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INFORMING DECISION-MAKING WITH INDIGENOUS AND LOCAL KNOWLEDGE AND SCIENCE

Review

Working with Indigenous and local knowledge (ILK) in large-scale ecological assessments: Reviewing the experience of the IPBES Global Assessment

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Abstract

1. There have been calls for greater inclusion of Indigenous and local knowledge (ILK) in applied ecosystems research and ecological assessments. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment (GA) is the first global scale assessment to systematically engage with ILK and issues of concern to Indigenous peoples and local communities (IPLC). In this paper, we review and reflect on how the GA worked with ILK and lessons learned.
2. The GA engaged in critical evaluation and synthesis of existing evidence from multiple sources, using several deliberative steps: having specific authors and questions focus on ILK; integrating inputs from ILK across all chapters; organizing dialogue workshops; issuing calls for contributions to identify other forms and systems of knowledge; and encouraging IPLC to be key stakeholders and contributors.
3. We identify content areas where attention to ILK was particularly important for questions in applied ecology. These include: (a) enriching understandings of nature and its contributions to people, including ecosystem services; (b) assisting in assessing and monitoring ecosystem change; (c) contributing to international targets and scenario development to achieve global goals like the Aichi Biodiversity

Targets and the Sustainable Development Goals and (d) generating inclusive and policy-relevant options for people and nature. However, challenges in engaging different knowledge systems were also encountered.

4. *Policy implications*. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment (GA) demonstrated the importance of Indigenous peoples and local communities (IPLC) to global biodiversity conservation and ecosystem management. Initiatives seeking to engage Indigenous and local knowledge (ILK) can learn from the experience of the GA. Successfully bringing ILK into assessment processes and policy arenas requires a deliberate framework and approach from the start that facilitates recognition of different knowledge systems, identifies questions relevant at various scales, mobilizes funding and recognizes time required and engages networks of stakeholders with diverse worldviews. In turn, fostering inclusion of ILK and partnering with IPLC can help future assessments understand how natural and cultural systems co-produce each other, identify trends of change through diverse biocultural indicators and improve sustainable development goals and policies.

KEYWORDS

biodiversity targets, ecosystem services, Global Assessment, Indigenous and local knowledge, IPBES, monitoring, social-ecological assessments, sustainable development

1 | INTRODUCTION

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is charged with conducting regular policy-relevant assessments on the status, trends and future of biodiversity and ecosystems and their contributions to people. As part of its mandate, IPBES has in its assessment processes worked with Indigenous and local knowledge (ILK), defined as 'knowledge and know-how accumulated across generations, which guide human societies in their innumerable interactions with their surrounding environment' (Thaman et al., 2013). IPBES has also encouraged Indigenous Peoples and local communities (IPLC) to be key stakeholders and contributors across their products (which have so far included methodological, thematic, regional and global assessments), as they are creators and holders of ILK, as well as impacted by policymaking around nature (Hill et al., 2020; see Box 1).

The IPBES Global Assessment (GA) is the first ecological assessment to systematically incorporate ILK at the global scale (Díaz et al., 2019; IPBES, 2019). Therefore, experiences from the GA's attempts to bridge knowledge systems will likely be relevant to other assessments. As authors who contributed to the GA, our goal in this paper is to critically evaluate the successes and challenges of working with ILK and the benefits of doing so. To do this, we discuss methodological steps taken for the GA and then outline key findings of the report that were enhanced by ILK. We conclude with lessons learned, particularly around methodological and epistemological challenges, while emphasizing the global relevance of ILK to ecosystem management and assessment. We highlight that successfully bringing ILK into assessment processes and policy arenas requires a deliberate framework and approach that facilitates recognition of different knowledge systems.

BOX 1 Who are IPLC? Why are they important?

IPLC are 'individuals and communities who are, on the one hand, self-identified as Indigenous and, on the other hand, are members of local communities that maintain intergenerational connection to place and nature through livelihood, cultural identity and worldviews, institutions and ecological knowledge' (IPBES, 2019). Using ILK and other forms of knowledge, IPLC have shaped the ecologies, conservation initiatives and resource economies of vast regions of the world, as IPLC either control, use, manage or co-administer an estimated ~38 million km^2 (at least 25%–28% of the world's land area; Garnett et al., 2018).

2 | MATERIALS AND METHODS

2.1 | Developing an approach to ILK in the GA

There have been many calls to better incorporate ILK into global science-policy processes (Ford et al., 2016; Turnhout, Bloomfield, Hulme, Vogel, & Wynne, 2012; Usher, 2000), as well as concerns about the challenges and

BOX 2 Questions related to ILK guiding the GA

1. What have been the contributions of ILK, practices and innovations to the sustainable use, management and conservation of nature and nature's contributions to people at regional and global scales?
2. What are the most important features, pressures and factors related to and/or enabling or constraining these contributions, as well as impacting present and future quality of life of IPLC?
3. What policy responses, measures and processes can contribute to strengthen and improve the institutions and governance of nature and its contributions to people with regard to IPLC?

efficacy of doing so (Hill et al., 2020; Nadasdy, 1999). Reasons for including ILK have included the need for more comprehensive data (Moller, Berkes, Lyver, & Kislalioglu, 2004) and as a mode for inclusion, participation and respect for IPLC (Maffie, 2009). However, both ILK and science come from distinct types of *knowledge systems* (or 'the agents, practices and institutions that organize the production, transfer and use of knowledge'; Cornell et al., 2013), which are often asymmetrical in terms of power and can be incommensurable. Therefore, researchers have been encouraged to seek opportunities to collaborate and connect knowledge systems resulting in co-produced outcomes (Bohensky & Maru, 2011; Raymond et al., 2010; Tengö et al., 2017).

One solution proposed has been the multiple evidence base approach, which explicitly recognizes the complementarities between scientific evidence and ILK (Tengö, Brondízio, Elmqvist, Malmer, & Spierenburg, 2014; Tengö et al., 2017). Both knowledge systems share some characteristics, including observation of empirical changes in nature, collection of longitudinal data and use of experiments to test ideas (Berkes, Colding, & Folke, 2000; Thornton & Scheer, 2012). Yet at the same time, ILK emerges from very different epistemological contexts than formal science, which creates challenges for integration and aggregation (Raymond et al., 2010). The GA made the assumption that different types and dimensions of ILK, while locally based, are manifested in regional landscapes and ecosystems, and thus can be globally relevant when assessed in systematic ways (Brondízio & Le Tourneau, 2016; Garnett et al., 2018). The GA approach accepted that, while some types of ILK can be synthesized and aggregated together, other types should be recognized as context-specific and place-based evidence on their own (Díaz et al., 2018). Three key questions on ILK and IPLC guided the GA throughout the process (see Box 2).

2.2 | Implementing the methodological approach to ILK in the GA

The GA was conducted from 2016 to 2019 and aimed to critically assess the state of knowledge on past (since 1970s), present and possible future (2030–2050) trends in living nature and its contributions to people. As in other assessments, the overall methodological approach was based on critical evaluation, review and synthesis of existing evidence from multiple sources, including both published scientific and grey literature (e.g. I/NGO reports). This mandate lent itself to inclusion of ILK, as the GA was not restricted to peer-reviewed literature, as other assessment processes have been (Ford et al., 2016). IPBES as a whole has been working on a more systematic approach to ILK and inclusion of IPLC across all their work products (Hill et al., 2020), and the GA approached ILK through several steps, outlined below:

1. Setting up an 'ILK Authors Liaison group' at the first lead author meeting. These self-selected group members (27 in total) were experts ranging across ecological and social disciplines and were tasked with oversight of ILK content in each chapter and links between chapters.
2. Devising key ILK-related questions to provide a common reference across chapters.[1] The liaison group formulated 27 chapter-specific questions related to (a) the contributions of ILK to the sustainable use of nature at different scales; (b) the pressures and challenges related to ILK and IPLC; and (c) policy responses to improve nature governance with regard to IPLC (see Appendix S1).
3. Developing a comprehensive and systematic literature review of both peer-reviewed and other works, including identification of databases, keywords and additional contributing authors[2] who could write on specific issues related to ILK (see Appendix S2).
4. Issuing a special online call for additional contributions, information, authors, networks and organizations to find other forms and systems of knowledge. The call was issued after the assessment of literature had begun, and was open for five months in English, Spanish and French and included a translation tool to facilitate wide diffusion. It was distributed through IPBES networks and those of the lead authors (e.g. listserves). This resulted in the identification of 1,199 additional relevant documents in 16 languages (including some indigenous languages, although about 83% were in English); 20% of the documents were considered 'grey literature' (e.g. reports, policy briefs, manuals) and there was wide geographic distribution (Figure S1).
5. Encouraging IPLC participation, including review of drafts and through dialogue workshops. In total, eight different dialogues were held and reached over 250 people at different stages of writing the assessment. The aim of the dialogues was to share information about the GA with IPLC representatives while it was ongoing and receive guidance and feedback on the content of the assessment. Dialogues were organized as shorter side events to

[1]This was in contrast to the previous pollination assessment where one chapter was dedicated to biocultural diversity, pollinators and their sociocultural values, much of which was derived from ILK. IPBES Regional Assessments also used ILK across chapters and organized consultations with IPLC as part of the process (e.g. Roué & Molnar, 2017).

[2]Contributing authors are volunteers who contributed specific texts to the GA and who were recruited for their particular expertise. Lead authors on the GA were nominated by governments or other representative organizations and served throughout the writing process.

BOX 3 The Arctic ILK Dialogue: An example of guidance from IPLC to the GA

A 2-day IPBES Consultation Meeting was held in Helsinki (6–7 June 2018) to bring together holders of Arctic ILK with researchers to review, evaluate and provide additional information to the Second Order Draft. The meeting, funded by the Government of Finland, was attended by 23 participants, including nine indigenous representatives (chosen based on their involvement in the work of the Arctic Council), 10 IPBES experts and five resource people from Finnish institutions. All participants were provided with materials and data from every chapter. Each session of the workshop was structured around two parts: an introduction where an IPBES expert briefly presented the main findings of a specific chapter, followed by an open discussion chaired by an indigenous representative for feedback and/or criticism. The consultation engaged numerous topics such as the ability of Arctic indigenous peoples to manage transboundary biodiversity, effective management strategies and the contributions of Arctic IPLC to reach global goals. A set of 66 reviewer comments were then formally submitted as part of the external review process on behalf of the Dialogue participants.

existing meetings where IPLC were present, panels at conferences attended by IPLC or as longer workshops specifically focused on the GA (see Box 3; also see Table S1).

3 | RESULTS: ILK IN THE GA

ILK emerged as a particularly useful source of information for the GA in several key areas, many of which are of relevance to applied ecologists and future ecological assessments. While this is not an exhaustive list of all ILK used in the GA, we highlight these areas below as being representative of how the GA combined different knowledge systems.

3.1 | Using ILK to enrich concepts of nature and assess nature's contributions to people

The concept of 'nature' formed a key part of the GA, defined as 'all the living components of the natural world', and is analogous to many ILK-derived concepts like 'Mother Earth', 'Pachamama' (Andes) or 'Country' (Australia). Views of nature include ideas of whether humans are separate from or an integral part of their environment, the latter being a concept widely shared among IPLC (McElwee et al., 2018). Literature was reviewed on the co-production of benefits from nature, particularly IPLC practices that enhance biodiversity and ecological functioning, such as land management for ecosystem heterogeneity and creation of new ecosystems composing wild and domesticated species (Garibaldi & Turner, 2004; Molnár, 2017). These practices are often based on ILK-derived principles such as health of the land, caring for country and reciprocal responsibility (Sangha & Russell-Smith, 2017).

The GA also followed a recent IPBES decision to use the concept of *nature's contributions to people* (NCP) rather than 'ecosystem services' based on a more comprehensive understanding of human-nature interactions and a wider range of values, including those embedded in ILK (Díaz et al., 2018; Pascual et al., 2017). Eighteen categories of NCP were assessed, and ILK from all regions of the world contributed to understanding the co-produced nature of many realized NCP (that is, those potential NCP derived from nature that are effectively co-produced with the help of anthropogenic assets; Table 1). Table 1 shows a few indicative NCP, even though all 18 were assessed using different types of ILK, with some being more comprehensive than others; for example, NCP 12 relates to food provisioning, with well-demonstrated examples of ILK perspectives on agrodiversity and human health, while the assessment of other NCP (such as regulation of climate) was less able to use ILK-based evidence.

3.2 | Using ILK to assess and monitor status and trends in nature

A number of IPLC use indicators of ecosystem change derived from ILK; such indicators can be considered biocultural, as they consider jointly nature and human quality of life (Caillon, Cullman, & Verschuuren, 2017; Sterling et al., 2017). These biocultural indicators reflect a holistic approach to material and immaterial dimensions of nature adapted to particular economic, ecological and cultural environments (Berkes, 2012; Molnár, 2017). These observations often cover remote and less studied habitats and regions that present difficulties for scientific monitoring (Huntington, Fox, Berkes, & Krupnik, 2005). ILK can thus help generate understanding of diverse phenomena, ranging from habitat disturbance, culturally important species and drivers of change (Garibaldi & Turner, 2004; Tam, Gough, Edwards, & Tsuji, 2013).

The GA reviewed over 100 papers and reports on IPLC indicators, compiling more than 321 unique indicators that are locally developed, tested and relevant, many used for decades or longer (Mantyka-Pringle et al., 2017; TEBTEBBA, 2008; Turner & Clifton, 2009); since the GA was published, hundreds more have been documented (see Table 2). These indicators of nature were synthesized by grouping them according to selected Essential Biodiversity Variables and mapped against major ecosystem types. Notably, most ILK-based indicators reviewed showed negative trends (Table 2).

3.3 | Using ILK to shape target-setting and achievements toward global goals

The GA assessed global progress on key biodiversity and sustainable development goals, like the Aichi Biodiversity Targets (ABTs), Sustainable Development Goals (SDGs) and targets of major

TABLE 1 Contributions of ILK to understanding and managing selected NCP

Key NCP	Discussion of how ILK or IPLC relate	Examples of ILK-derived indicators
NCP 2: Pollination and dispersal of seeds and other propagules	ILK informs management practices that enhance pollinator activity There are many totemic and/or spiritual relationships between people and pollinators represented in ILK ILK has helped revitalize practices of beekeeping in some areas. Many IPLC have introduced hives into agroforestry systems Lower use of pesticides among many IPLC fosters pollinator health	Timing of flowering signals and honey harvest-times can indicate pollinator health Narratives of specific pollinators and the species they prefer can provide indicators for monitoring Pollinator behaviour and population size can be used as indicators of ecosystem health Nomenclature and vernacular taxonomy can inform about the diversity of pollinators
NCP 9: Regulation of hazards and extreme events	Many IPLC use ILK to predict extreme events and adapt to their impacts, including using oral and other traditions to pass on knowledge about frequency, impacts and warning signs	Observation and monitoring of multiple factors to anticipate extreme events, including behaviour of animals Ways to manage ecosystems to reduce hazards
NCP 12: Food and feed	Many food systems derive from long-standing crop selection and domestication of local landraces and varieties based on ILK Knowledge transmission in ILK often includes the importance of biotic interactions for producing food, such as connections between plants, animals, fungi or soil microorganisms Food is produced and consumed through social networks and is influenced by cultural and spiritual dimensions in different IPLC Quality and diversity of food available to IPLC is globally decreasing because of changes in food systems	Nomenclature and list of species (both wild and cultivated) that are important for diet and health Narratives and practices regarding cultivation practices and techniques that enhance agrodiversity Nomenclature and classification may provide clues identifying species or varieties that are genetically distinct Reference to specific species in narratives and oral traditions in places where those species no longer exist indicate extinctions and can be used to monitor trends
NCP 14: Medicinal, biochemical, and genetic resources	ILK has helped identify and name new species ILK has helped identify sources of new drugs for development through bioprospecting ILK about place–based medical systems provides IPLC with locally available and effective products There have been trends towards a rapid rate of loss of medicinal plants for IPLC at the global level	Nomenclature, classification and lists of medicines indicate diversity of health practices and biodiversity Knowledge of plant distribution within ecosystems and landscapes Knowledge of threats and drivers of change (e.g. quantities traded and overexploited species)
NCP 15: Learning and inspiration	Nature has highly influenced artistic expression, education and skills among IPLC Identity, learning and inspiration combine attention to natural and cultural factors through concepts like sense of place Sacred sites are important both for learning and inspiration but also for the conservation of biodiversity Learning and inspiration contributes to resource management, e.g. learning from songlines in Aboriginal Australia Children's direct relationship with nature is crucial for learning. Disruption of transgenerational learning processes among IPLC is related to loss of languages, loss of co-produced habitats and socio-cultural disruption	Depictions of nature symbolized within art, theater, language and other forms of artistic or cultural expression Declines in transgenerational learning and language losses

Note: References for the examples above can be found in Table S2.

biodiversity-related conventions such as the Ramsar Convention and others. The analysis included documenting IPLC contributions to achieving targets and how progress (or lack of it) might affect them. The review suggested that IPLC and ILK have made important contributions, although these are not always acknowledged (Table 3). Given the holistic nature of ILK, IPLC can aid in the identification of trade-offs and synergies between goals, such as how expansion of terrestrial protected areas (ABT11) may have unintended consequences on IPLC quality of life (SDG 3; Agrawal & Redford, 2009). However, despite the contributions noted in Table 3, evidence suggests there is a gap between indicators defined in global policies and those that are locally important or derived from ILK (Zorondo-Rodríguez et al., 2014).

3.4 | ILK in scenarios and pathways

The GA made use of scenarios to understand changes to nature, NCP and good quality of life, relying on two types of scenarios (exploratory and intervention).[3] However, in both cases, most global scenario archetypes do not directly address ILK and IPLC. For

[3]Exploratory scenarios examine a range of plausible futures, based on potential trajectories of drivers, and are used for high-level problem identification and agenda setting. Intervention scenarios are those that evaluate alternative policy or management options, and can include either 'target-seeking' or 'policy-screening' analysis: target-seeking scenarios are pathways to achieve one or more specific goals (e.g. ABTs or SDGs), while policy-screening (also known as 'ex-ante scenarios') are scenarios used to evaluate the effects of alternative policy or management options (IPBES, 2016).

TABLE 2 Indicators of trends in nature developed, tested and used by IPLC and based on ILK

Trends in ecosystems	Total ILK indicators	Examples of indicators	Direction of trends
Decreasing resource availability	74	Distance needed to walk to hunt. Length of harvest season Daily catch	83% are negative
Declines in wild species populations	283	Abundance of culturally significant species	56% are negative
Decreases in health conditions of wild animals	88	Behaviour of animals Colour of fat of harvested animals	80% are negative
Arrival of new pests/alien species	25	Increased pest occurrence	95% are negative
Shifting species compositions within landscapes	59	Changing proportion of palatable and unpalatable plants on rangelands Appearance of new species	81% are negative

Note: These indicators are locally based contextualized indicators that are often difficult to upscale; references for the examples above can be found in Table S2.

TABLE 3 ILK and IPLC contributions to global goals

Target/goal	Role for ILK	Implications for IPLC if target not met
ABT 2 (Biodiversity values)	Using ILK and IPLC worldviews, some countries (e.g. Bolivia, New Zealand) recognize the rights of ecosystems to exist, reproduce and thrive	Without recognition of ILK values, IPLC rights may be violated
ABT 8 (Pollution)	Local observations enable IPLC to monitor, map and report pollution	IPLC remain largely unsupported in their struggles against polluting operations and face challenges in receiving compensation
ABT 9 (Invasive alien species)	IPLC perspectives, worldviews and interpretations influence reactions to new species. ILK has helped to strategically manage impacts	Introduced species impact IPLC livelihoods and cultures in dynamic and sometimes contradictory ways. Management strategies that ignore this complexity risk aggravating social impacts and being locally unpopular
ABT 15 (Restoration)	IPLC have played an active role in restoring ecosystems. Some restoration has relied on ILK to select which ecosystems should be restored and how	The failure to restore degraded ecosystems in areas inhabited by IPLC threatens their cultural well-being and undermines access to important NCP
SDG 13 (Climate action)	ILK can help understand climate change impacts on biophysical and socioeconomic systems. Knowledge co-produced between science and ILK can result in climate mitigation and adaptation strategies that are better adapted to highly variable local conditions	IPLC are disproportionately affected by lack of action on climate change, exacerbating their vulnerability
SDG 14 (Life in oceans)	ILK can identify marine species at risk of extinction. IPLC have also enhanced recovery, conservation and sustainability of marine and freshwater fisheries and ecosystems	Deterioration of marine ecosystems affects food security and social and spiritual integrity of many IPLC

Note: References for the examples above can be found in Table S2.

TABLE 4 Existing and potential integration of ILK in scenarios

Type of scenario assessed	Actual inclusion of ILK	Potential benefit for scenarios from use of ILK
Exploratory	Limited to sources used in meta-analysis	ILK frequently embodies long-term social-ecological knowledge and can be invaluable to informing, interpreting and improving long-range projections and future scenarios, as well as better understanding of uncertainty
Target-seeking	Limited to particular scenarios (e.g. 1 of 2 critical pathways for sustaining freshwater ecosystems is through increasing groundwater recharge, wetlands and alternative storage techniques, some of which employ ILK)	ILK includes approaches on how to share information and adaptive practices to manage transitions, including practices such as storytelling
Policy-screening	Some relevance at global level, but restricted to specific policies like recognition of land tenure or IPLC-managed protected areas	ILK can helpfully inform local policy development pathways for sustainable future by providing indications of important local values

Note: References for the examples above can be found in Table S2.

TABLE 5 Policy instruments, use of ILK and involvement of IPLC

Key policy instruments	Degree to which ILK is represented in policy (High, Medium, Low) and examples	Degree to which IPLC are involved in policy making (High, Medium, Low) and through what processes	Regional trends
Payments for environmental services (PES)	Low to Medium Values for determining benefit-sharing Identification of key ecosystem services	Medium to High IPLC often highly engaged in benefit-sharing	Higher involvement of IPLC in Latin America, with more secure tenure rights. Little involvement in Africa
Reduced emissions from deforestation and degradation (REDD+)	Low to Medium Community-based monitoring	Low to Medium State recognition of IPLC land rights have led to some successful local REDD + projects. Some IPLC advocacy at global fora	Higher involvement of IPLC in Latin America
Marine protected areas	Medium Fishing quotas for recovery Identification of key species	Medium to High IPLC have been involved in policymaking for specific MPAs, including based on customary tenure	High involvement of IPLC in Oceania and certain parts of the Arctic
Sustainable wildlife management	High Monitoring of populations (e.g. early detection of animal health)	Medium to High IPLC have benefited from compensation policies	Mostly implemented in terrestrial ecosystems in Africa and coastal/marine ecosystems in the Arctic
Invasive Alien Species removal policies	Low Baseline and risk assessments	Low IPLC prevent, detect and eradicate IAS in their territories but rarely included in policy design	Mostly implemented in Australia, Canada and New Zealand
Ecological restoration programs	Medium Culturally important species for restoration	Medium IPLC have initiated or been involved in local restoration projects	Involvement of IPLC in Southeast Asia, New Zealand and Mexico
Pollution reduction policies	Low to Medium Monitoring of pollution impacts and biomonitoring	Medium IPLC have advocated for expulsion of polluting activities from their territories	Mostly implemented in the Arctic, North America and some parts of the Amazon Basin

Note: References for the examples above can be found in Table S2.

intervention scenarios, few exist at the scale and scope needed, so the GA primarily used sustainability-oriented exploratory scenarios as substitutes. These scenarios are global but are constructed on the basis of meta-analyses of local studies and IPBES Regional Assessments, relying primarily on expert knowledge, thus ILK and IPLC perspectives were incorporated in only a few examples. Regional and local exploratory scenarios that were analysed did occasionally incorporate information from ILK and IPLC; for instance, Participatory Scenario Planning has been used to address and integrate the priorities of distinct stakeholder groups in local studies and projects (Butler et al., 2016; Oteros-Rozas et al., 2015). Available target-seeking and policy-screening scenarios to compare

alternative policy options intended to alter the future state of nature and NCP also showed limited direct uses of ILK, although some did include specific policies related to IPLC (Table 4).

3.5 | Using ILK and IPLC involvement to generate options for decision-makers

The GA was mandated with identifying policy options available to achieve global targets and to improve management of nature and NCP. Literature reviews included assessments of how ILK has been used in policy formulation, which has varied widely, as well as how IPLC influence policy processes. For example, IPLC have managed to exert substantial influence in several state-centred policymaking processes (Shawoo & Thornton, 2019), and increasingly some countries and subnational governments are adopting biocultural approaches to policy that include ILK in the formation of 'knowledge governance' structures (Manrique, Corral, & Pereira, 2018). However, there is wide variation in which policies incorporate ILK or involve participation of IPLC (Table 5). Moreover, IPLC still face numerous challenges and barriers, including a lack of holistic planning approaches able to make use of the multifaceted nature of ILK and lack of formal informational and participatory mechanisms (Cariño, 2005).

4 | DISCUSSION

Significant knowledge has been produced by both formal science and ILK on varied aspects of environmental change, which combined lend multiple lines of evidence on the nature, scope and attribution of such impacts at local to global levels. However, seeking complementarities between multiple knowledge systems is not always straightforward or without problems. Below we discuss some of the key challenges, lessons learned and policy relevance of the use of ILK in the GA.

4.1 | Challenges to incorporating ILK in assessments

Even though the systematic literature reviews used by the GA were open to multiple sources of evidence (Tengö et al., 2014), and online calls for references and case studies were useful for opening up the process beyond initial experts' knowledge, the GA still faced a number of challenges in ensuring that different knowledge systems were engaged in a transparent, equitable and legitimate manner (Hill et al., 2020). Understanding of the depth and breadth of ILK is still insufficient, and there are major documentation gaps that may result in the exclusion of important ILK in peer-reviewed studies (Cámara-Leret & Dennehy, 2019). For example, there is considerable regional unevenness in existing literature, with more ILK documented from the Arctic and less from other major areas like sub-Saharan Africa and Eastern Europe (although there was some literature found for every major region). Because assessments only review existing publications and do not create new data, it is not possible to achieve a perfectly representative balance of evidence across all regions of the world, although it is a useful process to identify knowledge gaps. Future assessments will need to pay attention to, and develop ways of dealing with, the underrepresentation of ILK literature; in our case, the online call for additional resources did in fact generate evidence we had not found in the peer-reviewed literature.

It was also challenging to balance the need for large-scale synthesis of ILK with the attention to contextualized knowledge, often represented through specific local case studies. For example, in assessing indicators of ecosystem change, it was difficult to reconcile the generalizable indicators most used in scientific monitoring (often expressed as percentages of population change or through spatial analysis) and those derived from ILK, where data are often non-quantitative, developed within oral traditions and based on interconnectedness (Berkes & Berkes, 2009; Huntington et al., 2005; Turner & Clifton, 2009). This is why IPBES has stressed the need to use a gradient of complementary approaches, ranging from generalizing to context-specific through a multiple evidence base crossing spatial and temporal scales (Díaz et al., 2015, 2018). For the GA, this meant a variety of inputs, ranging from systematic reviews of local case studies, regional consultations with IPLC representatives and aggregated geospatial data at the global level, among others.

4.2 | Logistical needs for assessments

Inclusion of ILK in assessments requires extra money and time, a commitment from the start (such as in conceptual frameworks and methodologies) and use of networks to ensure engagement and support from IPLC for elements that can be co-produced (e.g. see Hill et al., 2020). Yet the benefits of such investments can be large; for example, ILK-based indicators about nature proved to be highly useful to help link changes in natural systems with direct and indirect drivers and impacts on local livelihoods, which has been a challenge for science-based indicators alone (Caillon et al., 2017).

Improving future assessments requires expansion of the peer-reviewed literature, including more collaborative and co-produced studies with IPLC (Reyes-García & Benyei, 2019; Tengö et al., 2014; Thorton & Scheer, 2012). Mutual trust and collaboration are keys to improving co-production of ecological research (Adams et al., 2014; Cámara-Leret & Dennehy, 2019) as is inclusivity and reflexivity in research design (Parsons, Fisher, & Nalau, 2016). In other words, ILK and science can co-construct common research agendas for the benefits of both nature and IPLC (Armitage, Berkes, Dale, Kocho-Schellenberg, & Patton, 2011). Examples of this include the work of the NGO SwedBio, which has used the Pollination Assessment produced by IPBES in 2016 to engage IPLC in thinking through lessons learned for agricultural management (Malmer et al., 2019).

Co-production would be particularly useful in areas where the GA identified gaps in use of ILK, namely around scenarios and future forecasts concerning nature, NCP and quality of life. Future global

scenarios could incorporate more ILK through use of more local participatory target-seeking scenarios, and these could be used to better formulate global goals, given that many of the existing targets and goals do not necessarily reflect the heterogeneity of IPLC and their priorities and worldviews. Yet to be effective, such participatory approaches must engage IPLC from the very beginning and throughout the process, construct scenarios that truly represent ILK and local priorities and deal with power differences among stakeholders (Oteros-Rozas et al., 2015).

4.3 | Translating ILK into policy contexts

The GA demonstrated the global importance of IPLC to biodiversity and ecosystem management, particularly given how much of the world's important conservation lands are under use, management, and ownership by them (Garnett et al., 2018). However, the GA also concluded that general trends of loss of ILK, declines in nature and NCP used by IPLC, and challenges to political rights and customary lands have all challenged decision-making by IPLC (IPBES, 2019). Use of multiple knowledge systems and engagement of IPLC are pathways to improving ecological policy, but require convincing decision-makers that they can benefit from these inputs.

The evidence provided in the GA can help make the argument that inclusion of IPLC capabilities and social-cultural values are critical for both ecosystem assessments and achieving policy goals for human well-being, such as the SDGs. For example, in one case study reviewed from Australia, customary management of tropical savannas provided food and medicine, cultural practices and other NCP that enabled the Indigenous traditional owners to maintain their knowledge and skills, resulting in a wide range of benefits (healthy lives, early childhood development, pride and self-respect, ability to pass on ILK to the next generation), but which were mostly ignored by natural resource policies (Sangha & Russell-Smith, 2017). The other numerous examples in the GA of positive benefits from a biocultural approach, as well as negative examples of policies that have failed to improve livelihoods or ecological health when IPLC and ILK are ignored, were aimed at improving decision-makers' evidence bases, given constraints on IPBES assessments making specific policy recommendations.

5 | CONCLUSIONS

The GA has demonstrated the validity of working with different knowledge systems, and the IPBES strategy to integrate ILK and activities to engage IPLC can be useful for other assessments. Indeed, we believe all ecological surveys, monitoring and large-scale assessments could benefit from reciprocal engagement in co-producing knowledge or identifying complementarities between multiple knowledge systems (Tengö et al., 2014, 2017). As we have noted, ILK has particular relevance for ecological assessments in several key areas, including defining how natural and cultural systems co-produce each other, identifying trends of change through diverse biocultural indicators and improving the implementation of sustainable development goals and policies.

The process carried out in the GA has also contributed to side benefits of capacity building for authors and strengthening connections between IPBES and IPLC networks. Further, acknowledging different value systems in decision-making has the potential for improving power asymmetries and equity issues in both science practice and policy implementation. Lessons learned from the GA can enable better future assessments and solutions through evaluation of a diversity of often distinct knowledge systems and interlinkages between culture and nature, achieved through combining overall synthesis with context-specific perspectives. The GA has shown the usefulness of a multifaceted and systematic approach to nature assessments that not only identifies where ILK can inform existing understandings of ecosystem health and human well-being, but also identifies the challenges and opportunities for engaged knowledge production in the future.

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AUTHORS' CONTRIBUTIONS

All authors were involved in the GA, either as Co-Chairs, Coordinating Lead Authors, Lead Authors, Fellows, or Contributing Authors. P.M. led the writing team, with the help of A.F.-L. and E.S.B., and all authors contributed critically to the writing and gave final approval for publication.

DATA AVAILABILITY STATEMENT

Data have not been archived because this article does not use data.

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Additional supporting information may be found online in the Supporting Information section.

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