Global Environmental Change 81 (2023) 102692

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Status, challenges and pathways to the sustainable use of wild species

Jean-Marc Fromentin [a,*], Marla R. Emery [b,1], John Donaldson [c], Ganesan Balachander [d], Elizabeth S. Barron [e], Ram P. Chaudhary [f], Marie-Claire Danner [g], Maria A. Gasalla [h], Agnès Hallosserie [i], Marwa Halmy [j], Christina Hicks [k], Daniel Kieling [g], Mi Sun Park [l], Brenda Parlee [m], Jack Rice [n], Tamara Ticktin [o], Derek Tittensor [p]

[a] MARBEC, University of Montpellier, Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), Institut de Recherche pour le Développement (IRD), Centre National de la Recherche Scientifique (CNRS), Sète, France
[b] Forest Service, United States Department of Agriculture, Burlington, VT, United States
[c] Department of Plant and Soil Sciences, University of Pretoria, Pretoria, South Africa
[d] Krishi Bounty Private Limited, Chennai, India
[e] Department of Geography, Norwegian University of Science and Technology, Trondheim, Norway
[f] Research Centre for Applied Science and Technology, Tribhuvan University, Kathmandu, Nepal
[g] Centre de Synthèse et d'Analyse sur la Biodiversité (FRB-CESAB), Fondation pour la Recherche sur la Biodiversité, Montpellier, France
[h] Department of Biological Oceanography, University of Sao Paulo, Sao Paulo, Brazil
[i] Fondation pour la Recherche sur la Biodiversité (FRB), Paris, France
[j] Department of Environmental Sciences, Alexandria University, Alexandria, Egypt
[k] Lancaster Environment Center, Lancaster University, Lancaster, United Kingdom
[l] Graduate School of International Agricultural Technology, Seoul National University, Pyeongchang Campus, Republic of Korea
[m] Department of Resource Economics and Environmental Sociology, University of Alberta, Edmonton, Canada
[n] Fisheries and Oceans Canada, Ottawa, Ontario, Canada
[o] Department of Botany, University of Hawaii, Mānoa, United States
[p] Department of Biology, Dalhousie University, Halifax, Nova Scotia, Canada

ARTICLE INFO

Keywords:
Sustainability
Biodiversity
Wild animals
Wild plants
IPBES

ABSTRACT

The use of wild species is extensive in both high- and low-income countries. At least 50,000 wild species are used by billions of people around the world for food, energy, medicine, material, education or recreation, contributing significantly to efforts to achieve the United Nations Sustainable Development Goals. However, overexploitation remains a major threat to many wild species. Ensuring and enhancing the sustainability of use of wild species is thus essential for human well-being and biodiversity conservation. Globally, the use of wild species is increasing due to growing human demand and efficiency, but its sustainability varies and depends on the social-ecological contexts in which the use occurs. Multiple environmental and social (including economic) drivers affect the sustainability of use of wild species, posing major current and future challenges. In particular, climate change has already increased the vulnerability of many uses and is expected to increase it further in the coming decades, while global and illegal trades are, in many cases, key drivers of unsustainability. There is no single "silver bullet" policy to address these and other major challenges in the sustainable use of wild species. Rather, effective policies need to integrate inclusive actions at multiple scales that adopt right-based approaches, pay attention to equitable distribution of access and costs and benefits, employ participatory processes, strengthen monitoring programs, build robust customary or government institutions and support context-specific policies, as well as adaptive management.

* Corresponding author.
E-mail address: jean.marc.fromentin@ifremer.fr (J.-M. Fromentin).
[1] Present address: Norwegian Institute for Nature Research (NINA), Trondheim, Norway.

https://doi.org/10.1016/j.gloenvcha.2023.102692
Received 22 January 2023; Received in revised form 25 April 2023; Accepted 10 May 2023
Available online 29 May 2023

1. Introduction

Billions of people in all regions of the world benefit from and often rely on the use of wild species for food, medicine, energy, materials, income, and non-material values (IPBES, 2022b). Concurrently, direct human exploitation of wild species has been identified as one of the main drivers of biodiversity decline in terrestrial, freshwater and marine ecosystems (Díaz et al., 2019). For example, 37% of shark, ray and chimera species, 12% of wild tree species, 1340 wild mammal species and many wild cactus, cycad, and orchid species are threatened with extinction due to unsustainable use (IUCN, 2020; Dulvy et al., 2021; IPBES, 2022b). Nonetheless, human use of wild species is not always and everywhere detrimental and there are many examples of sustainable use of wild species throughout the world, as well as successful efforts to restore populations that have been severely overexploited, such as vicuña and eastern Atlantic bluefin tuna (Lichtenstein, 2009; Fromentin et al., 2014).

The scale and extent of use of wild species has been the subject of several international assessments, such as those by the Food and Agriculture Organization of the United Nations (FAO, 2020b, a) and by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) at global (IPBES, 2019) and regional levels (IPBES, 2018a,b,c,d). These assessments provide strong background on the status and trends of biodiversity as a whole and on some specific groups of wild species, such as fishes or trees and their associated practices (fishing and logging). However, the status of many other groups of wild species commonly used by people (e.g. vascular plants, mushrooms and insects) and several key practices (gathering, hunting, and nature-based tourism, Fig. 1), remain poorly documented. Therefore, IPBES launched the first comprehensive intergovernmental effort, carried out by 85 independent experts from 37 countries and more than 200 contributing authors, to document the status and trends of all types of use of wild species worldwide and to provide policy- and solution-oriented approaches that ensure and enhance sustainable use of wild species while recognizing the diversity of practices, uses and contexts (IPBES, 2022c). Here, we report the key findings of this assessment.

2. Sustainable use of wild species is critical for people and biodiversity conservation

The concept of sustainable use has evolved through time and differs among cultures. Nonetheless, the scientific literature on this topic, particularly prior to the 21st century, came mainly from authors from high-income countries, which strongly influenced international agreements and other policy documents negotiated in the last half century (see section 2.2 in Rice et al., 2022). Since the United Nations Conference on Sustainable Development in 1992, the cultural practices and traditional livelihoods of indigenous peoples and local communities (often closely tied to nature) have been increasingly recognized by international bodies, including IPBES (Hill et al., 2020) and are prominent in the Global Biodiversity Framework (https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf). Modern conceptualizations revolve around the idea that sustainable use emerges from the dynamics of social-ecological systems that maintain biodiversity and ecosystem functions in the long-term while contributing to human needs and well-being (IPBES, 2022b). Critically, sustainable use of wild species encompasses both social (including economic) and ecological considerations, as well as the multiple aspects of their interactions (Cooney, 2007; Ostrom, 2009). It is a dynamic process, as wild species, the ecosystems that support them and the social systems within which uses occur, change over time and space.

The contributions of wild species to human well-being are vital and

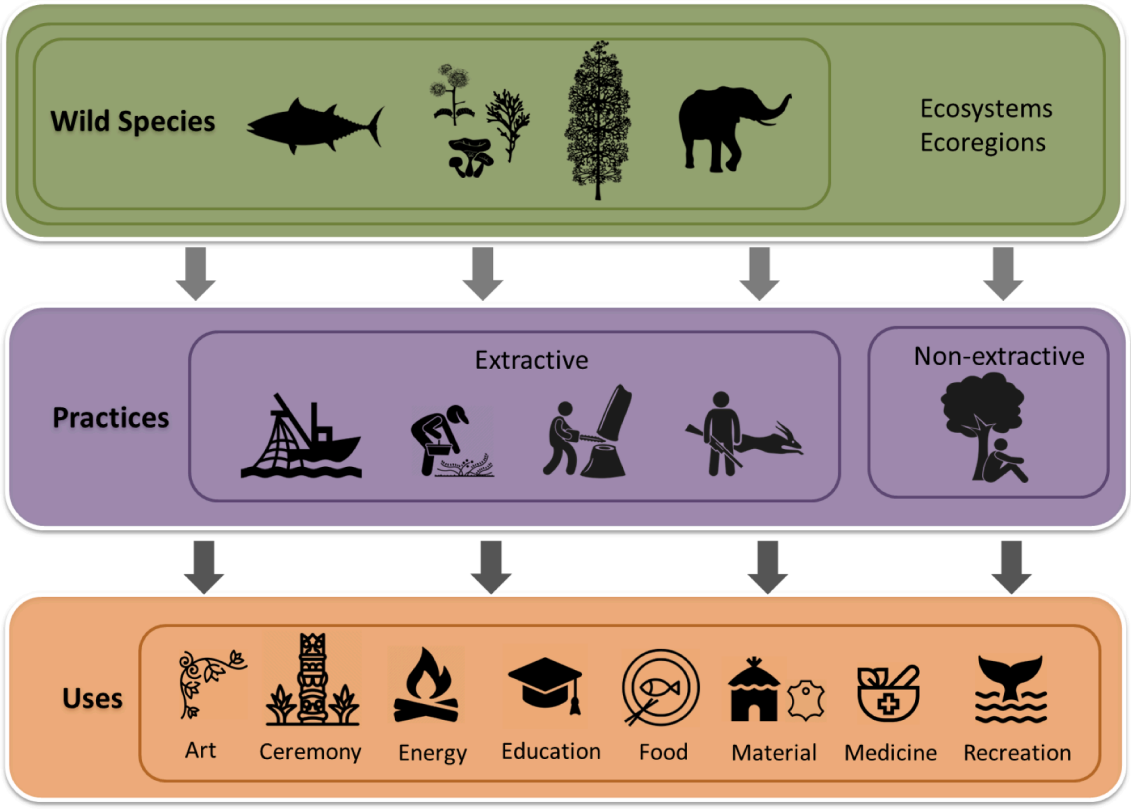

Fig. 1. Categories of wild species, practices and uses. Four general categories of wild species: aquatic animals, plants (excluding trees) together with algae and fungi, trees and terrestrial animals are separated because of differences in the status of use, the practices of these groups and the policy options for managing them. The use of these groups of wild species takes place in various ecosystems and ecoregions. Practices are split into extractive (including fishing, gathering, logging and terrestrial animal harvesting) and non-extractive ones. Uses have been divided into eight categories, which are not mutually exclusive.

occur through many types of uses (Fig. 1), which can be continuous and quotidian or episodic and occasional (IPBES, 2022b). About 50,000 wild species are documented to be used, including 7500 species of wild fishes and aquatic invertebrates, 31,100 species of wild plants (including 7400 species of trees), 1500 species of fungi, 1700 species of wild terrestrial invertebrates and 7500 species of wild amphibians, reptiles, birds and mammals (section 3.2.1 in Barron et al., 2022). Among those, more than 10,000 species are used for human food, making the sustainable use of wild species critical for achieving food security and improving nutrition in rural and urban areas worldwide. For instance, marine and freshwater fisheries constitute a key source of protein, fat, and micronutrients for people worldwide (Hicks et al., 2019). With a total annual harvest of 90 million tons, about 60 million tons are consumed directly by humans and 30 million tons are used as feed for aquaculture and livestock (FAO, 2020a). Terrestrial animal harvesting (of which hunting is the primary form) also contributes to the food security of many people living in rural and urban areas worldwide, especially in low-income countries (Coad et al., 2019). Wild plants, algae and fungi provide food, nutritional diversity, and income for an estimated one in five people around the world, while 2.4 billion people, especially in low-income countries, are estimated to rely on biomass for cooking and heating (OECD/IEA, 2017; Sorrenti, 2017). Uses of wild species are also important sources of income and form the basis for economically and culturally important activities worldwide. Annual trade in wild plants, algae and fungi is estimated to be worth over $1 billion and the establishment of supply chains can fuel economic development and diversification (Sorrenti, 2017). Fishing, logging, and nature-based tourism are vital to regional and local employment and economies worldwide and contribute to public infrastructure, development and provisioning of related goods and services (Balmford et al., 2015; FAO, 2020a, b). The use of wild species also provides non-material contributions by enriching people's physical and psychological experiences, including their religious, spiritual and ceremonial lives (Russell et al., 2013). In many cases, a single species may have multiple uses and contributes to human well-being in multiple ways (section 1.3.4 in Fromentin et al., 2022).

The use of wild species supports peoples' basic needs worldwide and contributes to the achievement of the United Nations Sustainable Development Goals (SDGs). People living in vulnerable conditions are often the most reliant on wild species and would benefit directly from more sustainable uses to secure their livelihoods. An estimated 70% of the world's poor depend directly on biodiversity and on businesses it fosters (UNCTAD, 2017). Supporting and enhancing sustainable use of wild species would thus make direct and significant contributions to meeting many SDGs (Fig. 2), in particular the goals of "no poverty" (Goal 1), "zero hunger" (Goal 2), "clean water and sanitation" (Goal 6), "affordable and clean energy" (Goal 7), "decent work and economic growth" (Goal 8), "industry, innovation and infrastructure" (Goal 9), "reduced inequalities" (Goal 10), "climate action" (Goal 13), and "life below water and on land" (Goals 14 and 15). However, these potential contributions remain largely overlooked in current global policies (Fig. 2) and deserve greater attention (see section 1.6 in Fromentin et al., 2022).

Sustainable use of wild species is also central to the identity and culture of many indigenous peoples and local communities, contributing to their livelihoods through subsistence and trade in formal and informal markets. The cultures and knowledge of indigenous peoples and local communities are diverse, but usually include common values regarding the use of wild species, such as an obligation to engage nature with respect, reciprocal responsibilities, avoid waste, and manage harvests for fair and equitable distribution of benefits for community well-being (Brondízio et al., 2021). Frequently, these values are codified in customary institutions and systems of governance that help to ensure sustainable uses of wild species (Comberti et al., 2015; Berkes, 2018). Today, indigenous peoples manage the use of wild species on more than 38 million km^2 of land in 87 countries, which occupies over a quarter of the world's land surface and coincides with approximately 40% of terrestrial protected areas and ecologically intact landscapes (Garnett et al., 2018). Globally, rates of deforestation and other forms of ecosystem decline are generally lower in indigenous territories (Sze et al., 2022).

Moving from unsustainable to sustainable use of wild species is also critical for biodiversity conservation because overexploitation remains a major threat to many wild species (Díaz et al., 2019). Further, management systems that promote sustainable use of wild species can contribute to broader conservation objectives that help reverse the current biodiversity decline. For example, effective management systems have contributed to the conservation of species-rich forests at local levels as well as at landscape scale (Dollo et al., 2009). Globally, protected areas receive 8 billion visits for nature-based tourism purposes and generate US$600 billion per year (Balmford et al., 2015), making significant contributions to overcoming frequent funding shortfalls for the protection of these areas. In some countries, revenues from extractive uses of wild animals, including hunting and fishing licenses and concession fees, deliver an important and substantial income stream that could be allocated to habitat and biodiversity protection, provided rights and customary practices of indigenous peoples and local communities in their traditional lands and resources are not over-ridden (UNDP, 2018).

3. Status and trends in the uses of wild species

Globally, the use of wild species is increasing due to the growing human population, consumption and efficiency. However, the status of uses of wild species displays strong disparities according to types and

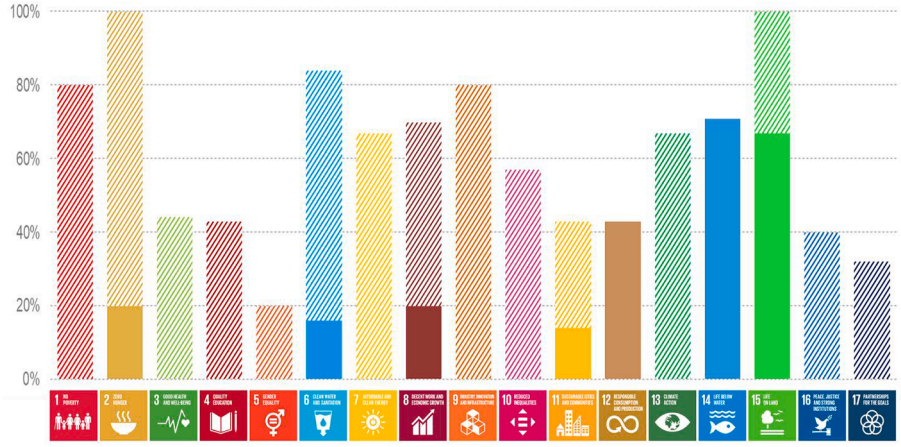

Fig. 2. Acknowledged and overlooked contributions of sustainable use of wild species to Sustainable Development Goal (SDG) targets. Each percentage represents the number of targets in an SDG to which sustainable use of wild species can contribute out of the total number of targets in that SDG. Plain color bars represent the percentage of targets for which the potential contributions of sustainable use of wild species is already acknowledged. Hatched color bars indicate the percentage of additional targets that sustainable use of wild species could contribute.

scales of use and the social-ecological contexts in which they occur. Regarding fishing, about 66% of marine wild fish stocks are fished within biologically sustainable levels, whereas 34% are overfished (FAO, 2020a), but this global picture masks strong spatial heterogeneities (Fig. 3). In countries or regions with strong fisheries management, fish stocks are, on average, either healthy or increasing in abundance, whereas in countries and regions with less-developed management for commercial fisheries, harvest rates are, on average, 3-fold greater and stocks are in poor shape (Hilborn et al., 2020). For small-scale fisheries that have been assessed around the world, many have been found to be unsustainable or only partially sustainable due to changing social-ecological contexts. This is especially the case in Africa for both inland and marine fisheries and in Asia, Europe, and Latin America for coastal marine fisheries (see section 3.3.1 in Barron et al., 2022). Unintentional bycatch of threatened and protected species is not only unsustainable for many sharks, rays and chimera, but also for several populations of wild marine turtles, seabirds, marine mammals and some bony fishes. Recent advances in monitoring and managing fishing have reduced the mortality of many bycatch species, but global uptake of effective bycatch management measures is severely lagging in many fisheries (Lewison et al., 2014).

Trade in wild plants, algae and fungi has increased rapidly over the past 40 years (Fig. 3) and is likely to continue to do so, as there is a growing demand for wild species in the food and aromatics industries and to complement chemical medicines, particularly in high-income countries (see section 4.2.4 in Balachander et al., 2022). Although much of the trade in ornamental plants is supplied through cultivation, poaching of ornamental species from the wild is an ongoing problem (Phelps and Webb, 2015). Harvests of plants that have been sustainable in the past may become unsustainable if, for example, harvesting is undertaken without following established techniques and protocols or if new technologies are employed that increase the volume of harvest or result in damage to the individual specimen (Hernández-Barrios et al., 2015).

Practice	Use category	20-year global trends		Comments
		use	sustainable use	
FISHING	Food Feed	↓	↑	Corresponds to large-scale fisheries with intensive management, data rich
		↗	⇕	Corresponds to large-scale fisheries with weak management, data limited
		⇕	⇕	Corresponds to small-scale fisheries, based on a range of sources
	Medicine Hygiene	↑	⇕	Based on stock status and total weigh of products
	Recreation	↑	⊘	Data limited
GATHERING	Food Feed	↗	→	Based on a range of sources
	Medicine Hygiene	↑	⇕	Based on population trends, threatened categories and CITES listing
	Decorative Aesthetic	↗	→	Based on threatened categories and CITES listing
LOGGING	Materials Construction	↑	⇕	Based on total legal wood removal
	Energy	↑	⇕	Based on a range of sources
TERRESTRIAL ANIMAL HARVESTING	Recreation	⇕	→	Based on population trends, threatened categories and CITES listing
	Food Feed	⇕	↓	Based on increasing demand for wild meat in commercial markets, population trends
NON-EXTRACTIVE PRACTICES	Recreation	↑	⇕	Based on amount of tourism revenue generated
	Ceremony Ritual	⇕	⊘	Data limited
	Medicine Hygiene	⇕	⊘	Data limited

Fig. 3. Global trends in use and sustainable use of wild species from 2000 to 2020. The figure only shows the top two to three use categories for each practice, selected based on which uses were best documented in the systematic literature review performed for this IPBES assessment. Trends in use or in sustainable use refer to an assessment of the overall state of use of wild species in relation to the specified practice. The multi-directional arrow depicts highly variable trends across areas or sectors for a given category of practice-use. The colors of the arrows refer to the confidence levels associated with those trends. Grey: inconclusive; Orange: unresolved; Purple: established but incomplete; Blue: well established. Trend in use include all types of use (sustainable and unsustainable ones). Trends in sustainable use specifically refer to whether the intensity and form of use have been deemed sustainable over the 20-year period. Data supporting global trends and regional variations come from practice-based systematic reviews of over 1600 scientific references. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

The use of natural forests through logging is increasing and will likely continue to do so, in part because production from plantation forests is not expected to match rising global demand (Fig. 3). Some destructive logging practices and illegal logging continue to threaten sustainable use of natural forests. Illegal logging has declined in parts of the tropical Americas, as well as parts of the tropical and mountain regions of Asia due to improved monitoring and transboundary collaborations (Hoare, 2015). However, illegal logging has increased in other regions, including Southeast and Northeast Asia and parts of Africa (Guan et al., 2016). About 20% of the world's tropical forests (3.9 million km^2) are currently subject to selective logging. Selective logging can reduce the impacts of timber harvesting, but the outcomes depend on the planning and techniques used to minimize damage to the residual forest stand, as well as forest soils, flora and fauna (Arets et al., 2011). Logging for energy accounts for 50% of all wood consumed globally (FAO, 2020b). Sustainable fuel wood logging remains a renewable energy opportunity that provides income, heating and cooking in low-income countries where 1.1 billion people have no access to electricity or alternative energy sources, provided air pollution and emissions that contribute to climate change are mitigated (Cornwall, 2017). The use of wood for fuel is declining in several regions, but is increasing in sub-Saharan Africa and accounts for 90% of all timber harvested in Africa. When comparing supply–demand balances, fuel wood demand can be met at global and national scales, but localized shortages and associated forest and woodland degradation occur in areas where people have few alternatives for cooking and heating (FAO, 2020b; IPBES, 2022b).

Unsustainable terrestrial animal harvesting in combination with other factors, such as land degradation or climate change, have led to the decline of many wild populations (Fig. 3). In tropical areas, the sustainability of hunting for food has been negatively affected by social changes, such as the introduction of cash market economies, global trade, urbanization, and road infrastructure, which have resulted in shifts from local-level subsistence towards more intensive wild meat trade (Pangau-Adam et al., 2012). Large mammals are the most targeted species for subsistence and commercial hunting, comprising 55% to 75% of total wild meat biomass hunted annually (see section 3.3.3 in Barron et al., 2022). Considerable regional variations in the way recreational hunting is pursued, governed and administered make any generalization about its sustainability or unsustainability inappropriate. Where species and habitats are well managed and hunting is regulated through strong customary or government institutions, hunting can and does have positive impacts on conservation of wild species and livelihoods of indigenous people and local communities (Begg et al., 2018; IUCN, 2016; Dickman et al., 2019). In a few positive cases, depleted populations are recovering under management systems that allow regulated recreational hunting by generating revenue that allow for increased land area for population expansion (Lindsey, 2011). Harvesting live animals for legal or illegal pet trade is also increasing and estimated to affect more than 1000 species of birds, reptiles, fishes and mammals (see section 4.2.4 in Balachander et al., 2022). Although the value of species traded as pets is less than 1% of the total trade of wild species, the number of individuals traded is in the millions.

Nature-based tourism is an important non-extractive practice with wild species. Demand for media (e.g., documentaries) and *in situ* observing (e.g., wildlife watching tourism) related to wild species is growing (Fig. 3). Although non-extractive practices are frequently less harmful to wild species and ecosystems than extractive ones, wildlife watching may have unintended detrimental impacts through changes to species behaviour, physiology, or damage to habitats (Toso et al., 2022). Many of the unsustainable impacts of the tourism industry could be mitigated through context-based understanding, implementation of best practice guidelines, education of tour operators and tourists, collaborative engagement with all stakeholders and sector-specific regulations (IPBES, 2022b). However, the implementation of such regulations can lead to conflict and, at times even spark violence, if not properly incorporated into the local social-ecological system (Sada Guevara, 2020).

4. Drivers of (un)sustainable use of wild species

The sustainability of use of wild species is influenced by multiple environmental and social (including economic) drivers as well as mediating factors that mitigate or amplify negative impacts at multiple scales. For instance, the sustainability of wild meat hunting is increasingly driven by a shift from primarily subsistence purposes to recreation, entertainment, and both legal and illegal trade (Spira et al., 2019). Environmental drivers, such as landscape and seascape change, climate change, pollution and biological invasions often negatively impact the abundance and distribution of wild species, which can in turn increase stress and challenges among the human communities that use them (Bellard et al., 2016; Musinguzi et al., 2016). These drivers notably land degradation and climate change, also place pressure on the ability of the ecosystems to sustain extractive harvests at previous levels (Hoegh-Guldberg et al., 2018; Hopping et al., 2018). There is also significant inequity in who benefits and who is at risk from unsustainable use of wild species. Rural populations in the Americas, Asia and Africa (nearly 3.5 billion people) rely heavily on the use of wild species (Barrett et al., 2011) and the lack of alternatives for people living in conditions of poverty may make it necessary for them to intensify their pressure on wild species, further depleting a resource in decline and creating a downward spiral. However, the economic and political systems that perpetuate poverty and inequity are the underlying drivers of such unsustainable uses of wild species (Barbier, 2010). Importantly, the inequitable distribution of access and costs and benefits from the use of wild species greatly undermines its sustainability (Ribot et al., 2010; Bennett et al., 2019).

Global trade has expanded considerably over the past 40 years and is a major driver of increased, and often unsustainable, use of wild species (Harfoot et al., 2018). Global trade is an important income source for exporting countries and can be a source of local wealth. However, it decouples the consumption of wild species from their place of origin, introduces infrastructures and dynamics different from those that govern local trade relations and practices. Global trade can also shift governing strategies from collective community actions that previously supported sustainable use to individual or corporate actions that lack the knowledge base and motivations necessary to support long-term sustainability (Wamukota et al., 2014; Stoll et al., 2018). In the absence of functioning regulations that operate across the supply chains, global trade generally increases pressure on wild species, leading to unsustainable use and sometimes to population collapses (Fields et al., 2018). Global trade has also been recognized as a major source of introduction of non-native and invasive species that may displace or otherwise adversely impact local wild species traditionally used by people (Lockwood et al., 2019).

Illegal harvest and trade in wild species occur across all practices and most often lead to unsustainable uses ('t Sas-Rolfes et al., 2019; Unodc, 2020). Globally, data suggest illegal trade in wild species is the third largest class of illegal trade, with an estimated annual value of US$ 69–199 billions (World Bank, 2019). Volume and value of illegal trade in wild species is greatest for trees and fishes, but also strongly affects other rare and high value species (Symes et al., 2018; Unodc, 2020). Illegal trade is further associated with social injustices and violent conflicts and may involve criminal networks (World Bank, 2019). For example, the vaquita, a species of porpoise only found in the northern Gulf of California, is currently on the verge of extinction, due to poaching and illegal trade by criminal organizations of an equally endangered, but highly valuable fish known as the totoaba (O'Connor et al., 2022). International cooperation is often required to address illegal harvest and trade (Rosen and Smith, 2010; Tittensor et al., 2020).

Effective governance, institutions and policies can however promote positive outcomes and mitigate negative impacts of such above drivers. For instance, multilateral agreements like those of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and associated legislations have been successful in addressing

many aspects of legal and illegal trade and seemingly decreased pressure on some wild species (section 4.2.2 in Balachander et al., 2022). Effort to decrease pressure on wild species has also contributed in an increase in the proportion of farmed specimens in the trade of wild species, notably for fishes, birds, amphibians and plants (Vall-llosera and Cassey, 2017; Hierink et al., 2020). Shifts to farmed stocks can indeed reduce harvest impacts on wild populations, provided wild specimens are not specifically in demand and regulations and control are in place to avoid entry of illegally harvested wild specimens into supply chains (Hinsley et al., 2017). Such farming practices (including captive breeding) can however have a negative impact on local livelihoods, equitable sharing of benefits, conservation of natural habitat, *in-situ* management of wild populations and illegal harvesting (Cooney and Jepson, 2006; Lyons and Natusch, 2011; Cooney et al., 2015). These farming practices must also take into account the welfare of farmed animals and the potential introduction of invasive alien species and transmission of zoonotic diseases. Likewise, international policies that support the rights and practices of indigenous peoples and local communities to lands, waters, and customary sustainable uses are effective in many instances, but are often not recognized at national and subnational levels (Popp et al., 2019). As a result, the ability of indigenous peoples and local communities to maintain and restore sustainable uses of wild species continues to face ongoing threats (Atlas et al., 2021).

In many parts of the world, women bear the primary responsibility for feeding their families, collecting, processing, cooking, rationing and storing food, giving women a key role in the sustainable use of wild species (Ingram et al., 2016). In addition, income generated by women from the harvesting of wild species adds to the purchasing power of households (Espinosa, 2010). Nonetheless, gender is seldom taken into account by institutions and policies governing the use of wild species, although the Global Biodiversity Framework recently called attention to the roles and perspectives of women to address the biodiversity crisis (https://www.iucn.org/story/202212/post-2020-global-biodiversity-framework-gbf-and-environmental-human-rights-defenders). This general lack of recognition leads to the exclusion of women from decision-making processes and to inequities in the distribution of costs and benefits, often resulting from disparities in property rights and lack of security of tenure and access to wild species (Rohe et al., 2018). Conversely, it has been shown that securing women's participation in decision-making leads to better resource governance and conservation outcomes (Agarwal, 2009; Leisher et al., 2016).

The lack of comprehensive indicators for monitoring the status and trends in the use of wild species posed major difficulties for assessing the sustainable use of wild species (IPBES, 2022b). Of the hundreds of indicators codified in multilateral agreements, such as the SDGs and the Aichi Biodiversity Targets, only a small percentage relates specifically to the (sustainable) use of wild species. Further, the sensitivity and specificity of many of these indicators have not been well established (see sections 3.2 and 2.3 in Barron et al., 2022; Rice et al., 2022, respectively). Few scientific studies have developed and used global indicator frameworks for gathering, terrestrial animal harvesting, and nature-based tourism (Fig. 4). Indicators of social sustainability are fewer or lacking for all practices, particularly aside from economic and governance indicators (Fig. 4). Addressing these limitations will provide more consistent information about the status of uses of wild species and, importantly, support ongoing analyses of the effectiveness of policies and management systems. Monitoring in many indigenous peoples and local communities' land territories often focuses on interlinked social and ecological elements and can inform the development of local and global indicators that recognize these linkages at different scales (Lyver et al., 2017).

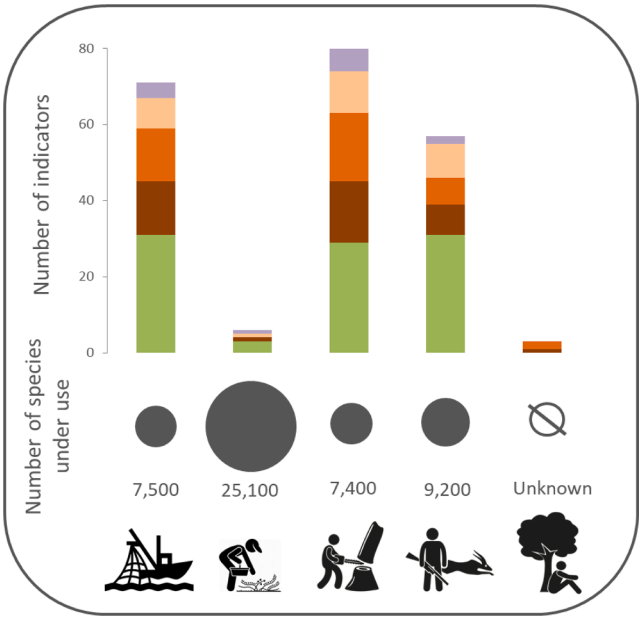

Fig. 4. Wild species used worldwide compared with indicators of sustainable use by practice. This figure displays the estimated number of wild species by practice type (fishing, gathering, logging, terrestrial animal harvesting and non-extractive practices), in comparison with the number of global indicators of sustainable use of wild species by practice type. The indicators are grouped as ecological (green), management and monitoring (dark orange), economic (medium orange), governance (light orange) and other (light purple). The terrestrial animal harvesting scoring is based primarily on regional indicators due to the paucity of global indicators. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

5. Possible futures

Scenarios projecting the future use of wild species remain scarce and incomplete, especially for gathering, terrestrial animal harvesting, and nature-based tourism. Those available point to a future where sustainable use of wild species becomes increasingly vulnerable to growing human demand, technological developments, and climate change (IPBES, 2022b). For all practices, demand is closely linked to growing human population and consumption. Unless consumer preferences change, the pressure on wild species and on the management systems in place to ensure sustainable use will continue to increase (Frost et al., 2014; Santos et al., 2017). For example, the demand for gathered wild plants, algae, and fungi will continue to increase both locally, where most products are consumed, as well as in international markets (Bondé et al., 2020), while the demand for (wild and farmed) fish is expected to almost double by 2050 (FAO, 2020a). Current and future technological changes can have a negative impact on the use of wild species through more efficient, more intensive and more rapid extractive practices, or a positive impact through better monitoring, enforcement and reducing impacts of harvesting methods (Yilmaz and Koyuncu, 2019). Climate change has already increased the vulnerability of many uses that are currently sustainable and is expected to increase it further in the future (see section 5.4 in Gasalla et al., 2022). Impacts of climate change on the sustainability of uses include changes in wild species distributions, dynamics and trophic interactions, increased frequency of extreme events, and chemical and ecological modifications (Pörtner et al., 2021). For

example, increased intensity and frequency of floods, droughts and wildfires resulting from climate change modify forest composition and productivity (Brando et al., 2019). Climate change is also expected to decrease world fish catch globally, with a particularly pronounced effect in tropical oceans, while creating new opportunities in mid- to high-latitude oceans because of poleward shifts in the ranges of marine species (FAO, 2018). Climate change thus impacts different regions of the world differently, amplifying issues of inequity for many countries that are heavily affected even though they have historically contributed little to CO_2 emissions (Blasiak et al., 2017). The effects of climate change further interact with other environmental and social drivers and could exacerbate existing social vulnerabilities and inequalities (Hoegh-Guldberg et al., 2018; Boyce et al., 2020).

6. Leverage points for transformative change

Scenarios projecting the future use of wild species indicate that transformative changes are required to meet current and future challenges. To do so, it is essential to move towards a common conceptualization of sustainability while acknowledging diverse value systems (IPBES, 2022a). Ambitious goals are necessary, but insufficient. These high-level goals need to be translated into meaningful and inclusive actions that support the sustainable use of wild species at multiple scales. This IPBES assessment has identified seven key elements of policy action that have been shown to support sustainable use of wild species (see section 6.6 in Park et al., 2022). These seven key elements are all necessary considerations and are listed below in no particular order:

The first key element is the necessity for policy options to be inclusive and participatory. Stakeholder diversity and engagement promote buy-in and collaboration and expand the knowledge base for decision-making through approaches such as co-management, provided power imbalances and conflicts are managed (Castello et al., 2009).

The necessity to recognize and support a plurality of knowledge systems, values and rights represents the second key element. Bringing together scientists and holders of indigenous and local knowledge can create robust information about social and ecological conditions, increase risk tolerances and improve decision-making (He et al., 2011).

Ensuring fair and equitable distribution of access and costs and benefits is the third key element for sustainable use of wild species. People's perceptions of fairness and justice shape their willingness to comply with regulations that govern sustainable use. Inequitable distribution of benefits often undermines sustainability by fostering overharvesting, poaching and short-term gains over long-term sustainable management. In contrast, secure rights of access and use and participation in governance mechanisms and accountability positively influence the sustainability of uses of wild species (Orensanz et al., 2013).

The fourth key element emphasizes the need for context-specific policies, i.e. policies that are tailored to their social and ecological contexts. There is indeed no single "silver bullet" recipe that can be applied in all contexts and for all species and practices. Policy instruments and tools commonly fail when they do not take into account the ecological, cultural, political and historical features in which use of wild species take place (Biggs et al., 2019). Actions to empower local communities and respect their rights, access, and customary rules are fundamental to the development of context-specific policies (Tobin, 2008).

The fifth key element emphasizes the importance of monitoring both social and ecological aspects of uses of wild species. Monitoring is resource intensive and requires substantial commitment and investment to be effective (Schmeller et al., 2017). Co-production of knowledge by scientists and indigenous peoples and local communities (who may have generations of knowledge and customary monitoring practices) can create robust information about the conditions of wild species uses and serve as a basis for monitoring programs, particularly for species and uses for which scientific information is lacking (Brondízio et al., 2021).

Policy instruments also need to be aligned at international, national, regional and local levels to be more effective (which represents the sixth key element). Fewer negative and unintended consequences occur when attention is paid to coordinated interactions among approaches, actors, and scales (Brinckmann et al., 2018). For instance, policies enacted to govern diverse sectors including, but not limited to, agriculture, energy and transportation, often affect uses of wild species (Díaz et al., 2019).

Lastly (i.e. the seventh key element), sustainable use of wild species requires building robust government institutions and/or supporting customary institutions. Institutions that are structured around collaborative and decentralized learning and shared interests in sustainable use are more effective than centralized systems with "top-down" governance. Because the species under use, the ecosystems that support them, and the social systems within which uses occur continuously change over time and space, sustainable use of wild species is an ongoing adaptive process that requires constant negotiation and adaptive management. Therefore, institutions at all scales must be capable of adjusting to changing circumstances to face current and future challenges (Battaglia et al., 2017; Lee, 2018).

These seven key elements have been integrated into many voluntary agreements and certification schemes across all practices, but their uptake is lagging in globally and regionally binding agreements (see section 2.2 in Rice et al., 2022). Fishing is the only practice with globally binding agreements that include many of them, although key elements 1 (inclusive and participatory decision-making) and 3 (equitable distribution of access and costs and benefits) remain largely absent (Fig. 5). Integrating these seven key elements into legally binding agreements and certification schemes for all practices is a prerequisite for the future of sustainable use of wild species.

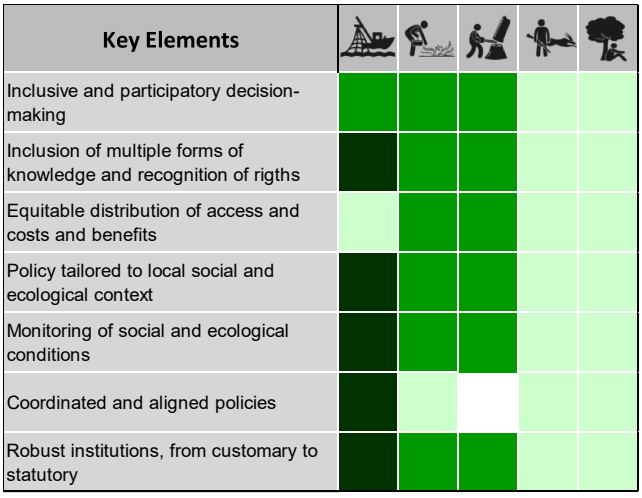

Fig. 5. Key elements of policy action supporting the sustainable use of wild species. Pictograms represent (from left to right): fishing, gathering, logging, terrestrial animal harvesting and non-extractive practices. Color coding is incremental and based on analyses reported in Section 2.2.6 in Rice et al., 2022 and summarized in section 6.6 in Park et al., 2022. Light green: key elements present in voluntary agreements (i.e. collaborative partnerships between parties or sectors aiming at improving governance or conservation outcomes, such as the community-based ecotourism organizations). Medium green: key elements present in voluntary agreements and certification schemes (i.e., procedures giving assurance that a use is in conformity with certain standards, such as the Forest Stewardship Council). Dark green: key elements present in voluntary agreements, certification schemes and legally binding agreements (i.e., contracts between parties making the terms and conditions of their relationship mandatory and enforceable, such as the UN agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks). No color (white): Not present in any of the above three agreement types. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

7. Conclusion

Sustainable use of wild species will also require moving beyond the human-nature dualism to a more systemic view of humanity as an integral part of nature (section 1.3.3 in Fromentin et al., 2022). The human-nature dualism is a perception and conceptualization of nature, which tends to separate nature (what exists by itself) from culture (what has been produced by humans). It is deeply embedded in many, but not all, cultures and is pervasive and integrated into many national and international agreements and policies (especially those related to environmental issues). Such a conceptualization is, however, not neutral, as views of the human-nature relationship profoundly influence our perception of the biosphere and the language used to describe, understand, and act on it (Descola, 2005). Importantly, this conceptualization fostered the illusion that humanity could exist apart from or control the rest of nature, to the point that the limitless human use of nature has led to major environmental crises (Plumwood, 2002). The scientific community indeed pointed to this direct responsibility of human activity in climate change (IPCC, 2019b, a), the decline of biodiversity (IPBES, 2019) and the modification of the main natural planetary processes, inaugurating a new and adverse geological era called the Anthropocene (Zalasiewicz et al., 2019). Considering humanity to be part of nature, i.e., one member or citizen of nature among others (Leopold, 1949), would lay the foundation for a more respectful and sustainable relationship, as demonstrated by many indigenous peoples' and local communities' traditional values, practices and uses (Brondízio et al., 2021).

CRediT authorship contribution statement

All the authors have participated to the conception of this review article and to the writing of this manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

We are grateful to the continuous insights and encouragement of the IPBES Secretariat, including A. Larigauderie, B. Myers, H. Ngo, S. Schiele and S. Yoshino. The IPBES Bureau and Multidisciplinary Expert Team, as well as the Management Committee, were invaluable sources of information and advice. We are especially indebted to L. Dziba, A. María Hernandez Salgar, M. Stenseke and S. Demissew Woodmatas for their wise counsel at critical moments. C. Brown, of the Policy Support TSU, provided important early support for Chapter 6, while the technical wizardry of Wairimu 'Nimoh' Mwaura and B. Omare was essential to the digital nature of our work. Our great thanks to N. Casajus for his assistance in the development of figures and M. Haas for bringing her graphic design expertise to benefit the assessment. Integration of indigenous and local knowledge was central to this assessment. Dialogue workshops were an essential component of that effort and we are profoundly grateful to the many individuals and organizations representing indigenous peoples and local communities (IPLC) who participated in them. Our thanks to UNESCO, notably N. Crawhall, for hosting the first workshop in Paris, and to E. Vachon and I. Julian for their warm welcome of the second workshop at the Biosphere environmental museum in Montreal. One silver lining of the pivot to virtual meetings was the expanded number of IPLC who were able to participate in the third dialogue workshop. This essential work would not have been possible without the Indigenous and Local Knowledge technical support unit, which is sponsored by UNESCO and expertly led by P. Bates.

The authors have no competing interests to declare and received no specific funding for this work. All authors involved in IPBES assessments and deliverables are involved on a voluntary basis. We are, however, indebted to the governments, organizations and individuals that generously supported this assessment. The French Foundation for Research on Biodiversity (FRB) and the French Biodiversity Agency (AFB), especially G. Landrieu, co-hosted TSUs. Support for our in-person meetings was provided by the University of Montpellier and Agropolis (in-kind support for the first author meeting), the second author meeting received support from the National Museums of Kenya and the Swiss Academy of Sciences (in particular E. Spehn) provided in-kind support for the final SPM meeting. We would also like to acknowledge the support of our home institutions and governments: L'Institut Français de Recherche pour l'Exploitation de la MER, Ifremer (France), USDA Forest Service (United States) and the South African National Biodiversity Institute (South Africa).

We are most grateful to the following lead authors, fellows, and review editors of the IPBES Sustainable Use Assessment report: C. Akachuku, C. Alvez Islas, E. Archer, V. S. Avila-Foucat, B. Bayarbaatar, D. Biggs, R. Bitariho, I. Borokini, E. S. Brondízio, M. Chatakonda, A. M. Cisneros-Montemayor, R. Cooney, M.-C. Cormier-Salem, R. Dasgupta, S. Devkota, S. Dhyani, I. Díaz-Reviriego, J. Diniz, C. Djagoun, A. Elfaki, C. Fabricius, T. Furukawa, E. Gandiwa, E. Gilman, G. Halouani, S. Hernandez, L. Hiwasaki, J. Hess, R. Hilborn, E. Katz, R. Kigonya, R. Kohsaka, K. Kok, J. Kolding, V. Lavadinović, G. Lichtenstein, L. Margayan, J. Mariño, H. Masski, D. M. Matias, M. Mbiba, L. I. Mesa Castellanos, C. E. Michaud-Lopez, E. J. Milner-Gulland, T. Ming Lee, C. Minte-Vera, P. J. Mograbi, P. Mosig Reidl, P. Kumar Nayak, P. Pacheco, A. Parma, P. Pascua, A. Richter, D. Roe, H. Queiro, K. Raab, S. Carvalho Ribeiro, J. Sathyapalan, C. Simão Seixas, C. Shackleton, S. Shackleton, M. A. Shah, P. Shanley, A. Shkaruba, U. Babu Shrestha, A. Sidorovich, R. Azevedo Matias Silvano, Z. Skandrani, K. St. Martin, H. Stokland, E. Turnhout, R. Wynberg, Y. Zeng.

References

't Sas-Rolfes, M., Challender, D.W.S., Hinsley, A., Veríssimo, D., Milner-Gulland, E.J., 2019. Illegal wildlife trade: scale, processes, and governance. Annu. Rev. Env. Resour. 44 (1), 201–228.

Agarwal, B., 2009. Gender and forest conservation: The impact of women's participation in community forest governance. Ecol. Econ. 68 (11), 2785–2799.

Arets, E.J.M.M., van der Meer, P.J., Verwer, C.C., Hengeveld, G.M., Tolkamp, G.W., Nabuurs, G.J., van Oorschot, M., 2011. Global wood production: assessment of industrial round wood supply from forest management systems in different global regions Alterra, Wageningen-UR.

Atlas, W.I., Ban, N.C., Moore, J.W., Tuohy, A.M., Greening, S., Reid, A.J., Morven, N., White, E., Housty, W.G., Housty, J.A., Service, C.N., Greba, L., Harrison, S., Sharpe, C., Butts, K.I.R., Shepert, W.M., Sweeney-Bergen, E., Macintyre, D., Sloat, M.R., Connors, K., 2021. Indigenous Systems of Management for Culturally and Ecologically Resilient Pacific Salmon (Oncorhynchus spp.) Fisheries. Bioscience 71, 186-204.

Balachander, G., Halmy, M.W.A., Parlee, B., Biggs, D., Chatakonda, M., Cisneros-Montemayor, A.M., Cormier-Salem, M.-C., Dasgupta, R., Devkota, S., Diniz, J., Elfaki, A., Hiwasaki, L., Lichtenstein, G., Richter, A., Shah, M.A., Shanley, P., Shrestha, U.B., Lee, T.M., Bayarbaatar, B., Kieling, D., 2022. Chapter 4: The drivers of the sustainable use of wild species. In: Thematic Assessment Report on the Sustainable Use of Wild Species of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. , in: Fromentin, J.M., Emery, M.R., Donaldson, J., Danner, M.C., Hallosserie, A., and Kieling, D. (eds.). (Ed.). IPBES Secretariat, Bonn, Germany. 399 pp.

Balmford, A., Green, J.M.H., Anderson, M., Beresford, J., Huang, C., Naidoo, R., Walpole, M., Manica, A., 2015. Walk on the Wild Side: Estimating the Global Magnitude of Visits to Protected Areas. PLoS Biol. 13 (2), e1002074.

Barbier, E.B., 2010. Poverty, development, and environment. Environ. Dev. Econ. 15 (6), 635–660.

Barrett, C.B., Travis, A.J., Dasgupta, P., 2011. On biodiversity conservation and poverty traps. PNAS 108 (34), 13907–13912.

Barron, E.S., Chaudhary, R.P., Carvalho Ribeiro, S., Gilman, E., Hess, J., Hilborn, R., Katz, E., Kigonya, R., Masski, H., Mesa Castellanos, L.I., Mograbi, P.J., Nayak, P.K., Queiroz, H., Sidorovich, A., Silvano, R.A.M., Zeng, Y., Djagoun, C., Danner, M.C., 2022. Chapter 3: Status of and trends in the use of wild species and its implications for wild species, the environment and people. In: Thematic Assessment Report on the

Sustainable Use of Wild Species of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES Secretariat, Bonn, Germany, p. 512.
Battaglia, P., Andaloro, F., Consoli, P., Pedà, C., Raicevich, S., Spagnolo, M., Romeo, T., 2017. Baseline data to characterize and manage the small-scale fishery (SSF) of an oncoming Marine Protected Area (Cape Milazzo, Italy) in the western Mediterranean Sea. Ocean Coast. Manag. 148, 231–244.
Begg, C.M., Miller, J.R.B., Begg, K.S., Hayward, M., 2018. Effective implementation of age restrictions increases selectivity of sport hunting of the African lion. J. Appl. Ecol. 55 (1), 139–146.
Bellard, C., Cassey, P., Blackburn, T.M., 2016. Alien species as a driver of recent extinctions. Biol. Lett. 12 (2), 20150623.
Bennett, N.J., Cisneros-Montemayor, A.M., Blythe, J., Silver, J.J., Singh, G., Andrews, N., Calò, A., Christie, P., Di Franco, A., Finkbeiner, E.M., Gelcich, S., Guidetti, P., Harper, S., Hotte, N., Kittinger, J.N., Le Billon, P., Lister, J., López de la Lama, R., McKinley, E., Scholtens, J., Solås, A.-M., Sowman, M., Talloni-Álvarez, N., Teh, L.C. L., Voyer, M., Sumaila, U.R., 2019. Towards a sustainable and equitable blue economy. Nat. Sustainability 2, 991–993.
Berkes, F., 2018. Sacred Ecology, 4th ed. Routledge.
Biggs, D., Ban, N.C., Castilla, J.C., Gelcich, S., Mills, M., Gandiwa, E., Etienne, M., Knight, A.T., Marquet, P.A., Possingham, H.P., 2019. Insights on fostering the emergence of robust conservation actions from Zimbabwe's CAMPFIRE program. Global Ecol. Conserv. 17, e00538.
Blasiak, R., Spijkers, J., Tokunaga, K., Pittman, J., Yagi, N., Österblom, H., MacKenzie, B. R., 2017. Climate change and marine fisheries: least developed countries top global index of vulnerability. PLoS One 12 (6), e0179632.
Bondé, L., Assis, J.C., Benavides-Gordillo, S., Canales-Gomez, E., Fajardo, J., Marrón-Becerra, A., Noguera-Urbano, E.A., Weidlich, E.W.A., Ament, J.M., 2020. Scenario-modelling for the sustainable management of non-timber forest products in tropical ecosystems. Biota Neotropica 20.
Boyce, D.G., Lotze, H.K., Tittensor, D.P., Carozza, D.A., Worm, B., 2020. Future ocean biomass losses may widen socioeconomic equity gaps. Nat. Commun. 11, 2235.
Brando, P.M., Paolucci, L., Ummenhofer, C.C., Ordway, E.M., Hartmann, H., Cattau, M. E., Rattis, L., Medjibe, V., Coe, M.T., Balch, J., 2019. Droughts, wildfires, and forest carbon cycling: A pantropical synthesis. Annu. Rev. Earth Planet. Sci. 47 (1), 555–581.
Brinckmann, J.A., Luo, W., Xu, Q., He, X., Wu, J., Cunningham, A.B., 2018. Sustainable harvest, people and pandas: Assessing a decade of managed wild harvest and trade in Schisandra sphenanthera. J. Ethnopharmacol. 224, 522–534.
Brondízio, E.S., Aumeeruddy-Thomas, Y., Bates, P., Carino, J., Fernández-Llamazares, Á., Ferrari, M.F., Galvin, K., Reyes-García, V., McElwee, P., Molnár, Z., Samakov, A., Shrestha, U.B., 2021. Locally based, regionally manifested, and globally relevant: indigenous and local knowledge, values, and practices for nature. Annu. Rev. Env. Resour. 46 (1), 481–509.
Castello, L., Viana, J.P., Watkins, G., Pinedo-Vasquez, M., Luzadis, V.A., 2009. Lessons from integrating fishers of arapaima in small-scale fisheries management at the Mamirauá Reserve, Amazon. Environ. Manag. 43 (2), 197–209.
Coad, L., Fa, J.E., Abernethy, K., Van Vliet, N., Santamaria, C., Wilkie, D., El Bizri, H.R., Ingram, D.J., Cawthorn, D.-M., Nasi, R., 2019. Towards a sustainable, participatory and inclusive wild meat sector. Center for International Forestry Research (CIFOR).
Comberti, C., Thornton, T.F., Wyllie de Echeverria, V., Patterson, T., 2015. Ecosystem services or services to ecosystems? Valuing cultivation and reciprocal relationships between humans and ecosystems. Glob. Environ. Chang. 34, 247–262.
Cooney, R., Jepson, P., 2006. The international wild bird trade: what's wrong with blanket bans? Oryx 40 (1), 18–23.
Cooney, R., Kasterine, A., MacMillan, D., Milledge, S., Nossal, K., Roe, D., 't Sas-Rolfes, M., 2015. The trade in wildlife: a framework to improve biodiversity and livelihood outcomes. International Trade Centre, Geneva, Switzerland.
Cooney, R., 2007. Sustainable Use: Concepts, Ambiguities, Challenges, in: Group, I.S.S.C. s.S.U.S. (Ed.), Strategic Planning Meeting. IUCN, White Oak Plantation, Florida, 76 pp.
Cornwall, W., 2017. Is wood a green source of energy? Scientists are divided. Science, doi: 10.1126/science.aal0574.
Descola, P., 2005. Ecology as cosmological analysis. In: The Land Within: Indigenous Territory and the Perception of Environment. IWGIA, Denmark, pp. 22–35.
Díaz, S., Settele, J., Brondízio, E.S., Ngo, H.T., Agard, J., Arneth, A., Balvanera, P., Brauman, K.A., Butchart, S.H.M., Chan, K.M.A., Garibaldi, L.A., Ichii, K., Liu, J., Subramanian, S.M., Midgley, G.F., Miloslavich, P., Molnár, Z., Obura, D., Pfaff, A., Polasky, S., Purvis, A., Razzaque, J., Reyers, B., Chowdhury, R.R., Shin, Y.-J., Visseren-Hamakers, I., Willis, K.J., Zayas, C.N., 2019. Pervasive human-driven decline of life on Earth points to the need for transformative change. Science 366, eaax3100.
Dickman, A., Cooney, R., Johnson, P.J., Louis, M.P., Roe, D., signatories, 2019. Trophy hunting bans imperil biodiversity. Science 365, 874-874.
Dollo, M., Samal, P.K., Sundriyal, R., Kumar, K., 2009. Environmentally sustainable traditional natural resource management and conservation in Ziro Valley, Arunachal Himalaya, India. J. Am. Sci. 5, 41–52.
Dulvy, N.K., Pacoureau, N., Rigby, C.L., Pollom, R.A., Jabado, R.W., Ebert, D.A., Finucci, B., Pollock, C.M., Cheok, J., Derrick, D.H., Herman, K.B., Sherman, C.S., VanderWright, W.J., Lawson, J.M., Walls, R.H.L., Carlson, J.K., Charvet, P., Bineesh, K.K., Fernando, D., Ralph, G.M., Matsushiba, J.H., Hilton-Taylor, C., Fordham, S.V., Simpfendorfer, C.A., 2021. Overfishing drives over one-third of all sharks and rays toward a global extinction crisis. Curr. Biol. 31 (21), 4773–4787.e8.
Espinosa, M.C., 2010. Why gender in wildlife conservation? Notes from the Peruvian Amazon. The Open Anthropology Journal 3 (1), 230–241.
FAO, 2018. Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options, FAO Fisheries and Aquaculture Technical Paper 627. In: Food and Agriculture Organization of the United Nations, p. 210.
FAO, 2020b. The State of the World's Forests 2020 - Forests, biodiversity and people. Food and Agriculture Organization of the United Nations, Rome, p. 214.
FAO, 2020a. The state of the world fisheries and aquaculture 2020. Sustainability in action. FAO Fisheries and Aquaculture Department, Rome, 224 pp.
Fields, A.T., Fischer, G.A., Shea, S.K.H., Zhang, H., Abercrombie, D.L., Feldheim, K.A., Babcock, E.A., Chapman, D.D., 2018. Species composition of the international shark fin trade assessed through a retail-market survey in Hong Kong. Conserv. Biol. 32 (2), 376–389.
Fromentin, J.-M., Bonhommeau, S., Arrizabalaga, H., Kell, L.T., 2014. The spectre of uncertainty in management of exploited fish stocks: The illustrative case of Atlantic bluefin tuna. Mar. Policy 47, 8–14.
Fromentin, J.M., Emery, M.R., Donaldson, J., Hallosserie, A., Michaud-Lopez, C. E., P., A., St. Martin, K., Stockland, H., 2022. Chapter 1: Setting the scene. In: Thematic Assessment Report on the Sustainable Use of Wild Species of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, in: Fromentin, J.M., Emery, M.R., Donaldson, J., Danner, M.C., Hallosserie, A., and Kieling, D. (eds.). (Ed.). IPBES Secretariat, Bonn, Germany. 76 pp.
Frost, W., Laing, J., Beeton, S., 2014. The future of nature-based tourism in the Asia-Pacific Region. J. Travel Res. 53 (6), 721–732.
Garnett, S.T., Burgess, N.D., Fa, J.E., Fernández-Llamazares, Á., Molnár, Z., Robinson, C. J., Watson, J.E.M., Zander, K.K., Austin, B., Brondizio, E.S., Collier, N.F., Duncan, T., Ellis, E., Geyle, H., Jackson, M.V., Jonas, H., Malmer, P., McGowan, B., Sivongxay, A., Leiper, I., 2018. A spatial overview of the global importance of Indigenous lands for conservation. Nat. Sustainability 1, 369–374.
Gasalla, M.A., Tittensor, D.P., Kok, K., Archer, E., Borokini, I., Halouani, G., Matias, D.M., Mbiba, M., Milner-Gulland, E.J., Pacheco, P., Fabricius, C., Kieling, D., 2022. Chapter 5: Future scenarios of sustainable use of wild species. In: Thematic Assessment Report on the Sustainable Use of Wild Species of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES Secretariat, Bonn, Germany, p. 142.
Guan, J., Cerutti, P.O., Masiero, M., Pettenella, D., Andrighetto, N., Dawson, T., 2016. Quantifying Illegal Logging and Related Timber Trade, Illegal logging and related timber trade: Dimensions, drivers, impacts and responses: A global scientific rapid response assessment report. International Union of Forest Research Organizations (IUFRO) World Series, pp. 37–59.
Harfoot, M., Glaser, S.A.M., Tittensor, D.P., Britten, G.L., McLardy, C., Malsch, K., Burgess, N.D., 2018. Unveiling the patterns and trends in 40 years of global trade in CITES-listed wildlife. Biol. Conserv. 223, 47–57.
He, J., Zhou, Z., Yang, H., Xu, J., 2011. Integrative management of commercialized wild mushroom: A case study of Thelephora ganbajun in Yunnan, Southwest China. Environ. Manag. 48 (1), 98–108.
Hernández-Barrios, J.C., Anten, N.P.R., Martínez-Ramos, M., Clough, Y., 2015. Sustainable harvesting of non-timber forest products based on ecological and economic criteria. J. Appl. Ecol. 52 (2), 389–401.
Hicks, C.C., Cohen, P.J., Graham, N.A.J., Nash, K.L., Allison, E.H., D'Lima, C., Mills, D.J., Roscher, M., Thilsted, S.H., Thorne-Lyman, A.L., MacNeil, M.A., 2019. Harnessing global fisheries to tackle micronutrient deficiencies. Nature 574 (7776), 95–98.
Hierink, F., Bolon, I., Durso, A.M., Ruiz de Castañeda, R., Zambrana-Torrelio, C., Eskew, E.A., Ray, N., 2020. Forty-four years of global trade in CITES-listed snakes: Trends and implications for conservation and public health. Biol. Conserv. 248, 108601.
Hilborn, R., Amoroso, R.O., Anderson, C.M., Baum, J.K., Branch, T.A., Costello, C., de Moor, C.L., Faraj, A., Hively, D., Jensen, O.P., Kurota, H., Little, L.R., Mace, P., McClanahan, T., Melnychuk, M.C., Minto, C., Osio, G.C., Parma, A.M., Pons, M., Segurado, S., Szuwalski, C.S., Wilson, J.R., Ye, Y., 2020. Effective fisheries management instrumental in improving fish stock status. Proc. Natl. Acad. Sci. 117 (4), 2218–2224.
Hill, R., Adem, Ç., Alangui, W.V., Molnár, Z., Aumeeruddy-Thomas, Y., Bridgewater, P., Tengö, M., Thaman, R., Adou Yao, C.Y., Berkes, F., Carino, J., Carneiro da Cunha, M., Diaw, M.C., Díaz, S., Figueroa, V.E., Fisher, J., Hardison, P., Ichikawa, K., Kariuki, P., Karki, M., Lyver, P.O.B., Malmer, P., Masardule, O., Oteng Yeboah, A.A., Pacheco, D., Pataridze, T., Perez, E., Roué, M.-M., Roba, H., Rubis, J., Saito, O., Xue, D., 2020. Working with Indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people. Curr. Opin. Environ. Sustain. 43, 8–20.
Hinsley, A., de Boer, H.J., Fay, M.F., Gale, S.W., Gardiner, L.M., Gunasekara, R.S., Kumar, P., Masters, S., Metusala, D., Roberts, D.L., Veldman, S., Wong, S., Phelps, J., 2017. A review of the trade in orchids and its implications for conservation. Bot. J. Linn. Soc. 186, 435–455.
Hoare, A., 2015 Tackling illegal logging and the related trade. What progress and where next. Chatham House, London.
Hoegh-Guldberg, O., D. Jacob, M. Taylor, M. Bindi, S. Brown, I. Camilloni, A. Diedhiou, R. Djalante, K.L. Ebi, F. Engelbrecht, J.Guiot, Y. Hijioka, S. Mehrotra, A. Payne, S.I. Seneviratne, A. Thomas, R. Warren, and G. Zhou, 2018: Impacts of 1.5ºC Global Warming on Natural and Human Systems. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M.Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 175-312. https://doi.org/10.1017/9781009157940.005.

Hopping, K.A., Chignell, S.M., Lambin, E.F., 2018. The demise of caterpillar fungus in the Himalayan region due to climate change and overharvesting. PNAS 115 (45), 11489–11494.

IPBES, 2018a. Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Africa of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. , in: Archer, E.D., L.E.; Mulongoy, K.J.; Maoela, M.A.; Walters, M.; Biggs, R.; Cormier-Salem, M-C.; DeClerck, F.; Diaw, M.C.; Dunham, A.E.; Failler, P.; Gordon, C.; Harhash, K.A.; Kasisi, R.; Kizito, F.; Nyingi, W.D.; Oguge, N.; Osman-Elasha, B.; Stringer, L.C.; Tito de Morais, L.; Assogbadjo, A.; Egoh, B.N.; Halmy, M.W.; Heubach, K.; Mensah, A.; Pereira, L.; Sitas, N. (eds.). (Ed.). IPBES secretariat, Bonn, Germany, 49 pp.

IPBES, 2018b. Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Asia and the Pacific of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. , in: M. Karki, S.S.S., S. Okayasu, W. Suzuki, L. Acosta, Y. Alhafedh, J. A. Anticamara, A. G. Ausseil, K. Davies, A. Gasparatos, H. Gundimeda, F. H. Ibrahim, R. Kohsaka, R. Kumar, S. Managi, N. Wu, A. Rajvanshi, G. S. Rawat, P. Riordan, S. Sharma, A. Virk, C. Wang, T. Yahara and Y. Youn (eds.). (Ed.). IPBES secretariat, Bonn, Germany, 44 pp.

IPBES, 2018c. Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Europe and Central Asia of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. , in: M. Fischer, M.R., A. Torre-Marin Rando, A. Mader, A. Church, M. Elbakidze, V. Elias, T. Hahn, P.A. Harrison, J. Hauck, B. Martín-López, I. Ring, C. Sandström, I. Sousa Pinto, P. Visconti, N.E. Zimmermann and M. Christie (eds.). (Ed.). IPBES secretariat, Bonn, Germany, 48 pp.

IPBES, 2018d. Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for the Americas of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. , in: J. Rice, C.S.S., M.E. Zaccagnini, M. Bedoya-Gaitán, N. Valderrama, C.B. Anderson, M.T.K. Arroyo, M. Bustamante, J. Cavender-Bares, A. Díaz-de-León, S. Fennessy, J. R. García Marquez, K. Garcia, E.H. Helmer, B. Herrera, B. Klatt, J.P. Ometo, V. Rodriguez Osuna, F.R. Scarano, S. Schill and J. S. Farinaci (eds.). (Ed.). IPBES secretariat, Bonn, Germany, 44 pp.

IPBES, 2019. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. . in: S. Díaz, J.S., E. S. Brondízio E.S., H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y. J. Shin, I. J. Visseren-Hamakers, K. J. Willis, and C. N. Zayas (eds.). (Ed.). IPBES secretariat, Bonn, Germany, 56 pp.

IPBES, 2022a. Summary for Policymakers of the methodological assessment report on the diverse values and valuation of nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, in: Pascual, U., Balvanera, P., Christie, M., Baptiste, B., González-Jiménez, D., Anderson, C.B., Athayde, S., Barton, D.N., Chaplin-Kramer, R., Jacobs, S., Kelemen, E., Kumar, R., Lazos, E., Martin, A., Mwampamba, T.H., Nakangu, B., O'Farrell, P., Raymond, C.M., Subramanian, S.M., Termansen, M., Van Noordwijk, M., and Vatn, A. (eds.). (Ed.). IPBES secretariat, Bonn, Germany, 37 pp.

IPBES, 2022b. Summary for policymakers of the thematic assessment of the sustainable use of wild species of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services., in: J.-M. Fromentin, M.R.E., J. Donaldson, M.-C. Danner, A. Hallosserie, D. Kieling, G. Balachander, E.S. Barron, R.P. Chaudhary, M. Gasalla, M. Halmy, C. Hicks, M.S. Park, B. Parlee, J. Rice, T. Ticktin, and D. Tittensor (eds). (Ed.). IPBES secretariat, Bonn, Germany, 33 pp.

IPBES, 2022c. Thematic Assessment Report on the Sustainable Use of Wild Species of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, in: Fromentin, J.M., Emery, M.R., Donaldson, J., Danner, M.C., Hallosserie, A., and Kieling, D. (eds.). (Ed.). IPBES Secretariat, Bonn, Germany.

IPCC, 2019a. Summary for Policymakers. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems, in: P.R. Shukla, J.S., E. Calvo Buendia, V. Masson-Delmotte, H.- O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.) (Ed.). IPCC, 36 pp.

IPCC, 2019b. Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, in: H.-O. Pörtner, D.C.R., V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai,, A. Okem, J. P., B. Rama, N.M. Weyer eds. (Eds.). IPCC, 35 pp.

IUCN, 2020. The IUCN Red List Data. Retrieved September 28, 2020, from IUCN Red List of Threatened Species website: https://www.iucnredlist.org/.

IUCN, 2016. Informing decisions on trophy hunting: : A briefing paper for European Union decision-makers regarding potential plans for restriction of imports of hunting trophies. IUCN 19.

Lee, D.E., 2018. Evaluating conservation effectiveness in a Tanzanian community wildlife management area. J. Wildl. Manag. 82 (8), 1767–1774.

Leisher, C., Temsah, G., Booker, F., Day, M., Samberg, L., Prosnitz, D., Agarwal, B., Matthews, E., Roe, D., Russell, D., Sunderland, T., Wilkie, D., 2016. Does the gender composition of forest and fishery management groups affect resource governance and conservation outcomes? A systematic map. Environ. Evid. 5, 6.

Leopold, A., 1949. A Sand County Almanac, and Sketches Here and There. Oxford University Press, USA.

Lewison, R.L., Crowder, L.B., Wallace, B.P., Moore, J.E., Cox, T., Zydelis, R., McDonald, S., DiMatteo, A., Dunn, D.C., Kot, C.Y., Bjorkland, R., Kelez, S., Soykan, C., Stewart, K.R., Sims, M., Boustany, A., Read, A.J., Halpin, P., Nichols, W. J., Safina, C., 2014. Global patterns of marine mammal, seabird, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots. PNAS 111 (14), 5271–5276.

Lichtenstein, G., 2009. Vicuña conservation and poverty alleviation? Andean communities and international fibre markets. Int. J. Commons 4, 100–121.

Lindsey, P., 2011. An Analysis of Game Meat Production and Wildlife-based Land Uses on Freehold Land in Namibia: Links with Food Security. Zimbabwe, TRAFFIC East/Southern Africa, Harare, p. 92.

Lockwood, J.L., Welbourne, D.J., Romagosa, C.M., Cassey, P., Mandrak, N.E., Strecker, A., Leung, B., Stringham, O.C., Udell, B., Episcopio-Sturgeon, D.J., Tlusty, M.F., Sinclair, J., Springborn, M.R., Pienaar, E.F., Rhyne, A.L., Keller, R., 2019. When pets become pests: the role of the exotic pet trade in producing invasive vertebrate animals. Front. Ecol. Environ. 17 (6), 323–330.

Lyons, J.A., Natusch, D.J.D., 2011. Wildlife laundering through breeding farms: Illegal harvest, population declines and a means of regulating the trade of green pythons (Morelia viridis) from Indonesia. Biol. Conserv. 144 (12), 3073–3081.

Lyver, P.O'.B., Timoti, P., Jones, C.J., Richardson, S.J., Tahi, B.L., Greenhalgh, S., 2017. An indigenous community-based monitoring system for assessing forest health in New Zealand. Biodivers. Conserv. 26 (13), 3183–3212.

Musinguzi, L., Efitre, J., Odongkara, K., Ogutu-Ohwayo, R., Muyodi, F., Natugonza, V., Olokotum, M., Namboowa, S., Naigaga, S., 2016. Fishers' perceptions of climate change, impacts on their livelihoods and adaptation strategies in environmental change hotspots: a case of Lake Wamala, Uganda. Environ. Dev. Sustain. 18 (4), 1255–1273.

OECD/IEA, 2017. Energy Access Outlook 2017: From poverty to prosperity, World Energy Outlook Special Report. International Energy Agency, 144 pp.

Orensanz, J.M., Cinti, A., Parma, A.M., Burotto, L., Guerrero, S.E., Cordero, E.S., Sepúlveda, C., Granda, V.T., 2013. Latin American rights-based fisheries targeting sedentary resources. Part I, FAO Fisheries and Aquaculture Technical Papers. Food and Agriculture Organization of the United Nations.

O'Connor, J., Roa, O.H., Eberle, C., 2022. Vanishing vaquita. Technical Report. United Nations University, p. 22 pp.

Ostrom, E., 2009. A general framework for analyzing sustainability of social-ecological systems. Science 325 (5939), 419–422.

Pangau-Adam, M., Noske, R., Muehlenberg, M., 2012. Wildmeat or bushmeat? Subsistence hunting and commercial harvesting in Papua (West New Guinea), Indonesia. Hum. Ecol. 40 (4), 611–621.

Phelps, J., Webb, E.L., 2015. "Invisible" wildlife trades: Southeast Asia's undocumented illegal trade in wild ornamental plants. Biol. Conserv. 186, 296–305.

Plumwood, V., 2002. Environmental Culture. Routledge, The Ecological Crisis of Reason.

Popp, J.N., Priadka, P., Kozmik, C., 2019. The rise of moose co-management and integration of Indigenous knowledge. Hum. Dimens. Wildl. 24 (2), 159–167.

Park, M.S., Hicks, C.C., R., W., Mosig Reidl, P., S., D., Islas, C.A., Raab, K., Avila-Foucat, V.S., Parma, A., Kolding, J., Shkaruba, A., Skandrani, Z., Danner, M.C., 2022. Chapter 6: Policy options for governing sustainable use of wild species. In: Thematic Assessment Report on the Sustainable Use of Wild Species of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. , in: Fromentin, J. M., Emery, M.R., Donaldson, J., Danner, M.C., Hallosserie, A., and Kieling, D. (eds.). (Ed.). IPBES Secretariat, Bonn, Germany, 178 pp.

Ribot, J.C., Lund, J.F., Treue, T., 2010. Democratic decentralization in sub-Saharan Africa: its contribution to forest management, livelihoods, and enfranchisement. Environ. Conserv. 37 (1), 35–44.

Pörtner, H.O., Scholes, R.J., Agard, J., Archer, E., Arneth, A., Bai, X., Barnes, D., Burrows, M., Chan, L., Cheung, W.L., Diamond, S., Donatti, C., Duarte, C., Eisenhauer, N., Foden, W., Gasalla, M.A., Handa, C., Hickler, T., Hoegh-Guldberg, O., Ichii, K., Jacob, U., Insarov, G., Kiessling, W., Leadley, P., Leemans, R., Levin, L., Lim, M., Maharaj, S., Managi, S., Marquet, P.A., McElwee, P., Midgley, G., Oberdorff, T., Obura, D., Osman, E., Pandit, R., Pascual, U., Pires, A.P.F., Popp, A., ReyesGarcía, V., Sankaran, M., Settele, J., Shin, Y.J., Sintayehu, D.W., Smith, P., Steiner, N., Strassburg, B., Sukumar, R., Trisos, C., Val, A.L., Wu, J., Aldrian, E., Parmesan, C., Pichs-Madruga, R., Roberts, D.C., Rogers, A.D., Díaz, S., Fischer, M., Hashimoto, S., Lavorel, S., Wu, N., Ngo, H.T., 2021. IPBES-IPCC co-sponsored workshop report on biodiversity and climate change. IPBES and IPCC, p. 256.

Rice, J., Ticktin, T., Díaz -Reviriego, I., Furukawa, T., Gandiwa, E., Lavadinović, V., Margayan, L., Pascua, P., Sathyapalan, J., Akachuku, C., Hallosserie, A., 2022. Chapter 2: Conceptualizing the sustainable use of wild species. In: Thematic Assessment Report on the Sustainable Use of Wild Species of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES Secretariat, Bonn, Germany, p. 134.

Rohe, J., Schlüter, A., Ferse, S.C.A., 2018. A gender lens on women's harvesting activities and interactions with local marine governance in a South Pacific fishing community. Maritime Studies 17 (2), 155–162.

Rosen, G.E., Smith, K.F., 2010. Summarizing the evidence on the international trade in illegal wildlife. Ecohealth 7 (1), 24–32.

Russell, R., Guerry, A.D., Balvanera, P., Gould, R.K., Basurto, X., Chan, K.M.A., Klain, S., Levine, J., Tam, J., 2013. Humans and nature: how knowing and experiencing nature affect well-being. Annu. Rev. Env. Resour. 38 (1), 473–502.

Ingram, V., Haverhals, M., Petersen, S., Elias, M., Sijapati Basnett, B., Sola, P., (2016) Gender and Forest, Tree and Agroforestry Value Chains: Evidence from Literature, in: C. J. P. Colfer, B.S.B., & M. Elias (Eds.) (Ed.), Gender and forests: Climate change, tenure, value chains and emerging issues. Routledge, Taylor & Francis Group, 22 pp.

Sada Guevara, S., 2020. The Mexican Biosphere Reserves Landscape and sustainability, in: M.G., R., M.F., P. (Eds.), Unesco Biosphere Reserves. Earthscan London, pp. 47-60.

Santos, M.J., Dekker, S.C., Daioglou, V., Braakhekke, M.C., van Vuuren, D.P., 2017. Modeling the Effects of Future Growing Demand for Charcoal in the Tropics. Frontiers in Environmental Science 5.
Schmeller, D.S., Böhm, M., Arvanitidis, C., Barber-Meyer, S., Brummitt, N., Chandler, M., Chatzinikolaou, E., Costello, M.J., Ding, H., García-Moreno, J., Gill, M., Haase, P., Jones, M., Juillard, R., Magnusson, W.E., Martin, C.S., McGeoch, M., Mihoub, J.-B., Pettorelli, N., Proença, V., Peng, C., Regan, E., Schmiedel, U., Simaika, J.P., Weatherdon, L., Waterman, C., Xu, H., Belnap, J., 2017. Building capacity in biodiversity monitoring at the global scale. Biodivers. Conserv. 26 (12), 2765–2790.
Sorrenti, S., 2017. Non-wood forest products in international statistical systems, Non-wood Forest Products Series, no. 22. Food and Agriculture Organization of the United Nations, Rome.
Spira, C., Kirkby, A., Kujirakwinja, D., Plumptre, A.J., 2019. The socio-economics of artisanal mining and bushmeat hunting around protected areas: Kahuzi-Biega National Park and Itombwe Nature Reserve, eastern Democratic Republic of Congo. Oryx 53 (1), 136–144.
Stoll, J.S., Crona, B.I., Fabinyi, M., Farr, E.R., 2018. Seafood trade routes for lobster obscure teleconnected vulnerabilities. Front. Mar. Sci. 5, 239.
Symes, W.S., McGrath, F.L., Rao, M., Carrasco, L.R., 2018. The gravity of wildlife trade. Biol. Conserv. 218, 268–276.
Sze, J.S., Carrasco, L.R., Childs, D., Edwards, D.P., 2022. Reduced deforestation and degradation in Indigenous Lands pan-tropically. Nat. Sustainability 5, 123–130.
Tittensor, D.P., Harfoot, M., McLardy, C., Britten, G.L., Kecse-Nagy, K., Landry, B., Outhwaite, W., Price, B., Sinovas, P., Blanc, J., Burgess, N.D., Malsch, K., 2020. Evaluating the relationships between the legal and illegal international wildlife trades. Conserv. Lett. 13, e12724.
Tobin, B., 2008. In: The role of customary law in access and benefit-sharing and traditional knowledge governance: Perspectives from Andean and pacific island countries. and the United Nations University (UNU), p. 102 pp.
Toso, Y., Lucrezi, S., Cerrano, C., 2022. Conservation or degradation? Assessing the behaviour of underwater photographers in Italian marine protected areas. Tourism in Marine Environments in press.
UNDP, 2018 Human Development Indices and Indicators: A Critical Evaluation, United Nations Development Programme.
UNCTAD, 2017. 20 years of Biotrade. Connecting people, the planet and markets. In: United Nations Conference on Trade and Development, p. 96 pp.
UNODC, 2020 World Wildlife Crime Report: Trafficking in Protected Species, New-York, 134 pp.
Vall-llosera, M., Cassey, P., 2017. 'Do you come from a land down under?' Characteristics of the international trade in Australian endemic parrots. Biol. Conserv. 207, 38–46.
Wamukota, A., Brewer, T.D., Crona, B., 2014. Market integration and its relation to income distribution and inequality among fishers and traders: The case of two small-scale Kenyan reef fisheries. Mar. Policy 48, 93–101.
World Bank, 2019. Illegal Logging, Fishing, and Wildlife Trade: The Costs and How to Combat it, p. 69.
Yilmaz, R., Koyuncu, C., 2019. The impact of ICT penetration on deforestation: A panel data evidence. Rev. Econ. Perspect. 19, 345–364.
Zalasiewicz, J., Waters, C.N., Williams, M., Summerhayes, C.P.E., 2019. The Anthropocene as a Geological Time Unit. A Guide to the Scientific Evidence and Current Debate. Cambridge University Press. 382 pp.