

Knowledge for ambitious, integrated, value-explicit and just collective actions towards global biodiversity targets

Authors

Larissa Nowak^a, David Leclère^b, Thomas Schinko^c, Christopher Wong^c, Elliott Woodhouse^c, Zuelclady M. F. Araujo-Guiterrez^b, Daniel Braun^d, Nicklas Forsell^{e,f,g}, Samantha Hill^h, Mark A. J. Huijbregtsⁱ, Sarah K. Jonesⁱ, Marcel T. J. Kok^k, Koen Kuipersⁱ, Juliette Landry^l, Alexandra Marques^k, David Obura^m, Francesca Veronesⁿ, Thomas Kastner^a

Affiliations

^a Senckenberg Biodiversity and Climate Research Centre, Senckenberg – Leibniz Institution for Biodiversity and Earth System Research, Frankfurt am Main, Germany

^b Integrated Biosphere Futures Research Group, Biodiversity and Natural Resources Program, International Institute for Applied Systems Analysis, Laxenburg, Austria

^c Equity and Justice Research Group, Population and Just Societies Program, International Institute for Applied Systems Analysis, Laxenburg, Austria

^d Braun, Daniel, Center for Development Research, University of Bonn, Bonn, Germany

^e Moon Soul Graduate School of Future Strategy, Korea Advanced Institute of Science and Technology (KAIST), 34141, Daejeon, Republic of Korea

^f KAIST Institute for Climate-Environment-Energy (KICEE), 34141, Daejeon, Republic of Korea

^g MetaEarth Research Center, Korea Advanced Institute of Science and Technology (KAIST), 34141, Daejeon, Republic of Korea

^h UN Environment, World Conservation Monitoring Centre (UNEP-WCMC), Cambridge, UK

ⁱ Radboud Institute for Biological and Environmental Sciences, Radboud University, Nijmegen, The Netherlands

^j Bioversity International, Parc Scientifique Agropolis II, Montpellier, France

^k PBL Netherlands Environmental Assessment Agency, The Hague, The Netherlands

^l Institut du développement durable et des relations internationales, Paris, France

^m CORDIO East Africa, Mombasa, Kenya

ⁿ Industrial Ecology Programme, Department of Energy and Process Engineering, Norwegian University of Science and Technology, Trondheim, Norway

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Abstract

Parties to the Convention on Biological Diversity (CBD) agreed upon goals and targets for biodiversity in the Kunming-Montreal Global Biodiversity Framework (GBF). The success of the GBF depends on the collective actions of the Parties, i.e. member states, to the CBD. Essential challenges in this context include ensuring that efforts across Parties are sufficient to collectively meet global ambitions, are integrated across biodiversity and other sustainability dimensions, and are just and value-explicit. In this perspective, we lay out how scenario- and model-based research can support this process. We describe how designing scenario narratives and quantifying different aspects of these narratives, specifically, target downscaling and narrative-specific modelling, combined with evaluating planned and implemented actions towards the GBF, can create locally relevant knowledge to help address these challenges and support a successful GBF. We highlight the importance of co-producing such knowledge and identify potential entry points for disseminating the outcomes at the science-policy interface, informing relevant national and global biodiversity governance.

Keywords

Biodiversity, equity, justice, nature values, scenarios, narratives, models

1. Introduction

Anthropogenic pressures drive unprecedented declines in global biodiversity and undermine the provision of nature's contributions to people (NCP; IPBES, 2019). In response, Parties to the Convention on Biological Diversity (CBD) adopted the Kunming-Montreal Global Biodiversity Framework (GBF), committing to halt and reverse biodiversity loss and realise a vision of "living in harmony with nature" by 2050 (CBD, 2022a). Achieving this vision, however, requires concerted, transformative actions with potentially far-reaching consequences across societies (Bennett et al., 2019; IPBES, 2024b).

Implementing the GBF requires CBD Parties to translate global targets and goals into national targets and goals, and to update their national biodiversity strategies and action plans (NBSAP), a process embedded within a multidimensional approach to planning,

monitoring, reporting, and review (see Box 1; CBD, 2022c). For a successful GBF, CBD Parties face the challenge of ensuring that collective actions are sufficiently ambitious, integrated across sustainability dimensions, and consider diverse nature value and justice perspectives. Without successfully addressing these challenges, national actions for the GBF risk falling short of global-level ambitions, generating unnecessary trade-offs between sustainability outcome goals and GBF action targets due to a lack of policy coherence, and stalling over conflicting views about what is fair and sustainable (Bell-James & Watson, 2025; IPBES, 2024b; Marques et al., 2014; Weitz et al., 2018).

Scenarios and models can support biodiversity governance processes and identify pathways towards transformative change for biodiversity and the broader sustainability agenda (IPBES, 2016; L. M. Pereira et al., 2020). Scenario narratives can describe (future) policy interventions and related changes in the direct and indirect drivers of biodiversity change, while models can translate these narratives into quantified environmental pressures, biodiversity and NCP outcomes (IPBES, 2016). However, existing scenario and modelling applications for biodiversity governance fail to integrate ambition, integration across sustainability objectives, plural values and justice within one analytical framework. We propose new research avenues to mobilise and advance scenario and model applications to address these challenges (Figure 1).

Box 1: Global and national processes related to the Kunming-Montreal Global Biodiversity Framework (GBF)

A multidimensional approach to planning, monitoring, reporting, and review has been adopted as part of the GBF at the fifteenth meeting of the Conference of the Parties to the CBD (CBD-COP15; CBD, 2022c) and detailed at CBD-COP16. This approach defines the main mechanisms to strengthen transparency and accountability: (i) Parties to the CBD must revise or update their National Biodiversity Strategies and Action Plans (NBSAP) in alignment with the GBF and submit national targets in a standardised format via an online reporting tool (CBD, 2022a, 2022c; <https://ort.cbd.int/>). The national targets must contribute towards each global goal and target of the GBF, while considering the respective country's resource availability and means of implementation. This step was originally due by CBD-COP 16 in October 2024, but as of March 2026, 115 of 196 CBD Parties have reported national targets for every global GBF target. (ii) A monitoring framework (CBD, 2022b) provides a set of agreed-upon indicators to track progress towards the GBF, including headline and binary indicators for planning and monitoring at national, regional, and global levels, as well as optional component and complementary indicators, which can support more in-depth analyses. (iii) Parties to the CBD must submit national reports on the progress towards implementing their NBSAPs and national targets by the end of February 2026 (7th national report) and June 2029 (8th national report). In these reports, parties are required to provide data on headline and binary indicators defined in the monitoring framework, and may optionally report on complementary and component indicators (CBD, 2022b). (iv) A global analysis ('stocktake') of the NBSAPs and national targets to assess Parties' collective planned ambitions towards the GBF will be put forward at each CBD-COP until CBD-COP19. Based on national reports and other sources of information, the CBD will perform global reviews of the collective progress towards implementing the GBF at CBD-COP17 and CBD-COP19 (CBD, 2022a, 2022c). The global report and review are envisioned to inform revisions and the implementation of the parties' NBSAPs and national targets, and to initiate a stepping up of efforts. Such an ambition cycle will be essential to the success of the GBF (CBD, 2022c; Landry, Deprez, et al., 2024; Landry, Kok, et al., 2024). (v) Additionally, there will be the option for voluntary country-by-country peer reviews of NBSAPs, and (vi) the option of reporting by non-state actors on their commitments. The provisioning of implementation support mechanisms, as well as the need for enabling conditions (including finance, knowledge, technology transfer, and capacity sharing), has been formulated in the GBF.

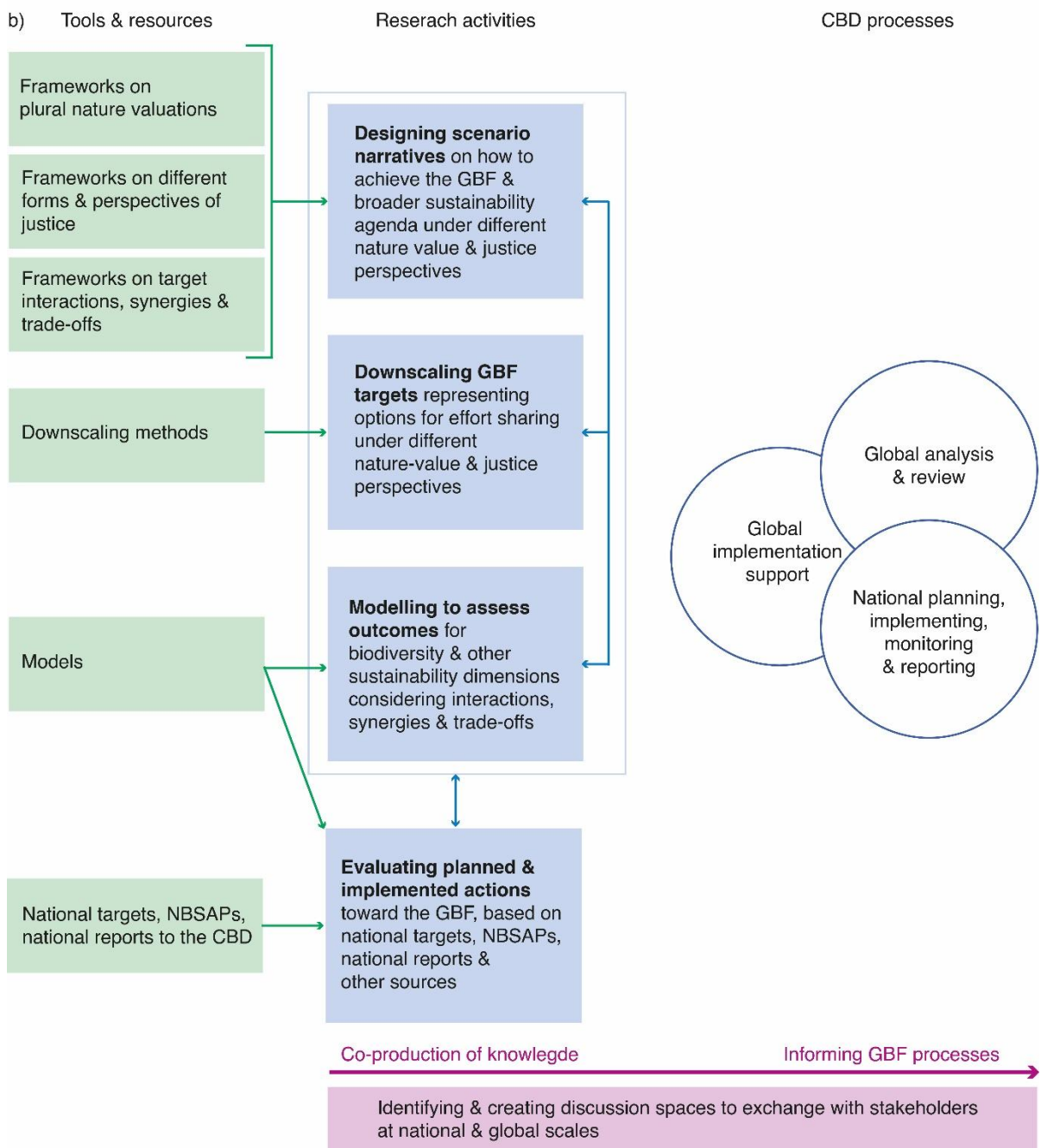
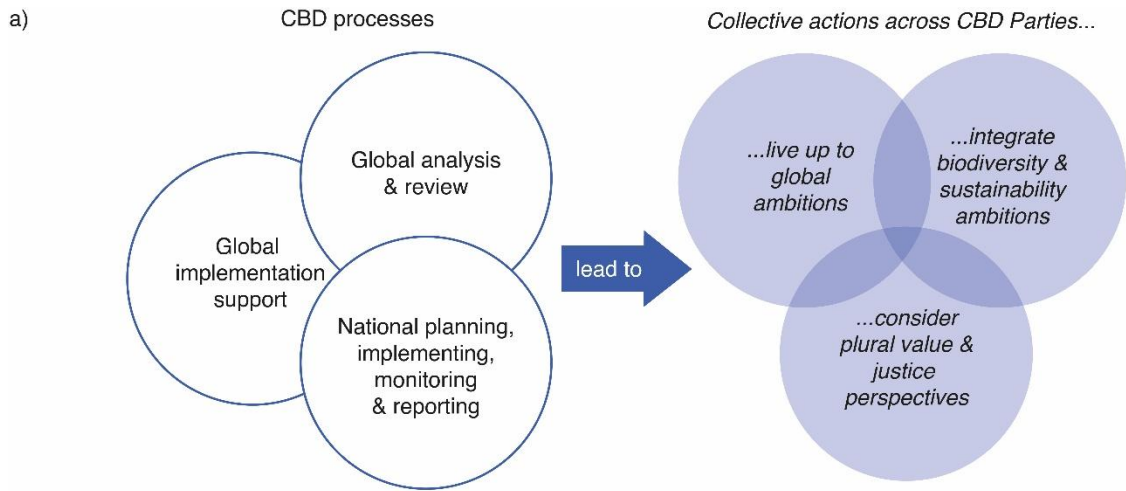


Figure 1: a) For a successful implementation of the Kunming-Montreal Global Biodiversity Framework (GBF), the national- and global-level CBD (Convention on Biological Diversity) processes (detailed in Box 1) should ideally yield collective actions across CBD Parties that live up to global ambitions, integrate across biodiversity and other sustainability ambitions, and consider plural nature value and justice perspectives. b) We propose to integrate and advance scenario- and model-based research activities to create knowledge in support of these challenges: designing scenario narratives, downscaling global biodiversity targets, modelling scenario narratives, and evaluating planned and implemented actions towards the GBF. To operationalise these research activities, different tools and resources need to be mobilised and further developed, including frameworks that help conceptualise plural nature value perspectives, different forms and perspectives of justice, and target interactions, as well as quantitative downscaling methods and models. Co-production with stakeholders from policy and society will be critical and warrants the identification and creation of discussion spaces for such exchanges. Ultimately, the outcomes of this research are meant to inform CBD processes in support of implementing the GBF, but such research will also be important beyond 2030 and for other multilateral environmental agreements. The research activities (blue boxes) are presented in greater detail in sections 3.1 to 3.4 of this perspective.

2. Towards ambitious, integrated, value-explicit and just biodiversity actions

2.1. Challenges for successfully implementing global biodiversity targets

No Aichi target, preceding the GBF, was fully achieved (Secretariat of the Convention on Biological Diversity, 2020; Xu et al., 2021). To address global biodiversity loss, it is critical that the GBF succeeds. A crucial factor for success is ensuring that national targets set by the CBD Parties are collectively sufficiently ambitious to meet the scope and level of global ambitions, while also ensuring that these ambitions translate into tangible implementation efforts (Maney et al., 2024; Reed et al., 2025; Xu et al., 2021). The multidimensional approach to planning, monitoring, reporting, and review adopted under the GBF is intended to ensure this. Yet, initial evaluations of the few updated NBSAPs submitted before CBD-COP16 indicated that planned national actions may again be insufficient to meet global ambitions (Bell-James & Watson, 2025; Reed et al., 2025).

Successful implementation of the GBF requires integrated actions that account for interactions among ambitions for biodiversity and other sustainability objectives. This entails assessing how progress towards one GBF target influences progress towards another, and

how achieving these targets will jointly contribute to the envisioned biodiversity outcomes as stated in the GBF goals (Kok et al., 2024; Leadley et al., 2022; Marques et al., 2014). In addition to considering interactions among the GBF ambitions, it is crucial to account for potential synergies and trade-offs with other sustainability objectives and actions towards them, including the Sustainable Development Goals (SDGs) and the Paris Agreement (UNFCCC, 2015; United Nations General Assembly, 2015). Synergies may, for example, be created by jointly planning measures to conserve biodiversity and mitigate climate change (Jung et al., 2021; Pörtner et al., 2023), while trade-offs can arise when climate mitigation strategies fail to account for biodiversity impacts (e.g., Hof et al., 2018) or when different land uses, such as food production for adequate nutrition and area-based conservation, compete (Arneth et al., 2023; Pörtner et al., 2023). Identifying synergies and trade-offs within a given context enables their strategic harnessing or mitigation, whereas overlooking them can result in inefficient resource use or unintended negative consequences (Gupta & Singh, 2024; Phang et al., 2020; Weitz et al., 2018). Accordingly, the CBD recommends that Parties identify and utilise potential synergies and address potential trade-offs between NBSAPs and other biodiversity-related conventions, multilateral environmental agreements, and the SDGs (CBD, 2022a, 2022c). Such an integrated approach also addresses the challenge of biodiversity mainstreaming across policy domains (Kok et al., 2024).

The plural ways people value nature is another critical aspect in designing and successfully implementing actions towards the GBF (IPBES, 2022; L. M. Pereira et al., 2020; Perino et al., 2022). Accounting for nature values is critical because achieving biodiversity targets requires behaviour change (at the organisational and individual level), which can be influenced by how nature is valued (Perino et al., 2022). Importantly, people's relationships with nature are diverse, and some perspectives, particularly those of indigenous peoples and local communities, are frequently overlooked in political and economic decisions (IPBES, 2022). Yet, evidence suggests that engaging with, especially local, values of nature in decision-making can lead to more just and sustainable outcomes, for example, related to protected areas (Pascual et al., 2023). Moreover, recognising diverse nature values, incorporating them into decision-making, reforming policies, rights, and regulation so that institutions embrace plural nature values, and shifting societal norms towards sustainability-aligned values have all been identified as crucial leverage points for achieving transformative change for a more just and sustainable future (Pascual et al., 2023). The critical role of plural nature values is recognised by the CBD, which commits to fully integrating "biodiversity and its multiple values" into policy instruments (GBF target 14; CBD, 2022a).

Considering diverse perceptions of justice is equally essential for successfully designing and implementing actions towards the GBF (IPBES, 2024b; Obura et al., 2023). The concept of justice has been described as “the constant and perpetual will to render to each [their] due” (Hanger-Kopp et al., 2024; Miller, 2021). Justice is context-dependent and multidimensional and encompasses interrelated questions such as how benefits and burdens should be distributed (distributional justice), who should participate in decision-making (procedural justice), and whose perspectives and knowledge should be recognised (recognition justice) (Hanger-Kopp et al., 2024; Lenzi et al., 2023; Schlosberg, 2004; Sze & London, 2008). Importantly, there can be different perceptions of what constitutes justice (Hanger-Kopp et al., 2024; Zimm et al., 2024). It is crucial to recognise this plurality of justice perceptions and be explicit about their implications for actions towards the GBF (Dooley et al., 2021). Accounting for justice when designing and implementing actions for biodiversity is critical for several reasons. First, the necessary transformative change with its expected far-reaching consequences raises questions of justice, including but not restricted to who should bear the burden of this transition (Armstrong, 2024; Lehmann et al., 2025). Moreover, ignoring justice when designing and implementing biodiversity actions risks overlooking potential justice implications and perpetuating injustices tied to historic conservation policies (Woodhouse et al., 2025). Justice is also an important leverage point for environmental policies (IPBES, 2022, 2024a). Whether a policy is considered fair can influence its acceptability, and if perceptions of justice are not accounted for, they may become barriers to enacting transformative change (Feola et al., 2019; Martin et al., 2020; Muradian & Pascual, 2018; Thaller et al., 2023).

2.2. Gaps in scenario- and model-based research

Scenarios and models are widely applied to assess potential futures of biodiversity and the environment, and can guide environmental and biodiversity policy and governance (IPBES, models and scenarios). The Shared Socioeconomic Pathways (SSP)-Representative Concentration Pathways (RCP) scenario framework, combining socioeconomic development pathways with radiative forcing trajectories, has generated a substantial body of research on future climate change and informed assessment reports of the Intergovernmental Panel on Climate Change (IPCC; IPCC, 2023; Riahi et al., 2017; Van Vuuren et al., 2011). Building on this climate-focused work, the SSP-RCP scenario framework has been applied to project future trajectories of biodiversity and NCP (e.g., Chaplin-Kramer et al., 2019; Leclère et al., 2020; H. M. Pereira et al., 2024) and featured in assessment reports of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES; e.g., IPBES, 2019). Complementing these approaches, the Nature Futures Framework

(NFF) was developed to enable the integration of plural values of nature into scenario and modelling applications and support the co-design of positive visions for people and nature (L. M. Pereira et al., 2020). The NFF has since been applied across different regions and scales, including to relate existing scenarios, such as the SSPs, to nature-value perspectives and to develop new visions and scenarios of nature-positive futures (Okayasu et al., 2025).

Despite these crucial developments, alternative, nature-value-explicit scenarios for implementing the GBF are only beginning to be developed (e.g., Burns et al., 2025), and these endeavours have not yet been placed into the context of the wider sustainability agenda. Moreover, considerations of justice are, to date, rarely featured in such analyses (Woodhouse et al., 2025). Recent efforts, for example, the concept of safe and just Earth system boundaries or justice considerations in land-use scenarios, represent important progress but often rely on single justice perspectives rather than systematically exploring plural justice perspectives and their implications (e.g., Rockström et al., 2023; Venier-Cambron et al., 2024). For instance, Venier-Cambron et al. (2024) quantify a “just conservation” scenario in which regional biodiversity intactness and food sovereignty are promoted, but do not explore other perspectives on what just conservation might entail. Approaches that systematically examine alternative perceptions of distributional justice in the allocation of remaining carbon budgets compatible with global climate targets are more common (Dooley et al., 2021). Yet, similar approaches have rarely been applied to other biodiversity-relevant pressures (Lucas et al., 2020), and are broadly lacking for the 23 action targets of the GBF. Furthermore, diverse perspectives on additional important dimensions of justice, such as procedural and recognition justice, and their implications for biodiversity governance, are not yet assessed systematically. Lastly, while recent synthesis efforts (e.g., IPBES, 2024a) are an important resource for CBD Parties to put forward integrated action plans, interactions across GBF targets are complex (e.g., Leadley et al., 2022) and vary across contexts (e.g., Jaureguiberry et al., 2022), and the GBF targets themselves only partially address important interactions with other sustainability objectives (e.g., Arneth et al., 2020). Scenario and model applications could be particularly instrumental at identifying what integrated actions might look like at global (e.g., Kok et al., 2024) to national scales (Mosnier, Javalera-Rincon, et al., 2023).

3. Advancing scenario- and model-based research to support biodiversity actions

Here, we discuss how scenario- and model-based research activities can be integrated and advanced to create knowledge in support of the challenges related to designing and implementing successful biodiversity actions (Figure 1). Specifically, we propose to generate

novel scenario narratives focused on the GBF implementation at national to global scales, with an emphasis on systematically integrating multiple nature-value and justice perspectives, and engaging the broader sustainability transformation agenda. These scenario narratives can provide the foundation for new quantitative analyses, including target downscaling and modelling, that require methodological innovations. Together, these research activities aim to fill key knowledge gaps related to ambition, integration, nature values, and justice in GBF implementation.

3.1. Designing scenario narratives

To identify plausible pathways towards achieving the GBF in concert with other sustainability objectives, a valuable research activity will be designing alternative scenario narratives that explicitly reflect different nature-value and justice perspectives, and identify potential interactions, synergies, and trade-offs among these ambitions. Designing such scenario narratives requires better integrating topics that, to date, often remain siloed: diverse nature value perspectives, diverse justice perceptions, and relationships among GBF targets and goals and other sustainability objectives. Such an integration can build on and further develop existing theories and conceptual frameworks.

Designing scenario narratives that align with specific nature value perspectives can build on the NFF. The NFF distinguishes three key value perspectives for nature (instrumental, i.e., valuing nature for the benefits that can be derived from it; relational, i.e., valuing the reciprocal relationship people can have with nature; intrinsic, i.e., valuing nature for its own sake) and allows a mix of those perspectives, offering the possibility to envision a plurality of desirable positive nature futures (Paz Durán et al., 2023; L. M. Pereira et al., 2020). When designing scenario narratives for the GBF, the NFF can support a systematic exploration of how GBF goals and targets would be interpreted and which policy measures would be preferred for achieving them under different nature value perspectives (e.g., Burns et al., 2025; Woodhouse et al., 2025).

A rich literature on environmental justice (e.g., Figueroa & Mills, 2001; Schlosberg, 2004; Sze & London, 2008) can serve as starting point for justice considerations in scenario narratives for the GBF. When designing these narratives, it will be crucial to consider different dimensions of justice and explore alternative justice perceptions to understand their policy implications. The AJUST Framework is an example of a conceptual framework that supports a systematic and transparent representation of plural justice perceptions in scenarios (Hanger-Kopp et al., 2024). This framework outlines different justice dimensions

(distributional, procedural, recognitional, corrective, and transitional) and how they can be systematically considered in research and policy. Such a framework can help to align scenario narratives with specific conceptions of different justice dimensions, make these justice perceptions transparent in the narratives, and identify which policy options towards achieving the GBF would be preferred under these perceptions (e.g., Woodhouse et al., 2025).

To be integrated, scenario narratives for the GBF should proactively identify potentially relevant, context-specific interactions, synergies, and trade-offs between the GBF targets and goals, but also with goals and actions related to a broader range of sustainability objectives, including climate change, pollution, and socioeconomic aspects, such as reducing inequalities, strengthening human rights, combating hunger and poverty. Multiple framings, including the Doughnut economics (Raworth, 2018), the safe and just Earth system boundaries (Rockström et al., 2023), the Sustainable Development Pathways (Soergel et al., 2024; Van Vuuren et al., 2022), and considerations on nature- and people-positive futures (Obura et al., 2023), can serve as a basis for reflections on how to integrate across environmental and social sustainability dimensions. Moreover, frameworks designed to systematically identify and analyse target interactions, such as those in Marques et al. (2014) for the Aichi targets and in Weitz et al. (2018) for the SDGs, can support the context-specific identification of potential interactions, synergies, and trade-offs and their formal integration into scenario narratives for the GBF.

Co-production of scenario narratives between academics and non-academic stakeholders will be important to capture a broad, representative range of nature value and justice perspectives, facilitate mutual learning, and ensure the narratives' relevance for policy and biodiversity governance. These scenario narratives should capture different scales (IPBES, 2016): while scenarios at national or subnational scales can explore options for national and subnational planning and implementation towards the GBF, global-scale scenarios can help understand how national contributions may add up and interact globally (Rosa et al., 2017). Moreover, sectoral or actor-oriented scenarios, e.g., focusing on the agricultural, forestry, or financial sectors, cities, or businesses, can help explore more specific policy options. Such scenario narratives can build the qualitative baseline for quantitative analyses, specifically target downscaling and modelling.

3.2. Downscaling global biodiversity targets

The GBF is a bottom-up global framework, implemented sovereignly by the CBD Parties at the national level, with support from contributions from non-state actors. Deliberation among Parties about fair effort distribution might benefit from information on multiple alternative benchmarks for national-level actions on specific GBF targets. These alternative benchmarks should illustrate national-level actions that are sufficiently ambitious to add up to the global target ambition, while reflecting contrasting principles for how Parties may share burdens. Negotiating explicit rules for effort-sharing remains politically sensitive, and no international consensus exists on equitable mechanisms for distribution (Lehmann et al., 2025; Pettinotti et al., 2024). Research exploring what constitutes fair burden-sharing regarding financial contributions and efforts to meet specific GBF targets may guide the design and implementation of actions towards the GBF, foster trust among Parties, and increase ambition (Winkler, 2020).

Downscaling global GBF targets to the national level enables exploration of and reflection on options for effort distribution among Parties under different nature-value and justice perspectives embedded in scenario narratives. Different perceptions of distributional justice and different nature-value perspectives may influence what is considered an appropriate distribution of efforts towards a global GBF target. For example, an intrinsic valuation of nature might call for a global distribution of area-based conservation (target 3) that maximises biodiversity benefits. In contrast, an instrumental valuation might lead to a greater focus on protecting NCP in multifunctional landscapes. An egalitarian perspective on distributional justice would advocate equal contributions towards the global area-based conservation target, whereas a utilitarian perspective might prefer cost-effective distributions. Target downscaling should aim to translate such considerations into alternative quantitative benchmarks for national-level actions towards specific GBF targets (Box 2 exemplifies downscaling of GBF target 3).

Box 2: Sharing efforts towards the global 30 by 30 target

Area-based conservation is an essential tool to address the global biodiversity crisis. Accordingly, target 3 of the GBF calls for conserving at least 30% of land, waters, and seas globally by 2030 (global 30 by 30 target; CBD, 2022a). Existing global studies on the extension of protected areas primarily focus on spatial planning methods to identify where conservation efforts could maximise specific objectives, such as biodiversity conservation benefits or the delivery of selected NCPs (e.g., Jung et al., 2021; Neugarten et al., 2024). Yet the question of how to distribute protected areas globally is rarely studied explicitly through the lens of different perspectives on nature values and justice. Achieving GBF target 3 can raise questions of distributional justice because area-based conservation can impose financial burdens and reduce the availability of land for other uses, including agricultural production, while protecting local biodiversity, and NCP provisioning may be beneficial to a country. Different perspectives on distributional justice may yield different preferred distributions of the global 30% under protection. Moreover, different nature value perspectives might yield different preferences about which areas to protect, for example, whether to protect areas with high biodiversity values, wilderness areas, areas of high cultural value, or areas crucial to provisioning certain NCPs. Exploring alternative value- and justice-informed scenarios for distributing the global 30% under protection among CBD Parties can help assess under which perspectives national-level ambitions would mirror global-level ambitions and when they might deviate. To illustrate such an approach, Figure B2.1 showcases three simplified alternative scenarios of distributing efforts towards protecting 30% of land area globally (taken from Nowak et al., 2025; Woodhouse et al., 2025): “efficiency”, a scenario under which the protection of vulnerable and irrecoverable carbon is maximised at minimised agricultural opportunity cost, reflecting an instrumental valuation of nature and a utilitarian understanding of justice; “environmental capacity”, a scenario under which biodiversity conservation is maximised, reflecting an intrinsic valuation of nature; compared to a scenario of “equal share”, in which each country protects 30% of their land area. Such quantifications can establish a baseline for debates on fair ways to share effort towards GBF target 3.

Box 2 (continued):

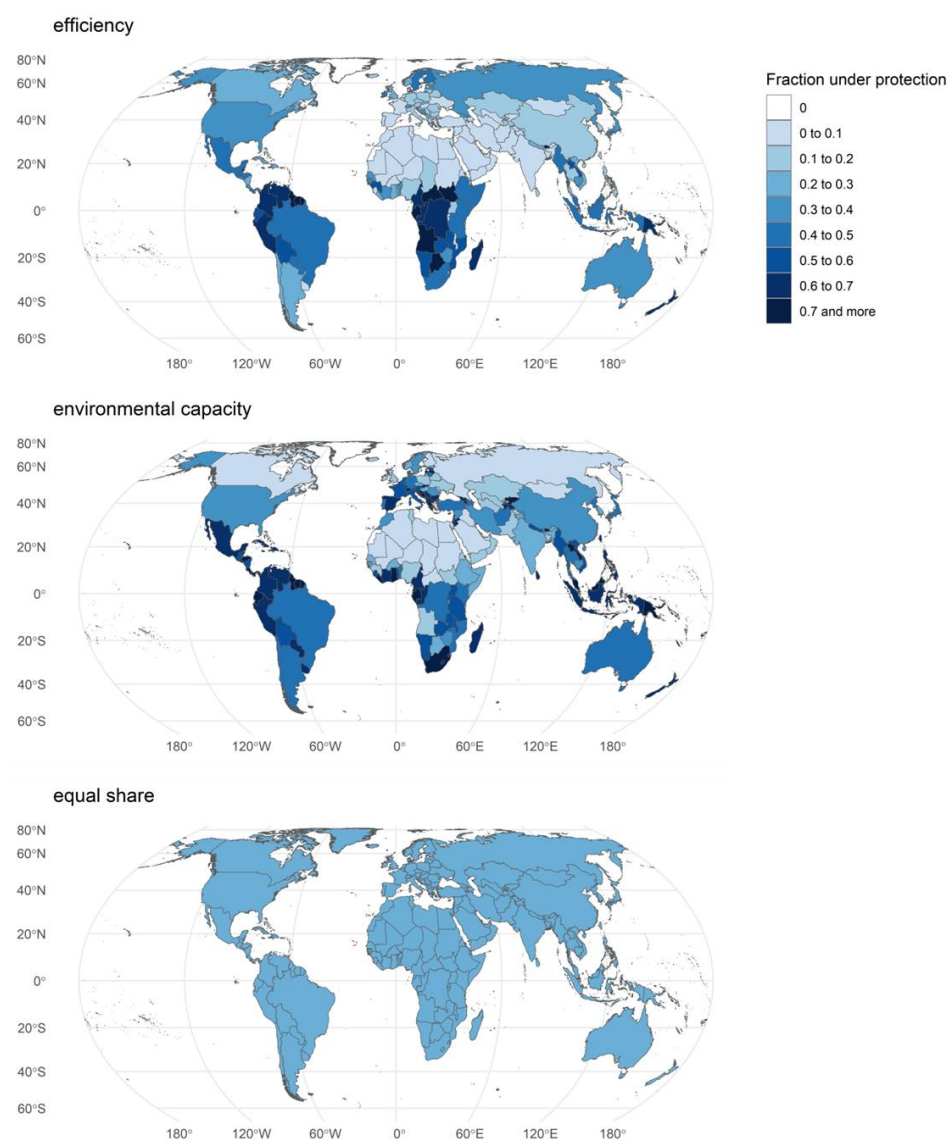


Figure B2.1: Three scenarios of distributing efforts towards protecting 30% of land area globally. Given is the fraction of each country that would be under protection under an “efficiency”, “environmental capacity”, and “equal share scenario” (adapted from Nowak et al., 2025; Woodhouse et al., 2025).

Focal GBF targets for downscaling are those that explicitly specify a quantitative ambition, or from which such a quantitative ambition can be derived, and for which national-level contributions must add up. This includes targets related to biodiversity financing (target 18 on reducing harmful and scaling up positive incentives for biodiversity, target 19 on mobilising financial resources), which are strongly related to questions of just effort sharing (Lehmann et al., 2025; Pettinotti et al., 2024). However, this also applies to targets such as target 2 (restoring 30% of all degraded ecosystems), target 3 (conserve 30% of land, waters

and seas), target 7 (reducing excess nutrients lost to the environment by 50%), or target 11 (restoring, maintaining and enhancing nature's contribution to people), for which appropriate quantitative national-level ambitions should be delineated.

Previous work on sharing greenhouse gas emission budgets and downscaling selected planetary boundaries according to different principles of distributional justice shows that various distributional patterns are possible (e.g., Bai et al., 2024; Höhne et al., 2014; Lucas et al., 2020; Raupach et al., 2014; Ryberg et al., 2020; Steininger et al., 2022; Zhou & Wang, 2016). Such work can build an evidence base for debates about distributional justice in the context of international sustainability ambitions. Systematically applying a similar approach to the GBF, while enriching it with value perspectives for nature, can reveal preferred distributions of contributions towards the GBF targets under different value perspectives and justice perceptions and help understand what they imply for national-level ambition.

Target downscaling has technical requirements. First, appropriate indicators and data to quantify the targets must be identified. The GBF monitoring framework can support this (CBD, 2022b), but may need to be complemented with additional indicators and data for some targets. Moreover, conceptual considerations on effort sharing under given value and justice perspectives must be translated into quantitative distributions, which can, in itself, lead to a diversity of outcomes (e.g., Steininger et al., 2022). Finally, the question of whether similar sharing principles should be applied across all targets or whether targets should be distributed following different sharing principles must be addressed. Co-production with stakeholders can support the identification and interpretation of meaningful value- and justice-explicit scenarios for effort-sharing, on which research can then focus.

Beyond identifying national-level benchmarks, target downscaling can be useful for exploring measures at the subnational level or between different sectors and actors. This could not only support national-level implementation processes but also help non-state actors design their own action plans. The Science-based Targets Initiative and Science-based Target Network develop targets to help companies, financial institutions, or cities reduce greenhouse gas emissions and align their actions with environmental and societal sustainability goals (<https://sciencebasedtargets.org/>, <https://sciencebasedtargetsnetwork.org/>). Yet, efforts are needed beyond these sectors and actors to assess how actions towards global environmental and sustainability ambitions add up and interact. Outputs from target downscaling can be complemented with modelling to explore in greater detail questions about target interactions, trade-offs, and synergies,

helping to understand how different effort distributions might affect the collective success of the GBF.

3.3. Modelling scenario narratives

Models enable us to quantify whether narrative-specific actions and policy options will lead to achieving national or global outcome goals and targets specified in the GBF, and how other sustainability dimensions might be affected. They can also be used to explore in detail how actions on specific drivers might interact in affecting outcomes. Outputs of such modelling can inform agenda-setting and policy design phases. In the Global Biodiversity Outlook (GBO) 4 and 5, target-seeking scenarios were used to explore different pathways to achieve biodiversity and broader sustainability objectives, consistent with the 2050 vision of the Strategic Plan for Biodiversity 2011-2020 (Secretariat of the Convention on Biological Diversity, 2014, 2020). Insights from modelling studies have been used by the Secretariat of the CBD (e.g., CBD, 2021, 2022d) to inform on relationships between targets and outcomes, the importance of considering sustainable production and consumption targets, important interactions between targets (e.g., targets 1, 2 and 3), and to delineate numerical values for specific targets (e.g., target 2).

Research is needed to strengthen the capacity of models to quantitatively assess scenarios of actions towards the GBF and other sustainability goals, and explore synergies and trade-offs. First, the possibilities of modelling direct drivers and subsequent impacts on biodiversity are currently incomplete and characterised by uncertainty, both at a global and local level. For example, for terrestrial ecosystems, land-use change, biological invasions and climate change are more frequently modelled direct drivers of biodiversity loss, but uncertainties can be large (e.g., Leclère et al., 2020; Seebens et al., 2021; Thuiller et al., 2019), and a limited number of studies include more than one driver (e.g., Bellard et al., 2018; Kok et al., 2024; H. M. Pereira et al., 2024). Other important drivers like pollution and direct exploitation (Jaureguiberry et al 2022) are more sparsely covered, even as single drivers. Similarly, biodiversity models often report on single or, at best, a few biodiversity metrics (e.g., Kok et al., 2024), and multiple models are required to capture a broad range of biodiversity outcomes relevant to the GBF goals and better understand related uncertainties (e.g., Leclère et al., 2020; H. M. Pereira et al., 2024). Similarly, while projections of multiple NCPs are emerging (Chaplin-Kramer et al., 2019; H. M. Pereira et al., 2024), they are characterised by incomplete NCP coverage and uncertainties. Hence, improvements in modelling methods and more frequent use of multi-model projections could inform an

increasing share of GBF action targets, outcome goals, and related interactions via model and scenario studies.

Another area of needed research concerns the limited completeness and granularity with which models can represent ecological and human systems, policy interventions and human wellbeing. Although some are more detailed than others, large-scale model frameworks, such as integrated assessment models (IAMs), often have a simplified representation of the direct and indirect drivers of biodiversity change, or policy interventions that might be implemented or planned. For example, so far, models mobilised in global model and scenario analysis had a relatively coarse representation of land use management practices (Leclère et al., 2020) and related pollution. They have rarely explicitly modelled important indirect drivers and related interventions such as repurposing agricultural subsidies (e.g., Springmann & Freund, 2022) or reforming human institutions (e.g., Holzhauser et al., 2019). Moreover, they often lack representations of feedback from changes in nature and NCPs onto the economy and broader human wellbeing outcomes (Chaplin-Kramer et al., 2024; Johnson et al., 2023), or their distributional impacts across actors and geographies. Improving the level of detail with which models represent ecological and human systems could enable them to capture a broader range of interventions, action targets, and related impacts on ecosystems and human wellbeing. This would significantly improve their capacity to engage with justice considerations and potentially important limitations in this regard.

In addition to these modelling innovations, scenario- and model applications need to be conducted at multiple scales. Global scale studies will be important to assess aggregated outcomes and, for example, capture feedback through natural systems (e.g., climate change) or human systems (e.g., trade and consumer vs producer perspectives), as well as distributional justice issues (e.g., effort sharing, finance mechanisms). Modelling at national to subnational scale will allow tailoring scenario frameworks and modelling tools to specific contexts, and provide greater opportunities for stakeholder engagement. This would offer opportunities to address recognition and procedural justice, factor in incorporating political or cultural feasibility dimensions, and weave model and scenario application-based knowledge with other forms of knowledge. It might also be possible to combine multiple scales, for example by conducting coordinated national-scale modelling across multiple countries. For instance, the Food, Agriculture, Biodiversity, Land-use and Energy (FABLE) consortium uses integrated assessment tools developed by in-country researchers with stakeholder input. It runs scenario marathons where country teams align on global targets (e.g., GBF targets 1, 3, 10), iteratively adjust national models, review impacts, and refine

ambition to meet global targets (Jones et al., 2023; Mosnier, Javalera-Rincon, et al., 2023; Mosnier, Schmidt-Traub, et al., 2023).

3.4. Evaluating planned and implemented biodiversity actions

Quantitative evaluations of the planned and implemented actions towards the GBF should complement scenarios for the GBF. Such evaluations can shed light on whether current commitments and implementation by CBD Parties (and non-state actors) are sufficiently ambitious to realise the GBF targets by 2030 and identify ambition and implementation gaps. Moreover, such analysis can help assess if the implementation of the GBF targets is putting the world on a credible pathway towards realisation of the 2050 goals (Kok et al., 2024). To detect and account for potential synergies and trade-offs between sustainability objectives, it will be critical that such analyses look beyond the GBF and include other nature-relevant national commitments including those in nationally determined contributions (NDCs) and national adaptation plans (NAP) under the United Nations Framework Convention on Climate Change (UNFCCC), or the national restoration plans under the United Nations Convention to Combat Desertification (UNCCD).

Relevant information to evaluate progress towards the GBF must be extracted from national targets, NBSAPs, and national progress reports to the CBD (Box 1). This self-reported information varies between Parties in the type and amount of information provided, and countries often miss deadlines for submitting new targets and reports, challenging comprehensive progress evaluation. Evaluations of progress towards the GBF might learn from analyses of progress towards the climate goal of the Paris Agreement (e.g., Den Elzen et al., 2022; Nascimento et al., 2024), which build on information provided in NDCs, for example, quantifying impact on global emission levels and macroeconomic indicators (Den Elzen et al., 2022), and assessing whether countries' policies bring them on track to meet their NDC targets (Nascimento et al., 2024).

4. Creating knowledge to support biodiversity actions by 2030 and beyond

By integrating the different scenario- and model-based research activities laid out in this perspective, it will be possible to address research questions (Table 1) and produce knowledge in support of sufficiently ambitious, integrated, value-explicit, and just collective actions towards the GBF. The scenario narratives, target downscaling, and modelling can enrich one another. Scenario narratives reflecting alternative views about value-explicit and just efforts towards GBF action targets and goals could provide a guide for national-level

dialogues on the GBF implementation. Such narratives could portray alternative assumptions about the distribution of priorities, efforts, and interventions across actors (e.g., along value chains) and geographies (e.g., across and/or within countries). Their quantification could focus not only on global outcome indicators, but also on distributed (e.g., across actors and geographies) and diverse (e.g., reflecting different views on what matters) outcome indicators. Such quantification could explicitly link to narrative-specific national-scale translations of global targets, either as assumptions about just actions under GBF targets (e.g., changes in protected area coverage at the national scale) or as just outcomes (e.g., changes to nutrient surplus at the national scale). The downscaled targets could be used as a benchmark for the model projections (e.g., to assess how model projections would depart from various measures of just and sufficient actions and outcomes), or even as input to the modelling (e.g., to ensure that projections are compatible with just and sufficient actions and outcomes). Such model projections would thereby complement the knowledge provided by the downscaled targets, by providing a richer benchmark of what just and sufficient national-level actions might look like, how they could be achieved, and what the implications would be for a broad range of outcomes relevant to multiple actors and perspectives. In addition to informing on interactions, synergies and trade-offs between actions and goals of the GBF and other sustainability ambitions, this would provide a crucial knowledge base to understand the implications of alternative views about value-explicit and just actions towards the GBF. Comparisons between the outcomes of such scenario- and model-based research and evaluations of planned and implemented actions towards the GBF can help understand the justice and nature-value perspectives implied by these actions, identify gaps and options for ratcheting up efforts.

Such knowledge creation can provide an evidence base for the iterative processes of national planning, implementation, and reporting towards the GBF, for the global analysis and review, and for the possible subsequent ramping up of national-level ambitions to achieve the 23 action-oriented GBF targets due in 2030. Moreover, it may support the development and implementation of a post-2030 action framework under the CBD for further progress towards the 2050 biodiversity goals. Finally, scenario- and model-based research activities that pay particular attention to plural valuations of nature and conceptions of justice, and to interactions among sustainability dimensions, may also inform actions towards other multilateral environmental agreements. Co-producing such knowledge with policy and societal stakeholders will ensure policy uptake, mutual learning and representation of diverse value and justice perspectives. Identifying and establishing spaces and processes for such an exchange will be a key task, underscoring the critical role of transdisciplinary research.

Table 1. Examples for research questions that may be addressed with the suggested scenario- and model-based research activities.

Research activity	Research questions
Designing scenario narratives	<ul style="list-style-type: none"> - What are preferred policy options to achieve the GBF? - Which target interactions, synergies and trade-offs might become relevant? - Which measures to achieve the GBF would be compatible with other sustainability ambitions, including those in the Paris Agreement and the Sustainable Development Goals? - What are critical sectors, and who are critical actors for achieving the GBF? - Which policy options are preferred by different stakeholder groups (with different value and justice perspectives), and is consensus/compromise possible? <p>These questions can be addressed for different nature value perspectives and justice perceptions, at given geographical scales, for given sectors/actors.</p>
Downscaling GBF targets	<ul style="list-style-type: none"> - What are preferred distributions of efforts for a given GBF target? - Will similar or different principles guide effort sharing for different GBF targets? - How much would patterns of effort sharing differ? <p>These questions can be addressed for different nature value perspectives and justice perceptions, for given geographical scales, sectors/actors.</p>
Modelling of scenario narratives	<ul style="list-style-type: none"> - For a given scenario narrative: - Which target interactions are to be expected? - Would the global GBF outcome goals be achieved? - What would be outcomes for biodiversity, NCP and other sustainability dimensions beyond the GBF goals? - Comparing scenario narratives: - How do alternative scenarios (representing alternative value and/or justice perspectives) differ, e.g., in terms of outcomes for biodiversity and other sustainability dimensions? <p>These questions can be addressed for different geographical scales and sectors/actors.</p>
Evaluating planned and implemented actions towards the GBF	<ul style="list-style-type: none"> - What are the currently planned and implemented actions towards the GBF? - Are planned and implemented actions collectively sufficient to put us on a credible pathway to achieve the global GBF outcome goals? - What would be outcomes for biodiversity, NCP and other sustainability dimensions beyond the GBF goals according to planned and implemented actions? - Which information gaps exist in the reporting of planned and implemented actions?
Downscaling + modelling	<ul style="list-style-type: none"> - How will a given distribution of efforts towards one target affect the achievement of other targets? - Will a given distribution of efforts indeed lead to positive outcomes for biodiversity & NCP, and other sustainability dimensions?

	<ul style="list-style-type: none"> - What could be benchmarks for sufficiently ambitious, integrated, value-explicit and just collective actions towards the GBF?
Downscaling + evaluations of planned and implemented actions	<ul style="list-style-type: none"> - How does a given distribution of efforts towards a target, informed by specific value and justice perspectives, compare to the reported planned or implemented actions? - Which underlying value and justice perspectives do planned and implemented actions imply in terms of sharing efforts?
Scenarios + modelling + downscaling + evaluations of planned and implemented actions	<ul style="list-style-type: none"> - How do the scenarios and the planned and implemented actions differ or align in terms of achieving the GBF goals and outcomes for biodiversity, NCP and other sustainability dimensions beyond the GBF goals? - What does that tell us about value perspectives and perceptions of justice that might underlie planned and implemented actions? - How would national (and lower level) actions need to be updated in order to align closer with benchmarks for sufficiently ambitious, integrated, value-explicit and just collective actions towards the GBF?

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