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Locally Based, Regionally Manifested, and Globally Relevant: Indigenous and Local Knowledge, Values, and Practices for Nature

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Annual Review of Environment and Resources

Locally Based, Regionally Manifested, and Globally Relevant: Indigenous and Local Knowledge, Values, and Practices for Nature

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Keywords

Indigenous peoples, Indigenous and local knowledge, values of nature, environmental governance, biodiversity, climate change

Abstract

The knowledge, values, and practices of Indigenous peoples and local communities offer ways to understand and better address social-environmental problems. The article reviews the state of the literature on this topic by focusing on six pathways by which Indigenous peoples and local communities engage with management of and relationships to nature. These are (a) undertaking territorial management practices and customary governance, (b) contributing to nature conservation and restoration efforts with regional to global implications, (c) co-constructing knowledge for assessments and monitoring, (d) countering the drivers of unsustainable resource use and resisting environmental injustices, (e) playing key roles in environmental governance across scales, and (f) offering alternative conceptualizations of the interrelations between people and nature. The review shows that through these pathways Indigenous peoples and local communities are making significant contributions to managing the health of local and regional ecosystems, to producing knowledge based in diverse values of nature, confronting societal pressures and environmental burdens, and leading and partnering in environmental governance. These contributions have local to global implications but have yet to be fully recognized in conservation and development policies, and by society at large.

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1. INTRODUCTION

Since the 1980s, an accelerating global environmental crisis, driven by climate change, biodiversity loss, and pollution, has led to an awakening of interest in the knowledge, values, and practices of Indigenous peoples and local communities as a way to understand and better address regional and global problems. Attention to Indigenous and local knowledge has been highlighted as important for understanding the drivers and impacts of these crises from local to global levels and for identifying fairer development pathways (1–3). Additionally, Indigenous peoples and local communities have increasingly organized social movements to engage with environmental and development issues, efforts that have furthered calls for a more reciprocal conceptualization of human-nature inter-relationships, as well as calls to reclaim rights and confront injustices. In parallel, the academic literature on Indigenous and local knowledge, values, and practices has progressively included attention to interdependencies between humans and nature in integrated social-ecological systems (e.g., 4), recognition of complementarities and synergies among knowledge systems (5–7), the need for decolonization of methodologies and knowledge production (8, 9), and more visibility of research by and collaboration with Indigenous scholars (9).

This article reviews the state of literature regarding Indigenous and local knowledge, values, and practices about nature and is organized around six pathways by which Indigenous peoples and local communities engage with management of and relationships to nature. These are (a) undertaking territorial management practices and customary governance, (b) contributing to nature conservation and restoration efforts with regional to global implications, (c) co-constructing knowledge for assessments and monitoring, (d) countering the drivers of unsustainable resource use and resisting environmental injustices, (e) playing key roles in environmental governance across scales, and (f) offering alternative conceptualizations of the interrelations between people and nature. We contextualize this review by discussing definitions and categories, such as Indigenous peoples, local communities, and Indigenous and local knowledge, while also acknowledging their contestation. Our review of these six pathways includes both systematic and expert-based evaluation of the literature from non-Indigenous and Indigenous scholars, including gray literatures, which have evolved at the intersection of social movements by Indigenous peoples and rural-based organizations, academic and collaborative research and engagement, and regional and global environmental assessment efforts. Further, we include literature and knowledge produced by collaborative networks of Indigenous and non-Indigenous peoples, in particular, the analysis and findings of the “Local Biodiversity Outlooks 2 (LBO-2): Indigenous Peoples’ and Local Communities’ Contributions to the Implementation of the Strategic Plan for Biodiversity 2011–2020 and to Renewing Nature and Cultures” (10).¹ As a disclaimer, as authors, we recognize that we are mostly non-Indigenous and do not claim to speak on behalf of any group, but we recognize our own positionality within multiple knowledge systems.

2. INDIGENOUS PEOPLES’ AND LOCAL COMMUNITIES’ RIGHTS, KNOWLEDGE, AND PRACTICES: LONG STRUGGLES FOR RECOGNITION

Since the 1950s, numerous global efforts have emerged for the recognition of Indigenous peoples’ rights and knowledge. These include the signing of the Indigenous and Tribal Populations Convention of 1957; the creation of the Working Group on Indigenous Populations by the United

Indigenous and local knowledge:

cumulative body of intergenerational knowledge, practices, values, and worldviews, and embedded in the relationships between local people and nature

Pathways: alternative possible trajectories for knowledge, interventions, and change that prioritize different goals, values, and targets

Nature: umbrella term for diverse worldviews of the natural world, also serving as synonym for biodiversity, biosphere, ecosystems, Mother Earth, or other terms

Knowledge systems: mental constructs including a coherent set of cognitions, cosmologies, and practices developed by cultural groups

Decolonization of methodologies: research approach aiming at advancing collaborative and participatory methods, while recognizing existing colonial ideologies, discourses, attitudes, and unequal power dynamics

Environmental governance: social function through which actors interact to influence decisions, processes, and outcomes influencing interactions between humans and nature

¹LBO-2 was edited by this article’s coauthors Joji Carino and Maurizio Farhan Ferrari and their collaborators.

Nations (UN) Economic and Social Council in 1982; the Indigenous and Tribal Peoples Convention, also known as International Labour Organization (ILO) Convention 169, in 1989; the establishment of the UN Permanent Forum on Indigenous Issues in 2000; and the adoption of the UN Declaration on the Rights of Indigenous Peoples in 2007. Meanwhile, processes of recognition and inclusion have also expanded to a wider array of social-cultural groups under the label of local communities. However, there is no common legal framework that considers the rights of local communities, although as recently as 2018, the UN adopted the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas, which includes some local communities among other groups. We discuss all these complications below.

The UN has recognized and used multiple criteria to define Indigenous peoples, including ancestry as well as distinct cultural features such as language, religion, membership in tribal systems, material culture, cosmology, livelihood, origin and residence, among others. Yet, there is no universally agreed upon definition for Indigenous peoples, “based on the rationale that the identification of an Indigenous people is the right of the people itself—the right of self-identification and a fundamental element of the right to self-determination” (11, p. 4). According to the ILO, there are 476.6 million people who define themselves as Indigenous, including ~5,000 groups speaking ~4,000 languages and representing ~6.2% of the world’s population. Indigenous peoples range from small isolated groups to large populations and are found across most regions of the planet; the majority of Indigenous peoples (~85%) do not live in countries that have ratified the Indigenous and Tribal Peoples Convention of 1989 (12). Although as a global aggregate 73.4% of the world’s Indigenous population lives in rural areas, in regions such as the Caribbean and Latin America and in North America, the majority of the population is living in or around urban centers. Still, Indigenous peoples globally have twice the proportion of employment in agriculture (agriculture, fisheries, forestry) (~55%) compared to non-Indigenous people. They also contribute significantly to sectors such as market services, government, construction, and manufacturing (12, 13). Indigenous peoples are estimated to currently inhabit and manage at least 28% of the global land area (14). Although the global reality of Indigenous peoples is regionally diverse, they share some common conditions; according to the ILO, “Indigenous peoples continue to be the poorest among the poor” (12, p. 20). Irrespective of the poverty-line used, they are two to three times more likely to be in extreme poverty in both rural and urban areas, with inequality felt more directly by Indigenous women, compounded by gender-related discrimination, violence, and harassment (12, p. 20). However, more comprehensive measures of well-being for Indigenous populations are still lacking.

Although no single definition of local communities is internationally accepted, many international platforms and organizations recognize local communities for their diversity across rural and coastal regions, historical linkages to place and use of natural resources, domains of ecological knowledge, dynamic and hybrid resource management techniques and technologies, customary and formal institutions to manage natural resources, and diverse worldviews and forms of relationship to nature (1). To distinguish local communities from Indigenous peoples, for instance, the ICCA Consortium uses the following working definition for local community: “a self-identified human group that acts collectively in ways that contribute to defining a territory and culture through time,” further distinguishing them from traditional communities as those “that maintain livelihoods, beliefs and values, knowledge, languages and institutions in some continuity with the past” (15, p. 15). The local community is also considered important in contexts where Indigenous peoples are not legally recognized or allowed to use the term for self-identification. Local communities involve a larger population than Indigenous peoples, but there are no clear estimates on the number of people or area covered. These communities include micro, small- and

medium-scale farmers, pastoralists, fishers, extractors and foragers, foresters and agroforesters managing a significant portion of the world's terrestrial and coastal landscapes and biodiversity. Pastoralists, who move within and beyond borders and across land held in different types of customary rights, often following pathways with long histories of transhumance, are estimated to represent approximately 200 million people (including both Indigenous and non-Indigenous people), and together with agropastoralists, comprise approximately 500 million people globally (16). Shifting cultivators are another category comprising an unknown population, given an absence of census data, but are estimated to involve as many as 1 billion people depending on definitions (17). In a broad sense, local communities may represent a substantial percentage of rural populations in developing countries, as well as segments of rural populations in developed countries. More narrowly, the term is often used to refer to rural and coastal populations that are considered traditional with place-based and ethnic-based identities (15). They are responsible for diverse production systems, managing cultural landscapes, safeguarding agrobiodiversity and the genetic diversity of domesticated animals, and carrying the know-how of material culture and technology, food cultures and medicines, and associated intangible heritage (17–19). Indeed, the Convention on Biological Diversity (CBD) has organized several ad hoc expert group meetings to analyze the status of local communities to facilitate their recognition within the context of Article 8(j): Traditional Knowledge, Innovations and Practices (15, 20–22).

Although not free of contestation, the acronym IPLCs—Indigenous peoples and local communities—has gained widespread usage by a number of organizations and conventions to refer to individuals and communities who are, on the one hand, self-identified and holding hard-fought rights as Indigenous peoples and, on the other hand, members of local communities that maintain intergenerational connections to place and nature through livelihood practices, cultural identity, worldviews, institutions and ecological knowledge (1). The acronym has gained usage in international fora, including among coalition networks of Indigenous and non-Indigenous groups, to denote commonalities and shared concerns, while still recognizing that there remain significant differences between and among Indigenous peoples and local communities. At the same time, there have also been understandable concerns on the part of Indigenous organizations about the combined term and acronym. Besides differences in histories of the recognition of rights, a broad, unspecific definition of local communities could include rural and coastal local communities who may be considered as settlers of Indigenous lands, with associated conflicts. For instance, on October 26, 2020, the Inuit Circumpolar Council (ICC) issued a policy paper specifically addressing their opposition to the usage of the term local communities in association with Indigenous peoples. The statement calls attention to the lack of clarity of both the term and the rights of local communities, raising concerns about its potential to erode Indigenous peoples' rights and negatively impact their long-term efforts and struggles, and calls for an end to the conflation of the terms (see <https://www.inuitcircumpolar.com/news/icc-policy-paper-on-local-communities-chronicles-opposition-to-the-undermining-and-erosion-of-inuit-rights/>).

The term Indigenous and local knowledge (ILK)² refers to the worldviews, knowledge, practices, and innovations embedded in the relationship between Indigenous peoples and/or local communities and nature; it can include knowledge about the natural world, techniques and technologies of resource management, and local institutions governing social relations and relationships with nature. Indigenous knowledge, and that of local communities, is situated in place and social

²Other terms often used interchangeably with ILK include local and Indigenous knowledge systems, traditional ecological knowledge, and local ecological knowledge, among others.

Values of nature: sets of beliefs/concepts upheld by people about the meanings of different dimensions of nature, influencing one's behavior toward the natural world

context, and is at the same time continuously evolving through the combination of written, oral, tacit, practical, scientific, and other forms of knowledge attained from various sources, validated by experimentation and direct interaction with nature (23). The importance of mainstreaming Indigenous and local knowledge in global environmental policy has been firmly established in international conventions such as the CBD, where Article 8(j) explicitly recognizes the unique role of Indigenous peoples and local communities in conserving life on Earth (CBD 1992). Indigenous and local knowledge has also been prominently recognized by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and incorporated across the platform's work program, conceptual framework, and assessments (see Section 3.3, below). Similarly, Indigenous and local knowledge and issues pertaining to these populations have been included in the UN World Heritage Convention, the UN Framework on Climate Change (UNFCCC), and reports of the Intergovernmental Panel on Climate Change (IPCC) (6, 10, 17, 24).

Both Indigenous peoples and local communities and Indigenous and local knowledge are umbrella concepts to represent the most culturally diverse segment of the world's population. To different degrees, Indigenous peoples and local communities experience conditions of political marginalization, poverty, racial discrimination, cultural erosion, and violence, often have limited formal rights to land and associated resources, and often lack access to both conventional and culturally sensitive health care systems. They often are denied education that is appropriate to their cultures, as well as public services such as safe water, energy, health, and sanitation (e.g., 12, 13, 25). Furthermore, Indigenous and local knowledge has often been ignored and denied in development projects, and in some cases the rejection of such knowledge and practices and its replacement with scientific and technical understandings has been an explicit aim.

In this review, we use the extended version of both terms, Indigenous peoples and local communities (separated by comma or combined where appropriate) and Indigenous and local knowledge, to reflect their broader usage in the literature, reports, and online resources cited in the article. In some sections, we refer to only Indigenous peoples to reflect the cited literature, and in others, we specifically refer to local communities.

3. PATHWAYS THROUGH WHICH INDIGENOUS PEOPLES AND LOCAL COMMUNITIES HAVE CONTRIBUTED TO THE MANAGEMENT, CONSERVATION, AND UNDERSTANDING OF NATURE: LOCAL TO GLOBAL EVIDENCE

Over more than a century, the literature on Indigenous and local knowledge and associated practices, and the pressures Indigenous and local communities face, has expanded across a wide range of academic fields, from biological to social sciences and humanities, and covering myriad issues, from utilitarian concerns about ecosystem management, to the nature of knowledge and worldviews, to customary institutions, and to conducting collaborative research (26). Particularly notable in recent decades has been the growth of Indigenous scholarship, bringing attention to emic understanding of values, research ethics, drivers of environmental change, and local problems and conflicts, such as those associated with economic development pressures and conservation initiatives (27). These literatures have demonstrated the diversity and sophistication of Indigenous and local knowledge systems and the contributions of both Indigenous peoples and local communities to managing the health of local and regional ecosystems, to producing knowledge based in diverse values of nature, to confronting societal pressures and environmental burdens, and to leading and partnering in environmental governance (e.g., 28–30). Here, we analyze recent scholarship on these contributions and issues, organized into six interconnected pathways.

3.1. Pathway 1: Territorial Management Practices and Customary Governance

The first pathway through which Indigenous peoples and local communities contribute to territorial management and nature conservation is customary governance and practices that create and maintain biodiversity, based on formal and informal institutional and social arrangements embedded in multiple values of nature (31). Examples include resource use agreements and collective rules governing commons; religious beliefs and caring for intangible elements of nature embodied in sacred landscapes, waterscapes, or marine areas (32, 33); taboos over use and conservation of specific species (34); harvesting restrictions and seasons; and selective harvesting and grazing, often to deliberately create small-scale disturbances to increase landscape heterogeneity (35, 36). These customary management systems are increasingly recognized as effective cultural and ecosystem-based approaches to maintain landscape biodiversity and agrobiodiversity, including through traditional agriculture (37, 38), aquaculture, and various forms of forest conservation. Customary management practices, often characterized by the absence of a stark divide between nature and culture, such as between agriculture and forests, wild and strictly domesticated, or foraging and direct planting, have contributed to the sustainable management of wild and domesticated biodiversity in many places (39, 40).

LBO-2 highlights numerous examples of customary territorial management by Indigenous peoples and local communities (10). For instance, in Sabah, Malaysia, Indigenous peoples have practiced the customary *tagal* system, a system that sustained inland fisheries for many generations. *Tagal* was renewed and formalized in the village of Melangkap in 1986, which has since enjoyed an increase in fish numbers and in the number of endemic species, thus receiving government recognition in recent years. The Pgaz K'Nyau (Karen) people practice rotational farming as a self-reliant economy in northern Thailand. To address the need for cash income, social enterprises were developed and promoted by young women and men in the village of Hin Lad Nai, responsibly marketing wild honey, tea, bamboo shoots, and other forest products to sustain and improve their livelihoods while preserving cultural identity. Indigenous women of the Torres Strait Islands play a vital role as custodians and teachers of significant traditional knowledge in building community resilience. As valued members and leaders of community organizations, women bring a unique strength and insight to land and sea management, including in community monitoring of sea grass on which many marine species depend (10).

The high-diversity landscapes that have resulted from customary management practices often comprise a complex mosaic of forested and open areas including agriculture; wet, irrigated, and dry places; and coastal habitats.³ They are often managed adaptively by changing the local disturbance regimes (36), and these areas offer multiple tangible products such as food, forage, fodder, timber, and medicinal plants, as well as intangible elements linked to religious or other relational values (e.g., 38). Some of these managed ecosystems are local hotspots of native biodiversity, such as mountain hay meadows in Europe (41) or dehesa oak and cereal tree savannahs in southern Spain. In other cases, both Indigenous peoples and local communities have combined wild and domesticated species to create new agroecosystems (e.g., agroforestry systems, managed forests, nurturing of pollinators) (40, 42, 43). It is likely that such managed systems have been major drivers of tree domestication across the planet (38, 44–46).

Customary territorial management practices have also contributed to the management of domesticated biodiversity. In different ways, Indigenous peoples and local communities maintain

³Examples recognized globally include socio-ecological production landscapes and seascapes (see <https://satoyama-initiative.org>) and Globally Important Agricultural Heritage Systems (see <http://www.fao.org/giahs/en/>).

a large diversity of agroecosystems and a wealth of local varieties and breeds of plants and animals, thus facilitating future adaptations to changing social and ecological systems (40). Domestication selects for specific traits, integrating them into social-ecological niches that often differ from their original habitats. These processes have occurred over millennia, since the Epipaleolithic (~20,000–5,000 years ago) in the Mediterranean region and at similar periods in Papua New Guinea, Mexico, South America, and Central Asia (47). For instance, pastoral Neolithic sites (3,700 and 1,550 cal. BP) show the long-term legacy of nutrient hotspots in African savannas (48). Similarly, both Amazonian and Central South American soils and forests show long-term legacy of Indigenous management (44), including a rich legacy of domestication and agrobiodiversity that has global economic implications, from manioc, pineapple, and peanuts to cocoa, papaya, tobacco, and many others (42, 49, 50). For instance, the pre-Columbian sweet potato traveled from South America, where it was domesticated, to the Pacific, ultimately reaching Papua New Guinea where it became a very important staple food and continued to diversify in isolation from its area of origin due to new ecological conditions and selection by humans. These effects of diffusion and genetic isolation, and adaptation and selection, are examples of coproduction resulting from local ecological and biological evolutionary processes over time.

In summary, a rich literature across all continents has documented the contributions of both Indigenous peoples' and local communities' management and stewardship of nature in coproducing genetic, species, and ecosystem diversity, and enhancing natural processes with anthropogenic assets through knowledge, practices, or technology. However, these relationships are not free of pressures. Many of these positive contributions associated with customary management have been invisible to others, thus likely to be disrupted, and accelerated changes on the ground, contributing to making practices less sustainable, and resulting in degradation and resource depletion (see Section 3.4). This is particularly the case when local norms and practices face the pressure of commodity and extractive industries as well as government interventions, or demands from local to international markets for local products (10, 51). For instance, the IPBES Global Assessment recently concluded that although the decline of nature is lower in Indigenous lands than in other areas, compilation and analysis of 502 social-ecological indicators developed and used by Indigenous peoples and/or local communities to monitor nature show that approximately 72% are deteriorating (1).

3.2. Pathway 2: Contributing to Nature Conservation and Restoration Efforts with Regional to Global Implications

The second pathway through which Indigenous peoples and local communities contribute to nature management is direct conservation activities, resulting in both alliances and conflicts (52, 53). Indigenous peoples have traditionally been integrated, or even coerced, into conservation initiatives through a variety of top-down approaches, such as integrated conservation and development projects or participatory monitoring projects. Although some of these initiatives have been represented as comanaged, many have questioned the actual participatory nature of these approaches (54, 55), the lack of real benefits for people on the ground, and questionable conservation itself. More recently, a myriad of initiatives that have built alliances between Indigenous peoples and local communities and others have become standard practice in the fields of conservation and monitoring to use diverse tools to engage local populations in conservation efforts (56).

The worldviews of Indigenous peoples in particular shape their approaches to conserving land, rivers, and coastal areas, which are often based on inclusive and multiple values for nature woven into social contexts (for Indigenous conceptions of sustainability, see 57). Principles and indicators of these worldviews include health of the land, "caring for country," and reciprocal responsibility

promoting respect for nature based on diverse senses of continuities between all elements, including humans, nonhumans, and biophysical elements such as wind, water, rocks, or soil (33, 58, 59). Together, these forms of relationship to place have nurtured conservation outcomes, such as regulation of freshwater fluxes through complex social collective rules or keeping savannas open for wildlife and livestock through livestock customary migration rules.

These local management practices have significant implications for regional and global conservation (1). Indigenous peoples manage or have tenure rights over at least 37.9 million km² of land in ~90 countries on all inhabited continents, representing more than a quarter of the world's terrestrial surface, intersecting at least 37% of all remaining natural lands across the Earth and approximately 40% of the world's terrestrial protected areas (14). If one considers customary tenure as a proxy for the area that also includes those managed by local communities, a significant portion of which lack recognition as such, it is estimated that it may extend over 8.54 billion hectares or approximately 65% of the global land area, inhabited by approximately 1.5 billion people (60). In many cases, these territories also overlap with different types of government, corporate, and/or private control.

Recent evidence shows that Indigenous lands have ecosystems that are more structurally intact than the global average for terrestrial regions and are experiencing less biodiversity loss (1), as they remain largely free from extensive industrial and intensive agricultural operations (e.g., 61, 62). Approximately half of the Indigenous land mapped by Garnett et al. (14) is still primary vegetation, compared with a global average of 39% (63); only 7% is cultivated or urban (global average = 24%) (see 64), and two-thirds is categorized as natural, compared with only 44% of other lands (14). Indigenous lands, and that of many local communities, often contain more intact ecosystems that support high and/or unique biodiversity, such as high mountain and desert habitats (47). Additionally, Indigenous peoples' lands include many of the world's healthiest forests and encompass at least 36% of the world's intact forest landscapes (65), which are considered crucial for local livelihoods and climate change mitigation. However, in regions such as the Amazon basin, where Indigenous lands have been key in avoiding deforestation, forest degradation is also increasing as a result of multiple and compounding pressures (66).

Indigenous lands are critical strongholds for crucial environmental services and a substantial proportion of the world's biodiversity (e.g., 67, 68). For instance, a comprehensive analysis of land mammal composition across mapped Indigenous lands throughout the entire planet found that at least 2,175 mammal species (approximately 49% of all the mammal species for which there is reliable habitat data) have more than 10% of their ranges in Indigenous lands, and at least 14% have >50% of their ranges within Indigenous lands (69). Because mammal species are largely considered as a bellwether, Indigenous lands are likely crucial for the long-term conservation of the planet's biodiversity (see also 70).

Involving both Indigenous peoples and local communities as equal partners in conservation has created synergies between local land-use practices and the management goals of protected areas (10, 68) and reduced rates of habitat loss. As illustrated in the LBO series, innovative community-based conservation successes are emerging in various parts of the world (10, 71). For instance, the Gunditjmarra community in southwest Victoria, Australia, engineered water channels to farm *kooyang* (eels) and other fish for thousands of years, until the invasion, colonization, and dispossession of their traditional homelands in the early 1800s. From the 1980s, the Gunditjmarra regained control over parts of the aquaculture system through recognition of their right to protect their cultural heritage, which included securing a freehold title. Over the past 40 years, the Gunditjmarra community has been partnering with universities and research organizations to produce technical scientific reports to document and revitalize the Budj Bim Cultural Landscape. Together with the Indigenous Protected Area program, the community has been managing their territory consistent

with International Union for Conservation of Nature (IUCN) standards, and in 2019, Budj Bim was accepted by the United Nations Educational, Scientific and Cultural Organization World Heritage Committee for inscription as a World Heritage Site.⁴ In Canada, through the Pathways Initiative, Indigenous peoples and governments are taking leadership together to establish Indigenous protected and conserved areas and to recognize the integral role of Indigenous peoples as leaders in conservation. Respecting the rights, responsibilities, and priorities of First Nations, Inuit, and Métis peoples as well as national biodiversity goals have helped to harness support for more collaborative conservation efforts for larger societal benefit in the spirit and practice of reconciliation.⁵

Indigenous and local knowledge and practices also play an important role in increasing the effectiveness of ecosystem restoration activities in degraded ecosystems (72, 73). For example, the Maya in Quintana Roo, Mexico, are actively restoring populations of *balché* and other native tree species to ensure that sufficient food is available for bees.⁶ In other cases, locally based restoration by Indigenous peoples is often a response to the overexploitation and/or degradation by outsiders (e.g., deforestation, mining, pollution, logging)⁷ (74). Indigenous peoples as well as local communities are increasingly leading and partnering on restoration activities, in collaboration with either protected area administrators and scientists (75) or neighboring farmers (76). An increasing number of cases are based on the incorporation of Indigenous and local knowledge in programs initially conceived as science-based restoration (77) in conservation areas and surroundings (78). The IPCC Special Report on Climate Change and Land recognized the role of Indigenous peoples and local communities in restoration and ecosystem conservation activities as making a major contribution to climate change mitigation, noting that recognition of land rights should be considered a climate strategy (79).

3.3. Pathway 3: Co-constructing Knowledge for Assessments and Monitoring

The third pathway through which Indigenous peoples and local communities contribute to the conservation and management of nature is by producing knowledge, informing science and environmental assessments, and monitoring environmental and climate change. For scientists, conservation managers, and policy-makers, having access to place-based and socially contextualized knowledge can elaborate a richer evidence base for conservation decision-making (80), and Indigenous conceptions of expertise and knowledge have been contributing to progressive shifts in science and research (81, 82). The intimate connection and livelihood dependence that Indigenous peoples and local communities maintain with their local ecosystems through direct management, local observations, and intergenerational transmission of knowledge (83) create a deep understanding of multi-decadal trends in nature and managed anthropogenic seascapes and landscapes, and facilitate monitoring not only of their key natural and managed resources but also of other salient features at the interspecific, species, population, ecosystem, and landscape levels (54).

Indigenous and local knowledge, which often emphasizes the importance of learning about the environment from experience on the land rather than from didactic teaching in classrooms,

⁴See Reference 10, pp. 138–139, box 25, titled World Heritage Listing as a Tool to Heal Gunditjmarra Country; Budj Bim Indigenous Protected Area, Australia.

⁵See Reference 10, pp. 139–140, box 26, titled Indigenous Peoples' Protected and Conserved Areas; The Pathway to Canada's Target 1.

⁶See Reference 10, p. 168, box 33, titled El Balché: Sacred Trees and Bees of the Maya People, Mexico.

⁷See Reference 10, p. 98, box 13, titled Loko i'a; Indigenous Aquaculture and Mariculture in Hawai'i, USA, and box 11, p. 92, titled Tribes Address Salmon Declines in the US Pacific Northwest.

is also increasingly expanding discussions around environmental education curricula and methods (84, 85), as well as recognition of alternative conceptions of expertise and ways of knowing, which are not tied to academic expertise and publications (19, 86). Oral histories, storytelling, and music-making continue to be powerful conduits for intergenerational transmission of knowledge (87, 88). As an example, Aboriginal stories regarding coastal inundation in Australia can be traced to environmental changes over 7,000 years ago (89). However, although these forms of knowledge are inherently dynamic and constantly adapting to changing political and social-ecological scenarios, knowledge loss and erosion have been documented (e.g., 90) and are closely related to marginalization, disenfranchisement, state-sanctioned violence, cultural and physical attacks, and dispossession, as well as migration and economic pressures (86, 91). Likewise, as mentioned earlier, in some regions a significant proportion of Indigenous peoples live in urban areas, which can limit, but not impede, opportunities for intergenerational ecological knowledge transfer.

There are many examples and further potential for Indigenous peoples' and local communities' engagement monitoring, mapping, and reporting changes in local biodiversity, including species' ranges, baselines, and trends (10), the presence of pollution (92), invasive alien species (e.g., 93, 94), impacts of restoration programs, or local climate change impacts (72, 95). Unlike many scientific indicators that try to maximize comparability across local contexts, Indigenous or local indicators are often more closely linked to human-nature interrelations and tend to be more holistic (33, 96). For example, monitoring targets and methods used locally may greatly differ from those of scientists. Reyes-García et al. (97), for instance, documented 746 local indicators of climate change reflecting impacts on physical, biological, and socioeconomic systems. Similarly, as mentioned above, authors of the IPBES Global Assessment report summarized more than 500 local social-ecological indicators from the literature to evaluate status and trends in Indigenous peoples and local communities lands (1).

However, interactions between Indigenous and local knowledge and science can often be asymmetrical and at times incommensurable, as a result of power asymmetries and difficulties in navigating and recognizing differences in worldviews and values (7, 23) or from the lack of investment on the part of scientists for meaningful collaboration to emerge (98). This concern has given rise to innovative collaborative arrangements over the past two decades between researchers and Indigenous or local populations for knowledge coproduction, including frameworks such as the multiple evidence-based approach, which explicitly recognizes the complementarities between scientific evidence and other knowledge systems (6). Technological cross-fertilization with Indigenous groups is growing, as shown in the use of GPS and drones for community mapping, cloud computing, citizen science, and cross-knowledge network initiatives (99). Along with local initiatives, international collaborative efforts (14) and several online geospatial platforms are giving visibility to the pressures on Indigenous lands. For instance, the LandMark initiative (100), among others,⁸ has been scaling-up these efforts by providing a global picture of Indigenous lands. The platform has gathered more than a million maps covering 11.2% of the world's land area, but the effort is far from complete. New citizen-science types of applications are also emerging in support of both Indigenous peoples' and local communities' land rights and resource management more broadly, for

⁸Among many examples, see Tierras Indígenas [Indigenous Lands (<http://tierrasindigenas.org/>)] for Paraguay, Rede Amazônica de Informação Socioambiental Georreferenciada [Amazon Geo-Referenced Socio-Environmental Information Network (<https://www.amazoniasocioambiental.org/>)] for the Amazon, Mapping for Rights (<http://www.mappingforrights.org/>) for the Congo Basin, the Indigenous and Community Conserved Areas (ICCAs) Registry by the ICCA Consortium (<https://www.iccaregistry.org/>), as well as the World Database on Protected Areas by UNEP-WCMC and IUCN (<https://www.protectedplanet.net/en/about>).

example in Brazil's Amazon Environmental Research Institute (IPAM) applicative "*Tô no Mapa*" [I am on the map (<https://tonomapa.org.br>)], University College London's Extreme Citizen Science (ExCiteS) (<https://www.geog.ucl.ac.uk/research/research-centres/excites>), and Digital Democracy (<https://www.digital-democracy.org>), among others, which allow communities to map territories, resource uses, pressures, and rights recognition. Likewise, community-based monitoring and information systems are progressively expanding as tools for highlighting local needs and priorities, making Indigenous peoples' and local communities' contributions visible, and providing concrete data and information of local and regional relevance (101). Likewise, the consortium-based Indigenous Navigator Project is a participatory monitoring tool helping to fill in major gaps in disaggregated data regarding Indigenous peoples (10).

Increasingly, Indigenous and local knowledge has been incorporated as part of global-scale environmental assessments (1, 102), evolving from the use of case studies to highlight specific contributions to progressively more systematic coverage (103), as well as developing participatory mechanisms for increasing the representation of Indigenous peoples and local communities (23). For instance, in 1999 UNEP published "Cultural and Spiritual Values of Biodiversity" as a complementary contribution to the first edition of the Global Biodiversity Outlook (GBO) (104). The Millennium Ecosystem Assessment, published in 2005, included sections dedicated to Indigenous and local knowledge, particularly within its chapters related to cultural ecosystem services. In 2004, the Intergovernmental Arctic Climate Impact Assessment drew explicit attention to Arctic Indigenous peoples and their knowledge systems. The Arctic Biodiversity Assessment (105) prepared by the Conservation of Arctic Flora and Fauna working group of the Arctic Council examined issues related to Indigenous peoples and biodiversity in the Arctic including oral histories and other types of evidence on Indigenous knowledge.

Another relevant example was the publication in 2016 of the first LBO report, "Local Biodiversity Outlooks: Indigenous Peoples' and Local Communities' Contributions to the Implementation of the Strategic Plan for Biodiversity 2011–2020" (see 71), developed by the Indigenous caucus engaging the CBD, in particular the International Indigenous Forum on Biodiversity, as a complement to the fourth edition of the Global Biodiversity Outlook (GBO-4). CBD Parties welcomed the publication and requested that a second edition be prepared to accompany the fifth edition of the Global Biodiversity Outlook (GBO-5) and expected it to inform the development of the post-2020 global biodiversity framework. LBO-2 brings together information from published academic and nonacademic sources and highlights more than 50 stories by Indigenous and non-Indigenous authors about their perspectives and experiences around the current social-ecological crisis, contributions to the UN Decade on Biodiversity, and, more broadly, local solutions across biodiversity, climate change, and sustainable development challenges (10). LBO-2 proposes a series of six essential interconnected transitions toward 2050 to meet the CBD's vision of "living in harmony with nature," and like GBO-5, assesses progress made in implementing the Strategic Plan for Biodiversity 2011–2020 (known as the Aichi Targets).

IPBES, and more recently the IPCC, has also made particular efforts toward recognizing the value of including different knowledge systems in its assessments (4, 106). The establishment of IPBES' first work program in 2012 represented a landmark in institutionalizing the inclusion of Indigenous and local knowledge in global and regional level assessments (23). The approval of IPBES' culturally inclusive conceptual framework (4) and related analytical tools, such as on nature's contributions to people (106, 107) and multiple values of nature (108), and a dedicated approach to recognizing and working with indigenous and local knowledge, also served to support inclusion of Indigenous and local knowledge in various assessments. These include assessments on pollination, land degradation and restoration, and four regional assessments [Americas, Europe and Central Asia, Africa, and the Asia-Pacific regions, and the Global Assessment (see

<https://ipbes.net/assessing-knowledge>) (4, 23)]. The Global Assessment (2016–2019) developed and followed a strategy for incorporating Indigenous and local knowledge and issues concerning Indigenous peoples and local communities systematically across the assessment process, including a question-based review of evidence and secondary-data integration as well as online and face-to-face consultation workshops (103, 109). Negotiated and approved by an intergovernmental plenary of 132 countries, Indigenous and local knowledge and issues concerning Indigenous peoples and local communities are featured prominently throughout the report and its “Summary for Policymakers” (1, 2).

For the IPCC, these issues have become more prominent over time in reports, but its coverage is still general in scope and limited in length, due to historical and contextual complexities (23, 102). The reports and the “Summary for Policymakers” of recent assessments (see <https://www.ipcc.ch/reports/>), including the Fifth Assessment Report (2014), the Special Report on Global Warming of 1.5°C in 2018, and the Special Report on Climate Change and Land (79), all mention the effectiveness and potential feasibility of adaptation options based on Indigenous and local knowledge, as well as noting the many threats that climate change poses to the lifeways of Indigenous communities, including in knowledge transmission (see also 110).

3.4. Pathway 4: Countering the Drivers of Unsustainable Resource Use and Resisting Environmental Injustices

The fourth pathway through which Indigenous peoples and local communities contribute to nature management and conservation is in preventing, limiting, and halting activities that directly result in environmental degradation, given that they are often on the frontlines against such pressures. The rapid expansion of extractive frontiers (e.g., large-scale agriculture and mining, industrial fishing, deforestation, hydropower, and oil and gas production) encroach and endanger, particularly but not only, Indigenous lands and waters and the very foundations of local cultures and ways of life (111–113). For example, oil extraction and both small-scale and industrial mining are increasingly operating in lands managed by Indigenous peoples (91), and there is strong evidence that they are experiencing large burdens of environmental pollution linked to this expansion of commodity frontiers and industrial development (see 10, 82). Indigenous peoples have also been confronted by the spread of invasive alien species, which pose significant threats to the cultural and ecological integrity of their territories (93, 114, 115). Similarly, deforestation and reduced access to forest resources (e.g., through the establishment of protected areas) have left many communities without secure sources of food and livelihoods, sometimes because of criminalization of traditional hunting and harvesting practices (116). Other pressures include unsustainable fishing, which damages the survival of those who rely on aquatic resources for their basic needs, and urbanization and expansion of farming can also overtake Indigenous lands, reducing their access to resources.

As a result, Indigenous peoples in particular increasingly find themselves also on the frontlines of pervasive conflict and violence (27, 91). In some cases, Indigenous and non-Indigenous leaders working to counter these threats are paying a high price, facing increasing intimidation, criminalization, and violence, including assassinations of leaders (10, 13, 25, 91). The LBO-2 report summarizes numerous cases on this front, including evidence from the UN Special Rapporteur on the Rights of Indigenous Peoples on a spectrum of abuse including attacks, stigmatization and smear campaigns, forced displacement, criminalization, and arrest and legal action (10). It shows that the majority of assassinations of human rights defenders are related to defending land, Indigenous rights, or the environment, and that this violence happens at the source of national and global supply chains of extractive, agribusiness, and infrastructure projects controlled by corporations,

Environmental justice: fair treatment, meaningful involvement of people regardless of race, ethnicity, gender, nationality, class, and religion in developing, implementing, and enforcing environmental policies and regulations

interest groups, and governments (1, 10).⁹ Most recently, Indigenous groups in different regions have been strongly affected by the COVID-19 (coronavirus disease 2019) pandemic, whether because they lack access to basic health services or because of political disregard (119, 120). In the Brazilian Amazon, for instance, the spread of infection coincided with increasing pressures from deforestation, logging, mining, and weakening of environmental governance and the rights of Indigenous and traditional communities by the government (121, 122). At the same time, in collaboration with external organizations, communities have worked to take sanitary measures into their own hands, monitor infections, and raise funds to support local responses (123).

Indigenous peoples, as well as local communities, have contested and resisted oppression from the advent of colonialism to the present (75, 124, 125). Some of these actions have been preventive, whereas others have occurred after the activity has started, with many successful examples of natural resource development and large-scale infrastructure projects that have been stopped (91). These include the fight of the Dongria Kondh against bauxite mining in their sacred homelands in India, and the opposition raised by Yuracaré, Trinitario, Mojeño, and Tsimané' communities in lowland Bolivia against the plans to construct a road crossing the Isiboro-Sécure Indigenous Territory and National Park in the Bolivian Amazon (124, 126, 127). Another emblematic example is that of the Shipibo-Conibo Indigenous community of the Peruvian Amazon confronting the palm oil company Plantaciones de Pucallpa S.A.C (now Ocho Sur P.S.A.C), which illegally acquired and deforested approximately 7,000 hectares of untitled lands, with massive environmental and social impacts including violence, death threats, and intimidation. The Shipibo-Conibo territory extends more than 85,000 hectares, but only 218 hectares were formally titled. The community mobilized to hold the company accountable on multiple fronts, including through a formal complaint to the Roundtable on Sustainable Palm Oil leading to a stop work order; appealing to European financiers and the London Stock Exchange's Alternative Investments Market; submissions made to the UN and regional human rights mechanisms; a criminal case in Peru, leading to a high-level investigation by the Special Prosecutor for Organized Crime; a ground-breaking constitutional lawsuit against the Peruvian government for failing to process their land titling claim; and influencing a decision by the world's largest sovereign wealth fund, Norway's government pension fund, to divest from Alicorp, a consumer goods company buying palm oil derived from Ocho Sur's plantation (10).

Unfortunately, Indigenous peoples' and local communities' opposition to extractive industries or infrastructure development projects is often not viewed as preventing and halting environmentally damaging activities, but instead portrayed, through a false dichotomy, as opposing economic development. These pressures can generate legacies of reduced cultural expression, potentially leading to the unraveling of the sociocultural fabric that has sustained communities over time (28, 128). However, resistance to environmental injustices has also contributed to revitalizing knowledge systems, values, practices, and ties to land of Indigenous peoples, and in many cases also local communities (23, 27, 129). Some Indigenous communities, even in remote parts of the world, have been able to marshal international support for the defense of their rights and resources, sparking high levels of social mobilization and upscaling their struggles from the local to the global (e.g., 75, 130). According to some scholars, the commonalities across all these local struggles and conflicts reflect the existence of a global movement for environmental justice (91, 124).

⁹See also "Defending Tomorrow: The Climate Crisis and Threats Against Land and Environmental Defenders" (117). For examples of an on-the-ground initiative, see the African Environmental Defenders' initiative (<https://envirodefenders.africa/>) and "The Challenges of Protecting Community Land Rights: An Investigation Into Community Responses to Requests for Land and Resources" (118).

3.5. Pathway 5: Playing Key Roles in Environmental Governance Across Scales

The fifth pathway through which Indigenous peoples and local communities contribute to nature management and conservation is by engaging in environmental governance across scales. After more than two decades of strategic involvement within international platforms such as CBD and UNFCCC (6, 24), more formal recognition of Indigenous people's engagement in global policy forums and debates about the state of the planet's environment is finally expanding, albeit slowly (102, 131). Through the active participation in several international policy forums (132) and after strong investment in institutional capacity-building (133), Indigenous peoples' and local communities' organizations and networks have managed to exert meaningful influence in several state-centered decision-making processes around environmental governance (134).

For example, these organizations played a crucial role in negotiating the Nagoya Protocol on Access and Benefit-Sharing (135, 136), which is increasingly recognized as having contributed to a shift in practices affecting both Indigenous peoples and local communities. However, progress on its implementation at the national level has been slower than expected, and there have been calls for broader benefit-sharing streams, consistent with community protocols, such as those based on biocultural approaches (10, 137). A promising example documented in LBO-2 is the Rooibos Benefit-Sharing Agreement in South Africa,¹⁰ which is considered the largest benefit-sharing agreement between industry and communities to date (10). Although particular in many aspects, the agreement includes numerous institutional features relevant to other cases, such as patience and incrementalism, honesty and trust, genuine dialogue, legal support, government leadership, and unity among Indigenous peoples (138).

Similarly, Indigenous and non-Indigenous organizations have actively participated in international policy development to reduce pollution burdens (10, 91, 92) and their contributions have been crucial in shaping several pollution-related international agreements (e.g., 139). In this regard, the Arctic Council has played a fundamental role in amplifying Indigenous peoples' concerns at the international level (140). Indigenous organizations have also been strong advocates globally for strengthening right-to-know laws as well as the use of Free, Prior and Informed Consent (FPIC) in relation to natural resource development (141). Additionally, they have substantially contributed to initiate, maintain, and strengthen initiatives for communicating, educating, and raising awareness about biodiversity at multiple levels (10). Many of these actions have been channeled and coordinated through Indigenous organizations and networks, such as the International Indigenous Forum on Biodiversity or the ICC, among others.

Indigenous organizations in particular have also influenced, in various degrees, decision-making processes around climate change (133, 142), such as the addition of a Local Communities and Indigenous Peoples Platform within the UNFCCC (143), and in raising concerns regarding payment mechanisms for Reducing Emissions from Deforestation and Forest Degradation (REDD+) (144). Additionally, some countries and subnational governments are adopting biocultural approaches to policy that recognize both Indigenous peoples and local communities in the formation of knowledge governance structures (145, 146), such as comanagement institutions and changes to state laws to recognize customary rights in the context of forest management in Canada (147), changes to fisheries regulations in Palau (148), and ecocultural restoration initiatives with Māori communities in New Zealand/Aotearoa (137), among many others.

Despite all these successes, Indigenous peoples still face substantial barriers to participation in environmental governance and to engagement in policy processes (149). These challenges include

¹⁰See Reference 10, p. 181, box 37, titled "The Rooibos Benefit-Sharing Agreement: Breaking New Ground with Respect, Honesty, Fairness, and Care, South Africa."

a lack of sustained funding support (114, 150), limited adherence to FPIC (151, 152), and a general absence of robust, participatory and inclusive decision-making processes related to conservation (153). These obstacles are particularly important for non-Indigenous local communities, many of whom still confront the challenge of lacking representation and invisibility in both policy and practice (154). As a result, the roles and contributions of both Indigenous peoples and local communities are still poorly recognized in biodiversity policy, with only 10% of Parties in the Strategic Plan for Biodiversity 2011–2020 having reported the inclusion of Indigenous and local knowledge (and participation) in their National Biodiversity Strategies and Actions Plans. In most countries, mechanisms for full and effective participation at the national and local levels are yet to be developed (1, 10). This lack of participation is reflected in the management of the world's protected areas: Although approximately 40% of protected areas lie on Indigenous peoples' lands (122), less than 1% of them are managed exclusively by them (155). Similarly, the lack of attention to culture-based solutions as integral to biodiversity conservation, restoration, and sustainable use is now considered as a missed opportunity in the 2011–2020 Strategic Biodiversity Framework (10), with hopes for more attention in the post-2020 framework under negotiation in 2021.

3.6. Pathway 6: Offering Alternative Conceptualizations of Interrelations Between People and Nature

The sixth pathway through which Indigenous peoples and local communities contribute to nature management and conservation is by offering alternative concepts of relations between people and nature, and this diversity of worldviews, concepts for human-nature relationships, cosmologies, and philosophies is important for biodiversity conservation. These Indigenous cosmologies are highly diverse, but in general often include a lack of division between concepts of nature and culture (156). Tied to this is a belief that many nonhuman entities, which can include animals, plants, the Earth, rivers, or entire landscapes, have human agency and that interactions with them must be based on respectful relations of kinship and reciprocity (157). Many aspects of the environment may also be considered to be infused with spirits, which must also be acknowledged and treated with respect (158). Ways of maintaining respect and reciprocity can include taboos against hunting certain species, the need to share and not waste food, and only harvesting or hunting what is needed. For many communities, sustaining these respectful and reciprocal relationships with nature is at the center of their knowledge, values, and practices (86), and yet these are under constant external and internal pressures.

At various scales, Indigenous philosophies have helped broader societies to think through issues such as sustainable living by including integration of nature and culture, prioritizing reciprocity, emphasizing care, learning and adaptiveness (58, 159), and acknowledging spiritual dimensions. Such philosophies and worldviews can also aid in rethinking concepts fundamental to international work on the environment, including reconceptualizing the term sustainability beyond social, economic, and environmental pillars (57); for example, the Māori concept of the double spiral can be used to understand sustainability as an interrelationship of the past, present, and future. Similarly, fundamental concepts in environmental management have also been challenged or enhanced by exploring Indigenous cosmologies, including through the lens of biocultural conservation (137, 160–162).

In some cases, Indigenous philosophies are also forming the basis of a reconceptualization of political engagement, where nonhuman actors such as mountains and rivers are brought into the political arena, for example in Peru, Ecuador, and Bolivia. Indigenous philosophies and conceptions of nature have also wrought legal changes, for example in New Zealand/Aotearoa where rights of personhood have been granted to the Whanganui River, following pressure from Māori groups to recognize their conception of the river to improve its legal protection (163). At the

national level, many nations are now including rights to nature in their national laws and constitutions, and are doing so as a direct result of recognition of Indigenous conceptualizations of nature (164). For example, nature-embracing Andean spiritual traditions seeing Mother Earth as a sacred home have been incorporated into both the Bolivian and the Ecuadorian Constitutions. Connected with key dimensions of Indigenous ontological regimes in relation to nature, these laws set out rights-based systems recognizing nature as a right-bearing entity holding intrinsic values (165).

A multitude of pressures, however, including those promoted by standardized education, are driving changes in both the values and knowledge of Indigenous peoples (166, 167), all of which can catalyze rapid shifts in how nature is valued (168–170), as well as cultural erosion and knowledge loss (e.g., 110, 171, 172). The growing emphasis on market-based conservation and more utilitarian views of nature conservation also pose challenges for how communities on the ground relate to nature (e.g., 173–175), for instance, balancing financial incentives and governance approaches based on relational values such as respect, humility, reciprocity, and gratitude for nature (e.g., 29, 86, 176). In some cases, formal governance regimes have undermined local institutions and community organization, eroding Indigenous values and lifestyles (177–179).

There are also numerous concerns regarding the appropriation of Indigenous philosophies, and Indigenous and local knowledge more broadly (180). This type of cultural misappropriation is a risk given imbalances of power between Indigenous peoples and local communities and their governments, the private sector, political movements, NGOs, or other actors who may choose to embrace certain philosophies and their symbols and use them for their own goals (181). Engagement of Indigenous and non-Indigenous organizations at all levels of debate and discussion is needed to help minimize these risks. As demonstrated by LBO-2 and other efforts, these networks and organizations have dedicated significant efforts at highlighting alternative worldviews and practices toward nature to positively influence environmental governance processes (10).

4. CONCLUDING REMARKS

The academic literature on Indigenous and local knowledge and practices has evolved significantly from utilitarian views to increased attention to values and worldviews toward nature, political struggles and violence, research ethics, drivers of environmental change associated with economic development pressures, climate change, and conservation initiatives, as well as social, cultural, and demographic changes experienced by communities. In addition, a burgeoning body of literature and evidence published by Indigenous peoples' and local communities' individuals and organizations outside of academic journals, and the voices of leaders and activists, are demonstrating the many ways they contribute to biodiversity conservation, sustainable use and environmental governance, and the measures that might facilitate these processes. Collaboration between the academic community, and particularly Indigenous scholars, with partners in both Indigenous and local communities can stimulate coproduction of knowledge for the sorts of transformational changes for a fairer and more sustainable world (182). Indigenous scholars and practitioners have argued that a radical transformation of current nature conservation approaches is needed moving from the current exclusion and alienation of Indigenous peoples and local communities to new rights-based collaborative approaches that support and promote community-led conservation and customary sustainable use and interactions with nature (9, 159, 183). For example, the LBO-2 report argues for six key transitions to better support communities and society more broadly in renewing their relations with nature and governance systems toward more sustainable futures:

- Cultural transitions toward diverse ways of knowing and doing
- Land transitions toward securing customary land tenure

- Governance transitions toward inclusive decision-making and self-determined development
- Incentives and financial transitions toward rewarding effective culture-based solutions
- Food transitions toward revitalizing Indigenous and local food systems
- Economic transitions toward sustainable use and diverse local economies

As our review has shown, the values, ways of life, knowledge, resource governance and management systems, economies, and technologies of both Indigenous peoples and local communities are making significant contributions toward addressing current environmental crises, which calls for deep transformations in our relationships with nature. Their contributions are indeed locally based, regionally manifested, and globally relevant. Today, they are recognized in the literature as essential to meet internationally agreed goals for biodiversity conservation and sustainable use, climate change mitigation and adaptation, the UN's 2030 Sustainable Development Goals, and to maintain livelihood options for Indigenous and non-Indigenous communities who directly depend on nature. However, such recognition has not yet been fully embraced by mainstream conservation and development policies (184). The transitions proposed above provide a way forward offering an intergenerational vision honoring the historical struggles and wisdom of past generations, drawing from the experience and innovations of today's generations, and embodying the legacy and hopes for future generations.

SUMMARY POINTS

1. Indigenous peoples and local communities are key actors in environmental governance who maintain intergenerational connections to place and nature through livelihood practices, cultural identity, worldviews, institutions, and ecological knowledge.
2. Indigenous peoples and local communities contribute to territorial management and environmental stewardship through customary governance and practices that create and maintain biodiversity. These practices are based on formal and informal institutional and social arrangements embedded in multiple values of nature.
3. Although often excluded or even displaced by formal conservation efforts like protected areas in the past, Indigenous peoples' and local communities' engagement in environmental management and restoration efforts have demonstrated successes with regional to global implications.
4. Indigenous peoples and local communities produce knowledge, inform science and environmental assessments, and monitor environmental change. Recently, ethical concerns have given rise to innovative collaborative arrangements for knowledge coproduction, which explicitly recognize the complementarities between scientific evidence and evidence generated by other knowledge systems.
5. The Local Biodiversity Outlooks-2 bring together over 50 stories by Indigenous and non-Indigenous authors about their perspectives and experiences around the current social-ecological crisis, contributions to the UN Decade on Biodiversity, and, more broadly, local solutions across biodiversity, climate change and sustainable development challenges.
6. Indigenous peoples and local communities prevent, limit, and halt activities that directly result in environmental degradation, given that they are often on the frontlines where such activities happen. Nonetheless, their actions of resistance are often penalized,

resulting in increasing intimidation, criminalization, and violence, including assassinations of leaders.

7. Indigenous peoples and local communities increasingly engage in environmental governance across scales yet continue to face barriers to participation in regional and global environmental governance.
8. While diverse, Indigenous peoples and local communities' values and worldviews offer alternative conceptualizations of relations between people and nature, often emphasizing the need to sustain respectful and reciprocal relationships with nature.
9. The academic literature on Indigenous and local knowledge and practices has evolved significantly from utilitarian views to increased attention to values and worldviews toward nature, political struggles and violence, research ethics, drivers of environmental change associated with economic development pressures, climate change, and conservation initiatives, as well as social, cultural, and demographic changes experienced by communities.

FUTURE ISSUES

1. Further research can continue to identify, recognize, and make visible the contributions of Indigenous peoples and local communities to environmental stewardship in ways that are multidimensional (social-cultural, economic, environmental), multiscalar, and participatory, for instance, assessing contributions to environmental management (e.g., watershed, ecosystems), food production, agrobiodiversity, combating invasive species, biodiversity protection and restoration, climate mitigation, and to regional economies more broadly.
2. An important area of work remains in reconciling how Indigenous philosophies can be understood and inform other situations, such as treating nature and culture as interwoven, prioritizing reciprocity, emphasizing care, learning and adaptiveness, and acknowledging spiritual dimensions, without appropriation of these philosophies or divorcing them from their important place-based context.
3. An important future issue involves research and action around the struggles of Indigenous peoples and local communities to counter threats to nature, particularly those perpetrated by extractive industries. Currently such struggles are often presented in ways that do not reflect their contributions to maintain nature, but rather one of conflict and criminalization. Future work can help clarify where and how these struggles occur and the role of values of nature within them, as well as how others can serve as allies to these communities.
4. In the face of growing pressures against Indigenous peoples and local communities, and an unprecedented global biodiversity and climate crisis, one key future issue will be which governance approaches and policies are most effective at facilitating and safeguarding their contributions to environmental stewardship. One possible path is rights-based approaches to nature and environmental management, such as through increasing recognition of their rights and agency in biodiversity and climate policy fora. Research can

help document the social and environmental outcomes of rights-based approaches and the conditions that facilitate or hinder their long-term successes.

5. There is an absence of prognostic scenarios that take into account, on the one hand, the perspectives of Indigenous and local communities on environmental management and governance pathways for regional landscapes and seascapes, and on the other hand, scenarios modeling the impact of land use, environmental and climate change on these populations.
6. There is limited knowledge on the impact of declining nature's contributions to people/ ecosystem services on Indigenous peoples and local communities, including regulating, material, and non-material contributions. Likewise, existing indicators of human well-being for Indigenous peoples and local communities are limited, often relying on aggregated objective indicators such as income. Multidimensional indicators of well-being at various scales could help to identify needs specific to different regions and social groups.
7. Collaborative approaches can contribute to advance ways to promote knowledge co-production to bridge Indigenous and local knowledge systems and science, with an aim to support better assessments, monitoring, and decision-making for people and nature. For instance, collaborative research on Indigenous and local indicators of social-ecological change offer opportunities for collaborative assessment and monitoring of biodiversity and ecosystem function and the impacts of climate change at local and regional levels.

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