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Towards a multidimensional biodiversity index for national application

C. A. Soto-Navarro [1]✉, M. Harfoot[1], S. L. L. Hill [1], J. Campbell[2], F. Mora[3], C. Campos[1], C. Pretorius[1], U. Pascual [4,5,6], V. Kapos [1], H. Allison[1] and N. D. Burgess[1,7]

The lack of urgent action to reverse biodiversity loss is partly due to the complex nature of biodiversity as a feature of our planet. Subsequently, policymakers receive an often-confusing variety of narratives on why biodiversity matters, which makes it difficult to link biodiversity loss and risks to the attainment of sustainable development. Making this link clearer calls for a multidimensional perspective on biodiversity to reassess what we value, facilitate mainstreaming and support national decision-making. We propose a co-produced Multidimensional Biodiversity Index to connect biodiversity science to the political agenda that accounts for the diversity of values underpinning nature–human relationships.

Biodiversity and human development are intrinsically linked (Box 1)[1–6]; people rely on biodiversity and its derived contributions to well-being in different ways, whereas development often negatively impacts biodiversity both directly and indirectly via the promotion of a narrow set of values in society towards living nature[7]. Effective policy interventions for biodiversity conservation and management ought to be inextricably linked to any socio-economic development agenda, so that biodiversity-related risks are no longer undervalued in policy- and decision-making. Without such a coupled approach, different types of biodiversity knowledge cannot meaningfully inform decisions aiming to achieve dual goals on enhancing ecological integrity and improving human well-being.

In a world where 1 million animal and plant species are threatened with extinction[1], damaged ecosystems already negatively impact 3.2 billion people[8] and the global human population is already exposed to global disease outbreaks[9] and currently in a pandemic era[10], we need ways to assess and monitor the 'health' of biodiversity. We therefore propose a Multidimensional Biodiversity Index (MBI) to be used and adapted by national policymakers as a way to measure key values underpinning nature–human relationships, and to spotlight the looming risks of biodiversity loss to societies and economies.

Biodiversity is defined by the Convention on Biological Diversity (CBD) at genetic, species and ecosystem levels, and complexity arises at all three levels of community organization. The need to address biodiversity as a multidimensional construct has long been discussed in the scientific community[7], but the development of synthetic measures for biodiversity is considered a difficult and controversial issue. In response, metrics and indicators continue to proliferate in attempts to capture different facets of, and values derived from, biodiversity. However, despite widespread recognition of the importance of multidimensionality, it is rarely applied in decision-making.

Current biodiversity policy is mostly informed by multiple unidimensional indicators covering different facets of biodiversity[7,11–15].

Many of these can help assess the cumulative impacts on biodiversity outcomes of responses taken across countries to identify whether national commitments and implementation are contributing towards global biodiversity targets. This is particularly important within the context of the CBD and its reporting mechanisms. However, those indicators do not relate to human values about biodiversity and are often difficult to apply at the scales where policy decisions need to be designed and implemented—typically from national to local. Hence, there is still a need for better integration, better representativeness and more multidimensional assessments of biodiversity. Without this, it is difficult for decision makers, including elected representatives within national and subnational governments and technical and policy advisers in natural resource-based departments, to make effective use of the extensive data collection and analysis achieved by the scientific community to inform sustainable development.

In our experience, there is a demand from policymakers at national levels for more pluralistic perspectives on (and thus measures of) biodiversity and to synthesize different types of biodiversity knowledge to make it more actionable. A multidimensional measure for biodiversity should reflect contextual socio-ecological trends and scenarios and unpack key facets of the concept of biodiversity including the values underpinning human well-being[7,16].

We recognize two major challenges in developing a workable multidimensional measure for biodiversity. First, biodiversity is an emergent and dynamic property of ecosystems, with different functions and scales to consider, and its parts are interdependent. Second, given the different ways biodiversity may be conceptualized as living nature and the diversity of its values, it is challenging to combine the often-conflicting goals of biodiversity conservation and human developmental aspirations[7]. Here, we discuss these challenges and outline a way towards conceptualizing and ultimately operationalizing a policy-focused MBI that incorporates both ecological and human-centred pluralistic perspectives on biodiversity for use by national governments.

[1]UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), Cambridge, UK. [2]Secretariat of the Convention on Biological Diversity, Montreal, Quebec, Canada. [3]Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), Ciudad de Mexico, Mexico. [4]Basque Centre for Climate Change (BC3), Leioa, Spain. [5]Basque Foundation for Science (Ikerbasque), Bilbao, Spain. [6]Centre for Development and Environment, University of Bern, Bern, Switzerland. [7]Centre for Macroecology, Evolution and Climate, GLOBE Institute, University of Copenhagen, Copenhagen, Denmark. ✉e-mail: carolina.soto-navarro@unep-wcmc.org

Box 1 | The role of biodiversity health in underpinning human well-being and sustainable development

Biodiversity loss can undermine the achievement of all the SDGs[3]. Healthy economies depend on a healthy biosphere, which in turn relies on healthy and resilient biodiversity. Healthy ecosystems function better and deliver benefits to people. Hence, opportunities for human prosperity and sustainable development rely on the future and health of biodiversity. A coupled

MBI that considers biodiversity and people as part of a healthy system could contribute to mainstreaming and integrating biodiversity considerations in national socio-economic development strategies and action plans. Figure adapted with permission from: ref. [50], under a Creative Commons licence CC BY 4.0; and ref. [51], Global Goals.
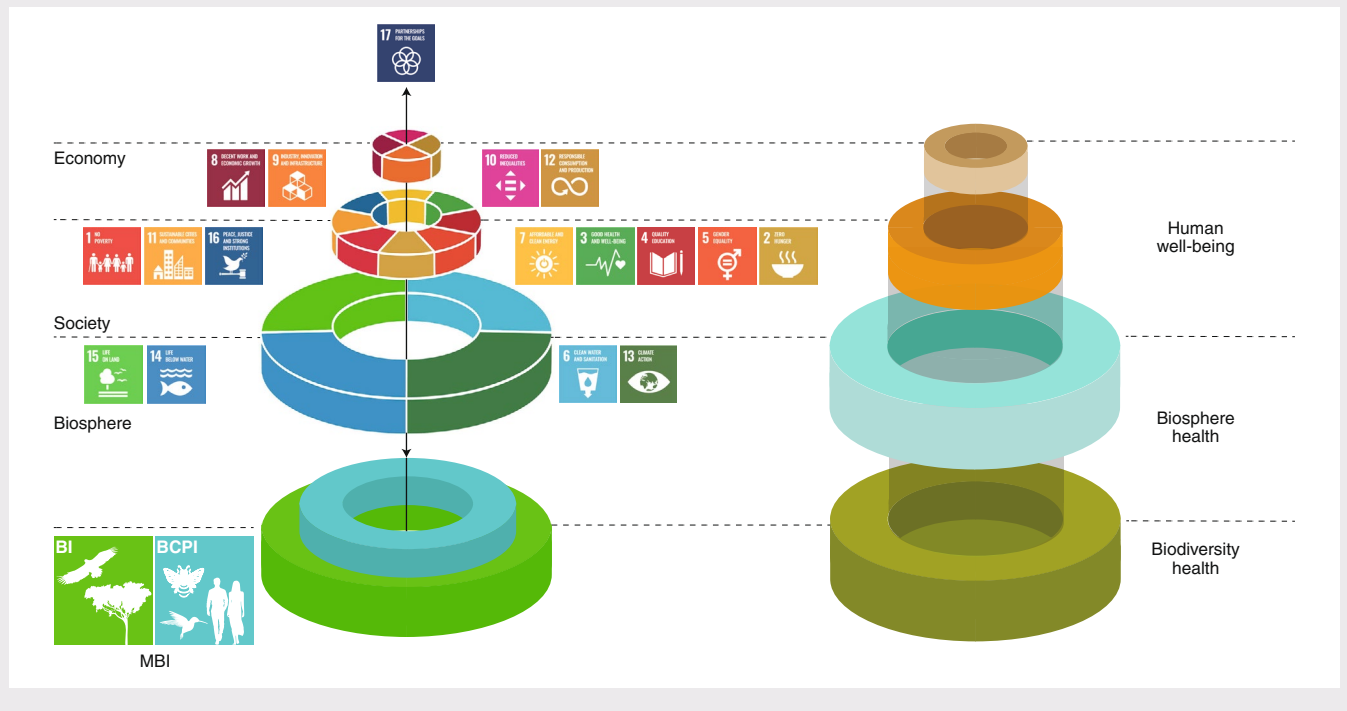
Learning from other sectors

Our analyses of how different sectors have tackled the challenge of assessing complex societal issues such as human development[17], poverty[18], modern slavery[19], global rights[20] or corruption[21] suggest that, despite their limitations and criticisms, multidimensional indices are effective tools for policy analyses, advocacy and social awareness[22].

In the economic realm, despite its well-known limitations[23,24], gross domestic product (GDP) continues to be the de facto policy goal for policy leaders and the 'thermometer' used to measure and monitor a nation's overall economic health and prosperity. It is well understood that if we run down the stock of produced and human assets, we will reduce the economy's productive capabilities. Likewise, relentless human pressures on biodiversity as a natural asset, undermining its stability, resilience and ability to support human development and well-being aspirations, can have catastrophic effects on society of equal or greater magnitude to any economic crash. Nevertheless, there is no national-scale GDP analogue for biodiversity with similar decision-making impact to influence national policy alongside macroeconomic indicators.

Governments are increasingly recognizing that transitions and transformations needed to achieve the Sustainable Development Goals (SDGs) are all connected[25]. In addition, many economists are also calling for a paradigm shift in the way that economic progress is measured, arguing that economies must be designed to thrive and balance, not necessarily to grow[6,26–29]. As the *Dasgupta Review*[6] points out, one could think of ecosystems as productive assets, and biodiversity as one descriptive feature of these assets. Of course, this should not preclude understanding biodiversity from a more

pluralistic perspective[7]. But the point is that as policy-making is most often determined by economic imperatives, policy interventions must also acknowledge that biodiversity plays a key role in the functioning of economies that they themselves try to protect and foster. One way to see the critical role of biodiversity to the economy is by noting its role in reducing uncertainty regarding the material contributions nature offers to people and on which economies largely depend, such as stability for food security[6,30]. The variability of species and the genetic variation within those species enables ecosystems to respond to change, acting as a natural insurance[31] or a diverse portfolio that spreads risk, especially in the context of increased risks due to climate change[32].

Economists increasingly emphasize the need for a transition towards a mindset that considers both the social and ecological conditions underpinning collective human well-being and economic prosperity[6,24], which brings lessons to the biodiversity community to learn from and the potential to follow similar approaches.

Another successful index widely used to inform and coordinate multisectoral efforts on designing and implementing development strategies, and as a platform for public debates on policy priorities, is the human development index. Whether or not the human development index and GDP are flawed, discussions around these metrics have leveraged strong political action and societal advocacy, reshaping our understanding of sustainable development and economic prosperity.

In our view, a multidimensional index of biodiversity health such as the MBI could contribute to: framing storytelling on biodiversity around both the ecological and human dimension to biodiversity conservation to leverage policy change; linking biodiversity

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Box 2 | A 'biodiversity lens' for multifaceted policy decisions on sustainability

To steer the global economy towards sustainable development, national economies should be assessed using a pluralistic, not uni-dimensional, approach. This requires national governments to monitor changes in different 'lenses' of sustainability (that is, economic, environmental and social sustainability), not just movements in GDP. The dominance of GDP has normalized the concept of economic growth at the cost of any consideration of reduction in natural capital and indeed social capital. Hence, misusing GDP growth as a policy goal is distorting decisions about real societal progress, as it promotes short-sightedness by assessing the economic metabolism of nations only proxied by short-term income[24,27,52]. In the absence of 'contenders' or any compensating ecologically and socially focused metric, perverse consequences of reliance on GDP will continue.

Adopting an MBI, together with other metrics measuring performance on different societal and environmental objectives, could act as a counterweight to these consequences, make policymakers value living nature's essential role in the wealth of nations and help to mainstream biodiversity risks into the socio-economic political agendas. The MBI would provide governments with a biodiversity lens within the realm of environmental sustainability that can monitor progress, identify changes, synergies and trade-offs between lenses required to achieve sustainable development, and inform decision-making if used to reflect the projected impact of scenarios of different choices or actions. Other measures that offer different lenses on environmental sustainability include, for example, the Ocean Health Index[53], the Environmental Performance Index[54], the Ecological Footprint[55], the Sustainable Development Goals Index and dashboard[56], the Strong Environmental Sustainability Index[57], the Global Green Growth Index[58] and the Agrobiodiversity Index[59].

Temporal assessments of relationships between different sustainability lenses explored as potential synergies can also help governments to monitor policies and inform decisions on long-term national sustainable development paths through, for example, biodiversity-extended benefit/cost ratios. This could also inform target setting at national and subnational scales to help meet international policy goals. An example of the complementary use of different lenses on sustainability is the combined criteria of the Multidimensional Poverty Index and unidimensional income-based poverty measures to reprogramme conditional cash transfer programmes[60].

It is possible to argue that, while near-universal uptake of GDP as a measure of national economic progress has driven a number of negative consequences in the dash for growth, the adoption of any index, including the MBI, might lead to perverse policy decisions. For the MBI, the long time lags between policy implementation and conservation outcomes[61] suggest that the long time frames required for investment to lead to upturns in biodiversity health—compared with those shorter time frames for investment in creating upturns for economic growth—might result in abandonment of investment due to political short-termism just at a point when benefits might be about to accrue. Nevertheless, there is still an urgent need to help governments take necessary steps to preserve biodiversity as a foundation for sustainable development. Hence, maintaining a better grasp of biodiversity through pluralistic assessments such as the MBI could represent a solid step forwards, but developing scenarios for potential perverse outcomes and defining mitigation pathways will be a crucial part of the development of an MBI to ensure it is responsibly used.

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conservation to human well-being and thus to the idea of sustainable development as outlined in the 2030 Agenda for Sustainable Development; providing a coherent national-level framework to monitor state and progress on safeguarding biodiversity that matters to people; and providing countries with a national condition indicator for the state of biodiversity and its derived contributions to its citizens, which is important to both current and future uses of living nature and for citizens to be able to demand, monitor and help enforce ambitious biodiversity conservation decisions.

Annually/biannually calculated changes in biodiversity health could guide policymakers in priority setting and policy formulation on biodiversity conservation. This, together with the analyses of associations between changes in other societal indices (Box 2), would help to derive more comprehensive conclusions on progress and trends towards sustainable development. An MBI can also help track progress towards broader societal visions such as living in harmony with nature[33], ecological civilization[34] or One Health[35] that capture the idea that biodiversity health interacts with human well-being.

The policy opportunity
On current trajectories, the environmental dimension of the SDGs will not be achieved by 2030[2], with further negative impacts across all other SDGs[1,36,37]. The failure to meet the targets of the *Strategic Plan for Biodiversity 2011–2020*[1] has created an urgent need for national governments and civil society to raise ambition and forge a new transformative global plan for biodiversity[38]. The current policy momentum represents a crucial opportunity to rethink and challenge how we conceptualize, measure and monitor biodiversity health. This provides an important double policy opportunity for

an MBI aligned with the implementation of the post-2020 global biodiversity framework (GBF) and the SDGs.

Conceptualization of biodiversity health
We define biodiversity health captured by the MBI as a state in which biodiversity is maintained at the genetic, species and ecosystem levels for both its intrinsic value and to enable the provision of biological processes such as production[39] required to underpin fully functioning ecosystems and the continued flows of associated contributions to human well-being and human development. This definition encompasses both an ecological perspective that values the intrinsic and insurance values of biodiversity and that considers it as part of living nature from the 'supplier' side (that is, ecological processes), and a social perspective that reflects the 'recipient' side (and that includes instrumental values (that is, what nature does for us) following economic reasons) but also other values, including relational ones[16,40,41] (Fig. 1).

From an ecological perspective, biodiversity health is a property of a stable and resilient Earth system (biodiversity for nature). The variety of species in the system, their interactions and the genetic variation within those species enable ecosystems to respond to change, support complementary ecosystem functions (thereby increasing ecosystem stability) and result in positive effects on outputs derived from Earth system processes such as productivity[39].

From an ecological perspective, supporting biodiversity health means preserving biodiversity for its own sake (intrinsic value) but also as elements (stocks and processes) that underpin the stability, productivity and resilience of ecosystems, preventing ecosystem collapse (insurance value), and that directly and indirectly contribute to people's well-being. Key facets of biodiversity health include
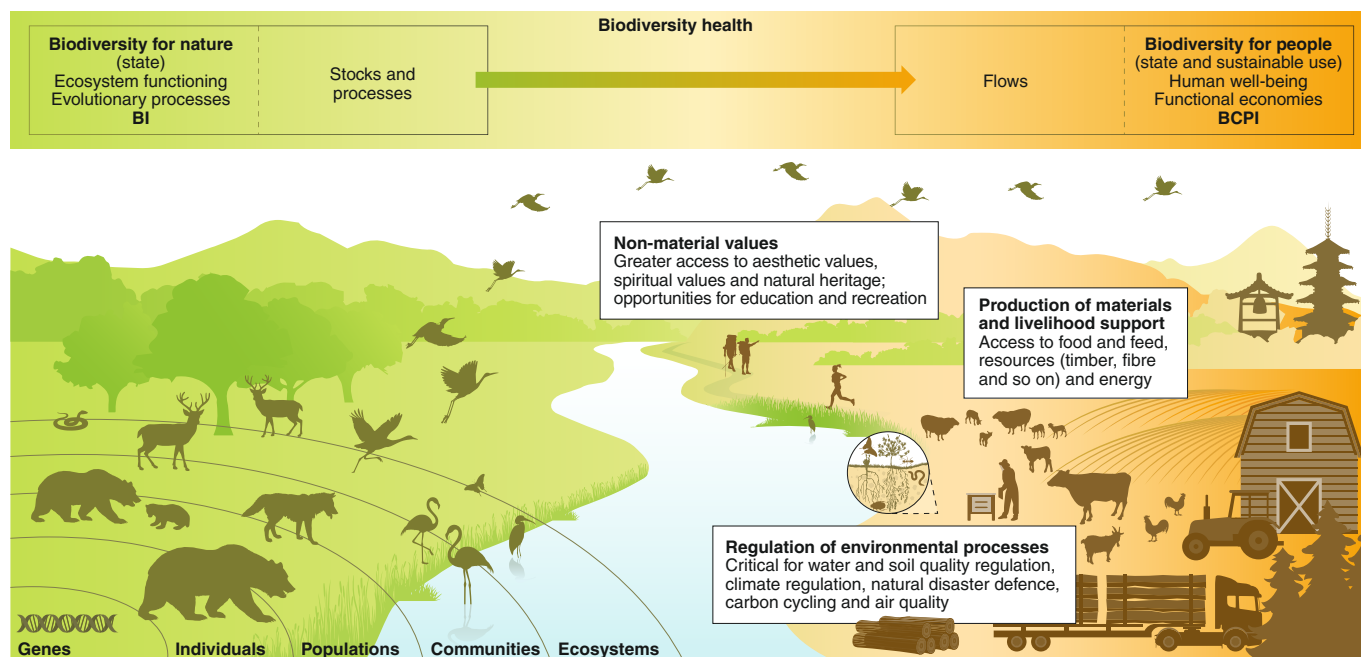
Fig. 1 | Conceptualization of biodiversity health. We define biodiversity health captured by the MBI under (1) an ecological perspective (that is, biodiversity has intrinsic value as well as insurance value against Earth system collapse) and (2) a social perspective (that is, biodiversity is a condition to maintain the wide spectrum of values and benefits on which human well-being and economies rely). The grading in the colours highlights how biodiversity flows and underpins human development and functional economies. The MBI provides an assessment of biodiversity health as a function of the state of biodiversity (visualized as stocks and processes) and the state and sustainable use of its contributions to people (visualized as flows and human–nature relations).

functional diversity, ecological integrity (that is, connectivity, intactness and resilience) and the evolutionary processes of biodiversity. Ecologically centred biodiversity health should be assessed using fundamental attributes (such as richness, abundance and phylogenetic diversity) at the gene, species and ecosystems levels (Fig. 1).

From a social perspective, biodiversity health means a state in which the provision of the positive contributions that humans derive from biodiversity is maintained through sustainable use and direct protection (of instrumental and relational values). These positive contributions are the conduit between biodiversity and human development and influence the attainment of 'social sustainability' in terms of the diversity of values of nature's contributions to people[16]. Assessments of biodiversity health under this perspective require examining biodiversity from a human-centred pluralistic perspective to define the values people hold and derive from living nature, how and to what extent societies wish to transform the various assets (including biodiversity as natural asset) in ways that can support economies and thus people's developmental aspirations across socio-cultural contexts[7].

An integrated framework for nature and people

We propose the MBI as a synthetic or summary measure of the achievement, at the national level, of key public 'biodiversity health objectives' building on both ecological and socio-economic data. To inform a 'core' MBI framework, we mapped the explicitly biodiversity-linked SDGs and targets with the goals and targets proposed in the zero draft of the monitoring framework of the post-2020 GBF[22,38]. Arguably, a core MBI structure could allow for regional or supranational assessments of biodiversity health to be performed and therefore for interoperability among countries. It should thus comprise indicators and metrics that are relevant to the post-2020 GBF and the environmental SDGs[22].

We outline a core framework (Fig. 2) that considers multiple indicators structured in four analytical and aggregation levels: (1) two sub-indices (Biodiversity State sub-index (BI) and Biodiversity

Contributions to People sub-index (BCPI)); (2) a set of relevant dimensions under each sub-index representing fundamental facets of biodiversity as part of living nature and general categories of the contributions that biodiversity provides to people[42]; (3) a set of public biodiversity health objectives, and sub-objectives where relevant, under each dimension; and (4) policy-relevant metrics, indicators or proxies under each objective measuring performance as distance to a desired state or reference point.

Biodiversity State (BI). The BI represents ecological integrity using three dimensions: diversity, abundance and function. These represent biodiversity at the three levels recognized by the CBD (that is, genes, species and ecosystems[43]), summarize changes in conservation status[44] and cover essential biodiversity variables[45]. We suggest that these dimensions are underpinned by, but not limited to, six biodiversity health objectives that we define as the conservation and recovery of (1) genetic diversity, (2) phylogenetic diversity, (3) taxonomic diversity, (4) species populations, (5) community composition and (6) habitats (terrestrial and freshwater) (Fig. 2).

Indicators for the BI should represent the structure and function of ecosystems, the composition of biological communities, the diversity and traits of species, the risk of loss of unique functions and traits, and genetic composition. Examples of global indicators that could be considered for inclusion are indicators of trends in primary forest cover, species richness and phylogenetic diversity, as well as, potentially, widely used global metrics[13,15].

Biodiversity Contributions to People (BCPI). The BCPI measures the status and use of the realized benefits that people obtain from biodiversity. We use the concept of nature's contributions to people[16,42,46] as a pluralistic approach to recognizing the diversity of contributions that people obtain from biodiversity. Hence, we propose three key dimensions for the BCPI: (1) regulation of environmental processes, (2) provision of materials and (3) supporting non-material (but nevertheless key) health and livelihood-related

contributions to people's well-being. These in turn reflect six public biodiversity health objectives and sub-objectives: (1) safe water, (2) climate change mitigation, (3) natural disaster protection, (4) food provision (with three sub-objectives on sustainable agriculture, maintenance of agrobiodiversity and traditional knowledge), (5) livelihoods (for example, forestry and eco-tourism) and (6) health and quality of life (with three sub-objectives on sense of place, proximity to nature and protection of special places) (Fig. 2).

Metrics for the BCPI should represent human-centred desirable outcomes derived from biodiversity, measured as the current state and the contributions of biodiversity to people. Of course, what may be considered 'desirable' is something that needs to be agreed upon in each nation, following "procedural ethics that is committed to openness, learning, and adaptation"[7]. Examples of indicators to consider include those based on metrics related to agricultural land under conservation agriculture, forest cover under sustainable management, population using safely managed drinking water supplies and metrics valuing the physical and psychological experience derived from living nature (such as areas with high outdoor recreation potential).

We suggest that a scorecard-style framework could be used to report/communicate the implementation of the MBI framework at national levels (Box 3). This would require the (re)definition of further biodiversity objectives and/or sub-objectives under this core structure to account for context-specific biodiversity and contributions to people values. Hence, the MBI metric should be built up with indicators relevant at national scales.

The need for cautious inference

Arguably, indices are easier to communicate to a wider audience and valued by policymakers (that is, they are more straightforward to interpret than finding a common trend in many single indicators). They are utilized globally to monitor compliance of international agreements, allocation of resources and benchmarking[22]. Nevertheless, indices often lack transparency and are sensitive to the choice, weighting and standardization of its components[47,48], so they can produce perverse outcomes and misleading policy messages (Box 2). We acknowledge that the challenges in developing a multi-dimensional index for biodiversity health that captures essential (often context-specific) evolving needs of humanity as related to human nature would necessarily remain[7], and what we propose here is only one approach that involves several assumptions and caveats[22].

Some of the elements within the MBI structure might not be measurable yet, or there may be no existing data for many countries. The MBI represents a model to aspire to as a unified framework to assess biodiversity health that countries should aim for and work towards to better inform decisions about current and future uses of and relations towards living nature[7].

Building on indicators proposed under the post-2020 GBF, and those already in use for the SDGs, would also ensure global policy alignment of the MBI to the post-2020 GBF and the environmental dimension of the 2030 Agenda (SDG indicators have the added benefit of statistical scrutiny through the UN Statistical Commission). This would improve the temporal and spatial comparability of the index and ensure that there is a global and national commitment to continue to collect the data that underpin it. Hence, the MBI can highlight core datasets that nations need to maintain and invest in.

A further limitation in implementing the MBI may be difficulties in assessing biodiversity's contributions to people. Nevertheless, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services approach to the inclusive evaluation of nature's contributions to people provides a solid background to support countries in that direction[16,42,46] (see ref. [22] for a further discussion on caveats and limitations).

We argue that the national implementation of the framework is important for two reasons. First, the MBI supports the understanding that the flows from biodiversity to people are context-dependent,
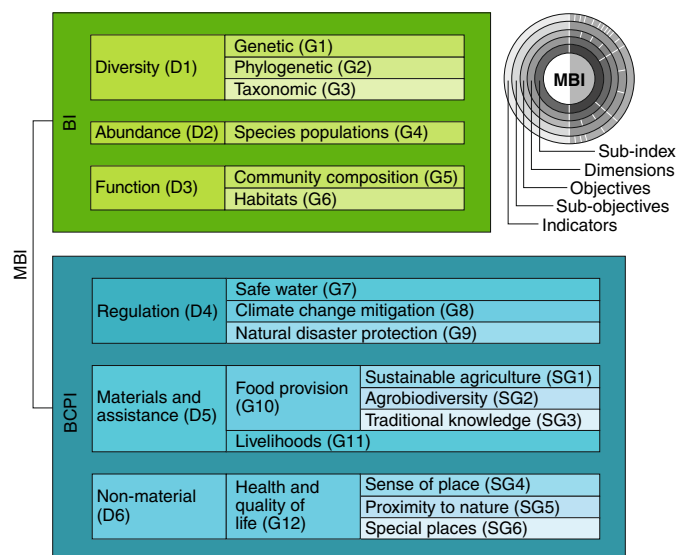

Fig. 2 | Proposed core MBI and nested structure. Each sub-index score is derived from a wide range of indicators and metrics. Indicators/metrics in the outer layer could be arranged around public biodiversity health objectives (G) (and sub-objectives (SG)), given the diversity of values about living nature, and those around specific biodiversity dimensions (D). Dimensions combine to indicate the current status for each of the biodiversity health objectives.

so solutions must be tailored to the social-ecological context-specific values and problems related to biodiversity conservation and protection[49]. For example, rapidly growing economies will face in the next decade the challenge of counterbalancing the ramping up of human demand for biodiversity-related assets, processes and flows with sustainable use to ensure future provision. This context-dependency of the pluralistic perspectives on biodiversity, which supports bottom-up deliberative approaches on biodiversity values, may limit the feasibility and value of developing a 'global' MBI.

Nevertheless, it may be possible to develop regional or supranational approaches to allow for intercountry comparisons if pluralistic perspectives on biodiversity can be commonly represented at those levels in a sufficiently agreed manner, noting that the social component of the index may be more likely to be contested across different cultural contexts. Second, recognizing the necessity of maintaining bespoke use of the derived flows of biodiversity to people is key to enhancing biodiversity governance.

It could be argued that the implementation and success of the universal agenda for biodiversity (post-2020 GBF and SDGs) will require national sustainable development policies and establishment of voluntary national commitments and frameworks for monitoring progress. In this respect, there is a possible analogy with climate change. The Paris Agreement marked a new generation of climate governance, with agreement on the 2 °C target providing added impetus to national action, monitoring and reporting. If analogous success is to be achieved for biodiversity, incorporating elements of the climate model (that is, a combination of top-down global targets and bottom-up nationally determined contributions) could reinvigorate biodiversity governance. Hence, voluntary biodiversity commitments by countries (possibly termed nationally determined contributions for biodiversity) that contribute towards internationally agreed targets might be a pathway for countries to raise their ambition and leverage a paradigm shift for biodiversity governance. The MBI could play a potential role for countries as a framework to analyse if the sum of voluntary commitments would be 'enough' to

Box 3 | A biodiversity knowledge product for science–policy interfacing and data-driven biodiversity policy-making

The MBI is intended to support national governments with different information needs (from high-level policymakers to government officials and policy analysts) with meaningful messages on biodiversity packaged into a 'blueprint' or knowledge
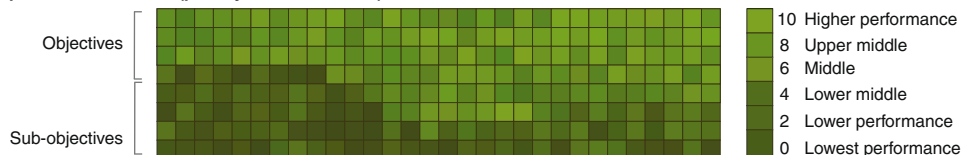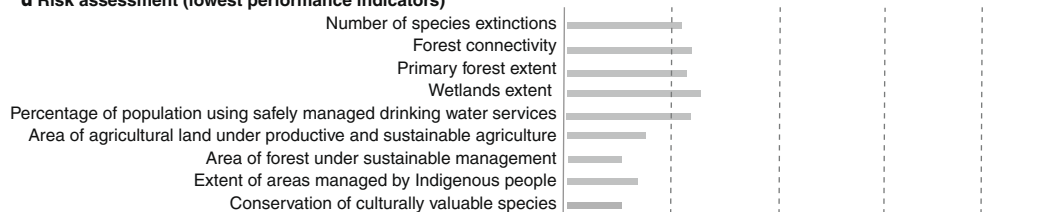
MBI national scorecard—Sylvana

a MBI scores

Index component	Score	Trend	Average distance to goals	Edition	2012–2014	2014–2016	2016–2018	2018–2020
(i) Overall MBI score	5.6			Score	4.3	4.9	5.2	5.6
(ii) BI	2.9							
1st dimension: diversity	3.9							
2nd dimension: abundance	2.7							
3rd dimension: function	2.1							
(iii) BCPI	2.7							
4th dimension: regulations	4.2							
5th dimension: materials and assistance	2.7							
6th dimension: non-materials	1.2							

(iv) MBI and sub-indices scores
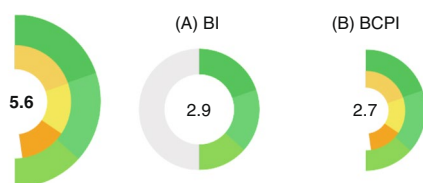
(v) Radar plot
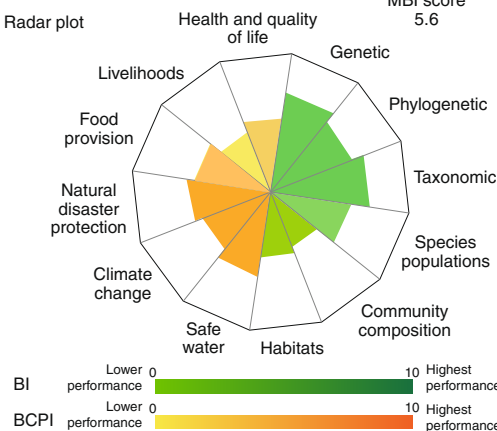
b Spatial assessments

Spatial assessment of forest health
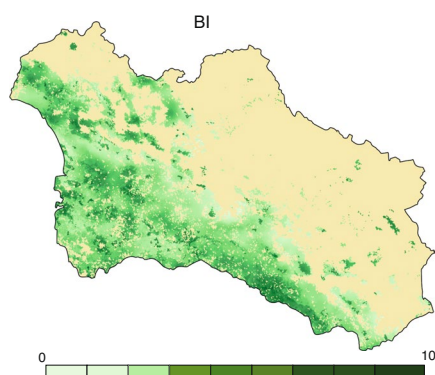
BI sub-index scores on forest health for Sylvana at 1 km spatial resolution as a function of a suite of ecological indicators for evaluating the integrity of structural biocomplexity in forests. Forest health is measured as an average of the scores on three dimensions: forest abundance (a), forest diversity (b) and forest function (c). Each dimension is calculated as an average of indicators on the variety of species and key structures associated with the composition (indicators i–ii), structure (indicators iii–vi) and function of forest stands (indicators vii–xii).
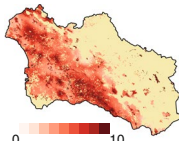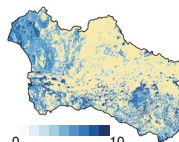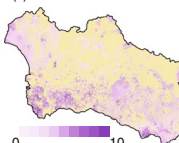
Indicators

(i)	Stand density condition
(ii)	Forest tree diversity (Shannon estimates)
(iii)	Local (alpha) tree species diversity for forest ecosystems
(iv)	Forest tree beta diversity (Shannon estimates)
(v)	Forest tree species
(vi)	Mammal intactness (that is, richness intactness of terrestrial mammal species)
(vii)	Forest biocomplexity
(viii)	Forest stand maximum height
(ix)	Natural regeneration in forest ecosystems
(x)	Forest quantity
(xi)	Forest connectivity
(xii)	Forest fragmentation

c Heat maps and scoreboards (priority areas for action)

d Risk assessment (lowest performance indicators)

Box 3 | A biodiversity knowledge product for science–policy interfacing and data-driven biodiversity policy-making (Continued)

product. MBI national scorecards can inform coordinated actions by different ministries, help communicate with non-biodiversity decision makers and act as a monitoring and accountability tool within governments

The figure represents a hypothesized national scorecard on biodiversity health for the fictional country of Sylvana. Index and/or sub-index scores aggregated at the national level (**a**) might (1) provide an easier-to-understand message on progress over time and a general sense of whether a country is moving in the right direction on biodiversity conservation given desired biodiversity-related socio-economic outcomes; (2) benchmark a country's performance against its aspirational or previous scores; (3) facilitate communication with citizens; and (4) leverage advocacy by grasping the complex and multidimensional nature of biodiversity and its contributions to people. Different visualization options allow assessments of the level of achievement on biodiversity health objectives; monitoring of progress and distance to targets over time; and comparisons across subnational regions. These scores can reveal patterns that do not directly emerge by looking at the objectives separately.

Greater value to inform policy decisions derives from delving into the framework and individual objective scores, which could involve dashboards or heatmap visualizations (**c**) to identify areas of high versus low performance, and risk assessments (**d**) to identify strengths and weaknesses through the scores and trends of indicators.

The framework could also be used to aggregate and communicate social-economic dimensions or objectives that are meaningful for different contexts and users, as well as to calculate spatially explicit scores relevant for a particular country that can help identify critical areas with high 'potential' for prioritization of actions. A fictional example of an MBI sub-index on 'forest health' of the country Sylvana is shown (**b**) using metrics associated with the abundance of species, diversity and function of forest stands as indicators of forest biocomplexity (a crucial element for sustainable forest management). Importantly, the MBI allows for areas to be assessed on the basis of the pluralistic values they provide (for example, the potential to conserve biodiversity but also to capture and store carbon and provide recreational opportunities for the citizens of Sylvana).

The MBI alone does not identify conservation priorities, neither is it prescriptive about the specific policies and actions required in Sylvana. It identifies which health objectives, in principle, need to be prioritized to improve the biodiversity state and achieve a sustainable use of its derived contributions to people. Information derived from the MBI framework could be harnessed alongside data on, for example, cost-effectiveness of interventions, to inform conservation planning, policy decisions, strategies and regional action plans to maximize the potential of return in the form of positive biodiversity outcomes (increased MBI scores) and sustainable use of contributions for the people of Sylvana. Map image in **b** reproduced from Freepik.com.

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generate the global coordinated action necessary to achieve global biodiversity goals. Nevertheless, whereas in the climate sphere progress can be measured using a single parameter (that is, emissions), the complexity of biodiversity, the lack of fungibility between its facets and the divergent nature of the two main goals on safeguarding biodiversity (to preserve ecological integrity and to safeguard the multiple values of contributions to people from biodiversity[7]) make it necessary to use a multidimensional assessment of progress.

A roadmap for an operational MBI at the national level

Developing an MBI is both a technical and a political process that demands both scientific input and policy steer. We propose four steps as a roadmap to develop an operational MBI, based on short-, mid- and long-term actions (Fig. 3).

Short-term actions should focus on (1) implementing an inclusive co-production process with decision makers, experts and relevant stakeholders, including Indigenous Peoples and Local Communities (IPLCs); and (2) developing the knowledge foundations of the index in an open and transparent consultative manner to reflect the best available data and science. Hence, Fig. 2 only represents a first approach as the final conceptual framework should be co-designed through a consultative process with experts and end-users, while ensuring scientific independence, to ensure that scalability and diverse perspectives and policy needs for biodiversity conservation are incorporated (that is, countries are clear about their reasons and benefits of a national MBI). Scientific robustness requires interoperability through existing networks and stakeholder engagement for data mobilization and integration, and accounting for traditional ecological knowledge and values held by IPLCs. This includes testing the framework through the implementation of national case pilots to foster accountability, policy acceptance and surface conceptual and design improvements. Figure 3 also illustrates a testing process coordinated by a network of experts working at different scales and governance levels comprising: dialogue and consultation to incorporate context specificities and public priorities;

data contribution and mobilization including the identification of scientifically validated indicators to quantify objectives; data integration and MBI production; and MBI applications and policy use.

Mid-term actions (3) should focus on fostering an iterative process of monitoring and evaluation to implement improvements, and ensure alignment with user needs and responsiveness to changes in management or policy.

Long-term actions (4) should focus on leveraging the long-term sustainability of the tool by building partnerships and foster formal uptake by governments, statistical commissions and/or intergovernmental agencies as potential custodians. Capacity building and support for policymakers in developing biodiversity policies that are grounded in multidimensional assessments of biodiversity is also a crucial component of this process, as is ensuring that the index is used for national biodiversity assessments in the context of relevant intergovernmental policy processes including the SDGs and the CBD.

Finally, given the cross-cutting nature of biodiversity, it is important to ensure scalability, relevance and applicability to different sectors. By ensuring that the framework is relevant to different sectors, the MBI could help to identify opportunities for non-state actors (including the private and finance sectors) and quantify the potential contribution towards enhancing biodiversity health of reducing threats derived from economic activities.

These four steps are designed to create four fundamental conditions for policy uptake and usage: the index is contextualized for national biodiversity policies and socio-ecological conditions; it is based on robust science while respecting perspectives from other knowledge systems, including Indigenous and local knowledge; it is responsive to positive and negative changes and 'responsibly used'; and it is relevant as a frame of reference for national biodiversity assessments.

Here we have discussed the need for a shift in how we measure and communicate biodiversity by linking it to the attainment of sustainable development through science–policy interfacing. Having measures that can grasp the pluralistic perspectives of biodiversity[7] can

Inmediate actions

MBI testing process

(1) Relevance to policy needs and socio-ecological contexts

The potential impact of the MBI rests on its alignment with in-country policies and users' needs.

The conceptual framework must:

- Be consultative (governmental, intergovernmental and other organizations co-design process).
- Respond to in-country and decision-makers needs.
- Be of explicit policy value.
- Account for socio-ecological contexts.
- Remain easy to understand and to communicate to end-users.

Science and policy users

Organizations (IPLCs, CSOs, NGOs)

(2) Robust and evidence-based

The scientifc foundations must be based on the best available science and data. The MBI should be:

- Co-developed. NGOs, research bodies and umbrella organizations with an interest in conservation and biodiversity policy.
- Transparent. Countries understand how and why they are assessed in order to engage decision-makers.
- Balanced between scientific robustness and ease to use and interpret.
- 'Sensibly developed'. Quality control process based on both conceptual and statistical considerations.

- Prototyped through use cases or 'champion countries' to test applicability and surface design improvements.

Data users   **Modellers**   **Data and monitoring networks**

Iterative

(i) Dialogue and consultation

MBI
Sub-index
Dimensions
Objectives
Sub-objectives
Indicators

Incorporate public priorities
Maximize alignment of the conceptual framework to context specificities and public priorities according to both national adopted targets and multilateral agreements

MBI framework
core + tailored

Socio-ecological context defined
Identify locally driven provision and demand for contributions from biodiversity, and local pressures of biodiversity loss

Variable identification   Knowledge exchange

(ii) Data contribution and mobilization

Collection and provisioning of datasets

Multi-type data ingestion

Heterogeneous raw data and sources   Indicators already available

Synthesis of information   Spatiotemporal scope

Assess data limitations

Standardized source layers and datasets

Dataset dashboard

Country A   Country B   Country C

Gap-filled data (Global indicators and national data)

Multiple data layers on ecological and human-centred desirable outcomes derived from biodiversity

(iii) Data integration and MBI production

Ground layers
Contributions
Biodiversity status
Country A

MBI algorithms
Index
Sub-indices
Dimensions
Objectives
Sub-objectives

Index products
Red flags and risk assessment
Spatial assessment
Indicator and score trends
Goals, dimensions, sub-indices and index score

(iv) MBI applications and use

Intervention planning
National scorecards

National reporting
Index and sub-index scores

NBSAPs

Global policy alignment
2030 Sustainable Development Agenda
Post-2020 GBF

(3) Responsive

The MBI must reflect changes in biodiversity state and the state and use of its derived contributions to people in response to changes in policies and actions.

Specifically, it should:

- Respond to management so changes in policy create changes in the index.
- Respond quickly to any change in biodiversity state and its derived contributions to people.
- Allow flexibility to adapt to constraints of data availability, quality and quantity.
- Be responsibly used. Care should be taken in drawing conclusions and recommendations based on the conceptual context in which the index was developed.

(4) Long-term sustainability

Partnerships
Build public–private partnerships, foster sustainable financing and formal uptake by governments and intergovernmental agencies for reporting cycles.

Non-state actors
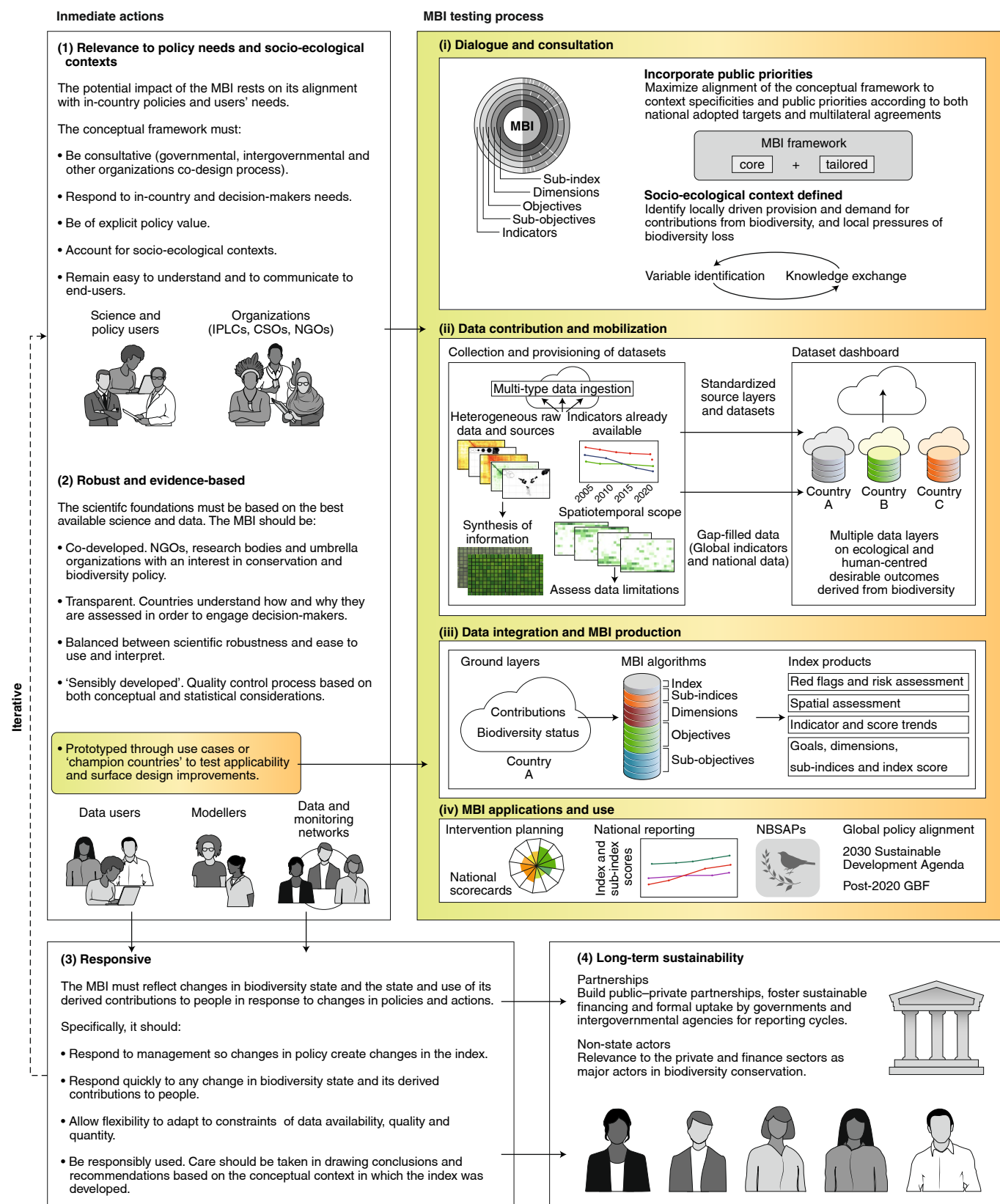Relevance to the private and finance sectors as major actors in biodiversity conservation.

Fig. 3 | Roadmap to operationalize an MBI on biodiversity health. Immediate, mid- and long-term actions are needed. Key actors and workflows for the implementation and use of national MBIs are also shown. NGO, non-governmental organization; CSO, civil society organization; NBSAP, National Biodiversity Strategy and Action Plan.

help to overcome bias in public decision-making, which at present is dominated by narrow considerations of economic growth to the exclusion of crucial ecosystem assets, biodiversity-led contributions and associated values. The MBI could help bridge the gap between evaluation and implementation of actions to leverage transformative change and influence potential radical shifts in finance flows at

the national level. We hope that these ideas can shape an agenda for policy, science and practice to work together on this large undertaking, and thereby inspire interdisciplinary efforts and bridges across knowledge systems in the pursuit of collaborative spaces. This will be essential to forge a shared level of ambition and political intent to advance a common fundamental motivation—to stem loss and set biodiversity on the path to recovery, ensuring human well-being in a new era of environmental and social sustainability.

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Author contributions

Competing interests

Additional information