030.

4.1 Multi-actor approach[3]

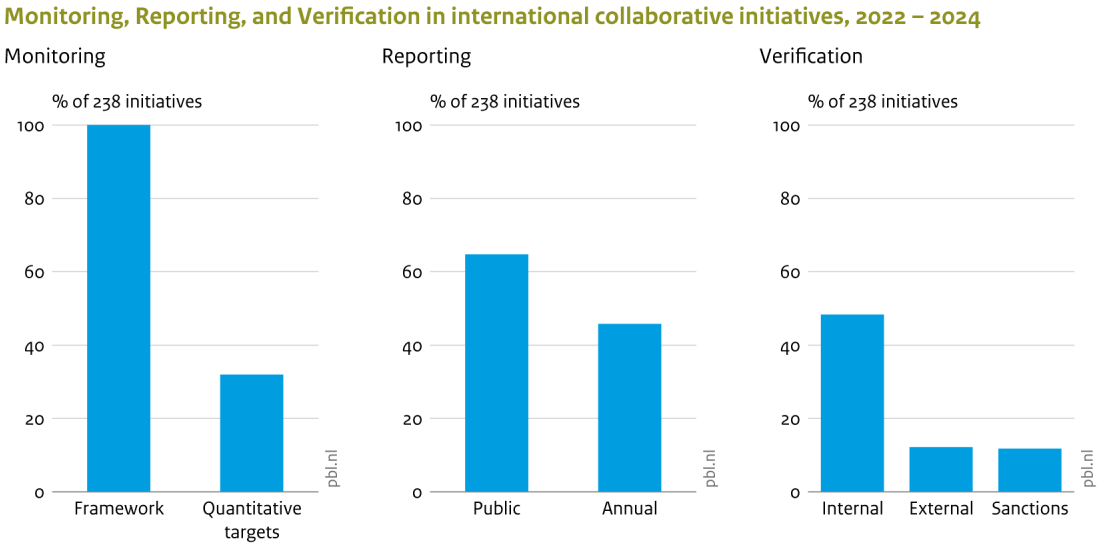
The GBF relies on both a whole-of-government and a whole-of-society approach to realise its goals and targets. This requires an improved and more holistic understanding between Parties and non-state actors of the challenges and progress made towards the goals of the GBF. Whole-of-society includes amongst other cities, regions, companies, investors, civil society organisations, local communities and religious groups. However, within the GBF section on responsibility and transparency, the reference to non-state actor contributions is very limited: 'Information on non-state actor commitments and contributions towards the GBF will be considered as part of planning, monitoring, reporting and review, as applicable' (GBF section J, article 16g). Such a formulation positions non-state actors outside the framework for responsibility and transparency, and leaves the question open which information may be considered as relevant. This is further reflected in the current negotiations of the review mechanism, in which non-state actors are invited to share their commitments to NBSAPs and their contributions to the realization of the GBF goals and targets through a standard template. This does not recognise the role as frontrunners that many non-state actors take that goes beyond the ambitions of many countries (and might not be reflected in the NBSAPs or national reporting) and the active role non-state actors take in monitoring and reporting their actions for biodiversity. Indeed, like for countries, a global reporting mechanism for non-state action is needed and, importantly, non-state actors could be given a much more active role in the global reporting as well as review process. Furthermore, it is necessary to create space for dialogue

[3] This section is an updated version of the conclusions of the PBL/IVM Policy brief "Accountability of commitments by non-state actors in the CBD post-2020 Global Biodiversity Framework", by O. Widerberg, M. Kok, K. Negacz, M. Petersson, & P. Patberg, PBL publication number 4440, The Hague: PBL Netherlands Environmental Assessment Agency, 2021. https://www.pbl.nl/uploads/default/downloads/pbl-2021-accountability-off-commitments-by-non-state-actors-in-the-cbd-4440.pdf

between Parties and non-state actors as part of the national and global review. This section, on the 'multi-actor approach', attempts to make suggestions how to do that.

The success of the whole-of-society approach not only rests on the critical mass of non-state actors actively taking action to contribute to restoring nature and support the GBF goals, but also on the credibility of their actions. Boosting the credibility of non-state action by enhancing responsibility, transparency, and accountability is therefore crucial to achieve the GBF goals (Chan et al. 2022; Landry et al. 2024; Widerberg et al. 2021). One of the challenges for a whole-of-society approach is the risk of green washing and allowing unwanted special-interest influence on the intergovernmental process. It will be necessary to align the accountability and transparency mechanism for state and non-state biodiversity action in the GBF's responsibility and transparency framework, to harness the potential and avoid the pitfalls of a whole-of-society approach and provide an incentive to non-state actors lagging behind to increase their efforts. In turn, credible action that delivers results can instil confidence and ownership amongst governments to take on bolder national goals, targets, and policies in their NBSAPs. It can also encourage mutual learning by bringing diverse perspectives and helping to build productive linkages between state and non-state actors, including developing approaches that help to create a level playing field, regulatory certainty, and policy frameworks that address actors that stay behind.

In an earlier analysis, we have shown that existing non-state monitoring and reporting systems of international collaborative initiatives for biodiversity provide a basis to contribute to the global reporting reviewing progress (Widerberg et al. 2021). Unfortunately, this hardly seems to be recognised in current negotiations. Figure 4.1 presents updated information and demonstrates that 238 out of 367 international initiatives already have a monitoring framework in place and 33% of them have quantitative targets, and that 65% of these also report on their activities. 48% of the initiatives have internal verification procedures in place and about a quarter of these also have established external verification procedures and sanctions. These are primarily standards such as ecolabels. Accordingly, existing international monitoring and reporting mechanisms demonstrate that there are large amounts of data already available in the public sphere on the biodiversity actions by non-state actors. The global analysis of non-state actor actions under the GBF would thus have an abundance of monitoring and reporting data to build on. Recording and reporting of non-state biodiversity action can build on the existing data providers to avoid duplication and streamline accountability mechanisms. A key challenge is to align the existing non-state reporting with the GBF on goals, targets, and indicators as well as with review mechanisms for state action. It would allow for a richer and more complete picture of what actions are taken to achieve the goals of the GBF. It could also point towards gaps in regional, thematic, and/or ecosystem coverage, which non-state actors that needs to be engaged, and where there is potential for more action.



Source: IVM/PBL BioSTAR 3 database, data collection 2022 – 2024

Figure 4.1 - Monitoring, reporting and verification mechanisms in international collaborative initiatives for biodiversity with monitoring framework in place (367 initiatives assessed, out of which 238 have a monitoring framework in place. BioSTAR 3, 08 October 2024).

An important next step for the non-state actor agenda for biodiversity, with the growing recognition that biodiversity loss and climate change are deeply intertwined, is to show and report how they commit and contribute to both nature positive outcomes and net-zero emissions at the same time. The institutional question that arises here is how the Action Agendas for biodiversity and climate change can be connected. From a CBD perspective, it is important to account for how non-state actions in other policy domains (also in, for example, restoration and the Sustainable Development Goals (SDGs)) are helping or hindering the achievement of the goals of the GBF and how non-state initiatives outside the CBD would harness their potential for the achievement of biodiversity goals. A point of attention for the analysis and to avoid greenwashing is preventing double counting between non-state commitments between conventions and between non-state actor and Party reporting. Joint membership of Action Agendas within CBD and UNFCCC could be encouraged and the CBD could benefit from advancements already made in the climate domain. This would be an important step in realising a ratcheting effect through Action Agendas (Bulkeley et al. 2023; McKenna & Ghosh 2022; Widerberg et al. 2021).

We can see at least four ways for complementing the responsibility and transparency mechanism of the GBF with an accountability mechanism for non-state actors.

a. Aligning national and non-state actor commitments:
    - Ensuring that non-state commitments are in line with the GBF, such as via a ‘science-based targets’ approach using a consistent set of indicators aligned with the GBF indicator framework that accounts for the various possible contributions by non-state actors;
    - Developing a close connection between stakeholders and relevant national agencies when developing NBSAPs to foster a whole-of-society approach and develop policy frameworks that provide ambition and regulatory certainty to drive more action by non-state actors, thereby realising a ratcheting effect; and,

- Building a robust, publicly available international platform or network of databases for recording non-state commitments and align databases for nature, climate, restoration, and the SDGs more broadly, and streamline ongoing efforts by, for example, IUCN, WCMC, and other academic groups in the field.

b. Aligning national reporting with that of non-state actor commitments:
   - Following a carefully crafted approach to avoid reporting fatigue and information overload, for instance, by following company reporting requirements set by law, such as the EU's reporting directive or voluntary reporting standards developed by GRI or CDP;
   - Developing national inventories of non-state biodiversity action that support domestic biodiversity goals and to showcase such action in National Reports. Such inventories could also feed the CBD Action Agenda for Nature and People and similar platforms related to the Sustainable Development Goals and the Global Climate Action Agenda. Moreover, in the CBD Reporting Tool, countries are asked to report on non-state action, but it remains an open question to what extent this will be used by Parties.

c. Aligning country-by-country review processes and review of non-state actor commitments:
   - Bringing non-state actors into the national and global review process could strengthen the whole-of-society approach, by sharing experiences and highlighting possible collaborations exploring thorny issues and transformative pathways;
   - Showcasing how non-state actors can provide governance functions such as new standards and commitments, knowledge gathering and sharing, and financing in order to achieve national and global biodiversity goals;
   - Inserting experiences on whole-of-society approaches in countries and international initiatives and including non-state actors into joint learning processes and technical dialogues in the Subsidiary Body on Implementation (SBI) or the open-ended forum for voluntary country review;
   - Identifying conflicts between biodiversity actions and other internationally agreed goals on climate change and the SDGs more broadly, hence ensuring alignment between non-state action in NBSAPs and NDCs.

d. Aligning non-state actions with the global analytical review processes:
   - Developing a collaborative 'data and analytics' community to collect, analyse, and publish all non-state biodiversity action to contribute to the global analysis and stocktake. Involving current data gatherers on biodiversity action by non-state actors could create a powerful way forward;
   - Inviting and engaging custodians of specific targets to contribute to the global analysis and stocktake of both state and non-state actor commitments and actions;
   - Developing a common reporting platform for non-state action amongst CBD, UNFCC, and UNCCD and a joint global progress review on nature and climate, building on existing Action Agendas in these conventions to ensure greater accountability of non-state actors commitments;
   - Ensuring aggregation of data for non-state biodiversity action by publishing periodic 'gap analysis' reports, estimating the gap between current biodiversity action and the GBF goals, similar to those carried out for climate change and the UNFCCC;

- Publishing an annual 'Yearbook of Biodiversity Action' that gathers, analyses, and presents the reported progress regarding the Action Agenda for Nature and People.

4.2 Multiple-evidence base approach

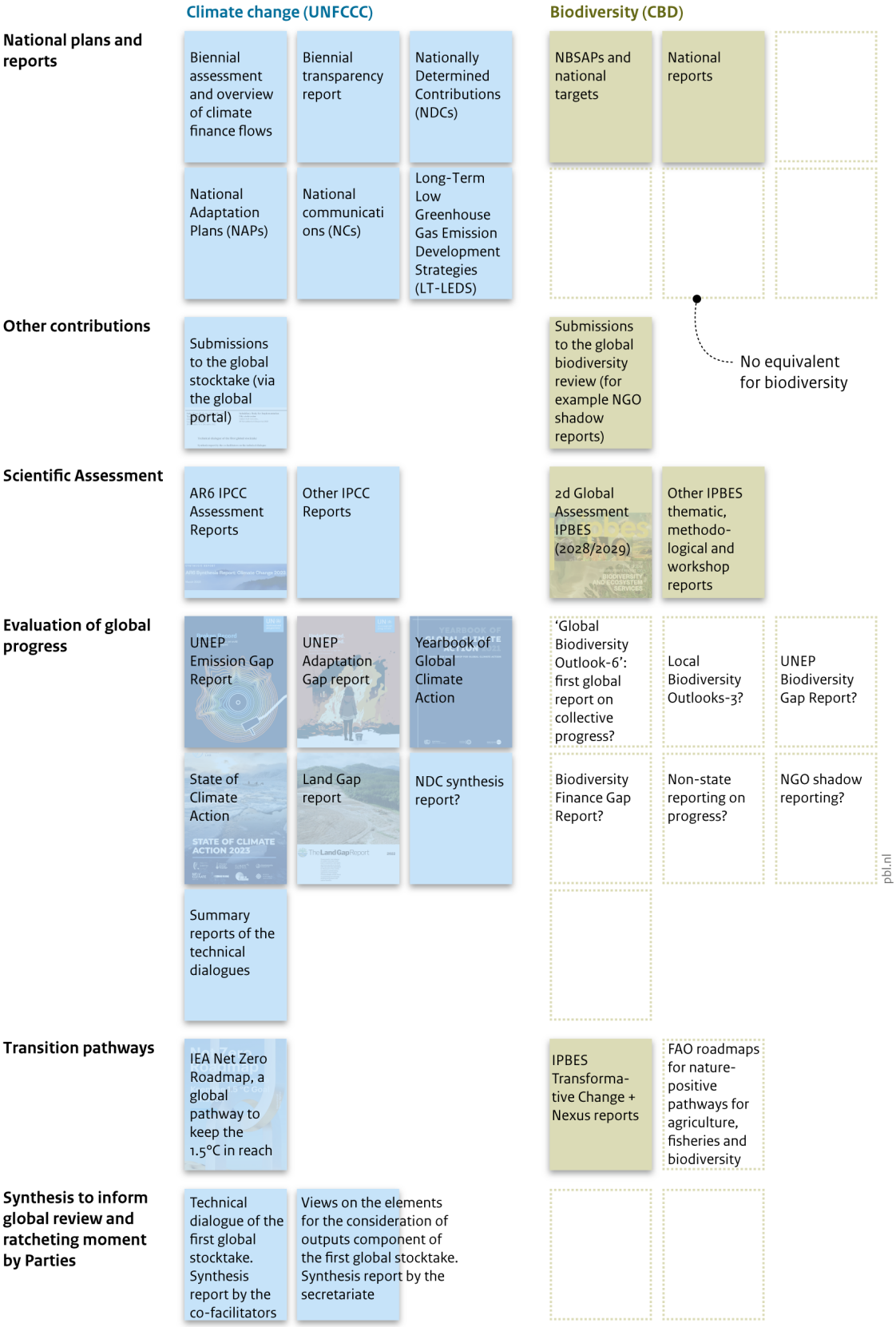
COP-16 will consider the different sources that could be used for the global review. Currently, only national reports and a global report on collective progress are not, which introduces the risk that too narrow a set of sources will be used for the review. In the previous section, we described how the multi-actor approach is about incorporating the contributions of multiple actors and including diverse perspectives, and we suggested ways to structure the review process and technical dialogues to enhance inclusivity, diversity, contestation, and collaboration. Such processes would be enhanced when supported by a diverse and rich knowledge base, for which we already gave some possible examples above. In the following section we aim to outline how different kinds of knowledge sources can support the global review.

We take inspiration from the multiple-evidence base approach introduced by Maria Tengö and her colleagues (2014) for enhanced ecosystem governance. The multiple-evidence base approach proposes the use of parallel knowledge systems where indigenous, local, stakeholder, and scientific knowledge systems are viewed to generate different manifestations of valid and useful knowledge across the globe. This inclusivity of knowledge systems also aligns with the whole-of-society approach advocated by the GBF, ensuring that diverse stakeholder perspectives are considered and that different stakeholders take their own responsibility in providing their analysis for consideration in the global review. Through complementarities, different knowledge systems can contribute to an enriched picture of collective progress towards the GBF goals. The analysis of such an enriched picture, including complementarities, synergies, and contradictions across diverse knowledge systems, can enhance the understanding of progress made or the lack thereof. The multiple-evidence base approach also highlights the importance of indigenous, stakeholder, and local knowledge systems on their own terms, where evaluation of knowledge as useful and relevant for the issue of investigation occurs primarily within rather than across knowledge systems. It also recognises the differences within types of scientific knowledge and forms of evidence, such as between disciplines of natural and social sciences, or qualitative and quantitative approaches. Brought together through a collaborative process, multiple evidence on global progress (including through, for example, technical dialogues or the open-ended forum for global review) will create an enriched picture of understanding in the knowledge base for the global review. Such an enriched picture has the potential to widen the scope, depth, and value of the assessment, and is equally a starting point for further knowledge generation, within or across knowledge systems through cross-fertilisation and co-production of knowledge. This knowledge base also becomes crucial for evaluating progress and identifying barriers, enablers, and challenges to address, such as entrenched practices or "lock-ins" that hinder progress in the implementation of the GBF for a variety of actors. The process may also enhance the robustness, legitimacy, and relevance of the assessment outcomes for a wide range of actors. Crucially, the purpose of the resulting knowledge base should not be to hide or erase existing differences between knowledge systems, but rather to make insightful their underlying plurality of perspectives on what the objectives of biodiversity governance should be and how to intervene in these (Pascual et al. 2021).

The question is what such a diverse knowledge base may look like in practice. In Figure 4.2 we present this through a comparison between the UNFCCC and CBD. First of all, we make a distinction

between different knowledge sources which we loosely link to different stages in the policy process. We start with *national plans and national reports*; Parties are bound to make an NBASP and NR and submit to CBD. But also other *contributions on country progress* could be made here, such as NGO-shadow reports that complement and reflect on the National Reports by Parties, requiring the CBD to also open up for such submissions. Significantly, the scientific basis will be provided by the *scientific assessments* of IPBES. It seems however not realistic to expect IPBES to provide the regular *evaluation of global progress* such as is foreseen in the planning of the CBD, nor that IPBES will provide a detailed policy evaluation of progress amongst countries or on progress on specific issues, as this is not in their mandate. Here the comparison with the UNFCCC is particularly relevant as IPCC Assessment reports are complemented with UNEP gap reports, that looks at the progress made by Parties and non-state actors towards the realisation of the goals of the Paris Agreement. Within the CBD, the Local Biodiversity Outlooks (2020) published by the Forest Peoples Programme with other indigenous and local groups provides a case in point of how an important stakeholder group presents their reports on their contributions to the goals of the CBD. This could be followed by other major non-state actor groups such as business, finance, cities, and regions. Similarly, one could think of NGO shadow reports on the global level. In view of identifying ways forward for realising the long-term goals, specific reports could be developed that outline a diversity of *transition pathways*. This could help identify ways forward that, in turn, could become part of the decision-making at ratcheting moments in the CBD-process, towards 2030 and beyond. Like IEA publishes pathways for net-zero in the energy-sector, FAO could publish transition pathways for nature-positive for agriculture, fisheries, and forestry. UNDP could do so for nature positive development and poverty reduction. Lastly, the results of the global analysis and review should be brought to the negotiations identifying major dilemmas and choices to be navigated. This way, a diverse knowledge base can inform tangible COP-decisions for further collective action. This requires a synthesis to inform the *global review and ratcheting moment* by Parties. The example of the UNFCCC, with reports by the co-facilitators of the global stocktake and the secretariat, show some possibilities for reporting that could be considered in the CBD context, as this is yet to be decided upon. Figure 4.2 also suggests that more efforts by both Parties and non-state actors will be needed to develop a multiple-evidence base approach further in the context of the global biodiversity review.

Comparison of knowledge base for climate change (UNFCCC) and biodiversity (CBD)



Source: PBL

Figure 4.2 - Comparison of knowledge base for climate change (UNFCCC) and biodiversity (CBD)

4.3 Conclusions

Ideally, the mechanisms for planning, monitoring, reporting, and reviewing in the CBD should form an ambition cycle that fosters learning and improves implementation to realise the goals and targets of the GBF towards 2030 and beyond. Parties should take the outcomes of the global reviews into account in the future revisions and implementation of their NBSAPs with a view to improving actions and efforts. Based on the outcomes of the global review, in case of ambition and implementation gaps, future COPs need to take decisions to step up efforts with a view of achieving the 2050 goals of the GBF. This is the so-called ratcheting effect of the transparency and accountability mechanism as agreed in the GBF.

A purpose-oriented approach ensures that the global review sends clear signals and recommendations to both parties and non-state actors about the necessary actions to achieve the changes needed (Landry et al. 2024). This is particularly important given the complexity of biodiversity governance, where the success of the GBF depends on a dynamic and adaptive process. By promoting an inclusive and forward-looking review, the process can act as a facilitating tool, encouraging actors to revise and enhance their contributions and commitments. It should be based on a multiple-evidence approach and identify concrete pathways for improvement, barriers, and opportunities and foster a culture of learning, adaptation, and increased ambition where necessary.

To achieve a ratcheting effect through the global analysis and global review process should not be an exercise for its own sake. Each review cycle should lead to greater ambition and more impactful actions. This means that the review process should not report on progress only, but also serve as a critical tool for course correction and scaling up efforts. With increasing attention to biodiversity and nature in the UNFCCC, the global analysis and review may benefit from broadening its scope to include nature relevant policies and measures within the UNFCCC, such as in the 'race to zero' and the 'race to resilience' spearheaded by the UNFCCC climate champions.[4] By focusing on outcomes that matter, the review can support Parties but also non-state actors in adjusting their strategies and actions to meet the GBF 2050 goals.

[4] https://climatechampions.unfccc.int/un-climate-change-high-level-champions/.

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Appendix 1: Overview of the IMAGE-GLOBIO modelling framework

Introduction

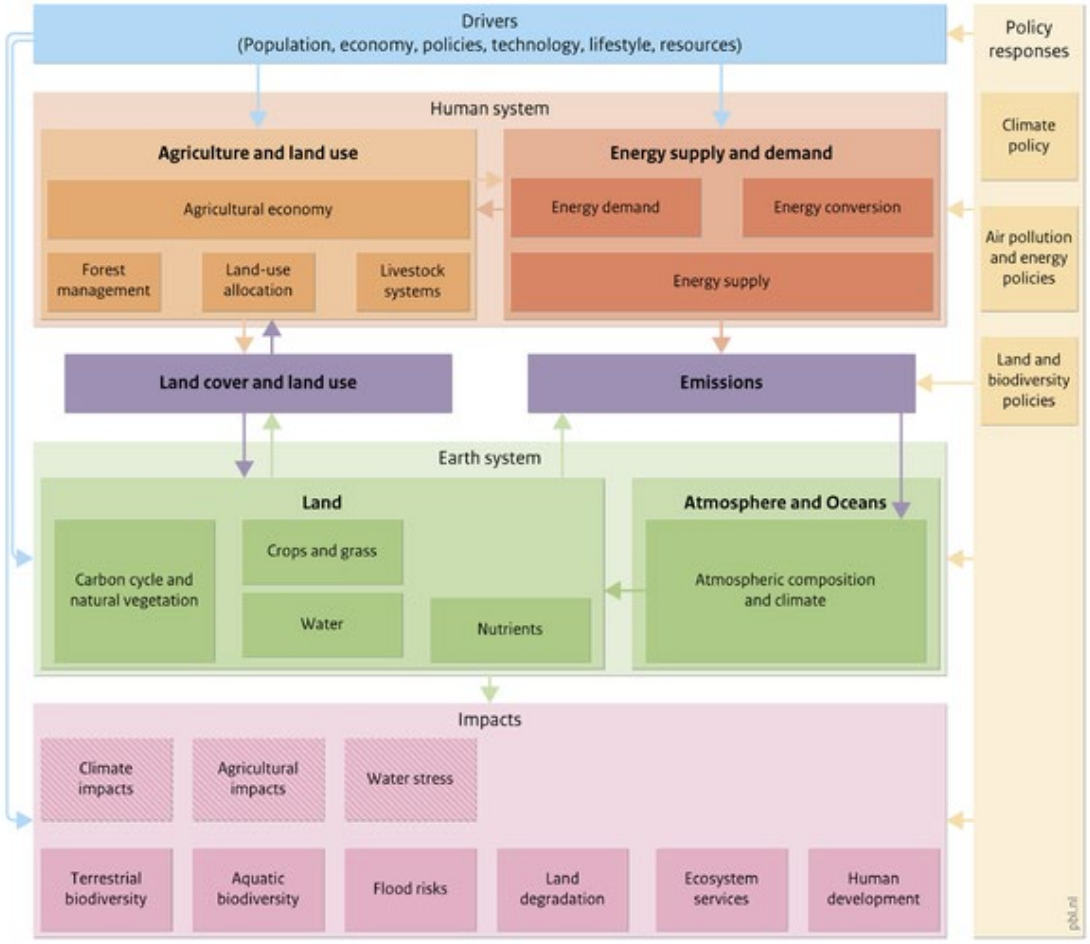
In this study we applied the IMAGE-GLOBIO modelling framework to evaluate the four scenarios in terms of different biodiversity indicators, ecosystem services, climate change mitigation, and food production. In this appendix we provide an overview of the framework, including the main inputs required to run the models and the outputs used in this study.

The IMAGE framework

IMAGE 3.4 is an integrated assessment modelling framework that simulates the interactions between human activities and the environment to explore long-term global environmental change and policy options in the areas of climate, land, and sustainable development. Here, we present a summary documentation of the modelling framework. More detailed information, including input-output tables of and flow diagrams of all sub-modules, can be obtained from the online model description (models.pbl.nl/image).

The IMAGE framework is structured according to the causal chain of key global sustainability issues (see Figure A.1). IMAGE comprises two main systems: The Human or socio-economic system describes the long-term development of human activities relevant for sustainable development. The Earth system describes changes in the natural environment. The two systems are linked by the impacts of human activities on the Earth system, and by the impacts of environmental change in the Earth system on the Human system.

IMAGE consists of various sub-models describing land use, agricultural economy, the energy system, natural vegetation, hydrology, and the climate system. Socioeconomic processes are modelled at the level of 26 regions. Most environmental processes are modelled on the grid-level at 30 or 5 arc-minutes resolution. Agriculture, forestry, and land-use dynamics are modelled on the IMAGE-LandManagement model's grid-level (Doelman et al. 2018). Food consumption, demand for crop and livestock products, trends in agricultural intensification, and trade dynamics are represented by the economic general equilibrium model MAGNET (Woltjer et al. 2014). Gridded land-use dynamics are implemented in the dynamic global vegetation model LPJmL to model effects on the carbon and hydrological cycle (Müller et al. 2016; Schaphoff et al. 2018) and to the global nutrient model (GNM) to model the nitrogen and phosphorus cycles (Beusen et al. 2015). LPJmL provides data on potential crop and grass yields, land-use change emissions, and irrigation water use while considering the impact of climate change. Adaptation to climate change in the food system is included by informing MAGNET about the regional impact of climate change leading to changes in agricultural production and trade flows. The simulation model TIMER represents the energy system with high technological detail for 12 primary energy carriers, including bioenergy. Land use for the production of bioenergy as determined by TIMER is implemented on the grid-level in IMAGE-LandManagement. GHG emissions from energy, industry, and land use are inputs to the simple climate model MAGICC, which emulates complex climate models to calculate global mean temperature change (Meinshausen et al. 2011). The climate policy model FAIR-SimCAP uses MAC curves to determine cost-optimal emission pathways to achieve specific climate targets (den Elzen et al. 2008).



Source: PBL 2014

Figure A.1 - An overview of the IMAGE framework and its components

Land and biodiversity policies

Policies to achieve more sustainable land use and to protect biodiversity can be introduced in the various IMAGE components. Interventions can address the demand system (dietary shifts, reduced waste, constraints on bio-energy demand), the agricultural and the forest production system (management, efficiencies) and the land-use system (restriction on certain land use types, REDD, nature conservation). As a linked system, IMAGE can assess the system-wide consequences of measures introduced, including trade-offs and feedbacks (Doelman et al. 2022). For example, restrictions on land use through more nature conservation might lead to less biodiversity loss, but also to higher land and food prices, and affect consumption and food security. On the other hand, demand reducing measures tend to lower land and food prices, and loose some of the potential benefits through extensification. Taken simultaneously, measures on land use (which increase prices), and demand production systems (which lower prices) avoid leakages and risks in food security (Stehfest et al. 2019). In this study, policy measures are implemented on demand, production and land-use regulation. These measures affect the entire coupled modelling system, from land use patterns, emissions and nutrient cycles to biodiversity and hunger. Specific effect on biodiversity and ecosystem services are addressed by the GLOBIO model as described in the next section.

The GLOBIO modelling framework

GLOBIO is a modelling framework designed to assess the impacts of human activities on biodiversity and ecosystem services. It uses inputs on the magnitude of human pressures across the globe to quantify multiple indicators of biodiversity and ecosystem services. In this study, two of the five modules of the GLOBIO modelling framework were used, GLOBIO and GLOBIO-Species. The framework also includes a land-use allocation tool to downscale coarse-grain land-use projections to a higher spatial resolution (10 arc-seconds), in order to better capture fine-grain spatial heterogeneity relevant to biodiversity (for details on the land allocation tool (see Schipper et al. 2020). More information on the model can be found on the model website (https://www.globio.info/).

GLOBIO

The GLOBIO model quantifies local terrestrial biodiversity intactness, expressed as the Mean Species Abundance (MSA) indicator (Alkemade et al. 2009; Schipper et al. 2020), as a function of climate change, atmospheric nitrogen deposition, land use, roads, and hunting (tropical regions) (Figure A.2). The impact of habitat fragmentation, as a result of both land use and roads, is also included. Changes in MSA are quantified with pressure-impact relationships established through meta-analytical approaches based on empirical data (e.g., Benítez-López et al. 2017; Midolo et al. 2019), in combination with data on pressure levels. The impact of the different pressures on MSA is quantified for plants and vertebrates separately, and then combined into one overall MSA value per grid cell (10 arc-seconds; Schipper et al. 2020). In this study, we applied version 4 of the GLOBIO model as described in Schipper et al. (2020). We obtained pressure data on climate change (in terms of global mean temperature increase, in °C), atmospheric nitrogen deposition ((kg ha^{-1} $year^{-1}$; 0.5° resolution), and land use from IMAGE (Figure A.1). Global road data are from the GRIP database (Meijer et al. 2018). To quantify hunting pressure in tropical regions, the distance to settlements is required. Following Schipper et al. (2020), we obtained locations of settlements from OpenStreetMap (http://download.geofabrik.de), the Humanitarian Data Exchange (www.data.humdata.org), and national databases.

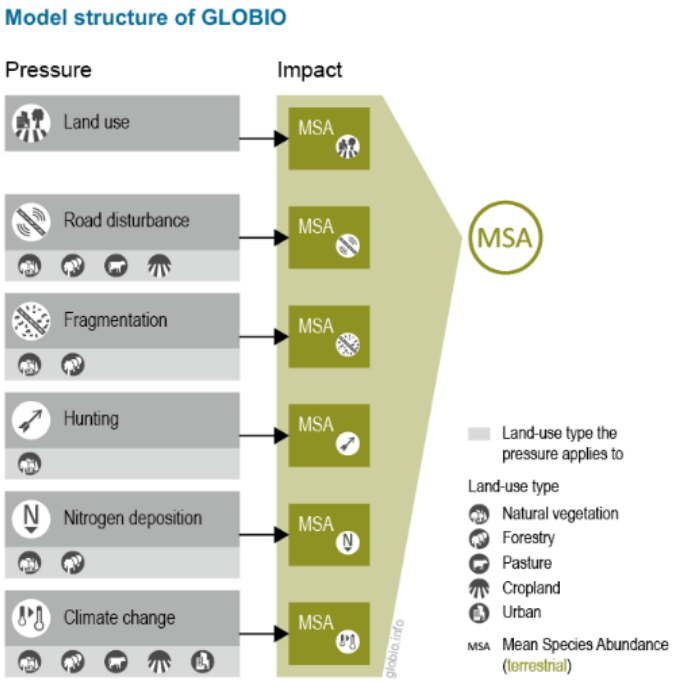


Figure A.2 – Model structure of GLOBIO (from www.globio.info).

GLOBIO-Species

GLOBIO-Species calculates the impacts of various pressures on the distribution and abundance of individual vertebrate species (Figure A.3), building upon the InSiGHTS model (Visconti et al. 2016; Baisero et al. 2020) and the approaches described by Santini et al. (2019) and Gallego-Zamorano et al. (2020). This allows for calculating multi-species indicators based on species distribution and abundance, notably the Red List Index (RLI) and the Living Planet Index (LPI). Details on how we applied GLOBIO-Species for the present study are provided in Kok et al. (2023).

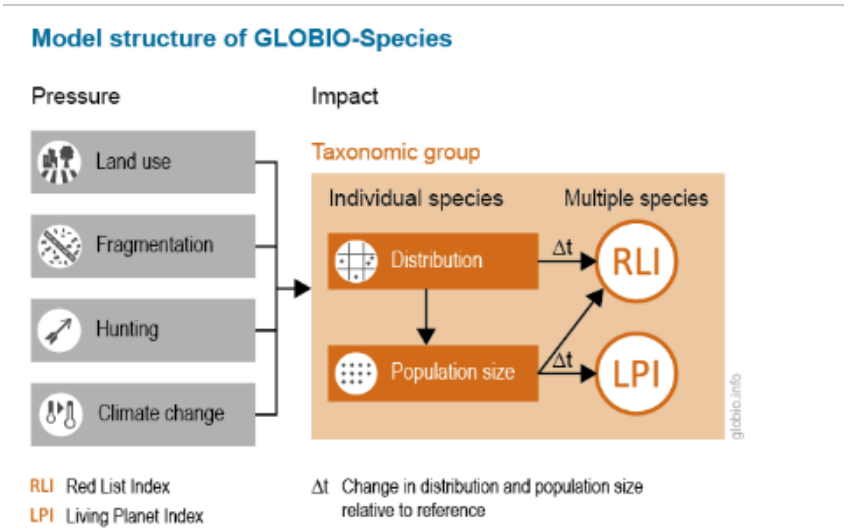


Figure A.3 – Model structure of GLOBIO-Species (from www.globio.info).

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