



## Working with indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people

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Working with indigenous and local knowledge (ILK) is vital for inclusive assessments of nature and nature's linkages with people. Indigenous peoples' concepts about what constitutes sustainability, for example, differ markedly from dominant sustainability discourses. The Intergovernmental Platform on Biodiversity and Ecosystems Services (IPBES) is promoting dialogue across different knowledge systems globally. In 2017, member states of IPBES adopted an ILK Approach including: procedures for assessments of nature and nature's linkages with people; a participatory mechanism; and institutional arrangements for including indigenous peoples and local communities. We present this Approach and analyse how it supports ILK in IPBES assessments through: respecting rights; supporting care and mutuality; strengthening communities and their knowledge systems; and supporting knowledge exchange. Customary institutions that ensure the integrity of ILK, effective empowering dialogues, and shared governance are among critical capacities that enable inclusion of diverse conceptualizations of sustainability in assessments.

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### Current Opinion in Environmental Sustainability 2019, 43:8–20

This review comes from a themed issue on **Indigenous conceptualizations of 'sustainability'**

Edited by **Pirjo K Virtanen, Laura Siragusa and Hanna Guttorm**

Received: 28 July 2019; Accepted: 17 December 2019

<https://doi.org/10.1016/j.cosust.2019.12.006>

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## Introduction

Global deterioration of nature continues unabated, driving major changes to earth's life support systems and human societies who depend on them [1]. In response, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) was established in 2012 with the overall purpose of strengthening 'the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, and long-term human well-being.' IPBES recognizes that the diverse social, cultural and environmental knowledge of indigenous peoples and local communities (IPLC) contributes extensively to sustainability across large parts of the globe, and thus has a major role to play in assessments and policy formulation for biodiversity and ecosystem services [2–5].

IPBES therefore committed to "recognize and respect the contribution of indigenous and local knowledge<sup>33</sup> to the conservation and sustainable use of biodiversity and ecosystems" as one of its eleven operating principles.<sup>34</sup> The IPBES Plenary, the governing body involving all member states, at its 5th Plenary meeting in 2017, adopted the "Approach to recognizing and working with indigenous and local knowledge in IPBES" (IPBES 5/15/Annex II to decision IPBES-5/1, hereafter the ILK Approach). This commitment reflects wide-spread international recognition, for example through the UN Declaration on the Rights of Indigenous Peoples, that IPLC have the right to be meaningfully engaged in decision-making processes that impact their livelihoods, cultures and societies. Furthermore, the scope and content of ILK brings insights of great relevance for ecosystem governance, such as in controlling deforestation, reducing carbon dioxide emissions [3] understanding climate change and in sustaining and restoring resilient landscapes [2,3,5].

The ILK Approach builds on a substantial body of work where IPLC have taken opportunities to promote recognition of the value of their knowledge, including the Millennium Ecosystem Assessment (MEA) [21] and the Convention on Biological Diversity (CBD), especially

<sup>33</sup> The Conference of Parties to the CBD at its 12th Meeting in October 2014 decided to replace the term 'indigenous and local communities' with 'indigenous peoples and local communities' in documents, reflecting many years of advocacy led by the International Indigenous Forum on Biodiversity about the problematic simplification in the original term in the CBD. IPBES is using the term 'Indigenous and Local Knowledge' (ILK) as a shorthand to capture the immense diversity and complexity. In this article, we adopt the Indigenous and Local Knowledge (ILK) shorthand and the term 'indigenous peoples and local communities' (IPLC).

<sup>34</sup> Clause II 2 (d) from 'Functions, operating principles and institutional arrangements of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services'. Adopted by the second session of the plenary meeting to determine the modalities and institutional arrangements for IPBES, held from 16–21 April 2012 in Panama City, Panama. Available from: <https://ipbes.net/functions-operating-principles-institutional-arrangements-intergovernmental-science-policy-platform>.

the adoption of the Nagoya Protocol. The ILK Approach is composed of three elements: (i) concepts, practices, and steps to undertake IPBES assessments; (ii) enabling conditions for the inclusion of ILK, including policy support tools and capacity building; and (iii) institutional arrangements, including a participatory mechanism. Here we present, for the first time in the international literature, the concepts, practices and steps to undertake IPBES assessments, with case studies from experiences globally that illustrate their rationale. We identify potential solutions to ongoing challenges for working across knowledge systems in assessments more broadly. As IPBES is establishing new standards and platforms for co-production across knowledge systems that hold implications for action and equity in other science-policy-practice arenas, we begin with a brief discussion of the key issues for working across ILK and science.

IPBES has recognized that ILK systems are verified, implemented, challenged and applied within their own processes of validation [6] and their own conceptualizations, for example, of what is 'nature' and 'sustainability'. Diverse internal practices of IPLC who occupy their traditional territories (Box 1) ensure legitimacy and credibility for their ILK, based, for example, on historical experiences via natural experiments, expert peer-review, cultural norms and collective procedures to evaluate and validate knowledge [7,8]. The crucial distinguishing feature of ILK systems is that they are established, controlled and managed by IPLC through formal and informal institutions that guide practice [9<sup>••</sup>,10,11]. These institutions arise *in-situ*, some spanning regions and

### Box 1 Who are indigenous peoples and local communities? Based on [14,15,16<sup>••</sup>]

The United Nations recognizes that no formal definition of whom are indigenous peoples and/or local communities is needed—self-identification is the key requirement. Descriptions provided here, based on prior studies [14,15,16<sup>••</sup>] are for guidance and information in the context of working with ILK in assessments of nature and nature's contribution to people and their quality of life.

Indigenous peoples include communities, tribal groups and nations, who self-identify as indigenous to the territories they occupy, and whose organization is based fully or partially on their own customs, traditions, and laws. Indigenous peoples have historical continuity with societies present at the time of conquest or colonisation by peoples with whom they now often share their territories. Indigenous peoples consider themselves distinct from other sectors of the societies now prevailing on all or part of their territories.

Local communities are groups of people who maintain inter-generational connection to place and nature through livelihood, cultural identity, worldviews, institutions and ecological knowledge. Local communities may be settled together, or they may be mobile depending on seasons and customary practices. Communities who come together in urban or peri-urban settings around common interests, such as beekeeping or tree-planting, are considered here to be 'communities of interest' or 'communities of practice' rather than local communities.

continents, reflecting beliefs, values and learning from collective practices, lived experience, everyday observation and monitoring of the environment, within the context of long-term people-nature interactions. They are transmitted through myriad forms, including song, dance, paintings, rituals, accounting and tenure systems organising the lives of millions of people across the world [12,13].

Building synergies between ILK and scientific knowledge systems has been recognized as a key opportunity to move towards sustainable ecosystem governance at multiple scales [9<sup>••</sup>,17,18]. ILK encompasses diverse worldviews and transmission contexts that incorporate cultural, economic, religious and pragmatic dimensions. Conceptualizations of sustainability include the ideas of living in harmony with nature and living in balance and harmony with Mother Earth with deep spiritual dimensions [6,19]. Scientific initiatives have at times resulted in ILK being removed from its cultural context, distilled and synthesised to the extent that undermines its original meaning and on-going capacity for validation, change and adaptation, [10]. As a result, there is a legacy of mistrust; communities identify risks such as knowledge theft, lack of appropriate benefit sharing, and heightening of power inequities [20,21]. Equitable partnerships that address power asymmetries, and provide IPLC with opportunities to navigate the engagement between science and ILK in ways that strengthen their rights and governance, and do not further entrench histories of oppression, are critical [22]. Efforts to build synergies, therefore, require time to build trust, identify differences and commonalities, generate common visions, and co-produce knowledge and practices through respectful partnerships that reflect the interests of all parties and support mutually beneficial outcomes [9<sup>••</sup>,23]. This paper, about the IPBES ILK Approach, provides evidence-based guidance about concepts, practices and steps that will meet the diverse challenges in working across knowledge systems for inclusive assessments [24]. While several of the authors have played various roles in IPBES, this paper represents their individual views and scholarship, and has not been formally endorsed by IPBES.

### Building an approach to working with ILK through ongoing learning

The ILK Approach adopted by the IPBES Plenary in 2017, presented and analysed in this manuscript, reflects practices of dialogue and co-production across knowledge systems, developed through global workshops [8,25,26], literature review, expert working groups, debates, including at the 2016 and 2017 IPBES Plenaries, and collections of relevant case studies. These cases were assembled, based on information-richness, within the IPBES Indigenous and Local Knowledge Task Force, a group of experts appointed by the IPBES Plenary for the first work program, 2014–18, whose key role was to advice

on procedures for working with ILK. The ILK Approach incorporates lessons from the pollination assessment, completed in 2016, and the regional and subregional dialogues held in 2016 for the four regional assessments (completed in 2018) [9<sup>••</sup>,27–31]. Testing has continued through the Land Degradation and Restoration Assessment, and the Global Assessment, completed in 2018 and 2019 respectively, and the ILK Task Force provided further advice on methodologies in 2019 (IPBES/7/INF/8). Outcomes from the later assessments, application of improved methodologies, and greater ongoing engagement by IPLC in IPBES, will undoubtedly lead to greater learning, insights and potentially future changes to the ILK Approach by the IPBES Plenary, based on accumulated evidence of what works (or doesn't) and why [32<sup>•</sup>]. Here we focus on showing how the Approach supports ILK in assessments, the evidence behind it, and case studies that contributed to its development, through consideration of four components: (i) key concepts; (ii) practices; (iii) steps; and (iv) specific challenges identified in the text of the ILK Approach. We then discuss gaps that require ongoing attention and conclude with identifying key opportunities.

### Key concepts for working with diverse knowledge systems in assessments

Three evidence-based premises, (clause 6<sup>35</sup>) underpin working with ILK in assessments. First, ILK is dynamic and holistic, encompassing governance, social, economic accounting, tenure and family institutions, language, naming and classification systems, resource use practices, rituals, spirituality and worldviews [33]. Through practice (seeing, doing, devising solutions, applying proven successful institutions, principles and frameworks), knowledge is transmitted across generations, and problems are resolved, based on experiences accumulated through centuries of people-nature interactions [11,13].

Second, ILK is highly diverse, existing at the interface between the enormous variety of ecosystems and of cultural systems (e.g. farmers, fishers, beekeepers, pastoralists, hunter-gatherers, traditional medical practitioners) and their co-evolved biocultural diversity worldwide [16<sup>••</sup>,34<sup>•</sup>]. Diversity reflects the history of interactions, for instance through trans-continental contacts over millennia, migrations and the more recent processes of colonization and post-colonial assertion of rights [35,36]. While generally rich at the fine scale, and more limited at broader scales, ILK has multi-scalar dimensions, for example in relation to migratory species in the Americas and 'dreaming tracks' that cross Australia [37,38] (Box 2).

<sup>35</sup> Numbered clauses refer to the clauses in the IPBES ILK Approach, found at IPBES 5/15/Annex II to decision IPBES-5/1.

**Box 2 What are indigenous and local knowledge systems?  
Excerpt from IPBES 5/15/Annex II to decision IPBES-5/1**

Indigenous and local knowledge systems are in general understood to be bodies of integrated, holistic, social and ecological knowledge, practices and beliefs pertaining to the relationship of living beings, including people, with one another and with their environments. Indigenous and local knowledge is grounded in territory, is highly diverse and is continuously evolving through the interaction of experiences, innovations and various types of knowledge (written, oral, visual, tacit, gendered, practical and scientific). Such knowledge can provide information, methods, theory and practice for sustainable ecosystem management. Most indigenous and local knowledge systems are empirically tested, applied, contested and validated through different means in different contexts.

Maintained and produced in individual and collective ways, indigenous and local knowledge is at the interface between biological and cultural diversity. Manifestations of indigenous and local knowledge are evident in many social and ecological systems. In this context, the approach understands 'biocultural diversity' as biological and cultural diversity and the links between them.

The definitions of 'indigenous and local knowledge' or 'indigenous peoples and local communities' are often context specific and vary within and across regions.

Third, ILK is managed by distinctive cultural institutions, each with their own methods of validation, and rules about who can hold what types of knowledge, where and when it can be transmitted, and how it can be shared [7,39]. Who is involved in working with ILK is therefore critical. The IPBES approach recognizes the need for three types of actors in assessments: ILK-holders; ILK-experts; and Experts on ILK (Table 1) (clause 6d).

### Practices for ensuring IPLC and ILK involvement in assessments

Our analysis of the IPBES decision document, the ILK Approach, identified sixteen discrete sets of practices scattered across the clauses, which we have grouped into four categories: respecting rights; supporting care and mutuality; strengthening IPLC and their knowledge systems; and supporting knowledge exchange. Table 2 introduces these four categories, together with the number of the relevant clause from the Approach; and presents the practices included within each category, the associated evidence base and a case study for each practice. **Respecting rights** involves: ensuring adherence to Free Prior and

Informed Consent (FPIC); building on positive initiatives of relevant multi-lateral agreements such as the *UN Declaration on the Rights of Indigenous Peoples* and the CBD; and avoiding any activities potentially prejudicial to rights. **Supporting care and mutuality** focuses on key capacities including: building trust; promoting inclusiveness and cultural plurality; acknowledging the (relatively slow) time frames of customary decision-making; and respecting diverse styles of engagement, for example, rituals and ceremonies. **Strengthening IPLC and their knowledge systems** requires: promoting activities *in-situ* where the knowledge is produced, governed and validated; ensuring that information storage adheres to relevant standards; building capacity; ensuring meaningful participation; and working with existing IPLC organisations and networks. **Supporting knowledge exchanges** relies on: collaborative problem definition; catalysing exchanges that recognize knowledge systems as working in parallel, each with their own histories and validation methods; and supporting empowering dialogues as iterative two-way processes.

The practices in these four categories are not mutually exclusive but interact and reinforce each other through underlying capacities and challenges. First and foremost is the ongoing capacity of IPLC to maintain the customary institutions and governance systems that ensure the integrity, validity and ongoing transmission of their knowledge systems and vice-versa. ILK has governance-value, and is recognized by IPLC as an irreplaceable source of guidance in building the future of their societies [22]. The second underlying capacity is that of individuals being able to work across knowledge systems, to develop strategies for dealing with the subtle, sometimes unconscious manifestations of power that emerge from the encounter, and undertake the deep processes of negotiation and reflection required to respect different worldviews [75]. Scientists need to recognize that both science and ILK include knowledge and practices that undermine, as well as support, ecosystem sustainability. Third is the capacity of the dialogue workshops to support knowledge exchange. Several factors have been identified as important: hosting the dialogue with an IPLC in their territory where the *in-situ* functioning of an ILK becomes more evident (scaling-deep); respecting cultural

**Table 1**

**Types of actors required for working with ILK in assessments. Adapted from IPBES 5/15/Annex II to decision IPBES-5/1**

<i>Indigenous and local knowledge holders (ILK-holders)</i>	Persons from indigenous peoples and local communities with knowledge from their own indigenous peoples and local communities.
<i>Indigenous and local knowledge experts (ILK-experts)</i>	Persons from indigenous peoples and local communities who have knowledge about the issues and contexts of indigenous and local knowledge across their region and/or globally. They may also be indigenous and local knowledge holders.
<i>Experts on indigenous and local knowledge (Experts on ILK)</i>	Persons who have knowledge about the issues and contexts of indigenous and local knowledge across their region and/or globally, who are not from indigenous peoples and local communities.

Table 2

## Practices for working with ILK recognized in the IPBES ILK Approach, evidences behind practices and selected case studies

# <sup>a</sup>	Practices for working with ILK recognized in the IPBES Approach	Evidence behind this practice	Case study example
Respecting rights			
11	Seek free prior informed consent	FPIC is recognised as a human right under international law and some nation-state laws [40]; good FPIC practices have been shown to strengthen collective knowledge and culture, while poor FPIC practices can undermine these [41,42].	<i>Projects on Resilience of Coastal Social-Ecological Systems</i> at Hakai-Simon Fraser University in eastern Canada, that supported power-sharing through FPIC (and the right of the community to decline involvement in research) led to broader relevance, richer ideas and interpretations in research [43].
5c	Involve collaboration with and build on initiatives and guidelines of multilateral agreements and other entities	Discourse analysis has demonstrated that the CBD initiatives have opened positive recognition of ILK and IPLC [44]; World Heritage and other multilateral environment agreements have produced some positive practices for working with ILK, providing a foundation [45] for ongoing improvement [46].	<i>CBD Action Plan for customary sustainable use (global)</i> : The CBD supported IPLC to document their own case studies that facilitated their full and effective participation and resulted in the adoption of Plan of Action. The case also highlighted the challenge for recognition of the role of IPLC in areas less clearly directly linked to ILK [9**].
11	Activities should not occur where they would prejudice the internationally recognized rights of indigenous peoples and interests of local communities	Evidence is accumulating that ILK, and its role in biocultural conservation, is strengthened through activities that fully respect internationally-recognised rights—for example, to self-determination, to maintain their social and cultural institutions, to practice and revitalise their cultural traditions and customs and so on [47*].	<i>The Circumpolar Biodiversity Monitoring Program (circling Europe, Asia, North America and Arctic Islands)</i> : This international program has a co-governed Board that recognises the rights of eight nation-states and six Indigenous Peoples' Organisations, including the Sami Council [48]. They collaborate based on mutual rights-recognition, leading to Arctic community-based monitoring that features traditional and ecological knowledge [49].
Supporting care and mutuality			
7a	Build mutual trust between ILK-holders and natural and social scientists through cultural respect and sensitivity	Cultural respect and sensitivity is important to trust-building and increases the success of cooperative work and knowledge coproduction [50].	<i>Supporting traditional meadow management in Hungary and Romania, Europe</i> : Trust and respect between local traditional farmers and scientists was developed through following ethical guidelines. As a result, ILK and ecological evidence was co-produced, leading to new policies to protect traditional management practices and their biodiversity [51].
7e	Promote non-discrimination, inclusiveness and the recognition of social and cultural plurality	Inclusiveness and the recognition of social and cultural pluralities in the world promotes the full and effective participation of IPLC, enabling effective dialogues across knowledge systems [20,52].	<i>Reinstatement of customary seabird harvest by Māori in New Zealand</i> : Recognition of the social and cultural significance of harvest of <i>kuia</i> (Grey-faced petrel chicks) led to co-produced population models informed by Māori traditional knowledge and science, and the first harvest in 50 years in 2010 [53].
7c	Acknowledge the time needed for decision-making by customary and traditional institutions	Experiences with FPIC highlight the need to ensure people represent themselves through their own institutions and make decisions according to procedures and rhythms of their choosing, which may take considerable time [54,55].	<i>Transforming cross-cultural water research in Australia</i> : Allowing sufficient time for Aboriginal community members to decide whether and how to partner increased mutual trust and resulted in detailed documentation of the complex, diverse ecological and hydrological values of Ngan'gi speakers about the Daly River, and outputs of direct interest to the Indigenous research partners [56].
7d	Work in culturally appropriate environments, respecting diverse styles of engagement	Intercultural respect, the ability to nurture an equitable intercultural space and the participation of local intermediaries, leaders and interpreters can effectively help dialogues, negotiations and knowledge co-productions [55].	<i>Story-telling by leaders and elders (Africa, South America)</i> has been identified as effective for linking revitalisation of ILK with conservation practices among communities including Tsimane (Bolivia); Betsileo and Tanala (Madagascar); Daasanach (Kenya); and other places [57].

Table 2 (Continued)

# <sup>a</sup>	Practices for working with ILK recognized in the IPBES Approach	Evidence behind this practice	Case study example
Strengthening IPLC and their knowledge systems			
7f	Promote and strengthen the conservation of the <i>in-situ</i> knowledge systems of IPLC where it is gathered, used, applied, renewed, enhanced, tested, validated, transmitted, shared and governed	Strengthening knowledge <i>in-situ</i> , through the work of the knowledge-holders using their customary institutions, has been shown to ensure its relevance, legitimacy and energy: ‘the leaves of a tree, connected to their vital source, display health and vigour’ [58], p. 285.	<i>Mayan-Q’anjob’al “Chib’al”, Guatemala (Central America)</i> : The cultural tradition and practice of hunting birds and dragonflies during migration enabled the identification, using traditional knowledge, of the peak migratory period; scientific surveys using this information confirmed dramatic population declines [37].
18b	Facilitate, as appropriate, the access to and management of available sources of ILK, in line with relevant standards and conventions	Locally focused cultural community revivals globally are producing many ILK resources <i>in-situ</i> , in diverse languages [59]. Several international standards and conventions, including the Nagoya Protocol require agreements and protocols to protect IPLC rights [60].	<i>Communities researching their own Customary Tenure Systems to ensure benefits from REDD (Reducing Emissions from Deforestation and Degradation)</i> : Indigenous researchers, working with non-government organizations, documented their own people’s customary tenure systems, shared through a network of indigenous peoples’ organizations across continents, which became important input to global issues (climate change) and processes (REDD) [61].
17e	Build the capacity of IPLC to engage in and benefit from IPBES	Experiences with IPLC engagement in the <i>CBD</i> identify that specific mechanisms to build capacity at multiple scales, local, domestic and international, result in greater participation and benefit-sharing [62].	<i>Satoyami Initiative in Japan and globally</i> : Japanese government recognized that specific mechanisms were needed to keep ILK of rice terrace and other satoyama-satoumi landscapes, and introduced Payment for Ecosystem Services schemes that provide financial and labor support for knowledge-holders and youth [63].
8b	Ensure meaningful participation and engagement of IPLC	The engagement of the IPLC actors who manage the validity and integrity of their knowledge systems through their cultural institutions has been identified as critical to weaving ILK together with science [9**].	<i>Himalayan healers’ knowledge in Dolpo, Nepal</i> : Participatory building of a Traditional Tibetan Clinic increased recognition for the senior knowledge-holder, <i>amchis</i> , Nepal. Meetings of <i>amchis</i> during workshops to share knowledge without intervention by scientists facilitated their development curricula and recognition at the national level by the Ministry of Health [64].
7b, 26, 27a,	Work with existing organizations and networks of IPLC	Several IPLC networks and organizations have gained important skills and capacity in working with international biodiversity processes, such as the <i>CBD</i> , through influence and learning [65]. Useful assessment materials, such as the Local Biodiversity Outlooks, have emerged from the work of such networks [5].	<i>Peer-to-peer learning promotes the use of ILK in the Kimberley region, Australia</i> : Knowledge exchange among 250 Indigenous Rangers at an on-country workshop empowered their learning through social cohesion, collegiality, a sense of pride, and cultural connections [66].
Supporting knowledge exchange			
13	Search for collaborative definition of problems and goals in assessments	A process for joint problem definition has been identified as critical for successful collaborations between disciplines, sectors, and knowledge systems [67]. Collaborative approaches to biocultural indicators had led to re-conceptualizations of Sustainable Development Goals challenges in ways that produce benefits to ILK [68*].	<i>Muluri Farmers Conservation Group, Kenya</i> : Bringing traditional knowledge and science enabled collaboration definition of a multiple-benefit solution, domestication of medicinal plants, training, partnerships in communal libraries, developing technologies to generate a commercial natural product, resulting in enhanced biodiversity conservation [69].
18c	Promote and catalyze the mobilization of indigenous and local knowledge . . . in ways that reflect the concepts of parallel validation, or co-production	ILK can contribute to holistic and systemic understandings and actual governance of complex environments and adaptive responses to change. Realizing this potential requires ensuring that ILK is not compromised by scientific evaluations that reduce complexity and remove knowledge from cultural context [70].	<i>Farmers innovations to produce pesticides in Cameroon, Africa</i> : Farmers developed, validated and shared, alternative local pesticides to treat their cocoa plantations due to the non-availability and unaffordability of conventional pesticides following structural adjustment. The main successful pest control is a prohibited plant, hemp, highlighting the need for policy change [71].

Table 2 (Continued)

# <sup>a</sup>	Practices for working with ILK recognized in the IPBES Approach	Evidence behind this practice	Case study example
7b and e	Provide opportunities for participatory and empowering dialogues with IPLC on topics relevant to IPBES	Dialogue approaches allow for respectful interactions between knowledge systems that acknowledge the integrity of each system, and institutional and epistemological barriers [9**,23,2]. Platforms for interactions need to acknowledge asymmetries in rights as well as knowledge [72]. Indigenous-led initiatives are proving fruitful to overcome these asymmetries [39].	<i>Hin Lad Nai</i> dialogue: A contribution to IPBES post-assessment uptake, this dialogue revisited key messages from the Pollinators, Pollination and Food Production assessment. It also contributed to objectives articulated by the local community and organizations representing IPLC in the collaborative partnership underpinning the dialogue. A walking workshop approach, where participants, local and non-local, discussed while walking through the biocultural landscape of the indigenous community hosts, proved highly empowering [52].
7f	Strengthen the dialogue between knowledge systems as an iterative two-way process	Outcomes in terms of, for example, conservation and climate change action are shown to have higher relevance and be more effectively implemented when mutual understanding and usefulness for communities are emphasized and processed along with external goals [73].	<i>Fiji Locally Managed Marine Areas Network</i> : Ongoing iterative engagement over many years has produced a proliferation of useful two-way material, including fish lists, marine biodiversity assessments, books on the floras of Nauru and Tuvalu, and other useful resources for assessments [74].

<sup>a</sup> #Provides the number of the relevant clause from the IPBES ILK Approach IPBES 5/15/Annex II to decision IPBES-5/1.

protocols, rituals and institutions that regulate knowledge-sharing; ensuring collaborative partnerships with the local hosts in carefully preparing the dialogue together from the very beginning; creating a safe space for sharing, reciprocity and mutual benefits; and using boundary objects, such as maps, visual aids and posters, that connect across multiple knowledge systems [52,76\*].

The IPBES Approach (clause 8) identifies four-specific challenges for working across knowledge systems: scale; participation and representation; formats; and methods and tools. Challenges of scale (8a) are both horizontal and vertical, related to collating and combining knowledge across multiple knowledge systems; up from finer local-community scales to global syntheses, and down from these syntheses to the finer scale [77]. Keeping the local cultural contexts and meanings of ILK is a particular challenge for upscaling and synthesis, while the multi-scale diverse interactions of ecosystems and IPLC test the application of generic frameworks during the assessment process [15,16\*\*]. Different responses underway are showing promise, for example, 'Local Biodiversity Outlooks' for the 4th Global Biodiversity Outlook to scale-up [5]; collated indices such as the vitality index of traditional environmental knowledge, for cross-scale application of locally meaningful biocultural indicators [68\*]; multi-scale scenarios to cross both horizontal and vertical boundaries [78]; thematic analysis of cases of biocultural approaches to pollinator conservation, to scale horizontally [16\*\*]; and place-centred dialogues bringing global and local actors together to downscale from assessment for policy implementation [66].

Challenges of participation and representation of IPLC (8b) in ways that fit the rules and resources of IPBES are formidable. The participatory mechanism, centrally a web-based platform (clause 28) which is yet to be implemented, and includes consultations, shared learning through discussions and strategic partnerships (clause 27) will assist in meeting this challenge. However, previous CBD experiences highlight that specific mechanisms to empower IPLC at local, national and international levels are needed [62]. International experiences in ensuring gender and regional balance may prove useful: the UN Permanent Forum on Indigenous Issues (UNPFII); the Local Communities and Indigenous Peoples Platform resulting from the Paris Climate Agreement [79]; Centres of Distinction for Indigenous and Local Knowledge [59]; and International Indigenous Forum on Biodiversity and Ecosystem Services [5]. Experts on ILK and especially ILK-holders and ILK-experts (see Table 1) are still poorly represented in IPBES task forces, expert groups and assessment author teams—different selection criteria beyond scientific metrics and excellence may need to be piloted. Specific calls for nomination of relevant expertise have been made, although key gaps remain [80,81].

Challenges of ILK formats (clause 8c) are related to the mismatch between the relatively inflexible text-based format of assessments, and the ILK material in different languages, in grey literature, in ritual, ceremonial, oral, dance, song and visual manifestations, symbols, documentaries and artwork [82]. Clause 17(d) of the Approach recognizes the need to portray these diverse 'practices, worldviews, voices and faces'. Creation of 'boundary

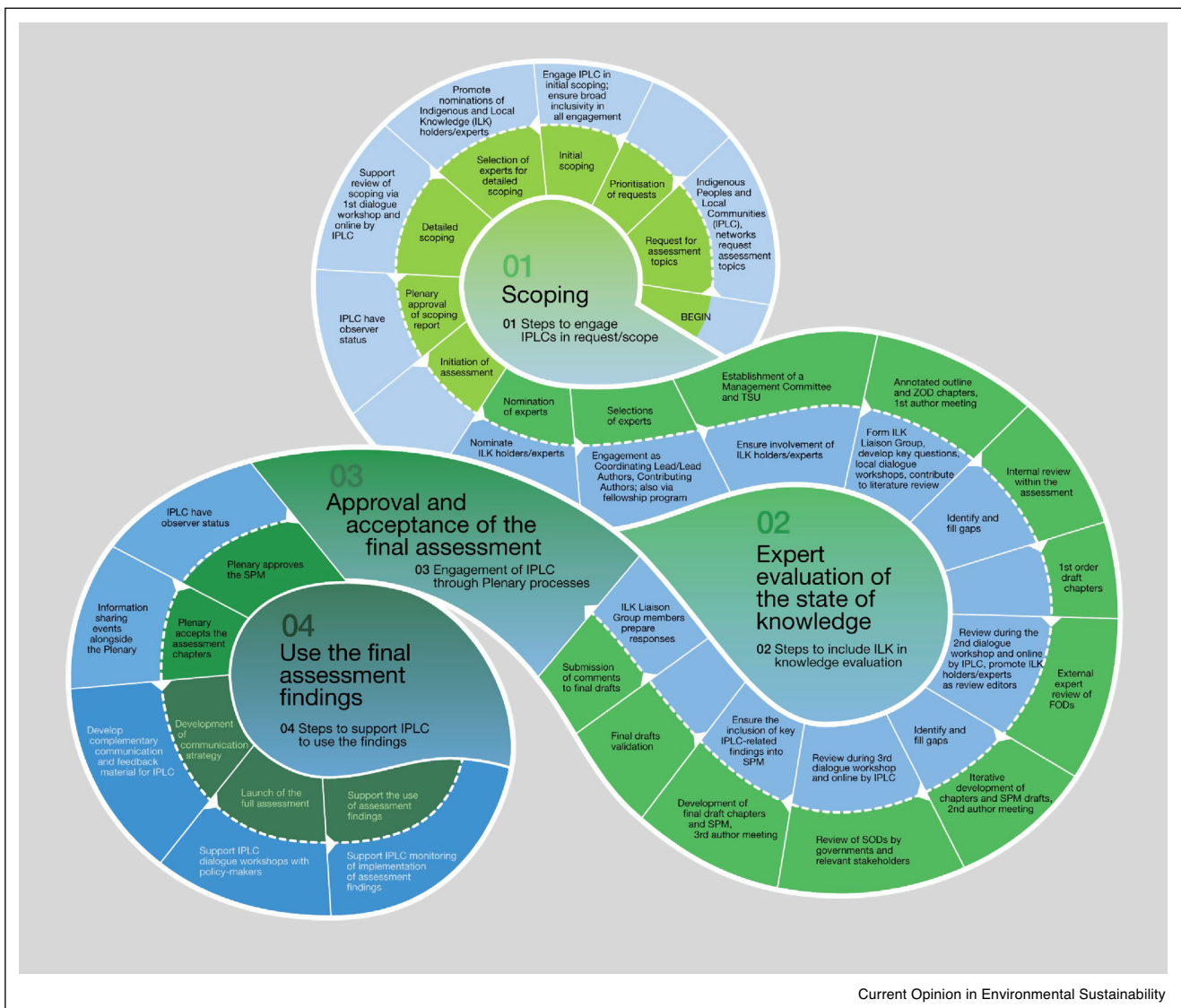
objects' (e.g. drawings, seasonal calendars) can provide material that links with IPLC and the global biodiversity audiences, and is suitable for inclusion in biodiversity assessments [76\*]. Digital platforms that can include video and story-telling may be the way of the future [57].

Finally, the challenge of methods and specific tools (8d), arises because most methods to work with ILK in assessments are new or yet to be developed. Strategic and innovative partnerships and investments are needed. Novel methods such as photovoice, yarning, many types of culturally specific practices (e.g. Kaupapa Māori method, Australian Aboriginal pathways, Anishnaabe Symbol-Based Reflection) are emerging to form an arena where much more work is needed [83].

### Steps for ensuring IPLC and ILK involvement in assessments

IPBES has developed a guide on the production and integration of assessments for experts who take part in their assessments [84]. The guide functions as a road map at global, regional and subregional levels across all scales and has the potential to aid local, national, subregional assessments inspired from the IPBES assessment process. The ILK Approach integrates additional steps to ensure engagement with ILK systems and IPLC throughout all four phases of the process, presented as a separate track in Figure 1 to aid understanding. The aim is to encourage, empower and inform IPLC in each stage. The processes provide many different entry points for IPLC and provide for many different roles as nominators, authors, reviewers,

Figure 1



Steps to ensure inclusion of ILK in assessments, shown in parallel for ease of understanding. Source: Based on IPBES [84], and the Approach clauses 13–17 (IPBES 5/15/Annex II to decision IPBES-5/1).



dialogue participants, fellows, observers at the Plenary sessions, organisers of communication events and other activities (see Supplementary Table 1 [at the end of this document] for details of these entry points).

The ILK Approach presents some generic questions as a starting point for scoping, focusing on the contributions of IPLC to sustainability in management of biodiversity, the pressures and factors undermining their contributions, and policy measures that will strengthen their roles, knowledge and practices (clauses 13 a, b and c). In addition, IPLC may have their own questions, and so it is vital to engage their networks in the initial scoping stage. Where detailed scoping is required, a dialogue workshop will be held to allow for active participation and engagement. In the second phase of the assessment, the expert evaluation of the state of knowledge phase, engagement of ILK-holders and ILK-experts as authors and reviewers, and of IPLC in the dialogues more broadly, is critical. In the third stage, approval and acceptance of the assessment, the roles of IPLC as observers at the Plenary comes to the fore. In the fourth and final stage, use of the assessment findings, IPLC are engaged in knowledge-policy workshops and in developing complementary communication and capacity-building tools. IPLC networks can support the monitoring of implementation of assessment findings by IPLC at local, national, regional and global levels.

### Key gaps in the IPBES approach

The ILK Approach, which is breaking new ground, is understood to be a first step in an iterative process in which IPLC are key partners. Here we highlight some of the more prominent gaps where further attention and action are needed.

*Sharing governance with IPLC* (e.g. in the IPBES Bureau), and a commitment to equity across ILK and science, will help ensure the different customary institutions that shape ILK and ensure its legitimacy and validity are able to operate effectively [85]. The Local Communities and Indigenous Peoples Platform of the United Nations Framework Convention on Climate Change, which has been established with a governing body of seven each from IPLC and governments, is a step towards shared governance [79]. Power asymmetries remain at the heart of many of the challenges in working with indigenous, local and scientific knowledge systems. IPBES could consider how shared governance can shift power imbalances—for example, by ensuring IPLC are sufficiently supported with time and resources to request assessment topics, influence decisions about key messages from assessments, have adequate resources for tailored policy uptake initiatives and an equitable share of the overall resource allocation. Shared governance approaches require the ability to move beyond consensus to find

ways of accepting contestation and incommensurable perspectives [32\*].

*Addressing transformation of ILK.* A recent review has highlighted the ongoing loss of ILK in the face of globalization, modernization, and market integration, with losses in some places disproportionately affecting medicinal and ethnobotanical knowledge [86]. Nevertheless, innovations are also transforming ILK, for example through traditions and technologies combining to solve new spatial problems arising from environmental change in the Arctic region [87]. Persistence of knowledge occurs where traditional practices are maintained consciously, where hybrid knowledge results from certain types of economic incentives, and where IPLC' engagement with their environment is enabled [88,89]. IPBES and other global initiatives can help promote policies that incentivise maintenance of ILK, including Indigenous languages and education approaches, in both conservation and development initiatives.

*Protection of intellectual property rights* associated with ILK is among the most morally compelling issues in international intellectual property law today, as conventional law does not provide adequate protection [60]. New, well-designed national and international laws and policies can provide protection both for IPLC' rights over ILK and for the public domain within the overall architecture of the global innovation framework [90]. Capability and tools are needed that support the human rights for protection of ILK, which currently is not adequately recognized in international law, as well as the well-established protection of intellectual property in inventions, literary and artistic works, designs, symbols and images through patents, copyright and so on [91].

*Experts in boundary-crossing and bridging knowledge systems* are important to support the roles of ILK-holders and ILK-experts in bringing in ILK through participatory action research, dialogue, use of boundary objects (such as maps) and other methods [76\*,92]. Individuals with boundary-spanning expertise, commonly drawn from disciplines such as ethnobiology or human geography, and from working in transdisciplinary research, can help explore new concepts such as 'nature's contribution to people'. Experts of IPLC backgrounds who have training in scientific disciplines are an emerging group with crucial boundary-crossing expertise.

### Conclusion

The diverse elements of the ILK Approach, including recognition of key practices—for respecting rights, supporting care and mutuality, strengthening IPLC and their knowledge systems and supporting knowledge exchange—and the diverse entry steps into the assessment cycle provide a strong foundation for engaging ILK and IPLC. The respect given to the diversity of

humanity's knowledge has allowed IPBES assessments to give space for different worldviews about nature and nature's linkages with people. This progress relies on the underlying capacity of IPLC to maintain the customary institutions that ensure the integrity of their knowledge systems; of individual experts being able to work across knowledge systems; and of effective dialogue workshops that support knowledge exchange. The benefits are beginning to emerge, through provision of much richer and more meaningful assessments that can account for diversity, such as unique Indigenous conceptualizations of sustainability. Policy options that are relevant at multiple scales are emerging. For example, a recent dialogue workshop found that the IPBES pollination assessment resonated strongly with the Karen indigenous people in northern Thailand and identified practical and useful policy-relevant findings about rotational farming systems for both local and national governments [52]. The ILK Approach appears to have many elements that will mitigate the potential risk of neo-colonialism, hegemony and further entrenchment of power asymmetries, in working with ILK.

The Approach provides an evidence-based pathway which recognizes that many key challenges remain including those related to scale; participation and representation; formats; and methods and tools. Our review has identified an array of potential solutions to these challenges where further testing and piloting are required. Our analysis also highlighted some key gaps that are yet to be considered in the Approach: shared governance with IPLC and a commitment to equity between ILK and science; transformation, loss and innovation within ILK; protection of intellectual property rights associated with ILK; and the requirement for experts in boundary-crossing and bridging knowledge systems. Power asymmetries remain a formidable barrier to working across knowledge systems in IPBES and other environmental assessments.

The journey along the path to working equitably across knowledge systems in assessments of nature and nature's contributions to a good quality of life for people, has begun. We do not yet have all the vehicles and the tools, to move well along this path and overcome the many hurdles identified. However, the outcomes of the recent Hin Lad Nai dialogue [52] suggest that working with ILK in global assessments can leverage policy-change that enables local people to secure the blue-green innovations that reflect their conceptualizations of sustainability, and are meaningful to their futures. Specific institutional arrangements within IPBES to further empower the contributions of IPLC can stimulate step-change in this important journey. Recognizing, respecting and engaging with humanity's diverse knowledge systems can help secure the future of nature and nature's linkages with people.

## Conflict of interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

## Acknowledgements

We thank and acknowledge the wonderful contributions made by all other members of the ILK Taskforce who were not able to find time to contribute to this paper, including Ana María Hernandez Salgar, Eriks Leitis, Eduardo Brondizio and Özden Görücü. We are deeply grateful to Douglas Nakashima, who headed the ILK Taskforce Technical Support Unit until 2018, and the current head Nigel Crawhall and staff member Peter Bates. We also thank the very fine contributors to other relevant dialogues, especially Adem Bilgin, Catherine Laurent, Jean-Yves Le Saux, Salvatore Arico, Meriam Bouamrane, Anthea Brooks, Serena Heckler, Prasert Trakansuphakon, Tui Shortland and Donara Sydeeva, and especially acknowledge Roger Mpande and Kazuhiko Takeuchi for their co-leadership of the Tokyo Workshop in 2013. The support of the IPBES Plenary and other members of the Secretariat, especially Anne Larigauderie, Thomas Koetz and Hien Ngo made the formulation of this paper possible. We thank Jacqui Smith of Whitespace Design Studio for her work on Figure 1. The co-authors wish also to thank each of our organisations for their support. Dr Hill acknowledges funding that enabled her the time necessary for leading the writing of this paper, from: CSIRO Land & Water, Australia, Indigenous Futures Initiative; and the National Environmental Science Program's Northern Australia Environmental Resources Hub, Australia, Project 5.4. Dr Tengö acknowledges the support of a grant for development research from the Swedish Research Council, Sweden (VR 2015-03441). Dr Molnár acknowledges funding from National Research, Development and Innovation Office, Hungary (GINOP-2.3.2-15-2016-00019).

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.cosust.2019.12.006>.

## References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
  - of outstanding interest
1. Cardinale BJ, Duffy JE, Gonzalez A, Hooper DU, Perrings C, Venail P, Narwani A, Mace GM, Tilman D, Wardle DA *et al.*: **Biodiversity loss and its impact on humanity.** *Nature* 2012, **486**:59-67.
  2. Mistry J, Berardi A: **Bridging indigenous and scientific knowledge.** *Science* 2016, **352**:1274-1275.
  3. Brondizio ES, Tourneau F-ML: **Environmental governance for all.** *Science* 2016, **352**:1272-1273.
  4. Garnett ST, Burgess ND, Fa JE, Fernandez-Llamazares A, Molnar Z, Robinson CJ, Watson JEM, Zander KK, Austin B, Brondizio ES *et al.*: **A spatial overview of the global importance of Indigenous lands for conservation.** *Nat Sustain* 2018, **1**:369-374.
  5. FPP: **Local biodiversity outlooks. Indigenous peoples' and local communities' contributions to the implementation of the strategic plan for biodiversity 2011-2020.** Moreton-in-Marsh, UK. Online: *Forest Peoples Programme with the International Indigenous Forum on Biodiversity and the Secretariat of the Convention on Biological Diversity. A complement to the fourth edition of the Global Biodiversity Outlook.* 2016 <https://www.cbd.int/gbo/gbo4/publication/lbo-en.pdf>.
  6. Diaz S, Demissew S, Carabias J, Joly C, Lonsdale M, Ash N, Larigauderie A, Adhikari JR, Arico S, Baldi A *et al.*: **The IPBES conceptual framework — connecting nature and people.** *Curr Opin Environ Sustain* 2015, **14**:1-16.

## 18 Indigenous conceptualizations of 'sustainability'

7. Tengö M, Brondizio E, Elmqvist T, Malmer P, Spierenburg M: **Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach.** *AMBIO* 2014;1-13.
8. Tengö M, Malmer P, Borraz P, Cariño C, Cariño J, Gonzales T, Ishizawa J, Kvarnström M, Masardule O, Morales A et al.: **Dialogue workshop on knowledge for the 21st century: indigenous knowledge, traditional knowledge, science and connecting diverse knowledge systems.** *Workshop Report; 10–13 April 2012, Usdub, Guna Yala, Panama: 2012.* Edited by. Stockholm, Sweden. Online: [http://www.dialogueseminars.net/resources/Panama/Reports/Panama-report\\_English\\_small.pdf](http://www.dialogueseminars.net/resources/Panama/Reports/Panama-report_English_small.pdf): Stockholm Resilience Centre.
9. Tengö M, Hill R, Malmer P, Raymond CM, Spierenburg M,
  - Danielsen F, Elmqvist T, Folke C: **Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability.** *Curr Opin Environ Sustain* 2017, **26–27**:17-25
 The study concentrates on international science-policy processes based on examples from IPBES and CBD and offers a framework for evidence-based guidance on how to bridge knowledge systems through five tasks: Mobilise, translate, negotiate, synthesise and apply multiple forms of evidence. The study further underlines what is essential in all these tasks: effective engagement of actors, institutions and knowledge-sharing processes.
10. Agrawal A: **Indigenous knowledge and the politics of classification.** *Int Soc Sci J* 2002, **54**:287-297.
11. Berkes F: *Sacred Ecology.* edn 4. New York, USA: Routledge; 2018.
12. Berkes F, Turner NJ: **Knowledge, learning and the evolution of conservation practice for social-ecological system resilience.** *Hum Ecol* 2006, **34**:479-494.
13. Diaw MC: **Modern economic theory and the challenge of embedded tenure institutions: African attempts to reform local forest policies.** In *Institutions, Sustainability, and Natural Resources: Institutions for Sustainable Forest Management.* Edited by Kant S, Berry RA. Netherlands: Springer; 2005:43-81.
14. Borrini-Feyerabend G, Kothari A, Oviedo G: **Indigenous and local communities and protected areas: towards equity and enhanced conservation.** *World Commission on Protected Areas. Best Practice Protected Area Guideline Series No. 11.* Gland, Switzerland and Cambridge, UK: IUCN; 2004.
15. Brondizio ES, Díaz S, Settele J, Ngo HT, Guèze M, Aumeeruddy-Thomas Y, Bai X, Geschke A, Molnár Z, Niamir A et al.: **Chapter 1. Assessing a planet in transformation: rationale and approach of the IPBES Global Assessment on Biodiversity and Ecosystem Services.** In *IPBES Global Assessment on Biodiversity and Ecosystem Services.* Edited by IPBES, Díaz S, Settele J, Brondizio ES, Ngo HT, Guèze M, Agard J, Arneth A, Balvanera P, Brauman KA. IPBES; 2019:3-70. Unedited.
16. Hill R, Nates-Parra G, Quezada-Euán JJG, Buchori D, LeBuhn G,
  - Maués MM, Pert PL, Kwapong PK, Saeed S, Breslow SJ et al.: **Biocultural approaches to pollinator conservation.** *Nat Sustain* 2019, **2**:214-222
 The authors identify practices of biocultural approaches to pollinator conservation by indigenous peoples and local communities across the world in 60 countries, analysed in accordance with the IPBES Conceptual Framework. The study identified seven policies that support biocultural approaches to pollinator conservation, including for example recognition of customary tenures and food sovereignty.
17. Takeuchi K: **Rebuilding the relationship between people and nature: the Satoyama initiative.** *Ecol Res* 2010, **25**:891-897.
18. Ulicsni V, Babai D, Vadasz C, Vadasz-Besnyoi V, Baldi A, Molnár Z: **Bridging conservation science and traditional knowledge of wild animals: the need for expert guidance and inclusion of local knowledge holders.** *AMBIO* 2019, **48**:769-778.
19. Dounias E, Aumeeruddy-Thomas Y: **Children's ethnobiological knowledge: an introduction.** *AnthropoChildren.* 2017.
20. Nadasy P: *Hunters and Bureaucrats: Power, Knowledge, and Aboriginal-State Relations in the Southwest Yukon.* Vancouver, Canada: UBC Press; 2004.
21. **Bridging scales and knowledge systems.** *Concepts and Applications in Ecosystem Assessment.* Edited by Reid WV, Berkes F, Wilbanks T, Capistrano D. Washington DC, USA: Island Press; 2006.
22. Whyte K: **What do indigenous knowledges do for indigenous peoples?** In *Traditional Ecological Knowledge: Learning from Indigenous Practices for Sustainability.* Edited by Neslson MK, Shilling D. Cambridge University Press; 2018.
23. Johnson JT, Howitt R, Cajete G, Berkes F, Louis RP, Kliskey A: **Weaving Indigenous and sustainability sciences to diversify our methods.** *Sustain Sci* 2016, **11**:1-11.
24. Díaz S, Pascual U, Stenseke M, Martin-Lopez B, Watson RT, Molnar Z, Hill R, Chan KMA, Baste IA, Brauman KA et al.: **Assessing nature's contributions to people.** *Science* 2018, **359**:270-272.
25. **The contribution of indigenous and local knowledge systems to IPBES: Building Synergies with Science.** *IPBES Expert Meeting Report.* Edited by Thaman R, Lyver POB, Mpande R, Perez E, Cariño J, Takeuchi K. Paris, France: UNESCO/UNU; 2013.
26. Lyver P, Perez E, Carneiro da Cunha M, Roué M (Eds): *Indigenous and Local Knowledge about Pollination and Pollinators associated with Food Production: Outcomes from the Global Dialogue Workshop (Panama 1–5 December 2014) Paris, France.* UNESCO; 2015. Online: [http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IPBES\\_Pollination-Pollinators\\_Panama\\_Workshop.pdf](http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IPBES_Pollination-Pollinators_Panama_Workshop.pdf).
27. Hill R, Scheyvens H, Shortland T (Eds): *IPBES-JBF Sub-regional Dialogue Workshop Report on Indigenous and Local Knowledge (ILK) for Pacific sub-region (1-4 Nov. 2016 in Whangarei, New Zealand) Tokyo, Japan.* Institute for Global Environmental Strategies; 2017. Online: <https://pub.iges.or.jp/pub/ipbes-jbf-sub-regional-dialogue-workshop-1>.
28. **Knowing our lands and resources: indigenous and local knowledge of biodiversity and ecosystem services in Asia..** Online: <http://unesdoc.unesco.org/images/0026/002607/260780e.pdf> In *Knowledges of Nature,* , vol 10. Edited by Karki M, Hill R, Xue D, Alangui W, Ichikawa K, Bridgewater P. Paris, France: UNESCO Publishing; 2018.
29. **Knowing our lands and resources: Indigenous and local knowledge of biodiversity and ecosystem services in Europe and Central Asia..** Online: <https://unesdoc.unesco.org/ark:/48223/pf0000247462> In *Knowledges of Nature,* , vol 9. Edited by Roué M, Molnar Z. Paris, France: UNESCO Publishing; 2017.
30. **Knowing our lands and resources: indigenous and local knowledge of biodiversity and ecosystem services in Africa.** In *Knowledges of Nature,* , vol 8. Edited by Roué M, Césard N, Yao A, Constant Y, Oteng-Yeboah A. Paris, France: UNESCO Publishing; 2017 <https://unesdoc.unesco.org/ark:/48223/pf0000247798>.
31. **Knowing our lands and resources: indigenous and local knowledge of biodiversity and ecosystem services in the Americas..** Online: <https://unesdoc.unesco.org/ark:/48223/pf0000260779> In *Knowledges of Nature,* , vol 11. Edited by Baptiste B, Pacheco D, Cunha MC, Diaz S. Paris, France: UNESCO Publishing; 2017.
32. Díaz-Reviriego I, Turnhout E, Beck S: **Participation and inclusiveness in the intergovernmental science-policy platform on biodiversity and ecosystem services.** *Nat Sustain* 2019, **2**
  - The Review assesses the state of research on IPBES processes to detect challenges and lessons learned based on its efforts to include various experts, stakeholders and knowledge systems. The Review considers procedural and substantive dimensions of inclusiveness and demonstrates a paradox between IPBES' demand for diversity and its goal of attaining consensus.
33. ICSU: *Science, Traditional Knowledge and Sustainable Development. Series on Science for Sustainable Development No. 4.* Paris, France: International Council for Science and the United Nations Education, Scientific and Cultural Organisation; 2002.
34. Merçon J, Vetter S, Tengö M, Cocks M, Balvanera P, Rosell JA, Ayala-Orozco B: **From local landscapes to international policy: contributions of the biocultural paradigm to global sustainability.** *Glob Sustain* 2019, **2**:e7

- The authors analyse main differences and connections between biocultural discourses within the framework of sustainability and discuss how biocultural discourses can contribute to local and global sustainability. The paper suggests that biocultural approaches need to acknowledge and articulate ontological, epistemological and ethico-political dimensions which are interrelated via cultural practices and power relations rooted in biocultural landscapes.
35. Coombes B, Johnson JT, Howitt R: **Indigenous geographies II: the aspirational spaces in postcolonial politics - reconciliation, belonging and social provision.** *Prog Hum Geogr* 2013, **37**:691-700.
  36. Roullier C, Benoit L, McKey DB, Lebot V: **Historical collections reveal patterns of diffusion of sweet potato in Oceania obscured by modern plant movements and recombination.** *Proc Natl Acad Sci U S A* 2013, **110**:2205-2210.
  37. Perez E, Esquit E, Martinez A: **La tradición del chib'al: un encuentro entre el conocimiento tradicional y el fenómeno de la migración de aves e insectos.** *Proyecto FODECYT No 084.* 2007.
  38. Walsh FJ, Dobson PV, Douglas JC: **Anpermirrentye: a framework for enhanced application of indigenous ecological knowledge in natural resource management.** *Ecol Soc* 2013, **18**:18 <http://dx.doi.org/10.5751/ES-05501-180318>.
  39. Hill R, Grant C, George M, Robinson CJ, Jackson S, Abel N: **A typology of indigenous engagement in Australian environmental management: implications for knowledge integration and social-ecological system sustainability.** *Ecol Soc* 2012, **17**:23 <http://dx.doi.org/10.5751/ES-04587-170123>.
  40. Hanna P, Vanclay F: **Human rights, indigenous peoples and the concept of free, prior and informed consent.** *Impact Assess Proj Apprais* 2013, **31**:146-157.
  41. Papillon M, Rodon T: **Proponent-indigenous agreements and the implementation of the right to free, prior, and informed consent in Canada.** *Environ Impact Assess Rev* 2017, **62**:216-224.
  42. Ban NC, Frid A, Reid M, Edgar B, Shaw D, Siwallace P: **Incorporate indigenous perspectives for impactful research and effective management.** *Nat Ecol Evol* 2018, **2**:1680-1683.
  43. Salomon AK, Lertzman K, Brown K, Wilson KB, Secord D, McKechnie I: **Democratizing conservation science and practice.** *Ecol Soc* 2018, **23**:12.
  44. Parks L: **Spaces for local voices? A discourse analysis of the decisions of the convention on biological diversity.** *J Hum Rights Environ* 2018, **9**:141-170.
  45. Disko S, Tugendhat H: *World Heritage Sites and Indigenous Peoples' Rights.* IWGIA; 2014.
  46. Pocock C, Lilley I: **Who benefits? World heritage and indigenous people.** *Herit Soc* 2018, **10**:171-190.
  47. Gilbert J, Lennox C: **Towards new development paradigms: the United Nations declaration on the rights of indigenous peoples as a tool to support self-determined development.** *Int J Hum Rights* 2019:1-21
- The authors analyse main differences and connections between biocultural discourses within the framework of sustainability and discuss how biocultural discourses can contribute to local and global sustainability. The paper suggests that biocultural approaches need to acknowledge and articulate ontological, epistemological and ethico-political dimensions which are interrelated via cultural practices and power relations rooted in biocultural landscapes.
48. Broderstad EG: **The promises and challenges of indigenous self-determination: the Sami case.** *Int J* 2011, **66**:893-907.
  49. Kouril D, Furgal C, Whillans T: **Trends and key elements in community-based monitoring: a systematic review of the literature with an emphasis on Arctic and Subarctic regions.** *Environ Rev* 2016, **24**:151-163.
  50. Burnette CE, Sanders S: **Trust development in research with indigenous communities in the United States.** *Qual Rep* 2014, **19**:1-19.
  51. Molnár Z, Kis J, Vadász C, Papp L, Sándor I, Béres S, Sinka G, Varga A: **Common and conflicting objectives and practices of herders and conservation managers: the need for a conservation herder.** *Ecosyst Health Sustain* 2016, **2**:e01215.
  52. Malmer P, Tengö M, Fernández-Llamazares A, Woodward E, Crawhall N, Hill R, Trakansuphakon P, Athayde S, Cariño C, Crimella D et al.: *Dialogue Across Indigenous, Local and Scientific Knowledge Systems Reflecting on the IPBES Assessment on Pollinators, Pollination and Food Production, 21th to 25th January 2019, Chiang Mai and Chiang Rai, Thailand. Workshop Report.* 2019. Edited by. Stockholm, Sweden. Online: <https://swed.bio/reports/pollinators-dialogue-report/>: SwedBio at Stockholm Resilience Centre.
  53. Jones CJ, Lyver PO, Davis J, Hughes B, Anderson A, Hohapata-Oke J: **Reinstatement of customary seabird harvests after a 50-year moratorium.** *J Wildl Manage* 2015, **79**:31-38.
  54. Colchester M, Ferrari MF: *Making FPIC Work: Challenges and Prospects for Indigenous Peoples.* Moreton-in-Marsh, UK: Forest Peoples Program; 2007.
  55. Parsons M, Fisher K, Nalau J: **Alternative approaches to co-design: insights from indigenous/academic research collaborations.** *Curr Opin Environ Sustain* 2016, **20**:99-105.
  56. Woodward E, McTaggart PM: **Transforming cross-cultural water research through trust, participation and place.** *Geogr Res* 2016, **54**:129-142.
  57. Fernandez-Llamazares A, Cabeza M: **Rediscovering the potential of indigenous storytelling for conservation practice.** *Conserv Lett* 2018, **11**:12.
  58. Castellano MB: **Ethics of aboriginal research.** In *Global Bioethics and Human Rights: Contemporary Issues.* Edited by Teays W, Gordon J-S, Renteln AD. Rowman & Littlefield; 2014:273-285.
  59. Ferris S: **Protecting the world's biodiversity: Tui Shortland.** *Cult Surv Q Mag* 2018, **42**:28.
  60. Rajani K, Ranjan T, Kumar RR, Patil G, Kumar M, Kumar J, Kumar M: **Traditional knowledge and its promotion through providing legal rights. The Role of Intellectual Property Rights in Agriculture and Allied Sciences.** Apple Academic Press; 2018:151-180.
  61. Alangui W, Tarabe A, Dolma Sherpa P, Alim J, Hien V, Sherpa P, Rai A, Thile Sherpa P, Thuy H, Lien H: *Customary Tenure Systems and REDD+: Ensuring Benefits for Indigenous Peoples.* . Online: Baguio, Philippines: Tebtebba; 2018 In: <http://www.tebtebba.org/index.php/content/2017-01-07-04-16-14/444-customary-tenure-systems-and-redd-ensuring-benefits-for-indigenous-peoples>.
  62. Parks L, Schröder M: **What we talk about when we talk about 'local' participation in international biodiversity law. The changing scope of indigenous peoples and local communities' participation under the convention on biological diversity.** *Partecipazione e conflitto* 2019, **11**:743-785.
  63. Saito O, Ichikawa K: **Socio-ecological systems in paddy-dominated landscapes in Asian Monsoon.** In *Social-Ecological Restoration.* Edited by Miyashita N, Nishikawa U. Springer; 2014:17-37.
  64. Aumeeruddy-Thomas Y, Lama YC: **Tibetan medicine and biodiversity management in Dolpo, Nepal: negotiating local and global worldviews, knowledge and practices.** In *Tibetan Medicine in the Contemporary World. Global Politics of Medical Knowledge and Practice.* Edited by Pordié L. Routledge; 2008:160-184.
  65. Witter R, Suseeya KRM, Gruby RL, Hitchner S, Maclin EM, Bourque M, Brosius JP: **Moments of influence in global environmental governance.** *Environ Polit* 2015, **24**:894-912.
  66. Hill R, Woodward E: **Kimberley ranger forum 2017 knowledge brokering activities and outcomes.** . Online: <http://www.nespnorthern.edu.au/wp-content/uploads/2018/03/Kimberley-Ranger-Forum-report.pdf> *A Report to the Kimberley Land Council.* Cairns: CSIRO; 2017.

67. Brondizio ES, Foufoula-Georgiou E, Szabo S, Vogt N, Sebesvari Z, Renaud FG, Newton A, Anthony E, Mansur AV, Matthews Z *et al.*: **Catalyzing action towards the sustainability of deltas.** *Curr Opin Environ Sustain* 2016, **19**:182-194.
68. Sterling EJ, Filardi C, Toomey A, Sigouin A, Betley E, Gazit N, Newell J, Albert S, Alvira D, Bergamini N *et al.*: **Biocultural approaches to well-being and sustainability indicators across scales.** *Nat Ecol Evol* 2017, **1**:1798-1806
- The paper presents a framework and examples of indicators developed through biocultural approaches that explicitly start with and build on local cultural perspectives — encompassing values, knowledges, and needs — and recognize feedbacks between ecosystems and human well-being. It demonstrates how set of indicators that capture both ecological and social-cultural factors, and the feedbacks between them, can underpin cross-scale linkages that help bridge local and global scale initiatives to increase resilience of both humans and ecosystems.
69. Otieno NE, Analo C: **Local indigenous knowledge about some medicinal plants in and around Kakamega forest in western Kenya.** *F1000Res* 2012, **1**:40 In: <http://f1000res.com/UDNyBK/F1000>.
70. Huntington HP, Carey M, Apok C, Forbes BC, Fox S, Holm LK, Ivanova A, Jaypoody J, Noongwook G, Stammler F: **Climate change in context: putting people first in the Arctic.** *Reg Environ Change* 2019:1-7.
71. Sonwa DJ, Weise SF, Coulibaly ON: **Contribution of traditional knowledge developed by farmers to control pests and diseases in cocoa agroforests in Southern Cameroon.** In *IUFRO World Series*, vol 23. Edited by Parotta JA, Oteng-Yeboah A, Cobbinah J. IUFRO (International Union of Forestry Research Organizations) Secretariat; 2009:14-20.
72. Shawoo Z, Thornton TF: **The UN local communities and indigenous peoples' platform: a traditional ecological knowledge-based evaluation.** *Wiley Interdisc Rev Clim Change* 2019, **10**:1-10 e00575.
73. David-Chavez DM, Gavin MC: **A global assessment of Indigenous community engagement in climate research.** *Environ Res Lett* 2018, **13**:17.
74. Thaman RR, Balawa A, Fong T: **Putting ancient winds and life into new sails: indigenous knowledge as a basis for education for sustainable development (ESD) – a case study of the return of marine biodiversity to Vanua Navakavu, Fiji.** In *Of Waves, Winds and Wonderful Things: A Decade of Rethinking Pacific Education*. Edited by Otunuku M, Nabobo-Baba U, Johansson-Fua S. 2014:163-184. Suva, Fiji.
75. Toomey AH: **What happens at the gap between knowledge and practice? Spaces of encounter and misencounter between environmental scientists and local people.** *Ecol Soc* 2016, **21**:19.
76. Zurba M, Maclean K, Woodward E, Islam D: **Amplifying indigenous community participation in place-based research through boundary work.** *Progr Hum Geogr* 2018, **43** <http://dx.doi.org/10.1177/0309132518807758>
- 'Boundary work' is a relatively new and innovative qualitative approach in place-based research and often involves the creation of 'boundary objects'. Such objects can be created collaboratively with Indigenous communities, and can be used to communicate knowledge, values and aspirations across social and political boundaries. This article provides an account of boundary work and a conceptual framework for use between geographers and Indigenous communities to create effective communities of practice.
77. Schoon M, Cox ME: **Collaboration, adaptation, and scaling: perspectives on environmental governance for sustainability.** *Sustainability* 2018, **10**:9.
78. Rosa IMD, Pereira HM, Ferrier S, Alkemade R, Acosta LA, Akcakaya HR, den Belder E, Fazel AM, Fujimori S, Harfoot M *et al.*: **Multiscale scenarios for nature futures.** *Nat Ecol Evol* 2017, **1**:1416-1419.
79. Belfer E, Ford JD, Maillet M, Araos M, Flynn M: **Pursuing an indigenous platform: exploring opportunities and constraints for indigenous participation in the UNFCCC.** *Glob Environ Polit* 2019, **19**:12-33.
80. Larigauderie A, Stenseke M, Watson RT: **IPBES reaches out to social scientists.** *Nature* 2016, **532**:313.
81. Futhazar G: In *From Climate to Biodiversity Procedural Transcriptions and Innovations within IPBES in the Light of IPCC Practices*. Edited by Hrabanski M, Pesche D. Abingdon: Routledge; 2017.
82. Berkes F: *Sacred Ecology*. edn 3. New York, USA: Routledge; 2012.
83. Dawson AS, Toombs E, Mushquash CJ: **Indigenous research methods: a systematic review.** *Int Indig Policy J* 2017, **8**.
84. IPBES: *The IPBES Guide on the Production of Assessments Core Version*. . Online: Bonn, Germany: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; 2018 In: <https://www.ipbes.net/deliverables/2a-assessment-integration>.
85. van Kerkhoff L, Pilbeam V: **Understanding socio-cultural dimensions of environmental decision-making: a knowledge governance approach.** *Environ Sci Policy* 2017, **73**:29-37.
86. Aswani S, Lemahieu A, Sauer WHH: **Global trends of local ecological knowledge and future implications.** *PLoS One* 2018, **13**:19.
87. Sheppard L, White M (Eds): *Many Norths: Spatial practice in a Polar territory*. Toronto, Canada: Actar Publishers; 2017.
88. Kis J, Barta S, Elekes L, Engi L, Fegyver T, Kecskeméti J, Lajkó L, Szabó J: **Traditional herders' knowledge and worldview and their role in managing biodiversity and ecosystem-services of extensive pastures.** In *Knowing our Lands and Resources: Indigenous and Local Knowledge of Biodiversity and Ecosystem Services in Europe and Central Asia*, vol 9. Edited by Roué M, Molnar Z. UNESCO Publishing; 2017:56-70 Knowledges of Nature.
89. Lyver PB, Timoti P, Davis T, Tylianakis J: **Biocultural hysteresis inhibits adaptation to environmental change.** *Trends in Ecology & Evolution*. 2019
- This article argues that adaptive policies and processes that favour protecting and enabling IPLC engagement with their environment and particular social-ecological context is essential to manage risks to environmental management. The key risk is biocultural hysteresis, a process whereby a number of social, environmental and economic drivers disrupt the relationships between IPLC and their natural resources, triggering a set of feedback mechanisms that diminish management. Key feedbacks, including knowledge loss and a breakdown in social hierarchies, worsen as IPLC spend more time outside their social-ecological context.
90. Okediji R: *Traditional Knowledge and the Public Domain; Waterloo, Canada: Centre for International Governance Innovation CIGI Papers No. 176 — June 2018: 2018.*
91. Alamgir ANM: **Intellectual Property (IP) and Intellectual Property Right (IPR), Traditional Knowledge (TK) and Protection of Traditional Medical Knowledge (TMK).** *Therapeutic Use of Medicinal Plants and Their Extracts: Vol 1: Pharmacognosy*. Birkhauser Verlag Ag; 2017:515-528: Progress in Drug Research.
92. Reid RS, Nkedianye D, Said MY, Kaelo D, Neselle M, Makui O, Onetu L, Kiruswa S, Kamuaru NO, Kristjanson P *et al.*: **Evolution of models to support community and policy action with science: balancing pastoral livelihoods and wildlife conservation in savannas of East Africa.** *Proc Natl Acad Sci U S A* 2016, **113**:4579-4584.