

Chapter 4: The drivers of the sustainable use of wild species^{1,2}

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Executive summary

Scope of the chapter

Policy changes to reverse the trend in declining wild species are required in many regions of the globe. To be most effective, these policy changes must be based on evidence about the drivers of both sustainable and unsustainable use of wild species. A comprehensive review and analysis of this evidence led to the identification of the core drivers and mediating factors (or issues of context, that affect the impact of each driver in different regions and jurisdictions) that should be considered by policymakers. These core drivers and a synthesis of evidence for each are presented in this chapter in the categories of environmental, political, social, economic, cultural, science, technology and education drivers. The aim is to illustrate the opportunities and challenges for policymakers seeking to improve sustainable use outcomes. The chapter also addresses the interactions between these drivers with the intention of providing an integrated understanding of how these drivers, as well as mediating factors, are interrelated and the outcomes that result from these interactions.

Definition of Driver

Drivers are defined (for the purposes of this report) as the factors that, directly or indirectly, cause or influence wild species use patterns. This chapter seeks to illustrate both the drivers that are leading to unsustainable use as well as those that are resulting in sustainable use. Evidence includes data about the causal, correlated and descriptive relationships between each driver and outcomes of the use of wild species (e.g., altered use through the practices, such as terrestrial animal harvesting, fishing, logging, gathering and non-extractive activities. This includes quantitative changes (e.g., increased/decreased use) and considers how drivers may lead to qualitative changes in use and practices (e.g., spiritual value). The aim is to show where, how and under what conditions core drivers significantly influence the patterns of wild species to use and where policy development or adaptation can moderate or exaggerate the impact of these drivers. Disentangling evidence about the impact of one driver from others can be complicated in complex systems (where there are many interrelated drivers, effects and feedbacks). The analysis and presentation of findings on drivers and mediating factors also consider how drivers, use and impacts may be defined and evaluated differently in different contexts, depending on values, experience and knowledge systems, including indigenous and local knowledge.

The drivers addressed throughout the chapter are grouped into six main categories:

- Environmental
- Political
- Social
- Economic
- Cultural values/religious beliefs, and
- Science, technology and education

For the understanding of the influence of drivers on the sustainable use of wild species, an analysis of data and information collected from published literature and other available sources was conducted, and a synthesis was done. Specifically, a literature review using major online

bibliographic databases (e.g., Web of Science) was undertaken to employ a variety of queries and search terms. Outcomes of these searches were analyzed and synthesized according to the main conceptual/disciplinary typologies of inquiry of this assessment and this chapter. This included consideration of the typologies of practices defined in Chapter 1 (fishing, gathering, terrestrial animal harvesting and non-extractive practices) and the characteristics of the wild species involved.

The team synthesized evidence about a diversity of practices and uses of wild species over time (from 1950-2021) and identified patterns and trends in different drivers in different socio-political, economic and cultural contexts (e.g., regional similarities and differences). From this secondary analysis, the experts could determine similarities and differences in how each driver's impact was mediated (e.g., compounded or diminished) in different contexts. The insights were synthesized into key conclusions and summarized into critical messages for each section of this chapter. Attention was paid to the quality and quantity of evidence related to these conclusions and messages. A confidence determination (scoring) was made based on such quantitative indicators (e.g., number of publications) and the source and quality of the publication. Recognizing that there are significant biases in institutional publication patterns, additional efforts were made to identify sources attributed to indigenous peoples and local knowledge or focused on evidence from indigenous and local knowledge. Consideration was also given to racial, regional and gender bias in patterns of published data; recognizing gaps in quantitative data, case studies were used in this chapter to illustrate the impact of drivers on use patterns qualitatively.

This review and analysis revealed the following insights about core drivers and mediating factors influencing wild species use patterns:

Environmental drivers:

Numerous environmental drivers are directly and indirectly impacting the use of wild species. These include habitat disturbance (e.g., deforestation, pollution) and climate change:

- **Habitat loss and disturbance** is a leading driver of the unsustainable use of wild species. Evidence points to declines in the health, population and distribution of wild species (owing to deforestation, pollution, extractive development and land clearing associated with agriculture and urbanization); these declines are problematic in almost all regions and concerning all practices defined in this assessment. Trends towards habitat loss and disturbance and their impacts on wild species are being halted or slowed in some regions as a result of improvements in land use planning, creation/adaptation of harvest regulations, the creation of protected and conserved areas, and banning pollutants that affect species health. Although rigid limitations against wild species use and habitats can appear effective, they can lead to the creation of illegal use patterns and inequitably impact vulnerable populations, including indigenous peoples and local knowledge (*well established*) {4.2.1.5}.
 - Deforestation is a significant cause of habitat degradation and loss. Deforestation and forest fragmentation negatively affect the health of many wild species populations associated with food-related hunting and fishing. It also affects the

abundance and availability of non-timber forest products (*established but incomplete*) {4.2.1}.

- Urbanization is among the major causes of habitat loss and disturbance. The loss of species habitat (due to land clearing and development) has had an adverse impact on the population and health of terrestrial, freshwater and marine species, and there is an upward trend in human - wild species conflict (*well established*) {4.2.1.5}.
 - Expansion and intensification of agriculture (including agroforestry and aquaculture) have been a major driver of wild species decline and, in turn unsustainable use globally (*well established*) {4.2.1.5.3}. Agriculture in some contexts relieves pressure on some wild species (e.g., by creating alternatives for food provisioning) (*established but incomplete*) {4.2.1.5}.
 - Rangeland degradation reduces various nature's contributions to people but mainly affects sustainable use of wild species as it has decreased capacity to provide forage for large herbivores, including domestic livestock (*established but incomplete*) {4.2.1.5}.
 - Pollution, be it from anthropogenic or natural sources, negatively impacts the abundance, distribution, availability, harvesting, gathering, and value chain of wild species in different ways and at different spatial and temporal scales (*well established*), {4.2.1.6}.
 - Hydroelectric power development is a significant cause of habitat loss and degradation of aquatic species. Globally, the number of dam constructions has increased dramatically over the past six decades to meet energy demands and flood control; it is estimated that dams have altered ecological flows in 48% of the rivers worldwide. Dams adversely affect aquatic and terrestrial biodiversity by altering or eliminating habitats, including blocking migratory patterns (*well-established*) {4.2.1.5}.
- **Climate change** is, directly and indirectly, affecting the sustainability of wild species use. Global temperature in 2020 was one of the three warmest years on record and the last decade was the warmest on record in a long-term climate change trend according to World Meteorological Organization (1.2 degrees C +/- 0.1) above the pre-industrial level (*well established*) {4.2.1.2}.
 - Climate change impacts on hydrological cycles and precipitation patterns have created stress on the health, population and habitats of wild species (inclusive of marine, terrestrial or freshwater ecosystems), which has, in turn, affected all practices and uses. These changes in hydrological cycles as well as warming temperatures are also affecting species productivity and distribution which in term affects use patterns. In some cases, species productivity has declined; in other instances productivity has increased due to warming conditions (*established but incomplete*) {4.2.1.2}.
 - Climate change is also directly affecting patterns of wild species use. For example, a northerly shift in commercial fish harvesting (over the last 40 years) can be correlated with the northerly shift in distribution of valued fish species.

A growing number of climate change hazards have also become barriers to use and had adverse impacts on communities who depend on wild species for food provisioning. In some cases (e.g., in arctic ecosystems) climate change is opening up previously inaccessible regions (*established but incomplete*) {4.2.1.2}

- Climate change disproportionately impacts the poor, local and indigenous communities. Because the current pandemic has impacted everyone to varying degrees {4.2.1.2} global efforts to reduce carbon emissions coupled with investments in the capacity of those most vulnerable to cope and adapt to climate change is seen as a major mediating factor that influences the extent of climate change impact on wild species use (*well established*). Climate-related impacts include changes in forest productivity and forest fire dynamics; where productivity decreases and forest fire frequency increases (due to declining precipitation and warming temperatures), the most significant impacts on wild species and use are anticipated. National and sub-national efforts to manage climate change impacts on forests can mitigate these impacts in the short-medium term (e.g., Reducing Emissions from Deforestation and Forest Degradation, REDD/REDD+) species {4.2.1.2.3}. Climate change is expected to decrease maximum fisheries catch by 7.7% globally and about 35% in tropical oceans, while creating new opportunities in mid- to high-latitude oceans because of marine species shifting range polewards (*established but incomplete*) {4.2.1.2.2}.
 - Although there is general evidence that climate change is leading to more unsustainable use, there are gaps in understanding of the specific impacts of climate change on sustainable use in many regions and more many practices (*established but incomplete*) {4.2.1.2}.
 - The effects of climate change are compounded and complicated by interactions with other environmental, socio-cultural, political, and economic drivers (*established but incomplete*) {4.2.1.2}.
- **Biological hazards:** Zoonotic disease and the use of wild species are interconnected. Species for wild meat {4.2.1.4}, which in turn leads to increased health risks, food insecurity and poverty for vulnerable communities {4.2.1.7}. Initial evidence reveals that the COVID-19 crisis has disproportionately impacted the poor, local and indigenous communities and their ability to sustain themselves. Intensified contact between people and wild species arising from the encroachment of human activities into forest ecosystems and increased demand for meat and medicine from wild species are the cause of zoonotic diseases, which constitute about 70% of known emerging diseases {4.2.1.4., 4.2.1.7}. Although the evidence is well-established that the emergence and spread of zoonotic diseases are due to increased contact between wild species and people, the evidence to link the use of wild species with zoonotic risks is unresolved (*established by incomplete*) {4.2.1.4, 4.2.1.7}.
 - Invasive alien species have both negative and positive impacts on the sustainable use of wild species; however, the negative impacts such as deteriorating ecosystem

health, decline or even extinction of native species are more prevalent (*well established*) {4.2.1.4}.

- Small tropical islands and coastal mainland regions are the hotspots of established alien species richness (*well established*) {4.2.1.4}. However, compared to the impact of invasive alien species in terrestrial ecosystems, there is a significant gap in knowledge about the ecological effects of invasive species in marine ecosystems globally (*established but incomplete*) {4.2.1.4}. Invasive species have negatively impacted the livelihoods and economies of indigenous and local communities. Key impacts include changes or abandonment of key practices necessary for food provisioning. However, in some instances, introduced species have contributed positively to the economy and livelihoods of indigenous people supplementing the provision of harvested fish and game as well as fuelwood, fodder, food products, timber and medicinal products (*well established*), {4.2.1.4}.

Political drivers:

- The capacity of governance systems (including formal and informal institutions, statutory and customary laws) to prevent, mitigate or manage problems of unsustainable use varies around the globe. Where governance systems are informed by monitoring of species health and use, equitable public participation of those dependent on wild species (mainly for food provisioning) and include robust mechanisms for dispute resolution, there is evidence of sustainable use (*well established*) {4.2.2.2}.
- In many regions, institutions and policies that regulate direct uses of wild species are weak (i.e., do not exist, lack clarity or are poorly enforced). Indirect impacts on sustainable use (e.g., habitat loss, contamination) are also poorly recognized and regulated but have significant implications for use in many regions and for many species (*well established*) {4.2.2.2}.
- Pluralistic governance arrangements that reflect a broad spectrum of use values, create more significant opportunities for inclusive and equitable decision-making. Lack of attention to issues of equity in managing the use, has led to other unsustainable outcomes, including food insecurity and vulnerability, particularly for those who depend on wild species to meet basic needs. Such pluralism offers a more significant opportunity to learn from users (e.g., indigenous peoples and local knowledge). Where there are barriers to learning from indigenous peoples and local knowledge (including institutional learning and adaptation) and other local users of wild species, there are fewer tools and opportunities for preventing, mitigating and managing unsustainable use (when compared to centralized and rigid institutions) (*well established*) {4.2.2.3, 4.2.2.4, 4.2.2.7}.
- Decentralized versus centralized governance arrangements can be more effective at ensuring sustainable use, particularly for wild species considered to be ‘commons’ and/or where rules/regulations of centralized institutions are not easily communicated or enforced. These are most successful where local users are engaged in rulemaking, where there are clear boundaries, secure property rights, mechanisms for monitoring, sanctions, and enforcement are in place (*well established*) {4.2.2.4, 4.2.2.5}.

- Institutions that are flexible and adaptive to new information from monitoring the health, population and distribution dynamics of wild species are better able to ensure sustainable use (*well established*) {4.2.2.2}.
- A robust civil society and culture of collective action have been influential in catalyzing management and policy change towards sustainable use. This advocacy has, in other cases, led to unsustainable use outcomes (*well established*) {4.2.2.2, 4.2.2.7}.
- The values of indigenous peoples and local knowledge have historically not been well represented in the mainstream governance of wild species. However, global recognitions (i.e., United Nations Declaration on the Rights of Indigenous Peoples) are catalyzing some changes at the national and sub-national levels as are legal challenges in some regions (*well established*) {4.2.2.2.5, 4.2.2.2.7}.
- Where there is greater interaction of government, communities, the private sector and academia and the quality of stakeholder contributions to policy making, sustainable use is more feasible (*established but incomplete*) {4.2.2.2, 4.2.2.3}.
- Where there is greater interaction between national and sub-national governments with indigenous peoples and local knowledge, industry and those involved in science, there are greater opportunities for ensuring regulation and management decisions accountable to users' needs. This kind of pluralistic governance approach can also better support multi-scale solutions to sustainable use problems (i.e., that are transboundary). There is also a greater potential for successfully managing conflicts between user groups (and ensuring coordination and collaborative solutions) {4.2.2.2.2}. However, this requires ensuring that conflicts are adequately addressed, overlapping mandates are avoided, and coordination and complementarity are encouraged (*well established*) {4.2.2.3}.
- The approaches to addressing unsustainable use and coordinating sustainable use are often poorly coordinated across scales and institutions. Different levels of governance are often poorly aligned and coordinated, which undermines keeping the use within a sustainable level—the lack of alignment limits protections of sustainable use. Lack of clarity and consistency (security) in recognizing and protecting use rights (i.e., including local and indigenous rights and customary rights) create problems of “open access” and, by extension perverse disincentives for conservation (*established but incomplete*) {4.2.2.3, 4.2.2.6}.
- Tenure security contributes to sustainable use (*well established*) {4.2.2.6}. Tenure arrangements that foster secure rights over land and resource use and trade can incentivize resource conservation, sustainable use, and diverse livelihoods, partly because there are more opportunities for effective regulation of use patterns (*established but incomplete*) {4.2.2.3} and they allow for longer-term planning. In regions where tenure insecurity has been reduced, there is evidence of improved food security and positive conservation outcomes for wild species (*well established*) {4.2.2.3, 4.2.2.6}.
- Where management is based on long-term relationships to place, practices of monitoring changes in species health, population and distribution tend to be well developed. These monitoring practices contribute to sustainable use in that they facilitate learning and adaptation. Such norms and practices of stewardship and adaptive learning are well

documented in the case of indigenous peoples and local communities (*well established*) {4.2.2.2, 4.2.2.4}.

Social drivers: Various demographic and social factors influence the sustainable (or unsustainable) use of wild species: migration and urbanization, social organization and reproduction, empowerment, effective participation and accountability, poverty and process of marginalization, gender equity and, rural development (roads, infrastructure, access to material assets and immaterial goods-market, credit, internet) (*well established*) {4.2.2.7}.

- Population growth, demographic change and mobility are affecting use patterns of wild species. Specifically:
 - Population density and growth are leading to increased demand/consumption of wild species in some regions, particularly in urbanized areas of the global south (*well established*) {4.2.3.2}.
 - Increased mobility is leading to unsustainable use of wild species in critical areas. Such mobility is associated with displacement (i.e., from conflict, environmental degradation) as well as economic opportunity (e.g., transnational labor movements). In addition to increasing pressure on species, there is growing displacement of local uses (e.g., of indigenous peoples and local knowledge) (*well established*) {4.2.3.2}.
 - Mobility across political and ecological borders, may be leading to unsustainable use, particularly where such mobility is accompanied by lack of attachment to the place(s) (*established but incomplete*) {4.2.3.2, 4.2.3.2.2}.
- Urbanization tends to lead to decreased consumption of wild species due to access to the market economy for food (*established but incomplete*) {4.2.3.2.3}.
 - Mobility of peoples across political and ecological borders, may be leading to unsustainable use, particularly where such mobility is accompanied by lack of attachment to the place(s) (*established but incomplete*) {4.2.3.2, 4.2.3.2.2}.
- Social organization and networks affect how the benefits and costs of wild species use are distributed. Societies that are more equitable tend to experience less poverty, conflict and social inequality, which are factors correlated with sustainable use patterns (*well established*) {4.2.3.5}.
 - Social inequity and poverty are a growing trend globally, particularly in the global south. In many regions, where alternatives to basic needs (e.g., shelter, food) and economic and social supports (e.g., education) are limited, there is greater dependence on wild species. However, it is an over-simplification to attribute unsustainable use of wild species to those living facing poverty (*well established*) {4.2.3.5}.
 - Although some evidence points to those living in poverty are culpable for increasing unsustainable use of wild species, the socio-economic and political systems that have created and perpetuated poverty and inequity are the underlying driver (*well established*) {4.2.3.5}.
 - Given that poverty is multidimensional, eradicating it requires a multifaceted approach. Access to food, shelter, education, employment, and health can lift

- people out of poverty and make them less dependent on wild species (*well established*) {4.2.3.5}.
- Equitable distribution of benefits from the sustainable use of wild species is a stated goal of many governance and institutional frameworks. However, implementation of these goals is often flawed. This directly impacts sustainability, creates incentives to over-harvest species, undermines long-term management of species, and can support unsustainable commercial extraction (*well established*) {4.2.3.4, 4.2.3.5}.
 - Use of wild species by women and indigenous peoples is under-recognized and poorly protected and consequently creates / aggravates problems of food insecurity and poor health for vulnerable populations (e.g., poor nutrition) and increases dependency on commercially produced food resources (*well established*) {4.2.3.4; 4.2.3.5}.
 - Social values and norms influence how wild species are used, and many aspects of their sustainability are interpreted:
 - Social groups who are most dependent on wild species tend to experience more significant concern and anxiety about their health and unsustainable use (i.e., have heightened risk perception (*well established*) {4.2.3.3.6}). These groups thus tend to be critical stakeholders in identifying sustainable use solutions (*well established*) {4.2.3.7}; among the groups with long-term dependencies and support for sustainable use are indigenous peoples (*well-established*) {4.2.2.5}.
 - Many indigenous peoples and local communities who have long-term relationships with wild species have well-developed relationships, knowledge systems, practices, and rules (i.e., customary laws) which ensure their sustainable use (*well established*) {4.2.3.5}.
 - Social norms create the social context in which wild species use is structured/organized, and interpreted by users. Where practices of hunting, fishing and gathering are fundamental to food provisioning and support livelihood and social identity, these practices and uses tend to be more sustainable (*established but incomplete*) {4.2.3.3}.
 - The harvest of wild species is recognized as essential to food security, health and well-being in many regions; where there is increasing risk (both reported and perceived) of bioaccumulation of contaminants, presence of disease (including transmissible disease to humans), hunting, fishing and gathering of wild species tend to decrease. However, trust in the actors involved in risk communication is a mediating factor (*well established*) {4.2.3.7}.
 - Gender inequity in how the costs/benefits of wild species use are distributed is visible in key regions of the globe (*well established*) {4.2.3.6}.

Economic drivers:

- The economic drivers of sustainable use of wild species can be understood through evidence-based research on both formal and informal economies, at different scales (from local to global) and in respect of particular economic activities. While the greatest

concerns with economic trends are those that are large in scale and involve exploitation of wild species for growing urban markets, the value and uses of wild species within local economies meet the needs of rural peoples, including indigenous peoples and local communities, are also essential considerations in a discussion on economic drivers (*well established*) {4.2.3.3.5, 4.2.4.2.2}.

- Global trade in wild species can create disincentives for sustainable use and lead to significant losses in some species in the absence of local, regional, and national regulation and management plans. Wild product trade often forms part of income diversification and risk reduction strategy for households living in poverty in developing countries (*well established*) {4.2.4.3.1}.
- Trade revenues can facilitate and incentivize conservation, but if regulation is absent or not enforced, it often encourages overexploitation and unsustainable use, including local extinction. Sustainability outcomes depend on mediating factors such as the total demand and scale of trade, governance arrangements, trade relations and local incentives for conservation, and species characteristics (*established but incomplete*) {4.2.4.3.1}.
- Sustainability outcomes depend on the enforcement of local management plans, national laws, and international cooperation. Lack of enforcement and monitoring bears the risk of undermining the potential for sustainable use that may provide critically needed revenue and incentives for conservation while at the same time failing to discourage illegal harvests and trade (*established but incomplete*) {4.2.4.3.1}.
- Strictly regulated trade, including trade bans, have played an important role in halting unsustainable use of threatened species, but in some cases, blanket trade bans have had unintended consequences on sustainability outcomes (*established but incomplete*) {4.2.4.3.1}
- Empowering local communities to capture the benefits from wild species conservation with legal user rights over wild species and co-design regulation contributes positively to sustainable use (*established but incomplete*) {4.2.4.3.1}.
- “Tax havens” and global crime facilitate unsustainable use of wild species (*established but incomplete*) {4.2.4.3.2}.
- Micro-credits and foreign investments can play a positive role in enabling sustainable uses if combined adequately with wider enabling factors such as human and social capital investments. In some cases, remittances support livelihoods and may reduce pressure on resources but provide the capital to enable unsustainable uses and practices (*established but incomplete*) {4.2.4.3.2}.
- Activities related to tourism and supporting infrastructure may disturb wild species and undermine sustainability outcomes. At the same time, revenues from tourism can be used for conservation projects which positively impact sustainable use of wild species (*established but incomplete*) {4.2.4.3.3}.
- Traditional ecologically more sustainable but economically less profitable practices may be supported when linked to tourism activities that generate additional revenues. At the same time, certain tourism-related activities, such as the sale of wildlife parts and the

use of live animals in entertainment, incentivizes unsustainable and sometimes illegal practices. (*established but incomplete*) {4.2.4.3.3}.

- In some cases, extractive forms of tourism (i.e., terrestrial animal harvesting and fishing) positively impact ecological, social, and economic sustainability by generating revenues for conservation and livelihoods. However, in many cases, the revenues do not reach local communities and do not contribute to conservation, in which case the extractive tourism can be unsustainable (*established but incomplete*) {4.2.4.3.3}.

Cultural values/religious beliefs:

- World views, religions, customs and belief systems directly and indirectly influence the practices and uses of wild flora and fauna (*established but incomplete*) {4.2.5}.
- Indigenous and local knowledge includes cultural norms and ethics that support sustainable use (*established but incomplete*) {4.2.5}.
 - Observation is central to sustainable use, allowing indigenous peoples and local knowledge to closely monitor and assess resources over time and providing a solid foundation for building sustainable management plans (*well established*) {4.2.5.2.5}.
 - Indigenous and local knowledge is poorly documented compared to other knowledges; where it has been documented and embraced, there are greater sustainable use outcomes. It also offers a crucial foundation for sustainable use in and beyond indigenous peoples and local communities. Realizing its full benefits will require enhanced documentation and greater recognition of Indigenous rights (*well established*) {4.2.5}.
- Cultural norms often mediate practices and uses of wild species; where there are long-term relationships between people-nature, examples around stewardship and care of wild species are more common (*well established*) {4.2.5.2}. Cultural taboos against harvest, consumption and other uses of wild species play an essential role in the conservation of some key species (e.g., sacred groves) (*well established*), {4.2.5.2.2}.
- Beliefs about the perceived medicinal value of wild species (coupled with clinical evidence about improved health outcomes) are a driver of the harvest and use of some flora and fauna (*well established*) {4.2.5.7}.
- Spiritual beliefs that wild species have an equal value to humans (e.g., are relatives or are gifts from the spirit world) are common in some cultures, particularly those of indigenous peoples. These beliefs often include recognitions or demonstrations of respect (e.g., ceremonies) when flora-fauna are harvested or used (*well established*) {4.2.5.2.5}.
- In many indigenous cultures, practices that facilitate good relationships with wild species (e.g., take only what you need) are interconnected with cultural values and norms of community well-being of communities (*established but incomplete*) {4.2.5.2}. “Take only what you need” is not a common principle or value in cultures tied to globalization and industrialization; these tend to focus more on the accumulation of wild species for profit.

- Many indigenous peoples and local knowledge have traditional norms and practices to ensure appropriate or sustainable, relationships with wild species. These norms and procedures are based on indigenous and local knowledge and are frequently central to spiritual practices. Often, they include significant sanctions or punishments when violated (*established but incomplete*) {4.2.5.2.7}.
- Human treatment of wild species in a humane way is also highlighted in the Convention on Biological Diversity's Addis Ababa Principles and Guidelines for the sustainable use of components of biodiversity (*established but incomplete*) {4.2.5.2.4}.

Scientific and technological innovation and education:

- Rapid transformations in the life sciences and modern biology have changed how the natural world is studied and understood, with enormous implications for managing wild species and conservation across all sectors and practices – including fishing, gathering, terrestrial animal harvesting, logging, and non-extractive practices like observing. Genomic technologies and bioinformatics have generated enormous data and analysis, and the trend is a continued and accelerated expansion of scientific understanding (*well established*) {4.2.6.2}.
- Advances in science and technology can contribute to and undermine the sustainable use of wild species. Positive contributions include an enormous expansion of invaluable scientific understanding and knowledge directly useful for the sustainable use and conservation of species, including new ways to identify, characterize, manage, and monitor species and set priorities for conservation. This knowledge and resulting tools are employed across practices, including fishing, gathering, terrestrial animal harvesting and logging, as illustrated in hundreds of studies in recent years (*well established*) {4.2.6.2}.
- Positive contributions of advances in science and technology also include information/knowledge and technical support for implementing policies and laws that regulate the use and trade of wild species. Conservation and sustainable use laws based on a deep understanding of species, populations, and ecosystems have proven more effective, as documented in numerous studies and policy evaluations. The indirect and direct negative impacts of destructive laws and policies are also illustrated by advanced scientific research (*established but incomplete*) {4.2.6.2}.
- Fishing, gathering, terrestrial animal harvesting, logging, and non-extractive uses all take place within the context of broader ecosystems, the health of which impacts the sustainable use of species and populations. Advances in science and technology also have direct impacts on sustainable use by impacting ecosystems from which species are harvested, including erosion and degradation of ecosystems, and nature's contributions to people, resulting from feedstocks for new 'biological factories,' as well as the positive impact of bioremediation (*established but incomplete*) {4.2.6.2}.
- Science and technology create conditions that support or undermine sustainable use and local livelihoods, indirectly or directly. Biotechnology and 'biological factories,' for example, can provide substitutes for unsustainably harvested species – plants, animals, and marine - thereby taking pressure off wild populations, but they can also negatively

impact small-scale producers and harvesters who depend on those species to make a living in a range country (*established but incomplete*) {4.2.6.2}.

- Information and communication technologies improve managers' decision-making processes by improving their ability to acquire timely and relevant data related to the population movement, scale, and management of wild species (*established but incomplete*) {4.2.6.3}.
- Information and communication technologies support managers and decision-makers ability to collaboratively analyze, access and share data and to work in partnership with colleagues, peers, decision-makers and public members (*well established*) {4.2.6.3}.
- It is well established that technology and urbanization contribute to decreased contact with biodiversity, leading to a decline in biodiversity-related knowledge and lack of awareness of its loss, unsustainable use, and importance in our lives (*well established*) {4.2.6.4}.
- Global trends toward standardization of education are decreasing attention to, and understanding of, local biodiversity and a decline in community resilience (*well established*) {4.2.6.4}.
- Research and practice demonstrate that indigenous, place-based, and experiential learning builds bonds between community members and their ecosystems, leading to a more robust environmental ethic (*established but incomplete*) {4.2.6.4}.
- Institutional disincentives within academic and research organizations discourage broad audiences' communication of relevant research results about biodiversity. Reform of academic incentive structures is needed that reward on-the-ground engagement with local groups and in biologically and culturally diverse regions and broader communication of findings beyond the scientific community (*established but incomplete*) {4.2.6.4}.
- Initiatives such as communication for social change, social learning, citizen science, and health-related sciences demonstrating links between human health and biodiversity can serve as a model; these fields are building bridges between science and the public, and their methods could improve understanding of the value of biodiversity and promote sustainable use of wild species (*well established*) {4.2.6.4}.
- Many local and indigenous groups are calling for systemic changes in educational systems to respect their cultures' traditions, knowledge, languages, values, history, and identities. Formal recognition by national educational systems of cross-generational knowledge transmission and a more comprehensive range of approaches to learning would support local stewardship and sustainable use of wild species (*established but incomplete*) {4.2.6.4}.
- Biodiversity education and communication can nurture a conservation consciousness which is fundamental to supporting the sustainable use of wild species. There is an emerging consensus that effective education programs respect local cultures, languages, and land, including women, elders, and youth, and promote inter-generational transmission of knowledge (*established but incomplete*) {4.2.6.4}.

Interactions among drivers:

In most instances of resource use, there is interaction amongst drivers leading to either synergistic or antagonistic effects. Interactions among the various drivers make use of a species sustainable or unsustainable and are shared. The level of interaction is often case-specific and depends on whether:

- o Use is restricted to a single jurisdiction versus being regional or transboundary.
- o Technology is relatively simple and stable versus highly mechanized and frequently innovated.
- o Alternative sources of food or livelihoods are of limited or ample availability.
- o Governance processes are robust or contested.
- o There are multiple competing uses, or
- o Little is known about the species.
- Whether a practice of using wild species is sustainable or not is highly complex and may be influenced by how drivers (i.e., environmental, social, economic, cultural, political and science and technology and education) interact, which is often also influenced by mediating factors such as species ecology, value systems, indigenous and local knowledge and context (*well established*) {4.3.2, 4.3.4}.
- The sustainability of fishing and fisheries is widely driven by the complexity of the web of interactions among environmental, social, economic and technology drivers, where species biology, ecosystem and multi-species interactions also matter significantly (*well established*) {4.3.2.1}.
- The economic trade driver interacts with environmental, cultural and social drivers to affect the sustainability of gathering and collecting wild species. Such effects may be mediated by the use of technology and tools to impact further the collection of fantastic resources (*well established*) {4.3.2.2}.
- Cultural and social drivers often interact with economic drivers, which are further mediated by factors such as species biology to shape the sustainability outcome of hunting, with the bulk of the studies coming from the tropics (*well established*) {4.3.2.3}.
- Political and economic trade drivers and mediating factors such as species management interact to determine if logging practices are sustainable, but regional differences are apparent (*well established*) {4.3.2.4}.
- Compared to other practices, the non-extractive use of wild species is relatively sustainable, though not as widely studied. Multiple drivers have been documented to interact to affect the sustainable management of species (*established but incomplete*) {4.3.2.5}.
- The ecological settings, species rarity, and the resilience of ecosystems can influence the sustainability of the practices. Understanding species biology and ecology and how they interact with drivers can affect the management and sustainability outcome of the practice (*established but incomplete*) {4.3.3}.
- Long-term, spatially explicit studies are essential for the assessment of the sustainability of the use of wild species. The interactions of drivers change with time and conditions, particularly when subjected to external shocks (e.g., economic or environmental) and

perturbations, which may impact the sustainable use of a species in the future (*established but incomplete*) {4.3.4}.

The schematic below illustrates how drivers ultimately influence the sustainability outcomes of wild species use and the complexity and interactions among the key drivers in producing sustainability outcomes of practices such as hunting and fisheries throughout the world (Figure 4.1).

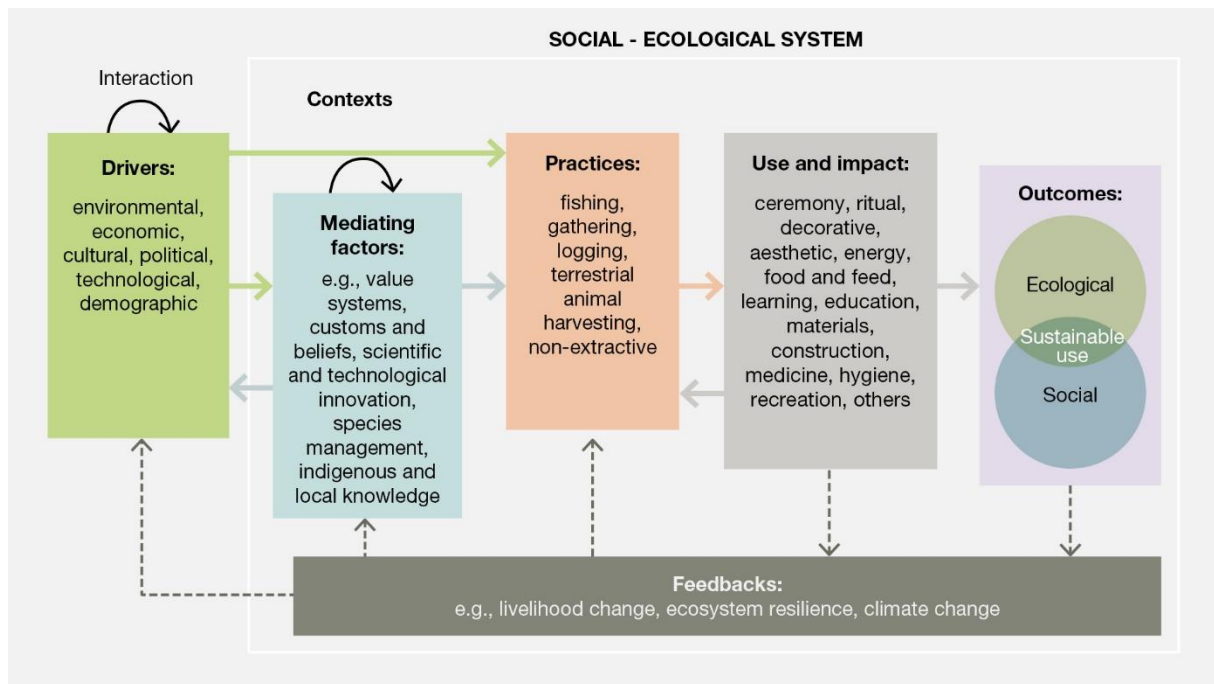


Figure 4.1 Conceptual approach to the drivers of sustainable use of wild species.

4.1 Introduction

Human societies across the globe, since time immemorial, have relied on natural resources, including water, plants, animals, and minerals, to sustain themselves and their wellbeing. Over time, however, with increases in population and growing consumerism, the levels of natural resource extraction have increased exponentially without due consideration to the sustainability of their use (Bergstrom & Randall, 2016). As a result, natural resources are depleting and wild species face an increased risk of extinction (see Chapter 3). For example, Estrada et al. (2017) estimated that almost 60% of primate species face a high risk of extinction and 75% suffer from decreasing populations due to human-induced pressures on their habitats. Global and local market demands are causing significant habitat loss due to the expansion in industrialized agriculture, logging, livestock operations, oil and gas drilling, the establishment of road networks, and mining in primate ranges. At the same time, other key drivers include the growing demand for wild meat, including aquatic wild meat and the illegal trade in primate species for use as pets or in their body parts for other purposes. These impacts show how the combination of drivers may affect the abundance of species being used and whether they are used sustainably. The effects on nature's contributions to people arising from these changes are severe for indigenous people and local communities who, due to their intimate relationships with nature, rely on natural resources and have developed knowledge and customs that can help protect nature and sustainably use wild species.

Against this background, the need to achieve sustainable development in general, and the sustainable use of wild species in particular, is now a matter of urgency. The conceptualization of sustainable use is assessed in detail in Chapter 2. This chapter aims to assess the factors that contribute to sustainable use with a particular focus on what drives resource use. In the context of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), drivers of change are all the factors that, directly or indirectly, cause changes in nature, anthropogenic assets, nature's contributions to people and good quality of life. This chapter deals with direct and indirect drivers of sustainable use of wild species, interactions among drivers, and their impact on the human population in general and on indigenous and local communities in particular. IPBES defines these drivers in the following way:

- Direct drivers of change can be both natural and anthropogenic. Direct drivers have direct physical (mechanical, chemical, noise, light etc.) and behavior-affecting impacts on nature. They include, among other things, climate change, armed conflict and war, pollution, different types of land use change, invasive alien species and zoonosis, and exploitation.
- Indirect drivers are drivers that operate diffusely by altering and influencing direct drivers, as well as other indirect drivers. They do not impact nature directly. Instead, they do it by affecting the level, direction or rate of direct drivers.
- Interactions between indirect and direct drivers create different chains of relationship, attribution, and impacts, which may vary according to type, intensity, duration, and distance. These relationships can also lead to different kinds of spill-over effects.
- Global indirect drivers include economic, demographic, governance, technological and cultural ones. Special attention is given, among indirect drivers, to the role of institutions

(both formal and informal) and impacts of the patterns of production, supply and consumption on nature, nature's contributions to people and good quality of life.

The framework this assessment follows (outlined in Chapter 1) does not deal separately with direct and indirect drivers. These can be difficult to separate due to their interactions when they are applied to sustainable use as an outcome of the resource use system. Understanding the drivers will set the stage for determining the appropriate mechanisms to ensure the sustainable use of wild species.

This chapter builds on the assessments undertaken in Chapter 3, which focused on the status and trends in sustainable use, the consequences for wild species in nature, and nature's contribution to people. The Chapter will define drivers of the sustainable use of wild species and develop the following areas.

- Provide a classification of different drivers in environmental, political, social, economic, cultural, scientific and educational themes based on the IPBES framework.
- Explain different worldviews (concept of drivers), intrinsic values (charismatic species, keystone species, flagship species), systems and practices of looking at other drivers of sustainable use of wild species.
- Show linkage between drivers of use of wild species, sustainable use of wild species and human well-being.
- Provide a brief explanation of the interaction among different drivers of the use of wild species as well as the impact on indigenous and local communities
- Show schematics of drivers of sustainable use of wild species.

The Chapter starts with a description of the different drivers, followed by an assessment of how these drivers affect the sustainable use of wild species.

Methodology

Drivers in this chapter are, the factors that, directly or indirectly, influence the sustainability of wild species use. Based on a conceptual framework illustrated in Figure 4.1, drivers have been divided into main categories (environmental, political, social, economic, cultural and educational). For addressing how each driver influences positively/negatively the sustainable use of wild species across the different practices (fishing/ gathering/terrestrial animal harvesting/logging/non-extractive practices); the following points were considered relevant:

Driver X

- Overview and definition
- Accounting for how **driver X** influences (positively/negatively) sustainable use of wild species across the different practices (fishing/gathering/terrestrial animal harvesting/logging/non-extractive practices).
- What are the trends and patterns of the influence of **driver X** globally, regionally etc., on each of the practices over the assessment period (last 50 years)?
 - a. Explain how **driver X** has contributed (positively/negatively) to the sustainability of fishing, and hunting globally?

- b. Explain how **driver X** influences gathering and harvesting of wild species (for fuel, medicinal plants...etc.) in non-forested lands (e.g., deserts, grasslands, wetlands...etc.).
- c. Explain how **driver X** in forested regions has influenced the sustainability of timber harvest regionally and globally.
- d. Explain how **driver x** influences sustainability of non-extractive practices that involve the use of wild species (e.g., observing such as bird watching) across different regions, and how that differs in developed countries versus developing countries?

A discussion on the Mediating Factors that operate across different scales and shape the influence of driver X will be included as relevant. Some of the questions that may be answered include:

- What are the exceptions to the major trends/patterns depicted? Why are there exceptions?
- What do these mediating factors tell us about solutions to unsustainable use (policy options, etc.)?
- What is some case studies that illustrate these issues?

The relevance and the significance of the drivers to the practices dictated the inclusion of these practices/examples of use in the discussion. A literature review was conducted to gather evidence on the drivers and how each influence the sustainability of wild species use. A database of relevant sources, including peer-reviewed research papers, articles, book chapters and reports, has been compiled. The database was compiled mainly by conducting literature searches on international scientific databases and bibliographic search engines. Authors also worked on diversifying the sources of information they relied on to include grey literature, government reports, conference proceedings, diversified bibliographical resources including sources written in languages other than English, and searching for information by directly contacting experts and field workers (see data management report doi: 10.5281/zenodo.6453228).

To achieve a balance between conventional scientific knowledge and local & traditional knowledge, the authors collected sources of indigenous and local knowledge. These sources included accessing information from reports of the indigenous and local knowledge-dialogue workshops along with the input from experts working directly with the indigenous peoples and local communities and some authors reached out directly to members of indigenous peoples and local communities. Sources collected covered the five practices (fishing, gathering, terrestrial animal harvesting, logging and non-extractive methods) and their drivers for in-depth analyses. Each of the main drivers has been disaggregated to the extent possible in each driver section. Analysis of the key drivers in producing sustainability outcomes of the use of wild species across the globe based on evidence from the data collected is still underway. Identification of the trends in these drivers at spatial and temporal scales will be provided.

4.2 The drivers of sustainable use of wild species

The Chapter is based on the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services framework of nature's contribution to people. Further, it develops ideas within this framework that are relevant to understanding the drivers of the use of wild species. This chapter in particular assesses the status and trends of drivers of use of wild species that lead to sustainable or unsustainable outcomes. The most important factors that contribute to ecosystem degradation are technological advances and changing social dynamics and may be equated with the five major indirect drivers of ecosystem degradation identified by the Millennium Ecosystem Assessment, namely changes in population, economic activity (which increased nearly sevenfold between 1950 and 2000), socio-political factors, cultural factors, and technological changes. These factors do not directly degrade ecosystems but operate more diffusely by amplifying and promoting the direct drivers of ecosystem degradation.

4.2.1 Environmental drivers

4.2.1.1 Overview

This section discusses drivers directly linked with the so-called “natural” environment: climate change and hydrometeorological hazards, land and ecosystem degradation, invasive alien species, land and seascape change, pollution, and environmental hazards. Climate change and related hazards have adversely impacted biodiversity and terrestrial, marine, and freshwater ecosystems. Although there is little direct evidence to show how climate change has, and will, affect wild species use, climate change and associated hazards have already, and are expected to further affect, food production systems, energy systems, water availability, and human health (Hoegh-Guldberg et al., 2018), which in turn impact how wild species are used. Land degradation, especially degradation of forests, rangelands, and croplands worldwide, has affected the capacity of nature to produce provisioning services and the availability and abundance of wild species. Conversion of grassland, savanna, and forests, mainly tropical forests, to agriculture, aquaculture, and urban development, has destroyed the primary habitats of species causing many species to be endangered. It also leads to the decline of commercially traded species. The expansion and intensification of agricultural and grazing lands have positive and negative impacts on the sustainable use of wild species. Intensification increases production capacity and reduces the dependence on wild resources while it also has costs—release of pollutants into the environment and increased greenhouse gases. In marine and freshwater ecosystems, many pollutants accumulate in organisms, and when humans consume food from polluted waters, they are exposed to pollutants (Sonne et al., 2018). This has serious implications for people who consume large amounts of fish and seafood, such as indigenous peoples and local communities who consume the blubber of marine mammals (Donaldson et al., 2012). Globally, urban areas are expanding at twice the rate of their population. Residential development is a leading driver of land-use change that has severe implications for biodiversity and wild species populations. Urbanization has negatively affected the abundance of species and caused even micro-evolutionary changes. Urbanization in coastal areas has adversely affected the diversity, life history, survival, reproduction and growth of many aquatic species. Likewise, dam building has substantially impacted riverine ecosystems, affected forests, and caused species losses.

On the other hand, there has been a growth in urban greenery, an increase in production and consumption of organic foods, and agroforestry practice worldwide. This positively impacts resource use, but the scale is very small compared to the degradation of natural habitats. Natural hazards, including geological or geophysical hazards that originate from internal earth processes (earthquakes, volcanic activities, landslides, tsunamis), and biological hazards, including zoonotic diseases, have had significant impacts on ecosystems and species and, by consequence, use of wild species. These hazard events arise from, or are exacerbated by, increased human interactions with their environment and prompt us to re-examine the relationship between people and wild species.

4.2.1.2. Climate change and hydrometeorological hazards

4.2.1.2.1. Overview

It is estimated that our planet has experienced human-induced warming of approximately 1° degree C since 1880 (Hoegh-Guldberg et al., 2018), with widespread impacts on biodiversity, which are accelerating in marine, freshwater, and terrestrial ecosystems, as well as increased frequency and intensity of extreme weather events resulting in hydrometeorological hazards (IPBES, 2019a). Further, climate change is projected to become an increasingly significant direct driver of change in nature and human well-being. Although predictions vary depending on the scenario and geographic region, the adverse impacts of climate change on biodiversity will become more pronounced in the next decades and will worsen with global warming (IPBES, 2019a). Adverse impacts on biodiversity and ecosystem functioning are expected to profoundly alter habitat for wild species, as species ranges shrink, and thus significantly influence the risk of global extinctions (IPBES, 2019a). For example, according to the Intergovernmental Panel on Climate Change, with an average increase in temperature of 1.5°C above pre-industrial levels, 6% of insects, 8% of plants and 4% of vertebrates will lose over half of their climatically determined geographic range. These figures will increase to 18% of insects, 16% of plants and 8% of vertebrates for global warming of 2°C. Coastal ecosystems such as mangroves, tidal marshes and seagrass meadows are affected by the multiple impacts of ocean warming, including sea-level rise, with a particular impact on loss of biodiversity and ecosystem services (IPCC, 2019). Evidence for marine ecosystems indicates that the majority (70-90%) of tropical coral reefs will go extinct, even if global warming is constrained to a 1.5°C (Hoegh-Guldberg et al., 2018), with dire consequences for the biodiversity (IPCC, 2019).

Increased frequency, intensity, and amounts of hydrometeorological hazards—such as heatwaves, heavy rainfall, drought, flooding, storms, and cold spells—are further expected at both 1.5 °C and 2 °C global warming, with risks projected to be lower at 1.5 °C compared to those at 2 °C (Hoegh-Guldberg et al., 2018). Storms and severe weather events can destroy or severely damage infrastructure and productive assets such as boats, landing sites, post-harvesting facilities and roads. This can lead to decreased harvesting capacity and access to markets, reducing the availability of food products and increasing their prices, resulting in higher incidences of malnutrition in communities, thus having severe consequences for food security, nutrition and health (Niiya, 1998). This, in turn would affect livelihood activities, including harvesting of wild species. Although hydrometeorological hazards differ from slow-

onset climate change impacts on temporal scale, this section reviews climate change and associated risks together as a driver affecting the use of wild species.

Although climate change and associated hazards will be a significant driver of biodiversity and wild species loss, there is little direct evidence to show how this driver will affect wild species use. It is clear that climate change will impact not only different ecosystems and their biodiversity but also, food production systems, energy systems, water availability, and human health (Hoegh-Guldberg et al., 2018), which will all affect the use of wild species. In terms of food systems, there is well-established evidence to support that climate change is likely to have negative impacts on agricultural productivity (Challinor et al., 2007; Chavas et al., 2009; Cline, 2007; Rötter & van de Geijn, 1999), though exactly how agricultural production will change has not been reliably quantified (Gornall et al., 2010). Along with other drivers, the impacts of climate change and associated hazards will increasingly exacerbate negative implications for use of wild species.

4.2.1.2.2. Fishing

Climate change is a driver that will likely shape the future of fisheries globally (Lam et al., 2016). Overfishing is seen as the biggest threat to the sustainable use of wild species in the earth's bodies of water (Auber et al. 2015; Frisk et al. 2018, Cisneros-Mata et al. 2019)—whether commercial or recreational—with scenarios and models predicting the increasingly significant threat of climate change to marine and freshwater ecosystems and their biodiversity (Cheung et al., 2018; Olsen et al., 2018; Reygondeau, 2019).

The evidence is well-established that climate change impacts waterbodies. Increasing temperatures, ocean acidification, sea-level rise, and changes in river flows have had impacts on the spawning period and stock size (Chandrapavan et al., 2019; Kaeriyama et al., 2014; Rogers & Dougherty, 2019; Tanimoto et al., 2012), growth and metabolism rates (Catalán, 2019; Martino et al., 2019; Shan et al., 2011), biomass (Bentley et al., 2017; Howell et al., 2013), mortality (Bartolino et al., 2014; Catalán, 2019; Hupfeld et al., 2015; Huserbråten et al., 2019; Ohlberger et al., 2018; Rodgers et al., 2018; Voss et al., 2019), and diseases (Carraro et al., 2018; Rowley et al., 2014; Vivekanandan et al., 2016; Yue et al., 2018) of fish, from the Arctic to tropical areas, including coral reefs. These, in turn, alter fish abundance (Genner et al., 2010; Hare et al., 2010; Jacobson et al., 2017), distribution (Dell et al., 2015; Hare et al., 2010; Healey, 2011; Reygondeau, 2019; H. Welch et al., 2019; Woodworth - Jefcoats et al., 2017), assemblages (Hoey et al., 2016), and migration and movement patterns (McLean et al., 2018; R. E. Scott et al., 2019), and these impacts vary considerably within and between populations (Fernandes et al., 2016; Genner et al., 2010; A. R. Hughes et al., 2019) as well as life stages (Dahlke et al., 2020).

The evidence is also well-established that these changes affect how commercially important wild species are exploited through fishing (Howell et al., 2013; Meynecke et al., 2006; Pinsky & Fogarty, 2012) and as a result, the global seafood market and food security (Hobday et al., 2016; Paukert et al., 2017; Reygondeau, 2019). Hindcast models indicate that the maximum sustainable yield of marine fish populations decreased globally by 4.1% from 1930 to 2010, with some regions experiencing losses of 15 to 35% (Free et al., 2019).

Between 2000 and 2050, maximum catch potential is projected to decrease globally by 7.7%, with global fisheries revenue projected to decrease by 10.4%, under high carbon dioxide emission scenarios. Figures in the tropics are projected to decrease by 38% and 33%, respectively (Lam et al., 2016). A study of fisheries in the northeastern United States over the past 40 years of warming temperatures shows a northward shift in fisheries, which corresponds to northward shifts in species distributions; further, the proportion of warm-water species caught increased (Pinsky & Fogarty, 2012). Studies predict that under warming temperatures, fisheries that target widely distributed species spanning large geographic areas and habitats would increase (Coleman et al., 2019), as is already evident with the case of the Atlantic cod (Kjesbu et al., 2010), while fisheries of species that reproduce rapidly may be more adaptable than fisheries focused on longer-lived species (Perry et al. 2010).

Evidence is well-established that climate change could further contribute to changes in the use of wild species through fishing, for example, through modification of fishing vessels to follow shifts in the spatial distribution of marine resources (Dell et al., 2015), fleet types and fishing regulations (Cheung et al., 2012). Climate and ocean currents in the early 20th century led to enhanced opportunities for fishing in West Greenland; this example demonstrates how climate change can provide opportunities and benefits in some regions (Thuesen, 1999). Similarly, increased interest in oil, gas, and fisheries in previously unreached places such as the Arctic due to decreasing ice cover (Harris et al. 2018; Lam et al. 2016) and the deep sea (see Glover and Smith 2003) could impact the use of wild species in these places.

The link between hydrometeorological hazards and the use of wild species through fishing is also well-established (Brander, 2007; Martino et al., 2019). Extreme events can decrease safety at sea and increase the prevalence of injuries and mortalities (Birkmann, Fernando, N., 2008.; De Silva and Yamao 2007). Hazards not only damage gear, boats, and landing sites (Musinguzi et al., 2016), but they can lead to changes in fish catch, size, and catch structure (Monteiro et al., 2016; Musinguzi et al., 2016; Santos et al., 2016). A study in Australia found a substantial decline in fisheries after an extreme marine heat wave in 2011, leading to fishery closure the following year (Chandrapavan et al., 2019), while a study in Denmark showed the rapid decline of eel fishery after a winter storm in the 19th Century (Poulsen et al., 2007). Moreover, studies show how coastal communities in Vanuatu that suffered from a tropical storm and El-Nino-induced prolonged drought (Eriksson et al., 2017) and lakeside communities in Tanzania whose economy changed as a result of drought (Kimirei et al., 2008) increased their reliance on fishing for their livelihoods. In Antigua and Barbuda, 16% of the fishing fleet was destroyed or lost and 18% damaged due to Hurricane Luis in 1995, resulting in an estimated decrease of 24% in gross revenues (Mahon, 2002). During Hurricane Katrina in 2005, the businesses of about 95% of the 62 seafood dealers in Mississippi were destroyed or their infrastructure so severely damaged that commercial fisher folk were unable to sell their catch or buy fuel or ice from them (Buck, 2005).

4.2.1.2.3. Gathering

Evidence of the linkage between climate change and hydrometeorological hazards and the gathering of wild species is inconclusive. In conjunction with other factors such as land use change and overharvesting, climate change has led to, for example, changes in communities

and geographical distribution of seaweed due to warming sea temperatures in Australia (Wernberg et al., 2011) and in Japan (Kumagai et al., 2018; Vergés et al., 2014) and decrease in populations of medicinal plants (Hopping et al., 2018) and thus, loss of associated indigenous knowledge (Hong et al., 2015). These impacts can have severe consequences for people with long histories of interaction with their natural surroundings, such as indigenous peoples and local communities, mainly pastoralists, who have had to adapt their livelihood strategies. A study points to climate change and drought as reasons why pastoralists in Tanzania have had to start farming (Tibuhwa, 2012), while other studies point to conflict induced by climate change, especially droughts and floods, as the primary reason behind changes in livelihood activities of pastoralists in Kenya (Omolo, 2010).

4.2.1.2.4 Terrestrial and marine animal harvesting

The evidence that links climate change and trends in climatic conditions with population densities, growth, diseases, mortality and distribution of hunted wild species is well-established. Changes in, for example, population densities of hares (Schai-Braun et al., 2019) quail phenology (Nadal et al., 2018), breeding patterns of ducks, increased biomass of seals and belugas (Hoover et al., 2013), mortality and distribution of walrus (MacCracken, 2012), imply a link between climate change and how wild species are hunted, but the evidence on this is incomplete. For example, studies in the Arctic region show a clear link between impacts of climate change, such as changes in weather, ice, and oceanographic conditions, with variation in the hunting season of walrus and whales (Metcalf & Robards, 2008) and melting sea ice for the increased catch of narwhals (Nielsen, 2009). The relationship between climate change, hunting, and conservation of polar bears has received more attention than other hunted wild species; the evidence is clear that the melting of the sea ice due to climate change threatens the habitat of polar bears.

In some cases, habitat changes affect bear distribution with increased incidence of human-bear conflict as polar bears move nearer to human settlements searching for food. Indigenous knowledge is clear that harvesting of bears is sustainable, however, scientific evidence is unresolved. Whether polar bears can be sustainably hunted (Regehr et al., 2017; Stirling et al., 2008, 2011; Tyrrell & Clark, 2014).

Evidence that hydrometeorological hazards have contributed to the use of wild species through hunting is scarce. A study conducted after a tropical cyclone in Tonga shows the relationship between tropical cyclones and increased mortality of fruit bats due to increased hunting and destruction of trees that bats feed from (McConkey et al., 2004). What can be inferred from this study is another link between wild species use and hazards: that changes in the climate and the frequency and intensity of hydrometeorological hazards will have negative impacts on agriculture, aquaculture and other livelihood activities, which would then lead to communities increasing other activities to obtain food, most notably by hunting, fishing, and gathering wild species. But the evidence on this is inconclusive.

4.2.1.2.5 Logging

The evidence of the link between climate change and logging is established but incomplete. Although agricultural land encroachment and unsustainable forest management practices are the biggest threats to forests and their biodiversity, forests are impacted by changes in the climate and thus, how products are harvested from them. Models predict a decline in commercially important trees in the taiga (Bu et al., 2008; Ma et al., 2019; Steenberg et al., 2013), while the opposite is predicted in warmer parts of the world (increased southern species in Northeastern China increase in some temperate and pioneer species in the Canadian Maritimes (Steenberg et al., 2013); increased forest productivity in the Pacific Northwest (Creutzburg et al., 2017); higher profits from forestry predicted in Lithuania (Mozgeris et al., 2019), while estimates from models in other studies are more ambiguous (De Cauwer et al., 2014; Halofsky et al., 2014).

Natural disturbances have shaped the development of structure and function of forest ecosystems (Attiwill, 1994b)). The link between hydrometeorological hazards and logging is well-established. Wildfires, floods and droughts are hazards most likely to impact the sustainable use of wild species on both land and in water. There is sufficient evidence on how wildfires in particular define the supply of trees and non-timber forest products, thus impacting their use. Fire has been used as a forest management tool in many parts of the world to maintain, for example, a balance between vegetation in desert grasslands and stimulate herbs and seeds production (Bock & Block, 2005), impact tree distributions (Halofsky et al., 2014) and species composition (Attiwill, 1994a) and rehabilitate forest diversity (Kelly, 2017; Vanha-Majamaa et al., 2007). Regular fire regimes that are a natural part of the lifecycle of some forests have positive impacts on the use of wild species in forests. For example, they can increase essential oil content of lemongrass (Darabant et al., 2016), maintain or increase abundance of morel mushrooms (Larson et al., 2016), sustain large hardwood trees (Long et al., 2018), contribute to the natural regeneration of forests rich in brazil nut (Porcher et al., 2018), and support the regeneration of eucalyptus forests (Attiwill, 1994a; Burton et al., 2019). However, evidence is well-established that altered or intensified disturbance regimes, most notably fire but also floods and droughts—which are expected to increase in intensity and frequency with climate change—will have negative impacts on forests and their products, and thus, how they are used. Frequent and severe wildfires will be devastating for particular vegetation types, causing land degradation, loss of habitats, deforestation, and the proliferation of alien invasive plant species. Frequent wildfires, especially during prolonged dry conditions, may disturb forest and savanna ecosystems (Kganyago & Shikwambana, 2019). Examples of negative impacts of changes in disturbance regimes on the use of wild species include a record-breaking flood in the Amazon that killed Brazil nut trees (Harraiz et al. 2017), while an extreme drought in the Amazon in 2010 decreased biomass and timber volumes (Vidal et al., 2016). A model predicts that the increased frequency of fires in India's Western Ghats will decrease the recruitment of a traditional medicinal plant (Varghese et al., 2015). These will impact how these forest products are used; a model for timber production in the Brazilian Amazon shows that fire losses can reach up to 183 United States Dollars +/- 30 ha/year in areas hit by recurrent fires that would be harvested between 2012 and 2041 (de Oliveira et al., 2019), while another estimates the vulnerability of timber supply in Canadian forest management areas to increase in some regions (Gauthier et al., 2015). Another model estimated timber supply could be reduced by up to 79%

due to climate change and fire in the eastern Canadian boreal forest, using the most extreme projected climate scenario, (Dhital et al., 2015).

On the other hand, there is established but incomplete evidence that climate change and hydrometeorological hazards have contributed to the sustainable use of forests and their products. Efforts to mitigate climate change have focused on forests in the global North through sustainable forest management, while in the global South, this has taken the form of Reducing Emissions from Deforestation and Forest Degradation (REDD/REDD+) projects. These have contributed to the sustainable use of wild species. Positive impacts of Reducing Emissions from Deforestation and Forest Degradation (REDD/REDD+) include minimizing human-wild species conflicts (Entenmann et al., 2014), biodiversity conservation and livelihoods opportunities. However, there have been concerns raised about the rights and forest-access by indigenous peoples and local communities (see also Chapter 2 of this assessment). Further, in recognition of the important role forests can play to reduce impacts of hazards such as storms, floods, and landslides, as well as impacts of climate change in coastal areas such as sea-level rise and coastal erosion (Ghosh et al., 2016; Hiwasaki et al., 2015), efforts to preserve forests have been implemented, for example, the Natural Forest Conservation Project in China, which put in place measures to ban commercial logging in some forests (Zhu et al., 2018).

4.2.1.2.6 Non-extractive uses

There is an increasing amount of work that explores the impacts that climate change and hydrometeorological hazards will have on tourism, especially nature-based tourism (Amelung et al., 2007; Becken & Hay, 2007; Hall & Higham, 2005; Hamilton et al., 2005; D. Scott et al., 2012). The implications for the use of wild species from wild species tourism are established but incomplete, with emerging evidence of negative impacts of climate change on Wild species tourism among pastoralists in Africa (Barnes et al., 2012; Bedelian & Ogutu, 2017).

4.2.1.2.7 Mediating factors

Climate change is a driver that is increasingly exacerbating the impact of other stressors on nature and human well-being (IPBES, 2019a). The difficulty of isolating the impacts of climate change on species with those of other stressors is well established in the literature. In the case of fishing, other stressors include overfishing, invasive species, habitat degradation and loss, pollution and eutrophication, and shipping (Cardinale et al., 2008; Collingsworth et al., 2017; Diop & Scheren, 2016; Halpern et al., 2019; Jacobson et al., 2017; McGreavy et al., 2018; R. I. Perry et al., 2010; Pratchett et al., 2011; Ustin et al., 2015). Studies in the Atlantic (Mullon et al., 2016) and in California (Aguilera et al., 2015) predict that governance, trade and market decisions will have a bigger impact on sustainable use of marine species than climate change. Another scenario predicts that the sustainable use of small pelagic fish depends more on how people respond to climate change rather than the climate change itself (Le Bris et al., 2018; Merino et al., 2010; Niiranen et al., 2013). What emerges from the existing literature is that climate change will interact with other environmental, socio-cultural, political, and economic drivers to negatively impact the marine, freshwater, and forest ecosystems, which in turn affect how humans use wild species. Climate change needs to be considered together with other

multiple and interacting drivers of sustainable use, with possibilities resulting in “non-linear abrupt change” (S. H. Schneider, 2004), so-called “tipping points.”

The negative impacts of climate change and hydrometeorological hazards on the sustainable use of wild species will have more severe implications for countries in the global South. Increased intensity and frequency of extreme climate and weather events from global warming will disproportionately affect vulnerable and poor people, especially in Africa and Asia (Hoegh-Guldberg et al., 2018). In particular, Small Island Development States are expected to be particularly at risk from impacts of multiple hazards, which can compound the effects each other. Small Island Development States and populations in the global South have limited capacities to adapt, thus making the impacts from climate change and related hazards more serious (Hoegh-Guldberg et al., 2018). This will have severe implications for the case for fishing, for which there are not many studies being done, and thus insufficient data, for countries in the global South (Comte & Pendleton, 2018). Many fisheries-dependent tropical regions are more at risk of climate change impacts (Cheung et al., 2018; Lam et al., 2016; Perry et al., 2010; Reygondeau, 2019) and have experienced significant declines in fish stocks since the 1990s (Golden et al., 2016), with the most significant projected decrease in catch potential and revenue decrease in the world (Lam et al., 2016). Thus, food security is expected to be an issue in countries in the global South due to the impacts of climate change on fisheries (Ficke et al., 2007; White et al., 2018). Similarly, it is well-established that communities that rely on fishing for their livelihoods would suffer more from the impacts of climate change, such as smaller fishing communities (Frusher et al., 2016; Tull et al., 2016) and traditional fisheries (Vivekanandan et al., 2016). This is also the case for low-income food-deficit countries, which heavily depend on fisheries for their national (Lam et al., 2016). The increasing vulnerability of coastal fishing communities, especially in the South global point to a need for adaptation planning to mitigate the impacts of climate change and related hazards on unsustainable use of wild species. Multi-level coordination across stakeholders on conserving fisheries and associated species and ecosystems would need to include interventions on land as well as in the ocean and freshwater water bodies, using, for example, ecosystem-based approaches (IPBES, 2019a).

Furthermore, it is necessary to consider how climate change impacts indigenous peoples, who usually live in areas that are more exposed to impacts of climate change and associated hazards, and thus, are experiencing profound, negative effects on their cultures, health, well-being, livelihoods, rights and ultimately, their survival (Galloway McLean et al., 2009). While the well-established evidence of indigenous communities using their traditional ecological knowledge to adapt how they harvest wild species as the climate changes (Berkes & Jolly, 2002; Berman & Kofinas, 2004; Sabo, 1991) or how they could adapt (Gautam et al., 2013), impacts of climate change—along with other endogenous and exogenous factors—on how wild species can be used will have serious repercussions, especially for indigenous peoples and local communities who rely on these species for their nutritional needs, as well as for social and economic well-being, health, and cultural survival (Nuttall, 2005). Further, there is established but incomplete evidence that indigenous and local knowledge can play a role in mitigating the negative impacts of unsustainable use of wild species exacerbated by climate change (Schmitt et al., 2013), thus underlining the importance of co-management of areas with local

communities and integrating local and indigenous knowledge to develop strategies to build resilience.

4.2.1.3. Land/ecosystem degradation

According to the IPBES assessment, “Land degradation” is defined as the human-caused processes that drive the decline or loss in biodiversity, ecosystem functions or ecosystem services in any terrestrial and associated aquatic ecosystems (IPBES, 2018b). Specifically, land degradation is the reduction or loss of biological or economic productivity and complexity (including soil erosion, deterioration in physical, chemical, biological or economic properties of soils and long-term loss of vegetation) of cropland, rangeland, pastureland, forest and woodlands in arid, semi-arid and dry sub-humid areas, that results from land uses or from a combination of processes, including those arising from human activities and habitation patterns (IPBES, 2018b). Land degradation is occurring in all land cover, land use and landscape types in all countries.

Although a national-level framework for assessing and reversing ecosystem degradation to support the national implementation of Aichi Biodiversity Target 15 and European Union Biodiversity Strategy Target 2 is available (Kotiaho et al., 2016), unfortunately, assessing ecosystem degradation and recovery at the global scale is not feasible (IPBES, 2018b). To assess anthropogenic ecosystem degradation, the reference condition of the pre-degradation state, also known as its natural state, is necessary. Still, it is a challenge to determine the natural state for an ecosystem because humans have been influencing the system for such a long time.

Multiple drivers including land use change, agricultural intensification, pollution, and invasive alien species drive land degradation (IPBES, 2018b). For instance, the damage cost of environmental degradation in the Middle East and North Africa is estimated at 9 billion United States Dollars per year, with a mean estimate of 5.7% of gross domestic product (Hussein, 2008). Land degradation in Syria due to high soil salinity resulted in a 37% decline in cotton and wheat yields (the main irrigated crops), representing the total annual loss in agricultural productivity at around 80 million United States Dollars. The wild meat hunting for food and medicinal products is driving a global crisis whereby 301 terrestrial mammal species are threatened with extinction, exacerbated by threats such as deforestation, agricultural expansion, human encroachment and competition with livestock (Ripple, Chapron, et al., 2016). Degradation of habitat negatively impacts the faunal community as a whole in Southeast Asia (Tilker et al., 2019), resulting in decreased community hunting practices. Further, spatially explicit models at the global scale revealed that 121–219 species in Borneo, the central Amazon and the Congo Basin will become threatened under current rates of forest loss over the following 30 years (Betts et al., 2017). In marine systems, coral habitat degradation due to anthropogenic pressures can have varying effects on reef fisheries. For instance, habitat degradation and plastic pollution compounds the impact of fishing on coral reefs as increased fishing reduces large-bodied target species, while habitat loss results in fewer small-bodied juveniles and prey that replenish stocks and provide dietary resources for predatory target species (Wilson et al., 2010).

Drylands worldwide are undergoing rapid land degradation and shifts in vegetation composition in response to climate change and anthropogenic disturbances. Accelerated hydrological–aeolian erosion processes and rapid vegetation shifts are important drivers of land

degradation. Soil erosion is a major concern for the environment and natural resources leading to the reduction in field productivity and soil quality, resulting in land degradation. The erosion reduces biomass and productivity by diminishing soil organic matter and quality, which ultimately influences the diversity of plants, animals, and microbes in an entire ecosystem. It is estimated that each year about 10 million ha of cropland worldwide is lost due to soil erosion, thus reducing the cropland available for food production (Pimentel, 2006). However, the rate of erosion differs across the continents. For example, soil erosion has little impact on crop productivity in Europe (Bakker et al., 2007), while losses associated with erosion are highest in agroecosystems of Asia, Africa, and South America (30-40 tons per hectare every year; Taddese, 2001).

4.2.1.4 Invasive alien species

Invasive alien species are plants, animals, pathogens and other organisms that are non-native to an ecosystem and which may cause economic or environmental harm or adversely affect human health (<https://www.cbd.int/ldb/2009/about/what/>). They can impact on the sustainable use of wild species, both positively and negatively, by altering the abundance of the wild species, by providing a substitute to the species that have historically been used by indigenous peoples and local communities, and by impacting alternative resources such as when crops or livestock are negatively affected by invasive species.

Invasive alien species are key drivers of human-caused global environmental change (Vitousek et al., 1997). The number of invasive alien species belonging to the different taxonomic groups except for microorganisms and many invertebrates is relatively well known. Almost 4% of the global plants (~14000 plant species) have become naturalized in ecosystems other than their native ones (Pyšek et al., 2020; Van Kleunen et al., 2015). Of the 1,517 recorded invasive alien species, 39% were introduced intentionally and 26% unintentionally, 22% both intentionally and unintentionally, while 13% had no information available (Turbelin et al., 2017). About 0.5% and 0.7% of the world's tree and shrub species (622 species) are currently invasive outside their natural range. Still, woody plant invasions are rapidly increasing worldwide (Richardson & Rejmánek, 2011). Alien insect species outnumber attacks of all other animal taxa; North America alone has 3,200 species of non-native insects (Liebhold et al., 2018; Pyšek et al., 2020). At least 175 species of gastropods have become established across 56 countries (Capinha et al., 2015), and 745 alien species of freshwater fish species have led to established alien populations (Tedesco et al., 2017). At least 78 species of alien amphibians and 198 species of alien reptiles were established outside their native range (Capinha et al., 2017). Likewise, 3,661 alien bird introduction records were reported, of which 37% of these species have become established (Dyer et al., 2017). The cumulative number of alien species richness across six taxonomic groups is given in Figure 4.2.

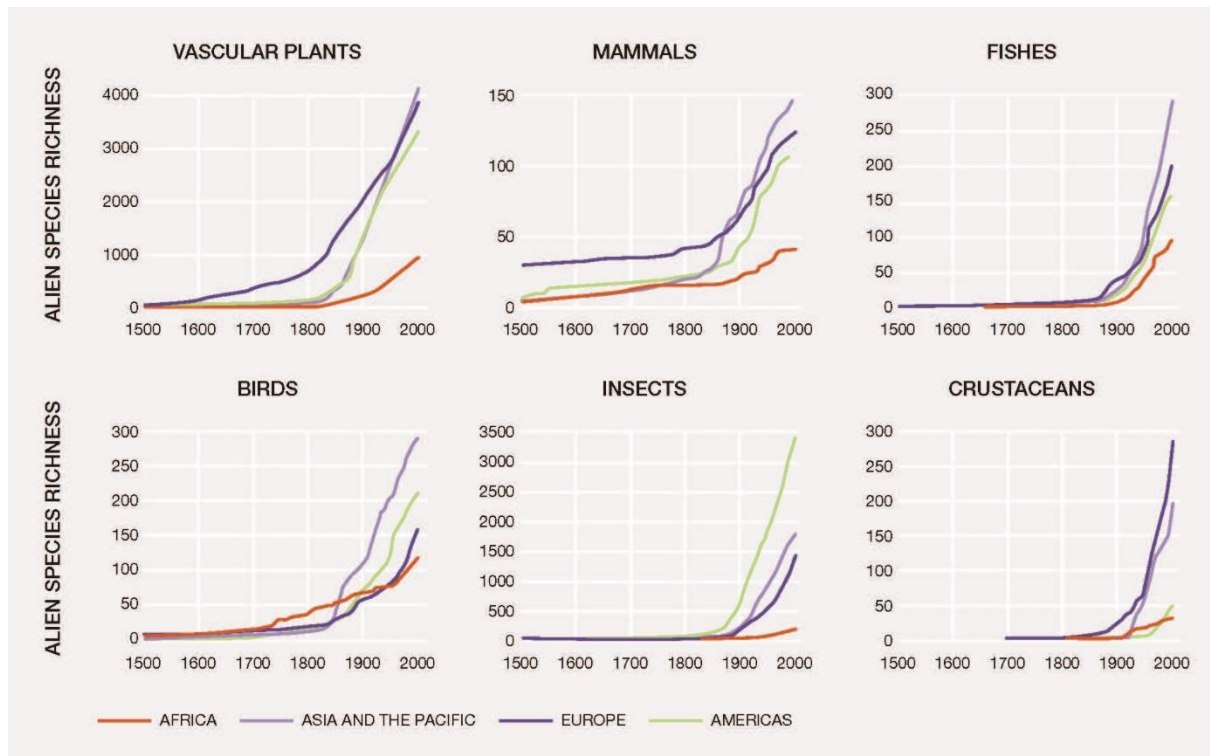


Figure 4.2 Trends in established alien species across six taxonomic groups in four world regions. Source: Pyšek et al. (2020) under license CC BY-4.0.

A wide range of invasive alien species either introduced deliberately (fish farming, pet trade, horticulture, forestry, agriculture, biocontrol) or unintentionally (transportation, travel and scientific research) through human transport and commerce has caused a loss in the global economy, human health, agriculture and overall wellbeing of humans. There are six broad introduction mechanisms of alien species: a) deliberate release (e.g., game animals, sport fishes, pets); b) escape from captivity (e.g., ornamental garden plants, pets); c) contaminants of commodities (e.g., weed seeds, pest insects, microbial pathogens); d) stowaways on transport vectors (e.g., marine organisms fouling ship hulls or in ballast water, latent endophytic pathogens in plants); e) via anthropogenic corridors (such as through the Suez and Panama Canals); or f) unaided spread from other invaded regions (Hulme, 2009). Species escape from Horticulture, forestry and agroforestry and the nursery are the dominant pathway for species invasions accounting for 31% of the species introduced outside their natural geographical range (Turbelin et al., 2017). The recent growth in the trade of exotic pets is another growing threat to species biological invasion (Lockwood et al., 2019). Some of these pet species cause zoonotic diseases, particularly those pets sourced from the wild (Day, 2011).

Invasive species generally have higher performance-related traits characterizing physiology, leaf-area allocation, shoot allocation, growth rate, size, and fitness than non-invasive plant species. These traits promote invasiveness under many different circumstances (Van Kleunen et al., 2010). Invasive species also have greater plasticity in their response to greater resource availability than non-invasive, but this plasticity is only sometimes associated with a fitness benefit (Davidson et al., 2011). Individual plants and animals are also less frequently infected (prevalence minus percent of individuals infected) in introduced compared

to native conspecific populations; and introduced animals and plants may escape 75% or more of the parasite and pathogen species from their native range (Torchin & Mitchell, 2004).

Invasive species may not have equal impacts on the sustainable use of wild species across all environments. Substantial variation in the spatial patterns of invasion was observed; small tropical islands and coastal mainland regions are the main recipients of invasive alien species and hotspots of established alien species richness across multiple taxonomic groups (Dawson et al., 2017; Turbelin et al., 2017). However, the impacts of invasions on nature's contributions to people, ecosystem services and human wellbeing are high in developing countries as those countries have limited options for preventing and managing invasive species (Pyšek et al., 2020). Regions within newly industrialized countries in the Global North, with high population densities and large surface areas support the most established alien species (Pyšek et al., 2020). In the world's islands, where valued species have often evolved without strong competition, herbivory, parasitism or predation, biological invasions cause a loss of biodiversity (Courchamp et al., 2003). Island endemics have limited experience with mammalian predators or herbivores and nowhere to escape (Pyšek et al., 2017). On islands, biological invasion is considered the second greatest agent of species endangerment and extinction after habitat destruction (Pejchar & Mooney, 2009; Wilcove et al., 1998). For example, about half New Zealand's flora comprises alien plants (Hulme, 2020). In freshwater ecosystems, the invasion rates are likely to continue to be high (Strayer, 2010). Marine non-indigenous fishes have increased alarmingly within a short period, causing structural changes and the decline of native species (Arndt et al., 2018). Invasive species also disrupt trophic cascades causing the mismatch of evolutionarily based strategies among predators and prey (Kimbrow et al., 2009).

Invasive alien species have devastating impacts on biodiversity and ecosystem health, causing declines or even extinctions of native species and impairment of nature's contributions to people worldwide (Pejchar & Mooney, 2009; Traveset & Richardson, 2006). An alien invasion is regarded as one of the major drivers of biotic homogenization (Colléony & Schwartz, 2020) and wild species extinction (Bellard et al., 2016) mainly through the introduction of novel traits, genes and behaviors by new alien species (McGeoch & Jetz, 2019). Bellard et al. (2016) reported that 1372 vertebrates are threatened by more than 200 invasive alien species, mainly in the Americas, India, Indonesia, Australia and New Zealand. Invasive species proliferation in primate habitats cause habitat loss and population declines, and extirpation of primate species, in addition to hunting for meat and culturally valued body parts (Estrada et al., 2018). Based on a recent analysis of data on global extinction in the International Union for Conservation of Nature Red List database (IUCN, 2017), invasive alien species contributed to the extinction of 261 (39%) out of 782 species of terrestrial and freshwater animal and 39 (25%) species of total 153 plant species worldwide (Blackburn et al., 2019). Invasive species negatively affect native species richness, abundance, fitness, and productivity (Cameron et al., 2016; Pyšek et al., 2012) and hinder ecosystem functioning such as regime shifts (Gaertner et al., 2014) and provision of ecosystem services (Castro-Díez et al., 2019). Other notable impacts of invasive alien species are eutrophication, expansion of natural fire regime, increased soil erosion, hydrological control, and alteration of soil stability (Rai & Singh, 2020).

The impacts of invasive alien species on local livelihoods are negative and positive. Some of the negative impacts of invasive alien species on local livelihoods include a decreased

supply of natural resources, particularly non-timber forest products, due to the loss of biodiversity and change in abundance of species, reduced agricultural production (livestock and crops and fisheries), harm to human health and safety, and reduce the cultural value of landscapes resulting in reduced resilience and adaptive capacity of households and communities along with loss of incomes (financial capital) and increased labor times (Shackleton et al., 2019). For example, people abandoned farming (Zavaleta 2000) or fishing (Cho & Tifuh, 2012; J. Travis, 1993) and emigrated from their areas due to the adverse effects of invasive species. A global analysis of the threat to crop production by almost 1300 known invasive insect pests and pathogens on a country-by-country basis for 124 countries revealed significant variations in countries regarding the potential threat from invasive species (Paini et al., 2016). Introduced species have positive impacts on the economy and livelihoods. For example, introduced species act as hosts, food sources, pollinators and seed dispersers for native species and provide herbivory predatory or parasite release (Goodenough, 2010). Invasive species provide the provision of fuelwood, fodder, food products, timber and medicinal products, as well as other livelihood benefits such as soil improvement through green manure and nitrogen fixation, live fencing, and cultural services, such as recreation and aesthetic values. (Shackleton et al., 2019)

Introduced species may also positively impact ecosystems, agriculture and food security. For example, an invasive tree in Florida (*Melaleuca quinquenervia*) has increased honey production that is worth 15 million United States Dollars per year (Serbesoff-King, 2003). The introduction of brush-tailed possums (*Trichosurus vulpecula*) to New Zealand was considered profitable for the ‘eco-friendly’ industry (at least 20 million United States Dollars per year), although it has resulted in massive defoliation and negative impacts on the biodiversity (Clout & Barlow, 1982; Forsyth et al., 2018). Indigenous Māori people of New Zealand also use fur and skins of brush-tailed possums for economic benefit. Still, the most economically-sustainable possum fur harvest strategy is unlikely to achieve even modest conservation outcomes (C. Jones et al., 2012) and a program to eradicate possum has started (Owens, 2017). Locals in Nepal used several species of invasive alien plants to produce compost, charcoal, bio-briquette, and forage for livestock and medicinal purposes (Shrestha et al., 2019). Overall, positive impacts of invasive alien species include provisioning services (fuelwood, fodder, timber and food products) and regulating services (soil improvement and shade). Cultural services (recreation and spiritual values) (Shackleton et al., 2019) For example, there are examples of small initiatives to make use of an invasive like *Lantana camara* as a substitute for rattan in making furniture in Male Mahadeshwara Hills, Karnataka (Kannan et al., 2016). However, the number of species causing negative impacts is double (37%) the number of beneficial species (16%) (Shackleton et al., 2019).

Some invasive species (e.g., green crab in Canada, Chinese mitten crab in China) have become a source of meat, common food and an omega-6 fatty acid. They can enhance the fishing industry's value chain and improve profitability while addressing waste management issues and environmental sustainability (Dave & Routray, 2018). Many other species, such as wild pigs (*Sus scrofa*), are considered the desired species for hunting (Engeman et al., 2013). Hunting invasive or introduced mammals, pigs, and monkeys may benefit native fauna and flora (Carvalho et al., 2015). In the ranches of Mexico, exotic species were introduced to provide year-round hunting opportunities for tourists (Barthel & Schuett, 2014).

Biological invasions and wild species disease are inextricably linked. Biological invasions can spread new diseases to wild species and humans. Biological invasions lead to novel parasite-host interactions and transmission opportunities, potentially affecting humans, wild species, ecosystem health and resilience (Pyšek & Richardson, 2010). Several potential zoonoses have originated from biological invasions in Europe and potentially elsewhere (Hulme, 2014). Zoonotic pathogens and parasites transmitted from animals to humans are a significant public health risk, and three-quarters of emerging human pathogens are zoonotic (White & Razgour, 2020). Invasive species directly affect human health; several species of invasive alien plants cause allergies, phytotoxicity, disease, eczematous dermatitis and asthma in humans (Rai & Singh, 2020). On the other hand, invasive species act as a vector for transmitting several diseases. Several human diseases and their sudden outbreak across continents are linked to biological invasions (Pyšek & Richardson, 2010; Rai & Singh, 2020). For example, an invasive mosquito called the Asian tiger mosquito (*Aedes albopictus*), spread through the transportation of eggs via the international trade of used tiger, is a vector for transmission of many viruses, including dengue, LaCrosse, Yellow fever, chikungunya and West Nile (Benedict et al., 2007). Some invasive species affect human health through environmental contamination, such as air pollutants (Jones et al., 2018). Invasive species also cause disease to native animal species. For example, the worldwide amphibian decline is driven by the emerging infectious diseases chytridiomycosis caused by *Batrachochytrium dendrobatidis*, an invasive fungus (Crawford et al., 2010). Invasive species also increase the outbreak of fungal pathogens, which adversely affect the health of native plants (Beckstead et al., 2010). For example, the amphibian pet trade is linked with the global spread of chytrid fungus (*Batrachochyrtium dendrobatidis*), which has led to a significant decline of amphibians (Alroy, 2015; Auliya, Altherr, et al., 2016; Thumsová et al., 2021). However, a few positive health impacts of invasive species are reported. For instance, extracts from *Lantana camara* are used as a mosquito repellent (Mng'ong'o et al., 2011). Additionally, ethnobotanical surveys on invasive alien plant species can provide benefits (e.g., *Lantana camara*, *Opuntia ficus-indica* and *Ricinus communis*) (Rahmatullah et al., 2010). Hunting and biological invasion are interconnected with each other. Removing invasive species affects hunting practices.

Hunting has been a significant pathway for introducing invasive species into Europe in the last century. About 24.3% of the mammals (36 species) and 30.2% of the birds (63 species) introduced into Europe in the previous century were released primarily for hunting purposes (Carpio et al., 2017). Likewise, around 30% of species of invasive introduced mammals in southern South America were introduced for hunting (Ballari et al., 2016). However, introduced game species have various negative impacts on the local ecosystems, such as predation (Barrios-Garcia & Ballari, 2012), competition with native wild species (Bartos et al., 2002; Bertolino & Lurz, 2013; Kumschick et al., 2011), diseases and their related consequences (Králová-Hromadová et al., 2011), hybridization (Baker et al., 2014; Barbanera et al., 2010), and habitat alteration (Kumschick et al., 2011). In some places of the world, vehicle-mounted and aerial or ground-based hunting has been used to cull or reduce populations of invasive animals (Barron, 2011; Bengsen & Sparkes, 2016; Capizzi, 2020; McLeod & Saunders, 2011). In some cases, the ground-based culling efforts have controlled overabundant mammal population and bird populations, such as the white-headed duck in UK and France (Henderson, 2009). In New Zealand, hunting is a primary strategy to control introduced wild deer (Latham et al., 2018).

Globally, the introduction and spread of marine non-indigenous fish species are facilitated by several anthropogenic factors such as building canals, shipping, intentionally introduced for fishery purposes, and aquarium trade (Arndt et al., 2018). In a freshwater environment, the introduction of non-native freshwater fishes for economic purposes, including aquaculture and aquarium trade, as well as improvement for wild stocks (Wei et al., 2019). About 23.6% of the freshwater fish introduced into Europe during the last century were released primarily for angling purposes. This suggests that angling was a significant pathway for introducing invasive fish species into Europe (Carpio et al., 2019). In some islands like Puerto Rico, around 80% (46 species) of fish in the inland waters are non-native and are imported for sport fishing and pet trade (Rodríguez-Barreras et al., 2020).

Introducing non-native freshwater fishes has adverse environmental and socio-economic effects (Wei et al., 2019). Invasive aquatic species eliminate native amphipod species in freshwater habitats in Europe and North America (Dick & Platvoet, 2000). The spread of invasive species also introduces novel pathogens to new areas (Bacela-Spychalska et al., 2013). Alien invasive species are the second most prevalent threat after habitat loss and degradation for freshwater fisheries in Canada, affecting 26 of 41 listed fish species and 6 of 11 listed mollusc species (Dextrase & Mandrak, 2006). In some regions, the harvest of invasive species provides economic benefits (Pienkowski et al., 2015), while in other areas, invasive species are a problem (e.g., commercial fishing in the United States of America) (Dudgeon et al., 2006). Despite the beneficial effects of angling by introduced fish, making angling sustainable, it hurts native fish species (Carpio et al., 2019). *Micropterus salmoides*, typically introduced for sport fishing purposes worldwide, is now listed by the International Union for Conservation of Nature as one of the 100 of the world's worst invasive alien species (Pereira et al., 2010). This species causes negative impacts on the local population, such as local extirpation of native species and food web changes (Pereira et al., 2010).

Invasive species in the marine environment may cause an alteration of benthic habitat structure, leading to the disruption of food webs, changes in nutrient cycles and energy transfer, or changes in the community structure, population decline and local replacement of native species through competition and predation and transmission of disease and potential hosts of parasites to native fishes (Arndt et al., 2018). Negative impacts of invasive species in aquatic ecosystems range from an abundance of marine communities, particularly macrophytes, zooplankton and fish (Gallardo et al., 2016).

Aquaculture also has negative impacts such as elevated input of nutrients and organic matter in habitat and water quality, the spread of diseases, biotic homogenization, loss of population viability resulting from hybridization and outbreeding depression, and the local extirpation of native species (Lima et al., 2018) and the conversion of natural infrastructure such as coastal wetlands into (fish, shrimp, etc.) farm (Hoanh et al., 2006). Additionally, an increase in water turbidity, nitrogen and organic matter concentration due to invasive species is consistent across the habitats and scales. However, there is little evidence of a decline in species diversity in invaded habitats (Gallardo et al., 2016). Salmon farming in Chile has faced several challenges such as sanitary crisis, social conflicts, market problems, lack of good governance (Chavez et al. 2019) along with ecological and environmental issues including eutrophication, adverse effect of pesticides on non-target species (Gerhart, 2017; Quiñones et al., 2019) and disease outbreak (Mardones et al., 2018). The knowledge of the ecological impact of invasive

marine fishes is still rudimentary globally despite the extensive literature on identifying new records, geographic spread, and pathways (Arndt et al., 2018). This might be why biological invasions are being widely disregarded when planning for conservation in the marine environment across local to global scales (Giakoumi et al., 2016).

4.2.1.5 Land and seascape change

This section will provide an overview of significant changes in landscape/seascape. It will start with a summary of where (urban, forest, agricultural and rangelands) changes have been occurring and how these have affected biodiversity and sustainable use of wild species.

4.2.1.5.1 Change in urban areas and impacts on biodiversity and sustainable use

Although urban areas cover less than 3% of the earth's surface, urbanization is a significant driver of global environmental change such as climate change, pollution, alteration of both abiotic and biotic ecosystem properties within, surrounding, and even at a great distance from urban areas (Grimm et al., 2008). Globally, the urban areas are expanding at twice the rate of their population (Seto et al., 2012). The urban population has increased from ~200 million in 1900 to about 4 billion in 2014 and is expected to reach 5 billion in 2030 (United Nations, 2014). Currently, more than two-thirds (75%) of the population of high-income countries live in urban areas. Still, the rapid growth of the urban population is observed in the low-income and lower-middle-income countries (IPBES, 2019a).

Residential development is a leading driver of land use change, with important implications for biodiversity, ecosystem processes, and human well-being (Pejchar et al., 2015). Urban land expansion modifies habitats causing biodiversity loss, alters biomass, natural processes, biogeochemistry, hydrology, land cover and surface energy balance, carbon storage, and causes climate change and pollution (d'Amour et al., 2017; Seto et al., 2012). Light pollution in urban areas also has behavioral and ecological effects on wildlife (Schirmer et al., 2019). Urbanization affects primary production in terrestrial and aquatic ecosystems by replacing and fragmenting natural areas with impervious cover, increasing nutrient supply, changing hydrological regimes, and altering the composition (decreasing the abundance of apex predators) and seasonality of primary producers (El-Sabaawi, 2018). Urbanization has both lethal (e.g., vehicle collisions and bird strikes) and sub-lethal effects (physiological and behavioral changes) on animals (Birnie-Gauvin et al., 2016). Increasing urban sprawl has contributed to the extensive fragmentation and reduction of natural habitats worldwide (Gelmi-Candusso & Hämäläinen, 2019). Urbanization has various adverse effects on ecosystem functioning, including the disruption of plant dispersal processes that animals mediate across the landscape (Gelmi-Candusso & Hämäläinen, 2019). The density and extent of housing are strong predictors of the decline of native species of birds (Lepczyk et al., 2008). Likewise, urbanization is cited as a potential contributor to amphibian population declines (Riley et al., 2005; Scheffers et al., 2012). Urbanization influences species traits and micro-evolutionary changes in many species of mammals, birds, fishes, and insects (Alberti et al., 2017). In

response to urbanization, some plant traits (e.g., woodiness, seed mass, and height) tended to increase (Williams, Hahs, and Vesk 2015).

Urban sprawl is expanding into marine environments with the construction of artificial structures. In Europe, the United States, Australia, and Asia, more than 50% of the shoreline is now modified by hard engineering, including groins and breakwaters, to protect against erosion and wave action (Dafforn et al., 2015). Urbanization, mainly coastal urbanization, increased pressure on the surf zones of ocean beaches that provide habitat for a diversity of fishes and are prime sites for recreational angling and commercial net fisheries (Olds et al., 2018). Coastal development, including buildings construction, also poses risks to marine turtles coming to beaches to lay eggs (e.g., Rushikulia and Gaharmatha in Odisha/Orissa where Olive Ridleys lay eggs). In an aquatic ecosystem, urban point sources of nutrients are the leading cause of hypoxia (decline in oxygen supply), resulting in adverse impacts on species' physiology, life history, survival, reproduction, growth of aquatic invertebrates (Galic et al., 2018; Jenny et al., 2016).

In recent years, sustainable urbanization, the concept of nature-based solutions and urban nature have been increasing as urban landscapes constitute the future environment for most of the world's human population. Urban forests are dynamic systems of trees, shrubs, green space, soil, and water, which provide many functions, services and benefits needed for the sustainable development of urban areas (Solomou et al., 2019). Urban nature has the potential to improve air and water quality, mitigate flooding, enhance physical and mental health and promote social and cultural well-being (Keeler et al., 2019). Urban greenery plays a significant role in reducing energy use for both heating and cooling (Ko, 2018). Urban green and blue spaces promote health by offering areas for physical activity, stress relief and social interaction (Kabisch et al., 2017). Green roofs in urban areas also deliver selected nature's contributions to people, such as the removal of pollution and reduced annual energy consumption (Francis & Jensen, 2017). Urban trees and grassland also provide habitats for different species of animals, including birds, bees, butterflies and hoverflies (Dylewski et al., 2019; Y. Han et al., 2019).

Overall, urban trees provide nature's contributions to people, including carbon sequestration, air quality improvement, storm water attenuation, food production, microclimate control, soil infiltration, visual quality, recreation, social capital, and energy conservation (Kabisch et al., 2017; Lovell & Taylor, 2013; Roy et al., 2012). However, little is known about how these trends affect the sustainable use of wild species.

More recently, rooftop gardens have become an essential part of urban agriculture. Urban rooftop agriculture can improve various nature's contributions to people, enrich urban biodiversity and reduce food insecurity (Walters & Stoelzle Midden, 2018). Urban and peri-urban agriculture contribute to 10 key societal challenges of urbanization: climate change, food security, biodiversity and nature's contributions to people ecosystem services, agricultural intensification, resource efficiency, urban renewal and regeneration, land management, public health, social cohesion, and economic growth (Artmann & Sartison, 2018). Urban agriculture impacts food security, nutrition, physical and mental health, and social capital (Audate et al., 2019).

Although urban development in developing counties is seemingly chaotic with high levels of poverty, there are opportunities to realize urban green infrastructure in those areas (Lindley et al., 2018).

Urban development (population growth, in-migration) also leads to decongestion and depopulation of rural areas that may have a beneficial impact on biodiversity, ecosystem services and populations of certain wild species in the rural areas. In and around urban areas, human-wild species conflict is responsible for billions of dollars of damage and costs associated with mitigation and prevention (Conover, 2001). Urban environments are a notorious source of mortality of Wild species, including roads, collisions with buildings, depredation and disease (Forman & Alexander, 1998; Loss et al., 2014; Nyhus, 2016).

4.2.1.5.2 Infrastructure development (dams and roads construction)

Humans have been modifying rivers for thousands of years for flood regulation, water supply, transportation, irrigation and, more recently, for settlements and industries, recreation, and hydropower generation (Ripl, 2003). Globally the number of dam constructions has increased dramatically over the past six decades to meet the energy demands and flood control. Dams have altered flows (fragmentation, flow regulation or both) of 48% of the rivers at various degrees worldwide (Grill et al., 2015). Only 37% of rivers over 1,000 kilometers remain free-flowing over their entire length, and 23% flow uninterrupted to the ocean (Grill et al., 2019). Currently, about 50,000 large dams (higher than 15 m) and an estimated 16.7 million reservoirs (larger than 0.01 ha) hold approximately 8,070 km³ of water (Lehner et al., 2011). Dam building substantially impacts riverine ecosystems and freshwater biodiversity, causing population loss (Dynesius & Nilsson, 1994). Dams have substantially modified ecosystems causing extirpation of fish migration (Liu et al., 2019), loss of native fish species, increases in non-native fish (Loures & Pompeu, 2019) and decreases in the diversity of benthic macroinvertebrate (Linares et al., 2019). The Himalayan region particularly in China and India, has approximately 55% of the world's larger dams and is considered as the region with the highest dam density in the world (Grumbine & Pandit, 2013; Pandit & Grumbine, 2012; WCD., 2000). The proposed dam locations in the Indian Himalayas are in areas of high species richness for angiosperms, birds, fishes, and butterflies (Grumbine & Pandit, 2013). Models showed that dam building could lead to the loss of 22 angiosperm and seven vertebrate taxa by 2025 due to the submergence and habitat degradation (Pandit & Grumbine, 2012). Dam construction alters the survival, phenology and growth of floodplain vegetation and reduces field yields below the dams (Forsberg et al., 2017). The reported effects of dams on fish and other aquatic mammals include blocking migration routes, habitat fragmentation and, changing from lotic to lentic water in the impounded areas, changes of water flow in downstream reaches (Wu et al., 2019). Although reservoir fish yields will compensate for some downstream losses, an increase in mercury contamination due to dams could offset the benefits (Forsberg et al., 2017).

Roads are the seeds of tropical forest destruction (Laurance, 2012). Rapid road constructions in the tropics affect many species, particularly those susceptible to hunting, roadkill, elevated predation and species invasions near roads. Road building increases forest disturbances and edge effects, facilitates legal and illegal logging and increases hunting pressure on wild species (Laporte et al., 2007).

Linear infrastructure such as roads, fences, walls, railways and pipelines create barriers that prevent species movements (Wingard et al., 2014). Linear infrastructure has caused habitat fragmentation, split populations, changed migration, nomadism and dispersal and altered

behaviors (Mueller & Fagan, 2008; Olson et al., 2011; Wingard et al., 2014). Structures like border fences cause direct mortality of wildlife particularly large carnivores and large herbivores, due to entanglement (Trouwborst et al., 2017). The border wall between US-Mexico reduces the area, quality, and connectivity of plant and animal habitats (H. Peters et al., 2016).

4.2.1.5.3 Change in agricultural land and impacts on biodiversity and sustainable use

Agricultural expansion and intensification has been proliferating across the globe since the 1700s; crops provide food, fibre, and biofuels, as does livestock farming, aquaculture and the cultivation of trees (Dudley & Sasha, 2017; Grassini et al., 2013; Ramankutty et al., 2018). Worldwide, agriculture has already cleared or converted 70% of grassland, 50% of savanna, 45% of the temperate deciduous forest, and 27% of the tropical forest (J. A. Foley et al., 2011). Between 1980 and 2000, more than 55% of new agricultural land came at the expense of intact forests, and another 28% came from disturbed forests across the tropics (Gibbs et al., 2010). The demand for food, feed and other products is expected to increase in the future resulting in 10 billion hectares of natural ecosystems being converted to agriculture by 2050 (Alexandratos & Bruinsma, 2012; Tilman et al., 2001b).

Agriculture as conventionally practiced is one of the greatest environmental drivers of wild species habitat loss, soil erosion, pollution, water stress, sedimentation of waterways, pesticide poisoning of humans and non-target species, and greenhouse-gas emissions (Power, 2010; Tayleur et al., 2017; Tilman et al., 2001a). Agriculture affects biodiversity mainly through converting natural habitats into cropland and pasture, intensifying management in long-established cultural landscapes and releasing pesticides and pollutants, including greenhouse gases (Dudley & Sasha, 2017). Across biomes and taxonomic groups, conversion to farms and ranches results in losses of average reduction of 13.6% of local species richness and 10.7% of species abundance (Newbold et al., 2015). Species losses result from habitat loss and fragmentation, and the use of pesticides, herbicides, fungicides and fertilizers (Brittain & Potts, 2011; Chagnon et al., 2015; Chiron et al., 2014; Geiger et al., 2010; Luzardo et al., 2014; Stevens et al., 2004).

Agriculture is also a major cause of global endangerment of flora and fauna, including pollinators (Alfaro-Shigueto et al., 2005; Green et al., 2005; Norris, 2008) (Figure 4.3). Deforestation caused by agricultural expansion in the tropics has led to population declines in commercially traded wild species (Symes et al., 2018). The sharp decline or extinctions of several species of farmland birds in Europe was attributed to agricultural intensification encouraged by the Common Agricultural Policy (Pain & Pienkowski, 1997).

The combined effect of deforestation and commercial trade of wild species further increases the average losses of species (Symes et al., 2018). Species loss affects productivity (biomass production by plants) and decomposition (mass loss of plant litter) impacts the sustainable use of wild species (Hooper et al., 2012). However, the plant species identity is also important in affecting the decomposition (Vivanco & Austin, 2008).

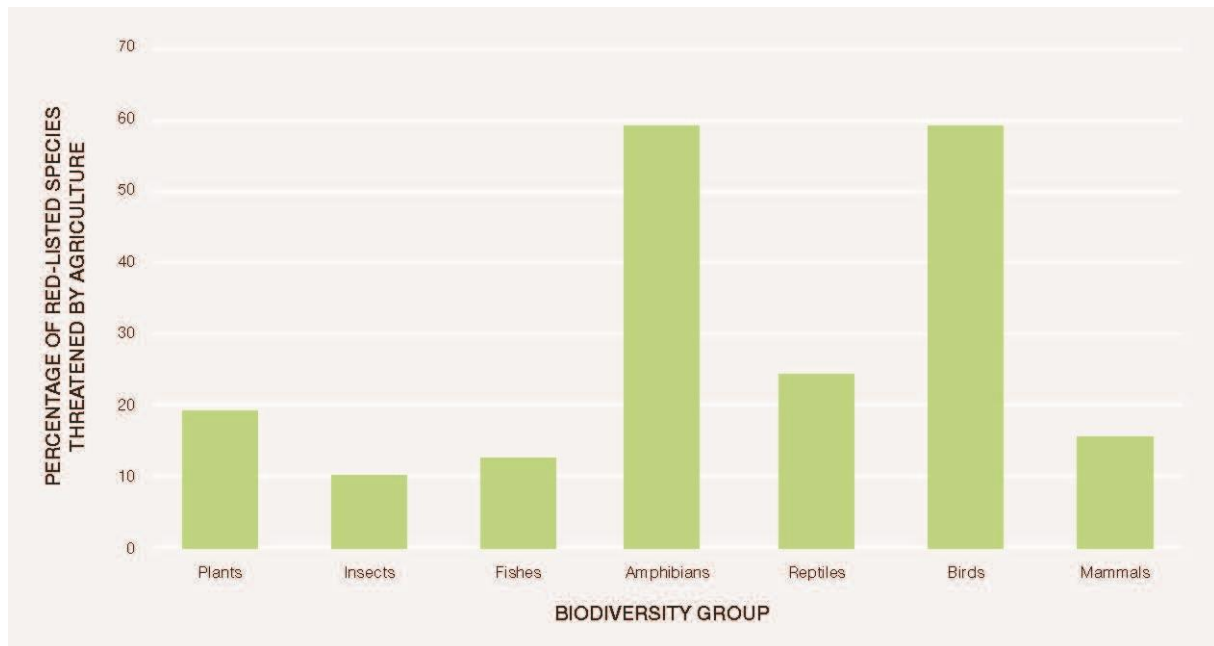


Figure 4.3 IUCN red-listed species threatened by agriculture (CR= Critically Endangered, EN= Endangered, VU= Vulnerable) in a range of biodiversity groups. Data are from the International Union for Conservation of Nature (IUCN) Red List database (<http://www.iucnredlist.org/search/search-basic>). Least concern (LC) species were excluded from the analysis. IUCN threat codes used to assess agricultural threats were 1.1, 6.2.1, 6.3.1, and 6.3.7. Source: Norris, (2008) @ 2008 Blackwell Publishing, Inc. license number 515479115045.

Agricultural expansion, particularly in the tropics, negatively impacts biodiversity and the territories occupied by indigenous people (Laurance et al., 2014; Scariot, 2013). Approximately 11% of the world's forested lands are included within territories occupied by indigenous peoples (Sobrevila, 2008). At least 36% of intact forest landscapes are within indigenous people's lands (Fa et al., 2020). Such peoples, as well as smallholder farmers and traditional peoples, derive life's necessities and monetary income from subsistence farming and hunting, fishing, and harvesting of wild products, including non-timber forest products from those indigenous lands maintaining biodiversity and ecosystem services (Scariot, 2013). Diverse agricultural systems exist (with combinations of short-lived and perennial crops and timber and non-timber products) developed over centuries in rural areas, including by indigenous peoples and local communities (IPBES, 2019a). Some indigenous communities, such as those of Australia, have complex systems of land management (e.g., seasonal and adaptive savanna burning), which ensure plentiful wildlife and plant foods (Gammage, 2011; McKemey et al., 2020).

There has been a call for improved practices and certification to reduce agriculture's social and environmental impacts. The codification of sustainable agricultural standards is growing, albeit worldwide coverage of certification is relatively small (Milder et al., 2015; Tayleur et al., 2017). Certification for sustainable agriculture has reduced inputs of chemical pesticides, fertilizers, and herbicides increased adoption of shade trees and soil conservation practices, and reduced water use and pollution (Blackman & Naranjo, 2012; Ibanez &

Blackman, 2016; Rueda et al., 2015). A project such as Future Resources, Agriculture and Nature Conservation in Germany was initiated to develop and test measures to preserve and increase biodiversity in the agricultural landscape. Positive and potentially indirect effects of certification on biodiversity were reported (Tschamntke et al., 2015). For example, sustainable certification schemes of palm oil significantly reduce deforestation but not fire or peatland clearance (Carlson et al., 2018). Hunting of small game is also increasingly becoming a driver of de-intensification of farming in ways which improve the food chains of the hunted species and many other species, notably pollinators (Brewin et al., 2020; Ewald et al., 2012; Sotherton, 1991). However, some complex trade-offs and unintended consequences of certification were also reported (Tayleur et al., 2017).

Despite being considered inefficient, the market size of organic foods has been growing (Trewavas, 2001) (Willer & Lernoud, 2017). Although being criticized as ideologically driven, organic farming systems produce lower yields than conventional agriculture, they are more profitable and environmentally friendly. They deliver equally or more nutritious foods that contain less (or no) pesticide residues than traditional farming (Regnold & Wachter, 2016). On average organic farming has increased species richness by about 30% (Tuck et al., 2014).

Agroforestry and small-scale farms (<2ha) also play a crucial role in maintaining the genetic diversity of managed species and agrobiodiversity (IPBES, 2018b; Ricciardi et al., 2018). Agroforestry has the potential for providing habitats outside formally protected land, connecting nature reserves and alleviating resource-use pressure on conservation areas (Bhagwat et al., 2008). Agroforestry also enhances functional biodiversity, carbon sequestration, soil fertility, drought resistance, and weed and biological pest control (Tschamntke et al., 2011). However, species selection is essential; agroforestry can promote undesirable species, including invasive species, if proper measures are not implemented (Udawatta et al., 2019). The knowledge of indigenous peoples and local communities, also influences decisions to preserve biodiversity in the agroforestry systems (Vallejo-Ramos et al., 2016).

In summary, there is no direct evidence of how agroforestry affects sustainable and unsustainable use. Although cultivation of medicinal plants is widely considered a means for relieving harvesting pressure on wild populations and can fulfil the demand for plant-based drugs and herbal remedies, a clear analysis of how they may offset pressure on wild species remains still unclear (Chen et al., 2016; Schippmann et al., 2002).

4.2.1.5.4 Change in forest areas and impacts on biodiversity and sustainable use

Forested ecosystems support a significant proportion of terrestrial biodiversity (Pimm et al., 2014). About 25% (40 million km²) of the earth's terrestrial surface is covered by forests, of which as much as 82% is now degraded (MacDicken et al., 2016; Watson et al., 2018). Globally tree cover has increased by 2.24 million km² (7.1% relative to the 1982 level) during the period 1982-2016 as a result of a net loss in the tropics being outweighed by a net gain in the extratropics (Song et al., 2018). The deforestation rates of tropical-dense forests continue to be high (i.e., 74,400 km²/ year) (Hansen et al., 2013). Nevertheless, about 129 million ha of global forest have been lost since 1990 (FAO, 2015). However, the intact forest landscapes, which are critical for stabilizing terrestrial carbon sequestration and storage, harboring biodiversity, water

provision, indigenous culture and the maintenance of human health, shrunk globally by 7.2% from 2000–2013 due to industrial logging, agricultural expansion, fire, and mining/resource extraction (Potapov et al., 2017; Watson et al., 2018). Deforestation substantially increased the odds of a species being listed as threatened, undergoing recent upgrading to a higher threat category and exhibiting declining populations (Betts et al., 2017). Forest or habitat loss also coincides with overhunting, wildfires, selective logging, biological invasions, and other stressors (Barlow et al., 2016; Betts et al., 2017).

These risks were disproportionately high in relatively intact landscapes; even minimal deforestation has severely affected vertebrate biodiversity (Betts et al., 2017). In high-risk hotspots such as Amazon, Borneo and Congo Basin, 121–219 species will become threatened under current rates of forest loss over the next 30 years (Betts et al., 2017). Likewise, there is a positive relationship between the global extinction risk of forest-dependent birds and the global intact forest landscapes. However, only 22.5% of global hotspots of range-rarity for forest-dependent birds are found within intact forests (Donald et al., 2018). Primary forest loss from 2002–2014 has been the highest in rainforest countries of Brazil, the Democratic Republic of the Congo, and Indonesia (Turubanova et al., 2018).

A study predicted substantial declines in suitable habitats for approximately 17000 species out of 19400 species of amphibians, birds and mammals studied due to land-use change alone (Powers & Jetz, 2019). The decline is disproportionately higher in South American, Southeast Asian and African countries (Powers & Jetz, 2019).

Deforestation and forest fragmentation negatively affect the abundance and availability of non-timber forest products and decrease the hunting success rate. Fragmentation has negative impacts on the genetic diversity of birds (Athrey et al., 2012) and fish population (Pavlova et al., 2017) and population fitness, threatening endangered species on land (Athrey et al., 2012). In contrast, in the aquatic ecosystem, alteration of habitat such as dam building is associated with a change in the genetic composition (Thompson et al., 2019). Deforestation restricts the availability of non-timber forest products, which in turn adversely affects local communities (Schmidt et al., 2020). Commercial deforestation negatively affects the rural people who depend on wild animals like a snail, wild meat, wild honey and wild and cultivated vegetables for subsistence (Appiah et al., 2009). A fragmented or declining environmental quality is likely to support lower populations and produce lower yields of some plants, algae and fungi and simultaneously affect what land use and livelihood options might be viable or not. Deforestation is also associated with declining consumption and diversity of nutritious fruits and wild foods (Ickowitz et al., 2013). Indigenous local community reported a decline in hunting success rates and fruit harvests after logging (Araujo Lima Constantino, 2016; Menton et al., 2009). Deforestation causes a reduction in the generation of hunting products, particularly the diversity of bushmeat, which reduces household dietary intake and cash income (Gillet et al., 2016). However, bushmeat hunting is more widespread in fragmented forests (Torres et al., 2018). Infrastructure development makes remote forested areas accessible, exacerbating the hunting and trapping pressure (Barlow et al., 2016). Additionally, hunting practice has evolved to meet urban market demand after urbanization and the opening of the roads (Ickowitz et al., 2013; Torres et al., 2018).

Forest expansion continues to occur in most industrialized countries, on lands abandoned by farming and animal husbandry and areas that continue to mature on land that was

deforested in the past century but have not been converted to a different land use since then (Keenan et al., 2015). Planted forests account for 25-100% of gains and increasingly substitute for natural forests, particularly in Africa, Southeast Asia, and Europe. The global rate of planted-forest expansion since 1990 is close to a target of 2.4% per annum necessary to replace wood supplied from natural forests in the medium term, although the rate has declined to 1.5% since 2005 (Sloan & Sayer, 2015). Although natural forests are usually more suitable as biodiversity habitat for a broader range of native forest species than plantations, plantation forests can provide valuable habitat even for some threatened and endangered species and may contribute to the conservation of biodiversity (Brockerhoff et al., 2008). Nevertheless, large-scale tree plantations also have negative impacts on biodiversity, quality and quantity of water and livelihoods, particularly loss of or restriction to previous livelihoods, and reduced access (Malkamäki et al., 2018). Furthermore, tree plantations, particularly monocultures, displaced native forests (Hua et al., 2018).

4.2.1.5.5 Change in rangelands and impacts on biodiversity and sustainable use

The rangeland condition affects biodiversity directly and indirectly because rangeland comprises high biodiversity values (Harris 2010). Rangelands are the most dominant land cover types on Earth, covering 25-45% of the land surface, depending on how these lands are defined (Reid et al., 2014). Globally, 4,734 mammal species are less endangered in rangelands and wildlands compared to croplands and urban areas (Pekin & Pijanowski, 2012). Grasslands are among the ecosystems with the highest species richness in the world (Wilson et al., 2012). Globally both expansions of rangeland and intensification of rangelands are caused by the increasing demand for livestock production that depends on grazing systems requiring grazing lands (Godde et al., 2018). This has led to unsustainable use, exemplified by deforestation and land degradation. On a global scale, almost half (49%) of grassland ecosystems were degraded and nearly 5% of this grassland experienced strong to extreme levels of degradation (Gang et al., 2014).

The major causes of the rangeland degradation are climate change, overgrazing, land-use change (converting pastureland to cropland), and shrub encroachment (R. B. Harris, 2010; Knapp et al., 2008; Reid et al., 2014; Tiscornia et al., 2019; Walker et al., 2006). Overgrazing occurs when stocking rates exceed the carrying capacity of grassland; this can be particularly in developing countries and lead to rangeland degradation (Bai et al., 2002; Fedrigo et al., 2018; Liu et al., 2013; Yao et al., 2016). In some regions, management of over-grazing stress is allowing for the reestablishment of forest areas (Navarro & Pereira, 2015).- Warming and the increased frequency of prolonged droughts are the major climatic changes that cause rangeland degradation (Gang et al., 2014; Tiscornia et al., 2019). Rangeland degradation reduces various ecosystem services but particularly affect the sustainable use of wild species as it has decreased capacity to provide forage for large herbivores, including domestic livestock (Hoppe et al., 2016; Liu et al., 2013; Paudel et al., 2010; Yao et al., 2016) and lower forage quality (Cao et al., 2013; Li et al., 2008; Pallarés et al., 2005).

Rangeland management systems are diverse, ranging from nomadic pastoral activities in sub-Saharan native savannas to sedentary Dutch dairy farming to industrial-scale farming in

North America and Australia (Godde et al., 2018). Most global rangelands are still common pool resources (except some privately owned in North America and Australia) and are used by indigenous pastoralists/ranchers, agropastoralists, hunters, conservationists, recreationists, and others (Reid et al., 2014). There have been shifts in pastoral land-use practices causing various changes in rangelands themselves, from contraction, loss, and fragmentation to expansion and reaggregation (Reid et al., 2014). These changes lead to either income diversification at the household level (Homewood et al., 2009; Reid, 2012) or intensification of the rangelands (BurnSilver, 2009; Nkedianye et al., 2009). Rangeland changes cause species decline. In North American grasslands, bird populations have experienced drastic declines over the past half century, particularly due to the land-use change and a rapid loss of habitat (Correll et al., 2019; Grand et al., 2019). Conversion of grasslands into other land uses is the major threat for grassland birds in Brazil (Jacoboski et al., 2017). Future climate change added vulnerability to these grassland birds in North America (Wilsey et al., 2019).

There is some evidence that indigenous pastoralist communities are displaced to create protected areas (Reid, 2012; Tang & Gavin, 2010) and to prohibit traditional management practices such as burning grassland to produce a new flush of nutrient-rich grass and remove old moribund grass material (Fernández-Giménez & Estaque, 2012; M. U. Johansson et al., 2012). The forced eviction of pastoralist communities to establish protected areas sometimes has led to an increase in wild species poaching (Reid, 2012; Scharf et al., 2010).

4.2.1.5.6 Habitat conversion

The conversion of natural ecosystems into anthropogenic ecosystems (such as farmlands, pastures, and plantations) is the most important direct driver of change in terrestrial ecosystems. This is driven indirectly by changing social dynamics—notably the drive for economic development. This significant expansion of agricultural land has been the critical factor that has enabled the human population to continue growing. While an estimated 1 billion people remain malnourished, the supply of food per capita has continued to increase steadily, largely due to improved technology and the intensification of cropland. Poor governance, however, has prevented a more equitable distribution of the benefits from food-producing plants. Additionally, about 1.3 billion tons of food produced for human consumption is wasted annually, and the loss per capita is higher in the industrialized world than in developing countries (FAO, 2011b).

Habitat loss and fragmentation, and the consequent reduction of much of the Earth's biodiversity, have been caused by the increasing human population density and energy use, mainly after the 19th and 20th centuries (Sala et al. 2000; Fahrig, 2003). The drivers of species loss include pollution and habitat conversion. Habitat conversion for human development directly trades economic profit for habitat loss. Economic activity that causes habitat loss includes urbanization, mining, water development, and agriculture. However, a leading cause of global change is likely the growing human modification of environments for agriculture (Keitt, 2009). The Cerrado is the richest savanna ecosystem in the world. Still, the intensive human occupation process has also transformed it into one of the most critical regions for cattle ranching and commodity crops in Brazil (Myers et al., 2000). The proportion of remaining

habitats in the Cerrado varies from 39% to 55% (Eva et al., 2004; Machado et al., 2004; Mantovani & Pereira, 1998; Sano et al., 2008).

Cattle ranching and intensive farming in the Cerrado ecoregion have caused a tremendous decline in natural habitat cover (Diniz-Filho et al., 2009). According to a study by Hermann and colleagues, land conversion rates far outweigh preservation attempts in the area. Collecting data from satellite images, silviculture in the area was expanded by 94% over the six-year study, and grassland was the main target for agricultural land conversion. On a larger scale, this reflects global developments in temperate grasslands (Hermann et al., 2016). An overwhelming number of studies have looked at the impact of agricultural habitat conversion on birds, often used as indicators of biodiversity status. They play vital roles in many ecosystems, ranging from pollination and seed dispersal to insect control and nutrient cycling. It has been estimated that approximately a fifth to a quarter of pre-agricultural bird numbers has been lost due to agricultural development (Gaston et al., 2003). In particular, avian breeding success is impacted by agricultural land conversion.

A study conducted by Cartwright et al. concluded that the formerly critically endangered Mauritius kestrel *Falco punctatus* experiences a decline in breeding success as the area of agriculture near a nest site is increased (Cartwright et al., 2014). This may be attributable to the increasing spatial variation in the availability of native prey, which is reduced by land conversion. In addition, loss of farmland bird populations has been observed in Europe. For example, farmland bird populations dependent on key aspects of these agroecosystems experienced a 40% decline between 1980 and 2000 (Cao et al. 2010). Cattle ranching and intensive farming in the Cerrado ecoregion have caused tremendous decline in natural habitat cover (Diniz-Filho et al., 2009). The drastic loss of spatially consistent natural cover in the Cerrado ecoregion denotes the decline of many endemic plant species, mirrored in the Atlantic rain forest ecoregion. The forest-grassland mosaic of Rio Grande do Sul, Brazil has been largely converted for agri- and silviculture. Due to extensive logging practices, the area's *Araucaria* broadleaf forest is only a mere fraction of its original extension, and the *Araucaria angustifolia* species has been recently placed on the International Union for Conservation of Nature and Natural Resources Red List of Endangered Species (Hermann et al., 2016).

4.2.1.6 Pollution and eutrophication

Key messages:

- Pollution, be it from anthropogenic or natural sources, brings negative consequences on the abundance, distribution, availability, harvesting, gathering, and value chain of wild species in different ways and at different spatial and temporal scales (*well established*).
- The interaction of state, indigenous peoples and local communities, different forms of conservation bodies (national and international, governmental and non-governmental organizations, and community-based organizations, and other stakeholders are central to the safeguarding of wild species and minimizing every possible cause and threat posed by pollution (*established but incomplete*).
- Acts and regulations are often inadequate or poorly addressed in terms of local evaluation methods such as Initial Environmental Examination and Environmental Impact Assessment - where in the majority of cases, the effects of pollution on wild

species are hardly understood. A better understanding of pollution-induced changes in wild species dynamics, effective implementation of regulations, and building capacity and awareness are paramount (*established but incomplete*).

Key points for policymaking:

- Sufficient support by governments for more research and better understanding of the pollution-induced changes in wild species and their sustainable use is paramount.
- More serious international pollution mitigation commitments and emission curtailment agreements are needed vis-a-vis checking the unsustainable exploitation of wild species, including their illegal trade.
- Developing a global policy framework for post-2020 achievable targets, with specific regional guidelines, to minimize and eventually stop the impact of pollution on the sustainable use of wild species is essential.

4.2.1.6.1 Overview

This section reviews environmental pollution, specifically air, water and land pollution, vis-à-vis the impacts on sustainable use of wild species. The pollution could either be anthropogenic or natural and is characterized as being due to chemical, physical or biological pollutants emanating from point or non-point sources.

Air pollution decreases the native populations of animals with serious negative impacts on wild birds, insects, reptiles, and wild mammals. The anthropogenic variables of air pollution are also responsible for the decline in lichens, wild-growing medicinal plants and many other wild species. Air pollution from industry harms wild species in different ways, such as bioaccumulation, causing diseases, mortality and physiological stress. The pollutants originate from human activities such as combustion of burnable waste, fossil fuels in thermal power plants and automobiles, which increases the concentration of gaseous and particulate pollutants in the atmosphere. The resulting air pollution and subsequent acid deposition change the chemistry of the lakes and damage wild plants. Air pollutants affect wild species by entering the food chain and damaging the supply and quality of food through bioaccumulation. The oxides of sulphur (sulphur oxide, sulphur dioxide, and sulphate), noxious nitrogen gas (nitrogen monoxide, nitrous oxide, nitrogen dioxide) ammonia (NH₃), volatile organic compounds, and carbon monoxide (CO) are the important chemical pollutants emitted from various anthropogenic activities, the effects of which on ecosystems and wild species therein are growing with the growth of urbanization and industrialization.

A major threat to wild aquatic species is the contamination of water bodies by different pollutants (physical, biological, chemical and radioactive) resulting from many sources (mining activities, industrial effluents, domestic sewage and agricultural runoff). Domestic and industrial waste, livestock waste, and agrochemicals are predominant pollutants in waterbodies. Oil pollution enters the ocean and severely contaminates beaches and sediment and causes serious harm to wild marine species. Oil spills in freshwater ecosystems, also have grave impacts on wild species. Phosphorus, nitrogen and many other nutrients are added to aquatic ecosystems continuously by agriculture and urban activities, which in turn cause diverse problems, such as oxygen limitation, toxic algal blooms, loss of biodiversity and threat to

important wild species of recreational value. It affects the quality of the environment or habitat in which they live and the availability and quality of the food supply. Acid rain, heavy metals, persistent organic pollutants and other toxic substances are issues of major concern, the effects of which on fish, fisheries and other wild aquatic species are felt across the world, especially in the developing world due to increasing population, urbanization and modernization. The elevated concentration of nutrients in freshwater bodies (eutrophication) triggers blooms, invasions and biodiversity loss in lakes, rivers and wetlands, thereby pushing the useful wild species to the brink of rarity or extinction. Plastic accumulation in the oceans severely impacts marine life, increasing the likelihood of coral reefs being affected by diseases and threatening overall ecosystem health and human livelihoods. Ingestion of microplastics is being reported in several marine invertebrate species. Microfibre ingestion in crabs affects food consumption and energy balance, while in marine worms, the ingestion of microscopic unplasticized polyvinylchloride reduces growth and energy reserves.

Soil pollution caused by a myriad of human activities (e.g., leakage of oil and chemicals, excessive use of chemical pesticides and fertilizers etc.) negatively effects soil health and consequently the soil biota. Excessive fertilizers, pesticides, and even nutrients, especially nitrogen, phosphorous and heavy metals composition in terrestrial soils, freshwater sediments and coastal ecosystems with cascading effects on wild species diversity, ecosystem function and human wellbeing. In the last few decades, there is some evidence that various types of xenobiotics have adversely affected wild species through soil-based impacts, thereby contributing quite a great deal to push these species to the brink of extinction. Whether soil microbes also go extinct many times without even being ever identified and how such extinctions are related to the extinction of wild species above-ground are some unanswered questions.

4.2.1.6.2 Key Gaps:

- Some extremely harmful pollutants such as polychlorinated biphenyls, despite a near-global ban over the past three decades, are still found to bioaccumulate in some wild species, indicating their presence and use in the environment.
- The rising global decline of insects, especially pollinators, due to air pollution-induced mortality or climate change-driven plant-pollinator mismatch needs more evidence, and effective intervention, given its huge implications for horticulture and agriculture sectors that comprise the backbone of the economy of developing countries.
- Lack of focused, in-depth studies on the impact of pollution on keystone wild species despite the dire need to understand their biology, ecology and conservation in the context of growing pollution, especially in developing countries.

4.2.1.6.3 Methodology

The experts used about 30 keywords in different permutations and combinations to search the relevant literature. Each term pertaining to different types and forms of pollution was paired with different words or terms used for wild species. For instance, terms such as pollution, pollutants, toxic chemicals, contaminants, environmental pollution, air pollution, water

pollution, soil pollution, noise pollution, toxic elements, heavy metals, organic contaminants, inorganic pollutants, automobile pollution, biotic pollution etc. were paired with terms such as sustainable use of wild species, wild species, wild resources, birds, fish, reptiles, freshwater life, marine species, forest species, wilderness, extinction, habitat modification, keystone species, global patterns of impact of pollution on wild species, regional changes in wild resources by pollution etc (Figure 4.4). Over 200 searches were performed that resulted in a large number of research articles, policy documents, book chapters and other papers, which in turn were refined to select the most relevant articles/sources in English since 1950 for inclusion. References cited in these articles were also considered, if appropriate, to ensure as comprehensive coverage of related research as possible.

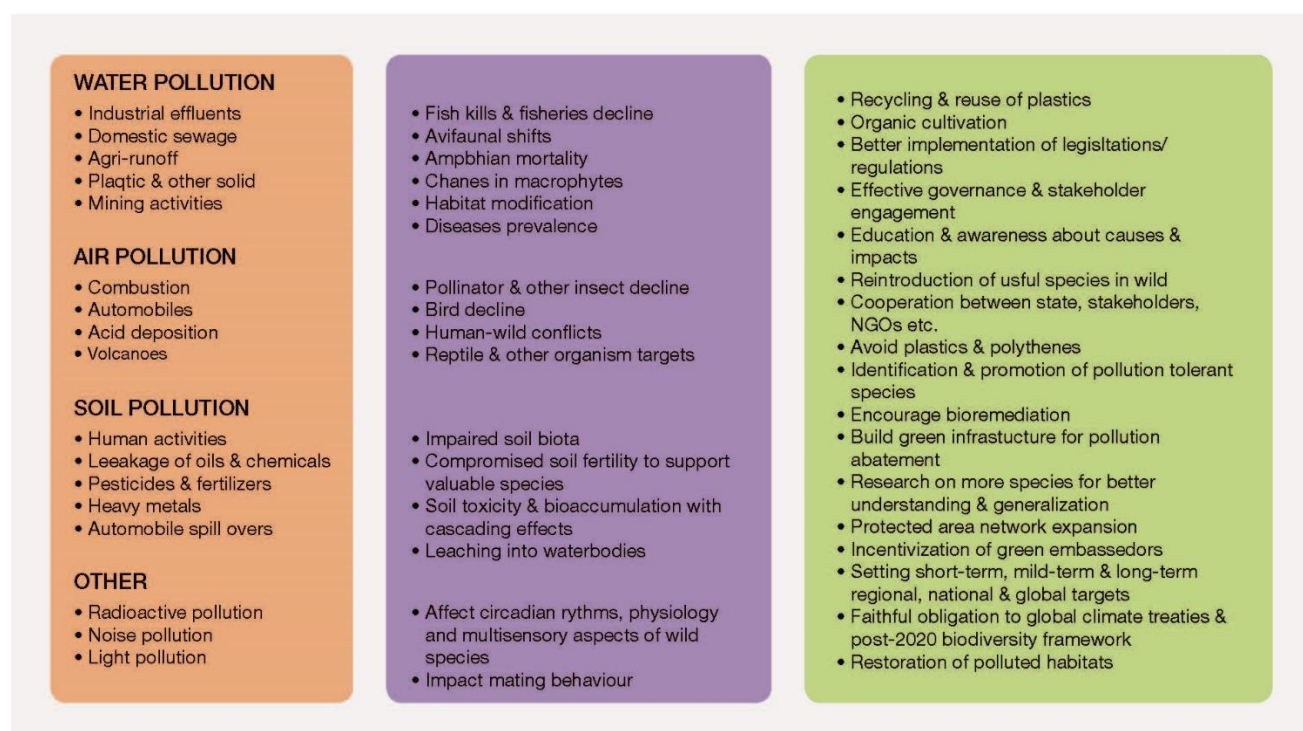


Figure 4.4 Typology of pollution and causes. The impact of pollution on the sustainable use of wild species is quite varied, and a suite of mitigation measures against pollution *vis-à-vis* wild species could be used, in isolation or combination, in context-specific situations.

4.2.1.6.4 Air pollution

Air pollution is one of the major global environmental concerns, with serious human health impacts and equally serious effects on myriad wild species. Gaseous air pollutants are emitted from various natural sources, such as volcanoes and forest fires, or anthropogenic activities that have significantly increased with population growth and industrialization (Kemp et al., 2011). Air pollution comprises a mixture of gases and particles (such as CO₂, CO, O₃, SO₂, CH₃, smoke and mixture of urban and industrial emissions) in undesirable and harmful amounts. Human beings have produced facilities that use many of the Earth's energy resources to make their life easier. Burning fuels such as coal, oil and natural gases result in pollution by releasing harmful substances into the environment. Burning fossil fuels in industries and the transport sector, industrialization and urbanization have led to increased concentrations of gaseous and

particulate pollutants in the atmosphere leading to air pollution (Tripathi and Gautam, 2007; Dwivedi and Tripathi 2007). These constituents interact with reactants in the atmosphere and result in secondary pollutants such as acid deposition.

Acid rain has negative impacts on aquatic organisms, including fishes. The marine ecosystems found in Belgium, Denmark, West Germany and the Netherlands (Whelpdale, 1983) are affected by acid rain. Acidification of surface waters has been reported in many, including Great Britain, Northern, Central and Eastern Europe, southwestern China, southeastern Canada, the Northeast, Upper Midwest and Appalachian Mountain regions of the United States of America. Large portions of the high elevation western North America are also potentially sensitive to acidic deposition, however. However, atmospheric deposition in this region is relatively low. Concern over the effects of acidic residue in the Mountain West and California may be overshadowed by potential effects of elevated nitrogen deposition, including eutrophication of naturally nitrogen-limited lakes (Fenn et al., 2003). Decreases in pH and elevated concentrations of dissolved inorganic aluminum have resulted in physiological changes to organisms, direct mortality of sensitive life history stages, and reduced the species diversity and abundance of aquatic life in many streams and lakes in acid-impacted areas (Driscoll et al. 2019).

Top-level predators such as bears and eagles, among many others, are particularly susceptible to the bioaccumulation of these types of air pollutants. Changes in the abundance of any species because of air pollution can dramatically influence the abundance and health of dependent species. The loss of some species of fish because of higher levels of aluminum may allow insect populations to increase, which may benefit certain types of ducks that feed on insects. But the same loss of fish could be detrimental to eagles, ospreys and many other animals that depend on fish as a source of food.

The major effects of industrial air pollution on wild species include direct mortality, debilitating industrial-related injury and disease, physiological stress, anemia, and bioaccumulation. Some air pollutants have caused a change in the distribution of specific wild species (Newman, 1979). The African urban centers have grown tremendously in the last thirty years and are still on a continuous rise (Obeng-Odoom, 2013). Motor vehicles, power generation plants and other industrial machinery produce toxic gases. Nitrous oxide, Sulphur oxide and Carbon monoxide pollution in the tropics may exert more adverse effects on sensitive species of diverse plants and animals, and photo-chemicals have resulted in shifts of vegetation from ozone sensitive to ozone tolerant ones (Barker & Tingey, 2012). Sulphur dioxide and hydrogen sulphide emitted from power plants, especially the coal-fired ones and paper and mill factories, have already resulted in acid rains in various parts of Africa (Europe & WHO., 2006; Josipovic et al., 2010; Nduka et al., 2008). The sources of NH₃ in Africa are municipal effluent, farmyard/feedlot manure, and inorganic mineral fertilizers (Carmichael et al., 2003). There have been many reported air pollution episodes involving injury or death to animals since the end of the nineteenth century (Newman, 1980; Newman & Schreiber, 1985). Some of the incidents involving the adverse effects of these airborne pollutants on mammals and birds have been recorded quite earlier. For instance, the earliest incident involving arsenic poisoning of fallow deer (*Dama dama*) in Germany was recorded in 1887. Among birds, there are examples of granivores, insectivores, and carnivores being affected in various ways by air emissions. Effects may range from subtle, such as a reduction in genetic diversity, to dramatic, such as a change

in population numbers (Newman, 1980; Newman & Schreiber, 1985). A review of decades of research on lead contamination in vultures across the world found 72% of articles from North America and Europe, with the rest corresponding to Asia (13%), South America (8%), and Africa (7%). Of these, 88% of studies showed the lead concentration beyond threshold limits (Plaza & Lambertucci, 2019). This corroborates with a series of case studies demonstrating the sustained impact of contaminants, such as dichloro-diphenyl-trichloroethane, dieldrin and diclofenac on vultures (Shore & Taggart, 2019).

The rising global decline of insects, especially pollinators and birds, due to air pollution-induced mortality is evidenced by the significant correlation between the increase in pollutants such as respirable suspended particulate matter and changes in pollinator bee survival (Thimmegowda, 2020). Similarly, high avian mortality due to fly ash calls for controlling sources such as atmospheric geo-engineering and industrial emissions (Dutta, 2017; Whiteside & Herndon, 2018). Sanderfoot and Holloway (2017) found consistent evidence for the adverse effect of air pollution on birds, primarily attributable to CO, O₃, SO₂, smoke and a mixture of urban and industrial emissions. One of the first case reports using monkeys as model systems recently linked animal social conflict to air pollution and global warming (Xu et al., 2021), the results of which indicate more daily social fighting behaviors under the polluted air. Even mate choice at different stages can be affected by pollution, which can influence individual fitness, population dynamics and community structure of wild animals (Candolin & Wong, 2019).

The anthropogenic variables of air pollution are responsible for the lichen decline (Giordani, 2007). The lichens can indiscriminately absorb a large range from the ambient air through their entire surface (Aznar et al., 2008; Conti et al., 2011). Accumulated pollutants in their thallus in line with atmospheric concentrations show a close correlation with their atmospheric levels and have proved the lichen's capability as an effective biomonitor (Adamo et al., 2008; Godinho et al., 2009; Wolterbeek et al., 2003). The loss of lichen diversity in response to environmental conditions is widely used as an indicator for several complex phenomena, including air pollution (Giordani, 2007). Gombert, Asta, and Seaward (2004) determined the decreased lichen abundance and spatial trends of lichen diversity around urban and industrial areas based on the fact that anthropogenic variables are responsible for lichen decline, irrespective of natural succession of epiphytic communities (Purvis et al., 2003). A study conducted by Douglas et al. (2017) indicated that samples from the Las Vegas valley are a good baseline of pollutants in lichens. Furthermore, lichen collected within the valley contained higher concentrations of target pollutants, suggesting that the accumulation of pollution is likely anthropogenic in nature (e.g., industries, vehicular traffic). Douglas et al. (2017) documented that vehicle emissions are a source of nitrate. Findings show NO₃- is lower in lichen biomass located in the South and East sectors while higher in the North and West sectors of Las Vegas Valley. It is possible that the South and East sectors with elevated copper, perhaps, are a contributing factor to lower NO₃- in lichen biomass.

4.2.1.6.5 Water pollution

Pollutants are a major driver of species declines in freshwater systems (Dudgeon et al., 2006). Water pollution is brought about by various sources such as domestic and industrial sewage, agricultural runoff, waste dumping, oil spills, sediment runoff etc. Water pollutants have been

found to be lethal to fish and other aquatic fauna or cause a range of sub-lethal effects, such as physiological stress, dysfunction of iono-regulatory and immune system, histopathological deformities, change in population dynamics and community structure (Luebke et al., 1997; Ozmen et al., 2008; Sodergren, 1992).

- **Acidification**

Acid precipitation and consequent acidification of waterbodies is a major cause of concern for wild aquatic bioresources and their sustainable use with substantial economic impacts (as estimated recently in UK by Mangi et al. (2018), for instance). Ndubuisi et al. (2015) reported 100% mortality of fingerlings of *Clarias gariepinus* at pH 3. Acidification, in conjunction with other drivers such as climate change, ultraviolet radiation radiations etc., has serious impacts on phytoplankton (Bach et al., 2017), macrophytes (Jackson & Charles, 1988; Tucker et al., 2021); and amphibians (Alton & Franklin, 2017). According to the United States of America, Fish and Wildlife Service sources, around 3,000 to 4,000 birds, such as snow geese, perished in December 2016 in the Berkeley Pit's toxic water due to heavy metals and sulfuric acid. In Hong Kong, the Mai Po and Inner Deep Bay ecosystem is under threat from a range of contaminants, especially high levels of chlorinated pesticides in marine sediments (Richardson and Zheng 1999; Richardson et al. 2000). The lower reaches of the Pearl River, which drain into Deep Bay receive 2 million tons of various types of wastes and wastewater annually, and are heavily polluted by domestic, industrial and livestock waste, and agrochemicals (Neller & Lam, 1994). River Nile from Aswan to Cairo involved severely polluted points resulting from sewage drains, and industrial and agricultural sources (Fishar, Kamel, and Wissa 2003; Fishar & Williams 2006) that reduced the richness of wild taxa. Pollution, together with monoculture palm oil plantation in Borneo, Malaysia (Zieritz et al., 2017), reduces the diversity of useful wild aquatic species with serious implications for livelihoods.

- **Oil spills**

Petroleum hydrocarbons are considered as hazardous wastes and the most frequent organic pollutants of aquatic ecosystems (Margesin and Schinnur 1997). The ingestion of oil by some wild aquatic species often causes mortality, while surviving organisms often show developmental and reproductive abnormalities (Jiang et al., 2010). The aquatic organisms that live within and around the coral reefs are at risk of exposure to the toxic substances within oil and smothering thereby suffering significant changes in diversity, species abundance and habitat structure worldwide (Hughes et al. 2007). In a study using coral nubbins in coral reef ecotoxicology testing, (Shafir et al., 2003) found that dispersed oil and oil dispersants are harmful to soft and hard coral species at early life stages. They found that the dispersant concentrations recommended by the manufacturer were highly toxic and resulted in mortality of all nubbins.

- **Eutrophication and Agricultural Runoff**

Nutrient pollution from improper and excessive fertilizer use has several negative consequences for ecosystems. Of the 63 large marine ecosystems evaluated under the Transboundary Waters Assessment Programme, 16% of the ecosystems are in the “high” or “highest” risk categories for coastal eutrophication due to nutrient run-off16 (ECOSOC, 2017). African aquatic

ecosystems are already suffering the wrath of application of pesticides upstream (Hecky et al., 2006; Odada et al., 2004). Toxic levels of pesticides capable of altering health of aquatic organisms have been found in several lakes and rivers in Africa (Mugachia, Kanja, and Gitau 1992; Kidd et al. 2001; Ezemonye and Ikpesu, 2008.; Okeniyia et al. 2009; Kohler and Triebkorn 2013). Along coastlines, rivers' low oxygen levels and hypoxic "dead zones" are due to large nitrogen and phosphorus loads draining from fertilized agricultural watersheds, or from sewage and atmospheric nitrogen deposition (Diaz & Rosenberg, 2008; Rabalais et al., 2014; Schmidt et al., 2017). The dead zone has been significantly expanded due to the anthropocentric contributions of nutrients from mostly agricultural, municipal, and industrial sources. Nutrient-fed hypoxia is ranked as an important threat to the health of aquatic ecosystems, including oceans (Rockström et al., 2009). Challenging threats to the environment exist in the Gulf of Mexico region, and chief among them is the seasonal hypoxic or "dead" zone that occurs annually off the coast of Louisiana and Texas (Diaz & Rosenberg, 2008). The presence of a large hypoxic water mass off the coast of Louisiana in mid-summer may concentrate brown shrimp into shallower coastal waters (Craig et al. 2005) making them more susceptible to predators, including humans with trawls resulting in increased catches, but the overall productivity of the brown shrimp population is diminished by the removal of these smaller shrimp from further increase in size before capture in farther offshore areas later in the season.

Coral bleaching and some mortality in reefs within Bahia Almirante, extensive necrosis of sponges, and dead bodies of crustaceans, gastropods, and echinoderms suggested that the extreme stress leading to mortality had occurred and that hypoxia likely excluded consumers that otherwise would have targeted dead and moribund prey (Altieri, 2008).

- **Plastic pollution**

Plastic pollution in aquatic ecosystems is generating huge impacts. Plastic pollution enters the ocean via rivers, sewage, fishing and other sources. About 90% of all the plastic that reaches the world's oceans gets flushed through just 10 rivers: Eight of them are in Asia: the Yangtze; Indus; Yellow; Hai He; Ganges; Pearl; Amur; Mekong; and two in Africa – the Nile and the Niger (Schmidt et al., 2017). Plastics kill or harm biodiversity, from zooplankton to fish, shellfish, sea turtles, seabirds and marine mammals. Impacts on wild marine species include entanglement, ingestion, and contamination of a wide variety of species. Battisti et al. (2019) recently prepared a 'black-list' of 258 species impacted by anthropogenic litter. They found that most of the species (including 79.8% seabirds) are impacted by ingestion rather than by entanglement. The number of marine species affected by contaminants increased from 247 to 680 within a few years (Gall & Thompson, 2015). Marine plastic pollution impacts marine biota and ecosystems at many different levels (Fossi et al., 2017; Moore et al., 2020; Ryan, 2016). Wilcox, Van Sebille, and Hardesty (2015) suggested that nearly all species of seabirds will eventually be found ingesting plastic. 21% of surveyed wedge-tailed shearwater (*Ardenna pacifica*) chicks on Heron Island in the southern Great Barrier Reef were fed plastic fragments by their parents, ingesting 3.2 fragments on average (Verlisa et al. 2013). Seabird species feeding at the sea surface are more susceptible to plastic ingestion than diving species (Ryan & Jackson, 1987). Sea turtles are exposed to various anthropogenic stressors, including marine plastic pollution, because of their use of diverse habitats, migratory behavior, and complex life

histories (Nelms et al., 2016). Procellariiform seabirds and marine turtles may be particularly risky because marine plastic debris's chemicals may imitate natural foraging stimuli (Pfaller et al., 2020).

Litter ingestion and entanglement in plastic debris have been recognized as serious threats to turtle species worldwide (Clukey et al., 2017; Duncan et al., 2017; Nelms et al., 2016). Five sea turtle species inhabit the SE Pacific (*Caretta caretta*, *Chelonia mydas*, *Dermochelys coriacea*, *Eretmochelys imbricata*, and *Lepidochelys olivacea*); all are listed as vulnerable to critically endangered on the International Union for Conservation of Nature Red List (IUCN, 2021) with documented interactions with marine litter. The green turtle (*C. mydas*) is the species most commonly mentioned to have ingested plastic items, with a frequency ranging from 28% in the Ecuadorian part of the northern Humboldt Current upwelling system (Alemán, 2014) to 56 and 91% in Peru (Alfaro-Shigueto et al., 2005; Jiménez et al., 2017). The olive ridley turtle (*L. olivacea*) also has a high incidence of plastic ingestion, reaching up to 43% in Ecuador (Alemán, 2014), but this species has a lower incidence in other parts of the northern Humboldt Current upwelling system (8%), both in Peru and southern Chile (Brito et al., 2007; Paz et al., 2005). Furthermore, specific cases of plastic ingestion have been reported for leatherback turtles (*D. coriacea*) from the northern Humboldt Current upwelling system in southern Peru and central Chile (Brito 2001) and a hawksbill turtle (*E. imbricata*) in Rapa Nui (Brain et al., 2015). Items most commonly found in stomachs or intestines of sea turtles are plastic pieces of intermediate size, including plastic bags, monofilament nylon, rope, and fishing nets (Brito, 2001; Guerra-Correa et al., 2007; Jiménez et al., 2017). Several authors suggested that plastic ingestion has been the cause of death of stranded turtles in Ecuador and Chile (Brito et al. 2007; Silva, Retamal, and Guerra-Correa 2007; Alemán 2014). Many different seabird species have been entangled in marine debris or have ingested plastic (Luna-Jorquera et al., 2012). Six species were found to have ingested plastic litter (*Pelecanoides garnotii*, *P. urinatrix*, *Phalacrocorax bougainvillii*, and *Spheniscus humboldti*); one is a true diving species, and one a plunge diver (*Pelecanus thagus*). One species with a relatively high frequency of plastic ingestion is the kelp gull *Larus dominicanus*, which is commonly observed feeding in fishing ports, garbage containers, and waste disposal facilities. Ingestion of microplastics is being reported in several marine invertebrate species (Cole et al. 2013; Foley et al. 2018; Wright, Thompson, and Galloway 2013). Several harmful effects have been reported due to microplastic ingestion, ranging from stomach ulcers, intestinal obstruction, reduced body condition, and increased contaminant load (Derraik, 2002; Lavers et al., 2014). Notwithstanding some local scale efforts to check the plastic influx into the aquatic ecosystems, the volume of marine plastic debris, for instance, is increasing at an alarming rate of 4.8 to 12.7 million metric tons every year (Jambeck et al., 2015). The polychlorinated biphenyls threaten the long-term viability of >50% of the world's Killer whales' (*Orcinus orca*) populations with strong impacts on reproduction and immune function (Desforges et al., 2018). This is despite a near-global ban on polychlorinated biphenyls over the past three decades. Recent molecular investigation in mangroves revealed lower species population sizes in polluted sites when compared with those in protected area (i.e., higher gene flow may help them counteract the effect of pollution on genetic diversity and differentiation) (Rumisha et al., 2018). Whether hunting waterfowl is a sustainable use or not is not clear. While game hunting is considered sustainable use of waterfowl species in many countries, in the Argentinian context, for instance, this is not

considered so due to many reasons (Uhart et al., 2019). The use of lead ammunition, questionable hunting quotas, lack of information on waterfowl population status, breeding sites, etc., are some of the critical concerns in this regard. The evidence above substantiates the significant impact of pollution on survival, dynamics and sustainable use of wild species that merit urgent policy intervention and management action.

4.2.1.6.6 Soil pollution

Various studies have shown that excessive use of pesticides and insecticides leads to loss of wild species and causes ecosystem degradation (Green et al., 2005; Kleijn et al., 2009; Rundlöf et al., 2015). In particular, pesticide use has contributed to reducing populations of birds, insects, amphibians and aquatic and soil communities, either through direct exposure or reduction in food and habitat availability (Hallmann et al., 2014; Kennedy et al., 2013). A Europe-wide study found that insecticide and fungicide use have consistent adverse effects on wild species diversity and that insecticides also reduce the potential for biological pest control (Geiger et al., 2010). Indirect effects of pesticides have been identified as one of the leading causes of decline in farmland birds in several European countries (Donald et al., 2001; F. Geiger et al., 2010). This decline is reflected in the falling trends for farmland bird index in several Organisation for Economic Co-operation and Development countries. Direct toxicity of nitrogen gases, ozone and aerosols, increased nitrogen availability, and soil-dependent acidification in terrestrial systems lead to reduced plant diversity in wild (Bobbink et al., 2010; Valliere et al., 2017). Industrial-based soil contaminants are of growing concern because of the increased ownership of motor vehicles, mining, and industries. Vehicular exhaust pollutants comprising polyaromatic hydrocarbons and tetraethyl lead (now in decline due to conversion to unleaded fuel) are deposited along the motorways and are increasing quantities of toxic metals deposited on the ground (Davies & Osano, 2005; Olade, 1987). A literature synthesis from Latin America recently (Marzio et al. 2019) found relatively high levels of metal contamination, primarily emanating from industrial activity, intensive agriculture, and urban contamination, with serious implications for wild species such as sharks.

It is worth mentioning that hunting with lead ammunition is now the main source of human-induced lead emissions to the soil in the Europe (Tukker et al., 2006), with potential implications for soil fauna. For instance, wild-growing mushrooms, exceptionally prized given the myriad of human-health benefits, are significantly affected by heavy metals (Dowlati. et al. 2021). It is well documented that mushrooms' fruiting bodies can bioaccumulate heavy metals (Garcia et al. 1998; Barua et al. 2019) in concentrations far higher than what is found in agricultural crop plants, vegetables, and fruit (Zhu et al., 2011). For example, in Yunnan Province, one of the leading production areas of wild edible mushrooms in China, the wild edible mushrooms are endangered by various pollutants, especially heavy metals, due to rapid urbanization and industrialization (Luo, 2013). The concentration of arsenic, cadmium and lead in mushrooms are potentially hazardous. These elements in edible mushrooms may enter the food chain and potentially harm human health. It can be seen from a study conducted by Liu et al. (2015) that arsenic and lead concentrations in all of the soil samples were below the safe limits and the cadmium concentrations exceeded the safe limit, indicating that the soil in the study area where the edible mushrooms grew had been significantly contaminated by cadmium.

The cause of the contamination might be the industries in the southern region of China (Fang et al., 2014). There is sufficient evidence for the impact of pollution on wild growing mushrooms worldwide.

In addition to soil, water and air pollution, the other types of pollution with a profound impact on wild species and wild species include noise pollution, light pollution and radioactive pollution. For instance, chronic and acute marine noise pollution produced by several human activities – such as maritime traffic, pile driving, and air guns cause detectable effects on intraspecific communication, vital processes, physiology, behavioral patterns, health status and survival of marine species, including some keystone predators and habitat-forming species (Di Franco et al., 2020). These individual-based effects may cascade to the ecosystem-wide impacts. Moreover, artificial light at night and noise have been found to interact and produce complex and novel effects on model songbird species, thereby pointing to multisensory pollution being a considerable threat to wild species and stress the importance of including both these anthropogenic stressors in future assessments of the ecological effects of urbanization and human activity (Dominoni et al., 2020). There is sufficient evidence to show that the pulsed telephony microwave radiation can produce adverse effects to wild species by way of affecting nervous, cardiovascular, immune and reproductive systems (Balmori, 2009). Therefore, utmost care must be exercised in installing such towers and technology in and around the protected areas that inhabit invaluable threatened wild species.

4.2.1.7 Environmental hazards

4.2.1.7.1 Overview

This section reviews environmental hazards, specifically geological or geophysical hazards that originate from internal earth processes (earthquakes, volcanic activities, landslides, tsunamis), and biological hazards. Hydrometeorological hazards, which are of atmospheric, hydrological or oceanographic origin (tropical cyclones, floods, drought, heatwaves, heavy rainfall, storms, and cold spells), are dealt with in section 4.2.1.2. Environmental hazards have had significant impacts on ecosystems and species. These hazard events arise from (for the case of zoonotic diseases), or their effects are exacerbated by (for the case of natural hazards), increased human interactions with their environment. Especially in the case of the coronavirus (COVID-19) pandemic, hazards from zoonotic diseases prompt us to re-examine the relationship between people and wild species.

Volcanic activities have had a significant impact on the world's ecosystem. Although volcanic soil is vibrant and helps maintain agriculture in many parts of the world, volcanic eruptions can be catastrophic, spewing lava and ashes, posing a severe risk to people and their livelihoods. Thus, volcanic activities can be considered natural sources of pollution. Ashes ejected from volcanoes can cause much nuisance to farmers, burying agricultural lands and destroying crops. The ashes can also negatively impact human health and animals, contaminating infrastructures and disrupting aviation and land transport (Small & Naumann, 2001).

The numerous active volcanic mountains in Africa are exemplified by the frequent rage of the Virunga Mountains. Their plumes are displaced over a long distance and cause changes

to the quality of rainwater, including acidity (pH up to 2), increased concentrations of Fluoride (up to 2,400 mg/L), Chloride (up to 1,750 mg/L) and Sulphide (up to 10,000 mg/L). These events have detrimental effects on the equatorial rainforest and likely impose possible strain on the dwindling populations of gorillas (*Gorilla beringei*) (Delfosse, 2005; Plumptre et al., 2007; Vaselli et al., 2008). Specifically, the gorillas, whose censused population stood at a finite 360 in 2003, face dual (anthropogenic and natural) challenges such as fragile and explosive political strife and raging volcanic activities of the Virunga Mountains (Gray et al., 2010; Kalpers et al., 2003; Vaselli et al., 2008).

4.2.1.7. 2 Pandemic and sustainable use of wild species

The Corona disease 2019 (COVID-19) pandemic has caused millions of deaths and suffering, brought challenges to public health, food systems, education and employment, and disrupted economy and human activities at an unprecedented scale (FAO, 2020a; ILO et al., 2020). A review of approximately 500 emerging infectious diseases, including pandemics, found that almost all pandemics and the majority of the emerging infectious diseases are caused by wild species-origin pathogens (60% are dominated by zoonoses, of which 71.8% originated in wildlife), showing a linkage between pandemics and biodiversity (Jones et al. 2008; IPBES 2020). The emergence of zoonoses is correlated with wild species (mammalian) diversity, human population density, and anthropogenic environmental destruction (Allen et al. 2017; Jones et al. 2008; Gibb et al. 2020). Studies have suggested that the emergence of the disease pandemics such as Zika (2015-2016), H1N1 (2009) and SARS (2002-2004) is the results of ecosystem alteration due to land-use change, deforestation, agricultural expansion and intensification, wild species trade, consumption and other drivers that disrupts natural interactions among wild species and their microbes, increases contact among wild species, livestock, people, and their pathogens (IPBES, 2020; Nuñez et al., 2020). Land-use changes, deforestation/forest fragmentation/habitat fragmentation, agricultural development/irrigation, and urbanization/suburbanization mainly cause increased pathogen transmission through alteration of the vector, host, and pathogen niche, changes in host and vector community composition, changes in behavior or movement of vectors and/or hosts, altered spatial distribution of hosts and/or vectors (Gottdenker et al., 2014). A recent analysis of 6801 ecological assemblages and 376 host species worldwide showed that the richness and abundance of human-shared pathogens are higher in the sites under substantial human use compared with undisturbed habitats (Gibb et al., 2020).

There are several ways zoonoses spillover—a process that enables a pathogen from a vertebrate animal to establish infection in a human—from wild species to humans (Magouras et al., 2020; Plowright et al., 2017). First direct contact of humans with wild animals. The spillover of pathogens from wild species to humans can occur directly through activities and hobbies of humans such as hunting, farming exotic animals, companionship and butchering wild species. For example, wild meat consumption is linked with the emergence and outbreak of the Ebola virus in the countries of central and west Africa (Coltart et al., 2017; Holmes et al., 2016). The origin of HIV/AIDS caused by HIV-1 and HIV-2 viruses are linked with repeated exposure to wildlife (Sharp & Hahn, 2010). Another way of increasing direct contact of wild species with humans is caused by selling and butchering live animals in wet markets (Orenstein,

2020). For example, waterfowl, especially Anseriformes (ducks, geese and swans) and Charadriiformes (gulls, terns and sandpipers), are thought to be the natural reservoir of Influenza type viruses (Webster et al. 1992; Olsen et al. 2006) and transmission of the virus from these avian species to humans might occur in bird markets (Lycett et al., 2019). A sizeable amount of transactions of the Convention on International Trade in Endangered Species of Wild Fauna and Flora -listed species could carry potentially zoonotic risks (UNEP-WCMC & JNCC, 2021). Similarly, the SARS virus outbreak (2002–2003) potentially originated from masked palm civets (*Paguma larvata*) sold in wild species markets in China (Wang et al. 2006; Xu et al. 2004). Similarly, avian influenza is linked with increased illegal pet trade (Kilpatrick et al., 2006). Wet markets have been characterized and are stereotyped as having poor hygiene and inhuman treatment of wild animals; these in term are thought to cause immunosuppression and the spread of pathogens (i.e., carried by animals) (Fischer & Romero, 2019; Magouras et al., 2020; Martin, 2009; Nakajima et al., 2021). Intensive wild species farming also causes the spillover of diseases. Avian influenza circulated from Ostrich farms in Africa (Abolnik et al., 2016), the recent detection of COVID-19 in mink in the Netherlands (Oreshkova et al., 2020), and an outbreak of rabies in the ranched population of kudu (Scott et al. 2013). Nevertheless, the exact timing, place of origin and source of infection of COVID-19 is still not fully known (Frutos et al., 2021; Pekar et al., 2021; Wang et al., 2020). Furthermore, livestock and companion animals are also linked with spillover and amplification of emergent infectious diseases such as Nipah virus (Daszak et al., 2013), Hendra virus (Plowright et al., 2017) and avian influenzas (Fournié et al., 2013).

Second, changes in land use such as environmental degradation, deforestation, and land conversion for agricultural land change are also associated with the disease emergence (Gibb et al., 2020; IPBES, 2019a). Land use change is considered the cause of over 30% of emerging infectious diseases, including the emergence of novel zoonoses globally (IPBES, 2020; Loh et al., 2015). Human-dominated landscapes harbor a higher level of species richness and abundance of wild species hosts of human pathogens (Gibb et al., 2020). Land use change increases human populations into landscapes where indigenous peoples and local communities have often lived since historical times at relatively low density creating new opportunities for contact between humans and livestock with wild species, thus increasing the risk of disease transmission (Böhm et al., 2013; Murray & Daszak, 2013; Rwego et al., 2008). Land use change is linked with the outbreaks of Ebola (Rulli et al., 2017), and Machupo virus (Aguilar, 2009). Additionally, land use change is directly connected with the increased transmission of vector-borne diseases such as Dengue fever (Vanwambeke et al., 2007), malaria (Fornace et al., 2019; MacDonald & Mordecai, 2019), yellow fever (Walsh, Molyneux, and Birley 1993).

Third, the anthropogenic introduction of invasive alien species is linked with disease emergence in new locations and transmission to new hosts (Cunningham et al., 2017; Walker et al., 2008). One of the examples of introductions and escapes of amphibians for the international pet trade causing wild species disease is chytridiomycosis that has caused amphibian declines and extinction (Cunningham et al. 2015; Beard and O'Neill 2005).

Fourth, climate change enhanced the spillover risk (IPBES, 2020); therefore, anthropogenic climate change that causes human and animal movements is also considered a driver of emergent infectious disease. Climate change allows microbes to make contact with new hosts to potentially invade new niches (Pecl et al., 2017). Climate change also facilitates

the rapid expansion of the host range and microbial species' capacity to colonize new hosts (Hoberg and Brooks 2015; Brooks, Hoberg, and Boeger 2019). The recent spread of bluetongue disease in Europe is caused by the climate-induced migration of biting midge vector (Purse et al., 2008). Similarly, the northern migration of vector-borne diseases such as tick-borne encephalitis is also facilitated by climate change (Hvidsten et al., 2020; Semenza, 2019).

Overall, the drivers of sustainable use of wild species, such as unsustainable and extractive use of wild species, including wild species trade, land use change, climate change, and invasive species, not only have consequences on the sustainable use of wild species but also are connected to the emergence, amplification and spread of disease-causing pathogens. These drivers facilitate the spillover of novel or known pathogens from wild hosts to humans, causing severe impacts on human life, economy, and society. Additionally, domestic animals are hosts of several pathogens, including Tuberculosis, Brucellosis (Rahman et al., 2020). The expansion of the domestic animal trade has led to deforestation and land use conversion. Therefore, curbing those drivers, such as preventing deforestation and regulating wild species trade, including the sale and consumption of wild animals that can host dangerous pathogens, may reduce the risk of future pandemics (Dobson et al., 2020). The protected areas with intact natural habitats and limited disturbances may play a role in buffering against novel disease outbreaks and spillover of diseases from wild species to people by maintaining ecosystem integrity (Di Marco et al., 2020; Terraube & Fernández-Llamazares, 2020). Furthermore, the restoration of biodiversity is a crucial frontier in the management of zoonotic disease risk (Keesing & Ostfeld, 2021).

4.2.1.7. 3 Terrestrial animal harvesting

There is evidence that intensified contact between people and wild species arising from the encroachment of human activities into forest ecosystems and increased demand for meat and medicine from wild species lead to transmission of zoonotic diseases, which constitute about 70% of known emerging diseases (Volpato et al., 2020). In Malaysia, a combination of deforestation, drought, and wildfires has led to alterations in the population movements and densities of flying foxes, large fruit bats known to be the reservoir for the zoonosis Nipah virus (Chua et al., 1999). Although elite gastronomic consumption is behind wild species consumption in Asia, food insecurity and poverty increase wild meat hunting in Africa (Volpato et al., 2020), evidence for clear linkages are lacking. There is a gap in the literature on the link between environmental hazards and hunting. While studies in Sub-Saharan Africa demonstrate such links, for example, poor fish harvest resulted in an increased number of bushmeat hunters in Ghana (Brashares et al., 2004), agricultural productivity was a driver of incidences of human Ebola virus infections in Sub-Saharan African countries over the 1976 – 2013 (Price, 2015), and the link between the West African Ebola virus epidemic with decreased consumption of bushmeat (Ordaz-Németh et al., 2017), which can be inferred as reduced hunting of wild species for wild meat. While it can thus be interpreted that an increasing number of zoonotic diseases can result in a reduction in wild meat consumption, which would then lead to increased pressure on other wild species, such as through fishing, the evidence is unresolved.

4.2.1.7. 4 Trends in environmental drivers

Environmental drivers, directly and indirectly, change the distribution and abundance of species and damage service provision of ecosystems and wild resources. Climate change, for example, causes shifts in the distribution and abundance of species; more than 80% of the species that show changes are shifting in the direction expected based on known physiological constraints of species (Root et al., 2003). Climate change will also lead to the extinction of many species in key regions (Thomas et al., 2004). The frequency and intensity of extreme events, such as heatwaves, droughts, heavy rainfall, storms and, coastal flooding, marine heatwaves are expected to increase with climate change (Mitchell et al., 2006). These extreme events cause damage to the ecosystems and habitats of wild species. Invasive species are also driving changes in ecological systems altering communities and ecosystems; however, the evidence supporting a general and primary role for invasive species in extinctions remains limited (Gurevitch & Padilla, 2004). Land degradation, particularly land-use-related pressure, has reduced local species richness by an average of 13.6% and the total abundance of plants and animals by 10.7% compared with what they would have been in the absence of human effects (Newbold et al., 2015). Pollution of land, air and water has a significant impact on biodiversity. One notable example of the pollution causing local extinction is the ‘dead zone’ in the Gulf of Mexico (i.e., mass mortality of coral reefs). Dead zones are the areas of water bodies where the survival of aquatic life is impossible due to low oxygen levels. Deforestation and forest disturbances, particularly in tropical regions, contribute to biodiversity loss, with the most significant adverse effects on species of high conservation and function value (Barlow et al., 2016). Sub-Saharan Africa has a youth population growth rate that is the highest of any region at nearly 20% (United Nations, 2019).

4.2.2 Political drivers

4.2.2.1 Overview

Decisions about the use of wild species define and are determined by the diverse systems of governance that exist at local to global scales. Formal and informal rules vary around the globe and by different species; much more evidence can be found about the structures and processes of formal governance (e.g., statutory international agreements) and their strengths and weakness in managing wild species use. The customary laws and rules developed by indigenous peoples and local communities are less well documented by comparison. The informal or customary rules governing wild species’ use and trade are also poorly documented.

Most wild species are defined as public goods or as common property; fewer wild species are defined as private property or found in privately owned spaces. Most governance arrangements dealing with wild species focus on terrestrial megafauna, forests, and freshwater fisheries, with fewer regulations related to marine species. Plants and other non-timber forest products have largely been overlooked, and their harvest and use are poorly regulated (Laird et al., 2010). Regulation of non-extractive use is an emergent area of governance but is poorly developed around the globe.

In regions where wild species have historically declined or extirpated, there are generally much stronger formal regulations to protect what remains; many of these regulations are highly restrictive of any use. In other regions, considered to have a larger number of wild species and spaces, there tend to be few rules related to use, or they are weakly enforced. A critical concern is regions where wild species use appears unsustainable (by various indicators), but there is a paucity of formal and informal rules for management.

Informal institutions (e.g., customary laws) are also crucial in shaping use; they exist even where formal rules do not; indigenous peoples and local communities, for example, who have strong relationships to place and histories of use of wild species have well-developed rule systems (i.e., rules-in-use). There is growing evidence that these kinds of institutions may be more effective at mediating or managing for sustainable use. Where governance systems are highly pluralistic (inclusive of different values of stakeholders) and are flexible and adaptive to ecological and social conditions, wild species use is managed to ensure both social and environmental sustainability. Many international agreements and institutions influence the rule systems within and between different nation states, mainly where there are transboundary use issues (Liu et al. 2020). These rule systems are viewed as increasingly important as the world becomes more interdependent due to travel and communication technology and globalized economies (Marauhn, 2013; Paavola, 2005). This section aims to assess how different political drivers influence the sustainable use of wild species, their synergies and interactions.

4.2.2.1.1 Methodology

A systematic literature review was carried out in respect of critical areas of literature using terms such as political drivers, land tenure, governance, political rights, gender, indigenous peoples and each of the regions, and practices (e.g., hunting, fishing). Authors found over 5000 sources. A review of these sources identified major themes and interpretations of patterns in political drivers. Experts developed the sections with 20 + years of experience related to aspects of biodiversity conservation and in the social sciences. Where there were gaps in regions, practices, etc., case studies were developed to illustrate an essential dimension of the political driver and its impacts on practices and uses.

4.2.2.1.2 Gaps

- There is greater published evidence about formal systems of governance when compared to informal systems and customary law, including that of indigenous peoples.
- There are gaps in the literature related to the governance of gathering and non-extractive uses (including viewing) when compared to the practices of hunting, fishing and logging.
- Regional gaps exist in literature published in English concerning governance for many parts of central Asia, Russia and some parts of Latin America, particularly in relation to informal institutions and governance systems of indigenous peoples and local communities.

4.2.2.1.3 Definitions

Governance is fundamentally about the distribution of power among different members of society; it encapsulates the interactions among structures, processes, rules and traditions that determine how people in societies make decisions and share power, exercise responsibility, ensure accountability, and how stakeholders have a say in the management of natural resources (Lebel et al., 2006; Raik & Decker, 2007). It includes formal laws and structures but has other types of collective action, rulemaking, institutions, and general social coordination (Dietz et al., 2003). Governance research also addresses impacts on sustainable use (Kenward et al., 2011).

In this assessment, the experts focus on environmental governance or the rules, practices, policies, institutions, and mechanisms that shape how humans interact with the environment and influence environmental outcomes (Lemos & Agrawal, 2006). It includes those mechanisms, and tools that allow actors (public and private sector, non-governmental organizations, local communities) at different scales (local-global) to manage conflicts, seek points of consensus and take accountable actions and decisions (Lemos & Agrawal, 2006).

Although these governance arrangements can be viewed in isolation from one another, a system view of institutions is needed to account for how different actors, laws, regulations, and mechanisms of governance function together (Figure 4.5). Pluralistic governance arrangements - a mix, hybrid, or bricolage of formal and informal meetings – tend to coexist at the same time (Jentoft & Bavinck, 2014; North, 1991). Different actors (e.g., governments) can be simultaneously involved in multiple, and sometimes conflicting, positions of governance at other times (Berkes, 2005).

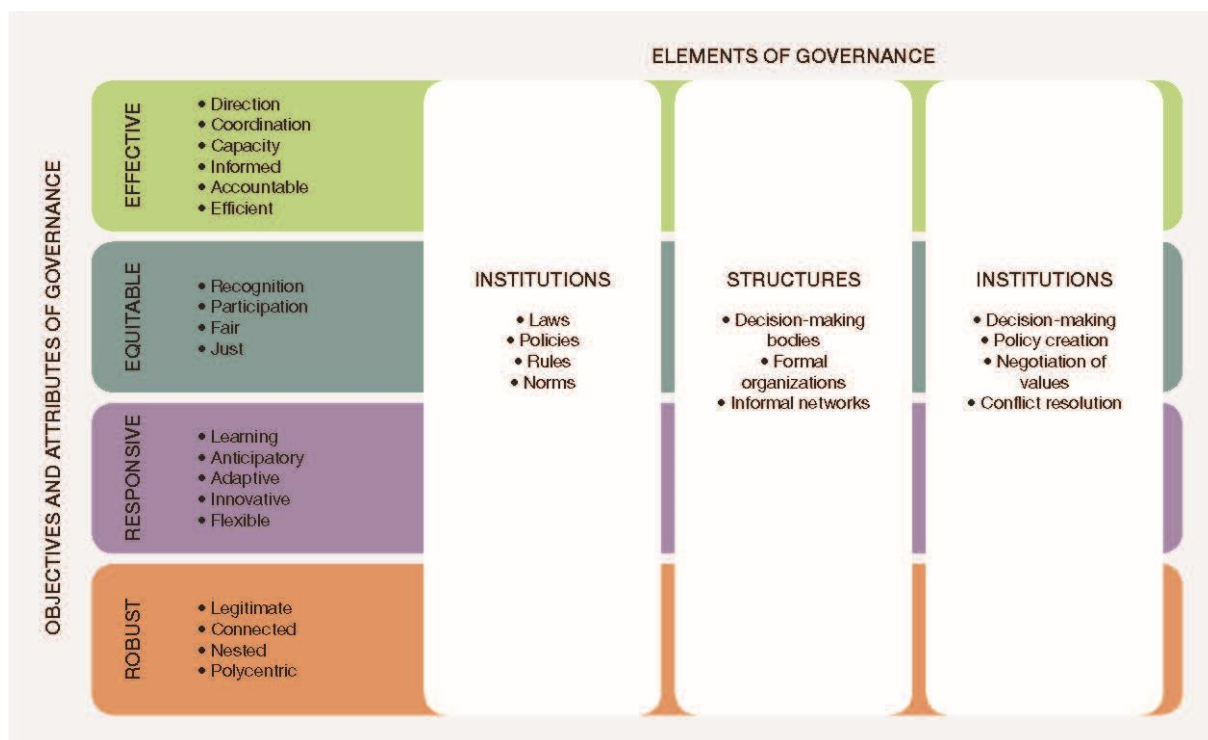


Figure 4.5 A practical framework for understanding the objectives, attributes, and elements of environmental governance. Source: Bennett and Satterfield (2018) under license [CC BY-4.0](https://creativecommons.org/licenses/by/4.0/).

Institutions, structures and processes of environmental governance are among the most important drivers of the use of wild species. They are equally critical mediators of how other drivers (e.g., climate change) influence use. Institutions are commonly defined as the ‘rules of the game,’ norms, values and procedures which shape human interactions with nature (Brechtin et al., 2003; McCay & Jentoft, 1996). They can give rise to compliance or resistance. An important question guiding the analysis of the evidence presented in this section is what are the characteristics of good governance regarding the use of wild species? In other words, what governance arrangements protect or contribute to sustainable use?

Institutions that operate from the local to a global level and comprise formal arrangements (e.g., laws, regulations, treaties) are also referred to as statutory or *de jure* governance arrangements. In contrast, informal arrangements (e.g., social norms, taboos, sanctions) with informal institutions are referred to as customary or *de facto* governance arrangements (North, 1991). Institutions can be seen as different (in)formal regimes and coalitions for collective action and inter-agent coordination, ranging from public-private cooperation and contracting schemes to organizational networking and policy arrangements (Geels, 2004; Teisman & Klein, 2000).

Policies are defined as those deliberate and specific principles that guide decisions or express a specific intent; like laws, they are implemented through specific policy instruments, procedures and mechanisms, the outcomes of which are measured against the original intent. Environmental policy focuses on problems arising from human impact on the environment (Schelly & Banerjee, 2018). For this chapter, processes refer to the various kinds of negotiated relationships and interactions between actor groups and how they lead to solving a problem or conflict of sustainable use. A variety of synthesis work related to environmental governance points to various success factors or design principles Box 4.1. (Armitage et al., 2011; Bennett & Satterfield, 2018; Lemos & Agrawal, 2006).

Box 4.1 Success factors for governance systems in managing the use of wild species

- Is there a good fit between the scale of the rule system and the scale of the use issue? Is there coordination within and between different systems of rules (across geographic scales) and between formal and informal rule systems (e.g., customary law of indigenous peoples and local communities)?
- Can rule systems respond to variability in patterns of wild species use? Are the rule systems adaptive and flexible (not rigid)?
- Do the rule systems include mechanisms of ongoing learning (i.e., monitoring)?
- Are the rule systems based on science and other kinds of knowledges of stakeholders and indigenous peoples and local communities dependent upon wild species?
- Are the rules seen as legitimate and enforceable?
- Are there diverse stakeholders engaging in rulemaking?
- Are the rule systems considered just (able to address inequities in the benefits of use and manage conflicts between different users)?

Much about governance arrangements, and their success in addressing questions of sustainable use, hinges on property rights associated with the species and its ecosystem,

including its definition as public, private, club, or commons. Most wild species globally are framed as commons, others as a public good, with fewer defined as club goods or private property. While a *defacto* position of governments is to enclose wild species that exist as a common and govern use like other kinds of public or private goods, this is not feasible. Different types of institutions (pluralism) are needed for different kinds of resources and in various types of property rights contexts (Ostrom 2009).

4.2.2.2 Formal, statutory governance arrangements

Key messages:

- A growing number of formal laws and policies supporting sustainable use have been developed among nation-states and at regional scales that facilitate sustainable use. Most of these laws relate to large fauna and timber, with more limited laws and policies related to smaller fauna and flora.
- Formal governance systems do not commonly account for indigenous peoples' and local communities' values of biodiversity but tend to support privatization and commercialization.
- Many policies governing wild species use are weak (lacking clarity in institutional responsibility). Many also lack legitimacy and are difficult to enforce due to a lack of engagement and consultation with stakeholders (mainly rural communities). Lack of coordination among different policies (which can sometimes conflict) compounds the challenges of legitimacy and enforcement.
- Pluralistic approaches that account for the diverse values and uses of wild species can be more effective in supporting and nurturing norms and practices of sustainable use.
- In cases where multiple institutions have been unsystematically developed (in an adhoc fashion), some ambiguities and conflicts complicate understanding and compliance with the “rules” of sustainable use.
- Pluralistic approaches that draw upon international and national policy frameworks and laws, and integrate customary law and local practices, are the most effective for supporting and promoting the sustainable use of wild species. This requires ensuring that conflicts and overlapping mandates are avoided and coordination and complementarity encouraged.
- Institutions that embrace science and indigenous and local knowledge in how they are designed and implemented are more effective in that they match ecological and socio-economic conditions; ongoing monitoring and evaluation of the effectiveness of institutions and their sensitivity to variabilities and changes in ecosystems and society also produce more sustainable outcomes.
- However, laws regulating wild species are often of poor quality, lack clarity in institutional responsibilities, do not result in participatory processes, engagement and consultation with stakeholders, particularly rural communities, are not coordinated with other measures, and are not implemented. This limits their effectiveness.

4.2.2.2.1 International agreements and conventions

Since at least the late 1800s and increasing regularity in the past half century, countries have negotiated hundreds of international legal agreements to address environmental problems they cannot resolve alone” (Mitchell, 2003). Some of these agreements pertain to the sustainable use of wild species. International agreements are defined here as legally binding arrangements among two or more states (e.g., treaties, conventions, accords, or modifications of such structures) (Aust, 2013).

The Convention on Biological Diversity is among the most relevant to this assessment, as its core objective is to facilitate sustainable use: “... the conservation of biodiversity, the sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilization of genetic resources...” (CBD, 2020). According to the Convention, member states must “as far as possible and as appropriate, adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity” (CBD 2020, Article 11).

The Convention on Biological Diversity implementation has been enlivened by creating targets, guidelines and principles to conserve biodiversity. The Aichi Targets aim to “reduce the direct pressures on biodiversity and promote sustainable use”; a key factor and mechanism in consideration is poverty reduction (CBD, 2020). These targets, however, have not been easy to reach for many member states, as indicated by the IPBES Global Assessment (IPBES, 2019a). This may be due to ambiguity in, and excessive complexity of, the targets and a lack of appropriate and quantifiable measures for tracking progress, as well as a lack of political will to make the necessary changes in the management and policy (Butchart et al., 2019).

Strategies to achieve these targets developed by some nation-states include a range of formal and top-down approaches aimed at planning, education and monitoring. The targets that are anticipated to be met or exceeded include Target 11 (Protected Areas). “Recent analysis shows that if national commitments are implemented as proposed, global protected area coverage will be on track to meet or exceed the 17% and 10% coverage targets for terrestrial and marine protected areas” (Bacon et al., 2019).

Part of the challenge in meeting Aichi Targets has been the limited availability of meaningful indicators and mechanisms for tracking progress. To date, none of the Aichi Targets have been met; the most significant progress has been made on Aichi Targets 1, 11, 16, 17, 19 (CBD, 2020).

Various efforts have been made to assess nation-state progress towards these targets. Although wealth (measured by the gross domestic product) may be a factor, “quality of governance” explains much of the variation in public and state investment in biodiversity conservation (Baynham-Herd et al., 2018) (Figure 4.6). Other analysis has revealed that greater engagement in developing national plans for achieving biodiversity (Target 17) does not correlate with greater gross domestic product (Whitehorn et al., 2019).

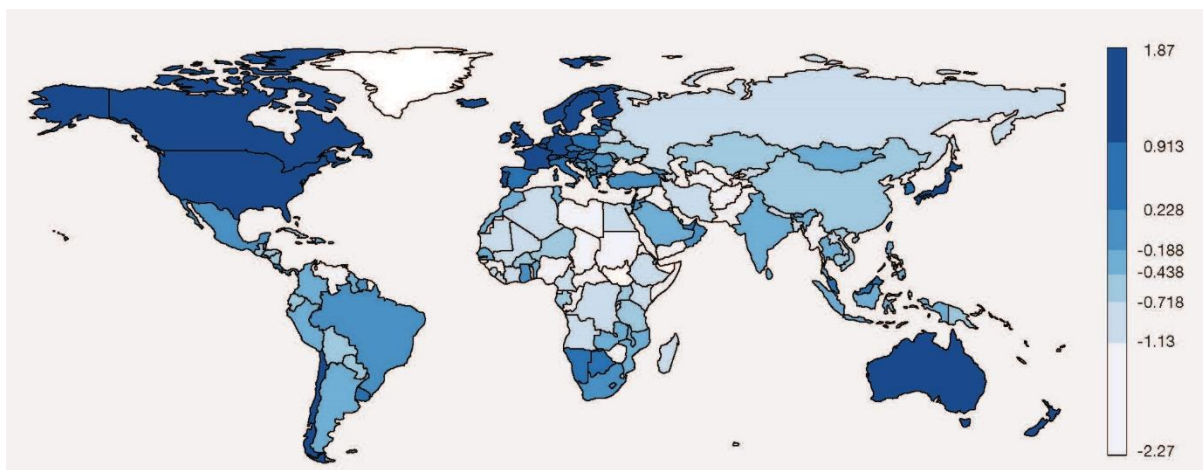


Figure 4.6 Global distribution of the World Bank’s worldwide governance indicators. *This map is directly copied from its original source (Baynham-Herd et al., 2018) and was not modified by the assessment authors. The map is copyrighted under license CC BY 4.0. The designations employed and the presentation of material on the maps used in the assessment do not imply the expression of any opinion whatsoever on the part of IPBES concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. These maps have been prepared or used for the sole purpose of facilitating the assessment of the broad biogeographical areas represented therein and for purposes of representing scientific data spatially.*

The Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity (CBD, 2004) challenges states to examine formal legal instruments for achieving these targets and customary law and traditions when drafting new legislation and regulations and creating cooperative and supportive linkages between all levels of governance. Throughout, the principles address drivers and causes of unsustainable use, including deficient policy frameworks, lack of respect for the rights and stewardship of local communities (Principle 2), market distortions (Principle 3), the need for integrated and interdisciplinary research and participatory approaches (Principles 6 and 9), and the need for more effective education and public awareness programs on sustainable use (principle 14). The Convention on Biological Diversity process, in turn, spurs national governments to draft legislation to implement commitments under the Convention on Biological Diversity and creates a forum for dialogue and global decision-making relating to biodiversity conservation and the sustainable use of its components. It is recognized that both top-down (e.g., statutory laws) and bottom-up approaches (i.e., informal and customary institutions) are needed and should work together to achieve the targets of sustainable use as in the Convention on Biological Diversity.

Box 4.2. New Zealand National Targets to Enhance Implementation of the Convention on Biological Diversity: “Whanau, Hapu and Iwi are Better Able to Practices their Responsibilities as Kaitiaki” (Related to Aichi Target 1, 18)

Māori have a strong interconnection with their natural environment governed by the cultural ethic of kaitiakitanga (guardianship). This ethic confers obligations on whānau (family), hapū (sub-tribe) and iwi (tribe) (collectively tangataTangata whenua) to steward biodiversity as articulated as taonga

(treasures), including species of indigenous flora and fauna, wai māori (freshwater), wāhi tapu or wāhi taonga (treasured or sacred sites), and whenua (land). The Treaty of Waitangi settlement process has been one part of this assessment, with settlements achieved with 86 groups to date. New Zealand Government engagement with Māori through the relationships supported by these settlements has shown that tangata whenua have worked proactively to lead locally based and culturally monitored conservation projects and indigenous biodiversity protection. For example, Waikato- Tainui fisheries bylaws, effective from 2014, will continue to support sustainable fishing practices and native eel migration while recognizing traditional management practices. The Manaaki Tuna Project (supported by the Waikato River Clean-up Trust) is a completed multi-year project to gather and preserve Waikato-Tainui histories associated with the Waikato River. Tracking the implementation is being done through several quantitative and qualitative indicators (e.g., with the intellectual property being held by tangata.

Sources: Department of Conservation (2019)

Although highly problematic and efforts to meet associated targets are opaque in many jurisdictions, the Convention on Biodiversity remains a critical tool for signaling the importance of biodiversity conservation and sustainable use of wild species.

The Convention on the Conservation of Migratory Species of Wild Animals (CMS) provides a global platform for the conservation and sustainable use of migratory animals and their habitats. The Convention brings together the States through which migratory animals pass, the Range States, and lays the legal foundation for internationally coordinated conservation measures throughout a migratory range. The aim of the Convention on the Conservation of Migratory Species of Wild Animals is the long-term conservation of migratory species that cross international jurisdictional boundaries in the course of their migration. It has been negotiated with the primary objective to endure the coordinated management of migratory species shared by multiple states. While the convention does not focus on harvest per se, it includes provisions that influence the possibility of species used by Parties, e.g., about taking of species listed in its Appendix I. The Convention also acts as a framework convention, under which tailored multilateral agreements on individual species or groups of related species can be negotiated at regional or global levels. The Convention includes animals of the following classes: Mammalia, Aves, Reptilia, Actynoptergii, Chondrichthyes and Insecta.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which came into effect in 1975, was developed to ensure international cooperation for protecting certain species of wild fauna and flora against overexploitation through international trade. CITES has 183 contracting Parties (www.cites.org accessed 30 April 2021) and it regulates international trade in approximately 38,700 species, 85% of which are plants. Species are listed in one of three appendices with approximately 3% of species (~1,100) included in Appendix I, 97% of species (~37,400) are included in Appendix II, and ~240 species are listed in Appendix III. The appendices have different legal implications and give different protection status as follows:

- Appendix I includes those species threatened with extinction which are or may be affected by trade. Trade in specimens of these species is subject to particularly stringent regulation and can only be authorized in exceptional circumstances. Commercial trade in wild sourced specimens is prohibited.

- Appendix II includes those species, which may become threatened with extinction unless trade in specimens of such species is regulated to avoid utilization incompatible with their survival. It may also include closely related species that must be regulated to make enforcement easier, sometimes referred to as ‘look alike’ species. Commercial trade in these species is allowed if it is not detrimental to the survival of the species.
- Appendix III includes species that any Party identifies as needing regulation within its jurisdiction to prevent or restrict exploitation and which require the co-operation of importing Parties to regulate trade.

CITES aims to protect wild species from over-exploitation associated with international trade and avoid utilization incompatible with their survival (Hutton & Dickson, 2000). Although CITES is not *per se* a treaty to promote the sustainable use of wildlife (OECD, 1997), the CITES vision 2008-2020 aimed to “Conserve biodiversity and contribute to its sustainable use by ensuring that no species of wild fauna or flora becomes or remains subject to unsustainable exploitation through international trade” (Wijnstekers, 2018). Similarly, the vision for CITES post-2020 is that “by 2030, all international trade in wild fauna and flora is legal and sustainable, consistent with the long-term conservation of species, and thereby contributing to halting biodiversity loss, to ensuring its sustainable use, and to achieving the 2030 Agenda for Sustainable Development” (CITES CoP 18.3, 2019). The effective implementation of CITES would therefore be expected to act as a driver for more sustainable levels of use and trade as well as the adoption of practices and processes that ensure greater levels of sustainability. This should be true for all species listed in CITES Appendices but could also be a more general driver for ensuring that the use of wild species is sustainable by raising awareness of the extent and impacts of trade in wild species, the provision of tools and resources, promotion of institutions to ensure sustainable use, and adoption of more sustainable practices by affected industries. The purpose of this section is to assess the evidence for CITES acting as a driver of more sustainable levels of use of wild species. Discussion of CITES as a policy tool and options for better governance of trade in wild species is provided in Chapter 6.

The assessment included evidence in the period from 1985-2021. CITES came into effect in 1975, so the period being assessed allows ten years from inception for the resolutions and decisions of CITES to take effect. The assessment relied extensively on information curated by CITES (www.cites.org), which includes all formal documentation, information documents, reports and links. To assess independent sources of evidence, an initial search was undertaken using the Web of Science in the period 1985-2021 for “Convention on International Trade in Endangered Species” OR “CITES. This yielded 416 publications. For additional analysis on non-detrimental findings, the search comprised terms “non-detriment* finding” OR “NDF” AND “CITES,” and the search was conducted in Google Scholar and Web of Science. Additional sources of evidence were obtained from the reference lists of these publications and CITES information documents and resources accessed from the website (www.cites.org).

- **Convention on International Trade in Endangered Species of Wild Fauna and Flora as a driver for more sustainable practices**

CITES adopted a series of indicators to measure progress with the vision 2008-2020 (CITES Strategic Vision 2008-2020, Notification 2015/032 Annex 2). Several of these indicators are

appropriate for the assessment of CITES as a driver, particularly those that measure progress with laws, institutions and tools to ensure that trade in wild species is sustainable and those that measure outcomes for the species regulated under CITES.

In terms of improving laws, institutions and tools, CITES require all contracting Parties to put in place appropriate legislation and institutions to implement the Convention, including separate Management and Scientific Authorities. One of the primary roles of Scientific Authorities is to assess risks associated with trade and determine that trade is not “detrimental to the survival of that species” (Article III, 2 (a), 3 (a), 5(a); Article IV, 2 (a), 6 (a)) and “maintains that species throughout its range at a level consistent with its role in the ecosystems in which it occurs” (Article IV, paragraph 3). These are consistent with the ecological dimensions of sustainable use identified in Chapter 2. As a result, the increase in Parties to CITES from 85 to 183 should have resulted in the establishment of institutions and governance systems to ensure the use of wild species is more sustainable. Parties to CITES vary in the extent to which they have appropriate legislation and institutions, reported in 2019 as 32 (17%) with legislation that does not support the implementation of CITES, 43 (23%) with legislation that only partially supports the implementation and 101 with legislation and institutions required to fully implement CITES (CITES CoP 18 Doc. 26 (Rev 1) 2019). This means that the systems to ensure more sustainable use have been strengthened as a result of CITES, at least in the 55% of Parties who are fully compliant with CITES and to a lesser extent in the 23% that are partially compliant. The remaining levels of non-compliance weaken the role of CITES as a driver of the more sustainable and legal use of wild species.

A further question is whether non-detrimental findings in all these countries have been implemented in a way that promotes more sustainable practices or levels of harvest and trade. CITES Resolution Conf 16.7 rev. CoP 17 emphasizes that non-detrimental findings should be based on the best available science, and guidelines for non-detrimental findings have been periodically refined through workshops and working groups to support this objective (Smith et al., 2011). General guidelines for non-detrimental findings (Rosser & Haywood, 2002) have included guidance and templates to assess the impacts of harvest and trade based on biological attributes of the species together with information on population status, management and controls, protection, and levels of trade. Further guidance has been developed at least for trees (Wolf et al., 2018), perennial plants (Wolf et al., 2016), sharks (Mundy-Taylor et al., 2014), aquatic invertebrates, and snakes (Natusch et al., 2015) and case studies have been compiled for more than 60 taxa comprising all the major plant and animal groups regulated under CITES (www.cites.org/eng/prog/ndf/index.php). The literature review in Google Scholar identified 327 publications referring to non-detrimental findings, of which 238 dealt with taxon specific information and a further 99 dealt more generally with non-detrimental findings. The templates and tools, therefore, exist to support the implementation of non-detrimental findings for the ~ 37 420 species regulated under Appendix II of CITES.

The levels of uptake and application of non-detrimental findings standards are harder to assess. Two of the indicators for the implementation of the CITES Strategic Vision 2008-2020 were (i) the number of Parties that have adopted standard procedures for non-detrimental findings, and (ii) the number of surveys of CITES listed species undertaken by exporting States to support non-detrimental findings (CITES 2015). These metrics can provide critical insights into how non-detrimental findings are being implemented. However, although all Parties have

to undertake non-detrimental findings and are supposed to report against the agreed indicators, there is no global summary record of progress with these indicators (CITES Secretariat, March 2021). A report compiled for the European Commission (Musing & Shiraishi, 2019) noted that 20 member States had undertaken surveys of the population status of at least some CITES listed taxa, five had undertaken studies of trends and impacts of trade on Appendix II species, and three had published the non-detrimental findings undertaken for CITES taxa. These limited data are insufficient to allow any assessment of the standards being applied to non-detrimental findings nor whether the application of non-detrimental findings has had positive outcomes for the affected species.

One indicator from the CITES Vision 2008-2020 that does measure the potential impact of non-detrimental findings as a driver of more sustainable levels of use, is “the number of Appendix-II species for which trade is determined to be non-detrimental to the survival of the species as a result of implementing recommendations from the Review of Significant Trade.” The Review of Significant Trade in specimens of Appendix II species (CITES Resolution Conf 12.8 (Rev CoP18), was designed to identify Appendix-II listed species that may be subject to unsustainable levels of international trade, i.e., where non detrimental findings may be failing to achieve their objective. The process involves monitoring recorded levels of trade in Appendix II species over five years and identifying species for further analysis based on various risk factors, specifically their threat status, high volumes in trade, a sharp increase in trade or increasing levels of trade. These species are then subjected to additional review and input from Range States to determine whether trade is sustainable and conforms to Article IV of the Convention. If trade in these species and from specific countries is deemed to not comply with Article IV, this can result in recommendations to strengthen the capacity of states to ensure sustainable use or to sanctions such as trade suspensions until the trade is compliant. The number of country-species combinations subject to recommended actions due to significant trade reviews varies between years. Between 1975 and 2000, there were 138 recommendations arising from the review of significant trade (RS process (IUCN, 2000), and, in 2020, suspensions were in force for trade in 41 species from 19 countries as a result of the review of significant trade.

In some cases, species have been subjected to repeat reviews due to concerns about unsustainable trade such as the grey parrot, *Psittacus erithacus*, which was included in the review of significant trade in 1988, 1992, 2006 and 2014 (VKM, 2020). Given that there are 37 420 species on CITES Appendix II, which would all be eligible for review if there were concerns about levels of trade, the implication is that trade in the vast majority of taxa is regarded as sustainable within the limits of what is assessed and monitored by CITES. However, a recent review on trade of seahorses (Foster and Vincent 2021) noted that implementation of the review of significant trade was failing to prevent trade that was not compliant with Article IV and was therefore failing in its primary mandate to ensure sustainable trade. They concluded that CITES needs to commit to more effective enforcement to improve the effectiveness of the review of significant trade, and this highlights the need for independent scientific assessments of the outcomes of CITES actions.

A further self-defining indicator of the success failure of non-detrimental findings as a driver of more sustainable use would be the uplisting of species or populations from Appendix II to Appendix I (IUCN, 2021). Between 1976 and 2020, approximately 460 species, subspecies

or populations/stocks were uplisted from Appendix II to Appendix I (counted here as the taxon specified in the proposal at the time of uplisting) (data from CITES Secretariat based on records compiled by UNEP-WCMC). The uplisting implies that efforts to bring trade in wild specimens to sustainable levels under an Appendix II listing were deemed inadequate. An example is the grey parrot, with a trend from repeat reviews and trade suspensions (noted above), finally leading to uplisting to Appendix I in 2016. In contrast, species of pangolin (*Manis spp.*) were uplisted in 2016 in response to rapid increases in trade volumes and did not follow problems identified with non-detrimental findings. Overall, the number of uplistings from Appendix II to Appendix I remains low relative to the many species listed in Appendix II. The number of uplistings has also declined over time, with 180 taxa uplisted from 1976 to 1994 compared to only 52 from 1997 to 2019. This implies that there might have been uncertainty about the appropriate Appendix in which to list species and that the processes established to ensure sustainable use of Appendix II species were starting to have an impact. It is also worth noting that taxa uplisted from Appendix II to Appendix I are not a random subset of those listed in Appendix II -cacti make up 52% of all plants uplisted, with a further 34% comprising succulent plants; tortoises and turtles make up 61% of all reptiles uplisted and Psittaciformes (including macaws, parrots, cockatoos) comprise 67% of uplisted birds. Uplisting of mammals have been less dominated by particular taxa, with marine mammals, bats, cats (Felidae) and primates all comprising between 13% and 19% of uplisted taxa. The predominance of certain taxa in uplistings indicates particular challenges with sustainable use of these taxa.

Less formalized processes for monitoring the standards of non-detrimental findings include interactions between the Scientific Authorities of importing and exporting countries where the Scientific Authority of an importing country can request evidence relating to non-detrimental findings from an exporting country or undertake their own assessment. There is no centralized record of such requests, so it is impossible to assess the number of species or trade events where such requests have been made. However, a good example is the European Commission Scientific Review Group (https://ec.europa.eu/environment/cites/srg_en.htm) which reviews evidence of sustainability for imports of wild species and compliance with the conservation requirements of Council Regulation (EC) No 338/97. These determinations may require exporting countries to provide additional evidence to show sustainable use. Again, there have been only a relatively small number of adverse findings given the volumes of species in trade, indicating that non detrimental findings are mostly regarded as being of an adequate standard to ensure sustainable levels of use.

The search for literature regarding CITES and non-detrimental findings yielded only seven publications from Web of Science and 327 from Google Scholar, partly reflecting a greater representation of publications in non-peer-reviewed literature. This is partly to be expected, given that non-detrimental findings are designed for regulatory purposes and are not necessarily intended for publication in scientific journals. Nevertheless, the literature search yielded only a small number of publications testing the outcomes of non-detrimental findings, and this represents a data gap given the importance of non-detrimental findings for promoting more sustainable use and achieving the objectives of CITES.

- **Convention on International Trade in Endangered Species of Wild Fauna and Flora as a driver for sustainable and legal trade**

As noted in previous assessments and reviews (Challender et al., 2015; IUCN, 2000), it is difficult to identify specific indicators to determine how CITES has contributed to sustainable use of wild species. Many indicators identified in previous studies measure inputs, (e.g., the number of Parties with increased capacity), or outputs (e.g., Parties that have implemented relevant resolutions and decisions) (CITES, 2015, notification 2015/032). These indicators are more about the operations and processes. To measure the impact of CITES on the sustainable use of wild species, other indicators related to the harvest and trade of species listed as threatened or endangered would be needed (Challender et al., 2015; Felbab-Brown, 2017; Foster & Vincent, 2021; IUCN, 2000).

One possible outcome of CITES listing and processes could be a reduction in the overall trade in wild species. The intention of listing species on CITES Appendix I is to halt commercial trade in wild-sourced specimens, so a reduction in trade in wild-sourced specimens would be the expected outcome for these species. The intention of listing a species in Appendices II and III is to ensure that trade from wild sources does not threaten the survival of the species in the wild. This does not necessarily equate to a reduction in use or trade. Nevertheless, CITES could act as a driver for reduced trade due to the greater regulation of trade from wild sources and increased scrutiny of the evidence that trade is sustainable.

A comprehensive analysis of CITES trade over 40 years showed that overall volumes of international trade in listed species increased from ca. 9 million ‘whole organism equivalents’ (WOE) per year between 1985 and 1995 to 100 million ‘whole organism equivalents’ per year between 2004 and 2014 (Harfoot et al., 2018). Although this suggests an increase in trade, the data refer to CITES trade records and need to take into account the dynamic nature of these data (Robinson & Sinovas, 2018). Specifically, the increasing trend in trade does not take into account the addition of new Parties to CITES nor the listing of new species. These factors can contribute to increased records of trade without any actual change in trade volumes (Robinson and Sinovas 2018). For example, the number of CITES Parties increased from 85 to 180 between 1985 and 2014, with 107 and 175 Parties at the midpoint of each review period, respectively (www.cites.org). This represents an increase of between 63% and 111%, so the rise in reported volumes of trade might be explained by an increase in reporting from other Parties rather than an actual increase in trade.

Similarly, changes in the number of taxa listed in CITES also affect any assessment of changes in trade volumes. They are also more challenging to interpret due to the listing of higher-level taxa (genera, families) where the number of species is not specified. Even if the overall number of species in trade has not changed by the same order of magnitude as the change in trade volumes, the listing of highly traded taxa, such as sharks, can lead to a substantial increase in the ‘whole organism equivalents’ being reported. On the whole, it is difficult to determine whether the overall increase in ‘whole organism equivalents’ from 1985 to 2014 represents an actual increase in the trade volume for CITES listed species.

Evidence from specific taxa provides a more nuanced perspective on whether CITES is a driver for reduced use of wild species. Studies have shown a reduction in recorded trade in specific CITES listed taxa for some species, in some regions, and for specific periods. Reduced volumes of trade have been recorded for the following taxa: birds globally since 2005 (Harfoot et al., 2018); birds in Southeast Asia (Harfoot et al., 2018; Shepherd, Leupen, et al., 2020) and Australia (Vall-Ilosera & Cassey, 2017); live reptiles from 2001 to 2012 (Robinson et al., 2015);

snakes (especially pythons) from 2002-2017 (Hierink et al., 2020); tortoises and freshwater turtles from Asia (Luiselli et al., 2016); some mammal species, although the trends are less clear (Harfoot et al., 2018; Nijman, 2010); bear trade in the Czech Republic (Shepherd, Kufnerova, et al., 2020); and African rosewood (*Pterocarpus erinaceus*) following listing on CITES Appendix II (Dumenu, 2019a).

Trends in trade are not always unidirectional. They often reflect changes in markets for wild species products and can include unintended consequences of CITES decisions. The causal factors for these shifts can be highly contested and are typically counterfactual, such as whether once-off sales of ivory in 2008 triggered an increase in illegal trade (Orenstein, 2013; Underwood et al., 2013). The recorded reduction in levels of trade across various groups may be attributable to CITES and associated national legislation (Harfoot et al., 2018; Shepherd, Leupen, et al., 2020). However, reduced trade can also result from other actions such as bans on the import of birds as a measure to contain the spread of avian influenza (Challender et al., 2015; Harfoot et al., 2018; Vall-Ilosera & Cassey, 2017). There are many factors affecting levels of harvest and trade (Challender et al., 2015; Sas-Rolfes et al., 2019) and, as noted by Underwood et al. (2013) “to understand the impact of these and other CITES decisions, it is necessary to identify hypotheses linking them with trade dynamics. Because CITES decisions are implemented in a constantly changing, complex socio-economic environment, a full causal analysis is required to consider all other potential trade drivers and their interactions along the trade chain. Without this comprehensive analysis, the impact of an individual driver may be confounded with the effects of other drivers”. Nevertheless, the decline in trade across a range of CITES listed taxa supports the conclusion that these outcomes have been driven at least in part by CITES decisions and associated national regulations.

A second trend that could be strongly influenced by CITES is a change away from trade in wild-sourced specimens. There has been a significant shift over the past 40 years from wild harvested specimens to animals that are claimed as captive bred and plants that are artificially propagated. This shift is especially evident for mammals, birds, reptiles, invertebrates and plants (Harfoot et al., 2018; Hierink et al., 2020; Hinsley et al., 2018; Li & Jiang, 2014; Nijman, 2010; Robinson et al., 2015; Setlikova & Berec, 2020; Vall-Llosera & Su, 2019). It should be noted that consistency across these publications is mainly because they all use the same CITES Trade Database, which is the official source of CITES data. However, some independent data sources also reflect a large proportion of trade from captive sources (Marshall et al., 2020). It is not always possible to attribute these shifts away from wild-sourced specimens to a listing on CITES Appendices because captive breeding and artificial propagation can also be driven by other factors such as the need for more consistent supply, better quality, or control of the supply chain (Harfoot et al. 2018; Kasterine and Lichtenstein 2018). An upward trend in the number of species being captive bred and the number of breeding facilities was recorded from 1960 (IUCN, 2000), and thus precedes CITES. Still, the trend has continued since 1975, with more species affected and a greater number of facilities. The number of facilities registered with CITES for captive breeding of Appendix I animals increased from 59 in 16 countries in 1997 to over 400 in 34 countries in 2021 (www.cites.org). The number of species registered for captive breeding has also increased from 16 to 34. For these species, there is a definite link to CITES because commercial trade from wild sources is prohibited.

The shift from wild sourced to captive, or artificially propagated sources, is expected to reduce unsustainable harvest levels from wild populations. The counterfactual evidence indicates that current trade volumes for many species would not be sustainable without specimens sourced from captive or artificially propagated sources. The data presented by Harfoot et al. (2018) shows a consistent decline in the rate of wild-sourced specimens, especially for reptiles and plants, and to a lesser extent for birds, invertebrates and mammals. More specific evidence for taxa such as crocodiles shows positive outcomes for wild species when trade is directed towards specimens from captive populations (Jenkins et al., 2004). However, captive breeding and artificial propagation do not always have positive outcomes. The potential benefits can be undermined by the possible laundering of wild-sourced specimens into trade under the guise of captive breeding (Lyons & Natusch, 2011; Martin, 2018; Nijman et al., 2018). In some taxa, there has also been continued unsustainable trade in wild-sourced specimens despite captive-bred or artificially propagated alternatives either due to demand for specimens with wild provenance or characteristics, e.g., orchids (Hinsley et al., 2018) or because it is still relatively easy to source specimens from the wild, e.g., parrots (Ribeiro et al., 2019) or because of weak enforcement. There is no synthetic review of the evidence, so it is not possible to assess the extent to which this undermines the intended benefits. An unintended outcome of shifts to captive breeding and artificial propagation is that it concentrates trade among the few actors who have the technology and capital to engage in these practices. This may exclude local communities with negative consequences for social equity, as well as sustainable livelihoods and conservation programs linked to wild populations in developing countries (Coconier & Lichtenstein, 2014; Cooney & Jepson, 2006; Roe, 2006; Roe et al., 2009).

A clear indicator for CITES acting as a driver of legal and more sustainable levels of harvest and trade would be an improvement in the conservation status of those species subjected to unsustainable international trade. One way to measure this is by using the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, where resource use is listed as a threat. For birds and mammals on the IUCN Red List, and listed in CITES Appendices, 84% of those listed in Appendix I and 76% of those on Appendix II had decreasing population trends (IUCN Red List 2021). The population trend data should be complemented by the Red List Index (Butchart et al., 2007), which provides a more composite index for tracking changes in the conservation status of groups of species. A Red List Index analysis specifically for species listed on CITES is not yet available. Nevertheless, other assessments of utilized species provide some insights into the impact of measures to address unsustainability levels of harvest and trade.

The Red List Index for all fully assessed species where international trade has been documented (www.iucnredlist.org/api/v4/rindex/image/988730) shows an ongoing decline in status from 1996 to 2020 without any evidence of an upward inflection that would indicate successful interventions. The rate of decline in the Red List Index for species in international trade is steeper than for all terrestrial species combined but comparable to the rate of decline for marine species. A more detailed assessment of the impact of conservation measures on the status of the world's vertebrates, using Red List Index for all data-sufficient species (Hoffmann et al., 2010), concluded that efforts to address exploitation (hunting) had limited positive impacts on the conservation status of affected mammal species between 1996 and 2008 (62 species deteriorated, six improved) but better results for birds from 1988 to 2008 (31

deteriorated, nine improvements). Separate analyses for birds (Butchart, 2008) and parrots (Olah et al., 2016) also show ongoing declines in the Red List Index for species in trade.

There are several caveats to using the available Red List and Red List Index data to assess the impact of CITES. The first is that Red List Index data refer to all utilized species and not only those listed in CITES. The second is that few, if any, species are only traded internationally, and many species listed in CITES are also traded domestically and not under regulation through CITES, e.g., bears (*Ursus* sp.) in Japan (Mano & Ishii, 2008), songbirds in Indonesia (Nijman et al., 2018), orchids in Vietnam (Bullough et al., 2021) and pangolin in Africa (Mambeya et al., 2018). Third, in most cases, utilization is not the only driver leading to decline, and it is often not possible to separate the effects of conservation measures aimed at use and trade. Analyses of birds (Butchart, 2008) and parrots (Olah et al., 2016) show that species in trade have continued to decline, but the more significant impacts of habitat loss make it difficult to determine the actual trend linked only to use and trade. A further example is reef-forming corals, where substantial decline in the Red List Index due to a coral bleaching event in 1998 obscured most other factors affecting the status of corals, including localized impacts associated with unsustainable use (Carpenter et al., 2008). Given these caveats, the general conclusion is that these higher-level analyses show limited evidence for positive changes to the conservation status of species affected by trade.

A review of the effectiveness of CITES (IUCN, 2000) noted the success of reducing unsustainable trade in furs from spotted cats and non-human primates. These were regarded as successful because they acted in conjunction with other interventions, such as media campaigns to end the use of furs. The report noted far less successful outcomes for rhino and many plant species. Additional literature on CITES listed taxa includes camelids (Kasterine & Lichtenstein, 2018), eels (Nijman, 2015), manta rays (Booth et al., 2020), orchids (Hinsley et al., 2018; Phelps & Webb, 2015), parrots (Martin, 2018), reptiles (Robinson et al., 2015), sea horses (Foster et al., 2016; Kuo & Vincent, 2018), snakes (Hierink et al., 2020), sturgeon (caviar) (Doukakis et al., 2012), as well as population studies for species where trade impacts should have declined - CITES for example, cycads (Okubamichael et al., 2016), and elephants (Chase et al., 2016). These studies present mixed outcomes associated with CITES, with some taxa showing strong recovery related to CITES such as vicuna (Kasterine & Lichtenstein, 2018) and crocodiles (Jenkins et al., 2004), others showing positive trends (e.g., manta ray and sea horses) (Booth et al., 2020; Kuo & Vincent, 2018). Others show ongoing declines despite being listed in CITES, such as African elephant (Chase et al., 2016) and African cycads (Okubamichael et al., 2016).

An important question regarding the role of CITES as a driver of legal and sustainable use is the extent to which unsustainable legal trade is replaced by unsustainable illegal trade without actually reducing the impact on the target species. Trade is typically regarded as illegal when it violates procedures and laws (Felbab-Brown, 2017) so listing a species in Appendix I of CITES makes commercial trade in wild-collected specimens illegal. Trade in species listed in Appendix II would also be unlawful if it does not comply with CITES conditions. There is evidence across many taxa for ongoing and often significant illegal trade in wild-collected specimens (UNODC, 2020); specifically for rhinoceros (Chapman & White, 2021; Emslie et al., 2016; le Roex & Ferreira, 2020), pangolin (Dumenu, 2019b; S. Heinrich et al., 2016; Kukrety et al., 2013; Nijman & Shepherd, 2021), reptiles (Auliya, Altherr, et al., 2016; Luiselli et al., 2016), big cats (IUCN, 2014; Morcatty et al., 2020; UNODC, 2020), cycads (Okubamichael et

al., 2016), orchids (Phelps & Webb, 2015), birds (Hinsley et al., 2018), sea horses (Foster et al., 2016; Kuo & Vincent, 2018), corals (Petrossian et al., 2020), sharks and rays (Friedman et al., 2018) and elephant ivory (Burn et al., 2011; Huang et al., 2021; Underwood et al., 2013a). Almost all species with high commercial value and where there is continuing demand appear to be subject to ongoing illegal trade.

Illegal trade is sometimes regarded as an issue of national-level implementation of CITES and not a problem of the Convention itself. However, since CITES can only be implemented through the actions of contracting Parties, the intention to achieve legal and sustainable trade depends on the capacity of Parties to develop and enforce supporting legislation. To prevent illegal trade, CITES requires Parties to exercise administrative control over trade for an increasing number of species, and it has been argued that many developing countries are unable to achieve the expected level of control (Chitov, 2019). This is compounded by a lack of appropriate institutions, corrupt officials, and the involvement of transnational crime networks (Dinerstein et al., 2007; McCusker, 2006; Rosen & Smith, 2010).

It is not possible in the scope of this chapter, to assess the capacity of Parties to implement CITES, but the evidence from other forms of illicit trade indicates that it requires considerable capacity and resources to counter illegal activities spanning the supply, transshipment and demand components of trade (Felbab-Brown, 2017). There is consistent evidence that unsustainable and illegal trade in wild species is a complex socio-ecological problem (Challender et al., 2015; Phelps et al., 2016; Roberts & Hinsley, 2020; Symes et al., 2018; 't Sas-Rolfes et al., 2019; TRAFFIC, 2008) and that the effectiveness of any measures to address illegal trade is highly contingent on local context (Felbab-Brown, 2017; Symes et al., 2018). The illicit economy for trade in wild species is poorly understood (Symes et al., 2018) and often poorly policed, except for a few charismatic species such as rhino and elephant ivory.

- **Unintended outcomes of Convention on International Trade in Endangered Species of Wild Fauna and Flora**

In addition to the evidence assessed above, two unintended consequences of CITES listing are briefly assessed.

Leakage and displacement: Listing a species can reduce trade in that species to sustainable levels but displace the trade to other similar species (i.e., which may be more abundant) or to other jurisdictions where there are less stringent controls. Displacement and leakage has been observed in several cases. For example, trade in eels (Nijman, 2015), where bans in Europe resulted in increased harvest and trade from Indonesia. Restrictions in trade in tiger products is one factor which has led to increased harvesting and trade in other species such as leopard, jaguar and lion (Morcatty et al., 2020; UNODC, 2020). Bans on trade in manta rays have increased harvest in areas with lower levels of enforcement (Friedman et al., 2018). A decline in trade in tortoises and freshwater turtles from Asia has been correlated with increased trade from the Nearctic region (Luiselli et al., 2016). The shift to other threatened species or less regulated regions requires an adaptive response to changing trade dynamics.

Increased demand: CITES decisions and the process used to list species have been identified as possible drivers of demand and trade. Proposals to list species on the Appendices are available at least 150 days before any decisions are taken and the listing process can take considerably longer if proposals are not accepted when they are first put forward. There is some

evidence for increased trade linked to the listing process, in which harvesters and traders acquire or offload stocks before listing and before restrictions come into place. This has been highlighted for earless monitor lizards, *Lanthanotus borneensis* (Janssen & Krishnasamy, 2018) and lion bone (Williams et al., 2017). The phenomenon of increased trade linked to impending restrictions has also been recorded for national-level regulations that are independent of CITES, e.g., a partial ban on the harvest of African cherry (*Prunus africana*), imposed by the government of Cameroon in 1991, resulted in the opportunistic and destructive harvest of twice the annual average amount of bark (Cunningham and Mbenkum, 1993). The limited evidence indicates that these are short-term spikes associated with the listing process, although they may negatively impact the affected species (Rivalan et al., 2007a).

A more contentious question is whether CITES listing decisions may drive increased demand and illegal trade. One argument is that when a species is moved from Appendix I to Appendix II, allowing legal trade, this stimulates demand (e.g., Orenstein, 2013), this demand may not always be met through lawful means, and this encourages illegal trade and laundering of illegally sourced specimens into legal trade networks. The counterargument is that CITES restrictions on the supply side of trade limit the availability of legally sourced specimens but fail to satisfy existing demand, resulting in illicit trade. The literature search provided limited evidence relating to this question. The studies focused primarily on issues such as the legalization of trade in rhino horn (Biggs et al., 2013; Crookes & Blignaut, 2015; Eikelboom et al., 2020) and bans on trade in elephant ivory (Conrad, 2012; Kurohata, 2020) (Orenstein 2013), but also includes analyses of laundering of wild-sourced specimens through captive breeding operations (Lyons & Natusch, 2011) and legal quotas (Daut et al., 2015). The evidence relating to key factors in these counterarguments, such as price elasticity, consumer behavior, and the dynamics of legal and illegal trade networks, is limited and often contradictory. For example, studies of the ivory trade in Japan showed that initial bans resulted in increased prices but did not reduce demand. In contrast, later interventions to raise awareness of the impact on elephant populations resulted in decreased demand (Kurohata, 2020). Studies of trade in wild meat (McNamara et al., 2016), succulent plants (Margulies, 2020) and more general trade in wild species (Symes et al., 2018) show how the drivers of trade are not straightforward and differ between species and regions. The evidence is insufficient to provide any clear findings and remains unresolved. Given the importance of this issue for the governance of the use of wild species, this is an area where further research is urgently required.

In summary, CITES has been an essential instrument for driving global action to ensure more sustainable use of species threatened by international trade and to strengthen institutions and tools to achieve this. It has been less successful when measured against outcomes for many species affected by unsustainable use levels. CITES decisions may not consistently achieve the desired outcomes because significant aspects of trade may occur outside of its scope of control. International trade is also not the only driver affecting many species. CITES decisions also does not address the underlying drivers of unsustainable and illegal trade both from the supply and demand side of trade.

Theoretical analyses of use systems have concluded that sustainable outcomes are more likely when the social and biological components are understood and included in the decision-making process (Ostrom, 2009). Commentators on CITES listings have argued for the need to strengthen input from communities whose livelihoods are affected by CITES decisions (Cooney

et al., 2021). These issues are being considered albeit in the context that listing proposals should focus on the biological status of the affected species as the primary factor in decisions to amend the Appendices. Nevertheless, there is a growing body of evidence relating to social aspects of trade in wild species, comprising economics, behavior change, the structure of legal and illicit markets, the role of communities in promoting sustainable use, and social drivers which could be used to ensure more durable outcomes for CITES decisions and reduce unsustainable and illegal trade.

4.2.2.2.2 Trans-boundary conventions/agreements

A variety of regional-level institutions facilitate and support sustainable use that predates or are not explicitly tied to the Convention on Biological Diversity (Table 4.1). For example, the Agreement on the Conservation of Polar Bears was signed May 26, 1976, to protect the species through a coordinated approach by the five polar bear range states (Union of Soviet Socialist Republics (now Russia), Norway, Greenland (Denmark), the United States of America, Canada). This agreement, coupled with rights, customary laws and knowledge systems, has supported sustainable use; as evidenced by scientific reports, the majority of polar bear sub-populations well studied in Canada, for example, are stable or increasing (Government of Canada, 2019). Although there is growing concern that melting sea ice in the north will lead to declining bear numbers, the global population of polar bears, estimated between 22,000 and 31,000 animals, with more evidence from science and Inuit knowledge that the population is growing or stable, rather than declining. (Government of Canada, 2019; World Wildlife Fund, 2016). The Government of Canada lists only the Hudson Bay and southern Beaufort subpopulations as “likely declined” (Government of Canada, 2019); however, traditional knowledge of Inuit and Inuvialuit peoples in these regions is not consistent with these conclusions (Inuvialuit Joint Secretariat, 2015).

Table 4.1 International agreements, conventions and treaties related to wild species

| Year | Institutions, conventions, major non-governmental/governmental organisations |
|------|--|
| 1916 | Migratory Birds Treaty |
| 1922 | International Committee for the Protection of Birds established in London, 1st green non-governmental organization |
| 1923 | Meeting in Paris of the first international non-governmental congress for the protection of nature |
| 1929 | Establishment of the International Office for the Protection of Nature, later absorbed by the International Union for Conservation of Nature |
| 1933 | London Convention for the protection of flora, fauna and scenic beauty in Africa |
| 1940 | United States of America Fish and Wildlife Service |
| 1942 | London Convention for the Protection of Nature in the Western Hemisphere |
| 1946 | International Convention for the regulation of Whaling |

| | |
|-------------|--|
| 1948 | Establishment of the International Union for the Protection of Nature that later became International Union for Conservation of Nature |
| 1950 | International Convention on the Protection of Birds ratified by 10 countries |
| 1958 | Convention on Fishing and Conservation of the High Seas Resources, ratified by 57 countries |
| 1961 | Creation of the World Wild Fund; Creation of African Wildlife Foundation, an American non-governmental organization dedicated to African Protected Areas |
| 1968 | African Convention on the Conservation of Nature and Natural Resources, Alger |
| 1971 | Ramsar Convention on Wetlands of International Importance |
| 1972 | Creation of United Nations Environment Programme (UNEP) |
| 1972 | Paris Convention on World Cultural and Natural Heritage (UNESCO) |
| 1972 | Stockholm Declaration, states natural resources including fauna and flora should be safeguarded for the benefit of future generations. |
| 1973 | Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) |
| 1973 | Agreement on the Conservation of Polar Bears |
| 1979 | Convention on the Protection of Migratory Species of Wild Animals (CMS) |
| 1979 | Convention on the Conservation of European Wildlife and Natural Habitats |
| 1979 | Convention for the Conservation and Management of the Vicuña |
| 1979 | European Union Birds Directive |
| 1980 | World Conservation Strategy: Natural Resource Conservation for Sustainable Development (International Union for Conservation of Nature – IUCN / United Nations Environment Programme - UNEP/ World Wildlife Fund -WWF), highlighted the importance of “sustainable use” of living natural resources as part of an overall conservation strategy. |
| 1982 | Adoption of the World Charter of Nature, prefiguration of an international law on the environment, United Nations |
| 1982 | United Nations Convention on the Law of the Sea (Montego Bay) |
| 1983 | International Undertaking on Plant Genetic Resources, Common Heritage of Humanity, Food and Agriculture Organization (FAO) |
| 1984 | International Tropical Timber Organization |
| 1987 | Our Common Future, Brundtland Report, United Nations |
| 1989 | International Labour Organization’s Convention No. 169 |

| | |
|------|---|
| 1991 | Global Biodiversity Strategy, International Union for Conservation of Nature (IUCN), United Nations Environment Programme (UNEP), Food and Agriculture Organization (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO) and World Resources Institute (WRI). |
| 1992 | Convention on Biological Diversity (CBD) |
| 1994 | Agreement on Trade-Related Intellectual Property Rights (TRIPS), World Trade Organization (WTO) |
| 1994 | United Nations Convention to Combat Desertification |
| 1995 | Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries |
| 1995 | United Nations Fish Stocks Agreement (conservation and management of straddling and highly migratory fish stocks) |
| 1999 | Agreement on the Conservation of African-Eurasian Migratory Waterbirds |
| 2000 | Intergovernmental Forum on Forests (IFF) |
| 2000 | Adoption of the millennium goals (Goal 7: Ensure sustainable development) |
| 2001 | International Treaty on Plant Genetic Resources for Food and Agriculture, Food and Agriculture Organization (FAO) |
| 2002 | Rio + 10 or Johannesburg Conference "Fight Against Poverty" |
| 2002 | Global Environment Facility (GEF) |
| 2004 | Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity |
| 2005 | Millennium Ecosystem Assessment (notion of ecological service) |
| 2007 | United Nations Declaration on the Rights of Indigenous Peoples |
| 2010 | Aichi Biodiversity Targets (20), Convention on Biological Diversity (CBD), Strategic Plan 2011-20 |
| 2012 | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) |
| 2014 | Nagoya Protocol on Access and Benefit-sharing |
| 2015 | 2030 Agenda for <i>Sustainable Development</i> , adopted by all United Nations Member States |
| 2016 | Food and Agriculture Organization Agreement on Port State Measures (to combat illegal, unreported and unregulated fishing) |

Box 4.3 The challenge of contestations and conflicts in the Convention on International Trade in Endangered Species of Wild Fauna and Flora over value differences

Some iconic species listed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora appendices attract a high level of controversial discussion and absorb large amounts of the agenda in its fora. A key challenge is the different values held towards the use and management of wildlife. A complicating element is the presence of influential non-governmental organizations, as representatives of civil society, which have become increasingly numerous and vocal in the Convention on International Trade in Endangered Species of Wild Fauna and Flora debates in recent decades, which

hold their values on the moral acceptability of trade and use of certain species (Biggs et al., 2017; Challender & MacMillan, 2019; Duffy, 2013). These non-governmental organizations provide a voice for civil society, are a source of scientific and practical information to parties and may assist selected lower-income countries at the Convention on International Trade in Endangered Species of Wild Fauna and Flora meetings. There is, however, concern among some academics and regional government bodies over the extent to which increased non-governmental organizations' presence has negatively impacted the extent to which the Convention on International Trade in Endangered Species of Wild Fauna and Flora can make evidence-based decisions and formulate policies on sustainable use (Bauer et al., 2018; Biggs et al., 2017; Challender & MacMillan, 2019; Cooney et al., 2021, CITES 2019). There is also concern over the extent to which this presence may undermine the ability of smaller countries to represent the interests of their citizens effectively due to the levels of resources large non-governmental organizations that may hold contrary value-based positions on wildlife trade that could be either pro- or anti-use (Challender et al., 2019; Duffy, 2013, CITES 2019). In addition, drawing from successful conflict management processes in other domains, it has been proposed that decision-making processes that combine different cultural value orientations towards plants, animals, and their sustainable use, be incorporated with scientific evidence (Biggs et al., 2017).

Box 4.4 Inuit (Inuvialuit) Knowledge (IQ) and the Success of the Agreement on Polar Bear Conservation

The 1973 Agreement on the Conservation of Polar Bears provided a framework for research and sharing of data at national and circumpolar scales (e.g., article vii) while at the same time respecting the authority of each nation to manage its own polar bear resources (Freeman 1996). In Canada, that authority took shape in two committees. The present-day Canadian Polar Bear Administrative Committee and the associated Polar Bear Technical Committee were created in the 1970s to bring together the various voices in polar bear science and management from federal, territorial, and provincial agencies. The Technical Committee facilitates management decisions by reviewing research results and making management recommendations directly to the constituent jurisdictions. These committees predate the settlement of the Inuvialuit Final Agreement signed in 1984. That agreement recognized the inherent right and authority of the Inuvialuit to manage polar bears among other lands and resources in their region. Over the years, some efforts have been made to ensure that Inuvialuit and Inuit knowledge informs the Polar Bear Technical Committee (and Polar Bear Advisory Committee). However, many scholars suggest 'science' mixed with public sentiment has become the dominant discourse and basis for decision-making (Clark et al., 2009; Tam et al., 2021; Tyrrell & Clark, 2014).

While inequities in voice between Inuit Knowledge holders and scientists have led to impacts on Inuit economies, well-being and co-management (Foote & Wenzel, 2009; B. Parlee & Inuvialuit Game Council, 2020), this system of governance remained relatively stable between 1970 and the mid-1990s, save for periodic efforts of interest groups to curtail Inuvialuit and Inuit harvesting rights. When the Inuvialuit settled a land claim agreement with the Canadian federal government in 1984, it significantly changed their role in the national and territorial resource management decision-making processes. The Inuvialuit Final Agreement recognizes and affirms, as other comprehensive land claims in Canada do for other indigenous peoples, the inherent rights of the Inuvialuit for self-government and power in decisions about lands and resources in their homeland. As a result of this agreement, various co-management processes and councils were established that mandated the participation of Inuvialuit in decisions regarding lands and resources in the region, including polar bears. Among these is the Inuvialuit Game Council.

In 1988, the Council and Inupiat from the Alaskan North Slope Borough signed the Inuvialuit - Inupiat Polar Bear Management Agreement in the Southern Beaufort Sea region, underpinning decision-

making about quotas of bear harvest in the region. As in other areas of the north, hunting is recognized as part of the way of life but is not antithetical to conservation (Freeman et al., 2005). Embedded within the oral histories and observational accounts are insights into polar bear ecology. Inuvialuit hunters track bears on the ice by looking for specific details about their size, sex, behavior, direction and condition. Over time and through interpreting and sharing with other elders and land users, Inuvialuit knowledge comprises longitudinal data about body condition, population variability, distribution, reproduction, mating behavior, and hunting practices, as well as broader patterns of ecological change, including weather patterns, seal abundance and distribution, sea ice conditions, and human-bear interactions. When interviewed in 2010, most Inuvialuit hunters observed few changes in the abundance of bears, including the number of cubs (e.g., Inuvialuit Joint Secretariat, 2015:182–184). Whereas sea ice conditions were observed to be deteriorating in some areas, making it more difficult and dangerous for hunters to pursue bears, the Inuvialuit from most communities observed that the bears themselves are healthy based on numerous indicators, including body fat and reproductive success. According to some elders, the abundance and location of suitable seal habitat has been changing, but this does not seem to affect the condition or number of bears. Elders attribute this to hunting becoming more and due to thinning ice in some regions and the increased abundance of harp seal, a primary source of food in the region. This knowledge, combined with the outcomes of scientific research, form the basis of decisions by the regional Inuvialuit government (i.e., Inuvialuit Game Council) to make decisions about the harvest of the populations of the south-Beaufort region. As a result, harvest quotas have tended to vary yearly as the distribution of bears has changed. "Reported harvest levels for bears in the southern Beaufort area have been below quotas set for "allowable harvest" (modelled by scientists and Inuit/Inuvialuit) or below what is considered sustainable at a population level in an otherwise healthy population (4.5%) (Regehr et al., 2017)."

This harvest has continued in recent years, despite outside pressure, due to the confidence and belief of Inuvialuit peoples in the rigour and validity of their own evidence, knowledge and experience.

Box 4.5 The Convention for the Conservation and Management of Vicuñas -and the lack of a Convention for Guanacos

The Convention for the Conservation and Management of the Vicuña (1979) was signed by Argentina, Bolivia, Chile, Peru and Ecuador and is an example of a regional institutional arrangement that succeeded in the management of a common pool resource over a vast area to protect a wild South American camelid that lives in the High Andes (Lichtenstein, 2010). In Article I of the Vicuña Convention, and in the signatory states' subsequent submissions to the Convention on International Trade in Endangered Species of Wild Fauna and Flora meetings, Andean people that had been bearing the burden of vicuña conservation were named as the main beneficiaries of future vicuña use. However, translating this article into national legislation and ensuring exclusive benefits to local people has proved difficult (Lichtenstein, 2010). Due to its fleece which has one of the finest fibres in the world, it has long been hunted, ultimately resulting in the species almost being driven to extinction in the middle of the 20th century. The species recovery was a result of concerted international conservation efforts through the Vicuña Convention, the entry into force of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, and the prohibitions imposed by the Fish and Wildlife Service of country (Lichtenstein, 2010; McNeill et al., 2009).

In contrast to the approach with Vicuña, another wild South American camelid species that lives in Andean countries - Guanaco - is also listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora Appendix II. Still, there is no multilateral-regional agreement between the range of countries regarding its sustainable use and conservation. The lack of common goals towards the conservation and sustainable use of the species results in its range countries (Argentina, Chile, Peru,

Bolivia, Paraguay) having very different management schemes that range from protection to culling. There is no sharing of information about best practices, and no coordinated national measures as in the case of vicuña. Guanaco populations are critically endangered in Bolivia and Paraguay and severely threatened in Peru (Baldi et al., 2016).

The Agreement on Conservation of Polar Bears sets out terms for sharing knowledge and monitoring populations, creating the foundation for local-regional decisions about Inuit harvest quotas. There have been key examples of such knowledge documented by Inuit that strongly suggest bear populations are healthy, contrary to models and assumptions that sea ice melt is having an adverse impact (Clark et al., 2009).

There are more examples of regional conventions and agreements related to large fauna and hunting practices, including agreements related to marine and freshwater fisheries. Most notably, regional fisheries management organizations cover almost all oceanic areas. Their members (generally national delegations) have established rules regarding the collection and sharing of data, accepted methods for assessing the state of fish stocks, and negotiations to allocate shares of allowed catch among members. Examples include the Inter-America Tropical Tuna Commission and Northwest Atlantic Fisheries Organization (DFO-Department of Fisheries and Oceans Canada, 2019).

Despite their comprehensive spatial coverage and formal cooperation processes, regional fisheries management organizations focus almost exclusively on tuna and other high-value species and have been criticized for overlooking possible impacts on bycatch species; there are also concerns they supposed science-based catch recommendations due to political factors and allowing for unbalanced negotiation power in quota allocation and participation of new or non-members in discussions (Haas et al., 2020).

Another convention is the International Whaling Commission, established initially to support the sustainable harvest of whales by member nations. Over time, open membership and vote-based rules led to the International Whaling Commission functioning as a *de facto* conservation convention, resulting in the eventual exit of some founding members wishing to continue whaling and ongoing debates regarding impacts on indigenous whaling practices (Punt & Donovan, 2007).

Aside from these global or very large-area examples, there are examples of bilateral or multilateral conventions to manage fisheries stocks—including cod and herring in Northern Europe, salmon and halibut in the US and Canada, and even preemptive agreements for Arctic fisheries. There is growing interest in further establishing such conventions between smaller countries, particularly as climate change increases the number of transboundary fish stocks. One recent example is the Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean (Balton, 2019).

A significant challenge with regional agreements related to fisheries is the problem of open access in ecosystems for which no binding global institutions exist. Fishing fleets are also increasingly mobile and tend to “operate like roving bandits because global markets often fail to generate the self-interest that arises from attachment to place” (Berkes et al., 2006). This high degree of mobility coupled with the adaptability of fishing fleets to respond to shifts in markets is also part of the governance challenge. “Developing the institutions to deal with commons issues is problematic and slow; new markets can develop so rapidly that the speed of resource

exploitation often overwhelms the ability of local institutions to respond” (Berkes et al., 2006). Most industrial fishing occurs in these areas, which lack governance (Kroodsma et al., 2018; Palacios-Abrantes et al., 2018). It is this transboundary nature of fisheries, coupled with a lack of strong institutions in many areas of the globe and for large numbers of fish species, that has led to problems of unsustainable use or overharvesting (Berkes et al., 2006; Kroodsma et al., 2018; Palacios-Abrantes et al., 2018; Tickler et al., 2018) (see Figure 4.7).

In addition to agreements explicitly related to fisheries, there are a variety of transboundary arrangements for freshwater ecosystems that have developed to address transboundary issues of water use as well as management of aquatic habitats (e.g., across the Canada-United States of America border, in the Mekong river basin) (Fox & Sneddon, 2007; Hildebrand et al., 2002). Their role in addressing questions of biodiversity loss and sustainable use is less well-developed.

Small-scale freshwater fisheries contribute significantly to the food security of those living in transboundary systems, including the Amazon, Congo and Mekong. However, their species use is threatened by a focus on these river systems as a source of development, including hydroelectric power (Winemiller et al., 2016). The absence of transboundary institutions that deal with questions of sustainable use at basin-wide scales is a major barrier to protecting indigenous peoples and local communities and the freshwater fisheries on which they depend (Chen et al. 2008; Begossi et al. 2019). “Institutions that permit and finance hydropower development should require basin-scale analyses that account for cumulative impacts and climate change. Proposed dam sites should be evaluated within the context of sustaining a portfolio of ecosystem services and biodiversity conservation” (Winemiller et al., 2016).

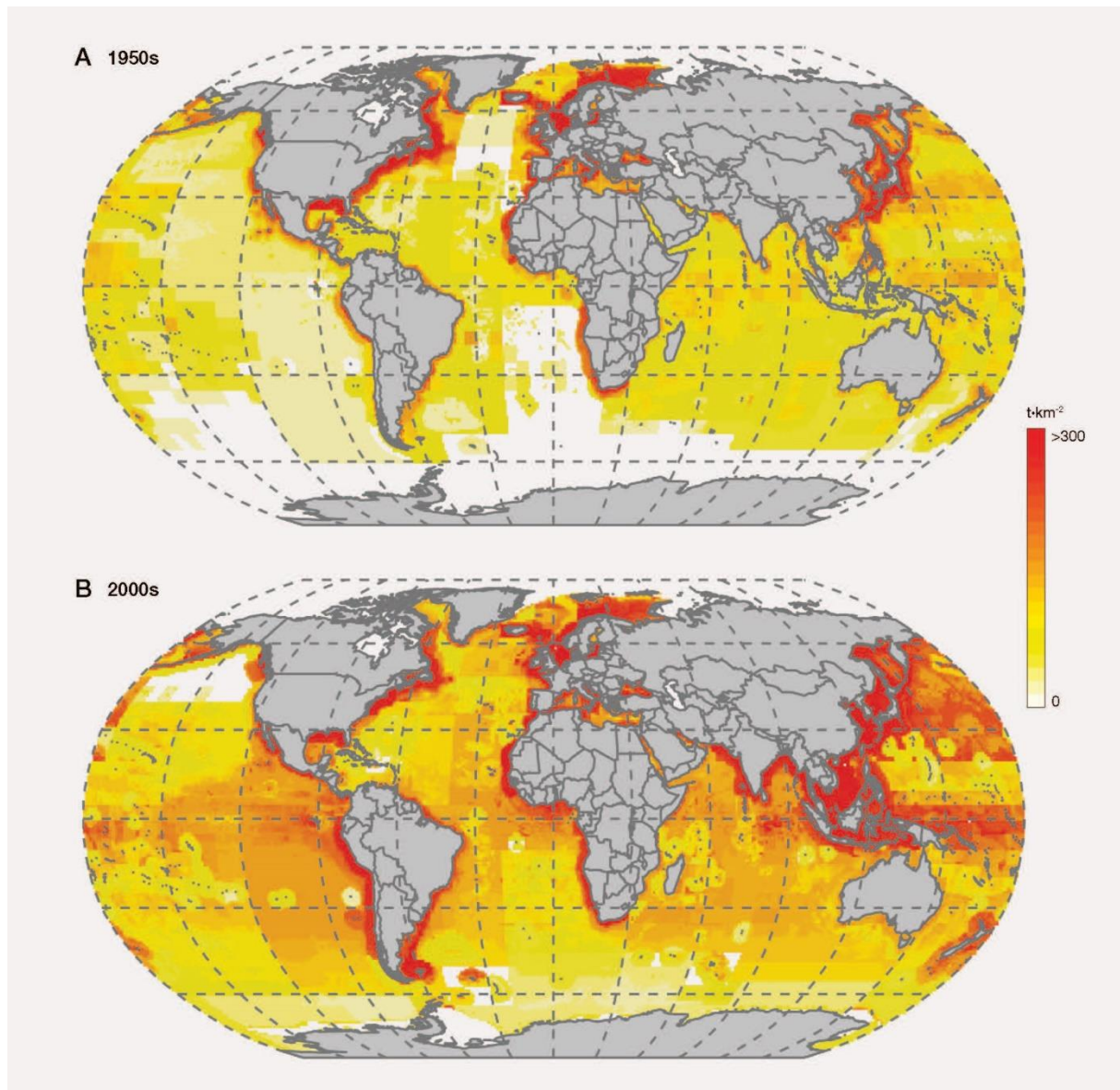


Figure 4.7 Map presents mean industrial fisheries catch in metric tons per square kilometer by-catch location during the (A) the 1950s and (B) 2000s. This map is directly copied from its original source Tickler et al. (2018) and was not modified by the assessment authors. The map is copyrighted under license CC BY-NC 4.0. The designations employed and the presentation of material on the maps used in the assessment do not imply the expression of any opinion whatsoever on the part of IPBES concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. These maps have been prepared or used for the sole purpose of facilitating the assessment of the broad biogeographical areas represented therein and for purposes of representing scientific data spatially.

Addressing broad questions of development in river basins requires institutions to “move beyond the current inward focus on project approvals in projects, toward an outward focus on the cumulative effects of all disturbances in a watershed” (Sheelanere et al., 2013). Balancing such large and basin broad perspectives should not be at the expense of recognizing

the complexity and diversity of the values and uses of biodiversity of indigenous peoples and local communities, whose fishing practices have long been sustainable (Baird et al., 2021).

The Mekong River Commission, for example, was founded in 1995 as a successor to the Mekong Committee (1957);. However, historically, there was a stronger focus on economic development, and the Mekong River Commission includes a greater scope on sustainability. States involved include Thailand, Laos, Cambodia and Vietnam. The Commission has multiple focal points, including sustainable development. However, the continued development of the Lower Mekong for hydropower and the absence of China from the membership of the Commission (where the headwaters of the Mekong Basin are located) have been highlighted weaknesses. As a result, the fishing livelihoods of many basin residents (particularly those directly affected by upstream/downstream and tributary effects of hydropower) have been compromised (Baird et al., 2020; Pearse-Smith, 2012; Soukhaphon et al., 2021). A more integrated approach to watershed management is needed that deals with the dynamics of transboundary use and cross-scale problems such as hydroelectric development (Hensengerth, 2009; Hirsch et al., 2006; Suhardiman et al., 2012).

Box 4.6 Hydro-electric Development in the Lower Mekong and its Impacts on Sustainable Use

The Mekong river is a large transboundary river originating from the Tibetan Plateau, spanning 4909 km and ending in the South China Sea (Chen et al., 2020; Soukhaphon et al., 2021). Its substantial geographic area, vast biodiversity, and connection to local communities make the Mekong one of the most important freshwater aquatic systems in the world (D’Souza & Parlee, 2020; Soukhaphon et al., 2021). Although purported as a source of clean energy, the rapid development of ongoing and proposed hydroelectric dams is adversely impacting local fishing communities and is a major driver of change in fishing practices (Chen et al., 2020; D’Souza & Parlee, 2020; Ziegler et al., 2013). Hydroelectric development complicates traditional practices, and, as a result, local people have had to cope with significant stress related to loss of livelihood and inability to engage in traditional practices (Baird et al., 2020; D’Souza & Parlee, 2020; Soukhaphon et al., 2021). Currently, over 65 million people live near or along the Mekong river, and thus, the cumulative impacts of hydropower affect communities for decades after their completion (Soukhaphon et al., 2021).

While hydropower dams exist throughout the Mekong basin, there is a significant number in the Lower Mekong Basin. Since the 1990s, 64 dams have been constructed in the Mekong basin, 46 of which are in the Lower Mekong Basin (Green and Baird 2020; Yoshida et al. 2020). Additionally, 123 dams are projected to be built in the Lower Mekong Basin in the future (Yoshida et al., 2020). One of the most controversial dams in this area is the Pak Mun Dam, a “run-of-the-river” hydroelectric dam that is situated at the confluence of the Mun and Mekong rivers in Northeastern Thailand, (Baird et al. 2021; Amornsakchai, 2000; Soukhaphon, Baird, and Hogan 2021). Since 1989, the Pak Mun Dam has caused contention and conflict between local communities and the Electrical Generating Authority of Thailand (Amornsakchai, 2000). Its location causes major impacts on upstream and downstream communities, including those beyond Thailand, in Lao, Cambodia, and Vietnam (Soukhaphon et al., 2021). For communities that utilize the river, this dam and its resulting embankment have caused both environmental and socioeconomic issues such as decreases in fish migration, flooding, increase in water level, increased reliance on store-bought food, loss of traditional community practices, and more (Baird et al., 2020; Foran and Manorom, 2009; Roberts, 2016; Soukhaphon et al., 2021). These negative and severe impacts mean that fishing is no longer a sustainable practice, and to cope, communities have had to diversify their livelihoods over the past thirty years.

Diversifying fishing practices include more innovations to fishing gear, including some local community members who use recycled material to create fish and shrimp traps (D'Souza & Parlee, 2020). Additionally, some community member takes advantage of fiberglass boatmaking programs initiated by their Tessabaan (Municipal Government) (D'Souza & Parlee, 2020). The Tessabaan also offers programs that teach people how to raise Tilapia in personal fishponds (D'Souza & Parlee, 2020). These personal fishponds provide a way for community members to feed their families while also generating income by selling fish (D'Souza & Parlee, 2020). Selling fish persists and is often preferable, but sharing fish is decreasing, as people cannot afford to share the little catch they have (D'Souza & Parlee, 2020). For upstream communities, such as those along the Sebok River, there may be even less sharing of fishing gear as people wish to preserve their store-bought gear (D'Souza & Parlee, 2020). D'Souza & Parlee, (2020) outline common diversification of both upstream and downstream, including preferring to sell their fish over sharing or eating, more reliance on store-bought fish, and wanting more fish stocking from the government. A major shift in perception of fishing livelihood has also occurred, as community members prefer to diversify outside of fishing, including the common practice of farming, mobile markets, and rural-to-urban migration (D'Souza & Parlee, 2020). Broader drivers of change have led to more focus on education and children supporting their grandparents by sending money back to their villages (D'Souza & Parlee, 2020). Local people must often engage in multiple diversifications to cope with stressors related to the Pak Mun Dam.

However, although community members can and have coped with the longitudinal impacts of the Pak Mun Dam, they wish to return to their previous lives. Since the implementation of the Pak Mun Dam, its decommission has been widely recommended by community members, scholars, and non-profits (Baird et al. 2020). The opening of the floodgates year-round, or for an extended period during the rainy season, is mentioned frequently as a way to help restore the environment to its original state, including bringing back the fish populations (Baird et al., 2020; D'Souza & Parlee, 2020; Foran and Manorum, 2009). It is clear that local community members are adversely affected and struggle with the long-term impacts of the Pak Mun Dam on their fishing livelihoods. As more hydroelectric development is projected to take place in the region, including the highly contested but not yet constructed Sambor dam, more research on hydroelectric development as a driver of change for communities in the region is needed.

Conventions and treaties related to the management of forest ecosystems and regulation of use are more common in some areas than others.

Box 4.7 Treaty on the Conservation and Sustainable Management of Forest Ecosystems in Central Africa and establish the Central African Forests Commission (2005)

The 1999 Yaoundé Declaration recognized the protection of the Congo Basin's ecosystems as an integral component of development processes. It reaffirmed commitments to work cooperatively to promote the sustainable use of the Congo ecosystem in accordance with their social, economic, and environmental agendas. The Declaration led to the formalization of commitments to protect the Congo Basin's ecosystems in a 2005 Treaty that legally recognizes the Central African Forests Commission as the decision-making body on forests. Representatives from all the governments have met regularly to discuss an agenda and develop a Convergence Plan (2003-2010) that identifies priorities under the themes of harmonization of forest policy and taxation, inventory of flora and fauna, ecosystem management, conservation of biodiversity, sustainable use of natural resources, capacity building and community participation, research, innovative financing mechanisms, and the convergence and harmonization of regulations including those concerning wild species use and management. While

regional level agreements have been slow to filter down to the national level, the alignment focus has been important in raising awareness and simulating data collection (via, for example, the Central African Forest Observatory and annual State of the Congo Basin Forest reports) at the national level, including on un-regulated wild species for which little data exists to inform policymakers.

A critical issue in the usefulness of global agreements is how they are implemented and enforced within national borders.

4.2.2.2.3 National Laws and Policies

Although sustainable use of wild species is a global issue, the nation-state has long been considered the answer to most governance problems, including those related to biodiversity conservation (Sampford, 2002). Laws and policies impacting wild species include both those directly regulating species and products and those indirectly doing so. Direct regulations (e.g., quotas, permitting, quality, safety and efficacy standards, trade restrictions, taxation) tend to exist when species are in commercial trade and governments seek to generate revenue or protect endangered species (Laird et al., 2010; Lele et al., 2010; Pierce & Burgener, 2010). Laws and policies that indirectly impact wild species often have an equal or greater impact on these species (Cronkleton & Pacheco, 2010; Dewees & Scherr, 1996; Novellino, 2010), and include agriculture, land tenure, taxation, labor, and broader natural resource laws (Laird et al., 2010). In most countries, permitting, harvest quotas, taxation, and restrictions on domestic and international trade are used by national governments to regulate the direct use of wild species. Some of the most common and well-established formal institutions at the national scale are related to the hunting and harvesting of large game.

Box 4.8 Marine ecosystems and sustainable use in Indonesia – towards an ecosystem approach to fisheries management

Indonesia is the world's second-largest producer of wild-capture fish; small-scale fishers harvest 60%. There are more than 2.62 million fishers in the marine and inland capture sector in Indonesia, and the country is one of the most fish-dependent countries in the world. The Indonesian government has been working with international organizations to establish marine protected areas to protect marine species, including coral reefs. Tourism impacts on coral reefs are among those non-extractive uses, increasing in scale and impact. What kinds of institutions and government tourism impact coral reefs in Indonesia? Fisheries management Law No. 31/ 2004 and Law No. 45/2009 regulates all matters concerning fisheries in Indonesia, including all aspects of fishing activities, use, management and enforcement. These include: (i) specifying a fishing method or gear; (ii) determining the maximum sustainable yield or total allowable catch for domestic and foreign fishing; (iii) specifying fishing and aquaculture activities; (iv) preventing activities such as pollution and destructive fishing of the resource and its ecosystems; and (v) rehabilitation of the resources and its habitat. Article 60 of Law No. 1/2014, amending Law No. 27/2007 also recognizes traditional communities' rights to cultural (traditional) fisheries harvesting practices. So, although there are no specific laws for Ecosystem Approach to Fisheries, this suite of laws is consistent with the Ecosystem Approach to Fisheries which attempts to balance social and ecological values and needs (Muawanah et al., 2018).

Many national laws, for example, limit the threat of over-harvest of species on public lands; they are premised on protecting the public interest in accessing game as subsistence, recreational, and

commercial value. For example, in many Central African countries, current legal and policy frameworks concentrate on a small number of generally traded, high-value wild species such as timber, “bushmeat” (i.e., wild species used for food with a focus on protected animal species), and a generally small proportion of traded, sometimes endangered plant species (Laird et al., 2010). Lower value species are generally not included in these frameworks (Sola et al., 2019). They have species important for food, medicine and construction (Ingram & Schure, 2010; Lescuyer et al., 2016). These systems of sustainable harvest contribute significantly to community well-being in most countries and for most species. Laws within nation states can operate harmoniously to support desired outcomes but are more often *ad hoc* and contradictory. The latter has been argued to be the case in Brazil, for example, which has been described as a “patchwork” of rules that are often weakly defined and enforced (Drummond & Barros-Platiau, 2006).

These have been effective due to the flexible way in which these regulations are adapted to local and regional variabilities in ecosystems and species population, distribution, and health. In Arctic ecosystems in Canada, regional co-management boards are responsible for research and monitoring caribou, muskoxen, bear, and other populations and regularly update harvest limits to ensure sustainable use. This is also true in respect of Titi or Sooty Shearwater birds (*Puffinus griseus*) in New Zealand (Lyver et al., 2008; Moller et al., 2009) and moose harvesting in Sweden and Norway (Lavsund et al., 2003). An important limitation of the effectiveness of national scale regulation of harvest and use of wild species is the degree to which these regulations are a fit with other kinds of institutional arrangements that are based on data from science and indigenous and local knowledge. Regulations and other types of institutional arrangements that are adaptive and flexible are particularly important in the case of wild species that are highly dynamic in distribution, migration, and population or highly sensitive to environmental conditions (e.g., climate change) (Berkes 2018; Berkes et al., 2000). For example, in the case of waterbirds, management (or a lack of appropriate management) in one part of the flyway, be it harvest, or site management related, may have consequences for the status of a population throughout its range. An integrated approach and coordinated management are crucial (the waterbird harvest specialist group, Wetlands International, 2015). Weak harvest regulations and the absence of customary laws related to sustainable harvesting are particularly concerning where there is a high degree of variability or environmental stochasticity and where there is the absence of ongoing monitoring of population dynamics; in such cases, even the most adaptive of regulations may be insufficient to prevent species decline.

Box 4.9 Bat conservation in the Philippines and New Zealand

Bats play an essential role in ecosystems around the world. In particular, fruit bats have known pollinators and seed dispersers, meaning that population declines have vast economic and ecological consequences. The Philippine bare-backed fruit bat, *Dobsonia chapmani*, is a species of endangered bat native to the islands of Cebu and Negros and was believed to be extinct in the early 1970s, only to be rediscovered in 2001 (Raymundo & Caballes, 2016). The combination of “hunting, deforestation, guano mining, and a general lack of environmental awareness” is believed to have contributed to the steep decline in bare-backed fruit bat populations (Raymundo & Caballes, 2016). Through their research on the bat hunters in the Philippines, Raymundo & Caballes (2016) found that majority of the local bat hunting was for subsistence. The two most common perceived drivers of bat population decline among hunters were large-scale hunting (and increasing numbers of hunters) and habitat destruction (from logging, agriculture, and forest burning for charcoal), with migration to favourable habitats and proximity to a reopened copper mine as less common drivers outlined. The main explanation for reliance on wild food, including bats, among local populations was found to be socioeconomic constraints.

According to Raymundo & Caballes (2016), the Wildlife Resources Conservation and Protection Acts of 2001 in the Philippines has successfully deterred some wild species hunting among individuals. However, it is vague enough that multinational companies can still destroy habitats with little consequence, partly due to the shortage of government personnel trained in enforcing conservation laws. In New Zealand, there have been successful management strategies in conserving long-tailed bats, *Chalinolobus tuberculatus*, which were previously in decline (Nelson et al., 2019). The primary drivers of the decline in bat species in New Zealand have been habitat loss and predation by invasive species. Conservation efforts included predator control of mustelids and rodents, which has protected native bats from invasive species. These conservation methods have, however, only been effective in safeguarding colonies and enabling their recovery where bat populations have not been threatened by habitat modification. In the Ellington Valley, a “strong collaboration between local conservation managers, field staff and scientists (that) involved the local community” has been vital in protecting bat populations. Communities in some New Zealand regions are encouraged to engage with bat conservation through different local, government-led projects (Nelson et al., 2019, p. 290). As highlight, Field Nelson et al. (2019) highlight that long-tail bat populations require ongoing, active management to be sustainable. Active management may not be successful in areas with habitats that have been destructed. Only by addressing the socio-economic pressures that local populations in Cebu and Negros will effective hunting regulation and protection areas are possible (Raymundo & Caballes, 2016). Providing support for developing food security may help to reduce local reliance on bat populations for subsistence. Although the drivers of population decline in New Zealand do not include over-hunting, the significance of engagement of actors from multiple levels, including local community members, field scientists, and conservation managers, in the effectiveness of conservation strategies of long-tail bats may prove to apply to the Philippine bare-back fruit bat. Although relocating bat populations has proven to be an ineffective conservation strategy (because of bats’ honing skills), the protection of further habitat destruction through the development of terrestrial protected areas may also serve to enable additional conservation strategies. Although there may be economic pressures to continue allowing multi-national corporations to use land in unsustainable ways, strengthening land-use restrictions may help limit further habitat destruction.

Box 4.10 Weaving commercial and subsistence harvest of moose (*Alces alces*) in Scandinavia

Scandinavian moose are among the most productive and heavily harvested populations in the world (Lavsund et al., 2003; Wikenros et al., 2020). From a total annual harvest of fewer than 10,000 animals in the early 1900s, harvest levels increased rapidly in the 1970s (Cederlund & Bergström, 1996; Lavsund et al., 2003). The tremendous population growth of moose in Scandinavia can be explained by several factors, including changing forestry practices, abandonment of marginal agricultural land, absence of predators, and changing moose harvesting practices (Browder, 1992; Lavsund et al., 2003; Ruusila & Kojola, 2010; Thulin et al., 2015). The most critical drivers are state and local management policies and regulations designed to maintain viable populations (Sjölander-Lindqvista & Sandströmb, 2019). Generally, these policies are rooted in the importance of moose as a game species and source of livelihood (Bjärstig et al., 2014; Sandström et al., 2013; Wikenros et al., 2020). The introduction of age- and sex-specific harvesting policies in the 1970s is assumed to be the most important factor in the present productivity of moose populations (Lavsund et al., 2003). As a result of selecting calves, yearlings, and adult males, the proportion of productive females, mean age of females, and recruitment rate increased (Lavsund et al., 2003). However, as moose population densities increased, so did impacts on commercial forests and transportation (e.g., moose-related traffic accidents) (Selby et al., 2005). In Sweden, for example, the economic impact of moose browsing damage on forestry can exceed the economic and

recreational values of moose hunting (Bjärstig et al., 2014). Consequently, damage to economically important forests and moose-vehicle collisions play a central role in moose management (Lavsund et al., 2003; Linnell et al., 2020; Sandström et al., 2013). One of the main moose management goals in Scandinavia is finding balance between a sustainable population for hunting and minimizing damage to forestry and public transportation (i.e., vehicle collisions) (Lavsund et al., 2003; Selby et al., 2005; Storaas et al., 2001). Local authorities and stakeholders play a significant role in management efforts. In Sweden, landowners and hunters have been delegated management responsibilities since the first Hunting Act in 1938 (Balčiauskas et al., 2020; M. Johansson et al., 2020). In Norway, there is an increased emphasis on local population management plans developed by the landowner. While in Finland, moose hunting is managed by a central organization for hunters that is organized locally into game management districts and local-level associations (Selby et al., 2005). Harvesting quotas are set based on data collected by hunters as well as vehicle collisions and damage to forestry (Danielsen, 2001). In Norway, for example, population indices based on local monitoring efforts are used as a tool in local moose management (Lavsund et al., 2003). While local management is a generally acceptable approach, it has not resolved a conflict among hunting and forestry stakeholders (Lavsund et al., 2003; Sandström et al., 2013). Competing interests and values continue to challenge the ability of stakeholders to establish trust and find mutually acceptable management solutions (Johansson et al., 2020; Linnell et al., 2020). For example, in Sweden, forestry and hunting groups disagree on how to limit browsing damage to commercially essential tree species while at the same time maintaining sustainable harvest levels (Sandström et al., 2013; Wikenros et al., 2020). To resolve conflicts, the Swedish government introduced a local ecosystem management system to coordinate moose harvesting at an ecosystem-level (Sandström et al., 2013). Management efforts, such as the recent ecosystem-based approach in Sweden, have contributed to a dramatic recovery of moose populations. However, the ongoing sustainability of moose populations may be challenged by several factors, including rapidly expanded carnivore populations (Wikenros et al., 2020), climate change effects on distribution ranges of moose (Johansson et al., 2020) as well as the geographic expansion of chronic wasting disease (Sutherland et al., 2018).

Box 4.11 Mobilization of local communities to create Brazilian extractive and sustainable development reserves, conservation units for sustainable use of natural resources

The movements triggered in the Amazon in the mid-1980s to create protected areas by the Brazilian State should, first, be considered social movements and not exclusively as environmental movements. They intended to react to the immediate threats suffered by the populations involved and their territories and social spaces, on which their cultural identity and economic survival depended (Browder, 1992). In the first National Meeting of Rubber Tappers, which took place in Brasília in August 1985 and when the National Rubber Tappers Council was created, it was the first time that extractive workers met to discuss land conflicts and forest conservation. The creation of extractive reserves was also a demand made at that meeting. The leaders participating in the meeting demanded that the rights to use these protected areas be transferred to local associations and granted in accordance with traditional land use standards, without the classic occupation models being copied (Allegretti, 1990), because contrary to the agrarian reform settlement projects, extractive reserves were already populated by traditional communities, who were familiar with local conditions and ecosystems. Among the main objectives of creating these areas, they claimed the creation of legal guarantees for extracting forest products and promoting a better quality of life for local populations (Butler, 1992). Thus, from the indigenous areas that already existed at the time, the National Rubber Tappers Council borrowed the idea of an area protected by the State, where local populations could practice their traditional culture and economic activities. However, extractivism should first be officially recognized as the main activity of these

conventional populations, to be differentiated from other rural activities, such as the settlers of the settlements of the National Institute of Colonization and Agrarian Reform, which were predominantly agricultural activities. In extractive reserves, the units of exploitation of extractive families, known as placements (*colocações*), are not formed according to traditional geographical references. The natural resources of the land, and not the land per se, define the boundaries between placements (Allegratti, 1990). In the case of extractive reserves, the terms "reserve" and "extractive" carry very particular connotations. The conventional use of the adjective "extractive" in the context of extractive workers in the Brazilian Amazon refers to a specific economic activity that depends on the maintenance of forest areas in the long run. Regarding the term "reserve," this designates an area with limits for human use, protected by the State, where the right of use is granted free and collectively to the populations in question (Allegratti, 1990). Since 2002 Brazil has had a National System of Conservation Units, which divides conservation units into two types: Integral Protection and Sustainable Use (Brazilian Ministry Environment, 2004). Extractive Reserves and Sustainable Development Reserves fall into this second category. The first Sustainable Development Reserve implemented in Brazil was the Sustainable Development Reserve of Mamirauá, in the state of Amazonas. Its history is relatively different from the creation of the extractive reserves since it was initially created as an Ecological Station after demand to allow the protection of some specific natural attributes, especially for the protection of the uacari-white primate (*Cacajao calvus calvus*), which at that time was already on the list of species officially threatened with extinction in Brazil, as well as the International Union for Conservation of Nature (Queiroz, 2005).

The degree to which laws are applied and enforced is also highly complicated and can vary by political priorities and institutional capacity (i.e., resources to hire fish and game officers). Where there is a strong synergy between centralized institutions and local and regional level knowledge and management systems (as with co-management), enforcement can be less costly (i.e., as there is a greater degree of self-regulation), limits social conflict and can lead to improved sustainable use outcomes. In some cases, national, level institutions can favour some kinds of sustainable use and disadvantage others. For example, in North America, a critical concern is how states and provinces privilege recreational, sports and commercial hunting over indigenous and subsistence harvesting of game (See section on indigenous institutions).

Laws related to the sustainable use of wild species, like other kinds of environmental laws, are usefully conceptualized along a sliding scale of 'hard' and 'soft' referring to the degree of enforceability. "Some hard laws contain soft requirements (e.g., to 'consider' or 'assess') while some soft law instruments contain hard law norms (e.g., legal principles)" (Dernbach & Mintz, 2011, p.539). It is widely held that a combination of hard and soft laws, including customary laws and social norms, when knitted together in a clear system, are the most effective at addressing problems in sustainability (Dernbach & Mintz, 2011). Soft law has the advantage of being flexible in allowing different stakeholders to respond and address issues in their own fashion, creating opportunities for more sustainable outcomes than narrow and rigidly enforced rules. However, too much flexibility may provide no incentive or assurance of compliance. One example of a potent combination of hard and soft laws related to protecting sustainable use occurs in the North Atlantic; the International North Sea Conferences focused on addressing pollution in the North Sea, which was indirectly impacting the sustainability of fishing and other kinds of harvesting and use of this ecosystem. The North Sea Conferences agreement was attributed with the strengthening and speeding up of the creation of harder laws within the

European Union (Skjærseth et al., 2006). The continued sustainable use of polar bears in the Northwest Territories, Nunavut, and Greenland, is also grounded in the interconnection between solid regulations and laws protecting the rights of Inuit, working together with the customary laws of Inuit, which are based on generations of Inuit knowledge (Clark et al., 2009; Schmidt & Dowsley, 2010; Tyrrell, 2006). Soft law includes consideration and implementation of the precautionary principle set out in the Rio Declaration (1992).

Statutory laws and policies governing the sustainable use of wild species are highly variable in their quality and comprehensiveness and their implementation, effectiveness, and enforcement, particularly in the global South and many countries with still high levels of natural biodiversity. There is a lack of clarity in institutional responsibilities and a low extent of consultation with and engagement of diverse stakeholders, particularly among ethnic or minority groups and the traditional land and resource custodians with varying levels of recognition, rights and responsibilities.

While on paper, the quality and comprehensiveness of legal and regulatory frameworks appear strong, there is variation in the strength (i.e., teeth) of various laws and policies as applied and enforced (Ingram et al. 2017; Abbott, Tsinda and Mugisha 2018; Tieguhong et al. 2015). A range of soft and harder policy tools can be most effective at encouraging sustainable use, including the development and implementation of international agreements and protocols within national borders (Harrop & Pritchard, 2011; Skjærseth et al., 2006).

Box 4.12 Precautionary principle – Barren Ground Caribou and mining in Northern Canada

During 1990-2015, barren-ground caribou in northern Canada declined by over 70% as part of a cycle of natural herd population cycles (Vors & Boyce, 2009). In the case of the Bathurst herd in the Northwest Territories, Canada. The population declined more than 98% from 475 000 animals to less than 8000; the management board highlighted the possible extirpation of the herd. Numerous factors were considered to be a driver of population decline of this herd; the most controversial being habitat degradation associated with mining activity and over-harvest by recreational hunters and indigenous peoples. Many indigenous governments interpreted the mining boom in the Bathurst range and disturbance of more than 30 million hectares of summer and fall range as the core driver of the decline. However, the management focus was on harvest regulations. This privilege of mineral resource development, whilst efforts were made to criminalize subsistence hunting, was perceived as a major injustice by many indigenous peoples.

Available harvest data coupled with oral histories and academic research provided ample evidence of sustainable use of Bathurst and other herds by indigenous peoples over the hundreds of years. In addition to adaptive and flexible harvesting practices (i.e., the decreasing harvest of caribou during periods of decline) and harvest substitution (i.e., harvest for other species such as fish, moose and muskoxen). The availability of other wild species, which have provided strong support for continued cultural continuity, economy and food security, has enabled Indigenous populations to ride periodic declines or variability in barren-ground caribou. The tracking of key indicators of population decline (e.g., body condition, reproductive success, habitat conditions) as well as catch-per-unit effort type information is regularly documented and shared by harvesters with one another. Well-developed sets of rules or norms of how to respect the caribou during times of decline form the foundation of decisions about

where, when and how many caribou to harvest during population declines. This case study on the Bathurst caribou reveals the value of indigenous knowledge as a management foundation. Moreover, strong social networks and norms of reciprocity have also offset inequities in those most affected by population declines (i.e., food sharing within and between communities) and also ensured sustainable use. Some of the fundamental elements within Dene knowledge systems that contribute to the sustainable use of caribou include the following listed in Table 4.2).

Table 4.2 Key elementss within Dene knowledge systems that contribute to sustainable caribou use

| Practices from indigenous knowledge | Contribution to sustainable use of Barren Ground caribou |
|---|---|
| Adaptive caribou harvesting—decreased harvesting during periods of decline (and corresponding increase in harvest of other species and/or substitution for market foods) (Nuttall 2005; Wray and Parlee 2013; McMillan and Parlee 2013; Jacobsen et al., 2016; Smith 1978; Winterhalder 1983) | Decreased hunting pressure on declining resources; diversification of traditional diets and/or increased dependence on market foods of lesser nutritional value |
| Increase in organization and communication at larger scales (Kendrick 2003; Doubleday 2007; Berkes 2009) | More complex institutional arrangements; opportunities for cross-scale decision-making |
| Increased in enforcement of informal property rights (for example, traditional hunting territory) and rules for caribou harvest (Padilla and Kofinas 2014; Berkes 1989) | Self-organized enforcement of rules to protect caribou |
| Strengthening and/or expansion of food sharing networks within and outside the caribou range (Jeans et al. 2017; Winterhalder 1983; Collings 1998) | Increase in knowledge generation and transmission (including with younger generations) within and between communities |
| Cultural rediscovery, social learning, and innovation to address food shortages (Berkes, Colding, and Folke 2000; Duhaime et al. 2008) | Increase in the breadth of potential solutions to food shortages |
| Cultural and spiritual learning | New spiritual learning; changes in the socio-cultural and spiritual relationship of people and caribou |

The regulation of hunting within national borders also combines hard and soft tools (Peters et al., 2020). It is suggested that changes in practice, law, and policy are urgently needed to promote sustainable trade and livelihoods (Tieguhong et al., 2015; Yobo & Ito, 2016). Institutional responsibilities generally fall under ministries of forest and wild species.

Interactions with agencies responsible for trade, enterprises, and particularly agriculture – given that the extent a species is wild or cultivated is often (Wiersum 2014), generally insufficient to ensure either sustainable resource use or livelihoods of people dependent upon the use and trade in these species (Awono et al., 2016).

In some countries there has been consultation with, and engagement of, diverse stakeholders around regulatory changes on wild species trade, for example via community forestry and plants, algae and fungi legal frameworks in Gabon, Cameroon, and Democratic Republic of the Congo (Awono et al., 2016; Ingram et al., 2017; Kimengsi et al., 2019; Laird et al., 2010; Lescuyer et al., 2019; Yobo & Ito, 2016).

Examples of formal, or statutory, institutional arrangements that can drive sustainable use of wild species include: environmental laws on endangered species and designation of protected areas (national parks, provincial/state parks, or international designations such as Biosphere Reserve, RAMSAR site or Geographic Indication); rules and regulations that manage fishing, hunting, logging, or harvesting of plants or other species through licenses, permits, quotas and others means; and tenure or ownership rights of land or seas where wild species lives, and rights to resources contained therein. Internationally, legally binding institutions include conventions or treaties.

4.2.2.2.4 Co-management and cooperative arrangements

Co-management and cooperative management arrangements are well developed in many areas of the world including Canada, New Zealand, Europe and parts of Asia where they have proven highly effective at engaging local users of resources in the design and implementation of formal governance (Berkes 2009) (Tables 4.3 and 4.4). These arrangements are particularly well-developed with respect to regulating harvest of fish and wild species as well as forest resources and protected areas. Co-management has been helpful in the management of small scale fisheries (Borrini-Feyerabend et al., 2004; Cárcamo et al., 2014, Jones et al., 2017). Although top-down fisheries management systems are critical in some cases, fisheries managers in many parts of the world have recognized for decades that most fisheries cannot be managed without the cooperation of local fishers, and in situations of significant resource competition (i.e., many users with diverse interests and values), co-management is critical to trust building and ensuring compliance with laws and regulations (Pomeroy & Williams, 1994). This is true in cases where resources are remote or scattered in areas where enforcement is difficult as “under these conditions, delegation of fisheries management and allocation of decisions to local fishers (at the) community level may be more effective than the management efforts that distant, understaffed and underfunded national government agencies can provide” (Pomeroy & Williams, 1994). Over the last 30 years the principles or factors that most critically contribute to the effectiveness of co-management of fisheries have been further developed. A critical factor in many regions of the world is recognition of the customary laws of local and indigenous peoples who have long-term relationships to fisheries resources and a vested interest in ensuring the sustainability of the resource. These customary laws are based on generations of indigenous and local knowledge and are continuously informed by systems of social learning (e.g., monitoring), are among the most vital kinds of co-management institutions, and tend to be most effective at ensuring sustainable use (Armitage et al., 2009; Berkes, 2009).

Box 4.13 Karuk and co-management of the forests in California and Oregon

The Karuk people are the indigenous peoples of the Klamath River valley which is a biodiverse region near the border between California and Oregon; their territory spans over 1.38 million acres. Many members of the nation depend on the forest for the subsistence foods from the forest and its waterways. Among the cultural practices and uses of the forest was cultural burning in support of managing forest fire risks and shaping the landscape in ways that nurtured the growth of particular kinds of resources and wild species habitats. The Karuk Tribe is now federally recognized by the U.S. government but was not historically recognized with land rights as a result their capacity to live and harvest resources from their homeland has been tenuous. A pilot project of co-management involving the Karuk Tribe and the United States of America Forest Service was established in the Klamath Basin of Northern California, with the intention of building greater equity in decisions being made about the use of resources of the forest. The project was successful due to simultaneous efforts of the United States of America Forest Service to reconsider colonial histories and institutions that excluded the Karuk people and the willingness of Karuk government to engage in institution building that blended Karuk laws and those of the state of Oregon and California in ways that are consistent with cultural values and uses. Challenges continue due to the rigidities of formal government and colonial systems which persist in forest management decision-making (Diver, 2016; Marks-Block et al., 2019).

Table 4.3 Co-management institutions and transboundary problems

| Species | Lesson related to managing for sustainable use |
|----------------|---|
| Pacific salmon | Salmon populations are under stress in northwestern Canada and the United States of America due to such factors as habitat loss and degradation (from climate change and resource development) and commercial fishing. “Management is complicated by the geographical scale of salmon production, encompassing terrestrial and aquatic habitats, extending from inland watersheds to ocean basins, and encountering different property and governance regimes” (Ebbin 2002). Commercial habitat use and fishing interests have long dominated management to the detriment of indigenous peoples and local knowledge, and the sustainability of fish stocks. Various kinds of shared decision-making models have emerged that redistribute some power to local fishers through legal agreements (e.g., Nisga’a Final Agreement) requiring the engagement of Indigenous Peoples and knowledge in the management have emerged in the last two decades and other kinds of Tribal and Indigenous-led conservation efforts (e.g., Columbia River Inter-Tribal Fish Commission, Nuu-chah-nulth Tribal Council) have improved management outcomes. However, many inequities and socio-economic and political barriers to sustainable use continue to exist that are detrimental to salmon and salmon-based economies and cultures (Atlas et al., 2021; Ebbin, 2002; Pinkerton, 1994). |

| | |
|---|---|
| Rangifer (porcupine caribou management board) | <p>One of the oldest and most successful transboundary co-management institutions is the Porcupine Caribou Co-Management Board shares power between management authorities of multiple Indigenous governments, Alaska, and the Yukonthe Yukonst Territories and federal governments of Canada. The Porcupine Caribou Co-Management Board is an advisory board established under the Porcupine Caribou Management Agreement (1985) to communicate information about the herd and provide recommendations to agencies responsible for managing the herd. The success of the management can be measured by the sustainability of the population which has remained relatively stable in recent years when compared to other caribou herds in the circumpolar north. Sustainability is also measurable by the ability of indigenous peoples in the region to continue to sustainably harvest caribou to meet subsistence needs. The strength of land claim institutions that protect Inuvialuit and Gwich'in rights to harvest, respect of indigenous knowledge and customary laws for harvesting, coupled with effective lobbying to protect caribou habitat from resource development are among the factors contributing to this success (Kendrick, 2003, 2003; Kofinas, 2005; Kruse et al., 1998; Moller et al., 2004; Nadasdy, 2003; Parlee et al., 2018; Peacock et al., 2020; Peacock. & Turner, 2000; Thomas & Schaefer, 1991; Usher, 1993).</p> |
| Central American Ccral reef and inshore fisheries | <p>The diverse fisheries of Central America and the Caribbean region largely overexploited, particularly those of the nearshore and coral reefs. Development without effective conservation and management measures has led to this problem. Most countries have weak legislation and no active or effective fisheries management plans. Centralized, top-down management has largely been to blame in this region, coupled with limited self-policing of local fishers. The political culture (i.e., weak institutions and poor enforcement of laws) of the region coupled with socio-economic conditions have been factors that have limited power-sharing and effective management towards sustainable use. In Costa Rica as in many other jurisdictions, “centralized regulation of fishing inputs (e.g., gear and seasonal restrictions) has largely failed to address overcapacity and, in some cases, has intensified competition and uncertainty among fishers” (Garcia and Heninen 2016: 759). The Marine Area of Responsible Fishing (Área Marina de Pesca Responsable, or AMPR), suggests the opportunities that can come for sustainable use through the involvement of local fishers’ organizations (Fargier et al., 2014).</p> |
| Forest ecosystems (e.g., Mesoamerican biological corridor) | <p>Co-management institutions can be an effective way to mediate transboundary resource management problems including competition between users as well as ensuring fit between ecological scales and political scales of decision-making. A bio-regional lens has been used in establishing protected areas and developing forest co-management institutions in some regions such as central America (i.e., Mesoamerican Biological Corridor) (Barquet, 2015).</p> |

**Transboundary
Protected areas
(e.g., Great
Limpopo
Transfrontier park)**

Transboundary of frontier governance arrangement in southern Africa have created opportunities for new kinds of governance of lands, species and protected areas. The South Africa Development Community signed a Treaty in 1992 aimed at managing complex natural resource management problems and creating economic opportunities (e.g., cross-border trade). It is recognized that many peoples in the region are dependent on species that span or are dynamic across borders. The potential for shared decision-making over these natural resources is seen as an important pathway towards sustainable use of natural resources as well as sustainable economic development more broadly. Despite the Treaty being more than twenty years old, conflicts persist due in large part to economic uncertainties and stresses on local communities and governments (Katerere et al., 2001). Other kinds of transboundary agreements and initiatives such as the *Great Limpopo Transfrontier Park* have also had mixed success; rather than decentralizing power to local people, large NGOs and donors may have centralized power elsewhere and limited the rights and interests of local organizations and communities (Duffy, 2006).

Over the last forty-five years, co-management arrangements have been emerging in various regions and for diverse species and habitats around the world. Conservation areas or protected areas have proven to be managed in ways that ensure sustainable use where co-management systems have been designed. Inclusive approaches to governance are evidenced as effective in many nation-states and with respect of numerous wild species including those of wild species, fisheries, timber and other forest resources. The engagement of citizens in governance can take many forms and range in rigor and depth along various kinds of continuums (e.g., Arnstein's Ladder of Participation) (Arnstein, 1969). Co-management is considered key in addressing many different types of sustainable use problems due to the integration of diverse stakeholders into the rule-making process, monitoring, and enforcement (Berkes et al., 1991).

Table 4.4 Success Factors in Co-management. Source: Armitage et al., (2009) © The Ecological Society of America under license number 5154840749156.

| <i>Condition of success</i> | <i>Explanation</i> |
|--|--|
| Well-defined resource system | Systems characterized by relatively immobile (as opposed to highly migratory and/or transboundary) resource stocks are likely to generate fewer institutional challenges and conflicts, while creating an enabling environment for learning. |
| Small-scale resource use contexts | Small-scale systems (eg management of a specific rangeland or local fishery) will reduce the number of competing interests, institutional complexities, and layers of organization. Larger-scale resource contexts (transboundary stocks, large watersheds) will exacerbate challenges. |
| Clear and identifiable set of social entities with shared interests | In situations where stakeholders have limited or no connection to “place”, building linkages and trust will be problematic. In such situations, efforts by local/regional organizations to achieve better outcomes may be undermined by non-local economic and political forces. |
| Reasonably clear property rights to resources of concern (eg fisheries, forest) | Where rights or bundles of rights to resource use are reasonably clear (whether common property or individual), enhanced security of access and incentives may better facilitate governance innovation and learning over the long term. Such rights need to be associated with corresponding responsibilities (eg for conservation practices, participation in resource management). |
| Access to adaptable portfolio of management measures | Participants in an adaptive co-management process must have flexibility to test and apply a diversity of management measures or tools to achieve desired outcomes. These measures may include licensing and quota setting, regulations, technological adjustments (eg gear size), education schemes, and so on. In other words, economic, regulatory, and collaborative tools should all be available. |
| Commitment to support a long-term institution-building process | Success is more likely where stakeholders accept the long-term nature of the process, and recognize that a blueprint approach to institutions or management strategies is probably not advantageous. Commitments of this type can provide a degree of relative stability in the context of numerous changes and stresses from within and outside the system. |
| Provision of training, capacity building, and resources for local-, regional-, and national-level stakeholders | Few stakeholder groups will possess all the necessary resources in an adaptive co-management context. At the local level, resources that facilitate collaboration and effective sharing of decision-making power are required. Regional- and national-level entities must also be provided with the necessary resources. |
| Key leaders or individuals prepared to champion the process | Key individuals are needed to maintain a focus on collaboration and the creation of opportunities for reflection and learning. Ideally, these individuals will have a long-term connection to “place” and the resource, or, within a bureaucracy, to policy and its implementation. Such individuals will be viewed as effective mediators in resolving conflict. |
| Openness of participants to share and draw upon a plurality of knowledge systems and sources | Both expert and non-expert knowledge can play productive and essential roles in problem identification, framing, and analysis. The tendency in most resource management contexts is to emphasize differences in knowledge systems. However, there are substantial contributions to social-ecological understanding, trust building, and learning, where the complementarities between formal, expert knowledge and non-expert knowledge are recognized. |
| National and regional policy environment explicitly supportive of collaborative management efforts | Explicit support for collaborative processes and multi-stakeholder engagement will enhance success. This support can be articulated through federal or state/provincial legislation or land claim agreements, and the willingness to distribute functions across organizational levels. Additionally, consistent support across policy sectors will enhance the likelihood of success, and encourage clear objectives, provision of resources, and the devolution of real power to local actors and user groups. |

4.2.2.2.5 Indigenous rights

Indigenous peoples and rights are defined and recognized variously in many parts of the globe. A typical pattern has been the history of colonization and its impacts on indigenous cultural-spiritual relationships, access and use of natural resources including wild species. A discussion of indigenous rights is a critical question to this assessment because many aspects of unsustainable use of wild species (i.e., compromised health, extirpation, etc.), have direct impacts on the health and well-being of indigenous peoples (Godoy et al., 2005; Posey, 1996; United Nations, 2019; Westra, 2012). This is because many indigenous peoples rely heavily on hunting, trapping, fishing, gathering of berries and medicinal plants, and visiting of sacred sites are critical to food security (Kuhnlein, 2015), cultural continuity, and health and well-being (Biddle & Swee, 2012; Burgess et al., 2009; Stephens et al., 2006). Indigenous peoples also have well established knowledge practices and belief systems that have contributed to the

sustainable use of wild species for generations; thus, the support and recognition of indigenous rights are a significant pathway toward wild species conservation (Gadgil 1993).

In 1982, United Nations Special Rapporteur of the Sub-commission on the Prevention of Discrimination and Protection of Minorities released a global report on systemic discrimination (United Nations, 1982). Following this, over 30 years of consultation and negotiations between nation-states and indigenous peoples led to the creation of the United Nations Declaration on the Rights of Indigenous Peoples (United Nations, 2007). The United Nations Declaration on the Rights of Indigenous Peoples sets out clear principles in respect of indigenous rights related to land and resource use. These rights are recognized as highly consistent with other principles of the United Nations including the Sustainable Development Goals.

The extent to which these rights are recognized by nation-states varies significantly. In some countries, there is little recognition of these rights nor ratification of the United Nations Declaration on the Rights of Indigenous Peoples principles. Canada, although slow to acknowledge the protocol, has made significant efforts to do so in recent years. In many ways, the United Nations Declaration on the Rights of Indigenous Peoples a fortification of other kinds of rights held by indigenous peoples and protected by the Canadian Constitution (1982), through historic and modern treaties, and Supreme Court case law. Many of these legal instruments protect the rights of indigenous peoples to hunt, fish, trap for subsistence, or sustain a reasonable livelihood based on their traditional lands and resources. These rights are often interpreted by the courts as superseding provincial and federal laws and regulations related to management, such as those associated with the east coast lobster fishery as has been the case in recognition of the Marshall Decision. indigenous peoples in Canada bear a significant burden of ill will by non-indigenous peoples who fear these rights will lead to declines or losses in resources. However, there is no evidence that recognition of indigenous rights results in “over-harvesting” and species decline (whether fish, wild species, timber or other resources) but data shows that the recognition of indigenous rights have led to significant conservation outcomes (Lynch et al., 2016; Popp et al., 2019; Stephenson et al., 2018). However, in some key cases, the subsistence and rights of indigenous peoples have often been undermined by poor management of resources For example, contamination of the Athabasca river fishery due to oil sands mining (Westman and Joly 2019; Kelly et al. 2010) collapse of Atlantic and Pacific fish populations due to industrial fishing (Atlas et al., 2021; Lotze & Milewski, 2004; N. Turner et al., 2013), moose population decline in Nova Scotia associated with habitat fragmentation, conversion and loss (Beazley et al., 2006; Popp et al., 2019), extirpation of boreal caribou herds in northern Alberta due to overharvesting of old growth forest (Collard et al., 2020; Johnson et al., 2015; Nagy-Reis et al., 2021).

Similar patterns are visible in many other countries with strong evidence of the impact of biodiversity loss on the health and well-being of indigenous peoples (Hunter et al., 2015; Kuhnlein, 2015). Fishing, forestry, hunting, gathering practices are not only essential component of their traditional diets but of culture and well-being (von der Porten et al., 2019). Hence rights to terrestrial and marine resources and territory are inseparable from broader indigenous rights to self-determination (Cisneros-Montemayor et al., 2016; Larson et al., 2016) as well as a more comprehensive suite of rights protected by the United Nations Declarations on the Rights of Indigenous Peoples and Human Rights more broadly. Efforts led by indigenous

organizations to reduce poverty through sustainable use of biodiversity tend to include key elements of indigenous resurgence strategies, involving the reinvigoration and reestablishment of indigenous land tenure, decision-making, rights, and leadership (von der Porten et al., 2019). Amazon forests managed by indigenous communities show lower rates of deforestation and carbon emissions (Blackman & Veit, 2018). Globally, indigenous territories see lower rates of ecosystem health declines compared to other areas (although trends are nonetheless mostly negative) (Díaz et al., 2019). In addition, it is essential to recognize that indigenous worldviews and decisions are unique and should be included and respected in approaches to knowledge co-creation and resource co-management (Hill et al., 2020).

In addition to the adverse impacts of formal institutions on Indigenous rights and sustainable use of wild species, there is clear evidence of how Indigenous knowledges and customary laws have been vital to sustainable use of wild species in many places globally. In addition to ensuring many conservation outcomes, Indigenous systems of stewardship have been protective of food security, health, culture and well-being (Berkes et al., 2000; M. B. Gadgil et al., 1993). For example, in the case of forest ecosystems in Nepal, customary laws associated with the conservation of ‘ranivana’ (community forests) were established by shamans and priests; over generations, they have proven successful in ensuring the conservation of valued forest species as well as equitable access for benefits to people (e.g., fuelwood, fodder and medicinal plants) (Khatri, 2008). Many more examples exist (see Table 4.5). A key challenge for these and other customary law systems is the extent to which they are in conflict with or are not recognized as a system of laws by nation states. Despite evidence of the social and cultural benefits, many kinds of rules are little recognized.

Table 4.5 Examples of indigenous customary laws and related norms that support sustainable use of wild species. (1)Kosoe et al., (2020); Ntiamoa-Baidu, (1991); (2) Sudo, (1984) (3) (4) de Mattos Vieira et al., (2015) (12) Waller & Reo (2018) (13) Deur, (2009) (14) Turner & Turner (2008) (15) McKemey et al., (2021) (16) Samakov & Berkes (2017), (18) (M. Gadgil (1987) (19) Parlee et al. (2006); (20) Gangadhar et al. (2018) (21) Hickey & Johannes (2002) (22) Chowdhury et al. (2014); Laugrand & Oosten (2010); (23) (Meyer-Rochow, 2009); (24) Kendrick et al. (2005); (25) Begossi & de Souza Braga (1992); (26) Pezzuti et al. (2010) (27) Nijhawan & Mihu (2020); Ross et al. (1978); (28) Golden & Comaroff (2015); (29) (Anbacha & Kjosavik, 2018; Argumedo & Pimbert, 2010; Arnold et al., 2021; Berkes et al., 2000; Carothers et al., 2021; Coldin g et al., 2003; DeGeorges & Reilly, 2009; Fowler, 2003; Francis, 2019; Gonzales, 2013; Kimmerer, 2011; McMillen et al., 2017; Mulrennan, 2014; Phalan et al., 2011; Sowerwine et al., 2019; Thomas, 2015; Watkin Lui et al., 2016; Welch, 2014).

| | Fishing | Terrestrial animal harvesting | Gathering | Non-Extractive |
|---|---|---|---|--|
| Landscape and habitat taboos | Taboos limit access to sensitive habitats as in (1) coastal lagoons in Ghana and (2) coral reefs in Micronesia. | Rotating goose hunting to limit hunting disturbance (3) Cree in northern Canada and the Piagaçu-Purus Reserve in Brazil (4). | (5) Sacred forests that protect valued habitats (e.g., Malawi). (6) | Taboos against travel in areas of glaciers as in northwestern Canada (7) (8) |
| Rituals and ceremonies that support habitat protection and regeneration | Making offerings or ‘paying’ the water as with the (9) Dene of northern Canada; and “first salmon ceremony” harvest rituals that limited early access to salmon spawning areas. | Respect of key migration corridors and water crossings and calving grounds of barren-ground caribou as with the Gwich’in of northern Canada and Alaska (11) Culling of deer population (harvest for food to limit over browsing and promote biodiversity richness (12). | Cultural burning practices that support the regeneration of medicinal plants as with the (13) Klamath. First food ceremonies to recognize spirits of berries and signal access to berry patches as in Northwest Coast Canada (14). Cultural burning in Australia to support social fertility and manage bush fire risk (15) | (16) Cleaning and care of sacred sites to ensure continued spiritual value and healing properties as in Kirghizstan. |
| Temporal and dynamic taboos and regulations related to harvesting in breeding / reproductive | Taboos instituted when stocks are decreasing - promote stock recruitment as in (17) South-East Asia. | | Care and stewardship of plants such as berries and medicinal plants are visible among the Gwich’in Nation (19) | Taboos against entry of sacred meadows limit impact on sensitive wild species habitats (e.g., high |

| | | | | |
|--|---|---|--|---|
| seasons (i.e., closed seasons) | | Bans hunting certain animals in the four months from July to October exist in many (18) Indian villages. | | altitude areas of India such as Bhadelguar) |
| Specific Species-Taboos | Taboos against harvest of sea turtle in (21) Vanuatu reefs. | (22). There are taboos based on indigenous and local knowledge against hunting of rare species or those under stress as with the <i>Mro</i> people of Bangladesh. Beliefs and rules about ‘not wasting’ meat are associated with the respect for Sedna or Senna as in Inuit culture in Nunavut and Siberia. | (23) Food and medicinal taboos against gathering of plants are common to protect against adverse health or dietary outcomes and/or ensure availability of species other specific uses. | (24). Access of particular wild species habitats can be seen in many regions and can be gendered (e.g., women should not visit caribou crossings while menstruating). |
| Taboos for Species Consumption (as food) | Fish species in the (25) Tocantins River (Amazon) are not eaten due to their value as medicine. Taboos against turtle harvest in the (26) Amazon as food (due to potential for illness). | (27) Taboos against the consumption of meat from hunting exist. For example, taboos against consuming primates. | (28) Food taboos are common and indirectly contribute to conservation of these species (e.g., as in Madagascar) | NA |
| Rules and incentives related to sharing observations (e.g., reciprocal care) | (29). Food sharing networks and incentives or reciprocity are common in many indigenous cultures and include care for others (e.g., more vulnerable populations) as well as care for the species and habitats. For example, when animals given themselves as gifts to feed the community, expressions of care and respect are shown for the animal and the ecosystem. | | | |

4.2.2.3 *Informal institutions, voluntary measures and collective action*

Informal institutions are defined as those sets of rules that are used (i.e., rules in use) that effectively form the basis of decisions about access, use, and sharing of resources (Berkes 1998). They can, along with international agreements and state-level institutions, be highly effective at ensuring sustainable use of wild species (Griffiths, 1986; Laird et al., 2010; Shanley et al., 2015). Informal institutions may develop as a softer dimension of, or response to, more formal institutions, but may also function as the sole mechanism for regulating sustainable use

They are critical in filling gaps in formal, state-level institutions, or where these formal institutions have failed (Ostrom, 2000). Voluntary organizations and efforts at collective action are also very important and can contribute significantly to addressing questions of sustainable use of a variety of species and myriad practices; some of the most effective voluntary organizations are in fisheries management (Blyth et al., 2002; Jentoft & Bavinck, 2014). Collective actions (e.g., information campaign, protest) are important for social groups who are not represented in formal kinds of governance and have been found effective at addressing issues of unsustainable use. These include actions by rural and subsistence communities, indigenous peoples, women and others. Indigenous and local communities are in the frontlines of resisting “development” schemes (Díaz et al., 2019). As an example, in the Puna area of South America, local communities such as the ones from Salinas Grandes and Laguna Guayatatoyoc engage in collective action against lithium mining in order to protect their pastoralist activities and livelihoods (Pragier, 2019). When compared to more formal institutions, less is known about informal institutions and collective actions; there are gaps in understanding of “the social and political mechanisms involved in large-scale collective action problems and how cooperation in large communities is facilitated or obstructed” (Duit, 2011, p.907). Forms of collective action aimed at addressing issues of unsustainable use often focus on questions of rights of access, benefit, and use.

Informal institutions are rooted in the social and cultural norms of communities and societal groups, and customary law can provide effective regulation of wild product harvesting. In the case of Cameroon, it was found that customary laws addressed who owns resources, who can harvest them, where harvesting will take place, in what quantity, and who benefits and in what ways; all with greater specificity and legitimacy than weak government regulations (Ingram, 2014; Laird et al., 2010).

Box 4.14 Politics of forest management in the Himalayas: Nepal and Myanmar

The Himalayan temperate forest zone has some of the highest percentage of endemic and threatened species in the world (Brandt et al., 2017). Many of the threatened species in this region depend on forests (Brandt et al., 2017). Five countries, including Nepal and Myanmar, contain >98% of the remaining forests in this region (Brandt et al., 2017). While deforestation is a concern in the Himalayan temperate forest zone Nepal and Myanmar have different results when it comes to forest management (Brandt et al., 2017). In general, Nepal is known for having successful forest management through their progressive community forest management that provides benefits to local communities (Anup et al., 2018; Baral et al., 2018; Brandt et al., 2017; Rai et al., 2017). However, studies examining Myanmar show that the country has weak forest policies riddled with corruption (Brandt et al., 2017; Lim et al., 2017). Rates of deforestation in unprotected areas from 2000 to 2014 were very low in Nepal at 0.6% whereas Myanmar

had the highest deforestation rates of the region at 1.7% (Brandt et al., 2017). Additionally, Myanmar had the third largest deforestation by area in the world from 2010 to 2015 (Reddy et al., 2019). In the Himalayan temperate forest zone, Nepal has the best record of successful community management (Brandt et al., 2017). In Nepal, 68% of forests are managed by the government and the remaining 32% are under community management (Brandt et al., 2017). Community forest management in Nepal has helped to enhance forest cover, conserve biodiversity and support local livelihoods (Anup et al. 2018). After the civil war in Nepal, the government used conservation, especially forest conservation, as a tool of state building (Dongol & Neumann, 2021). A key to Nepal's success with community forest management is the active involvement of villagers in the protection of their local forests (Anup et al., 2018). Community forest management was used as a tool to reduce conflict between the government and rural communities by giving those communities authority over the local forests (Dongol & Neumann, 2021). Not only are the citizens directly proximate to the forests included but distant users are also involved in forest management (Rai et al., 2017). Community forest management in Nepal provides forest products to distantly located citizens who are unable to physically participate in forest management activities (Rai et al., 2017). Providing forest products to these citizens has contributed to positive support for forest management in proximal and distant communities alike (Rai et al., 2017). Overall, Nepal's community forest management approach to reduce deforestation is a sustainable approach. On the other hand, Myanmar has fallen short with its forest management practices. A huge contributor to the current patterns of deforestation in Myanmar is the long history of military rule and conflict (Brandt et al., 2017). Myanmar's forests are controlled by the national government through a centralized forest ownership approach (Brandt et al., 2017). Timber extraction and agricultural advancement are often given priority over forest protection and sustainable use (Brandt et al., 2017; Lim et al., 2017). As a result, government forests are viewed as the equivalent of an open-access area (Brandt et al., 2017). Government forests in Myanmar have insufficient monitoring and enforcement mechanisms which leads to exploitation of forest products (Brandt et al., 2017). In conclusion, the community forest management system in Nepal has proven a successful method of forest conservation. Community forest management is a practice of forest management that is sustainable and increases biodiversity. This practice in Nepal has had tremendous results in the Himalayan temperate forest zone that is currently susceptible to deforestation. While Nepal has found success, Myanmar has struggled to maintain integrity in their conservation attempts. The political instability in Myanmar has provided a barrier to achieving effective forest management. The approach that Nepal used of building governance structures around conservation policies is an interesting approach and has been an important development for the region's conservation of forests.

There are similar examples from almost every corner of the globe and with respect to nearly every practice and use of wild species. Ndoye and Awono (2010) and Ingram, Ndumbe, and Ewane (2012) describe for *Gnetum africanum* how allocation of permits and quotas (which are not based on any inventory of the plants) and standard practices of bribes and corruption at official checkpoints, raises costs, increases losses, and leads to increased resource exploitation. Sunderland et al. (2010) and Ingram et al. (2017) report on the trade of bush mango (*Irvingia* spp.) and njansang (*Ricinodendron heudelotii*) (Ndumbe et al., 2018) in Central Africa, which is widely traded nationally and regionally and likewise conclude that government institutions are all but absent, with corruption an issue for those that do function. The Sami management of reindeer in Finland and Norway is the result of the interaction between local and national institutions (Marin & Bjørklund, 2015). In Finland, herders work with a range of new formal bureaucratic institutions that have come on top of customary ones. There is a

mismatch between the formal and informal institutions and their underlying logics and styles of thinking have resulted in a complex institutional dynamic affecting land and resource tenure (Marin & Bjørklund, 2015). Areki & Cunningham, (2010) report on the sustainability crisis around the wood carving species *Intsia bijuga*, which requires a complementary approach of strengthening weakened customary law and stronger and better-coordinated national regulation.

In some countries, lack of recognition by government of customary systems (including their criminalization) have undermined sustainability (Laird, McLain, and Wynberg 2010; Arnold and Pérez 2001; Wynberg and Laird 2007; Michon 2005; Lele, Pattanaik, and Rai 2010). However, in cases where species are under strong commercial pressure, for example *Prunus africana* across much of Africa (Wiersum et al., 2014), and customary systems of governance have broken down, statutory law is an important and often necessary complement to replace or reinforce customary law (Laird, McLain, and Wynberg 2010).

4.2.2.4 Customary laws and common pool resource institutions

Systems of natural resource management, including those related to wild species use, have changed significantly over the last thirty years in many jurisdictions from centralized, top-down conservation approaches to community-based approaches, which account for social and ecological dimensions of use (Agrawal & Gibson, 2001; Borrini-Feyerabend, 1996; Meinzen-Dick et al., 2002; Russel & Harshbarger, 2003). Part of the success of community-based institutions is attributed to the flexibility and adaptability of rule systems to ups and downs in resource availability and condition. Rules that integrate the well-established cultures and way of life of local peoples are most often successful and may be considered ‘customary’. “Customary rights” refer to community rules and regulations inherited from ancestors that are accepted, interpreted, and enforced by the community, which may or may not be recognized by the State (Awono et al., 2016). Whether recognized by statutory laws or not, rural communities often consider themselves to be the traditional owners of resources within their respective domains (Wily and Liz 2004; Laird, McLain, and Wynberg 2010).

A subset of these rules related to “commons” are relevant to this assessment, given that many wild species are defined as common-pool resources. Such institutions are well developed in many countries around the world and in relation to numerous species. These institutions delineate many aspects of management. Rights to use, harvest and associated trade may be governed through systems of short and long-term leases, loans, gifts, payment (including in-kind) and inheritance, which can differ depending on which societal and ethnic groups dominate access to resources and access to markets. These customary norms typically differ within a country and determine who owns resources and may access them; where and in which quantities harvesting may take place; and who benefits and how.

Box 4.15 Medicinal and aromatic plants in Asia

Medicinal and aromatic plants have played significant socio-cultural and economic roles in many rural households in the Himalayan region of Asia, for thousands of years (Joshi & Rao, 2011; Karki et al., 2005; Kumar et al., 2015; Kunwar et al., 2015; Lal & Samant, 2019; Olsen & Larsen, 2003). One such meaningful plant is the deciduous shrub *Ephedra*, which is traditionally used for primary health care in

rural households (Joshi & Rao, 2011; Khan et al., 2011; Sher et al., 2016) and has sacred or religious connections (Negi et al., 2018; Sher et al., 2016) dating back to the beginnings of Zoroastrianism (Falk, 1989). Ephedra also provides economically for households through harvest and trade (Karki et al., 2005; Olsen & Larsen, 2003; Sher et al., 2016), which is highly driven by interest from pharmaceutical companies (Lal & Samant, 2019; Negi et al., 2018; Sheng-Ji, 2001; Shinwari & Gilani, 2003; Upadhyay et al., 2019). The Ephedra genus has eleven different species throughout the higher elevations of the Himalayas, one of which is *E. gerardiana*, found in drier temperate and alpine areas (Lal & Samant, 2019). *E. gerardiana* is becoming increasingly vulnerable due to landscape change and over-harvesting in many regions (Roland, 2020) driven by the need for income in many rural subsistence communities. In the Uttarakhand state of India, a high number of medicinal and aromatic plants including *E. gerardiana* are found to be under pressure, resulting from factors which include: loss of indigenous knowledge (Kumar et al., 2015), disinterest from younger generations (Kumar et al., 2015; V. S. Negi et al., 2018) over-harvesting and illegal trade (Joshi & Rao, 2011; Kala, 2005; Phondani et al., 2015), land pressures (Kanwal & Joshi, 2015), lack of policy and conservation enforcement (Joshi & Rao, 2011; Kala, 2005) and climate change (Negi et al., 2018). Primarily because of the economic demand and overharvesting of medicinal and aromatic plants for harvest and economic trade, the need to turn towards partnerships with local farmers to cultivate certain plants is recognized. Pilot projects are underway in the Champawat district (Phondani et al., 2015) and the Byans valley (Negi et al., 2018) to create gardens for medicinal and aromatic plants to be sustainably harvested for household income and primary health care. While this is just a beginning, India is showing benefits of local markets and herbal gardens playing a role in sustainable growing and harvesting methods of medicinal and aromatic plants such as *E. gerardiana* (Joshi & Rao, 2011). In Pakistan's upper Chitral Valley and Astore district, medicinal and aromatic plants are vulnerable due to landscape pressures including deforestation (Khan et al., 2011; Shinwari & Gilani, 2003) and habitat destruction because of over-grazing and soil erosion (Alam et al., 2017; Khan et al., 2011; Ullah & Ur Rehman, 2016). According to Sher et al. (2016) and Shinwari & Gilani (2003) residents of this Himalayan region rely extensively on medicinal and aromatic plants for traditional healing and primary health care. Pharmaceutical companies, eager for *E. gerardiana* have increased the harvest demand in an economically challenged region (Ali & Qaiser, 2009; Shinwari & Gilani, 2003). *E. gerardiana* has been over-harvested by collectors eager to create income- whether nomads or local inhabitants (Alam et al., 2017; Khan et al., 2011; Ullah & Ur Rehman, 2016). This is largely a result of global demand and dealers without conservation policies, and limited local knowledge of the need for sustainable harvesting practices (Ali & Qaiser, 2009; Z. Shinwari & Gilani, 2003). In addition to landscape pressures, overharvesting of medicinal and aromatic plants for income purposes puts *E. gerardiana* in a continual vulnerable state. Similar to India, it has been recognized by researchers that in order to decrease pressure the delicate Himalayan ecosystem where medicinal and aromatic plants species have been recorded as extinct (Dhiman & Rautela, 2014; Z. Shinwari & Gilani, 2003) and over-harvesting for income purposes continues; cultivating *E. gerardiana* ex-situ by pharmaceutical industry and households will be a way forward to allow for sustainable harvest, sales, and use of this high-demand medicinal and aromatic plants. While *E. gerardiana* has been shown to be one of a few medicinal and aromatic plants that survive well in cultivation (Shinwari & Gilani, 2003), this has yet to be seen in Pakistan at the time of this research.

These common pool resource institutions have proven to be particularly effective at addressing what is defined as the open access problem (i.e., unregulated harvest). Many authors including (Berkes, 1989; McCay & Acheson, 1987; Van Den Berg et al., 2007; Wakjira & Gole, 2007) have evidenced the usefulness of customary and community-based resource management systems in the sustainable management of small-scale fisheries and of plants, algae and fungi.

Similarly, there is concrete evidence that participatory, community-based natural resource management approaches are effective in promoting sustainable use of wild species, in Africa (Abensperg-Traun, 2009; Rowcliff et al., 2004) and in Asia (Nasi et al. 2008), especially with the involvement of local and indigenous peoples and their traditional knowledge of sustainable use of wild species (Freeman, 1999; Hakimzumwami, 2000). At the same time, there is also evidence of failure of such approaches (Acheson, 2006).

In Cameroon, harvesting wild plants, algae and fungi on land held by a clan or family may take place only with the family's permission. On communal lands, any member of a community can harvest for subsistence use, but for high value traded products (such as *Prunus africana*, *Gnetum* spp and *Irvingia* spp), approval is generally required from the chief or village council. Outsiders often need permission to harvest and should provide in-kind or cash compensation before or after harvesting. In some communities, conflicts occurred when such proceeds were not used to benefit the wider community (Ingram et al. 2015).

In general, the principle of customary law and common pool resource institutions involving wild species are focused on safeguarding the health of species while at the same time meeting social and economic needs. Not all common pool resource institutions are effective; those that are successful generally adhere to the following eight design principles as defined by Ostrom (1990):

- Boundaries of users and resource are clear.
- Congruence between benefits and costs.
- Users had procedures for making own rules.
- Regular monitoring of users and resource conditions.
- Graduated sanctions.
- Conflict resolution mechanisms.
- Minimal recognition of rights by government.
- Nested enterprises.

Among the biggest threats to the sustainability of common-pool resource institutions is industrialization and globalization (Dietz et al., 2003). The social, cultural, and ecological stresses created through these processes effectively undermine the systems established within local or regional areas, or in respect of particular species, effectively creating a larger scale open-access problem and “tragedy of the commons” (Hardin, 1968).

Some mixes of governance and institutional arrangements can lead to unsustainable use of wild species when they are confusing and overlapping; developed without scientific evidence; without consultation with local communities and indigenous peoples, and broader stakeholder involvement; where multiple institutions exist to oversee or govern the same activities, but their mandates overlap and conflict, and coordination is not encouraged; and when good laws are not implemented. International and national institutional arrangements can fail to achieve intended results when they are not linked with strong institutions at the national levels, and global, national, and local objectives do not align. In many regions, pluralistic approaches that draw upon international and national policy frameworks and laws, and integrate customary law and local practices, are the most effective for supporting and promoting the sustainable use of wild species. Pluralism is most notable between statutory and informal or customary rules, sometimes as a complement to statutory systems of governance in a context of legal pluralism

(Griffiths, 1986; Laird et al., 2010). The balance of evidence from the Commons literature for the past few decades is that neither purely local level management nor purely higher-level management work well alone. Instead, there is a need to design and support management institutions both horizontally (across space) and vertically (across levels of organization). Issues need to be considered simultaneously at several scales when there is coupling or interaction between scales (Berkes et al., 2008; Ehara et al., 2018).

4.2.2.5 Trends in governance arrangements

Over time, governance arrangements constantly evolve and adapt (Garcia et al., 2014); stakeholders may try to craft their own arrangements, creating hybrid or completely new arrangements (Cleaver, 2017). Since the 1960s, natural resource management governance arrangements and approaches in many countries have moved from centralized to decentralized management, and from state-controlled to community, private, public and participatory. Participatory management, or co-management, approaches to natural resources grew up at this time in response to greater awareness of social justice issues, and to develop more effective sustainable management approaches that restore resource rights to communities and ensure they benefit from use of their land and resources (Agrawal & Gibson, 2001; Escobar, 1998; Ghermandi et al., 2013; Martín-López & Montes, 2015; Neumann, 2015). In some cases, participatory projects produced real gains for sustainable use and local communities (e.g., Gelose law in Madagascar, wood energy in Niger), and through projects carried out in various ecological and socio-political contexts (e.g., wild species management in Zambia and Zimbabwe with the Admade and Campfire programs, extractive reserves in the Brazilian Amazon) (Babin et al., 2002; Rodary et al., 2003).

In other cases, these projects re-enforced existing inequities and elite capture, and exacerbated tensions between groups. Social contracts can be diverted by a minority of local elites (made up of customary chiefs, elders of lineages, local elected officials, and/or administrative agents), to the detriment of the majority or specific groups (such as women, youths or the landless) in a community, which have no access to decision-making power, nor to the benefits of conservation, nor to natural resources or their markets (Brechin et al., 2003; Ribot et al., 2010; Sze, 2017; Vandergeest & Peluso, 2006; Wiersum et al., 2014).

Until the 1970s central governments tended to view natural resource governance as centralized and top-down. Given the perceived failure of top-down policies, decentralization became the new paradigm during the 1990s following a growing consensus that effective management and governance of environmental challenges required policies and actions that were compatible with the realities and perspectives of local communities that have the most direct contact with the environment yet have the most to lose from environmental degradation (e.g., Dressler (2010).

This was supported by an earlier shift in the field of conservation away from purely protectionist approaches towards greater integration of conservation and sustainable use. Articulated in the 1987 United Nations publication of the Brundtland Report (*Our Common Future: Report of the World Commission on Environment and Development*), this new approach linked conservation with sustainable development. The *Convention on Biological Diversity* and other agreements emerging from the 1992 UN Conference on Environment and Development

further linked conservation, sustainable use, and equity, as did national protected area, conservation, Forestry and other laws drafted to implement the Convention on Biological Diversity (Laird, McLain, and Wynberg 2010).

Box 4.16 Political drivers of sustainable harvest of sturgeon (*Acipenseridae*) in the Caspian Sea

The sustainable use of sturgeon of the *Acipenseridae* family, is a challenge for fishery management regimes throughout the world (Pikitch et al., 2005; Pollock et al., 2015). Sturgeon, or *Acipenseridae*, a group of semi-armored fish, pose some biological challenges to conservation due to their low reproductive rates, relatively long life spans, and long migrations (Scott & Crossman, 1973). Sturgeon are also the source of black caviar, a scarce and highly priced global commodity, meaning their exploitation is tied to boom-bust economic cycles and resulting in the collapse of many sturgeon populations (Pikitch et al., 2005). The Caspian Sea is the habitat for a variety of sturgeon species, primarily being Beluga (*Huso huso*), Russian (*Acipenser gueldenstaedtii*), Persian (*Acipenser persicus*), and Stellate (*Acipenser stellatus*) (Ruban & Khodorevskaya, 2011). The Caspian Sea represents an important example for international species conservation, with the shores of the sea backing onto multiple countries on the south-western border of Russia. Throughout recent history, sturgeon populations and associated products can be partially explained through the area's political history, specifically the rise and fall of the Soviet Union within the Caspian Sea region (Akhmadiyeva & Abdullaev, 2019). Due to this jurisdictional overlap, and political history, there are multiple socio-political influences that could affect the fishery. In a contemporary frame, a significant driver of unsustainable and declining sturgeon stocks in the Caspian Sea has been the prevalence of illegal fishing activity, with illegal sturgeon harvesting accounting for several times the level of legal harvesting (Aghilinejhad et al., 2017; Ermolin & Svolkinas, 2016; Ye & Valbo-Jørgensen, 2012). While illegal fishing activity has been closely tied to the price and scarcity of sturgeon products (Ruban & Khodorevskaya, 2011), others have shown that social factors also play a significant or parallel role (Aghilinejhad et al., 2017; Akhmadiyeva & Abdullaev, 2019; Ermolin & Svolkinas, 2016; Mirrasooli, 2019). The social perceptions of the legality and enforcement of sturgeon fishing regulation contribute to the actions of legal and illegal fishers, with the actions and behavior of enforcement officials discouraging, and in some cases encouraging, illegal fishing (Ermolin & Svolkinas, 2016). Underlying all of these social factors in the sustainability of sturgeon is the social context in which illegal fishing activities are occurring. The state of local employment, individual investments in fishing equipment, and general rates of poverty, all contribute to the persistence of illegal fishing activity (Aghilinejhad et al., 2017; Ermolin & Svolkinas, 2016; Mirrasooli, 2019). The role of local knowledge and familiarity with sturgeon stocks generally is a significant influencing factor in the occurrence of illegal fishing of sturgeon in the Caspian Sea (Aghilinejhad et al., 2017; Mirrasooli, 2019). Some have considered this factor to be a "lack of awareness" on behalf of the fisher people (Mirrasooli, 2019), while others have conceived this variable as "fishers' knowledge" (Aghilinejhad et al., 2017). Studies of indigenous management in North America concerning sturgeon have shown there is a lack of consideration and mobilization of indigenous knowledge (including fisheries knowledge) in fisheries (and specifically sturgeon) management (Oloriz & Parlee, 2020). Due to the challenges of complex overlapping jurisdiction harvesting regimes and the prevalence of illegal fishing, the state of sturgeon fisheries in the Caspian Sea is concerning. Studies here have begun to investigate the complex ways in which social and political factors influence this illegal fishing activity and highlight the need to approach the sustainable harvest of wild species from a more holistic perspective (Aghilinejhad et al., 2017; Akhmadiyeva & Abdullaev, 2019; Ermolin & Svolkinas, 2016; Mirrasooli, 2019; Pikitch et al., 2005; Pollock et al., 2015; Ruban & Khodorevskaya, 2011; Ye & Valbo-Jørgensen, 2012).

While environmental governance views were changing, so too were views about the role of indigenous peoples and local communities in conservation and sustainable use. Movements that pressured governments to recognize the land, resource, human, cultural, intellectual and other rights of indigenous peoples and local communities influenced global processes and laws like the International Labor Organisation's Convention No 169, the United Nations Declaration on the Rights of Indigenous Peoples, and work on traditional knowledge in the World Intellectual Property Organisation (Laird et al., 2010; Posey & Dutfield, 1996). Many national governments have moved to recognize the rights of indigenous peoples to control the use of their resources and associated knowledge, but in several countries, this continues to be little more than window dressing and centralized systems continue to control benefits from wild species (Arquiza et al., 2010; Castillo & Alvarez-Castillo, 2009; Novellino, 2010). However, the recognition of existing customary governance and institutions for natural resource management has become more common place (Bromley & Cernea, 1989; Wily & Liz, 2004).

The impact of changes in the governance and institutional framework of conservation on the sustainable use of wild species is difficult to quantify, which should not be surprising given the complex and multidimensional nature of wild species use (Alexiades & Shanley, 2004; Neumann & Hirsch, 2000). Individual cases support these approaches, however broader landscape level conservation gains are more difficult to identify. This is not a problem inherent to conservation and sustainable use that involves local groups and indigenous peoples, but instead reflects the outsized impact of global political, cultural and economic factors. These include international and national governance and institutions that do not adequately regulate sustainability or implement environmental laws, and a large and constantly expanding culture of consumerism in wealthy nations that is overwhelming wild species everywhere.

The growth in protected areas and innovations in protected areas management is another vital trend in governance. Historically, protected areas controlled by governments and reinforced through international agreements (e.g., the Aichi Target of "By 2020, at least 17% of terrestrial and inland water areas, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved...") have been an essential mechanism for conserving the world's biodiversity by increasing protected areas (Nepstad et al., 2006). Over the past two decades protected area governance has diversified, with significant growth in not only government-managed areas but also private and community-based management, and a variety of hybrid, partnership-based models that build multi-layered pluralistic approaches into protected area management (Borrini-Feyerabend et al., 2013). Collaborative governance of protected areas has the potential to yield multiple biodiversity and socio-economic benefits through the formation of alliances and partnerships between stakeholders (governments, the private sector, local communities, and non-governmental organizations), as a means of developing consensus and efficiently deploying available skills and resources (Munthali, 2007). Such arrangements can draw on various knowledge systems to foster trust and develop joint visions, promote experiential and experimental learning, and function as bridging organizations that lower the costs of collaboration and conflict resolution (Armitage, Plummer, Berkes, Arthur, Charles, Davidson-Hunt, Diduck, Doubleday, Johnson, Marschke, et al., 2009; Folke et al., 2005).

Although protected areas historically excluded use by indigenous peoples and local communities, institutional arrangements are changing (Colchester, 2004); some parts of the world now privilege use for subsistence and cultural continuity. This is true in the laws and arrangements associated with most protected areas in Canada, New Zealand and some areas of Australia (Lee, 2016; Muller, 2003; Ross et al., 2009; Smyth, 1995; United Nations, 2007; Zurba et al., 2019). Some protected areas are now defined as indigenous protected and conserved areas (Moola & Roth, 2019; Zurba et al., 2019). This new approach to protected areas management (i.e., that recognizes social, cultural use) has been positive in ensuring sustainable use. Specifically, “protected areas that explicitly integrated local people as stakeholders tended to be more effective at achieving joint biological conservation and socioeconomic development outcomes”(Oldekop et al., 2016).

4.2.2.6 Land tenure and resource rights

Key Messages:

- Land tenure and rights to resources in a given area can involve many separate rights, which taken together are essential components of sustainable use and broader good governance. Tenure arrangements that foster secure rights over land and resource use and trade can incentivize resource conservation, sustainable use, and diverse livelihoods, in part because they allow for longer-term planning.
- Secure rights are not guaranteed by a formal title or certificate. In fact, in some cases, customary systems are more secure than formal systems, though in general, due to encroachment on the tenure rights of indigenous peoples and local communities, some kind of formal recognition is increasingly needed. Still, many other contextual factors besides formal recognition determine level of security.
- For forests, centralized management that disregards robust traditional systems and cultural relationships with forests has failed historically to support conservation and sustainable management.
- In fisheries, centralized management has been shown to be difficult and unresponsive to local conditions, resulting in poor implementation of management measures and a subsequent large amount of illegal, unreported, and unregulated fishing activity in almost every jurisdiction.
- Indigenous territories store large quantities of global terrestrial carbon and see lower rates of ecosystem health declines compared to other areas, but governments have only recognized indigenous peoples’ legal rights to a small portion of the lands they occupy. Secure rights and robust customary governance systems are associated with lower deforestation rates.
- Even if men’s rights are secure, whether in individual or common property systems, women’s rights tend to be less secure. Securing women’s access to assets and participation in decision-making is seen as integrally related to sustainable livelihoods and resilience.
- Despite challenges associated with recognizing and securing tenure rights, the growing awareness of the role of tenure in achieving development and environmental goals has

created a range of new commitments, initiatives, and policy openings at the country level.

Land and resource tenure, understood here as the rights of an individual or group over the use of natural resources, is an essential component of sustainable use and broader good governance. Tenure determines who is allowed to use which resources, in what way, for how long and under what conditions, as well as who is entitled to transfer rights to others and how. During colonial and post-colonial regimes, tenure rights, granted by the state in the form of legal titles over land and other resources, often displaced and marginalized indigenous peoples and local communities who held land and resources under customary systems. The ongoing legitimacy of the latter has nonetheless been increasingly affirmed, including by the Inter-American Court of Human Rights and the United Nations Declaration on the Rights of Indigenous Peoples (United Nations, 2007). Yet, in practice the usurpation of customary rights is common, as is the harassment, criminalization, and murder of environmental and resource rights defenders (global witness).

Tenure arrangements that grant secure rights over land and resource use can incentivize resource conservation, sustainable use, and diverse livelihoods. Secure resource rights allow for longer-term planning and the use of such rights as collateral for investments (German et al., 2014) and public-private partnerships. This has sometimes been interpreted to mean that rights should be granted to individuals (De Soto, 2011), but decades of research on common property resources has demonstrated both the importance (for livelihoods, resources and human rights) and the effectiveness of common and communal governance systems (Ostrom, 1990; Ostrom & Nagendra, 2006).

Rights to land and resources in a given area can consist of many separate and overlapping rights, and may differ according to gender, age and ethnic group, as well as within communities and societal groups (Ingram et al. 2016; Wiersum 1997; Larson et al. 2010). Hence assuring security is not necessarily a simple task, as granting exclusive rights for one group may deny it to another that also manages and depends on resources for local livelihoods. There has been increasing attention to the potential for inequitable distribution of benefits and power imbalances in conferring resource rights (Fitzgerald et al., 2020). Conflicts over resource use are prevalent (and in the case of fisheries resources, increasing) (Spijkers et al., 2018), and lack of transparency and legal clarity can enable inequitable outcomes (Fitzpatrick et al., 2008). In this context, addressing tenure rights can become a mechanism not only for incentivizing sustainable use but for supporting just transitions to sustainability (Bennett et al., 2019). Access and rights to resources, extent of local control and coordination with customary land tenure arrangements are vital issues.

Box 4.17 Snow leopard in the Himalayas – ecotourism

With a habitat that ranges throughout the Himalayas and Central Asia, the snow leopard (*panthera uncia*) has a complex relationship with humans. A history of conflict with farmers, as well as decreasing habitat size and climate change, increasingly threaten the already-low population of this large felid. With an estimated population between 4,000 and 7,000 (Riordan et al., 2016) spread across 12 countries, diminishing wild prey has pushed leopards towards more steadily attacking livestock. Consequently, the

snow leopard interacts and is mainly threatened by retaliatory herders (Rashid et al., 2020). Contested living in arid highlands with access to grazing grounds continues to be one of the most significant challenges for the conservation of snow leopards (Jackson and Wangchuk, 2001; Vannelli et al., 2019). Throughout the “Roof of the World” region, efforts to maintain population levels have used community-based conservation, and have focused on the education of locals, often in partnership with community-based ecotourism (Hanson et al., 2019; Millican, 2016; Vannelli et al., 2019). For the impact on leopards to change, a cultural shift is needed in which snow leopards are not seen as another source of conflict but as an animal to protect who plays a role in the sustained socio-economic presence of communities. Community-based ecotourism with regards to the snow leopard has the opportunity to address various issues. In creating a niche for tourists, community-based ecotourism provides the opportunity to increase revenues for communities and their conservation efforts (Hanson et al., 2019). As a result, it creates a more positive image of leopards, rendered sustainable by the heightened education surrounding the carnivore. Even though sightings of leopards are rare, programs package outings with activities such as trekking, trophy hunting of ungulates, and homestays (Hanson et al., 2019). In addition to assisting in community initiatives and funding preservation, the income from nature-based tourism has also been used to compensate for lost livestock (Rashid et al., 2020). These initiatives have been taken up in Afghanistan (Simms et al., 2011), India (Kala & Makhuri, 2011;), Jammu and Kashmir (Jackson & Wangchuk, 2001) Nepal (Hanson et al., 2019), and Mongolia (Millican, 2016), among others. However, research is most abundant in India and Nepal, with Nepal being the first country to implement community-based conservation of snow leopards through the Annapurna Conservation Area Project (Jackson & Lama, 2016). Nature-based tourism has been changing the relationship to leopards, decreasing human-wild species conflicts, but it is neither sufficient nor sustainable as a single approach. This strategy should be combined with better anti-predation technologies and training (Simms et al., 2011), tourism that does not rely on wild species (Jackson & Lama, 2016; Jackson & Wangchuk, 2001; Mishra et al., 2003), and compensation unrelated to tourism (Hussain, 2000). Some authors (Mishra et al., 2003) have addressed the possibility of the relocation of already-small settlements outside of preserve areas, with the need for assistance in establishing sustainable livelihoods outside of herding. Until now, community-based ecotourism has been a relatively successful and sustainable effort in snow leopard preservation, but the ecological impacts of extraction may soon become too large to match in a timely manner. A proposed response to the multinational challenges that snow leopard conservation faces is for initiatives to attain a transboundary scale (Maheshwari, 2020; Riordan et al., 2016; Rosen & Zahler, 2016). Not only does the leopard’s habitat span a dozen nations, but it also does so along various borders. Thus, focusing on a country-based response may lead to several oversights or pitfalls in strategy. Maheshwari (2020) highlights the possibility for joint governance efforts in preservation, with the possibility of a rippling benefit to the fragile ecosystems inhabited by leopards. In speaking of the political and social drivers of sustainability, cross-boundary models of co-governance are a lever that could bolster conservation while exemplifying a globalized model of community-based conservation (Jackson & Lama, 2016; Rosen & Zahler, 2016; Zahler & Paley, 2016). In doing so, communities across the Roof of the World may become more interconnected and redefine their relationship to large carnivores without sacrificing their local identities.

As implied above, a large body of evidence shows that tenure rights which incentivize sustainable and equitable use of natural resources should be secure and involve local user communities. From (Larson & Springer (2016), a “systematic review of research on the environmental impacts of different property regimes in forests, fisheries and rangelands found that avoiding open access situations in fisheries and forests and transferring user rights to communities usually led to positive environmental impacts (Ojanen et al., 2015).” The benefits

of empowering local communities and recognizing local knowledge in management are not limited to local livelihoods and sustainability of resource sectors. Still, they have further positive impacts on other ecosystem services (for example, better-managed forests with improved production and carbon storage) (Chhatre & Agrawal, 2009).

Devolving tenure from centralized management to local communities can be challenging, despite evidence of the benefits. For forests, centralized management that disregards strong traditional management systems and cultural relationships with forests has been shown to lead to poor outcomes, failing to support conservation or sustainable resource use (Larson & Dahal, 2012; Ribot & Larson, 2012; Sunderlin, 2011).

Public trust institutions such as those in the United States of America are among the emerging shifts in land tenure that create incentives for conservation. They involve spending public and private funds, including donations to ensure lands are set aside for conservation (Hodge & Adams, 2012). While there is much literature on how to create land trusts, evidence about their impact on conservation outcomes and sustainable use of wild species is limited (Merenlender et al., 2004).

In fisheries, centralized management has been shown to be difficult and unresponsive to local conditions, resulting in poor implementation of management measures and a subsequent large amount of illegal, unreported, and unregulated fishing activity in almost every jurisdiction (Zeller & Pauly, 2019). Importantly, incomplete or passive decentralization, whereby centralized management is formally phased out but without the real transfer of meaningful authority to subnational governments (Ribot, 2006), and without legal frameworks and institutional support for local tenure rights, can also create power imbalances and vacuums with negative ecological and social impacts (Méndez-Medina et al., 2020). In the case of forest and wild plant species, when commercial pressures increase significantly, local and customary systems of governance are often overwhelmed and require support from statutory systems (Wynberg & Laird, 2007).

4.2.2.6.1 Gendered land, resource, and trade rights

Gender differences and inequalities are common in resource access and security and in the commercialization of wild products. There is limited information available on gender in trade, and a strong bias in the literature towards African countries (Haverhals et al., 2016), though this is changing (see, for example, Women's Studies International Forum issue 65, 2017; or <https://gender.cgiar.org/gender-in-value-chains/>). Gender differences in participation in trade are mainly the effect of social-cultural factors, including gendered resource access rights. In addition, due to the nature of value chain activities, cultural norms and overlapping customary and formal regulatory arrangements often position men in more favourable positions than women in the value chains of wild-sourced products. Although interventions have primarily focused on enhancing women's participation and benefits, they rarely consider the relationships between men and women. Hence, raising awareness of gender biases, relations, and potential trade-offs among those involved in value chains and those supporting inclusive and sustainable trade should accompany technological innovations and should occur across all stages of the value chain (Ingram et al. 2016).

Women make up a substantial amount of labor participation in wild seafood resources (e.g., up to 50% in seafood production chains) (Harper et al., 2017) and often fill key roles in value chains, including sales, marketing, and business administration. The literature on wild forest and tree product resources generally provides little information on male/female participation in trade. Where quantified, the male to female participation ratio ranged widely from zero to 100%. Information on the rates of participation was specifically lacking for processor (all locations) and trader (in Latin America and Asia) stages in chains. Female dominance is recorded at the harvester, processor, and trader stages; however, there were substantial differences depending on geographic region and product (Haverhals et al., 2016). At the harvester stage, female dominance only holds in Africa. Women are mostly confined to small-scale retail trade, and men run larger businesses. Generally, men and women gain different levels of revenue and profits from commercializing wild products and spend their related incomes differently, with solid differences occurring globally. Typically, but not always, men sell a higher proportion of wild forest and tree products than women (Haverhals et al., 2016).

Box 4.18 Fishing and gender: women marginalization and empowerment

Millions of women worldwide, paid or unpaid, work in the fisheries sector, mainly involved in the tasks that come before and after fish landing. But they also play a significant role in the catch of the small-scale fishery, according to the techniques and, more generally, the fishing system (target species, fishing grounds, fishing gear, value-chain, etc.). The contribution of women in the fishery has long been underestimated in the national and international statistics (World Bank, 2012). From the Food and Agriculture Organization of the United Nations, women represent just 14% of the 59.5 million people engaged in fisheries and aquaculture in 2018. However, their invisible role is increasingly highlighted and conceptualized, notably through a feminist approach (Frangoudes et al., 2019; Frangoudes & Gerrard, 2018). In 2019, the Food and Agriculture Organization of the United Nations, with WorldFish and Duke University, among others, launched a synthesis « Illuminating Hidden Harvests », for quantifying the contributions of small-scale fisheries to the three dimensions of sustainable development (social, economic and environmental), and better assessing the qualitative and quantitative contribution of the women in this sector (FAO, 2020b).

With a few exceptions - sea women of Iceland (Willson, 2016), freediving to fish sea cucumber or sea urchins, such as Vezo women in Madagascar (Astuti, 1995) or Mentawai women in Siberut (Burgos & Younger, 2019), the sea trips, especially of more than one day, whether artisanal or industrial fishing, are carried out by men. Also, in Madagascar (Barnes-Mauthe et al., 2013), fishers are predominately men (97% of fishers and 95% of fisher-gleaners), while gleaners are predominantly women (98% of all gleaners). Women generally only engage in fishing activities near the shores – lagunas, lakes, rivers or sea. They travel on foot or in non-motorized canoes. They fish with traps and holes or by hand or using spears on reef flats, seagrass beds, and mangrove mudflats; they target small species of fish (*Tilapia* and *Ethmalosis*), shrimp, molluscs and crustaceans. On the other hand, they have dominated the processing and marketing of catches for a long time. In particular, it is the fishermen's wives who have traditionally been entrusted with either all or part of the catch for exploitation and part of the catch is for family consumption and redistribution (*ndawal* in Wolof) (Thiao et al., 2018). Since the 1950s, with the development of sea fishing, particularly in tropical areas, in connection with multiple innovations - technical (motorization of pirogues, distribution of large nets, cold chain), economic (growth of urban markets), institutional (credit and fishing cooperatives) - women

often lost this central role at the wharf and were marginalized. Globalization (long-distance maritime migrations, export-based policy, including removal of trade barriers and low-cost transport) further accentuates this process of marginalization (M.-C. Cormier-Salem, 2017b). For example, in Mauritania, Imraguen fishermen now sell mullet fish (*Mugil cephalus*) and in particular the precious eggs to make bottarga to Asian or European export companies; women now have little access to this product and have lost one of the few sources of income in a context of strong constraints in the Banc d'Arguin National Park (Boulay & Cormier-Salem, 2012). The trajectories of women in small-scale fishery are nevertheless varied: in West Africa, it is often women, known as Mama Benz (because they would be used to circulate in shiny Mercedes, external signs of wealth and power) who have the capital to buy the means of production (canoes, engines, large nets, provision for the fishing campaign, etc..) and make fishermen their quasi-employees, not only in their countries of origin, such as Côte d'Ivoire, but also in the countries of migration of these fishermen (Bennett, 2005; Cormier-Salem, 2017b). Even in India, where fishing is a low-value activity, relegated to the poor and untouchable, women are becoming powerful thanks to globalization (Jalais, 2010). For example, in the Sundarbans, women, who do not have access to the products of the mangrove forest, fish for shrimp fry along the banks of the Ganges and Brahmaputra rivers. With the explosion of shrimp farms since the 1980s, they supply the industrial aquaculture sector and have gained economic and, therefore, social and political power. Besides, women are more and more involved in innovative projects to face poverty and achieve social and political recognition, such as marine protected areas co-management, ecocertification schemes and invest new sector such as shell-handicraft (Fröcklin et al., 2018). Despite recent synthesis (Frangoudes and Gerrard 2018; Frangoudes, Gerrard, and Kleiber 2019; FAO 2020b), women in fishing, fisheries labor, and fisheries decision-making still are invisible. The complexity of the intersectional identities and the on-going changes of the women's situations (gender, gender relations and power relations at diverse scales), need further contextualized studies.

Despite their contribution and prominence in specific resource sectors, women are often excluded from land and resource tenure rights and wider participation in management discussions; this is true for both legal and customary rights systems.

Resource access and control is a tenure issue, which is thus also important from a gender perspective. (Larson & Springer, 2016) write that “Women and families depend on tenure security for secure livelihoods and resilience” For example, women's tenure rights have been found to be associated with their increased participation in household decision-making, increases in household income, and increased expenditure on food and education (Giovarelli et al., 2013). However, women's security is not the same as men's, and their tenure rights tend to be weaker than men's in rural areas of developing countries (FAO, 2011). Securing women's participation in decision-making is seen as integrally related to ensuring women's resource rights (United Nations, 2013), as women “have different needs, uses and knowledge in relation to their ecosystems” (Aguilar, 2016). Agrawal et al. (2013) found a significant positive correlation between the number of women on community forestry executive committees and forest conservation outcomes. In another study, women's participation in forest-related decision making was found to be highly correlated with less disruptive conflict (Coleman & Mwangi, 2013).

4.2.2.6.2 Growing awareness and improved policies on community tenure rights

Despite challenges associated with recognizing and securing tenure rights, the growing awareness of the role of tenure in achieving development and environmental goals has created a range of new commitments, initiatives, and policy openings at the country level. Several countries are in the process of reforming their legal frameworks for land tenure, such as Cameroon and the Democratic Republic of the Congo. In other countries, such as Kenya and Liberia, new land laws have recently been enacted. Advocacy regarding the impacts of large-scale land acquisitions have prompted private sector commodity investors to adopt commitments to avoid “land grabbing” in their supply chains (e.g., see Oxfam 2016). Initiatives such as the Global Donor Working Group on Land and the European Union program of support to implement the Voluntary Guidelines on Governance of Tenure indicate that some international donors are providing support to tenure-related activities. These opportunities highlight the importance of learning lessons from previous tenure reforms, including key conditions for reforms and practices that can help advance them.

Nepal’s community forest user groups provide an important example of how greater tenure security has enabled community-based institutions to build sustainable livelihoods and improved forest management at scale. While forest devolution started in Nepal since the mid-1970s, significant progress in terms of community forestry was observed once the ‘Master Plan for the Forest Sector’ (1988) adopted a ‘user group’ approach, which was based on the existing indigenous forest governance arrangements in various parts of the country (Gilmour, 1990). Traditional users were granted usufruct rights over the forest. The Forest Act (1993) and Forest Regulations (1995) offered strong legal backing for community forestry, which has since contributed to community development, institutionalized inclusive and democratic governance at the local level, and developed leadership of women and other marginalized members (Pokharel et al., 2012). Currently there are over 18,000 forest user groups managing over one third of Nepal’s forest area.

Ensuring that reforms create enabling conditions for communities to develop resource-based livelihoods, with strong financial and technical support to meet regulatory requirements, has been another critical approach. Guatemala’s community forestry concessions are an exceptional example of community management regimes with positive results for both forests and livelihoods. Between 1994 and 2001, the Guatemalan government, with the backing of important international donors, signed 12 25-year community concessions contracts (for areas ranging from 7,000 ha to 85,000 ha) inside the Mayan Biosphere Reserve with local community groups (Monterroso & Barry, 2012; Radachowsky et al., 2012; Taylor, 2010). The previously conflictive forest landscape was transformed, as communities were granted rights to manage and sell both high-value timber and non-timber forest resources in about 400,000 ha. Although the regulations were strict (requiring Forest Stewardship Council certification), it was possible for communities to meet them because of the investment made in the arrangement by multiple actors including key government supporters (Monterroso & Larson, 2013). A comparative study of forests in the region (the Maya Forest of Mexico and Guatemala) found no significant difference in deforestation rates between the community concessions and protected areas (Bray et al., 2008). Income from collective timber and non-timber sales surpasses 44 million United States Dollars and is distributed to members, invested in social infrastructure, and reinvested in community forest enterprises (Monterroso, 2015). The cases from Guatemala and Nepal also demonstrate the ongoing importance of social movements, and specifically the higher-level

federations of community organizations, to overcoming implementation challenges (Paudel et al., 2012; Taylor, 2010).

4.2.2.7 Equity and benefit sharing

Key messages:

- Inequitable distribution of the benefits for the use of wild species undermines sustainability by encouraging over-harvesting, short term gains over long term sustainable management, poaching, and mining of resources by companies.
- Inequities exist between local communities and companies, governments, and others, but they also exist within communities, where elite capture of benefits is familiar with wild species use and trade, particularly when sold outside the community.
- Equitable distribution of benefits from the sustainable use of wild species is a stated goal of many governance and institutional frameworks. However, implementation of these goals is often flawed. This has a direct impact on sustainability, creates incentives to over-harvest species, undermines long term management of species, and can support unsustainable commercial extraction.
- Marginalization and exclusion stem from a range of political, economic and other factors and lead to inequity in resource allocation, distribution of benefits and participation in decision-making and management; such inequities mean that there are limits on who has access to and who benefits from (and who does not), from wild species use.
- People's perception of fairness and justice influences their willingness to comply with regulations that govern sustainable use.

The sustainability of wild species use is significantly impacted by the broader issues of equity that surrounds this use. Below the expert's review aspects of equity in use, including access to and distribution of benefits, extent of engagement and marginalization of stakeholders, and the role of civil society, social movements, and political processes in bringing more significant equity to use of wild species.

4.2.2.7.1 Impact of marginalization and inequality on sustainable use

Marginalization in sustainable use is a complex issue, which requires not only consideration for contemporary inequities but also historical, political, and social contextual factors that create an uneven playing field from initial distributions of access, capabilities, and power (McDermott et al., 2013). It is defined as the significant reduction of capacity and power, and political and economic exclusion, of rural and indigenous people to make or participate in decisions over the sustainable use of plants and animals in areas they depend on, with detrimental impacts on their livelihoods and well-being (adapted from Raleigh et al., (2010). Marginalization and disempowerment can have social equity implications, in that marginalized people may not have access to benefits or rights, they may not have a voice in decision-making process, and their values, knowledge, and culture may not be recognized (Martin et al., 2016).

Marginalization can be driven by a variety of mechanisms, including exclusion from decision-making, elite capture and power concentration, management systems not representative of relevant interests or experiences, and a lack of knowledge or recognized rights (Colfer, 2011). For example, women make up a substantial amount of labor participation in natural resource sectors (for example, up to 50% in seafood production chains) and often fill critical roles in value chains, including sales, marketing, and business administration. However, despite their contribution and prominence in resource sectors, women often are excluded from tenure rights and wider participation in management discussions; this is true for both legal and customary rights systems (Harper et al., 2017).

There has been a (poorly documented) history of evictions from protected areas, where access to and use of natural resources by local people has been restricted (West et al., 2006) (Burgess et al., 2014). Externally imposed or post-colonial laws often underpin these restrictions (e.g., McCarthy & Cramb, 2009), or influential international organizations (e.g., companies, or even large non-governmental organizations) can impose their vision of what nature should look like (Brockington & Igoe, 2006; Brockington & Scholfield, 2010).

Elite capture (or concentration of decision-making power in the hands of a few) and centralization across different levels of government can also entrench inequities and drive marginalization. For instance, studies have documented how local people who engage with government administrations benefit more from forest governance programmes (Wright et al. 2016). Involvement of external organizations runs the risk of reinforcing this elite capture and can create dependencies for local communities (Calfucura, 2018). Similarly, the promotion of market-based conservation mechanisms can shift power around natural resources use from local people to more powerful organizations (Martin et al., 2013).

People's perceptions of fairness and justice can influence their willingness to comply with rules and regulations intended to govern the use and management of natural resources (Colfer, 2011). There is extensive evidence from the common pool resources literature that empowering people affected by policy changes to participate in discussions, management, and monitoring of natural resources improves outcomes, both for sustainable use and for more effective and lasting implementation of rules to manage and restrict resource harvest and access (Biggs et al. 2019; Ostrom 2009). Fairness, and the nature of decision-making processes rather than participation itself, is considered to be central to both quality and justice in natural resources management (Reed, 2008; Smith & McDonough, 2001). Stakeholder engagement early on has been linked to more effective and longer-lasting solutions to environmental issues and can contribute to a more comprehensive understanding of the social-ecological context by integrating local and scientific knowledge (Reed, 2008). Co-management of protected areas is one governance model employed to recognise rights of indigenous or local people, while building support for sustainable use and natural resource management (Timko & Satterfield, 2008).

4.2.2.8 Impacts of peace and armed conflict on sustainable Use

Key messages:

- Impacts of conflicts on sustainable use are diverse and varied across contexts and through different pathways and indirect ways.

- Post-conflict settings pose significant risks to sustainable use for a variety of reasons

4.2.2.8.1 Definitions

Conflicts have a detrimental effect on human well-being and socio-economic development (Gates et al., 2012; Lopez & Wodon, 2005; Machel, 2001; Melander, 2005). A variety of definitions of what classifies as armed conflict exist (Gleditsch et al., 2002; Stewart, 2003). For the purposes of this assessment, the experts define conflict as periods of armed violence due to political insecurity, instability, or war. These conflicts often lead to a disruption of economies, government services and the extensive movement of people to flee conflict zones for personal safety and/or better opportunities. These conflicts have a range of impacts, mainly negative, on sustainable use, which are discussed below.

4.2.2.8.2 Direct pathways of impact

Armed conflict affects sustainable use through multiple pathways including where conflict directly affects wild species and via broad socio-political and economic pathways that arise because of the conflict, such as changing institutional dynamics, migration and displacement of peoples, and transformed economies and livelihoods (Gaynor et al., 2016).

Direct adverse effects of conflict on sustainable use include a reduction on economic activity, which can reduce deforestation (Burgess et al., 2016), unsustainable use of forest resources (Butsic et al., 2015; Machlis & Hanson, 2011) including the killing of wild animals and the destruction of habitat (Gaynor et al., 2016). Many forms of weaponry commonly utilised in armed conflict, such as land mines, can inadvertently kill wild species (Eniang et al., 2007). Large-scale habitat alteration may occur when armies destroy habitat for tactical advantages (e.g., defoliation used in the Vietnam war (Oriens & Pfeiffer, 1970)). Armed groups may also use protected areas as staging grounds, due to their remote location and plentiful natural resources, leading to overexploitation of certain species (Hanson et al., 2009; Machlis & Hanson, 2011). An increase in the availability of guns during and following a conflict may increase the prevalence and sophistication of hunting, further undermining sustainable use (Jacobs & Schloeder, 2001). Soldiers may also kill wild species at high rates for various reasons, including subsistence in the field; and high-value wild species products, such as ivory, are used to finance operations (Beyers et al., 2011; Yamagiwa, 2003).

4.2.2.8.3 Indirect pathways of impact

Indirect effects of conflict on sustainable use include the reduction of international development, investment, and support, which reduces the ability of policymakers, managers and research institutions to fulfil their conservation roles (Biggs et al., 2019; Conteh et al., 2017). Reductions in funding reduce the ability to enforce laws and regulations within protected areas, including stopping wild meat hunting and deforestation (Butsic et al., 2015; Kaimowitz & Fauné, 2020). The disruption of traditional institutions in local communities also creates challenges for post-war conservation activities. One of the most significant changes arising from armed conflict is the forced movement and migration of people, where large groups of

people in vulnerable situations form dense camps and extract natural resources such as wild foods and timber for survival (Jambiya et al., 2007). For people remaining in conflict zones, normal livelihood activities are drastically affected, as conflict disrupts industry and trade and creates shortages of goods. Therefore, local people may turn to natural resource use, especially as longer-term investments such as those required by farming and commerce become risky (Lanjouw, 2003).

The most common positive effect of armed conflict on the use of natural resources is the so-called “refuge effect”, where people avoid or move away from an area, creating places where pressure on wild species is lessened (McNeely, 2004). These areas can host flourishing wild species populations (e.g., the Demilitarised zone between North and South Korea (Kim, 1997) . Similarly, due to the reduction of international trade across borders during armed conflict, global trade of wild species products may be reduced (Lindsey et al. 2011). Another positive effect can arise when forced disarmament of local populations by armed groups may disrupt customary hunting efforts. Yet, these refuges may result in displacement of extraction of resources, as people that move away from conflict zones move into other areas where over-extraction and unsustainable use of natural resources occur (Alvarez, 2020).

4.2.2.8.4 The impacts on sustainable use in post-conflict settings

The end of conflicts can lead to rapid change in the development of agriculture and extractive industries with subsequent impacts on sustainable use (Machlis & Hanson, 2011). Many post-conflict regions possess valuable oil and mineral reserves and timber-rich forests that were off-limits to development because of the conflict. In post-conflict periods, rural return and its associated development can have catastrophic consequences for the natural environment and undermine sustainable use, as evidenced in Liberia (Brottem & Unruh, 2009), Cambodia (Loucks et al., 2009) and Colombia (Negret et al., 2017). Post-cold war case studies from Russia and previous republics of the USSR also provide insight into sustainable use in post-conflict settings. After the Soviet period, the state suddenly reduced and even stopped many essential food resources provided to communities. “These food shortages incentivized the development of an illegal market, especially for expensive products such as meat. Such incentives, with the help of cars, artificial lights and modern firearms, induced a strong increase of illegal hunting in all these newly independent countries” (Svizzero, 2019). This situation was not only the result of the collapse of the centralized government (e.g., formal laws) but was also because during the Soviet period, many kinds of community-based systems of natural resource management and customary laws had been severely eroded. Although, in many areas, new informal and formal institutions are now developing to fill the vacuum of central governance, a lack of coordination has led to conflicts between resource users. For example, in the Kamchatka region of Russia, there are many obstacles to the sustainable and equitable management of salmon fisheries and reindeer herds. These have arisen from tensions between formal regulations and informal entitlements (Gerkey, 2016).

Post-conflict periods can also have positive outcomes if state control is established rapidly after conflict ceases. New opportunities to plan for and regulate sustainable use in previously inaccessible areas can be developed. Where there is foreign or outsider control in post-conflict regions, however, these planning efforts and restructuring and creation of new

institutions can be unstable, lack relevance to local contexts and have limited longevity (i.e., green grabbing in Sierra Leone) (Cavanagh, 2018; Fairhead et al., 2012).

Understanding the influence of post-conflict on sustainable use is crucial for informing conservation actions in megadiverse countries (Hanson et al., 2009); however, in many cases, the relationship between armed conflict, post-conflict, and unsustainable use of resources is complex with confounding factors that need to be considered—establishing governmental control where illegal groups are present or where they had influence before the post-conflict periods is essential to avoid unsustainable use of resources. One potential way to improve governmental control of these areas is through working with the local communities to establish development and natural resource needs and objectives (Negret et al., 2019).

4.2.3 Social drivers

Key Messages:

- **Social drivers:** Various demographic and social factors influence the sustainable (or unsustainable) use of wild species: migration and urbanization, social organization and reproduction, empowerment, effective participation and accountability, poverty and process of marginalization, gender equity and rural development (roads, infrastructure, access to material assets and immaterial goods-market, credit, internet) (*well established*) {4.2.2.7}
- Population growth, demographic change and mobility affect use patterns of wild species. Specifically:
 - Population density and growth are leading to increased demand/consumption of wild species in some regions, particularly in urbanized areas of the global south (*well established*) {4.2.3.2}.
 - Increased mobility is leading to unsustainable use of wild species in critical areas. Such mobility is associated with displacement (i.e., from conflict, environmental degradation) as well as economic opportunity (e.g., transnational labor movements). In addition to increasing pressure on species, there is growing displacement of local uses (e.g., of indigenous peoples and local knowledge) (*well established*) {4.2.3.2}.
 - Mobility across political and ecological borders, may be leading to unsustainable use, particularly where such mobility is accompanied by lack of attachment to the place(s) (*established but incomplete*) {4.2.3.2, 4.2.3.2.2}.
- Urbanization tends to lead to decreased consumption of wild species due to access to the market economy for food (*established but incomplete*) {4.2.3.2.3}.
 - Mobility of peoples across political and ecological borders, may be leading to unsustainable use, particularly where such mobility is accompanied by lack of attachment to the place(s) (*established but incomplete*) {4.2.3.2, 4.2.3.2.2}.
- Social organization and networks affect how the benefits and costs of wild species use are distributed. Societies that are more equitable tend to experience less poverty, conflict and social inequality, which are factors correlated with sustainable use patterns (*well established*) {4.2.3.5}.

- Social inequity and poverty are a growing trend globally, particularly in the global south. In many regions, where alternatives to basic needs (e.g., shelter, food) and economic and social supports (e.g., education) are limited, there is greater dependence on wild species. However, it is an over-simplification to attribute unsustainable use of wild species to those living facing poverty. (*well established*) {4.2.3.5}
- Although some evidence points to those living in poverty are culpable for increasing unsustainable use of wild species, the socio-economic and political systems that have created and perpetuate poverty and inequity are the underlying driver (*well established*) {4.2.3.5}.
- Given that poverty is multidimensional, eradicating it requires a multifaceted approach. Access to food, shelter, education, employment, and health can lift people out of poverty and make them less dependent on wild species (*well established*) {4.2.3.5}.
- Equitable distribution of benefits from the sustainable use of wild species is a stated goal of many governance and institutional frameworks. However, implementation of these goals is often flawed. This has a direct impact on sustainability, creates incentives to over-harvest species, undermines long term management of species, and can support unsustainable commercial extraction (*well established*) {4.2.3.4, 4.2.3.5}.
- Use of wild species by women and indigenous peoples are under-recognized and poorly protected and consequently create / aggravate problems of food insecurity and poor health for vulnerable populations (e.g., poor nutrition) and increase dependency on commercially produced food resources (*well established*) {4.2.3.4; 4.2.3.5}.
- Social values and norms influence how wild species are used, and many aspects of their sustainability are interpreted:
 - Social groups who are most dependent on wild species tend to experience more significant concern and anxiety about their health and unsustainable use (i.e., have heightened risk perception (*well established*) {4.2.3.3.6}). These groups thus tend to be critical stakeholders in identifying sustainable use solutions (*well established*) {4.2.3.7}, Among the groups with long term dependencies and support sustainable use are indigenous peoples (*well-established*) {4.2.2.2.5}.
 - Many indigenous peoples and local communities who have long term relationships to wild species have well developed relationships, knowledge systems, practices, and rules (i.e., customary laws) which ensure their sustainable use (*well established*) {4.2.3.5}.
 - Social norms create the social context in which wild species use is structured/organized and also interpreted by users. Where practices of hunting, fishing and gathering are fundamental to food provisioning, and support livelihood and social identity, these practices and uses tend to be more sustainable (*established but incomplete*) {4.2.3.3}.
 - The harvest of wild species is recognized as essential to food security, health and well-being in many regions; where there is increasing risk (both reported

and perceived) of bioaccumulation of contaminants, presence of disease (including transmissible disease to humans), hunting, fishing and gathering of wild species tend to decrease. However, trust in the actors involved in risk communication is a mediating factor (*well established*) {4.2.3.7}.

- Gender inequity in how the costs/benefits of wild species use are distributed is visible in critical regions of the globe (*well established*) {4.2.3.6}.

4.2.3.1 Overview

There are numerous social drivers that (along with other economic, political and environmental drivers have a significant impact on patterns of use of wild species and the associated practices of use. The definition of social drivers as those social structures (class, ethnicity, gender and location), norms (e.g., unwritten but accepted rules of behavior), relationships and broad systems of social interaction that shape individual and collective uses of wild species (Dugarova & Utting, 2013). This section is focused on specific drivers within the context of social organization (demographics, livelihoods and urbanization, migration), social equity, poverty and exclusion, social movements, health and well-being.

4.2.3.1.1 Methodology

A systematic literature review was carried out in respect of key areas of literature using terms such as social organization, norms, population mobility, gender, indigenous peoples and each of the regions, and practices (e.g., hunting, fishing) as well as for well drivers identified in other assessments as begin related to biodiversity including urbanization, rural development, poverty and inequity. Published academic papers in the social sciences (e.g., sociology, geography, economics, interdisciplinary – environmental studies) were reviewed; they were mainly from English-speaking journals and were published in the last 20 years. Other kinds of publications (e.g., grey literature, conference proceedings, indigenous and local knowledge reports) were also included in the review, mainly where there was an absence of academic publication. Other kinds of reporting of indigenous and local knowledge were also a consideration (e.g., alternative media). A higher value was placed on papers that offered evidence/data about particular kinds of trends, patterns and dynamics in a social system (i.e., less consideration of conceptual/theoretical and editorial articles). Those publications offered a synthesis of data from multiple locations and over time. Authors found over 2000 sources. Based on a review of these sources, major themes and interpretations of patterns in political drivers were identified. Experts developed the sections with 20 + years of experience related to aspects of biodiversity conservation and in the social sciences. Where there were gaps in regions, practices, etc., and case studies were developed to illustrate an important dimension of the social driver and its impacts on practices and uses.

4.2.3.1.2 Gaps

- Social systems, like many aspects of ecosystems, are highly complex and there are many factors that affect sustainable use that are not well documented.

- There are gaps in literature related to governance of gathering and non-extractive uses (including viewing) when compared to the practices of hunting, fishing and logging.
- Regional gaps exist with respect to social norms, perceptions, and gendered dimensions of sustainable use in most parts of the globe with particular gaps apparent for Latin, America, Asia, particularly in relation to informal institutions and governance systems of indigenous peoples and local communities.

4.2.3.2 Demographics and mobility

4.2.3.2.1 Population growth and demographic change

Demographic shifts are occurring with significant population increases occurring in areas of the globe. These demographic increases are creating increased pressures on wild species. Globally the average population density is 25 people per km² but there are unique patterns in different parts of the world which are factors in the relationship of people to, and use of, nature including fisheries, wild species, timber resources and other resources. For example, in some island natures such as Macao, Special Administrative Region of China; Singapore; Hong Kong, Special Administrative Regions of China and Gibraltar, population density is well above the average. The population of Singapore for example, has nearly 8,000 people per km² (2,000 times more densely populated than Australia. Bangladesh is the most densely populated with 1,252 per km², followed by Lebanon (595 per km²), South Korea (528 per km²), the Netherlands (508 per km²) and Rwanda (495 per km²). Population in and of itself is not a pre-determination of unsustainability; norms of stewardship, for example, meditate patterns such as over-harvest in many regions. This is evident by the examples of Netherlands and Rwanda. Wild species are a reported rarity in the Netherlands (i.e., all land and species are managed), however, some of the most valued and largest megafauna in the world (e.g., mountain gorilla) are being sustainably managed in Rwanda (Abensperg-Traun, 2009). In addition to density, population growth (including rapid population) growth are a consideration in future sustainable use patterns. Population growth is highest in Sub-Saharan Africa. In other areas of the globe, the rate of population growth is falling (Anríquez & Stloukal, 2008; Saad, 2010).

Age differences also affect use patterns. For example, hunters are generally younger than non-hunters (Loibooki et al., 2002), mainly due to a lack of income-generating opportunities. In areas with high fertility, children may provide labor to gather natural resources (De Sherbinin et al., 2008; Gifford & Nilsson, 2014). However, conservation and norms related to protecting the environment tend to be more prevalent in younger generations. For example, in Nigeria, Togo and Niger younger people ate less bushmeat than older persons, in part be due to a growing ‘westernization’ of the lifestyles (Luiselli et al., 2019). This is also true in northern Canada.

4.2.3.2.2 Migration and mobility

Key Messages:

- Many peoples around the world (including indigenous peoples and local communities) have developed livelihoods over many generations, that are interconnected with the

migratory wild species; knowledge and practices (e.g., hunting, fishing etc.) developed over many generations have resulted in dynamic but sustainable use patterns. The loss, fragmentation and/or degradation of migratory species habitats is leading are major challenges to sustaining sustainable use.

- Forced migration due to war and conflict as well as environmental refugees is leading to changes in the use of wild species in some key areas of the globe.
- Increasing mobility (due to transformation innovations) and the globalization of markets is associated with a break-down of the social norms related with care and stewardship of place (lack of attachment of place).
- There is an unprecedented multi- directional movement of peoples around the world involving new patterns of transnational migration, identities and communities (Robinson 2007).
- Transcience is associated with a breakdown of social norms and institutions that governed human behavior and increase in individualistic human behavior and choices than are often antithetical to sustainability.

Livelihoods in many parts of the world are highly interconnected with the dynamics of ecosystems including the variabilities of migratory species. For example, in the circumpolar north, indigenous peoples have well developed systems of travel and tracking of wild species such as barren-ground caribou; although there is significant spatial and population variability (Vors & Boyce, 2009), their hunting practices have been sustainable for generations. One of the keys to such success has been the critical importance of learning and adapting to changes in population dynamics and health is the diversity of wild species valued for food security and the flexible livelihood strategies of harvesters who are able to adapt their harvesting practices to other species when caribou populations decline (Berkes et al., 1995; Nuttall, 2005; Winterhalder, 1983). Similar patterns of sustainable use of migratory species are evident in other regions. However, with increasing pressures of climate change and the loss of wild species habitats due to industrialization and land clearing, migratory species and associated livelihoods are under stress. Alternatives, however, are not easily constructed. “Given that many hunting and forest peoples are semi-migratory, their lifestyles do not allow for adequate care of livestock, other than easily transported species such as chickens. Dayaks of Long Segar, Kalimantan, for instance, move from villages to their fields at planting and harvest times so that government efforts to introduce cattle into such societies have been a miserable failure” (Bennett & Robinson, 2000). Protections of migratory species and livelihoods are urgent but also challenging given the rigidity of protected areas and mobility of such wild species and peoples; “traditional conservation strategies involving static tools (e.g., protected areas that have fixed spatial boundaries) may be ineffective for managing species whose ranges are changing” (Bull et al., 2013). Mobile or flexible protected area systems that support migratory species (including a high degree of variability in habitat use), are most successful in ensuring sustainable use (Bull et al., 2013; Hole et al., 2011; Maxwell et al., 2020).

Perhaps one of the most illustrative examples of livelihoods being interrelated with variable species relates to fishing. The rotation of fishing lakes is a well-established example in the case of indigenous peoples and local communities. It was a historic practice governed by customary law, among indigenous peoples in northern Canada to move camps and fishing from

one lake to another at various intervals to allow fish stocks to recover. Indigenous peoples from northern Canada, for example, historically would “rotate their fishing grounds and adjust gillnet mesh size according to what they anticipate to harvest, which results in a diffusion of harvesting pressure over space and time, and by species and size-class” (Berkes, 1989, 1998).

Fishers in other areas changing their fishing areas in response to local availabilities of the most valued target species, whether demand is for local or international markets (Cripps & Gardner, 2016). Aside from this essential characteristic of fisheries, however, there are also many continuing examples of seasonal migrations as fishers follow moving fish stocks or rotate through various fishing grounds depending on desired species and/or weather conditions (Kluger et al., 2019, 2020; Piezonka et al., 2020; Wanyonyi et al., 2016). Very often these migrations involve movement across more recently established political boundaries, or temporary settlement in communities with which they have historical understandings of shared space and economic linkages. In some cases, including, for example, that of the indigenous Bajau Laut peoples, migrant fishers and their cultures may not be fully recognized as belonging to any nation. For migrant fishers, traditional resource use strategies that involve continuous movement may conflict with modern boundaries and area-based management, which complicates and hinders their inclusion into resource use and management (Clifton & Majors, 2012), making them highly vulnerable to resource exclusion and unjust prosecution (Cisneros-Montemayor et al., 2018; Finkbeiner, 2015). It is essential that current and future management find proactive ways to include such traditional livelihoods, particularly given the rapid impacts of climate change and human use on local resource availabilities. International agreements and the recognition of the value of these customary uses and management strategies are essential in that regard, both for vulnerable indigenous communities and for broader sustainability goals (Vierros et al., 2020).

4.2.3.2.3 Forced migration – refugees

In 2000, 175 million people lived outside their country of origin. By 2013 this stood at 232 million. Of these migrants, 35% moved from one developing country to another, while 34% moved from developing to developed countries (The Partnership Platform, 2021). In addition to international migration flows, internal (within country) migration is highly significant – especially for movements from rural to urban areas – although data on numbers of internal migrants is much harder to ascertain (Cohen, 2013). People migrate for multiple reasons – from conflict to environmental degradation, access to better resources such as fertile land (Crawford & Kujirakwinja, 2016) disparities between countries, and the desire for economic or education or health or social opportunities.

Migration from regions of areas with high youth populations into high-income countries with older workforces is a critical factor in global migration (Hugo, 2011) and has attendant effects on natural resources (see migration section). These areas with high youth populations also directly overlap with areas of high risk to climate change (Hugo, 2011).

- **Conflict and migration**

Many migration patterns caused by political conflict are leading to unsustainable patterns of wild species use (Begemann et al., 2020; Black, 1994; M. Geiger & Pécoud, 2020; Gushulak,

2021; Hugo, 1996; Jacobson, 1998; McNamara, 2007). See more on this in political drivers' section on conflict.

- **Environmental refugees**

Environmental refugees are a growing concern around the world (Bose & Lunstrum, 2014; Myers, 2002); many peoples are displaced and become “refugees” due to land grabbing (Feldman & Geisler, 2013; Peemans, 2014; Sama, 2016; Zoomers, 2011), the impacts of industrialization (e.g., deforestation) as well as due to the effects of climate change (i.e., forest fire, flooding, drought) (Brisman et al., 2018; Hunsberger et al., 2017; Vigil, 2016). Green-grabbing and forced displacement for conservation goals including the creation of terrestrial and marine parks has also created refugees of many peoples (Agrawal & Redford, 2009; Dowie, 2011; West et al., 2006). Many emerging critiques of removal of indigenous peoples and local communities in the name of conservation and the significant impacts of health, well-being and transgression of human rights – coupled with lack of marked improvements in biodiversity outcomes, has led to new models of conservation and calls for the end of exclusionary conservation practices (Cernea & Schmidt-Soltau, 2003).

Box 4.19 Batwa as conservation refugees

The Batwa are an indigenous people of Uganda have long histories of use and livelihood in the region; their livelihoods are defined as “hunter-gatherer” were considered highly sustainable for many hundreds if not thousands of years. The Batwa were forcibly relocated from the Mgahinga and Bwindi Impenetrable Forests, to towns and villages, where they have struggled to adapt and sustain their families and communities. They were never compensated for their displacement and loss of livelihood; many families are now landless squatters. Their ability to access their ancestral home is limited. Tourist operators for the Mgahinga National Park (and Ugandan Wildlife Authorities), benefit significantly from tourism into the park (i.e., reported in the millions annually). This is in sharp contrast to the poverty now experienced by the Batwa many live in extreme poverty on less than 75 cents a day (compared with a Ugandan average daily income of 1.80 United States Dollars).

Those peoples whose livelihoods are strongly interrelated with lands under stress tend to be the most impacted. Land evictions can be highly gendered and disproportionately affect women such as in Cambodia (Lamb et al., 2017). The ways in which people respond to these stresses vary as do the associated implications of wild species use. The environmental impacts of these diverse migration flows and dynamics appear to be equally as complex and varied, and relatively underreported in the published literature (Hecht et al., 2015; Hunter et al., 2015). Migration, for example, can have positive or negative environmental implications, with different scenarios expected for sending versus receiving areas (Curran, 2002; Fussell et al., 2014) underreported in the published literature (Hecht et al., 2015; Hunter et al., 2015). Migration, for example, can have positive or negative environmental implications, with different scenarios expected for sending versus receiving areas (Curran, 2002; Fussell et al., 2014). This is evident in forest transition trends, especially in the tropics, where deforestation has been partly (but significantly) driven by migration into the forest frontier (Rudel et al., 2019), yet forest recovery is seen across global regions as a consequence of people leaving farming and rural areas (Aide et al., 2013; Nanni et al., 2019). In migrant-sending areas,

depopulation improves environmental outcomes through reduced resource use (Aide & Grau, 2004; Myerson, 2017), but can impact biodiversity in less obvious (and not always positive) ways through changes to landscape use (Davis & Lopez-Carr, 2014; Lambin & Meyfroidt, 2011). But out-migration facilitates the aging and shrinking of rural populations, thus potentially weakening the social organization, environmental knowledge, and community institutions that underpin sustainable land management systems (Robson et al., 2019). Depopulated communities may also be more vulnerable to land grabs and the incursion of ecologically damaging resource practices (Padilla 2012). In migrant-receiving areas, the arrival of people can help to alleviate such shortfalls. Yet where in-migration takes place in response to the presence of high-value resources/commodities, it drives environmental degradation in often ecologically sensitive areas (Pimm et al., 2014; Wittemyer et al., 2014).

- **Other migration patterns**

The migration of people underpins, and can exacerbate, demographic/population change and urbanization trends. In 1990, 153 million people lived outside their country of origin (International Organization for Migration, 2017). By 2017 this stood at approximately 258 million (OECD, 2018). Of these migrants, close to 35% moved from one developing country to another, while 34% moved from developing to developed countries (International Organization for Migration, 2017). In addition to international migration flows, internal migration is highly significant – especially for movements from rural to urban areas – although data on numbers of internal migrants is much harder to ascertain (Cohen, 2013; International Organization for Migration, 2017). People migrate for multiple reasons – from conflict to environmental degradation, disparities between countries, and the desire for economic or education or health or social opportunities.

- **Rural migration patterns**

For rural areas, the impacts of migration and urbanization are also complex and varied. Migration, for example, can have positive or negative environmental implications, with different scenarios expected for sending versus receiving areas (Curran, 2002; Fussell et al., 2014). For example, in the tropics (e.g., Indonesia, Amazon) legal and illegal logging, illegal mining and clearing of land for commercial cropping (e.g., soybean farming) has been driven, in part, by migration of marginalized populations (i.e., those living in poverty) to seek out new livelihood and economic opportunities. In some areas, reforestation and other forms of forest recovery are being evidenced as a consequence of people leaving farming and the rural regions (Aide et al., 2013; Grau & Aide, 2008; Nanni et al., 2019).

In migrant-sending areas, depopulation improves environmental outcomes because of reduced resource use (Myerson, 2017), but impacts biodiversity in less obvious (and not always positive) ways (Aide et al., 2013; Robson & Berkes, 2011; Rozendaal et al., 2019). For example, migration of males to urban areas has been found to result in the increasing feminization of natural resource collection which may impact the contribution of natural resources to households (Zhu et al., 2020). The drivers of migration into rural areas including poverty, but also landscape and resource and degradation due to over harvesting, industrialization and climate change. Migration can also be caused by land use conflict and political unrest. Land use conflicts can range from legal displacements of people and the erosion of their livelihoods due

to industrialization or can be associated with large scale conflicts (e.g., ethnic and political violence).

Voluntary or forcible removal of populations due to the imposition of large scale commercial agricultural, hydro-electric dams and mining projects, roads and associated infrastructure is a significant concern. Indeed roads, railways and changes in transportation corridors can lead to relocation, new patterns of settlement and different patterns of use of wild species.

4.2.3.3 Social organization

Key messages:

- Societies that have developed over the long term with a strong dependence upon place and resources have well organized and developed systems of natural resources management, including rules related to the sustainability of species (*well established*) {4.2.3.3.1}
- Social values expressed at different scales shape perceptions of wild species and the perceived benefits and risks of their use (*well established*) {4.2.3.3.2}.
- Social inequity and poverty are a major driver of unsustainable use however, it is the structures that have created the inequity that are the greater driver (*established but incomplete*) {4.2.3.3.3}.
- To face global changes, new individualistic/opportunistic strategies and competition are developing, calling into question traditional social structures (norms, values, institutions) and contributing to the overexploitation of nature (*established but incomplete*) {4.2.3.3.3}.

Social structure refers to the architecture and dynamics of society; some key dimensions of structure include institutions and social norms, cooperation, social cohesion, involvement, sense of community. The Organization for Economic Co-operation and Development describes a cohesive society as one which “works towards the well-being of all its members, fights exclusion and marginalization, creates a sense of belonging, promotes trust, and offers its members the opportunity of upward social mobility” (OECD, 2011). There are different degrees of rigidity (versus flexibility) in social organization (i.e., loosely organized to tightly organized) and different degrees of complexity and specialization. The units that structure a society (e.g., groups, institutions) are generally studied together with the dynamics of social change including how societies innovate, adapt over time and cope with extremal stresses such as a decline in a valued wild species. Those involved in environmental sociology and other disciplines concern with the environment increasingly consider the function of society in terms of a system and the interconnectedness of ecosystems and social systems (i.e., the social-ecological system) (Berkes 1998; Ostrom 2009) (see chapter 1).

A critical consideration in social systems is how individuals and institutions learn and adapt their practices (e.g., hunting, trapping, fishing) and uses to changing ecological conditions including variation and change in the health, abundance and distribution of wild species (Pahl-Wostl et al., 2010; Reed et al., 2010; Sigmund et al., 2010). Drawing on the extensive literature on social learning and natural resource management (and social-ecological systems), it is

evident that individual and institutional learning is key to sustainable use outcomes in almost every region of the globe and for a large number of wild species.

4.2.3.3.1 Social organization and place

The practices and uses of wild species by different social groups can be defined as social-ecological systems, many of which are highly complex and characterized by significant uncertainty, non-linearity and self-organization. In other words, they are messy and difficult to manage. For example, populations of wild species can vary significantly over time and the behavior of those who harvest the population can also vary depending on many other factors (e.g., the availability of other species to harvest, alternative economic opportunities, values and norms etc. (Laird et al., 2010; Steward, 1968; Zimmerer, 2006)).

The extent to which social structures are organized in relation to a particular kind of place, species or ecosystem also affects the extent to which social structures affect sustainable use (Laird et al., 2011). Societies that are more disconnected from place are thought to have less interest in protecting or conserving the species. This is sometimes framed as “sense of place” defined as “the collection of meanings, beliefs, symbols, values, and feelings that individuals and groups associate with a particular locality” (Williams & Stewart, 1998). It “reflects not only experiences with places but also the cultural, religious, historical, and personal meanings of places and the power and economic relationships that shape historical and current interactions with places” (Chapin and Knapp, 2015, p.39). As such sense of place shapes, the way wild species are defined (including imagined), understood and valued which in turn shapes use. People who pass through a place as a tourist will have a much different set of norms related to care and use of wild species than a property owner (Cross, 2001; Tonge et al., 2015), who, if only engaged for a short-term period, may in turn behave differently than a long-term property owner or an indigenous person with a long term and multi-generational relationship to place (Chapin & Knapp, 2015; Vaske & Kobrin, 2001).

“Sense of place does not always promote stewardship, however, because attitudes may not lead to actions, some actions do not promote sustainability, and different place identities in the same place may lead to different stewardship goals (e.g., conservation vs. development) (Chapin and Knapp 2015). There is much evidence that the longer one lives within or frequents a place that is associated with positive personal experiences, the greater the attachment to place and in turn the greater degree of conservation-oriented behavior (e.g., lack of vandalism, less waste, the greater the degree of investment of resources in stewardship). This is strengthened where property rights arrangements create incentives for care and investment (i.e., security of ownership creates more significant incentives for conservation). Self-efficacy, or the belief that one has the capacity effect a particular change, can influence whether intentions translate to behaviors consistent with sustainable use. Sense of place and associated pro-sustainable behavior through addressing issues of open access (i.e., securing property rights), education about the specific behaviors and opportunities to improve sustainable use (i.e., to nurture self-efficacy). Globalization and the transience and high degree of mobility tend to lead to poorer sense of place but may be positive if it leads to multiple kinds of place attachments (Chapin and Knapp 2015).

Box 4.20 Sense of place and sustainability (reproduced from Chapin and Knapp (2015)).

The following dimensions of sense of place and its effects on sustainability:

- Sense of place best motivates stewardship in homogeneous communities.
- Multiple senses of the same place can generate conflict.
- Globalization and human mobility may foster commitment to more places.
- These trends provide new stewardship opportunities at local-to-global scales.

4.2.3.3.2 Social norms

• **Social constructions of wild species**

Wild species are variously defined across cultures and societies. In addition to natural science taxonomies and characterizations, wild species are socially constructed through social-ecological interactions, knowledge shared through research and governance, as well as through popular media. For example, in North American wolf populations have long been considered a threat to people, a perception that was place on experiences of farmers and risks to livestock but has been perpetuated by cultural narratives (e.g., children’s fables of the “big bad wolf”) (Lappalainen, 2019). One interesting trend of the risk society literature is the extent to which some wild species which might have historically been viewed as a benefit and a contribution to well-being (and cared for accordingly) have been reframed as threats or risks to human health (Beck, 1992; Dempsey, 2013; Sidhu, 2003). For example, in many areas of North America, there are advisories issued by government related to harvesting and consuming many fish species due to the bioaccumulation of contaminants (Burger, 2000; Chess et al., 2005; Oken et al., 2012). Although there is variation in compliance with advisories, on the whole they lead to decreases in harvesting and other kinds of impacts (i.e., increase of catch and release). Advisories can also lead to an amplification of risk; this not only in the area specifically affected by an advisory but in other regions. For example, in Nunavut, concerns about contaminants in some species and some areas, led to changes in dietary patterns that had other kinds of consequences including directions (Furgal et al., 2005; O’Neil et al., 1997).

Depending on the degree of dependency on a species for subsistence (or other value), biodiversity in the region and mobility of harvesters, reports of a problem in one area and one species, can cause harvests to adapt and harvest other species, change to a market diet, or move to new areas to find healthier species (Tisdell & Svizzero, 2015; Winterhalder, 1986; Winterhalder & Smith, 2000). These kinds of adaptive strategies can have significant impact on diet and health (Badjeck et al., 2010; Hovelsrud et al., 2008; Marushka et al., 2019; Ross et al., 1978).

There are other implications for sustainable use. For example, shifts away from the harvest of local fish species for food security has indirectly led to an increase in industrial fishing practice that have impacts on species many thousands of miles away. This pattern is perpetuated by the cognitive dissonance that characterized the global food system; lack of awareness of the ecological and social costs of industrial harvests contributes to perceptions that buying food from the store is healthier than can be harvested locally (i.e., wild species) and in addition that resources from elsewhere are limitless.

Other aspects of globalization shape and, in turn uses, of wild species. For example, public media related to trapping, seal harvesting, whale harvesting and polar bear hunting has had a significant adverse impact on indigenous peoples and local knowledge in northern Canada whose cultures and economies are interrelated with the health of these species. Protests by animal rights activists coupled with popular films and social media sources that are opposed to animal use have tended to artificially construct wild species in more romantic and moral terms rather than those based on science of the knowledge of indigenous peoples and local communities. This moral position of global authorities against 'hunting' is a driver of declining interest of younger generations in cultural practices of hunting and associated with other adverse impacts on cultural continuity and well-being of indigenous peoples.

4.2.3.3.3 Livelihoods and development

A livelihoods approach offers an integrated way of thinking about the way in which societies organize themselves in making a living but also in producing other social, cultural and health well-being benefits (Negi et al., 2011; Rao & McGowan, 2002). A livelihood comprises: "the capabilities, assets (stores, resources, claims and access) and activities required for a means of living" (Chambers & Conway, 1992). Following the Brundtland Commission on Environment and Development and then expanded by United Nations Conference on Environment and Development (UNCED) in 1992, a large literature related to livelihoods and the ways in which can might be interpreted as sustainable, expanded, among which stressing the sustainable rural livelihoods and targeting the household level:

"A livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term" (Chambers & Conway, 1992).

Livelihood typologies vary and are also gendered (Oberhauser & Yeboah, 2011). Research and evidence is well developed in almost every global region; and much study highlights the ways in which different social groups are able to create, innovate, adapt and contribute to many dimensions of sustainability including sustainable use of wild species (Koziell, 2001; S. A. Mainka & Trivedi, 2002; Wollenberg et al., 2000). For the purposes of this assessment, the framed livelihoods around practices of wild species use and discuss how the social organization associated with these practices drives different aspects of sustainability.

- **Artisanal fishing livelihoods**

Small-scale fisheries generally present (some of) the following characteristics: (i) low capital investment, (ii) high labor activities often family or community-based, (iii) no vessel or small size vessel (< 12m and < 10 gross tonnage), (iv) relatively low production, which is household consumed or locally and directly sold and (v) operating close to the shoreline on a single day basis. There is a whole gradient, from the individual fisherman on board his dugout pirogue, to crews of more than 20 men on board large, motorized pirogues, all of whom, at least in West Africa, identify themselves as small-scale fishermen. It is therefore not easy to stick to the "official" definition, if not to show the limits of it in terms of the identity of the actors (how

they define themselves) and their evolving or adaptive strategies in the face of a changing environment. The small-scale fishermen are organized in fishing units, comprising from 1 to more than 15 men, most often recruited on a family or community basis. Working relations, both on land and at sea, are traditionally tacitly recognized: thus, for small-scale fishing, the means of production (pirogue, motor, catching gear, etc.) are usually the property of the eldest of the lineage, who also acts as captain of the unit (or the canoe); if he is too old to go out to sea again, he entrusts the responsibility to his eldest son. The fishing unit thus includes the captain as well as the crew, traditionally recruited from the extended family (sons, nephews, etc.) or allied members. The operating strategies (or fishing system) are defined by the captain.

Extensive literature on this topic has shown the importance of these strategies (decision-making processes) on resource management and the adaptive capacity of fishermen (or flexibility of fishing systems) for sustainable resource management (Chauveau et al., 2000; S. Garcia et al., 2014; Gustavsson et al., 2017; Kalfagianni et al., 2013; Marín & Berkes, 2010; Sønvisen, 2014). This is critical in many examples of “small scale fishing” as Cambodia and elsewhere (Béné, 2006; Marschke & Berkes, 2006; Mullon et al., 2005; Pauly, 2018; Pauly et al., 2002).

On the one hand, « responsible » and sustainable strategy and flexibility of the system to face the changes: this flexibility is based on the diversity of the elements that make up the fishing system: several fishing gears, various species targeted according to season and location, etc. Fishermen only take the resources they need for their own consumption and selling the surplus to meet their basic needs (or, at least, the reproduction of the system), with well-established and shared rules of use and access to resources, and a system for allocating shares when they return from the tides.

In the other hand: with modernization (motorization, mechanized gear, refrigeration on board, etc.) and professionalization (from part-time to full-time), the specialization of new or « young » fishing units, more concerned with profitability, crews recruited on a capital base (employees) targeting a single species with less selective catching techniques (e.g., large purse seines) for a specific export market (e.g., shark fins to supply the South-East Asian market). These opportunistic strategies are unsustainable, leading not only to biodiversity erosion, but also to increased vulnerability of fishermen and conflicts (Mullon et al., 2005; Pauly, 2018; Pauly et al., 2002). Faced with the crisis of fishery resources, it is also important to note the capacity of fishermen to innovate from a social and institutional point of view, to set up associations and cooperatives on a regional, national or international scale, to have their rights recognized on their territories (e.g., fishermen's committees which manage Marine Protected Areas, which set up set-aside areas for fishing, see section on "political drivers") (Likuge & Munas, 2013; Mbaye et al., 2020, 2020; Sjöstedt & Jagers, 2014).

- **Gatherer livelihoods**

There are many characteristics of gather livelihoods that support sustainable use that are similar to those of hunting livelihoods including flexibility, adaptive capacity (Bunce et al., 2016; Díaz-Reviriego et al., 2016; Maclean et al., 2013; Parlee et al., 2006). The management of landscapes for the purposes of gathering of food resources is an essential area of research, particularly, in relation of indigenous peoples (e.g., cultural burning practices) (Christianson, 2014; Marks-Block et al., 2021; McKemey et al., 2020; McWilliam, 1999). Concern about the risk of

bioaccumulation of contaminant in plants valued for food is leading to deterioration of many gatherer livelihoods.

Box 4.21 Biodiversity: Drivers of sustainable use of wild species

Vaccinium vitis-idaea (*natl'at* in Teetl'it Gwich'in; *puolakka* in Finnish) is a common evergreen dwarf shrub in the Ericaceae Family found across the circumpolar north (Gillespie et al., 2015). *V. vitis-idaea* produces small, red spherical berries and berry production can differ dramatically year to year depending on climatic variables over that past two growing seasons (Krebs et al., 2009). The berries are an essential food source for many northern inhabitants, including grizzly bears, red-backed voles and indigenous people (ibid.). This case study compares the sustainability of *V. vitis-idaea* harvest by people in two circumpolar regions: northern Canada and Finland. Wild *natl'at* berries have been harvested annually in northern Canada since time immemorial. The Teetl'it Gwich'in identify *natl'at* as one of the three most important berries and upwards of 90% of households collect them (Murray, Boxall, and Wein 2005). Annual harvest estimates range from 6-19 liters per household and for a total of 5,100 liters between the four largest Teetl'it Gwich'in communities and commercial harvesting is limited (Murray, Boxall, and Wein 2005; Parlee et al. 2005).

Berry picking effectively begins well before fruit production. Harvesters, primarily women, start “checking in” on their preferred patches and sharing information across their social networks (Murray 2002; Parlee et al. 2006). Select patches are generally located in easily accessible areas near communities or near family camp or cabin sites (Parlee et al. 2006). Berry observations intensify during the picking season and modern technology allows for the information to be shared across a large geographical area (Ibid.). In poor years, pickers may travel considerable distances to access productive patches. For example, Whitehorse, Yukon, had a particularly bountiful *natl'at* crop in 2016 and this enticed four women. Caring for particular berry patches is expressed in several ways, including direct management of habitat conditions to promote berry production (Murray, 2002; Parlee et al., 2005). The pickers are also very responsive to climate-driven variation in berry production and use their social networks to locate alternative, more productive patches (Murray 2002; Parlee et al. 2006). Across the Arctic Ocean in Finland, harvesting of wild *puolakka* berries is also a prominent activity with deep historical roots. It is estimated that 60-70% of Finns continue to participate in berry picking and harvest ~12 kg of *puolakka* berries/household each year (Peltola et al., 2014; Saastimoinen et al., 2000; Vaara et al., 2013). Unlike northern Canada, commercial harvesting of *puolakka* has occurred for more than 150 years (Peltola et al., 2014).

The majority of forests in Finland are owned privately; however, people are allowed to harvest berries for domestic and commercial use regardless of land ownership under the principle of “Everyman’s right” (Peltola et al., 2014). An estimated 8-10% of the total berry crop are harvested annually (Turtiainen et al., 2011). In Finland, urban as well as rural inhabitants harvest berries; ownership of a summer cottage significantly increases participation in berry picking by urban dwellers (Kangas & Markkanen, 2001; Pouta et al., 2006). Women tend to be more active berry pickers than men (Pouta et al., 2006). There are limited data documenting harvesting practices though the protection of secret berry patches is mentioned (Peltola et al., 2014; Pouta et al., 2006). The long-term harvesting history and small proportion of berry crop harvested annually indicates picking *puolakka* berries in Finland remains sustainable.

Interestingly, despite the limited documentation of customary practices “regulating” berry picking, there is evidence these practices exist. A common complaint with current commercial harvesting is companies have not provided foreign workers with information on appropriate locations and berry picking practices (Peltola et al., 2014). As seen in northern Canada, children are frequently

included in berry picking excursions which provides the opportunity for these practices to be transferred between generations (Kangas & Markkanen, 2001). The social and ecological context of the Teet'lit Gwich'in and Finnish peoples provide an interesting comparison of wild berry harvesting. The Gwich'in inhabit an expansive, largely undeveloped subarctic region and Finland is a relatively small country with intensively managed forests. Commonalities between the two groups suggest that sustainable harvesting is achieved, at least in part, by having high rates of participation within the population and intergenerational involvement. This ensures shared appreciation for social and culture aspects of berry picking; the development of customary practices to ensure harvest sustainability; and opportunities occur to transfer this knowledge to the next generation. The influence of women as the primary leaders of berry picking is less clear and requires further investigation. Other similarities include the berries are supplementary rather than a staple component of local diet, the quantity of harvest is directly related to local knowledge and the harvest is very responsive to annual variation, harvesting is labor intensive, and mechanization of harvesting is relatively limited. Changes in economic or social pressures that increase barriers to berry picking participation could also threaten populations of *Vaccinium vitis-idaea*. The fewer people who berry pick could decrease the societal value of berries and reduce incentives to conserve wild berry picking areas.

- **Hunting livelihoods**

Hunting livelihoods are characterized by different characteristics of social organization. In addition to a high degree of mobility (in the case of hunting of migratory species), many hunting societies developed within indigenous cultures share some common characteristics such as strong subsistence versus commercial harvest; social networks that facilitate food sharing; flexibility and adaptive to ecological conditions (Armitage, 2005; Granderson, 2017; Lu, 2010; Mulrennan, 2014; Pearce et al., 2015; Ruiz-Mallén et al., 2017), and intergenerational knowledge sharing that supports adaptation. Many hunting livelihoods in indigenous cultures are also based around beliefs, values and practices of reciprocity between wild species and dependent communities (i.e., people take care of the animals and the animals take care of the people) (Fernández-Llamazares et al., 2020; Kimmerer, 2011; Nadasdy, 2007; Nursey-Bray et al., 2010; Peterson, 2013; Welch, 2014; Wenzel, 2000).

Hunting also tends to be a very gendered practice. In many cultures, there are stereotypes of men the hunter, and women as gatherer are well established but have also been critiqued as social constructions of anthropology. For example, the archetype of “man the hunter” is deeply engrained in the anthropological record of the North (Bodenhorn, 1990; Van Voorst, 2009; Vladimirova & Habeck, 2018; Williamson, 2002). This bias has tended to become reproduced in the kinds of research carried out in the North as well as in policy contexts at regional, territorial, and national levels; although some greater attention has been paid to gender biases since the 1970s, there is still relatively little in the academic literature that relates women and hunting. Within this category, the theme of women and hunting is among the most complex. Although not well documented, women in many cultures play pivotal roles in hunting, ranging from spiritual rites to holding spears and other weapons (Geller & Stockett, 2007; Wadley, 2005). The gender bias is not unexpected given that men were the sole leaders of anthropological tradition up until the mid-twentieth century (Parlee, Andre, & Kritsch, 2014). There are more diverse kinds of gender identities than those that follow Judaeo-Christian archetypes (Kuokkanen, 2019; Subramaniam et al., 2016). But the bias is also one that seems

to have been easily and unapologetically replicated in other disciplines and research traditions, including that focused on traditional knowledge (Nadasdy, 2003).

In the case of indigenous peoples and local communities, hunting practices are highly intertwined with cultural identities. For example, in the case of the Dene, the practice of hunting is intertwined with what it means to be indigenous, interconnected with physical-spiritual health and well-being. For example, people refer to themselves as “caribou people.”. Even when resources have been lost or eroded, species are still intertwined with sense of self, community and spiritual belief systems. As a result, the loss is highly impactful on health and well-being. For example, the collapse of the North American plains bison, which was intertwined with the violent colonization of Canada and the United States of America, has devastated the indigenous people.

Sports and trophy hunting are also strongly interconnected with the identities and social organization of those engaged (Darimont et al., 2017; Ebeling-Schuld & Darimont, 2017; Mihalik et al., 2019). For example, the motivations for recreational and sports hunting can be tied to the desire for self-sufficiency and food security; in other cases, the practice of hunting is strongly interconnected with social relationships and rituals. Although there is much evidence that a primary motivation in hunting may be the desire to connect with nature, hunting of non-edible species is also associated with desires for control over nature (i.e., need for self-efficacy), and “show-off” (e.g., physical dominance) (Child and Dairmont, 2015; Darimont et al., 2017).

- **Small-scale agricultural livelihoods**

Small-scale agriculture has many kinds of organizational structures, including slash-and-burn and other kinds of agricultural practices. Agricultural practices can enhance (agro-biodiversity, such as agroecological practices/agroforestry. The rise in rural settlement and feudal systems in Europe in the 17th century is primarily attributed to land clearing, habitat destruction for some wild species and persecution of others. Other forms of small-scale agriculture are notably not commercial or feudal but tied to subsistence and cultural uses. For example, Huron Indians in southern Canada – were organized in small scale agricultural communities (i.e., corn production) but with mixed engagement with hunting-gathering. The shift away from small-scale agriculture in Europe and the Americas beginning in the 1900s and the mechanization of farming changed social structure in rural areas (i.e., farmers no longer held private property – lost to large-scale farms). Changes in social structures and property rights resulted in people no longer being closer to the land on “family farms” but became workers on industrial farms or left farms entirely (i.e., rural-urban migration). The loss of individual property rights to many small areas of land in the United States of America is attributed to the homogenization of land and resource uses, increasing use of pesticides (leading to habitat degradation and losses of species) including unsustainable uses of wild species (i.e., land clearing). There are exceptions to this trend, including reclaiming of land and the family farm in some areas.

- **Urban and peri-urban livelihoods**

There are important dimensions of urban and peri-urban livelihoods that intersect with wild species use. While most research has focused on dichotomies of urban versus rural, the longer-term persistence and importance of “fringe or urban transition zones” have developed since the 1980s (Simon, 2008). Population growth and consumer demand for “green neighbourhoods”

is a driver behind the phenomenon of expanding urban transition zones and urban sprawl and associated wild species habitat degradation. These patterns coincide with increasing concern about the adverse health impacts of living in high-density neighborhoods (e.g., air quality) as in major cities worldwide. It is also being driven partly by growing evidence of the health benefits, particularly for youth and children who are connected to nature (Cheng & Monroe, 2012). In some areas, city planning is offsetting the problem of urban sprawl in response to green consumers and instead maintaining maintaining of wild spaces within cities for non-extractive uses. Such efforts are also associated with the protection and reclamation and re-wilding of some peri-urban environments that might otherwise be taken by shopping outlets etc. Many such examples can be found in western Europe and some parts of North America (Checker, 2011; Kimari & Parish, 2020; Shackleton et al., 2017; Wolch et al., 2014).

Box 4.22 Agroforestry’s ‘roots’ in traditional land management systems in Southeast Asia

Agroforestry aims to intentionally integrate trees with wild species, crops, and livestock to develop an ecology of symbiosis. A tradition of not separating oneself from these ecological systems is prominent amongst indigenous peoples within the Southeast Asian region, specifically in Malaysia and the Philippines (Adnan & Othman, 2012; Camacho et al., 2016). Histories of colonial rule and the erosion of traditional land management practices and rights of the Malay Forest peoples have created unsustainable deforestation in many regions of Malaysia. In contrast, the resistance to colonialism and maintenance of indigenous practices within the Cordillera Mountains of the Philippines has helped promote sustainable harvesting of fuelwood and ecological health (Camacho et al., 2016). In a 2014 report undertaken by Malaysian feminist Carol Yong, Kuching-based, non-profit Sarawakians Access, and Peninsular Malaysia Orang Asli Village Network (Jaringan Kampung Orang Asli Semenanjung Malaysia); deforestation in Malaysia were intimately linked to a value-system based on a source of income. Massive shifts in forest land-use systems – from local customary land use systems to large-scale commercial, extractive and developmental uses– have caused “harmful impacts on communities’ access to forest resources for livelihoods and food security, consequently intensifying livelihood hardship and poverty” within regions of Malaysia. As “pre-existing customary land rights of forest peoples are systematically ignored and overridden,” the loss of natural wealth and biodiversity are affecting the Malay people in both material, and non-material ways– livelihoods, cash income, and social-cultural and spiritual needs are arguably the most affected (Adnan & Othman, 2012). For example, value systems associating plants ritual and spiritual purposes (i.e., for ceremony) have been abandoned and ostracized (Adnan & Othman, 2012). An interrogation of customary agroforestry systems can be a viable alternative to current mass extractive uses for sustainable local livelihood. Evidence of sustainable agroforestry practices may be found amongst the Ifugao peoples of the Philippines. (Camacho et al., 2016) explore how the indigenous communities (such as Ifugaos, Isneg, Tingguians and Ikalahans) in the Cordillera region, Philippines have upheld *muyongs* –key indigenous practices in woodlot or watersheds of privately or clan-owned forests – that has promoted sustainable forest management. Following traditional practices, Ifugao do not ‘own’ land through titles, but rather the rights to land use are community-based. Although *muyongs* are a “major source of fuel wood for the local people,” the ways of harvesting fuelwood are guided by customary practices. For example, the conservation of many endemic trees (e.g., *Ficus* spp.) are associated with spirits/*anito*, and are not being harvested for timber and fuel wood. Furthermore, the presence of endemic trees creates agroforestry environments that help maintain sufficient groundwater supply for *muyongs* (woodlots) and *payoh* (rice paddies).

4.2.3.3.4 Urbanization

Key Messages:

- Urbanization is a world-wide trend which generally decreases household dependence on wild food sources due to access to the market economy.
- Simultaneously, urbanization in some settings can increase the scale, use and harvest of wild species (to fuel urban markets) (*established but incomplete*) {4.2.3.3.4}.
- Urbanization spatially influences the sustainability of use of wild species; wild species are likely to becoming more depleted in areas closest to cities, whereas in depopulated rural areas, use of wild species is declining (*established but incomplete*){4.2.3.3.4}.
- Displacement of people due to stressors such as drought, environmental degradation, conflicts and loss of access to land leads to increased pressure on marginal lands and wild species where migrants, refugees and other displaced peoples now move to (*established but incomplete*) {4.2.3.3.4}.
- Both in-migration and out-migration can destabilize current natural resource use and weaken environmental knowledge systems and existing institutions (*established but incomplete*) {4.2.3.3.4}.

The world is also undergoing substantial urbanization. The number of people living in urban centers increased from 2.3 billion in 1990 to 3.9 billion in 2014 and is 1652 expected to reach 5 billion by 2030 (United Nations, 2014). The total area of cities doubled from 1992 to 2015, with impacts to tropical and subtropical savannas and grasslands (IPBES, 2019a). While the number of megacities (populations of more than 10 million people) will continue to rise, the growth of small to medium-sized cities is now a dominant trend, and where most future urban populations will be found (United Nations, 2014). Comparing IPBES regions, Africa, and Asia and the Pacific are urbanizing fastest, with future expansions in Asia and the Pacific expected to occur mainly in China and India (IPBES, 2019a). By 2050, it is likely that as many as 3 billion people will be living in informal areas and slums within cities, mostly in developing countries (Nagendra et al., 2018).

Urbanization is associated with the nutrition transition in which individuals are less dependent on wild food and more dependent on industrialized food production accessed through the market economy (Popkin, 2006; van Vliet, Quiceno, et al., 2015). However, knowledge of the nutrition transition in tropical and low-income countries is more limited (van Vliet and Nasi 2015). The impacts of urbanization on sustainable use are diverse and varied across different contexts and interacts with other factors such as the extent of infrastructure development, other sources of food, and cultural and socio-economic conditions (Table 4.6) (Poudyal et al., 2011). For example, urban consumption of bushmeat in the Congo basin is significantly higher in the Congo basin in Africa, than the Amazon basin in South America (Nasi et al., 2011).

Box 4.23 Urbanization and re-wilding in European cities

Urbanization and wild species use are a growing issue as in the city of London's Metropolitan Green Belt in the United Kingdom of Great Britain and Northern Ireland and natural areas the Ruhr

metropolitan area in Germany. The Ruhr area is the former center of the German coal and steel industry, comprises 20 cities and is one of the most densely populated conurbations in Europe. In both cases government-regulated green spaces were established in the 1920s-1940s to check urban sprawl and to secure recreational areas for the urban populations (Han & Go, 2019; Monclús, 2018; Schepelmann et al., 2016). Subsequent to their establishment the London's Metropolitan Green Belt and the green spaces in the Ruhr area went through very different developments. Due to wide public and political support and firm policy implementation, the London's Metropolitan Green Belt is still largely intact. 24% of the area are designated Areas of Outstanding Beauty and 5% are Sites of Special Scientific Interest. Thirteen percent of London's Metropolitan Green Belt land are priority habitat as identified by England's Biodiversity Action Plan, with 12 out of 20 national priority habitat areas sited in the London's Metropolitan Green Belt (APPG for London's Green Belt, 2019). But the London's Metropolitan Green Belt is increasingly coming under social pressure by calls to allow housing development in the belt area to address shortages in London's housing supply due to its steadily growing population (Elledge, 2017; Papworth, 2016). At the same time there are questions about the ecological quality and biodiversity in the London's Metropolitan Green Belt. In the context of the continuing decrease of biodiversity in the United Kingdom of Great Britain and Northern Ireland, there are calls for the ecological and biodiversity enhancement of the London's Metropolitan Green Belt through a Nature Recovery Network and the upgrading of existing and creation of new wild species habitats (APPG for London's Green Belt, 2019; Lawton et al., 2010; London Assembly, 2020; McNab, 2018). In contrast to the London's Metropolitan Green Belt, the green spaces in the Ruhr area and its main rivers Emscher and Ruhr continued to be heavily polluted and environmentally degraded until the decline of coal mining in the 1960s-1980s. The Emscher served as an open sewerage for industry and households and its hydromorphology and hydrological cycle have been irreversibly impaired through mine subsidence and canalization. For many decades it was the most polluted river in Germany. Growing public dissatisfaction with the severe environmental degradation in the 1960s turned the Ruhr area into one of the cradles of the German environmental movement. In the ensuing decades, industry decline, job losses and shrinking populations were grasped as an opportunity for the social, ecological and environmental 'structural change' of the Ruhr area (Bottmeyer, 2011; Schepelmann et al., 2016; Wuppertal Institute, 2013). The renaturation of the Emscher river and its tributaries through the 'Emscher conversion' and the establishment of a biotope network along the 'New Emscher Valley,' serve both as a beacon for the makeover of the Ruhr area and as literal and metaphorical breeding ground for revitalized nature and biodiversity, social, recreational, cultural and economic change. The species diversity in the Emscher catchment has increased from 170 in 1990 to 450 in 2019. Approximately one fifth of the species now found in the catchment are listed as endangered by state and federal governments. But the ecological rejuvenation of the Emscher catchment is only possible due to a large-scale wastewater management engineering project. New treatment plants and over 400 kilometers of underground wastewater canals have been constructed to ensure that no sewerage will be discharged into the Emscher (GRÜNE LIGA, 2019; Wuppertal Institute, 2013). Biodiversity in the London's Metropolitan Green Belt has largely been preserved since its inception but can also be enhanced to reverse overall trends of declining biodiversity in the United Kingdom of Great Britain and Northern Ireland, help mitigate climate change and provide other ecosystems services. After a severe destruction of biodiversity in the Ruhr area, biodiversity is currently being actively recreated in an interplay of deliberate human actions and nature reclaiming its place. The sustainability of biodiversity in the London's Metropolitan Green Belt in part depends on a willingness of human actors to preserve, increase and enhance habitats and to continue to restrict or limit construction in its area (APPG for London's Green Belt, 2019; CPRE, 2018). The long-term sustainability of resurging nature and biodiversity in the Ruhr region in part seems to depend on technology: "Technical and natural infrastructure in the Emscher region will always be interconnected

and technical ‘support’ for the natural hydrological cycle will be necessary here in the long term because of the subsidence caused by mining” (Wuppertal Institute, 2013).

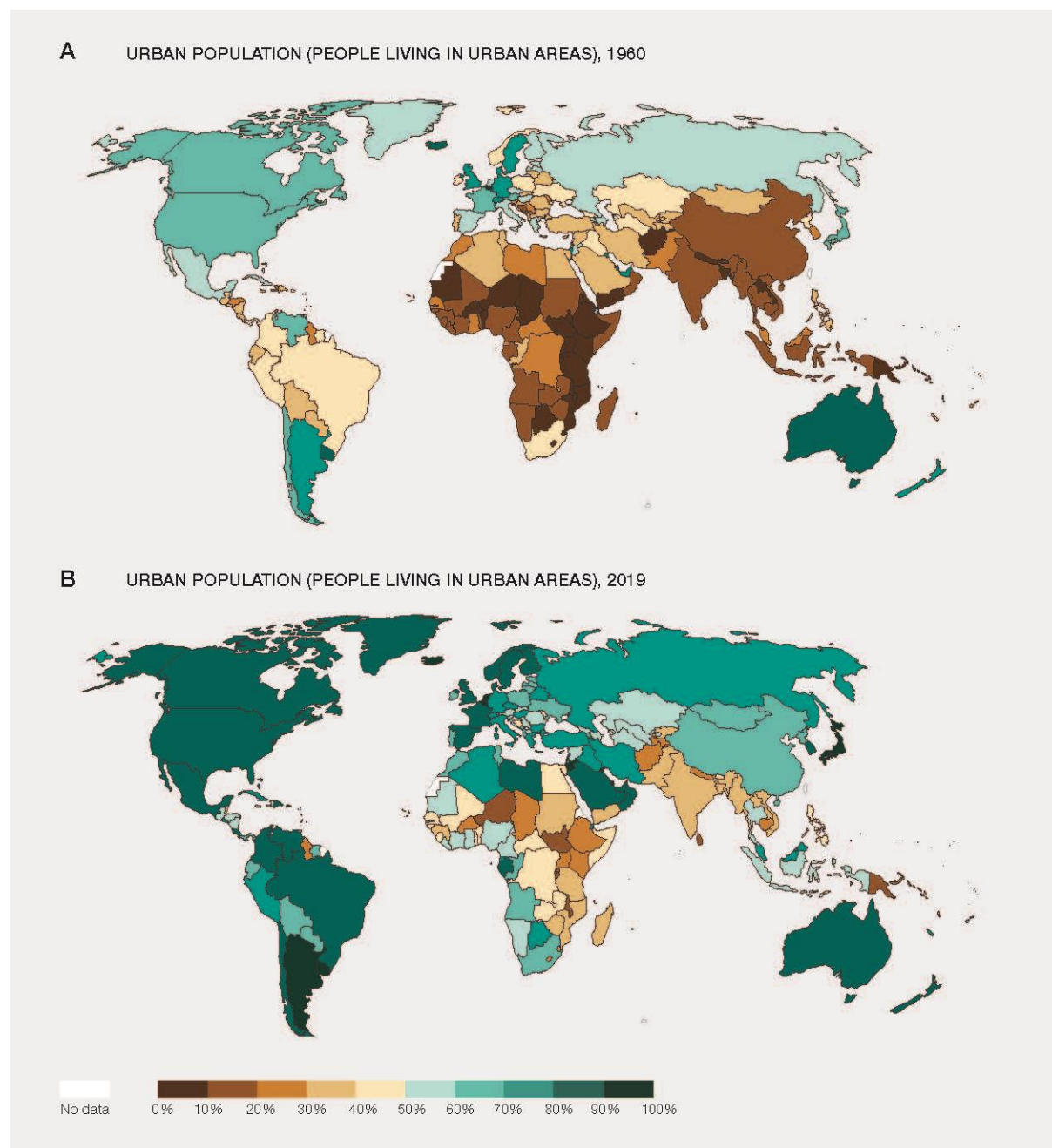


Figure 4.8 Urban population density. *This map is directly copied from its original source (United Nations et al., 2019) © 2019 by United Nations and was not modified by the assessment authors. The map is copyrighted under license CC BY 3.0 IGO. The designations employed and the presentation of material on the maps used in the assessment do not imply the expression of any opinion whatsoever on the part of IPBES concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. These maps have been prepared or used for the sole purpose of facilitating the assessment of the broad biogeographical areas represented therein and for purposes of representing scientific data spatially.*

The interaction between wealth and urbanization also depends on context, for example in sub-Saharan Africa meat from wild species is consumed by wealthier households in urban areas, but the opposite pattern is observed in lower income rural areas (Brashares et al. 2011). A further issue is the development of the peri-urban regions where densities are urban but economic infrastructure and services are still rural-oriented (Kulabako et al., 2010). These dense peri-urban contexts can lead to overexploitation and unsustainable use in densely populated areas and also to import of wild species from elsewhere (van Velden et al., 2018). Finally, although urbanization can physically separate people from nature, it may also engender awareness of the importance of nature to human well-being. The gentrification of rural areas also has potential to disrupt culturally and economically important plants, algae and fungi collection (Grabbatin et al., 2011).

Table 4.6 Examples of practices in urban area

| Context and Issue | Impact on Sustainable Use | Geographic region and Reference |
|-------------------------------------|--|--|
| Recreational Fishing | Recreational fishing is a popular activity in the United States of America. Urbanization measured by the growth in income, employment, structural shifts in demographics, and increases in average commuting time due to sprawling significantly and negatively impact public participation in fishing as measured by fishing license sales determined by regression analysis. | United States of America (Poudyal et al., 2011). |
| Bushmeat hunting for pigeons | Hunting for pigeons in Samoa is by both rural and lower income individuals as well as wealthier sports hunters from non-rural areas. Wealthier hunters tend to hunt for recreation and personal consumption whereas lower income hunters hunt for sale to restaurants and targeted consumers. Consumers of pigeons tend by the urban wealthy. | Samoa (Stirnemann et al., 2018) |
| Bushmeat consumption | In the Colombian Amazon rural and urban and residents eat bushmeat, as well as domesticated and industrially processed meat. However, in a rural to peri-urban to urban gradient the frequency of consumption of bushmeat decreases substantially. | Colombia (Van Vliet, Fa, et al., 2015) |

4.2.3.3.5 Rural communities and development

Key messages:

- Rural peoples play a vital role in sustainable wild species use – indirectly in supporting and sustaining wild species habitats (*established but incomplete*) {4.2.3.3.5}.
- Many rural livelihoods include the harvest of wild species as part of mixed and diversified livelihoods (i.e., that include small scale agriculture, hunting, fishing etc.); these kinds of livelihoods are on the decline due to the industrialization of agriculture and other large scale development pressures (e.g., clear cutting of forests) (*established by incomplete* {4.2.3.3.5}).
- Rural regions and livelihoods including the harvest of wild species play a crucial role in supporting the health and well-being of peoples, particularly where other livelihoods fail (e.g., in boom-bust economies) (*established but incomplete*) {4.2.3.3.5}.

- **Livelihoods – Diversified and Mixed Economies**

Many rural livelihoods include the harvest of wild species as part of mixed and diversified livelihoods (i.e., that include small scale agriculture, hunting, fishing, etc.); (Regmi, 2003; Wunder et al., 2014). These kinds of livelihoods are on the decline in many regions due to the industrialization of agriculture and other large scale development pressures (e.g., clear-cutting of forests) (Barrett et al., 2001; Ellis et al., 2004; Fabusoro et al., 2010). Livelihood diversification is particularly important for women (Lakwo, 2007).

The role of wild species within these rural economies can be measured by the proportion of wild meat that contributes to rural diets as in Africa (de Merode et al., 2004; Hasselberg et al., 2020), Asia (Erni, 2015; Pauly, 2018) and in indigenous communities in the Arctic (Kuhnlein et al., 2009) as examples. Changes in the dynamics and opportunities of sustainable rural livelihoods include the impacts of:

- Structural adjustment and economic policies displace small land holders in favour of export cropping and industrialization of resources (Lipton & Ahmed, 1997).
- Mining (Parlee et al., 2018).
- Exclusionary conservation (i.e., protected areas) (Bennett & Dearden, 2014).
- Climate Change (Agrawal & Perrin, 2009; Gentle & Maraseni, 2012; Ziervogel & Calder, 2003);
- Other factors (Devereux, 2001; Shameem et al., 2014).

- **Rural regions and wild species use – resilience**

Rural regions and livelihoods, including the harvest of wild species, play a key role in supporting the health and well-being of peoples, particularly where other livelihoods fail (e.g., in boom-bust economies). Although urban areas are expected to absorb virtually all of the future growth of the world's population (United Nations, 2019), the rural population remains representative (45%). Also, it has major challenges in achieving sustainable development for its dwellers, such as the balance between the environmental, social and economic dimensions. With almost half of the planet's inhabitants still engaged in exploiting natural resources, the conservation of biodiversity cannot be separated from the use of natural resources. This appropriation of natural resources is carried out by a myriad of rural or primary producers through the management of terrestrial, marine and freshwater ecosystems (Toledo, 2001). Many communities living in rural areas around the world depend on the use of wild species for their

livelihoods. This is the case of indigenous peoples and local communities, which possess significant knowledge of the wild species surrounding them and often use it for subsistence and other purposes (IPBES, 2019a). The use of wild species can directly or indirectly affect the development level of their regions. Either by common sense or by some areas of knowledge, rural development is usually associated with physical and services improvement in rural area (e.g., roads, infrastructure, access to material assets and immaterial goods-market, credit, internet), but it goes beyond improvements in infrastructure and services.

In the vast majority of times, the improvement of infrastructure in a region aims to increase the exploitation of natural resources in the territory to send the production to different markets (local or for exportation), in some situations, can in fact improve the infrastructure of services and the living conditions of the people who live there. Several cases illustrate the impacts of the transformations in the infrastructure of rural areas in the access and use of natural resources, including those giving origin to emerging diseases by land use changes (Patz et al., 2004), such as logging roads (Wolfe et al., 2000). Thus, it is essential to contemplate the different perspectives related to the concept of rural development and its interaction with the use of wild species, especially considering indigenous peoples and local communities, for whom the Western idea of development is not part of their worldview, causing a permanent tension between the development objectives of nations, founded upon concepts such as progress, and a broader conception which sees humanity as “essentially integrated within its environment and supported by the notion of the good life” (Cuadra, 2015), or the paradigm of *Buen Vivir* (Good Living), which emerged in Bolivia and Ecuador and raises a relationship of society in harmony with nature from a vision of socio-ecological transition (Matiolli & Nozica, 2017).

Although rural development can be associated with aspects of progress and infrastructure improvements in rural areas, with both positive and negative impacts on local biodiversity, it is important to situate the concept more broadly, considering, for instance, to what extent the existence of highways, power transmission lines, access to internet or other services and infrastructure contribute to the development of a region in an effectively sustainable way. For example, on roads near logging areas or close to forest areas, there is an increased risk of fauna loss, such as gorillas and other monkeys in Congo and neighboring countries (Wash et al., 2003). The impacts can also come from agricultural areas, whether recently implemented or not, as in the case of the changes brought about by the Green Revolution, also called conservative modernization specially in Latin America countries (Delgado, 2001), because, despite being associated with the idea of progress, with agricultural production on an industrial scale, and technological packages involving agricultural implements and modified seeds, it maintained the agrarian structure, not promoting improvements in the socioeconomic conditions of the poorest rural populations, and still causing severe environmental impacts.

In the same way that the concept of development, since the 1990s, started to be linked to the adjective “sustainable”, the debate on rural development also started to add the discussion around sustainability and environmental issues, the local and territorial approach, non-agricultural rural activities, rural-urban interrelationships, among others. From that period, the resumption of the debate on rural development takes place mainly around four key elements: the eradication of rural poverty, the question of the role of social actors and their political

participation, the idea of territory as a reference unit and the central concern with environmental sustainability (Schneider, 2004).

Rural development can also be understood as a process of social and economic change that occurs in rural areas, where there is a context of expanding interdependence in social and economic relations on an international scale, as one of the effects and conditions of globalization. This process of global transformation, which is increasingly influenced by modern technologies, was most clearly seen in the industrial or secondary production sector. Still, it also had an impact on the forms of productive organization and labor relations in the primary sector, in activities related to agriculture, livestock and fishing, as well as in forestry and plant extraction, for example.

The opening of markets also has caused an intensification of trade and the strengthening of large agri-food chains, changing the configuration of rural areas. In many regions of the world, the rural environment is no longer the specific place for agricultural activities and the varied forms of income complementation allow the income of many families living there to stabilize throughout the year and the children no longer need to leave rural areas to find jobs. In this sense, the notion of pluri-activity (Błąd, 2015) provides a broader meaning than that of diversification of production. Diversification meaning different forms of agricultural production, one oriented at non-food use, with the typical sub-categories of energy crops, fiber crops, herbs for medicinal use, agroforestry (for wood and biomass production), animal breeding, etc. As examples of pluri-activity, there are new on-farm activities, such as farm-based activities (industries, services) not related to food, agricultural production or tourism. Another kind of pluri-activity are new on-farm activities, i.e., farm-based activities (industries, services) that are not related to food, agricultural production or tourism. "Other important forms are sporting activities (not linked to tourism), equestrian activities (e.g., horse breeding), hunting, fishing, bike rental, school farms, offering of workshops/courses, care farms, haulage, etc." (Błąd, 2015).

An approach to rural development mainly aimed at developing countries focuses on rural household strategies and livelihood diversification (Ellis, 1998), showing that the initiatives and actions that generate significant impacts in improving the living conditions of these populations and that expand their perspectives to guarantee social and economic reproduction are, most of the times, in the very localities and territories where they live, i.e., it is essential to propose economic activities also related to the rural area vocation, not only to reinforce the natural resources but also to valorize socio-cultural aspects, protect immaterial heritage and keep the social reproduction. (Ellis & Biggs, 2001) defines rural development as a set of actions and practices that aim to reduce poverty in rural areas, aiming to stimulate a participation process that empowers rural inhabitants, making them capable of defining and controlling their priorities for change.

In the scientific and policy debates on the future of agriculture and rural development, multifunctional agriculture is another crucial notion. Apart from public goods (landscape, biodiversity, etc.), this includes goods and services produced for non-food markets (energy, care, tourism, etc.) as well as functions provided by agriculture as distinctive product attributes on niche food markets related to food quality, animal welfare, environment friendliness, etc. Functions that cannot be directly associated with goods, services or product attributes but

instead represent non-marketable public benefits of agriculture are considered relevant for the analysis of multifunctional agriculture (e.g., quality of life, food security, etc.) (Renting, 2009).

- **Rural development – wild species**

Among the impacts of economic development in a region and the conservation of local biodiversity (Ju et al., 2013), the risks and benefits of changes in land use to human health should also be considered. Land use changes include “deforestation, road construction, agricultural encroachment, dam building, irrigation, coastal zone degradation, wetland modification, mining, the concentration or expansion of urban environments, and other activities” (Patz et al., 2004). They are the primary drivers of a range of infectious disease outbreaks. Logging and road building in Latin America increased the incidence of cutaneous and visceral leishmaniasis (Desjeux, 2001). Road building is also linked to the expansion of wild meat consumption that may have played a vital role in the early emergence of human immunodeficiency virus types 1 and 2 (Wolfe et al., 2000). When cleared for human activities, tropical forests are typically converted into agricultural or grazing lands. This process is usually exacerbated by the construction of roads, causing erosion and allowing previously inaccessible areas to become colonized by people (Patz et al., 2004).

If in some regions the infrastructure in rural areas is expanded, in others, public services to the rural population are increasingly scarce, as the case of running water, electricity or the closure of rural schools and rural regions in several countries that lost their inhabitants due to the exodus in towards urban centers. Despite the demographic reduction, it is important to maintain a minimum of structure in these regions, even to guarantee alternatives to local families and not to exploit nature unsustainably as the only means of subsistence or source of income, also to meet cooking and heating needs when gas or electricity is not available.

The improvement in infrastructure in a rural area mostly benefits the integration of specific supply chains, but impacts considerably the local environment, communities and consequently, biodiversity, especially wild species. Currently, the lack of internet, good roads are an obstacle for rural people to market their products, as is the case of the Payun Matru Cooperativa (Lichtenstein, 2013) that works on guanacos (*Lama guanicoe*) in Mendoza/Argentina. In most cases they have to rely on intermediaries or go to the cities, with a tremendous economic cost. In this sense, access to credit, better roads, electricity and internet supply would enable local people to enter the market in a fairer way.

Current changes related to rural development include the processes of socioeconomic and structural changes in rural spaces, comprising rural and urban approaches, as in peri-urban agriculture and in consortium production models involving wild species and agricultural crops (Jacobi, 2009), as in systems agroforestry (McNeely, 2004) and home gardens (Cruz-Garcia & Struik, 2015; Kujawska, 2018).

In rural regions, agricultural or extractive activities are not exclusively practiced. There are more and more other types of associated activities, such as industrial (agro-industries), tourism and leisure, training, etc. In a more environmental and sustainable rural development perspective, it can also be considered that agroecological conversion initiatives through agroforestry systems can promote not only the recovery of the landscape, but also of biodiversity. In mountainous areas of the Greater Mekong sub-region, government programs, scholars, and private sector interests have promoted cash crop cultivation and harvesting of

plants, algae and fungi as strategies for rural economic development (McLellan & Brown, 2017), since they are both important parts of rural livelihood portfolios worldwide. However, little is known about how cash crops and plants, algae and fungi interact in the daily lives and economic decisions of rural people in this region, or how they may differentially encourage forest conservation practices and values.

Improvements in infrastructure, such as rural electrification, also cause changes in the ways of conserving and processing food and medicines, as well as reduction of fuel wood harvest, which is still the dominant source of energy in many rural areas (Giannecchini, 2007). In rural regions where it is possible to use refrigerators to conserve bushmeat or fish, a reduction in collective practices and individualization of marketing processes has been observed. These infrastructure improvements also facilitate the processing of products in rural areas, which generates positive and negative impacts on wild biodiversity. The benefits of rural electrification ripple outward to include increased incomes and economic development, improvements in health and education, protection of water catchment areas and forest environments, and enhancement of gender-balanced development. It also brings the challenge of non-biodegradable wastes. If not properly discarded, broken light bulbs can emit vaporous methylmercury that can easily enter in the bloodstream and also persist in soil and groundwater threatening human population and wild species (Allison, 2008).

Technological innovations can also be focused on processes carried out in rural areas, like in agricultural co-operatives in China since the New Rural Reconstruction movement (Luo et al., 2017). More recently initiatives focused on the Bioeconomy and the development of local or territorial resources have been conducted in different regions (Meis Mason et al., 2012).

Box 4.24 Changes in gathering practices in Nepal

In Nepal, large-scale gathering of wild species involving tens of thousands of harvesters began after the ban on collection and trade of yarsagumba (*Ophiocordyceps sinensis*) was lifted in 2001 (Shrestha & Bawa, 2013). Yarsagumba, a caterpillar fungus, is used to treat respiratory and heart diseases, and is also known as the Himalayan Viagra. Its harvesting is one of the key income sources for poor mountain communities in Nepal, where the availability of other livelihood opportunities is comparatively low (Shrestha & B3awa, 2014). Regarding the expenditure of income from yarsagumba, the largest proportion of the income was used for savings, followed by food and clothes, and children's education, helping to reduce poverty (Belcher, 2005). The poorer the family, the more dependent on a key species, such as the case of yarsagumba in Nepal. The higher reliance of the poorest households on the income derived from yarsagumba harvesting indicates that the consequences of resource degradation will be severe for households that are already poor. If the market price drops or remains unchanged and the decline in per capita harvest continues, the consequences will be a reduced income for the poorest people, showing the importance to stimulate maintaining a diversity also among the wild species gathered and marketed, but also seeking an alternative solution, like using a natural or compositive substitute. If the resource becomes scarce, communities will lose income. If there is no management work to maintain sustainable harvesting, it will not be possible to guarantee the livelihood opportunities.

There are diverse examples of wild species use and practices that are tied to income generation (Sher et al., 2017). There are cases of communities that depend mainly on a wild species, mainly where agricultural productivity is limited and there are few other livelihoods

opportunities. The harvest of fungal species (e.g., for pharmaceutical and other value) in the Himalayas (Nepal) is one example. (Yadav et al., 2019); agricultural activities being limited, the income from yarsagumba accounts for up to 65% of the total household cash income in some communities. Other examples are the cases of small-scale river fisheries in the Democratic Republic of Congo where it contributes up to 98% of the fishers' household income, or yet the case of açaí and other plants, algae and fungi in some regions of the Brazilian Amazon (Brondízio, 2002). Products obtained from forests or other natural environments play a crucial role in sustaining the livelihoods of poor people in developing countries through income generation and the creation of employment opportunities (Shrestha et al., 2019)

Another situation is when the interest of the markets is concentrated in only one species of plants, algae and fungi and the rural dwellers, in order to improve the production, reduce the biodiversity by eliminating other species with minor commercial interest. This is happening in Brazilian Amazon with the acai palm and is known as the phenomenon of “acaization” (Hiraoka, 1994). Local and national policies integrating the sustainable use of wild species and rural development should not focus only on key species, favoring the diversity of species. In the international markets and global chains this condition should also be stimulated. Local people with their multiple worldviews should participate in the definition of conservation strategies as well as local development, including other specific aspects associated with politics, such as corruption and access to technologies and others.

4.2.3.3.6 Social movements

Although there is a considerable deficit of research on the direct impact of social movements on sustainable use and biodiversity conservation, it is possible to establish indirect linkages. One of the most apparent indirect linkages is that occurring through community-based natural resource management and conservation. The international recognition of the benefits of community-based natural resource management to achieve resource and biodiversity conservation (Berkes, 2021; Hulme & Murphree, 2001) has come along with concerns about the vulnerability of local communities to globalization, shortsighted government regulations, marginalization, intensified land competition, and other global political economy threats (Villamayor-Tomás & Lopez, 2021). Increasing attention has been paid to the participation of local communities in social movements against those threats (Goldman, 1998; Peet & Watts, 2004; Scheidel, 2020; Villamayor-Tomas & García-López, 2018). Social movements have been essential promoters of transformative sustainable development agendas internationally, e.g., United Nations's 2030 Agenda (Dressler, 2010; Martinez-Alier et al., 2016); however, they also have strong roots in local environmental conflicts and community-based natural resource management practices. Local environmental conflicts are an endemic phenomenon of societies, with more than 3,000 instances registered (Scheidel, 2020), and potentially thousands more unregistered all over the world. Many of them involve local communities in defense of their livelihoods and encompass therefore both environmental and justice grievances. Communities' capacity to mobilize in defense of their livelihoods and the environment can indeed be considered two sides of the same action phenomenon (Martinez-Alier, 2003). In the end environmental justice movements and their “governance from below” strategies may be indeed the only recognizable challenge to the control of environmental governance by corporate

entities and multilateral organizations and their questionable approach to sustainability (Lemos & Agrawal, 2006).

Specifically, social movements can contribute to sustainable use via a number of pathways, including the organization of community-based monitoring, the strengthening of boundaries around community and conservation projects, the generation and promotion of local ecological knowledge, and the forging of “peoples and conservation” alliances internationally (Alessa et al., 2016; Villamayor-Tomas & García-López, 2018; Villamayor-Tomás & Lopez, 2021).

Movements can support local monitoring systems through the involvement of communities in data collection and analysis, the elaboration of environmental impact assessments in collaboration with scientists and researchers, and the organization of patrolling. In Indonesia, the Dayak indigenous movement for forest management rights developed a community-based mapping unit which documents Dayak land-use and traditional ecological information (e.g., flora and fauna, waterbodies, sacred areas, topography) to ensure conservation and prosperity (Alcorn, 2003). In Mexico and Guatemala, the movements for community forestry concessions were followed by the establishment of local governance systems, which included organizing patrols to monitor the forest’s uses and physical boundaries at local level (Klooster, 2000; Paudel et al., 2010) and regional level (García-López & Antinori, 2018).

Related to monitoring is the creation and defense of conservation boundaries via exclusive-use zones, such as the “extractive forest reserves” promoted by the rubber tappers movement in the Brazilian Amazon, and local forest communities in Petén, Guatemala (Cronkleton, 2008; Paudel et al., 2010); or the “trawler-free coastal fishing zones” reserved for artisanal fishing communities in Kerala and Goa, India (Kurien, 1991; Sinha, 2012).

Movements can also promote local ecological knowledge. This can occur through different ways, including the actual implementation of said knowledge like in the case of women’s Green Belt Movement in Kenya (Turner & Brownhill, 2004); educational and research campaigns, like in the case of the Dayak of Indonesia (Alcorn, 2003); the use of frames or narratives that legitimize said knowledge, like in the case of the Process of Black Communities movement in Colombia (Escobar, 1998); or the elaboration of maps and formal encoding of knowledge (Alcorn, 2003; Roberts, 2016).

The contribution of movements to international “peoples and conservation” alliances has also been well documented. In the forest context, the Mesoamerican Alliance of Peoples and Forests (Dupuits & Ongolo, 2020), the World Rainforest Movement, Friends of the Earth International, and the Global Forest Coalition (Šimunović et al., 2018) frame forest conservation as based on small-scale, autonomous and customary practices, traditional knowledge, and the collective land rights of local indigenous and peasant communities, challenging the dominant market-based discourse linked to Reducing Emissions from Deforestation and Forest Degradation programs. In the fisheries context, prominent examples are the World Forum of Fish Harvesters and Fish Workers and the World Forum of Fisher People (Mills, 2018).

4.2.3.4 Social norms, beliefs and risk perceptions

Social norms are strongly interrelated with spiritual belief systems in some cultures. For example, some resources are attributed as having sacred meaning and value; this belief in the sacred provides the architecture of norms around which sustainable use (conservation) is ensured. Some key examples include the beliefs around the radiated tortoise in Madagascar. (Jones et al., 2008). In other areas, forests or mangroves are considered to have sacred value as in India and parts of west Africa with significant literature point to the value of the social norms and beliefs about their sacredness in ensuring their sustainability (Bhagwat & Rutte, 2006; Lebbie & Freudenberg, 1996; Ntiamoa-Baidu, 2008; Sheridan, 2009). Social norms and beliefs about the sacredness of the whale, the sentience of the arctic ecosystem and norms (developed over generation) of stewardship also underlie sustainable harvesting (i.e., conservation hunting) of whales in Canada and Greenland (Foote & Wenzel, 2008; Freeman, 1999; Freeman et al., 2005).

Box 4.25 The fady system in Madagascar

Social norms are essential to ensuring sustainable use of resources in Madagascar. A system of norms, known as fady has been developed by indigenous peoples and local communities over many generations. Fady refers to the agreed upon system of behaviors that lead to the prohibition of use of some species or particularly kind of practices to ensure sustainability. It goes beyond “good manners” and is enforced through popular disapproval, and a belief that supernatural retribution will affect the transgressor if the fady is not respected or broken (there are numerous examples of fady leading to the long-term protection of species and habitats in Madagascar, for example, the fady against killing of the radiated tortoise (*Geochelonia radiata*) is highlighted as the primary mechanism that has saved this species from extinction.

Sources: Jones et al. (2008); Nussbaum & Raxworthy (2000)

Social structures also strong affect the way in which individuals, society and institutions perceive risks within their environment including risks related to the use of wild species. There is a large literature on social, cultural and environmental risk perception that details the central role played by formal education, media, science and others. A major issue and insight of much work around wild species and risk perception as well as indigenous knowledge systems is that scientists tend to view risks differently than the public at large differently (Krewski et al., 2008) and as a result, there are often challenges in managing perceived risk and what scientists often define as “real risks”. While there are debates as to whether the public misjudges ‘real’ risk when compared to those in the scientific community, accounting for perceived risk in institutions is as critical in addressing questions of sustainability of wild species.

Box 4.26 Social risk perception as a driver of species use – what fish should I eat?

The public receives fish consumption advice from a variety of perspectives, including toxicant, nutritional, ecological, and economic viewpoints. For example, United States of America federal and state agencies that are concerned about exposure to toxicants in fish, such as methyl-mercury and polychlorinated biphenyls, have issued fish consumption advisories recommending that at-risk groups limit consumption of fish (United States Environmental Protection Agency, 2004). However, national

organizations of physicians and nutritionists encourage fish consumption for the entire population as a way to increase dietary intake of the n-3 (omega-3) long-chain polyunsaturated fatty acids that may prevent cardio-vascular disease and improve neurological development (Kris-Etherton et al., 2002, 2007). Also, environmental groups have recommended that consumers avoid certain fish on the basis of concerns about species depletion or habitat destruction consequent to farming methods, site of origin, or type of harvesting (Oken et al., 2012). Whether how much, and what kind of fish a person eats are also influenced by economic and market considerations (e.g., cost and availability) as well as by taste, cultural tradition, recreational habits, and access to alternative foods. Thus, the consumer who wants to know “which fish should I eat?” is likely to encounter contradictory advice, especially because much of the available information considers a single perspective, such as maximizing health or minimizing ecological harms. For example, because farm-raised salmon is high in n-3 fatty acids and very low in mercury, it is promoted for its nutritional benefits. However, environmental groups consider it a “fish to avoid” because salmon aquaculture may adversely affect eco-system integrity and wild fish stocks (Oken et al., 2012), and relatively high levels of polychlorinated biphenyls have led to concerns about cancer risk (Hites et al., 2004). Furthermore, it may be difficult for consumers to know whether any given fish is “good” to eat because they often do not have access to the facts, they need to make fully informed choices, such as the size of the fish or how or where it was caught.

Source: Oken et al. (2012).

One aspects of risk perception directly relevant to wild species use related to prion diseases; public information and social media is known to directly impact decisions to hunt in the case of chronic wasting disease. For example, awareness of this disease in Wisconsin, resulted in an 11% decline in license sales (Heberlein & Stedman, 2009). In Alberta, sports hunters were less interested in visiting a site with higher chronic wasting disease prevalence (Zimmer et al., 2011). The degree of trust of the sources of information is a crucial dimension of this impact: if people trust the agent providing the information, they will trust the information provided to them by these sources; moreover, they are likely to have a lower sense of risk perception as they trust the agents “to take care of any potential problems” (Muringai & Goddard, 2018). The role of indigenous and local knowledge is also directly relevant to understanding how indigenous peoples deal with risk with some exceptions, scientists have historically disregarded indigenous knowledge (Baird et al., 2021; Brook et al., 2009; Kutz & Tomaselli, 2019). At the same time, indigenous peoples themselves have a high level of trust in their own knowledge and capacities to assess wild species health and use this knowledge to make decisions about harvest and consumption of traditional foods as well as in respect of other aspects of conservation (Berkes, 1998; Eichler & Baumeister, 2018; Friendship & Furgal, 2012; Gadgil et al., 1993; Wray & Parlee, 2013). The tendency to trust their own knowledge is rooted in the multi-generational knowledge, practices and beliefs that have been the foundation of successful environmental stewardship for generations (Berkes, 2018).

4.2.3.5. Social inequality and poverty

Key messages:

- Sustainability of wild species use can be understood by many diverse social values (e.g., sustainable use is not only ecological) (*well established*) {4.3.3.5}.

- Poverty and social inequality are drivers of unsustainable use, particularly where there are few livelihood alternatives (*well established*) {4.3.3.5.2}.
- The benefits of wild species use are inequitably distributed in many regions. Inequities are evidenced at local, regional and global scales by numerous kinds of indicators (e.g., income, gross domestic product, access to land) (*well established*) {4.3.3.5.2}.
- Indigenous peoples are among those who experience a high degree of poverty and social marginalization which greater limited their access to wild species valued for food provisioning and well-being (*well established*) {4.3.3.5.3}.

4.2.3.5.1 Overview

Nearly half of the world lives with less than 5.5 United States Dollars a day, and almost half the world's population — 3.4 billion people — still struggles to meet basic needs (World Bank, 2018). Globally, more than 800 million people are still living on less than 1.25 United States Dollars a day; many lack access to adequate food, clean drinking water and sanitation (United Nations Development Program; <https://sdgs.un.org>). Poor communities, which disproportionately include indigenous peoples, tend to be marginalized from policymaking and government and have little voice in the development of laws that they may be structurally unable to comply with (Wynberg et al., 2015). Although income was historically the primary measure of poverty, even here there has been a shift from absolute poverty (e.g., median income) to relative (e.g., median income relative to the average in a country or region). Income and material wealth indicators continue to be the most common, but well-being, equality, social inclusion, are increasingly recognized as factors contributing to deprivation as an understanding of poverty (United Nations, 2009). A significant challenge arises, however, when attempting to design indicators to be monitored and compared across nations, and even regions within nations; these indicators cannot account for differences in the relative prices of goods, cultural preferences in diets, existing subsidies, social and political marginalization, nutritional requirements depending on types of labor and environments, etc. (United Nations, 2009). Such indicators may thus be helpful in a very limited sense due to their comparability across time but can be poor—and potentially entirely inappropriate—reflections of poverty in given nations (Hagenaars & Vos, 1988; Kapteyn et al., 1988; United Nations, 2009). Indeed, the complexity of poverty as understood by different people and in different contexts should be seen as a main reason to consider the term and design its measurement depending on the specific case (Spicker, 2007).

Poverty has been recognized to be multidimensional in nature, and methods were developed to try to measure poverty through alternative instruments that capture deprivation beyond income and consumption. The creation of effective measures that better reflect poor people's experience enables the design of more effective policies (Alkire et al., 2015). The Multidimensional Poverty Index—shown in the world map (Figure 4.9) is the most common international instrument used in this context. Progress to diminish poverty is uneven across the different regions (see supplementary material - Appendix I).

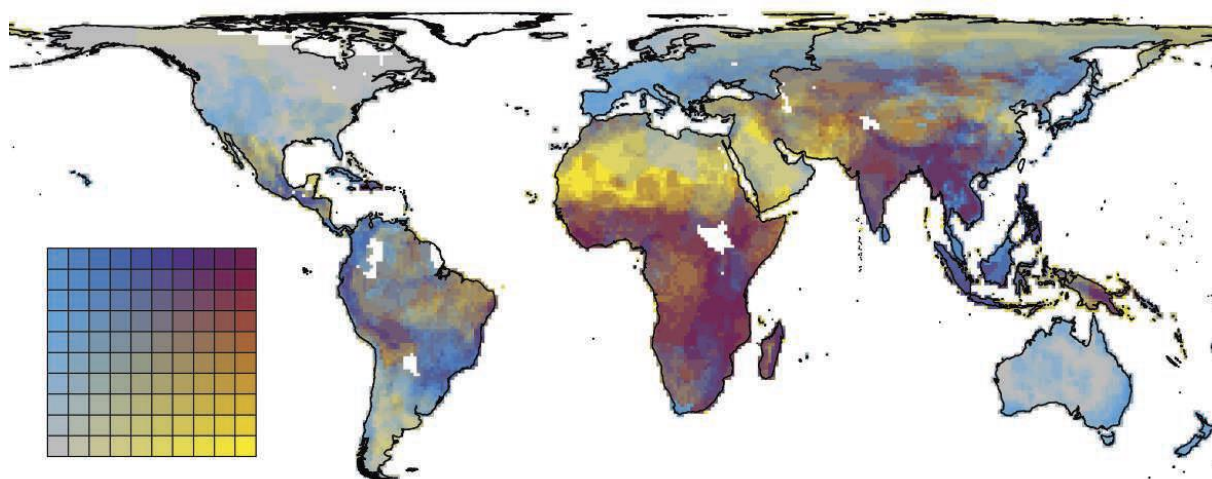


Figure 4.9 Map of poverty and potential biodiversity loss, showing the level of poverty (proxied by the log rate of human infant mortality) combined with the log number of threatened species of mammals, birds, and amphibians per one-degree grid square (Behrmann equal-area projection). White areas represent missing data. *This map is directly copied from its original source Sachs et al. (2009) and was not modified by the assessment authors. The map is copyrighted under license © 2009, The American Association for the Advancement of Science under license 5154810771990. The designations employed and the presentation of material on the maps used in the assessment do not imply the expression of any opinion whatsoever on the part of IPBES concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. These maps have been prepared or used for the sole purpose of facilitating the assessment of the broad biogeographical areas represented therein and for purposes of representing scientific data spatially.*

4.2.3.5.2 Poverty and use of wild species

Poverty and environment are closely interrelated. Extreme poverty and biodiversity hotspots can be geographically coincident (Barrett et al., 2011), but the majority of the rural poor in the developing world live in fragile and marginal lands (Barbier, 2010). Poverty is indeed prevalent in rural areas where livelihoods depend disproportionately on natural capital embodied in forests, rangelands, soils, water, and wild species (Barbier, 2010; Barrett et al., 2011). Plants, algae and fungi, fish and shellfish and wild meat have a well-established role in sustaining and protecting the existing living standards of the poor and ensuring that they do not fall into chronic poverty (Brown, 2003). A great diversity of wild species is harvested within subsistence (non-commercial) economies in the Americas, Asia and Africa as a cheap and easily accessible resource (IPBES, 2018a, 2018c). Wood-based fuels are a vital energy source for the majority of the African population contributing at least 70% of total energy consumption in sub-Saharan Africa (IPBES, 2018c). These examples show that most poor people throughout the world rely on the use of wild species for their living. Environmental degradation and resource depletion threaten their livelihoods.

A great bulk of the world's poorest and most vulnerable citizens live in disaster-prone regions and their number keeps increasing. Those groups are disproportionately affected by

shocks and stresses. According to dominant narratives, people living in poverty are the principal creators of environmental damage, whilst they often bear the cost of environmental damage. This has been proposed as representing a downward spiral, whereby the poor are forced to deplete resources to survive, and this degradation of the environment further impoverishes people. That neoliberalist and neocapitalism narratives often lead, on the one hand, to coercive environmental policies (Blaikie & Brookfield, 1986; Peluso, 1993), and on the other hand, to the privatization of common pool resources and land grabbing (Fairhead et al., 2012; Leach, 2015), that lead to the marginalization of the local people (Benjaminsen, 2015; Braun & Gatzweiler, 2014). When this self-reinforcing downward spiral becomes extreme, people are forced to move in increasing numbers to marginal and ecologically fragile lands or to cities (e.g., Nayak & Berkes, 2010). Other research, however, argues that this approach overly simplifies the poverty-environment relationship, ignores significant impacts from non-poor and industrial activity (Peluso, 1992), and undervalues the capacity of local communities in both perceiving and mitigating degradation when their management systems are in place and recognized (Angelsen, 1997; Scherr, 2000; Swinton et al., 2003; Tiffen et al., 1994). For example, poverty can be ultimately driven not by the state of surrounding resources, but by a lack of assets and access to other forms of labor, markets, and livelihoods, which subsequently limit peoples' options to the use of common resources that may have already been substantially depleted by historical industrial processes (Barbier, 2010; Dasgupta et al., 2005). Other determinants that contribute to poverty include the location of schools and health centers, access to infrastructure, natural resources endowment, access to input and, output markets, and access to jobs.

The current general relationship between poverty and environmental degradation and biodiversity loss may still be represented by a downward spiral, yet the historical large-scale degradation of the environment may likely not have occurred because of poverty, and the ultimate historical drivers of poverty and marginalization are many-fold and not explicitly related to environmental state. There are clear links between poverty/ and unsustainable use of wild species, though, as mentioned above, the initial direction of causality is unclear and very likely context dependent. In short, the question of whether resource users are “poor” because of unsustainable use, or if unsustainable use happens because users are “poor” is much less certain than what was historically assumed (Béné, 2003). In the case of some primary sectors, such as fisheries, the characterization of poverty and agency of users themselves is increasingly being reassessed as better economic data becomes available (Giron-Nava et al., 2018), informal markets and incomes are more recognized (Klein, 1999; Schuhbauer et al., 2019), and more focus is placed on first-hand perspectives (Macfadyen & Corcoran, 2002; Narayan et al., 2001). Another example is that of indigenous communities, including some of the most historically and currently marginalized peoples in the world. Despite high levels of poverty, dispossession, and multiple social stressors (Cunneen, 2005; United Nations, 2009), many such communities have rich and continuing histories of sustainable resource use (Cisneros-Montemayor et al., 2016; M.-C. Cormier-Salem, 2017b; Larrère & La Soudière, 1987; Tsing, 2015). In many cases, strategies for sustainability are intricately woven into culture itself, aside from resource use in and of itself, and yet can work in complement with (or sometimes outperform) “western” models of resource management (Bennett, 2018; Bess, 2001; Capistrano & Charles, 2012; Porten et al., 2016).

Under what conditions and to what extent are “people living in a marginal situation able (or not) to sustainably manage socio-ecological systems and/or to sustainably use wild species? As discussed in the Political Drivers section, it is increasingly recognized that local access rights can allow communities to sustainably use common resources (Ostrom, 2009). This does not necessarily require privatization in a market sense; for example, in marine systems, the recognition and support of local and indigenous traditional and customary management strategies and self-identified objectives can allow for sustainable use of biodiversity, both commercially and for subsistence (Berkes et al., 2000, 2003; Jentoft & Chuenpagdee, 2015). Contrary to the dominant discourses that make shellfish harvesters poor, with divorced, landless marginal women having access only to wastelands, and considering themselves marginal and unworthy, more and more scholars show that shellfish harvesting is a vital activity. It provides a source of nutrition and a very important source of income for women of all ages, who are gaining economic as well as political power through their activities (Burgos & Dillais, 2012; Lau & Scales, 2016).

- **Arctic**

Local communities across the Arctic face exceptional challenges stemming from historical and ongoing social, political, and now environmental change. In the Canadian Arctic, these communities are almost entirely indigenous (Inuit) and have been historically dispossessed of lands, resources, language, and culture. Nevertheless, the Inuit remain rooted mainly in traditional territories and rely on traditional diets for both subsistence and cultural identity (Kenny et al., 2018). With significant local declines in caribou (*Rangifer tarandus*, various subspecies), marine resources including fish and marine mammals are particularly important and the traditional ecological knowledge held by these Peoples increasingly recognized. However, movement across traditional fishing and hunting grounds is now restricted due to melting sea ice as a result of global warming. Additionally, methylmercury concentrations in seafood (particularly marine mammals and fatty fishes) pose threats to public health, particularly fetal and cognitive development (Chan & Receveur, 2000). Even as traditional Inuit ways of life are more respected, much more robust and cross-scale policies will be required to support their continued use of resources.

- **Latin America: The vicuña.**

Vicugna vicugna has one of the most valuable and highly priced animal fibers on the international market (Kasterine & Lichtenstein, 2018). The luxury garments made from vicuña are sold in the most exclusive fashion houses around the world. Whereas vicuña products are available only to very affluent consumers, the fiber is produced mainly by extremely low-income communities from the Andes that face high levels of persistent poverty and inequality. Despite the high market value of vicuña products, the generation and distribution of benefits to local people has been limited thus far (Lichtenstein, 2010).

Local communities “pay the cost” of vicuña conservation by allowing vicuñas to graze on communal or private land. The production of fiber also relies on a substantial investment that is borne mainly by Governments and local communities. However, most of the benefits are captured by traders and international textile companies. Vicuña fiber prices have historically

been related to factors such as: market demand; the bargaining power of the actors involved; actors' cash flow issues; volume of fiber stocked; and number of channels for commercialization (Brewin, 2007; Lichtenstein et al., 2002; Lichtenstein & Vila, 2003; Sahley et al., 2004). It is almost impossible for a remote Andean community (or producer) to negotiate with a European textile company or large trading company on equal terms. Efforts to increase the benefits accrued to the rural poor should explicitly redress access asymmetries and strengthen producer associations.

- **Africa**

In Africa, processes of marginalization and mangrove grabbing are largely mainly due to mangrove reforestation campaigns, or carbon policies under the frame of Reducing Emissions from Deforestation and Forest Degradation (Beymer-Farris & Bassett, 2012; M.-C. Cormier-Salem, 2017a). The women, who are making their household's livelihood from gathering oysters and cockles, are the most directly concerned with the preservation of the mangrove. For a long time, they conserved certain sites and developed customary rules that have maintained sustainable use of mangroves such as: defining harvesting season, designating zones shared between lineages and neighborhoods, and sacred places that are prohibited for use. In addition, they have reforested certain habitats with *Rhizophora* plants, and attempted to make better use of their products using appropriate schemes of labelling.

However, women are rarely recognized as part-stakeholder of the environmental policies defined internationally and implemented at national and local scales. They are not informed (or deliberately kept ignorant) of new devices such as Reducing Emissions from Deforestation and Forest Degradation. This has led in some cases to the loss of their access rights to the reforested mangrove areas.

- **Oceania**

As expected from ecological theory and models, as oceans warm due to climate change marine species are shifting to cooler areas towards temperate areas or deeper water, with a net loss of marine biodiversity and abundance in tropical regions. This poses many issues for Small Island Developing States that rely on marine ecosystem services. One example is Palau in the South Pacific, which for some time has transitioned into a tourism-based economy focused on coral reef biodiversity. The consumption of reef fishes is still vital in Palauan culture, as is the practice of fishing itself along the island nation; industrial fishing is less developed, but monetary benefits from fishing access agreements for foreign tuna fisheries (that export most catch) do contribute to the national economy. As a response to anticipated effects of climate change, and the growing pressure on local reef fishes from seafood demand by tourists, Palau has initiated a national strategy based on boosting consumption of sustainably caught tuna for the tourist market, thus allowing for the sustainability of local reefs and traditional Palauan subsistence fisheries (Wabnitz et al., 2017). The outcomes remain to be seen, but this is a good example of science-based policies that integrate local goals and that could be further supported through international initiatives.

- **Asia**

In the Sundarbans, the women, who collect prawn seed along the rivers, are the poorest, and belong to the lowest caste of the society (Jalais, 2010; Lahiri-Dutt & Samanta, 2013). They do not have access to land or the forest. They use a very simple and cheap technique, a mosquito net fixed on pole, for gathering the prawn seed. Thanks to the development of intensive shrimp farms in the North of the Delta, and the huge demand of prawn seed, they are becoming very rich and powerful. They have got a strong identity, not only as "working" women but as "earning" women, daring to reverse the hierarchical order of the village, refusing both tradition and the urban ideals of femininity.

4.2.3.5.3 Poverty and indigenous people

There are about 476,6 million indigenous people in the world today present in over 90 countries. Indigenous communities represent about 6,2% of the world's population but make up 15% of the world's extreme poor, and 1/3 of the rural poor (ILO et al., 2020). According to this recent report, over 73.4% of the global indigenous population live in rural areas, but there are substantial regional variations. The highest proportion of indigenous peoples residing in rural areas is found in Africa (82.1%), followed by Asia and the Pacific (72.8%) and Europe and Central Asia (66.4%). In Latin America and the Caribbean and in Northern America, a majority of indigenous peoples are urban dwellers (52.2% and 69.0% respectively). They live, own and occupy approximately one quarter of the world's lands and waters which represents 80% of the world's biodiversity. Indigenous peoples are nearly three times as likely to be living in extreme poverty as their non-indigenous counterparts represent a sizable share of the global poor (ILO et al., 2020). Indigenous peoples' life expectancy is up to 20 years lower than the life expectancy of non-indigenous people worldwide.

Research conducted by Hall et al. (2014) for the World Bank found that poverty among indigenous people manifested in various ways including insecure land and property rights, discrimination, heightened vulnerability to risk and climate change, and a wide range of health, education and other related socio-economic disparities (Hall et al., 2014). Indigenous peoples experience a high degree of socio-economic marginalization and are at disproportionate risk in public health emergencies. They often face impediments to their access to natural resources, essential services, the formal economy, and justice, as well as their participation in decision making. Factors such as lack of access to effective monitoring and early-warning systems, and adequate health and social services resulted in indigenous people becoming more vulnerable to the present COVID-19 pandemic (ECLAC., 2021). Poverty in indigenous groups is probably related to the historical-political conditions that untied indigenous peoples from the control of their territories relegated them to the margins of society or directly excluded them.

4.2.3.6 Gender equity

Key messages:

- The benefits and costs of wild species use are inequitably distributed across genders with women and those of diverse gender identities experiencing the greatest inequity (*established but incomplete*){4.2.3.6.2}.

- Access to wild species and uses tend to be gendered. This is evident in many indigenous societies. There are various kinds of roles and responsibilities as well as rules of use that apply to women (*established but incomplete*) {4.2.3.6.2}.
- Women have particularly crucial roles in foster sustainable use in many cultures; as they play a primary role in food production and education (*established but incomplete*) {4.2.3.6.2}.
- Many kinds of resource management institutions are gender blind and do not take into consideration the diversity of roles and responsibilities nor the inequities experience by women and gender diverse peoples (*established but incomplete*) {4.2.3.6.3}.

4.2.3.6.1 Overview

Gender shapes the social roles that men and women play and the power relations between them, which can have a profound effect on the use and management of natural resources. Gender is not based on sex or the biological differences between women and men; rather, gender is shaped by culture and social norms. Thus, depending on values, norms, customs and laws, women and men in different parts of the world have adopted different gender roles and relations. Within the same society, gender roles also differ by race/ethnicity, class/caste, religion, ethnicity, age and economic circumstances. Gender and gender roles then affect the economic, political, social, and ecological opportunities and constraints faced by both women and men.

The case for seeing women as having a special relationship to Nature has been made by ecofeminists for more than three decades. The term "ecofeminism" was coined in the 1970s to raise awareness about interconnections between women's oppression and nature's domination in an attempt to liberate women and nature from subordination (d'Eaubonne, 1978). Since then, ecofeminism has attracted scholars and activists from various disciplines, drawing on Marxist critic, animal studies, postcolonialism, and political ecology (Vakoch & Mickey, 2018). The Green Belt Movement in Kenya and the Chipko Movement in India are said to epitomize the essence of ecofeminism.

Conceptualizations of the nature of the link between women and nature vary from asserting a physiological connection (women as birth givers etc.), to a more socially based view linked to women's social role (as mothers, farmers, water carriers) (e.g., Shiva, 1998). Other authors consider that reducing women's decisions to a set of biologically determined characteristics devalues their agency, fails to recognize that they may also align with other identities (e.g., caste, class) and undermines the fact that they are situated in certain localities which impose and offer a specific set of constraints (Mawdsley, 2004). A common ground between these perspectives is that the roles and responsibilities of men and women in the management of biodiversity, and the ability to participate in decision-making, vary between and within countries and cultures.

4.2.3.6.2 Gender-specific roles, needs, dynamics and the sustainable use of wild species

The impact of women's participation and empowerment on sustainable use outcomes will be stressed through a few examples, illustrating what makes some gender-based practices

sustainable. For instance, across Africa, household chores are often divided according to gender; this in turn shapes the different ways in which women and men relate to trees. For example, in the case of the shea tree, women are the custodians of knowledge concerning the gathering and processing of shea products (Elias, 2016). The women have ingenious use of the shea nut, bark, roots and leaves: to increase milk production in lactating mothers, to relieve those suffering from malaria and to make the traditional ‘benga’ dish. Since they are not the ones to process shea nuts into butter, men are less concerned about the traits of shea nuts that yield quality butter but "male farmers prize the tree (...) for its shade and its role in improving the fertility of the soil in their fields" (Elias, 2016). Women are not the owner of the trees, but they have access thanks to the contributions perceived by men. Nevertheless, with "globalization" that means trade of forest-based local products on international markets and the increasing demand for quality fair trade products, the women often lost the control of the commercial network, and therefore are "marginalized" by men. From a case-study of fairtrade shea butter produced by women in Burkina Faso and consumed by European and North American women, (Elias & Saussey, 2013) showed the low returns for butter producers and doubt the ‘fairness’ and solidarity aspects of the movement.

In many parts of the world, women often bear the primary responsibility for feeding their families, collecting, processing, cooking, rationing and storing food, nurturing. In many developing countries, women collect and prepare highly nutritious foods from wild species to complement and add flavor to the staples of family meals. In addition, income generated by women from the harvesting of wild species adds to the purchasing power of households and therefore their food security. Men, on the other hand, are more likely than women to be responsible for gathering wild honey, birds’ eggs and insects, for hunting and fishing, and in many countries, for the commercial exploitation of a forest’s wood resources.

Box 4.27 Women and sustainable use of wild species

Women play a central role in the conservation and sustainable use of wild species. This can be highlighted in three main aspects: *First*, they are the most numerous in this activity area, present at all stages of the value chain (extraction, processing, distribution, consumption). *Second*, they depend closely on these species and uses for their livelihood and the well-being of their family. These activities occupy a major place in their calendar; they spend a lot of time for collecting three basic needs: food, water and fuelwood (e.g., fuelwood; Agarwal, 1986). Wild species are a source of essential income for themselves and their families. It is also a means of economic empowerment, social recognition, and status acquisition within the community. Besides, most of the women who use wild species are elderly, widowed or divorced, and have no land tenure rights (*see* section on poverty and marginalization). *Third*, closely dependent on these resources, they are most concerned with their conservation and sustainable use; they have intimate links with these species. Also, they have knowledge, practices, rules of use and access that preserve and value these species.

In a review conducted by Meinzen-Dick (2014) suggested that neither men nor women are inherently more resource-conserving; instead, their motives – issues related to closeness to nature, interests and needs for those species- and their material conditions and means – access and use rights to wild species, influences their sustainable practices. Property rights and security of tenure influence the motives and means that men and women have to exploit or conserve

natural resources (Meinzen-Dick, 2014). Thus, adoption of sustainable practices requires attention to control rights. In most circumstances there are gender-based differences and inequalities, which tend to favor males. Gender differences are evident in economic opportunities and access to and control over land, biodiversity resources and other productive assets, in decision-making power, as well as in vulnerability to biodiversity loss, climate change and natural disasters.

Box 4.28 Women's vital role in social movements to conserve biodiversity in the Brazilian Amazon

Deforestation in the Brazilian Amazon has accelerated significantly during the past few years, threatening livelihoods, and becoming a source of carbon emissions rather than a global carbon sink. However, during the period between 2004 and 2012, Brazil decreased deforestation by over 80%. Brazil's Federal government created 89 extractive and sustainable development reserves in Amazonia, between 1990 and 2009, encompassing 24 million hectares. During a 35-year period in Brazil, nearly half of the Amazon rain forest became protected through a system of extractive and sustainable development reserves. This remarkable accomplishment was the result of rigorous research, advocacy leading to policy change and the collective struggle of a robust social movement.

As deforestation accelerates in Brazil today, it is critical to remember the social processes and policies which led to an earlier, highly significant, national, and global conservation gain. As part of this process, women played a pivotal role. Thirty-five years ago, women were not permitted to be members of one of the most prominent organizations of the Amazonian social movement, the National Council of Rubber Tappers. However, the creation of a Secretariat of Women Extractivists within National Rubber Tappers Council was influential in transforming women's roles within the hierarchy of extractive reserves from invisible to one of consequence (Shanley et al., 2011). Over the ensuing years, to be more inclusive, the name of National Rubber Tappers Council was changed to the National Council of Extractivist Populations. The work of women in building capacity, cultivating ties with key governmental agencies and recognizing cultural connections to forests, provided a strong foundation for an increasing role of Amazonian women to promote sustainable management and conservation. The conceptual foundation of extractive reserves - multiple-use and sustainable forest management - are practiced by thousands of rural Amazonian women. Women have played a vital role in understanding the direct value of forests to food security and the health and welfare of families. Traditional knowledge of forest resources was central to determine the categories of extractive reserves, and what type of use and management would be permitted including hunting, fishing, logging, gathering etc. Local input from rubber tappers and forest-reliant communities contributed to the policies designating various categories of sustainable use. From not being allowed to be part of Brazil's largest Amazonian social movement, women now compose 40% of the membership of the National Council of Extractivist Populations and are leaders of 25% of conservation units (Shanley et al., 2018). Brazilian women currently occupy critical positions from leading grass roots organizations to high level positions in government agencies and worker's unions. While rubber tapper and conservationist Chico Mendes succeeded in launching a national campaign to create extractive reserves, women played a crucial role in expanding and making tangible a globally significant conservation movement.

4.2.3.6.3 Gender and public policies

Most programs to promote sustainability have been gender blind and thus ended up working primarily with men, who are more likely to occupy public spaces (including community organizations and government or external programs) and are often more readily recognized by

outsiders as the foresters, irrigators, fishers, and even farmers. Justice and equity concerns are now prominent in national and international policies. For instance, Aichi Target 11 calls for protected areas to be equitably managed by 2020, and Gender equality is called for in Sustainable Development Goals 5. However, understanding of how to consider and incorporate equity and the broader concept of justice into conservation and sustainable use of wild species remains nascent.

4.2.3.7 Indigenous peoples and food systems- impacts of pollution

Indigenous peoples and local communities experience large burdens of environmental pollution linked to the expansion of commodity frontiers and industrial development (Basu et al., 2018; Fernández-Llamazares et al., 2020; Landrigan et al., 2018). Increasing demands on indigenous peoples and local communities' territories from the expansion of industrial resource development and extraction, often result in pollution risks, which endanger the collective continuance of indigenous peoples and local communities, and the foundations of their cultures, subsistence-based livelihoods and ways of life (Armstrong & Brown, 2019; Parlee et al., 2018; Scheidel, 2020; Spice, 2018). Environmental pollution has been recorded in numerous indigenous peoples and local communities' lands worldwide, increasing risks and burdens of disease (e.g., Lewis et al., 2017), and forcing many communities to shift away from traditional lifestyles (e.g., Hoover, 2017). Many health impacts documented among indigenous peoples and local communities are mediated through the consumption of wild foods (Bordeleau et al., 2016; Ostertag et al., 2009), obtained through hunting (Cartró-Sabaté et al., 2019), fishing (Binnington et al., 2016), and gathering (Strand et al., 2002). As a case in point, freshwater crabs and turtles of several rivers in the Amazon Basin, which are both culturally and nutritionally important for indigenous communities, have been impacted by widespread high levels of Hg and Pb pollution (Schneider et al., 2010).

These pressures can generate legacies of intergenerational trauma and reduced cultural engagement, leading to declines in indigenous peoples and local communities physical and mental well-being, ultimately limiting their ability to engage in the many mutually reinforcing aspects of knowing and being (Fernández-Llamazares et al., 2020). For example, numerous studies reports impacts of pollution on indigenous peoples and local communities' mental health, including psychological disorders associated with pollution events (Nriagu et al., 2016). Pollution can also result in fear of consuming traditional wild foods (Turner & Turner, 2008), and the decline in wild species availability due to pollution can foster increased reliance on nutrient-poor and expensive market foods, often increasing the risk of malnutrition and chronic diseases (Fernández-Llamazares et al., 2020). For example, some indigenous communities in British Columbia (Canada) have stopped gathering seaweeds in large amounts due to fears about marine pollution (Turner & Clifton, 2009; Turner & Turner, 2008). Loss of hunting or fishing activities can also result in reductions in physical activity, with significant health implications (Hoover, 2017). Fears over pollution can also lead to declines in the use of traditional plant-based medicines, as documented among Native American communities (Arquette et al., 2002).

Environmental pollution impacts both material and nonmaterial cultural dimensions of indigenous peoples and local communities' ways of life, including their knowledge systems

(Pufall et al., 2011; Yakovleva, 2011). For example, herbicide treatments have contaminated plants used by California Native American communities for different cultural uses, such as traditional basket weaving (O'Neill, 2003). Other traditional practices, such as harvesting local plants for sustenance, ceremonial, or medicinal purposes, can also increase exposure to pollutants (Arquette et al., 2002). Thus, recommendations to refrain from fishing or gathering plants can affect indigenous peoples and local communities' cultural traditions based on these activities. And undermine the knowledge systems that underpin such practices (Fernández-Llamazares et al., 2020; Kuhnlein & Chan, 2000). Similarly, some studies have documented how pollution risks can affect the spiritual wellbeing of indigenous peoples and local communities (LaDuke, 1999; McCreary & Milligan, 2014; Temper & Martinez-Alier, 2013).

Environmental pollution jeopardizes the complex and intimate relations that many indigenous peoples and local communities establish with their lands and waters (Fernández-Llamazares et al., 2020; Hoogeveen, 2016), thereby affecting prospects for the continuance of indigenous peoples and local communities' practices of sustainable resource use. Because activities associated with gathering wild foods generally serve important community roles (e.g., intergenerational exchange, maintenance of language), concerns related to pollution regarding the sustainable use of biodiversity can also impact the continuance of these subsistence-based practices (Berkes & Farkas, 1978; Hoover, 2017). In response to this, indigenous peoples and local communities are actively contributing to develop innovative strategies to limit the spread of pollution and prevent it from the outset (see Fernández-Llamazares et al. 2020 for a review). For example, indigenous peoples and local communities are increasingly leading community-based pollution monitoring programs (Herrmann et al., 2014), engaging in international policy development to reduce pollution burdens (Basu et al., 2018; Selin & Selin, 2008) and articulating different forms of grassroots resistance to polluting activities on indigenous peoples and local communities' lands (Armstrong & Brown, 2019; Scheidel, 2020; Spice, 2018).

4.2.4 Economic drivers

4.2.4.1 Overview

Economic forces are considered among the most critical in addressing rapid declines in biodiversity including the use of wild species; economic systems directly impact species but also shape perceptions and norms about the importance of particular species and their value within society (Diaz et al., 2015). Direct drivers (e.g., a rise in export prices) are of major importance, however, indirect drivers and mediating factors (e.g., access to markets) can also have a significant impact on long term sustainability. Typically, economic drivers and mediating factors jointly determine sustainability outcomes (Mirza et al., 2020). Key element of economic analysis are factors affecting the supply of commodities related to wild species (e.g., lack of alternative employment opportunities) as well as demand (e.g., urbanization). Together, this facilitates trade, i.e., an exchange between buyers and sellers. The interactions between economic incentives, institutions and governance structures, in relation to wider ecological, cultural and social drivers and mediating factors are critical to understand sustainable use of wild species.

4.2.4.2 Methods, limitations, and gaps in knowledge

The content of this section is based on evidence from research in numerous disciplines including, resource economics, agricultural economics, geography, sociology, ecology and conservation biology. The subsections were developed with a systematic literature review, complemented by grey and peer-reviewed literature based on input of the experts. There are some notable challenges in the availability of data. There is growing availability of economic data on the performance of industries relying on wild species in some areas of the world (e.g., reports by the ‘Scientific, Technical and Economic Committee for Fisheries’ in the European Union), though many regions of the world lack even basic statistics on the economic situation of harvesters. In such case, official trade statistics may offer insights on scale of exploitation, though trade data insufficiently tracks the status of threatened species (Phelps et al., 2016; Phelps & Webb, 2015), and there are considerable discrepancies in official statistics and trade surveys for other species (e.g., ornamental plants in South East Asia). Also, sustainability outcomes cannot be assessed from static data, but require repeated observations, which are rarely available (Allebone - Webb et al., 2011; Coad et al., 2013; Taylor et al., 2015). This limits the quality and quantity of evidence regarding sustainability outcomes.

Key limitations in the literature are incoherent definitions of what sustainable use entails and also lack of objective measurements against some form of baseline. For example, a literature review on the trade in medicinal plants in Central Himalayan reveals that though there is often a degraded resource base, the empirical basis for inferring sustainability outcomes is relatively weak (Larsen & Olsen, 2007). The same is true for economic sustainability. Often, the role of middlemen is perceived to be important, but there is little quantitative evidence on which economic outcomes would be deemed fair or sustainable (Larsen & Olsen, 2007). Formulating guidelines for assessing sustainability would be an important step to make cases comparable (Cuesta & Becerra, 2013).

Another limitation is a ‘survivorship bias’ meaning that field studies tend to study what is there (and not what is lost and forgotten). Analysis from a bushmeat market in West Africa (Takoradi, Ghana) finds little evidence for overharvesting and unsustainable uses, potentially because the most vulnerable species have already disappeared in the past due to prolonged hunting (Cowlishaw et al., 2005). Quantitative data that is comparable across countries is often unavailable for subsistence and indigenous economies, particularly in relation to economic impacts and drivers of cultural, spiritual and social uses of wild species. There are also significant gaps in the availability of documented indigenous and local knowledge related to economic drivers at all scales and in relation to all species. This is partially due to remote government officials being mistrusted by indigenous communities, and also due to asymmetric power, different worldview and lack of investment on part of the scientists to have a meaningful collaboration and use of indigenous local ecological knowledge (Brondízio et al., 2021). Despite this gap, indigenous and local knowledge perspectives should be considered critical to our understanding of sustainable use of wild species, particularly as it relates to their social, cultural and spiritual importance to indigenous peoples. Some issues of sustainable use for some countries are also more studied than others. For example, species considered under CITES, particularly related to vertebrates have been a greater focus than other species including plants

and invertebrates. There are also gaps in our understanding of the economic drivers of sustainable use issues in some regions. As a result, the data available is uneven and recognition should be given to gaps that require further study and assessment. For example, Taylor et al. (2015) document quantity of evidence on the impacts of wild species hunting with data on 177 species from 275 sites across 11 African countries collected over 30 years. They find that research efforts and available information are not evenly distributed. There is less evidence from West Africa compared to Central Africa, and also less information about impacts on birds (Taylor et al., 2015).

4.2.4.3 Structure and composition of economies

4.2.4.3.1 Subsistence economic activity and the use of wild species

Subsistence economies are defined as those that are small in scale and in which the use of resources (including wild species) is limited and exclusively used to meet local needs rather than accumulated or sold for profit (Emery & Pierce, 2005; Natcher, 2009; Schumann & Macinko, 2007). Small scale and decentralized economies are generally characterized by short supply and important focal points for discussion on the sustainability of wild species. What is considered local varies (e.g., 30 miles in the United Kingdom of Great Britain and Northern Ireland – 400 miles in the United States of America) (Galli & Brunori, 2013). The development of small-scale food systems is considered vital to addressing a variety of ecological stresses (e.g., limit carbon footprint as transportation is limited); among these is the impact of food wastage. It is estimated that in North America and Europe, 250-300 kg of food per annum per person is wasted due to inefficient supply chains and large-scale market systems (Galli & Brunori, 2013). Many small-scale economies are characterized by livelihood diversification considered important in dealing with variability in the availability of species (e.g., due to migration, population cycles etc. periodic drought, fire, etc.). “Livelihood diversification is defined as the process by which rural families construct a diverse portfolio of activities and social support capabilities in their struggle for survival and in order to improve their standards of living” (Ellis, 1998). A growing body of work indicates how de-centralized and small-scale community and household economies adapt more readily to variability and shocks in the availability of wild species thereby are nimbler in ensuring conservation outcomes. For example, subsistence economies also are an insurance against down swings in the wage economy (e.g., mining sector) (Usher et al., 2003). In South Africa, “pastoralism still plays an important role for households, it has shifted from being the core economic activity to being an insurance against unemployment and contributing to subsistence” (Berzborn, 2007).

Wild species are fundamental to the health and well-being of indigenous communities and many remote and rural communities globally. The degree of dependence of a community on a resource for subsistence depends on the condition of resource, its proximity to the community, access rights, and restrictions as well as local and external demand and income opportunities; for communities with few other economic and food resources, dependence on wild species and other wild resources, is likely to be higher (Roe et al., 2002). The central point is that wild species contribute to the nutrition of many rural and indigenous peoples globally.

Although not easily quantifiable, harvest studies and nutrition studies in various parts of the globe suggest the nutritional value and estimated replacement value (dollars) of many species (Hickey et al., 2016). “The few studies that have assessed the relative and absolute contribution of wild meat to household economies in the tropics point to a thriving and financially-large informal sector, perhaps of the same order of magnitude, in terms of gross domestic product , as formal sectors like timber exploitation or agriculture” (Coad et al., 2019). Wild meat is critical to the food security of rural and remote communities comprising up to 90% of available protein in the diet. In northern Australia, for example, wild meat comprises up to 81% of protein intake for indigenous communities. As a result, there are complex and deeply embedded informal economic practices that allow for the sharing and trade of wild meat within small and medium sized communities. For example, in Yangambi, Congo, harvesting and trade of wild meat is illegal, but enforcement by the state is limited. This quasi-open access system may jeopardize sustainability in the long run, though for now “emblematic” species seem to persist while at the same time local communities are able to meet their daily food needs (van Vliet et al., 2019).

Box 4.29 "The fish of the rich devours the fish of the poor."

Key messages:

- Wild fish species cover the provision of micronutrients and proteins that are vital for millions of people, especially in developing countries
- The multiplication of fishmeal factories can lead to unfair competition with the artisanal fishing sector, an acceleration of the overexploitation of wild fish resources and the accentuation of food insecurity for local communities.

It is often suggested that aquaculture has potential to alleviate some of the fishing pressure applied to wild stocks. However, this development has been and, still is, strongly dependent on the availability of fishmeal and fish oil obtained from capture fisheries (FAO, 2020b; Péron et al., 2010) besides, industrial fish farming has negative impacts on environment (loss of habitat e.g., destruction of mangrove areas, invasive species, etc.) and local livelihood, depriving people of employments and competing domestic value-chain (Belhabib, Sumaila, & Pauly, 2015; Hoanh, Tuong, Gowing, & Hardy 2006, Konar et al., 2019). This last point is particularly worrying in developing countries, where international agreements are promoting fish exports to match the growing demand for fish in the markets of high-income Western countries and East Asia (FAO 2020). But, for millions of people, fish cover the provision of micronutrients and proteins, that are essential for a balanced diet, particularly for children under five years old (Hicks et al. 2019).

On the northwestern coast of Africa (Senegal, Mauritania, Gambia, Bissau-Guinea), international agreements in favor of fishing by fleets from the European Union, Russia and East Asia and high fish exports to the European Union, have led to local fish scarcity and price increases, that have made fish increasingly inaccessible to local consumers (Kaczynski & Fluharty 2002; Gagern & van den Bergh 2013; Corten, Braham, & Sadegh 2017; Thiao, Leport, Ndiaye, & Mbaye 2018). The fisheries in the African Large Marine Ecosystems have reached their peak, and in many cases, move beyond peak catches to a declining trend (Zeller et al. 2020). In addition, the development of industrial aquaculture at the international level has led to a new demand for fishmeal and fish oil. This development is questionable from an ecological viewpoint, as aquaculture depends on wild fish and terrestrial crops (which are also consumed by humans) for feeds and freshwater and land for culture sites (Troell et al.,

2014). It is also questionable from a social viewpoint, as the multiplication of fishmeal factories leads to unfair competition with the artisanal fishing sector and to an acceleration of the overexploitation of fish resources (such as sardinella/pelagic species), the accentuation of food insecurity, repercussions on employment, environmental nuisances and danger to public health (Aprapam, 2017; Troell et al., 2014).

In Senegal, 22 fish processing plants have been set up since the 2010s to manufacture fishmeal and fish oil from wild pelagic fish, mainly *Sardinella spp.* and *Ethmalosa spp.* to supply the Chinese industrial aquaculture and, ultimately, the markets of Europe, America and China (Aprapam, 2017; Greenpeace, 2019). In Mauritania, 29 factories of fishmeal were in activity in 2015, and two new ones had also been built in Gambia (Thiao et al. 2018). Sardinella (round *S. aurita* or flat *S. maderensis*) and Bonga shad (*Ethmalosa fimbriata*) are popular wild fish in West Africa because of their low price and constitute the primary source of protein (up to 80% of animal protein in some areas of Senegal) and nutrients for local human populations. These wild resources are thus fundamental for food security but also a key driver of social cohesion and a sign of cultural identity (Cormier-Salem & Samba 2010; Thiao et al. 2018). Fish is the staple of the national dish called “*cee bu jen*” or rice with fish, traditionally prepared with white grouper (*Epinephelus aeneus*). Since the 1990s, as demersal species are less abundant, costly and export-oriented, this dish is mainly cooked with pelagic species, notably fresh Sardinella or processed Sardinella called *kejax* (Mbengue, Cormier-Salem, & Gueye 2009). The deterioration of fish affordability for the local consumers due to a substantial increase in the price of the main consumed fish products since 2006 has ultimately resulted in a significant decrease in the quantity of consumed fish (from 36.5 kg/person/year in 1993 to 23.9 kg in 2013), which is further of lower quality (dried Sardinella crumbs replacing more and more fresh fish, (Thiao et al. 2018)). At the same time, fish exports, primarily through fishmeal and oil, jumped from 3,000 tones to 17,000 tons in 2003 and 2014, respectively (Thiao et al. 2018)

Using pelagic species like Sardinella to make fishmeal for farmed fish does not reduce the pressure on wild fish. Moreover, it deprives people in vulnerable situations of previously affordable, nutritious local fish and have a substantial impact on diet and public health (Pauly 2019). To face the multiplication of fishmeal factories and the unfair international agreements, a few initiatives are conducted, such as “SOS Yaboye” (SOS Sardinella) citizen mobilization in Senegal, that led to the shutdown of a new Chinese factory in the Gambia borders and public inquiries.

4.2.4.3.2 Indigenous economies and the sustainable use of wild species

Indigenous economies refer to both traditional and self-governing economies that are grounded in the cultural norms, practices and belief systems of one or more indigenous peoples (Appiah-Opoku, 1999; Argumedo & Pimbert, 2010; Cullen et al., 2007; Koptseva, 2015). While the concept of local (or small scale) is often equated with sustainability and conservation, some small-scale economic practices are not sustainable (Blaikie, 2006; Schumacher, 2011). Critical reviews of case studies have produced design principles that make both local economic benefits and sustain ecological values.

Interrelationships between indigenous economies and the sustainable use of wild species are complex given such economies have substantial social, cultural and spiritual dimensions. “The significance of traditional economies in indigenous communities goes beyond the economic realm—they are more than just livelihoods providing subsistence and sustenance to individuals or communities”(Kuokkanen, 2011). Many aspects of indigenous economic practices and associated resource management systems are considered well aligned with the sustainable use and conservation. Indigenous economies are more likely to manage resources

including use wild species in ways that are socially, culturally and ecologically sustainability when there is, a) security of tenure, b) a well-developed management system informed by indigenous knowledge, c) clear incentives and d) equitable sharing of benefits from sustainable use (Bawa & Gadgil, 1997). Market economies can also significantly influence the sustainability of indigenous economies and their use of wild species (Godoy et al., 2005). For example, in the Xingu territory of the Amazon Basin in Brazil, 28 villages in the northern Xingu region opposed large scale logging and mining operations and are producing 1-2 tons of certified organic honey annually which is being sold in one of Brazil's largest supermarket chains (Schwartzman & Zimmerman, 2005). The Soligas of the Biligir Rangan Hills of India harvest fruits from local fruit trees which are made into products (e.g., jams) which are exported from the region and provide local incomes (Bawa & Gadgil, 1997). Also, the Mumeka outstation economy in Australia is "as sustainable in 2003 as it was in 1979; indeed, this economy is structurally the same hybrid economy with customary (hunting), market (arts production and sale) and state (income support transfers) sectors in both periods" (Altman, 2003).

4.2.4.4 Globalization and telecouplings

A primary driver of sustainable use is increased mobility and connectivity, which implies that the use of wild species is affected by telecouplings, i.e., processes taking place in regions where the species are not endemic. Broadly, this happens along several dimensions. First, along the flow of goods and commodities, i.e., trade. Secondly, along the flow of financial transactions and money flows. Third, along the flow of people to watch and enjoy wild species, i.e., tourism. These three flows will be discussed in turn.

4.2.4.4.1 Trade

Key messages:

- Wild product trade often forms part of an income diversification and risk reduction strategy for rural poor households in developing countries (*well established*).
- Trade revenues can facilitate and incentivize conservation, but if regulation is absent or not enforced it often encourages overexploitation and unsustainable use, including local extinction. The sustainability outcomes depend on mediating factors such as the total demand and scale of trade, governance arrangements, trade relations and local incentives for conservation, and species characteristics (*established, but incomplete*).
- Sustainability outcomes depend on enforcement of local management plans, national laws, and international cooperation. Lack of enforcement and monitoring bears the risk of undermining the potential for sustainable use that may provide critically needed revenue and incentives for conservation, while at the same time fail to discourage illegal harvests and trade (*established but incomplete*).
- Trade bans have played overall a vital role in halting unsustainable use of threatened species, but in some cases, they may have negative consequences on sustainability outcomes and local livelihoods (*established, but incomplete*).

- Empowering local communities to capture the benefits from wild species conservation with legal user rights and co-designing regulation contributes to sustainable use of wild species (*established, but incomplete*).

This section will provide a conceptualization of trade, and analyze its impact at different scales, including the role of trade relations. The role of markets as drivers either for sustainable or unsustainable use will be explored as well as the importance of economic incentives to engage local communities in sustainable practices. The direct and indirect impacts (e.g., through invasive species, teleconnections, shifts of economic activities) of trade on the use of the target species and local communities will be presented. Trade is a basic economic concept involving the buying and selling of goods and services, or the exchange of goods or services between parties. Trade decouples the consumption of a commodity from the place of origin. When it comes to wild species this may involve the wild species directly (when the species is traded or body parts of it) or indirectly, when commodities derived from these species' habitat are traded, potentially leading to land conversion and loss of habitat. Hence, trade allows consumers in importing regions to buy certain goods that are not available domestically or only at higher prices, while sellers in exporting markets can sell volumes and obtain prices that are potentially higher than what could be obtained at local markets. International trade flows imply a diffusion of responsibility between importing and exporting regions in protecting wild species and biodiversity more general (Lenzen et al., 2007). Trade has particularly adverse effects on wild species, if the resource is left to open access, as potential trade revenues increase the incentive to harvest more or harvest illegally, undermining conservation (Brander & Taylor, 1998). Trade revenues do not always benefit local communities who may be the ones harvesting, but largely depends on the relations along the trade value chain. For example, fish traders often supply fishers with (loans for) equipment, which could enable sustainable or unsustainable exploitation (Elsler, 2020). In absence of functioning regulation, trade tends to put pressure on wild species in exporting regions, while alleviating biodiversity pressures in importing regions (Brander & Taylor, 1998). The scale of trade may range from the very local scale, where products are brought to the next bigger town, to the global scale.

As it was noted in IPBES global assessment (2019), expanding trade means that consumption affects practices and uses of wild species elsewhere. Essentially, trade established telecouplings, making use of wild species and ultimately biodiversity loss a global (rather than local) systemic phenomenon, at least if trade is a contributing driver (Lenzen et al., 2012). Also, international trade and human transport is now recognized as an essential and rapidly growing source of introduction of exotic invasions and diseases worldwide (Hulme, 2009). Lenzen et al. (2012) found that 30% of threatened global species are due to international trade, excluding considering the role of invasive species. Marques et al. (2019) concluded that trade was driving 25% of the global impacts on biodiversity in 2011, with significant regional differences. For example, 33% of Central and Southern America and 26% of Africa's biodiversity impacts were driven by consumption abroad.

- **Trade relations**

Trade relations encompass bi- and multilateral ties between harvesters, middle(women), traders, countries, and companies involved in the exchange of wild species. Complex harvester-

trader relations, producer cooperatives, and exporter-importer relations can be observed for fishing (Elsler, 2020), but also for hunting (Allebone-Webb et al., 2011). Trade relations operate at and across local and global scales. Local scale trade relations include those between harvesters and traders and harvesters and middle(wo)men, who are often imbalanced and characterized by dependence from harvesters on traders/middle(wo)men. Examples of global scale trade relations include trade relations between countries (through trade agreements), importers and exporters. Local and global scale trade relations are often intertwined through international market value chains.

Local scale trade relations, between and amongst harvesters, traders, and middle(wo)men include harvester-trader relations and producer organizations that commercialize harvests such as fishing cooperatives. They are often associated with artisanal harvesting. Harvester-trader relations can provide important social benefits (e.g., Merlijn 1989). However, they have also been associated with unsustainable use of wild species (B. Crona et al., 2010). At the same time, harvesting cooperatives that enable collective action have been associated with sustainable species use (e.g., McCay 2014; Ostrom 1990).

Local trade relations are often multi-dimensional including essential functions, such as providing loans for operations and investments (Drury O'Neill et al., 2019), access, information, and infrastructure (Bailey et al., 2016; Ferrol-Schulte et al., 2014), or advice, and support next to the exchange of seafood with different consequences for species use (Basurto et al., 2012; Ferse et al., 2014). Their different functions and characteristics can determine the outcomes for the use of wild species and the trade partners and affect incentives for the use of wild species. For instance, access to new markets can promote non-selective capture (Nascimento et al., 2017) and credits can decouple species harvest from environmental fluctuations (Crona et al., 2010; Kininmonth et al., 2017). In cases, where local trade relations promote sustainable use, trade relations have been found to promote self-governance or commercial interests align with conservation objectives, such as in the case of Indonesia where traders' loans enable fishers to reduce fishing pressure in an overfished marine ecosystem.

Some local trade relations promote self-governing strategies and contribute to local level institutional diversity (Basurto et al., 2012). This aspect is important because informal governance at the local level can be more effective or contribute to centralized governance. Trade partners can contribute to devising informal social norms and contribute to rulemaking. Traders may influence social norms through their key positions of channeling information to local communities (Crona & Bodin, 2010; Glaser et al., 2010). Also, traders may devise new rules. For instance, in the case of the Mexican squid fishery, traders have become influential in the fishery due to collusion and have set quotas to fishers which prevents catch discards (Frawley et al., 2019). On the downside, the traders' power allows them to significantly reduce the beach price fishers fetch for their catch (Elsler et al., 2021). Finally, traders and middle(wo)men can contribute to formal decision-making processes that harvesters, due to their limited financial and administrative capacities, do not have access to (Basurto et al., 2012; Frawley et al., 2019; Maryudi & Myers, 2018).

The functions of local trade relations can promote social sustainability. Traders and middle(wo)men may give insurance during hardship, personal support, and creating contingencies between supply volumes and demand (Ferrol-Schulte et al., 2014; González-Mon et al., 2019; Radjawali, 2010). This is particularly prominent in committed trade relations based

on kinship, friendship, or strong social norms of reciprocity (Drury O'Neill et al., 2019; Ferse et al., 2014; Nascimento et al., 2017; Sharp, 2016). However, committed relations do not necessarily promote sustainable species use. In Indonesia, for instance, fisher's use of blast fishing depends on their trust to a trader who can protect them from prosecution (see Box 4.30). In contrast, in relations in which commitment is lacking and strong power asymmetries due to gender differences or high indebtedness are present, exploitation and misconduct have been observed (Drury O'Neill et al., 2019; Matsue et al., 2014).

Box 4.30 Trade relations in an Indonesian multi-species fishery

In the Spermonde (Indonesia) multi-species fishery, fisher-trader relations are highly influential (Ferse et al., 2012; Glaser et al., 2010), as in many other tropical small-scale fisheries (e.g., Ferrol-Schulte et al. 2014; Merlijn 1989). The sustainability of fishing can be affected by fisher-trader relations through their influence on the reinforcement and emergence of fishing practices (Crona et al., 2010; Ferse et al., 2014). Schematically, two mechanisms shape fisher-trader relations' influence on fishing practices: first, interactions within the relation going beyond the exchange of fish (Pelras, 2000) and, second, fishers and traders' relations with other fishery actors (Radjawali, 2012). The fishing practices fisher-trader relations enable cannot a priori be classified as sustainable or unsustainable. Fishing migrations can reduce pressure on locally overfished marine populations but also expand depletion of fisheries elsewhere (Berkes et al., 2006; Merino et al., 2011). To enable fishing migrations, the trader provides large credits to the fisher (Ferse et al., 2014; Navarrete Forero, 2015). During the migration fishers would sell fish at sea and return after several months to repay the credit to the trader. Traders need to trust the fishers whom they loan vast credits. Trust either derives from kin relations or a history of working successfully together (Acciaioli, 2000). In Spermonde, fisher-trader relations also enable destructive fishing (e.g., blast fishing, cyanide fishing) which negatively impacts marine populations and their reef habitats (Mous et al., 2000). To enable destructive fishing, traders maintain relations with high-level authorities to circumvent enforcement of fishing regulations that ban destructive fishing (Nurdin & Grydehøj, 2014). Through this relation, the trader can guarantee to protect the fisher from prosecution (Radjawali, 2010). In consequence, fishers who work for a trader with such connections could use destructive fishing without risk of punishment (Glaser et al., 2015).

A nascent literature has started drawing first links between global trade relations and sustainable use of wild species. This literature highlights that the structure and dynamics of trade relations and trade networks matter, that multiple trade relations allow to divert trade routes from source to destination (Stoll et al., 2018), and that links to global traders changes local trade relations (Wamukota et al., 2014). Along global value chains there are different compositions of trade relations, for instance, there might be few exporters interacting with many local middle(women) (Purcell et al., 2017; zu Ermgassen et al., 2020). The resulting global trade network structure and its dynamics can be shaped by the expansion of exploitation of a particular species (Anderson et al., 2011; Berkes et al., 2006; Eriksson et al., 2015). Expansion can help cater increasing demand but also mask declines of wild populations in one area (Crona et al., 2016). The emerging global network structure has consequences for future propagation. For instance, the presence of multiple trade relations enables diverting trade routes from source to destination to avoid trade barriers (Stoll et al., 2018). High connectivity in trade networks can allow supply shocks to propagate through redistribution of sourcing (Gephart et al., 2016;

Tu et al., 2019) and have been associated with unsustainable biomass levels of fish populations. Access to international market value chains can affect local trade relations. For example, they allow diversification of harvested species (Abbott et al., 2015), can increase income for harvesters (Elsler et al., 2019), and reduce incentives for collective action (Bennett & Basurto, 2018). This last point is particularly important because self-governing strategies may shift from collective towards more individual based harvest and selling (Bennett & Basurto, 2018; Frawley et al., 2019; Lindkvist et al., 2017).

- **Wild species trade**

Wild species trade is any commercial exchange (involving money or barter) by people of wild animals, fungi, and plant (including algae) resources, both at local levels and across legal jurisdictions and international borders. Wild species trade can be legal or illegal, formal or informal; domestic or international, and can result in a sustainable or unsustainable use of animal and plant species. Wild resources are traded in many forms to produce a wide variety of products such as homeware, healthcare (including traditional medicines), food, cosmetics, ornaments, furniture, pets, fiber, and building supplies (Lee et al., 2020; 't Sas-Rolfes et al., 2019). Several wild species are hunted around the world for their perceived potency of certain body parts in traditional and religious practices, as well as for trophy collections (Atuo & O'Connell Timothy, 2015; Sinovas et al., 2016). Use for those purposes occurs regardless of the rarity or conservation status of those species. If anything, the perceived value of a species often increases with rarity (though this may not be true for some species; Sumaila et al. 2019)), leading to even more aggressive harvesting (Atuo & O'Connell Timothy, 2015) which may result in commercial or local extinctions (Ulman et al., 2020). Globally, the predominant direction of the trade of products derived from wild species is South-to-North, mainly driven by consumer demand from affluent developed countries and their profitable fashion, medical, and food industries (Ripple, Abernethy, et al., 2016; Sand, 1997). The value of legal wildlife trade from 1997 to 2016 totaled between 2,9 and 4,4 trillion United States Dollars. The top commercial categories were seafood (82%), furniture (7%) and fashion (furs and hides) (6%) (Andersson et al., 2021).

According to the latest update of the International Union for Conservation of Nature Red List of Threatened Species (July, 2019), improperly managed national and international trade is driving the decline of species in the land, oceans and freshwater. Trade can affect sustainable use of wild species directly through harvests and indirectly, for example by shifting towards practices that affect wild species through use and transformation of habitat (e.g., unsustainable logging /land use change). Naturally, those effects will be very different for terrestrial than for marine species (Bulte & Barbier, 2005). 72% of the species listed as threatened or near-threatened, (6,241) are being overexploited for commerce, recreation or subsistence (Maxwell et al., 2016). The same study revealed that unsustainable harvesting is now the most prevalent threat affecting threatened marine species and is the second most pervasive (after agriculture/aquaculture) for terrestrial and freshwater species. Overfishing has pushed two families of rays to the brink of extinction. Bushmeat hunting for mostly food and medicinal products is driving a global crisis whereby 301 terrestrial mammal species are threatened with extinction in developing countries (Ripple, Abernethy, et al., 2016). A recent quantitative meta-analysis of wild species trade revealed that overall wild species trade caused

a 61.6% decline in species abundance (Morton et al., 2021). Extraction for bushmeat trade caused declines of 59.7% (excluding subsistence studies), while pet trade precipitated extreme decreases of 73.0% (Morton et al., 2021). National and international trade significantly reduced species abundance by 76.3% and 65.8%, respectively, whereas local trade had limited impacts. Though impacts of trade on wild species are widespread globally, one can identify certain hotspots of human impact (Allan et al., 2019). Di Minin et al. (2019) identified global centers for unsustainable commercial harvesting of species. 4.3% of the land and 6.1% of the seas contain 82% of all species threatened by unsustainable harvesting and more than 80% of critically endangered species. Those centers of unsustainable commodity are found globally but are especially concentrated in Asia and North and South America, in areas where harvesting intensity was the highest and governance and political stability the lowest. The regions with the most mammal species threatened by unsustainable levels of hunting and trade of bushmeat were found to be in Asia (especially South-East Asia) and Africa, whereas the countries with the most mammal endemic species threatened include Madagascar, Indonesia, Philippines, Brazil, Papua New Guinea, India and China (Hughes, 2017; Ripple et al., 2015; Ripple, Abernethy, et al., 2016; Ripple, Chapron, et al., 2016; Symes et al., 2018). Although overhunting of wild meat is primarily a problem in developing countries, wealthier nations can exacerbate or possibly even drive the problem by inflating demand and prices for meat, trophy, medicinal and ornamental product (Lee et al., 2020; Ripple, Abernethy, et al., 2016). However, whether or not this is the case depends on a number of other factors (e.g., see Figure 4.10).

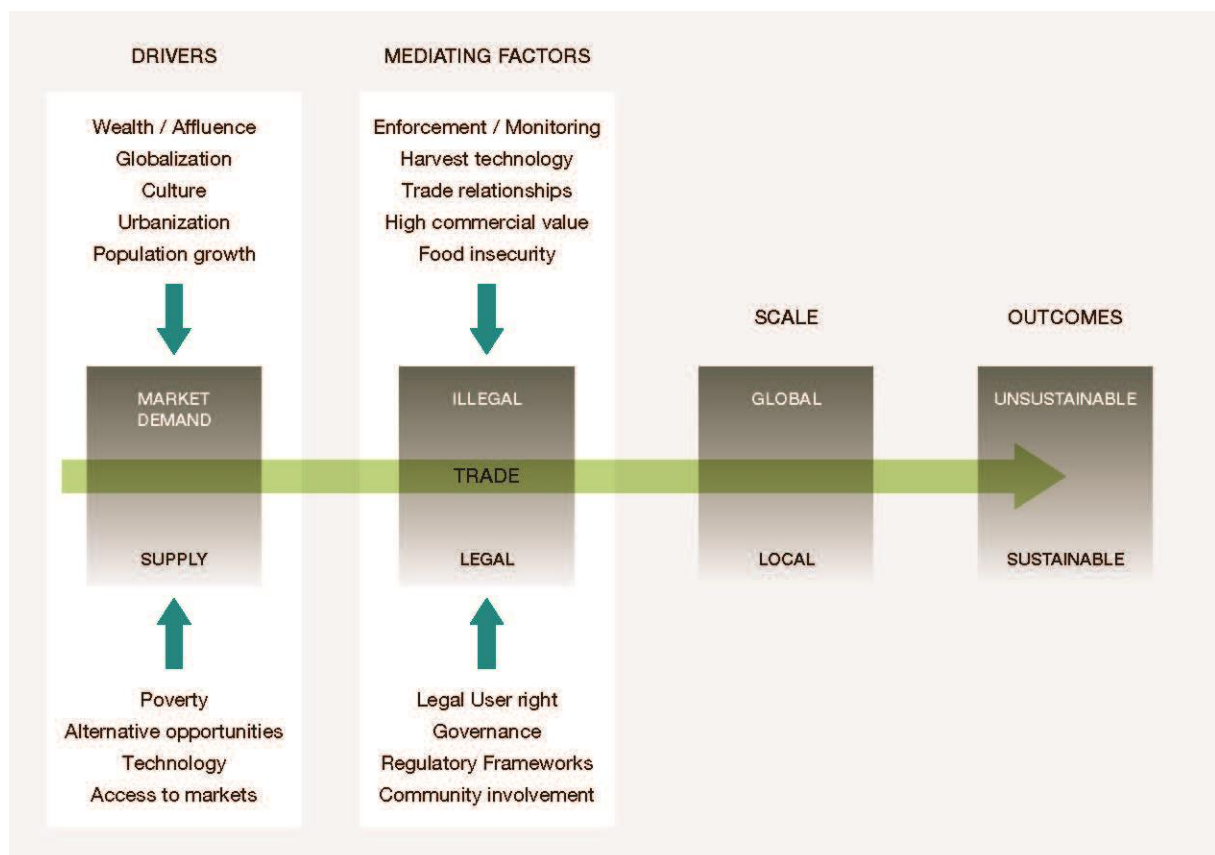


Figure 4.10. Wild species trade and sustainability of wild species. Several drivers can have an impact on wild species trade. The drivers are affected by mediating factors and result either

in legal or illegal trade. Unselective harvesting methods, incoherent regulatory frameworks, and lack of ability to recognize protected species imply that the line between legal and illegal trade is often fuzzy. Either legal or illegal trade can happen at local through global scale and be sustainable or unsustainable. For example, when there is market demand (a driver) for certain species as pets or for use in traditional medicine, poor enforcement (a mediating factor) may affect the sustainability outcome of such species that are traded legally and illegally in local and global context.

An analysis of CITES trade data from 1975 to 2014 revealed that on average over 100 million whole organism equivalents were reported in trade per year between 2005 and 2014 (Harfoot et al., 2018). In total, between 1975 and 2014, plant whole organism equivalents were traded at the highest volume (1.80 billion reported by exporters), followed by reptiles (152 million), invertebrates (79.8 million), birds (24.1 million), mammals (13 million), fish (12.8 million) and amphibians (1.07 million). There was a substantial shift from wild to captive sourced over time. Both the volume and value of international wild species trade are expanding (Roe, 2008). According to the IPBES global assessment (IPBES, 2019a), the international legal wild species trade has increased by 500% in value since 2005, and 2,000% since the 1980s, albeit a proportion of this increase may reflect enhanced captive breeding or ranching. TRAFFIC has estimated legal international trade, including timber and fisheries products, at 323 billion United States Dollars in 2009 (Cooney et al., 2015).

- **Wild species trade: Fishing**

Of all food items, fish and fish products are amongst those that are traded most widely in the world (Pavitt et al., 2021). Fisheries exports have been identified as a contributing factor to unsustainable exploitation, contributing to overfishing, and also fish stock collapses (Lenzen et al., 2012; Gars and Spiro, 2017; Crona et al., 2015). Using global export data from 1950-2006, Eisenbarth (2022) finds that exports have a significant effect on the probability of stock collapse. At the same time, the impacts from trade are primarily mediated by governance arrangements that organize access and regulation of fisheries (Erhardt 2018; Copeland and Taylor, 2009). This implies that trade will be a driver of unsustainable use in absence of functioning rules and regulations that safeguard sustainability.

Trade, and especially demand of fast-growing Asian economies is the most important driver of the depletion of shark stocks on a global scale (Erhardt & Weder, 2020). The diversity of traded shark species makes it more difficult to ban and discourage unsustainable practices, as species substitution could mask depletion of vulnerable species (Fields et al., 2018). Basking shark *Cetorhinus maximus*, is especially sensitive to exploitation and is listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Magnussen et al., 2007). Yet, tracking trade in basking shark products is difficult as shark products are often visually indistinguishable and therefore one cannot easily identify single species and origin (Cardeñosa et al., 2018; Magnussen et al., 2007). Full traceability, and strict control and enforcement of fishing regulations would contribute towards sustainable fishing (Bailey et al., 2016). In Tanjung Luar in East Lombok (Indonesia), almost half of the shark catch comprises CITES -listed species, and insufficient management regulations are in place to incentivize or enforce avoidance of threatened stocks (Yulianto et al., 2018). The

Arabian Seas Region plays an important role in the global trade of sharks and rays, where the United Arab Emirates and Yemen can be characterized as major regional trade hubs (Jabado & Spaet, 2017). Reported shark and ray landings represent 28% of the regional total fish catches, amounting to 56,074 tons in 2012, with most catches taking place in Iran, Oman, Pakistan and Yemen (Jabado & Spaet, 2017). While the fishery is mostly artisanal, some gear types (e.g., dynamite fishing) and exploitation levels have potentially unsustainable impacts (Jabado & Spaet, 2017). The large geographic area, complicate trade dynamics, and ongoing political instability and convoluted governance and administrative make a centralized control approach inherently difficult (Jabado & Spaet, 2017). The whole genus of seahorses was listed in CITES Appendix II in 2002 because of the adverse effects of harvests and trade on sustainability of wild populations. Evidence from Thailand suggested that seahorses were often caught as bycatch in trawl fisheries, allowing fishers to continue fishing if harvesting the target species was not so profitable, for example due to overexploitation (Kuo et al., 2018). Declining abundances, as reported in Malaysia and Thailand suggests that current harvest rates are unsustainable (Kuo et al., 2018; Perry et al., 2010).

- **Wild species trade: non-lethal fishing**

From 1990 to 2016, the number of direct export transactions of Appendix II Convention on International Trade in Endangered Species of Wild Fauna and Flora -listed marine species increased sevenfold (from around 14 000 in 1990 to about 98 000 in 2016) (Pavitt et al., 2021). Approximately 97% of those exports fall into the group of corals (Pavitt et al., 2021). This is only a small fraction of the total trade, as many fish species can be can be traded with few regulatory and monitoring systems in place (Biondo & Burki, 2020). For example, it has been estimated that trade in coral reef fishes alone range from 13 to 35 million fishes being traded annually (Biondo & Burki, 2020). More generally, pet trade can be an important driver of biodiversity loss and overharvesting of wild species (Baker et al., 2013; Bush et al., 2014; Ng et al., 2016). It can also be an indirect driver such as a vector for invasive species (Fitzpatrick et al., 2018; Lötters et al., 2018; Martel et al., 2014; Travis et al., 2011; Woeltjes et al., 2011; Yuan et al., 2018). The trade of living marine species for aquaria has become a major business (Rhyne et al., 2017). 20% of recent wild species trade reports are due to demand for pets or animals for use in entertainment (Baker et al., 2013; Bush et al., 2014).

In 2011, 6.9 million individual fish and 3.6 million individual invertebrates have been imported into the United States of America (Rhyne et al., 2017). Singapore is an important global hub of the ornamental aquarium trade in general, and freshwater mollusks in particular (Ng et al., 2016). A quarter of the sampled traded species have a history of introduction, which includes 19% that are either certainly or potentially causing negative impacts in their invaded habitats (Ng et al., 2016).

The endangered redline torpedo barb (*Sahyadria denisonii*) from the Western Ghats region (Sri Lanka) are caught for the aquarium trade. While this activity provides income to the local communities, the unmanaged fishery has led to unsustainable levels of exploitation, and some populations of torpedo barb have declined sharply, making the danger of a collapse immanent (Raghavan et al., 2018). International trade also threatens the sustainability of the Banggai cardinalfish (*Pterapogon kauderni*) that is a popular aquarium fish (Vagelli, 2008).

Overall, critical knowledge gaps pertain to the scale and scope of trade of ornamental fish and corresponding sustainability outcomes (Biondo & Burki, 2020).

- **Wild species trade: Gathering**

While roughly a third of all terrestrial plant species are at risk of extinction, the scale of exploitation is often inconclusive (Corlett, 2016). Also, the contributing role of trade in enabling unsustainable practices in absence of well-functioning regulations is established, but the exact scale of trade, as well as the sustainability impacts are often incomplete. Especially Southeast-Asia is a region where a massive commercial and often illegal trade of wild collected ornamental plants occur (Hughes, 2017; Phelps & Webb, 2015). Observed cross-border trade tends to be orders of magnitude larger than government-reported and the Convention on International Trade in Endangered Species of Wild Fauna and Flora statistics (Phelps and Webb 2015). Plant populations are declining across South-East Asia because of overharvesting to meet high demand from Chinese traditional medicine and herbal products industry. There are also many documented cases of trade in plants, algae and fungi leading to resource depletion (e.g., Belcher et al. 2005; Neumann and Hirsch 2000). In a comparative study on plants, algae, and fungi trade in Asia, Africa and Latin America, Kusters et al. (2006) conclude that trade of plants, algae, and fungi products tends to lead to positive livelihood outcomes, though perhaps also higher inequality between households. At the same time trade leads to resource depletion if left unmanaged.

Trade is an important driver that threatens orchids globally. All 29,000 orchid species are listed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora, which comprise 70% of all species listed (Gale et al., 2019; Hinsley et al., 2018). In spite of being officially protected, many orchid species around the world are under threat from illegal and unsustainable trade for horticulture, food and medicine (Hinsley et al., 2018). While orchid trade is concentrated in Asian countries, such as China and Nepal (Hinsley et al., 2018; Subedi et al., 2013), it takes place at a global scale. In Mexico, wild orchids are frequently traded on local markets (Cruz-Garcia et al., 2015). The harvesters and sellers are mostly women, with little or no formal schooling and come from indigenous communities. Often, the orchid trade is not the sellers' only economic activity, but an important part of a poverty alleviating strategy (Cruz-Garcia et al., 2015). Different harvesting practices persist, in particular in situ techniques (removing flowers and leaving roots and renewal buds) and ex situ techniques (extracting entire wild plants), where the latter is thought to be less sustainable. Though trading of wild species is regulated by Mexican law, these laws are often not known to harvesters, and also not applicable as trade of wild orchids is considered a traditional practice and therefore locally allowed (Cruz-Garcia et al., 2015).

Cacti are among the most threatened taxonomic groups assessed to date under the International Union for Conservation of Nature Red List Categories and Criteria, with 31% of the 1,478 evaluated species threatened, demonstrating the high anthropogenic pressures on biodiversity in arid lands. The dominant drivers of extinction risk are the unscrupulous collection of live plants and seeds for horticultural trade and private ornamental collections, smallholder livestock ranching and smallholder annual agriculture (Goettsch et al., 2015).

Across the literature, there was inconclusive evidence regarding whether trade could be contributing towards incentivizing sustainable use via higher prices and stability of income

provided to livelihoods. Also, the social and economic impacts were often inconclusive. Gathering is a practice often conducted by women of all ages with little or no formal education, who do often not have access to alternative economic activities. In Sierra Leone, more than 30 plant species are traded for medicinal purposes, three of which are considered vulnerable under the International Union for Conservation of Nature Red list: *Garcinia kola*, *Fleroya stipulosa*, and *Nauclea diderrichii* (Jusu & Sanchez, 2014). Whether or not harvesting practices are mainly sustainable depends on the actions of the collector. However, in a few cases (e.g., *P. guineense*) the species are never sustainably harvested (Jusu & Sanchez, 2014). Medicinal species that are traded in the largest volumes, sell at the highest prices, and travel the greatest distances, are most likely to be unsustainably harvested. A key issue in unsustainable use is the harvesting technique, as a number of species are harvested unsustainably (e.g., removing whole plants; ring debarking) (Jusu & Sanchez, 2014). Caterpillar mushroom (*Ophiocordyceps sinensis*) is a medicinal fungus found in alpine grasslands in the Himalayan mountain regions and the Tibetan Plateau (He, 2018). The harvest practices of communities involved in a co-management scheme of the nature reserve were more sustainable than those communities not engaged in such a scheme. This difference was mainly due to clarity and security of tenure and resource access, and also because of external support and training in sustainable practices (He, 2018). An obstacle towards ecological and economic sustainability is the difficulty to generate more excellent local benefits along the value chain, also when it comes to product grading which could incentivize more sustainable practices (e.g., not harvesting pre-mature mushrooms) (He, 2018). In the Palas valley (Pakistan), several species of morels (*Morchella* spp.) are collected by local families and traded all over Pakistan. A continuous decline in supply was observed, potentially indicating unsustainable use in the past (Sher et al., 2015). Though morels could play a role in supporting livelihoods, unsustainable collection techniques, unfavorable trade practices and limited income generation along the value chains pose obstacles (Sher et al., 2015). Stimulating and incentivizing the use of best practices of sustainable harvesting and collection methods can be an important step towards sustainable use (Becerra, 2009).

In central Australian rangelands, several native plant products (including *Solanum centrale* J.M. Black, *Acacia* Mill. spp.) are commercially harvested and traded in a small scale (Walsh & Douglas, 2011). While there is no evidence of overharvesting yet, narrow economic margins may increase future pressure on the resource. Also, sustainable practices rely heavily on future generations having necessary knowledge and skills (Walsh & Douglas, 2011). In Transkei, located in the Eastern Cape province of South Africa, hand brushes made from fronds of the wild date palm (*Phoenix reclinata*) are locally made and traded to nearby urban areas (Mjoli & Shackleton, 2015). The key actors involved in harvesting and trading are middle-aged to elderly women with little formal education and opportunities to earn cash income elsewhere. The trade of palm brushed played a significant role in supporting livelihoods of local traders. Demand is stable, if not increasing, in spite of increasing availability of synthetic substitutes because of cultural and practical value attached to palm brushes. As of now, there is no evidence that current practice is unsustainable (Mjoli & Shackleton, 2015). In the Congo Basin, bush mango (*Irvingia* spp.) nuts are harvested from forest landscapes for own consumption and trade, contributing on average to 31% of harvester's annual incomes (Ingram et al., 2017). Evidence regarding sustainability of harvesting is mixed. On the one hand, harvesters tend to gather fallen fruits, and trees are left or actively managed on farmland, suggesting sustainable use. On the

other hand, reports of declining wild resources, the need for harvesters to travel longer distances, together with clearance of the species' natural habitat, low levels of cultivation, continuing high demand, and a lack of consistent regulation and enforcement may threaten sustainability (Ingram et al., 2017). Across the Congo basin, the leaves of the *Gnetum* spp. forest lianas have long been harvested from humid forests for consumption and traded as a popular vegetable (Ingram et al., 2012). At least 2,550 people work across the value chain, *Gnetum* contributing on average to 62% of a harvester's annual income. Over 50% is unsustainably collected from the forest and rising demand, increasing prices and low levels of cultivation put further pressure on the resource (Ingram et al., 2012). Trade is mostly illegal, and sporadic customary governance and enforcement, and an rudimentary framework cannot ensure trade to be sustainable (Ingram et al., 2012). Gaharu (agarwood) is a highly valuable fragrant derived from *Aquilaria* spp. (Thymelaeaceae) that is traded internationally. In Indonesia, traditional harvesting practices are declining as more nonlocal collectors become involved, leading to more intensive harvesting practices. More intensified and less careful collection suggest that the current Indonesian trade in gaharu is not sustainable (Soehartono & Newton, 2002). In the case of argan oil, the boom has enabled some rural households in Morocco to send their girls to secondary school, increase consumption, but also increase their goat herds which impact negatively on the argan forest as well as privatization pressures (Lybbert et al., 2011). To use wild medicinal plant resources sustainably, both conservation strategies (e.g., *in situ* and *ex situ* conservation) and resource management (e.g., good agricultural practices) should be considered (Chen et al., 2016; Lichtenstein, 2010).

- **Wild species trade: Terrestrial animal harvesting**

Excessive hunting pressure, due in large part to commercialization and trade, is unsustainable and has reduced the populations of many tropical large mammal species (Benítez-López et al., 2017; Brashares & Gaynor, 2017; Lee et al., 2005; Milner-Gulland & Bennett, 2003). Regarding socio-economic impacts, hunting provides income and protein to local hunters, but if it does not go hand in hand with ecological sustainability, it will also negatively affect livelihoods in the long run (Bowen-Jones & Pendry, 1999; Cowlshaw et al., 2005; Taylor et al., 2015). Trade mediates demand from one region to another, potentially giving incentives to hunt in large scales, which together with uncontrolled access and poorly enforced regulation negatively affects the sustainability of protected and unprotected species (Bowen-Jones & Pendry, 1999). Wild meat (also known as bushmeat) hunting is usually not only practiced for subsistence, but is generally traded and serves local markets, as well as urban or even international markets (Bowen-Jones & Pendry, 1999; Brashares et al., 2011; Lindsey et al., 2013; Nielsen & Meilby, 2015). Typically, domestic trade is substantially larger than international trade (Brashares et al., 2011). There is established evidence that trade in wild animals for meat is one of the most critical threats to wild species in Central and West Africa (Bowen-Jones & Pendry, 1999; Cowlshaw et al., 2005; Lindsey et al., 2013; Thibault & Blaney, 2003). At the same time, there is incomplete information about the scale of wild species trade and also how this maps to sustainability outcomes. Evidence is mainly anecdotal, for example it has been documented that around five tons of wild meat is smuggled in personal baggage through Paris Roissy-Charles de Gaulle airport per week (Chaber et al., 2010).

Taylor et al. (2015) document evidence on the impacts of wild species hunting with data on 177 species from 275 sites across 11 African countries collected over 30 years. They find that research efforts and available information are not evenly distributed. There is less evidence from West Africa compared to Central Africa, and also less information about impacts on birds (Taylor et al., 2015). The International Council for the Exploration of the Sea data reveals that about 18 000 individuals of wild species mostly traded as hunting trophies were exported annually from South Africa between 2005 and 2014 (Sinovas et al., 2016).

Wild meat trade is as a severe problem in forest biomes and savannas, though it is extremely difficult to accurately quantify the number of wild species hunted or quantity of wild meat traded (Lindsey et al., 2013). However, case studies from 15 African countries suggest that given the scale and ubiquity of wild meat hunting, current uses are ecologically unsustainable, at least without immediate interventions (Lindsey et al., 2013). Ultimately, the expected loss of wild species will lead to severe economic and social impacts (Lindsey et al., 2013). In many cases, wild meat hunters are male, poor, without formal employment, and with little education and few livestock, though wild meat hunting can be quite lucrative (Lindsey et al., 2013). Social impacts of illegal wild meat trade include negative effects on food security in the long term through unsustainable harvesting, loss of potential tourism-based revenues and employment, and also loss of wild species heritage (Lindsey et al., 2013). A key element of unsustainable use tends to be high demand, much more than technology, in combination with absence of effective regulation (Bowen-Jones & Pendry, 1999). Increased urbanization and access to formerly remote areas are mediating factors that increase hunting pressure (Allebone-Webb et al., 2011; Bowen-Jones & Pendry, 1999; Brugiére & Magassouba, 2009; Lindsey et al., 2013). Economic activities that rely on a large number of personnel, such as the oil industry may drive up demand, increasing incentives to hunt, which can put additional pressure on wild species (Thibault & Blaney, 2003).

According to data using the standard classification schemes for utilization and threat types for the International Union for Conservation of Nature Red List, at least 45.7% of extant bird species (4,561 species) are used by humans, principally for pets (37.0%) and for hunting for food (14.2%), but other uses include sport hunting, ornamentation and traditional medicine (Butchart, 2008). International trade is a key driver, involving at least 3,337 species (33.9%, substantially higher than previous estimates), mostly for pet trade (Butchart, 2008). Trade generally correlates with declining abundances, and also increased risk of extinction, though other drivers are even more important (Butchart, 2008). Marsh et al. (2020) expand those results, also using International Union for Conservation of Nature data show that across the 25,009 species in 10 taxonomic groups, 10,098 (40%) had some purpose of use documented. The proportion of species documented as having at least one purpose of use coded ranged from 15% (crustaceans) to nearly 100% of cone snails (544 of 545 species) among aquatic groups, and 11% (amphibians) to 76% (conifers) among terrestrial groups (Marsh et al., 2021). In Africa, more than 354 bird species are hunted for that purpose in 25 countries (Williams et al., 2014). Atuo et al. (2015) analyze the trade in avian body parts around major protected areas in the Cross River region of south-eastern Nigeria, which is an economic activity pursued primarily by younger people and villagers with low monthly income. In spite of three of the top 5 most reported species being globally threatened, knowledge of the threat status of species was not common among hunters and traders (Atuo & O'Connell Timothy, 2015). Twelve (42%)

species were known to be declining and 5 (18%) are already listed as globally threatened under the International Union for Conservation of Nature /BirdLife threat criteria (Atuo & O'Connell Timothy, 2015).

A case study from the Hkakaborazi National Park reports that commercially valuable species that had been previously targeted by hunters (tiger, otter, pangolin) appear to be completely absent from current harvest records, which may suggest population decline and very low abundances (Rao et al., 2010). Though farming is the predominant occupation (70% of surveyed population) hunting was conducted by a quarter of the surveyed people, and hunting was reported to be a significantly higher source of income than any other livelihood activities (Rao et al., 2010). In Myanmar, a critical mediating factor that facilitates the ongoing illegal hunting and trade is weak enforcement of laws and regulations (Rao et al., 2010; Shepherd & Nijman, 2008).

In Japan two species of bears (*Ursus thibetanus* and *U. arctos*) are traded for their gallbladder and meat. Yet, information about the scale of trade is poorly documented and also obscured by the fact that hunting bears is allowed in Japan, as long as it meant to control nuisance caused by bears (Mano & Ishii, 2008). Though most Japanese bear populations are considered to be at a sufficient level to sustain hunting if well-managed, reconciling (perceived) threats of bears to the public and sustainability goals poses challenges to the bear nuisance management system (Mano & Ishii, 2008; Sakurai et al., 2013).

In North Sumatra, hunting and trade of blood pythons (*Python brongersmai*) is an important activity, with around 50,000 individual snakes hunted each year since 1997 (Natusch et al., 2020). Comparing changes in numbers, demography (e.g., sex ratio, proportion of adults vs. juveniles), and life-history traits (e.g., body size at maturation) of snakes brought to processing facilities in 1997 versus 2015 suggest that harvesting rates are unsustainable. (Natusch et al., 2020). Wild species breeding farms can help to enable sustainable use, though there is a danger that illegally caught wild animals are 'laundered' and traded through the legal channel (Lyons & Natusch, 2011). Hunting of Scorpion Mud Turtle (*K. scorpioides*) is an activity practiced by artisanal fishermen (only men) on Marajó Island, Brazil (de Cristo et al., 2017). While the scorpions are hunted for own consumption, a sizable number is traded and sold at urban centers. Current uses are often unsustainable, for example by setting fires in the grasslands, which causes scorpions to move into open areas where large quantities can be caught regardless of sex and size (de Cristo et al., 2017).

In Cambodia, an estimated 6.9 million snakes of seven species are estimated to be harvested from Tonle Sap Lake annually (Brooks et al., 2007, 2010). The most significant driver of snake exploitation is the domestic trade in snakes as crocodile food, and to a smaller extent demand from international markets for exotic leather, luxury food and traditional medicine (Brooks et al., 2010). The key driver, demand for snakes as crocodile food is strongly influenced by the price of alternatives, such as fish (Brooks et al., 2010).

- **Non-lethal terrestrial animal harvesting**

Pet trade can be an essential driver of biodiversity loss and harvesting of wild species (Baker et al., 2013; Bush et al., 2014; Ng et al., 2016). It can also be an indirect driver as a vector for zoonotic diseases and invasive species more generally (Borsky et al., 2020; Fitzpatrick et al., 2018; JNCC, 2021; Lötters et al., 2018; Martel et al., 2014; Travis et al., 2011; Woeltjes et al.,

2011; Yuan et al., 2018). Another indirect effect of pet trade is the habitat destruction caused by non-lethal harvesting, for example the collection of reptiles (Auliya, Altherr, et al., 2016; Goode et al., 2004, 2005).

Twenty percent of recent wild species trade reports are related to pets or animals for use in entertainment (Baker et al., 2013; Bush et al., 2014). At least 45.7% of extant bird species (4,561 species) are used by humans, from which 37% as pets (Butchart, 2008). In a systematic literature review, birds were the most species-rich class reported (585 species) in trade, followed by reptiles (485 species) and mammals (113 species) (Bush et al., 2014). The most common avian orders in reported trade were parrots (Psittaciformes), song birds (Passeriformes), and falcons (Falconiformes) (Bush et al., 2014). The capture of wild birds is a major source of population decline and wider environmental problems in Brazil, with about 23% of all bird species, (i.e., 295 out of 400) being hunted for pet trade (Alves et al., 2013; Fernandes-Ferreira et al., 2012). Trade as pets also threatens sustainability of parrots in Africa and Madagascar (Martin et al., 2014). Repeated bird surveys in Sumatra (Indonesia) have documented that trapping for pet trade depleted bird populations in the wild (Harris et al., 2017).

Pet trade is also an important driver for the decline of many reptile species globally, and particularly in Southeast Asia (Auliya, Altherr, et al., 2016; Böhm et al., 2013; Natusch & Lyons, 2012; Nijman, 2009; Nijman, Shepherd, et al., 2012; Nijman, Todd, et al., 2012; Shaney et al., 2017; Wakao et al., 2018). 35% of all reptiles are traded online, which is very hard to regulate (Marshall et al., 2020). This includes many endangered or endemic species with over 90% species and half of traded individuals taken from the wild. Especially the European Union plays a major role in reptile trade, having imported officially more than 20 million live reptiles between 2004 and 2014 (Auliya, Altherr, et al., 2016). Reptile trade threatens wild populations and effective control is hampered by ineffective regulation and monitoring (Auliya, Altherr, et al., 2016; Auliya, García-Moreno, et al., 2016). A survey in the Indonesian provinces of Maluku, West Papua and Papua, documented that at least 44% of amphibians and reptiles were traded illegally (Natusch & Lyons, 2012). Inability to identify species correctly, weak governance and harvesters being economically vulnerable (receiving little income compared to middlemen and exporters) are key obstacles towards sustainable use (Natusch & Lyons, 2012). Pet trade has, next to habitat destruction, been a major driver threatening the turquoise dwarf gecko (*Lygodactylus williamsi*) that is endemic to two small forests in eastern Tanzania (Flecks et al., 2012). Also, many turtles are traded as pets, potentially causing population declines in their natural habitat (Bush et al., 2014; Ceballos & Fitzgerald, 2004; Lyons et al., 2013; Nijman & Shepherd, 2015). In particular, Asian turtles are also being kept as pets, in addition to being collected or farmed for food and traditional Chinese medicine and hence have been reported to be heavily exploited and threatened (Cheung & Dudgeon, 2006; Nijman & Shepherd, 2015).

Primate species have also been threatened by the pet trade around the world (Ni et al., 2018; Norconk et al., 2020). Over two thousand individuals from seventeen Indonesian primate species continued to be sold in numerous open wild species markets as recorded intermittently from 1990 through 2014 (Nijman et al., 2017). In the early 2000s while orangutans, gibbons, langurs, macaques and slow lorises were all commonly traded, only the latter two groups made up the bulk of the trade in the last decade.

Except pet trade, fibre trade is an important driver of sustainable use of wild species. Vicuñas (*Vicugna vicugna*) produce one of the finest natural fibres in the world. Due to its

fineness, vicuña occupies a position in the luxury fashion market. It is used to produce garments, shawls and stoles for retail mainly in high end shops in Italy, Japan and Dubai. Before 1980, vicuñas were almost extinct due to overhunting. By 1960, it was estimated that the vicuña population had dropped from its pre-colonial population of 2 million to an estimated 10,000 individuals (Figure 4.11). International, regional and national conservation efforts were successful in halting further population decline. Strict conservation regulation, through the Vicuña Convention, and the entry into force of the Convention on International Trade in Endangered Species of Wild Fauna and Flora in 1975, helped to rebuild populations (Lichtenstein, 2010). After a successful first stage of absolute protection, a second stage started with the involvement of local communities in the national programs for conservation and management of the species. In 1979 the Convention for the Conservation and Management of Vicuña, was signed, which promoted the economic exploitation of the species “for the benefit of the Andean people” (Article 1, Convention for the Conservation and Management of the Vicuña, 1979). The involvement of local Andean communities in vicuña management, and fibre trade was key to the recovery of the species (Lichtenstein, 2010). On top of the historical strong cultural link between Vicuñas and Andean communities (Vilá et al., 2020) (see chapter 1), vicuña have become an economic asset to communities, reducing poaching and motivating communities to carry out anti-poaching and protection. From the community perspective, vicuña management also fulfills non-economic objectives. In the cases of Bolivia and Peru, these entail enhancing community identity, social cohesion, revitalizing communal work, reaffirming community boundaries and a means to solidify land claims (Lichtenstein & Ros, 2021). Participating in vicuña use probably also helps remote (and usually neglected) communities to become visible to local and central governments and be in a better position to ask for credit, schools, health service, better roads, infrastructure and support for economic activities (Lichtenstein, 2010). At present vicuñas are categorized as Least Concern (International Union for Conservation of Nature SSC Red List), and the current population trend is increasing (Acebes, 2019). Sustainable use through legal trade was key to success (Cooney, 2019). Without trade in vicuña fibre it is likely that communities will lose motivation and capacity to conserve vicuña and this could spark poaching and conflicts with domestic livestock (Vilá et al., 2020). Overall exports of vicuña fibre from range countries were approximately 60,000 kg of fibre over the period 2007-2016. Peru is the main exporter of vicuña fibre, accounting for 80% of exports (Kasterine & Lichtenstein, 2018). Peru produced 58,8 tons of fibre from 2012 to 2018 as a result of shearing 34200 vicuñas (Ministerio de Agricultura y Riego 2019).

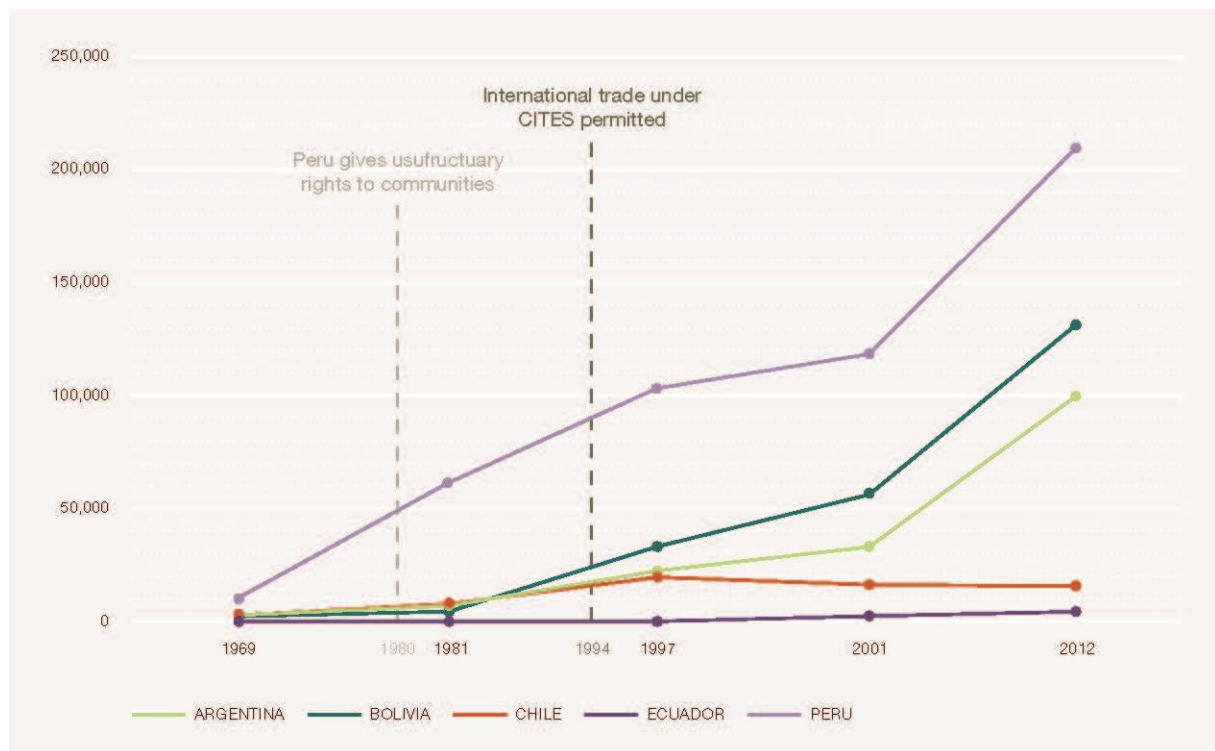


Figure 4.11 Change in vicuña numbers in the Andean countries 1969-2012. Source: Katerina and Lichtenstein (2018). © International Trade Centre (ITC). License CC-BY.

- **Wild species trade: Logging**

There is established evidence that trade is an important driver affecting sustainable use of forests. However, there is incomplete information regarding under which conditions trade alleviates and when it aggravates pressures. Chaudhary et al. (2017) use a model to project species extinctions of four vertebrate taxa (mammals, birds, amphibians and reptiles) due to wood extraction in 174 countries. Globally, 485 species are projected to go extinct due to current forest land use, where 32% of this projected loss can be attributed to exports. At the same time, trade reduces pressure on forests in importing countries. If the same consumption level would have to be met by only domestic sources, an additional 334 species are projected to go extinct (Chaudhary et al., 2017). Hence, trade may encourage sustainable ways of use in some areas, and lead to unsustainable uses in others.

There may also be important socio-economic dynamics as wild species are exploited over time (Marchak, 1995). In some cases, when commercially valuable tree species are gone, highly capitalized loggers may be replaced by lower budget loggers. Also, logging and land conversion for agricultural purposes often goes hand in hand. In some cases, landholders may convert the stocking forests even without using one single log because agriculture is so much more attractive, yet in other may even use the cash generated from timber to convert forests to plantations. Some smallholders making a living in forest landscapes supplement their incomes from logging (Angelsen et al., 2014) but as far as the rapidly depleting forests still allows it. Another important group depend on chainsaw milling with intensities that vary, leading to incremental forest degradation (Eba'a Atyi et al., 2016). Only limited number of communities have proven successful to sustain their commercial timber operations over time and remain competitive in timber market (Bray, 2020; Medina & Pokorny, 2011; Pokorny, 2013; Stoian et

al., 2018) yet that results from a combination of different factors, mainly long-term external support, willingness to maintain relatively lower extraction rates, access to high value timber species, and strong market engagement (Pacheco, 2012).

In tropical countries, trade liberalization has contributed considerably to deforestation in the past (Abman & Lundberg, 2019; Kaimowitz & Angelsen, 1998; Marchak, 1995; D. Pearce et al., 2003). In the period from 2001 to 2012, enacting regional trade agreements has led to significant increases in deforestation, with cumulative effects of 19%–26% above the annual average three years after removing the trade barriers (Abman & Lundberg, 2019). Often, deforestation is mediated by unclear property rights, corruption and overall insufficient incentives to conserve tropical forests (Bulte & Barbier, 2005; Ross, 2001). Though logging contributes to deforestation, conversion towards agricultural land is an important mechanism explaining deforestation as well (Abman & Lundberg, 2019; Faria & Almeida, 2016).

Big-leaf mahogany *Swietenia macrophylla* King (Meliaceae) is an important timber species in Latin America that is globally in high demand. Over the past decades, lacking enforcement and unsustainable harvest have depleted local stocks (Blundell, 2004; Kometter et al., 2004). As a result, it has been the first commercial timber species that has been listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, which implies that trade is restricted and controlled (Blundell, 2004). As a result, mahogany harvests have slowed down considerably in most regions (Grogan et al., 2010). For example, in Peru export volumes reached 52,138 m³ in 2002, while they gradually reduced to 3,071 m³ in 2007 (Grogan et al., 2010). At the same time, transforming an unsustainable timber sector towards sustainability, bears the risk that illegal extracted timber enters the legal channel. In the Peruvian Amazon, efforts are made to promote sustainable logging in the tropics. Peru introduced a legal concession timber harvesting system in 2000, which was later also part of the United States–Peru Trade Promotion Agreement, to curb illegal and unsustainable practices (Finer et al., 2014). Yet, there is evidence that legal concessions are used to also harvest trees in unauthorized areas, thus undermining conservation efforts (Finer et al., 2014). Illegal extraction is hard to detect if illegal harvests outside the concession are declared as authorized timber harvesting. Unless someone inspects the exact location where the logging should have taken place (and notices that the tree is still there or was never there in the first place) the violation will not be detected further down the value chain (Finer et al., 2014). Since most controls take place outside the forests, violations will not be detected easily.

Rosewood, mostly originating from Africa, is a highly priced commodity and tropical forests are threatened by increasing global demand since the early 2000s (Waeber et al., 2019). In 1992, Brazilian rosewood (*Dalbergia nigra*) was placed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora Appendix I in 1992. In 2013, Siamese rosewood (*Dalbergia cochinchinensis*) and all Malagasy species of *Dalbergia* and *Diospyros* (ebony) were added to Appendix II (Waeber et al., 2019). Yet, lack of clarity about which rosewood species are exploited and how to identify those makes it notoriously difficult to separate legal harvests from illegal ones. Rosewood comprised 35% of the value of all global wild species and forest product-related seizures from 2005 to 2014 (Waeber et al., 2019). A key challenge remains that the Convention on International Trade in Endangered Species of Wild Fauna and Flora regulations are based on individual species, while even experts are often unable to identify and distinguish different species. Also, harvesters do

not consider individual species (or genera), but rather consider the quality of the wood (Waeber et al., 2019). As a result, harvesters often end up in illegal practices, intentionally or unintentionally. If taxonomic confusion and weak governance render sustainable use impossible, uplifting to Convention on International Trade in Endangered Species of Wild Fauna and Flora Appendix I may be the only way to prevent overexploitation, as has been suggested for Malagasy rosewood (Waeber et al., 2019). While the Convention on International Trade in Endangered Species of Wild Fauna and Flora regulations are often very specific, information further down the value chain is much more crude, which makes enforcement and detection very difficult. For example, United Nations Comtrade Harmonized System (HS) Codes are often fairly general with broad descriptions, opening a channel for illegal harvests (e.g., 26% of seafood trade is declared as “Fish” and 22% of furniture trade is declared as “Tropical wood” (Andersson et al., 2021).

- **Mediating factors of trade**

Formal international wild species trade can link the high market with local indigenous/rural communities (e.g., python breeding (Lyons & Natusch, 2011); vicuña fibre trade (Lichtenstein, 2010)). Where local stakeholders benefit directly from a resource (with cash and also non cash benefits), they may have an incentive to protect it (Salafsky & Wollenberg, 2000). This is of course only possible if the different practices and wild species trade can be regulated, monitored, controlled, and enforced. In practice, enforcing regulation turns often to be unfeasible and difficult (Nielsen & Meilby, 2015). In such case, trade bans can play an important role in halting unsustainable use of threatened species. One example here is the International Whaling Commission that have contributed to the recovery of many whale species (Hurd, 2012; Roman et al., 2015). Also, trade relations are salient for sustainability outcomes. If most of the revenues from trade go to outsiders (e.g., middlemen), there may be little incentive to conserve for local communities (Elsler, 2020; Natusch & Lyons, 2012). Appropriately governed, trade may provide incentives to relevant local stakeholders to conserve and generate economic support to area-based conservation initiatives (‘t Sas-Rolfes et al. 2019). However, the mere fact that conservation would be beneficial to local communities, does not imply that strong incentives to conserve exist and conservation materializes. A study on the wildlife trade in Madagascar revealed that the households who are most dependent on the resource (and were expected to have the strongest interest to conserve) did not have different perception on conservation or were more inclined to take conservation efforts (Robinson et al. 2018). In the Columbian Amazon, most hunters now primarily hunt for subsistence, with only little pressure on wild species, but also little incentives to conserve (Ponta et al., 2019). While trade could be part of a strategy to incentivize conservation and also sustainable harvesting, there is also the risk that hunting rates outpace any efforts to implement conservation programs and rules regulating access and sharing of benefits. Hence, to ensure ecological and economic sustainability trade should go hand in hand with clear rules and regulations, ideally co-designed and co-enforced by local communities (Ponta et al., 2019).

If – and only if – trade generates benefits to local communities, it may promote rural development, contribute to avoid rural migration, return equitable profits from nature conservation to local communities, catalyze community investments in nature conservation, law enforcement and stewardship of wild species (Cooney et al., 2015; Jaramillo Castro,

Lorena, 2012; Roe, 2009); but see Dzvimbo et al. (2018). Therefore, wild species trade can give incentives to conserve habitat and species, potentially leading to species recovery (e.g., crocodiles in Australia (Fukuda et al., 2011), the Amazonian pirarucu (Campos-Silva & Peres, 2016)). Empowering local people to capture legal benefits from wild species trade can be an important step in reducing excessive illegal harvests, when efforts to provide alternative livelihoods are unsuccessful (Ripple, Abernethy, et al., 2016).

Local livelihood outcomes of wild species trade may provide incentives for conservation but also for overexploitation and extirpation (e.g., endangered frog *M. cowani* in Madagascar (Andreone et al., 2006), parrot harvest (*Ara ararauna*, *Ara macao* and *Amazona amazonica*) in Peru (González, 2003), plants, algae and fungi gathering (Kusters et al., 2006; Lybbert et al., 2011)). Balancing livelihood outcomes and conservation goals results in trade-offs, and sometimes it is challenging to reconcile both objectives (Robinson et al. 2018).

International demands, and high market value of traded species may encourage intensified exploitation, intensification or captive breeding, causing in some situations resource stocks to decline (Fischer, 2010). Moving from wild harvest to intensive management systems, including captive breeding for animals and cultivation, plantations and/or artificial propagation for plants, fungi and algae, can create benefits for or risks to conservation and livelihoods (Cooney et al., 2015). Concerns over the conservation, animal welfare, and local livelihoods impact of captive breeding were raised for several species. Captive breeding provides little or no incentive for in situ management and conservation (Lichtenstein & Vilá, 2003; Lyons & Natusch, 2011; Natusch & Lyons, 2012); it may create incentives for converting natural habitats (Weinstein & Moegenburg, 2004), depleting wild populations to secure breeding stock and reduces incentives for in situ management and conservation (Cooney et al., 2015).

Although international wild species trade is a big business, the distribution of benefits along the commodity chain remains usually uneven, with resource owners and users receiving only a fraction compared to intermediaries and retailers (Jenkins et al., 2002; Kasterine & Lichtenstein, 2018). Interventions aimed at enhancing benefits to local communities, and minimizing impacts on collected species, could be considered to promote opportunities from the trade (Robinson et al., 2018).

Informal wild species trade within countries, i.e., domestic, contributes to food security for millions of people, particularly in developing countries (Cawthorn & Hoffman, 2015; Coad et al., 2019). Despite its lack of recognition in national level accounting, rural people, including indigenous peoples and local communities, rely on trading wild resources, by selling and consuming wild meat, fish, insects and plants, extracting timber and forest products, and many other activities (Roe et al., 2020). Domestic trade can support the survival of traditional knowledge and culture by linking local communities in local/regional markets (Tinitana et al., 2016). The literature identifies three primary roles for wild species trade in supporting rural livelihoods: (i) supporting current consumption, (ii) providing safety-nets in response to shocks and gap-filling of seasonal shortfalls, and (iii) providing means to accumulate assets and providing a pathway out of poverty (Angelsen et al., 2014).

- **Illegal wild species trade and the role of regulation**

The illicit trade in animal products for consumer markets is global and putting many species at risk of extinction (Challender & MacMillan, 2014; Duffy, 2016; MacMillan et al., 2017; Phelps

et al., 2016; Rosen & Smith, 2010; 't Sas-Rolfes et al., 2019). Recent estimates of illegal logging, illegal fishing, and illegal wildlife trade in 2016 are between 69-199 billion United States Dollars a year (World Bank, 2019). However, the full impacts, including impacts on ecosystem services, are estimated to be between 1 and 2 trillion of United States Dollars per year (World Bank, 2019). In the case of elephants, an estimated 100,000 elephants of both savanna elephants (*Loxodonta africana*) and forest elephants (*L. cyclotis*) were poached between 2010 and 2013. In some countries, elephant populations declined by over 50% in under 10 years. Chase et al. (2016) estimated a population of 352,271 savanna elephants on study sites in 18 countries, representing approximately 93% of all savanna elephants in those countries. Elephant populations in survey areas with historical data decreased by an estimated 144,000 from 2007 to 2014, and populations were currently shrinking by 8% per year continent-wide, primarily due to poaching (i.e., illegal hunting) (Chase et al., 2016).

Concerns are growing that illegal hunting to procure ingredients for traditional medicine, is becoming the major threat to the survival of high-value conservation species including tiger (*Panthera tigris*), pangolins (e.g., Chinese pangolin (*Manis pentadactyla*)) and rhinoceros (e.g., *Rhinoceros* spp). Increased urbanization and a growing middle class in Asia have increased demand for wild meat and are fueling the lucrative illegal wild species trade, and potentially undermining rural livelihoods and food security (Lee et al., 2014, 2020))

In the South Fly region of Papua New Guinea, illegal trading of Bêche-de-mer (dried sea cucumbers), shark fins, and fish maw (dried swim bladders) is a serious threat to sustainability of marine species (Busilacchi et al., 2021). While legal and illegal commodities typically served the same Asian cities, the channels travelled different routes. In spite of prices offered by illegal middlemen being significantly lower than those offered by legal buyers, many fishers engage in illegal market (Busilacchi et al., 2021). The underlying reasons were dependencies to middlemen or kinship ties, urgent need for cash or inaccessibility of legal markets, or simply lacking information about legal alternatives (Busilacchi et al., 2021).

Illegal trade is often also supplied by species that were caught or hunted unintentionally. The inability to select or choose target species may imply that protected species may be caught. For example, snare traps capture most forest mammals, birds and reptiles regardless of protection status (Bowen-Jones & Pendry, 1999; Mbete et al., 2011; Noss, 1998). Also, many in fisheries many protected species are caught as by-take or by-catch (Lawson et al., 2017). For example, seahorses are often caught as bycatch in trawl fisheries (Kuo et al., 2018).

Many orchid species around the world are under threat from illegal and unsustainable trade for horticulture, food and medicine (Hinsley et al., 2018). A key challenge is that insights on the legal and illegal trade dynamics, and how those channels interact are largely incomplete (Hinsley et al., 2018). To transform the orchid trade towards sustainability, it is vital to track, trace, and sanction illegal trade and harvesting and also incentivize sustainable methods (Hinsley et al., 2018). This could involve uplisting orchid species from Appendix II to Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, use DNA barcoding to identify individual species and also establish small scale sustainable orchid breeding businesses (Subedi et al., 2013). Illegal wild species trade has been consistently tied to unsustainable levels of exploitation. Trade that is illegal and unsustainable, but preserves some level of social legitimacy among harvesters, and consumers, can undermine policies. Even though very large overall volumes of illegal wild species trade are observed, trade structure is

very complex (e.g., role of corruption) and highly heterogeneous, and extracting information from the trade is difficult because it is illicit, posing challenges to enforcement activities and policy solutions. Moreover, the illegal trade of wild species is often interconnected with the legal trade. There is therefore a strong need for legal trade to be heavily monitored and regulated (van Uhm & Moreto, 2018).

Harvesting and trade of wild species is often regulated through a large number of laws and regulations –sometimes internally contradicting, undermining sustainability goals (de la Torre et al., 2011). A comparative analysis in Colombia, Ecuador, Peru, and Bolivia on plants, algae and fungi identifies the inconsistency of legal norms, such as internal contradictions between national legislation and indigenous rights, and lack of clarity regarding legal requirements or responsibilities of individual authorities as the main obstacles (de la Torre et al., 2011).

In most African countries, hunting is regulated by legal instruments, usually controlled through systems of licensing and quotas. Wild species are generally either considered to be without ownership (*‘res nullius*) or owned by the state or president (Lindsey et al., 2013). What makes sustainable uses more difficult is the use of unselective capture techniques. For example, the use of snare traps are not species-specific, but capture most forest mammals, birds and reptiles (Bowen-Jones & Pendry, 1999; Mbete et al., 2011; Noss, 1998).

In 2001 the Indonesian Department of Forestry and the Wild species Conservation Society established the Wild species Crimes Unit in North Sulawesi, to curb over-exploitation of wild species. Over a two-year period, 6963 wild mammals on their way to markets were encountered, which is about 8 individuals per hectare and 96,586 wild mammals were documented during market surveys (Lee et al., 2005). While the trade of some protected mammals declined significantly over this period, overall trade in wild mammals increased by 30%, indicating that traders switch from controlled to uncontrolled species (Lee et al., 2005). For example, high volume of trade in non-protected species such as the Sulawesi pig *Sus celebensis* and large flying foxes (Pteropodidae), imply a greater risk of unsustainable harvesting for unprotected species (Lee et al., 2005).

Trade creates higher revenues in exporting countries, which may imply a shift from open access towards stricter enforcement (Copeland & Taylor, 2009). There may be higher revenues, mediated through trade may initiate a transition towards more private property, but also common property, depending on what makes monitoring easier, as shown for the case of palm trees in Nigeria (Fenske, 2014).

The International Tropical Timber Agreements, for the first time signed in 1983, encourage trade from sustainably managed forests. Global data reveals that total timber exports from member countries have not decreased as a result, but rather exports have shifted from member to non-member countries. Also exports have shifted across timber categories (Houghton & Naughton, 2017). In particular, tropical country members increased plywood exports.

- **The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international treaty to prevent species from becoming endangered or extinct

because of international trade. Under this treaty, countries work together to regulate the international trade of animal and plant species and ensure that this trade is not detrimental to the survival of wild populations. Any trade in protected plant and animal species should be sustainable, based on sound biological understanding and principles. In 2021, CITES has 183 Parties, and it regulates international trade in approximately 35,800 species, 84% of which are plants. It includes species in its three appendices with corresponding trade controls implemented through national legislation and enforcement measures. Endangered species are listed in several Appendices that have different legal implications and give different protection status. 3% of species (~1,000) are included in Appendix I, prohibiting any commercial international trade in wild-harvested specimens. Ninety-seven percent of species (~35,000) are included in Appendix II, requiring trade to be closely regulated and subject to a nondetrimental finding by the exporting country's Scientific Authority. This may also involve a process of setting and controlling trade quotas.

Appendix III is a list of species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation, and it encompasses 220 species.

Overall, CITES listings have a positive impact on sustainability by regulating trade, though it does not close all loopholes and may give adverse incentives when it comes to conservation (Conrad, 2012; Harfoot et al., 2018; Phelps et al., 2010; Rivalan et al., 2007b). Since CITES has been implemented, trade has shifted towards captive-sourced trade, alleviating pressure on wild species. At the same time, there is a risk that what is documented on paper does not match harvesting from the field and illegal harvests are declared and traded as legal (Finer et al., 2014; Lyons & Natusch, 2011). In Southeast-Asia, at least 35 million animals (0.3 million butterflies; 16.0 million seahorses; 0.1 million other fish; 17.4 million reptiles; 0.4 million mammals; 1.0 million birds) that were listed by CITES were exported in the period 1998–2007 (Nijman, 2010a). Of those, at least 30 million animals, which comprises about 300 species had been caught in the wild (Nijman, 2010a). Also, 18 million pieces and 2 million kg of live corals were exported (Nijman, 2010a). The main importers are European Union and Japan, while main exporting nations are Malaysia, Vietnam, Indonesia and China (Nijman, 2010a).

Trade bans may reduce the risk of biological invasions in destination countries (Cardador et al., 2019). A limitation of the effectiveness of CITES lies in its very nature that it regulates international trade, while trade often is domestic. For example, in Japan two species of bears (*Ursus thibetanus* and *U. arctos*) are hunted and traded for their gallbladder and meat mostly domestically. By removing legal trade, incentives to preserve wild species may diminish; this can push trade 'underground' where it is unmonitored, uncontrolled, and ultimately the preservation of a species can be ineffective and lost (Biggs et al., 2013; Conrad, 2012; Hutton & Dickson, 2000; Hutton & Leader-Williams, 2003; Rivalan et al., 2007b). Prohibition on trading wild species products such as tusks and timber reduce supply (which is the whole point), but this also tends to drive up illegal prices. Often, markets are supplied illicitly despite the trade's prohibition under CITES as poaching gangs are incentivized largely due to very high prices for these illicit goods (MacMillan et al., 2017).

Also, prohibiting trade does not necessarily create incentives for conservation, which could be especially relevant if the habitat of a species interacts with alternative land uses. Red

Sanders (RS, *Pterocarpus santalinus* L.) is an endangered timber tree species in Andhra Pradesh in Southern India. The species was put on the list of endangered species by CITES, restricting international trade substantially. Only a small quantity auctioned by governmental agencies enter the international market. High demand and limited supply from private landowners, creates strong incentives for illegal removals from public forests. Local communities do not tend to benefit from timber harvesting (as it is illegal) and does not create any incentives to conserve the forest. Providing incentives to private landowners to grow red Sanders on private land and ensuring that local communities benefit are key elements to encourage practices that are economically and ecologically sustainable. Yet, facilitating sustainable trade, without also creating opportunities to intensify illegal harvests is perceived as very challenging by various stakeholder groups.

A further challenge in implementing CITES Appendix II listing of species arises if species are caught as by-take or by-catch. The whole genus of seahorses was listed in CITES Appendix II in 2002 because of the adverse effects of harvests and trade on sustainability of wild populations. Evidence from Thailand suggested that seahorses were often caught as bycatch in trawl fisheries, allowing fishers to continue fishing if harvesting the target species was not so profitable, for example due to overexploitation. Globally, most of these by-catches were sold and traded without entering official statistics. As a result, official CITES data is often substantially lower than actual catches. Declining abundances, as reported in Malaysia and Thailand suggests that current harvest rates are unsustainable. What hampers sustainable use is the fact that CITES process of listing or uplisting can be slow and respond with a delay to evidence on how threatened-status of a species. Also, sustainable use would be further facilitated if trade data collected by public authorities mostly for tax reasons were closer aligned with individual species to provide insights on scale of trade.

4.2.4.4.2 Global financial flows

Key messages:

- “Tax havens” and global crime facilitate unsustainable use of wild species (*established, but incomplete*)
- Micro-credits and foreign investments can play a positive role in enabling sustainable uses if properly combined with wider enabling factors such as investments in human and social capital, but investments may also enable destructive, and unsustainable use (*inconclusive*).
- In some cases, remittances play a role in supporting livelihoods and may reduce pressure on resources, but may also provide the capital to enable unsustainable uses and practices (*inconclusive*)

Financial actors, such as international development and commercial banks and institutional investors are increasingly interested in sustainability, and play a role in ecosystem change (Galaz et al., 2018). ‘Green’ finance, with the explicit goal to have positive ecological and social impacts holds potential to contribute to sustainable use of wild species, though it is currently a niche market, as green bonds account for less than 0.6% of the total market (Scholtens, 2017). Also, most ‘green’ initiatives tend to focus on reducing emissions, rather than ecosystem change

(Galaz et al., 2018). Conservation finance is a promising instrument to facilitate and incentivize the sustainable use of wild species (Huwyler et al., 2014; Meyers et al., 2020; UNEP, 2021). Conservation finance can be defined as ‘mechanisms and strategies that generate, manage, and deploy financial resources and align incentives to achieve nature conservation outcomes’ (Meyers et al., 2020). Obstacles around conservation finance are related to underfunding, and also inefficient use of available funds, i.e., funds not ending up where they would make most sustainability impact (Anyango-van Zwieten, 2020, 2021). Financial standards may play a positive role in promoting sustainable practices. The recent Principles for Investment in Sustainable Wild-Caught Fisheries (www.fisheriesprinciples.org), launched in 2018 represent a voluntary framework to provide guidance to financial institutions in ensuring that investments in wild-caught fisheries are in line with environmental sustainability and social responsibility (Jouffray et al., 2019). While there is established, but incomplete evidence of large flows of finance being channeled through tax havens enabling unsustainable practices, there is much fewer, and generally inconclusive evidence of global financial flows being used to enable sustainable practices regarding the use of wild species. Literature on foreign investments targeting the sustainable use of wild species is limited to examples of micro-credit schemes and remittances, with a noteworthy absence of literature on larger foreign financial flows. Also, while large (foreign) corporations tend to have a key impact on sustainability, evidence on the question under which conditions those key actors can contribute to sustainable use of wild species is inconclusive.

- **The role of “tax havens” and global crime**

An increasingly globalized financial system may create opportunities and loopholes to engage in unsustainable and illegal practices. While it is well established that tax havens can have a decisive role in enabling the unsustainable use of wild species, evidence on the size of the actual impact is incomplete. Recent estimates show that between 10 and 30% of all foreign direct investments are channeled through tax haven jurisdictions (Galaz et al., 2018). Galaz et al. (2018) investigated flows of foreign capital from financial actors based outside Brazil, to the nine largest companies operating in the soy and beef sectors of the Brazilian Amazon — two sectors representing key drivers of deforestation. Between October 2000 and August 2011, 68% of all investigated foreign capital into this region was transferred through tax havens, representing 90–100% of foreign capital for some companies investigated (Galaz et al., 2018)

In the fishing industry, 4% of all registered vessels worldwide are currently flagged in a tax haven (Galaz et al., 2018). Belhabib, Greer, and Pauly (2018) used the database of the Criminal Record of Fishing Vessels, that includes all vessels that were caught or identified as involved in illegal, unreported, and unregulated fishing within national, regional and high seas jurisdictions, to investigate whether or not the vessels (2,800) and their associated companies or owners (900) were blacklisted. Using such list, less than 2% of fishing vessels caught or observed specifically engaging in unreported and unregulated activities were flagged in tax haven jurisdictions at the time of the offence, and only 11% of the total number of offending vessels belonged to companies whose address was listed within a tax haven jurisdiction (Belhabib & Le Billon, 2018). Still, tax havens play a larger role when looking at the vessels that have been caught violating more often and are consequently blacklisted. Using a list of 209 blacklisted vessels by regional fisheries management organizations and the vessels for which a

purple notice was issued by the International Criminal Police Organization, Galaz et al. (2018) found that 70% of the known vessels engaging in illegal, unreported and unregulated fishing are, or have been, flagged under a tax haven jurisdiction, in particular Belize or Panama.

The use of tax havens is problematic firstly because of substantive losses in tax revenues, undermining public investments in accordance with, among others, the ambitions of the United Nations Sustainable Development Goals. Secondly, the use of these jurisdictions reduces financial transparency, making it difficult to track the contribution of distant financial flows to sustainable use of wild species in land- and seascapes globally (Galaz et al., 2018).

While vessels have a salient role, ports are important, too. There are 4764 ports across the globe where fish might be offloaded, and approximately 2395 of these ports are under no legal obligation to implement the Food and Agriculture Organization of the United Nations Agreement on Port State Measures requiring inspections (Telesetsky, 2014). Also, complex financial transactions that may involve third-party state tax havens, and digital currencies play a role in facilitating the sale and trade of illegal catches (Telesetsky, 2014). Enforcing sustainable fishing practices through monitoring, control and surveillance projects requires substantial investments and maintenance costs. In West-African coastal countries, this implies reliance on foreign funding, where the longevity and stability can be uncertain (O'Neill et al., 2018).

Global drug-trafficking has an increasing impact on the sustainable use of wild species. It has been estimated that the contribution of fishing vessels to drug trafficking has tripled between 2010 and 2017 and may account for 15% of the global retail value of illicit drugs (Belhabib et al., 2020). This may fuel overcapitalization of fishing fleets and intensify fishing efforts and ultimately undermine conservation goals. In a similar vein, cocaine trade has been shown to lead to deforestation in Central America (Wrathall et al., 2020). Drug trafficking has negative impacts on conservation, as it (i) undermines social relations and participation that are needed for conservation, (ii) fuels a highly extractive and unsustainable activity taking place in remote, and often conserved areas, and (iii) erode conservation institutions and replace them with new rules around resource use and access (Wrathall et al., 2020).

- **Foreign investments and role of large corporations**

If extractive resource use is capital intensive, large corporations tend to play a large role in sustainability outcomes, though the exact impacts are inconclusive. Foreign investment in forest products, such as timber, pulp, and paper can be a factor in driving forest conversion (Seymour & Forward, 2010). Large capital requirements and the ability to cope with price fluctuations in certain industries tend to attract larger and vertically integrated companies, the Ghanaian tuna fishery being one example (O'Neill et al., 2018). Here, smaller companies showed to be weakly resilient to the constant fluctuations in prices, landings and wider financial-market dynamics typical for the global fishing industry. Bigger companies were more resilient, being protected by larger parent corporations with access to substantial capital, often less reliant on and less beneficial to local economies (O'Neill et al., 2018). In fishing, large corporations have a sizable impact on global marine stocks and can play influential roles in political decision-making. These corporations can thus be seen as keystone actors in the global seafood industry, with the ability to play a key role for positive and negative outcomes sustainability in this industry (Österblom et al., 2015).

On the Solomon Islands, unregulated investment in tropical timber harvesting, has led to ecologically unsustainable outcomes and created economic and political vulnerabilities (Firth, 2007). A study from the Fujian Province in China, where deforestation has been a major problem shows that more sustainable practices using a mix of longer standing species offer a potentially better return (Ying et al., 2010). Property rights reforms that stimulate private, and also potentially foreign investments, have played a role in a transition towards more sustainable practices in that case (Ying et al., 2010).

- **Micro-credits**

Loans in the form of micro-credits combined with trainings or briefings by the loan provider on the environment have shown to be effective in positively changing attitudes towards ecosystems in coastal communities. In a case study on coastal community livelihoods in Aceh, Indonesia, a community-based micro credit program resulted in 35% of respondents reporting a positive change in behavior towards the marine environment, among which a large group of fishermen (Novriyanto et al., 2012). These behaviors included acting if they found someone littering the ocean or removing coral. Reasons for this changed behavior included understanding the importance of protecting the marine environment but also general abiding by the micro-credit provider's conservation principles (Novriyanto et al., 2012). A micro-credit plan that was combined with training on, e.g., health and hygiene, coastal ecology and home industries in coastal villages in India, has had a positive impact on the economic status of women, as well as increased awareness of the importance of conserving the coastal ecology (Lakshmi & Rajagopalan, 2000).

However, loan programs can be ineffective when improperly targeted. For instance, a micro-credit loan scheme of the Indonesian government to promote smallholder timber production gained insufficient interest among smallholder farmers due to mismatches between the loan scheme and the characteristics of borrowers. These mismatches include: a minimum loan size that is too large for small farmers to manage, an overly burdensome application and reporting process, a lack of loan management at the local level, and improper geographic targeting (Nugroho et al., 2013).

Also, a study in coastal villages in the Iloilo Province, Philippines, shows that external financial support from non-governmental organizations can be an important mechanism to diversify economic activities and curb overfishing (Andriesse, 2019). However, financial capital will always be a complement to social and human capital, and the combination of those will affect sustainability outcomes. Hence, programs aimed at encouraging fishers' livelihood diversification to reduce overfishing need to take all those forms of capital into consideration (Andriesse, 2019). While various independent studies have shown the potential of loans to support sustainable use of wild species, the overall evidence how these maps to sustainability outcomes is incomplete.

- **Remittances**

Overseas remittances constitute a substantial foreign financial flow in a number of developing countries, and an important source of income for many rural and coastal households. For such households, remittances can be a poverty alleviation strategy, especially in the short term. The

evidence of remittances leading to sustainable or unsustainable use of wild species is inconclusive.

In the coastal community of Lofanga, Tonga, overseas remittances were identified as a supporting factor for local fishing practices not yet turning into overexploitation of the open access fishery system. Remittances in this community are a sustaining factor for current, traditional ways of living and fishing, without perceptible detrimental impact on the local fish stocks (Kronen & Bender, 2007). In Java, Indonesia, remittances sent home by mobile (mostly female) family members are used to invest in rural resources, such as dairy cows or planting of elephant grass as a fodder crop (Peluso & Purwanto, 2018) with positive impacts on local livelihoods.

Yet, remittances can also provide capital for changing to capital-intensive land uses such as timber production, potentially undermining sustainable use of wild species (Mayer, 2019). Still, the use of remittances for changing practices remains limited. Often, only a small fraction of remittances is used in capital formation, the largest share being used for daily consumptive purposes (Andriess, 2019; Cedamon et al., 2018). In the Sierra Gorda Biosphere Reserve in Mexico, most people rely to a large degree on remittances from emigrants. These remittances reduce financial pressure, but do not necessarily reduce incentives to hunt illegally (Arroyo-Quiroz et al., 2017).

In coastal communities reliant on fishing as primary livelihood, using remittances for investments can be especially difficult due to characteristic limiting factors, such as poor infrastructure, weak human, financial and social capital and attachment to traditional ways of living (Andriess, 2019). The impacts of investments – and the lack thereof – on sustainability outcome is inconclusive.

4.2.4.4.3 Tourism

Key messages:

- Activities related to tourism and supporting infrastructure may disturb wild species and undermine sustainability outcomes. At the same time, revenues from tourism can be used for conservation projects which have positive impacts on sustainable use of wild species (*unresolved*).
- Traditional practices that are ecologically more sustainable, but economically less profitable may be supported when linked to tourism activities that generate additional revenues. At the same time, certain tourism related activities, such as the sale of wildlife parts and the use of live animals in entertainment, incentivizes unsustainable and sometimes illegal practices. (*unresolved*).
- In some cases, extractive forms of tourism (i.e., terrestrial animal harvesting and fishing) has a positive impact on ecological, social, and economic sustainability by generating revenues for conservation and livelihoods. However, in many cases the revenues do not reach local communities, do not contribute to conservation, and extractive tourism is unsustainable (*unresolved*).

Mostly, tourism can be categorized as a non-extractive practice, though tourism based on trophy hunting and fishing can be described as extractive. Tourism itself is not a driver, but a practice, where the underlying driver is increased mobility. More specifically, the opportunity to travel

recreationally has increased on a global scale, and also possibilities to reach places that were inaccessible in the past for tourists.

- **Non-extractive forms of tourism**

Non-extractive forms of tourism, i.e., observing wild species affects sustainability in various ways. First, as a direct driver, tourist activities and infrastructure can disturb wild species, acting as a stressor. Second, tourism generates revenues which may allow for conservation investments. Third, revenues from tourists may give incentives to users to adapt practices that may be more or less sustainable. Hence, whether tourism has a positive or negative effect on ecological sustainability is highly context dependent. Pegas et al. (2015) assess how tourism affects the sustainability of 547 locally culturally important species. While a third of those were part of some form of nature-based tourism only three percent were actually threatened by tourism. This suggests that threats from tourism are mostly indirect, while it can play a big role in supporting species conservation and protect traditional practices.

Investment in conservation areas is an important dimension of tourism that contributes to the sustainable use of wild species. Tourism to protected areas generates an estimated 600 billion United States Dollars annually (World Bank 2018). In the United States of America alone, park fees contributed 21 billion United States Dollars in 2019 (National Park Service, 2019). In Africa, 14 countries generate an estimated 142 million United States Dollars in park entrance fees (UNWTO, 2015). Despite the growth in tourism investment over the past decade, it is estimated that African protected areas are currently experiencing at least a 1.25 billion United States Dollars funding shortfall for effective management and conservation of threatened species like lions *Panthera leo* (Lindsey et al., 2016). Marine reserves cover 6.97% (25.3 million km²) of sea area protected globally (Jantke et al., 2018) compared to 14.7% of terrestrial systems (Jones et al., 2018).

Responsible tourism, i.e., nature-based tourism, can play a role in conservation of wild species, provided that tourism flows and protected areas are carefully managed, and benefits are fairly shared (Das & Chatterjee, 2015; Fennell, 2020; INTOSAI WGEA, 2013). There are multiple examples where nature-based tourism as an economic development strategy has significant social and conservation benefits (Coria & Calfucura, 2012). For example, the Potato Park in the district of Cuzco, Peru is implementing an agro-nature-based tourism program, highlighting the diversity of native potato varieties, and other Andean grains such as quinoa and kiwicha (Argumedo & Stenner, 2008). It is managed by local economic collectives, where income is generated through walking tours, a restaurant using local ingredients, and through the sale of crafts and medicinal plant products (Argumedo & Stenner, 2008).

Tourism is also seen as a crucial tool, and perhaps the only viable tool, to conserve gorillas in Africa (Litchfield, 2008). For example, without mountain gorilla tourism in Uganda, it is unlikely that the small Mgahinga Gorilla National Park (34 km²) would even exist (Litchfield, 2008). Yet, it remains unclear to what extent gorilla tourism is sustainable. Most importantly, economic and ecological sustainability ask for an optimal number of visitors to visit gorilla tourism sites, which requires appropriate governance arrangements (Litchfield, 2008).

Economic revenues from tourism in Africa amount to 4.2 billion United States Dollars in 2013 (UNWTO, 2015). Potential revenues through tourism can also play a role in stimulating

more sustainable use, by incentivizing non-extractive practices, such as tourism tours overfishing or hunting. For example, Manta rays (*Manta alfredi* and *Manta birostris*) are charismatic fish species that are vulnerable to extinction. Globally, direct revenue to dive operators related to Manta rays are 73 million United States Dollars annually and direct economic impact, including associated tourism expenditures, are 140 million United States Dollars annually, making tourism substantially more profitable than Manta ray fishing (O'Malley et al., 2013). In the Ningaloo Marine Park, Western Australia, manta ray interaction tourism is suggested as a non-extractive alternative towards the hunting of reef manta ray, *Manta alfredi* (Venables et al., 2016). The shark-diving industry generates 18 million United States Dollars to the economy of Palau annually, benefiting several sectors of the economy, while ensuring the ecological sustainability of shark populations (Vianna et al., 2012).

Nature-based tourism can also help to preserve traditional practices that are ecologically more sustainable, but economically less profitable. This is in part because of the location of indigenous communities in remote locations and ecosystems characterized by ecological diversity including wild flora and fauna, and often indigenous economic practices are less consumptive and ecologically more sustainable. For example, mycological tourism can play an important role in preserving or achieving sustainable use of wild fungi, though it is important that such activities are carefully tailored to local context to ensure that local communities are benefiting and use is indeed sustainable (Jimenez-Ruiz et al., 2017). Yunnan is one of the hotspots of edible fungi in China, which has more than 600 species of edible fungi, and 30% of the edible fungi species in the world (Liu et al., 2018). Increasing demand triggers overexploitation and threatens ecological sustainability and income of farmers. Traditionally, local people harvest wild fungi without destroying their hyphae, while today young harvesters often simply uproot the fungi, which is much less sustainable. The traditional culture and rich fungi resources are becoming popular destinations for eco-tourism, which may help preserving sustainable practices (Liu et al., 2018).

Tourism can also play a role to maintain fishing activities using traditional gear that is less disruptive, but also gives lower yield than modern gear. One example comes from the Strait of Sicily in the Mediterranean Sea where bottom longline is a traditional fishing gear that is not used anymore, but the practice could be revived when combined with tourism activity (Cillari et al., 2012). As a cautionary note, whether or not traditional indigenous practices are (more) sustainable, depends on the specific context. Traditional fishing gear is often unselective, which may lead to a more balanced catch profile, which gives ecological and economic benefits, as well as costs (Burgess et al., 2016; Kolding & van Zwieten, 2014). For example, on the Galapagos islands a traditional unselective longline fishery has caused substantial undesired bycatch of protected megafauna species, such as turtles (Cerutti-Pereyra et al., 2020).

Tourism can also act as a stressor, though the negative impacts of non-extractive wild species tourism on population health of wild species is poorly understood, as many studies are site-specific and lack long time series (Burgin & Hardiman, 2015). Unregulated tourism centered around wild species attractions tends to have adverse effects on wild species populations. Negative impacts stem from touristic activities, the intensification of tourism infrastructure, destruction of habitat (Mbaiwa, 2003) that can even result in reduced recruitment and juvenile survival in species like the cheetah *Acinonyx jubatus* (Broekhuis, 2018). Also, marine provisioning-tourism in the Cayman Islands has had an impact on the physiology of

southern stingrays (*Dasyatis americana*), through non-natural food, higher injury rates from boats, and higher parasite loads from crowding conditions (Semeniuk et al., 2009). Increased boat traffic has also had an adverse impact on behavior and stress levels in the Scandola marine protected area (UNESCO World Heritage Site, Corsica island), on the population of the Osprey *Pandion haliaetus* (Monti et al., 2018). Birds use less time to search for prey, and are more stressed, indicated by corticosterone levels in chick feathers being three times higher in high-traffic areas compared to places with lower touristic flow (Monti et al., 2018). On Panaon Island in the Visayas region of the Philippines whale shark (*Rhincodon typus*) tourism is a growing industry, where the impacts on the shark population remains unclear (Araujo et al., 2017). 56% had anthropogenic scars from boat propellers, fishing gear or vessel collision, though it is not clear to what extent these are caused by tourist activities (Araujo et al., 2017). This shows that motorboats can be a threat to marine species, and rules around speed limits, and also distance regulations can mitigate some of those threats.

Tourism can degrade coral reefs through coastal development, as well as through unsustainable tourist activities (Gil et al., 2015). In the touristic region of the Mayan Riviera, Mexico coral cover decreased by 79% from 2011 to 2014 near the peak snorkeling area in the bay (Gil et al., 2015). In a control region that was less exposed to tourists, a similar decline was not observed, suggesting that uncontrolled tourist activities were the main cause of the decline (Gil et al., 2015). Improvements can be made by targeting tourists directly and educating them about how to sustainably dive or snorkel. Showing tourists a video message about sustainable use prior to a trip has led to a five-fold reduction in the rate of contact compared to a control group in an experiment in Puerto Rico (Webler & Jakubowski, 2016).

Tourism can also encourage unsustainable uses of wild species, snake charming being one example. While snake charming in Morocco is practiced for at least 500 years, it now mostly used to attract tourists (Pleguezuelos et al., 2018). Mortality during transport and captivity is high and hunters select predominantly snakes that have certain traits that appeal to tourists (e.g., large body size), undermining population sustainability (Pleguezuelos et al., 2018). Consequently, a population decline of Egyptian Cobra *N. haje* has been observed, though it not established to what extent this is due to hunting (Pleguezuelos et al., 2018). Similarly, gathering shells and selling those to tourists has adverse effects on marine ecosystems, as shown in Zanzibar, Tanzania (Gössling et al., 2004).

In some cases, nature-based tourism has resulted in unintended consequences for biodiversity (Hinch, 1998). For example, tourists may increase demand for locally caught seafood. A case study from Fernando de Noronha, located about 345 km offshore the Brazilian coast illustrates that tourists consume 70% of the caught fish, posing further sustainability challenges (Lopes et al., 2017). Also, ecotourists can have very different views and relationships to nature than indigenous communities. Therefore, careful consideration of the alignment between the conservation values of the nature-based tourism enterprise and the social and cultural values of communities is critical for sustainability outcomes (Hinch, 1998).

To mitigate negative effects of tourism on wild species, it is important that management schemes are in place that make sure that tourism is taking place sustainably. This implies steering the number of tourists, which is often managed through licenses, as well as the practices, which often implies enforcing rules of conduct, and giving out licenses. For example, in the Ningaloo Marine Park, Western Australia, a management plan is implemented to make

sure that whale watching takes place sustainably (Andersson et al., 2014). The number of whale shark tours at Ningaloo increased by approx. 70% and the number of interactions with whale sharks by 370% between 2006 and (Andersson et al., 2014).

While sustainable tourism needs to carefully regulate the number of tourists and type of tourist activities, this may create tensions. An unfair distribution of benefits within communities and inability to coordinate on a larger scale may undermine sustainable use, as was illustrated in the case of whale watching in Baja California, Mexico (Young, 1999). The poaching of African elephants is estimated to represent 25 million United States Dollars in lost revenue annually (Naidoo et al., 2016). However, those annual losses to tourism are small compared to the estimated 597 million United States Dollars that ivory from Africa's poached elephants was worth annually on Chinese black markets from 2010–2012 (Naidoo et al., 2016). Also, the potential benefits from conservation do not necessarily trickle down to local communities, who may still experience crop losses and damages from elephants (Blignaut and de Wit 2008). Hence, the investment in conservation areas for elephants for tourism may not be as successful as it might be if communities were benefiting directly (Naidoo et al., 2016). A way to counter this is to involve local communities directly into the benefit sharing of wild species populations. This can be done through either providing communities a portion of entrance fees, as done in Uganda (Ahebwa et al., 2012) or including them into private land conservation schemes, as done in Kenya (S. Blackburn et al., 2016).

Marine protected areas are important governance arrangements to make sure that marine resources are sustainably used. Support for such measures depend on how the costs and benefits are distributed. For example, on Mafia Island (Tanzania) a marine protected area faced local opposition because fisheries closures were affecting mostly those who live near those closed areas or have been fishing there historically. Gear and size regulations that affect all fishers similarly did not meet similar opposition (McClanahan et al. 2008). In a survey among locals at the Pacific Coast of Costa Rica within a 30 km radius surrounding the Manuel Antonio National Park, perceived tourism to have positive effects on biodiversity through increased values of flora and fauna and decreased hunting and deforestation (Broadbent et al., 2012).

Common property rights arrangements can be an important tool to control unsustainable tourism growth and make sure that the benefits are distributed in a fair way. Such management approach was also ranked as the most favorable one among stakeholders in long-term whale shark (*Rhincodon typus*) tourism in Bahia de Angeles, located in the oriental coast of Baja California, Mexico (Rodríguez-Dowdell et al., 2007). Further evidence on potential success factor of community-based management comes from Bigodi Village, located in the Kamwenge district of western Uganda. The is managed by a community-based organisation that tries to reconcile ecological, economic, and social sustainability (Gosling et al., 2017). Tourism initiatives include guided walks, homestays with local households and visits to the houses of crafters, healers, and elders, where the Bigodi community benefits from the wetland sanctuary as 75–80% of the tourism generated funds are invested into village infrastructure, including a school, library, a clinic, roads, pathways, sanitation and training courses (Gosling et al., 2017). Territorial user rights have shown to be a promising governance arrangements, though it requires trust and careful consideration of local contexts to foster sustainable use and reconcile conflicting objectives and practices (Biggs et al., 2016).

- **Extractive forms of tourism – terrestrial animal harvesting and fishing**

So-called ‘trophy hunting’ is one dimension of tourism that is fiercely controversial (F. Nelson et al., 2013). The idea – and images – of the hunting of iconic species for recreational value is unappealing to a growing urban population (Biggs et al., 2019; Manfredo et al., 2017; Parker et al., 2020). Hunting can at times have adverse population consequences (e.g., Packer et al. 2011), especially in combination with environmental factors (Wilfred & MacColl, 2016). The revenues by trophy hunting are sizable, but small compared to total tourism expenditures and often not benefiting local communities, leaving conservation benefits unclear in many cases (Campbell, R., 2013; Chardonnet, 2019; Grijalva, 2016; Naidoo et al., 2016). In Tanzania, for instance, hunting operators distributed to the communities an average annual sum of 1.04 million United States Dollars, i.e., 0.08 United States Dollars per hectare per year (Chardonnet, 2019). For comparison, the Maasai Mara conservancies in Kenya – where trophy hunting is forbidden – distribute around 40 United States Dollars per hectare per year, while also contributing to local employment (Chardonnet, 2019; Oduor, 2020).

However, systems of trophy hunting have been shown to have potential to ensure the sustainable use of wild species if managed appropriately (Baker, 1997; Begg et al., 2018; Dickman et al., 2019; IUCN, 2016). For example, in Namibia, wild species have multiple economic uses and values including that of wild species tourism and trophy hunting, often on the same property (Naidoo et al., 2016; Richardson, 1998). Moreover, they are often a primary source of revenue in regions that are either non-conducive for commercial photo tourism safaris or politically unstable (Lindsey et al., 2007). Trophy hunting often provides vital financial resources needed for conservation, though it also puts pressure on a population, which – unless well-regulated and managed in line with scientific principles – undermines sustainability goals. Sustainability may be especially threatened in the presence of illegal harvesting and interaction with other drivers (Muposhi et al., 2016). Community-based hunting of the snow leopard, *Panthera uncia*, in Tajikistan offers an example of the benefits of well-managed trophy hunting. There, adequate revenue-sharing and transparency community-based trophy hunting programs have improved the availability of food resources for the snow leopard by incentivizing communities to protect and manage wild ungulate populations at levels that can sustain trophy hunting as well as predation by snow leopards (Kachel et al. 2017).

However, while trophy hunting creates revenues, conflicts arise if benefits of various conservation activities are distributed unequally. In the Tarangire National Park in the Maasai Steppe (Tanzania), widespread conflicts between centrally-issued trophy hunting concessions and village–private tourism ventures have been observed (Sachedina & Nelson, 2010). These conflicts arise because local communities capture revenues directly from tourism whereas hunting revenues go to the state, putting a constraint on the viability of community-level tourism ventures (Sachedina & Nelson, 2010). A key challenge regarding sustainable use remains setting appropriate quota in light of insufficient scientific evidence (Lindsey et al., 2013). Hunting quota are often too high or insufficiently taking into account population dynamics, especially if populations are declining and abundances are low (Packer et al., 2009). Examples include African lions and leopards in Tanzania (Packer et al., 2009), lions in Zimbabwe (Loveridge et al., 2007), leopards in several African countries (Trouwborst et al., 2020) and elephants across parts of Southern Africa (Selier et al., 2014). Differences in ecosystem productivity may call for a variable and more selective hunting pattern, while quotas are often

constant over time and unselective (Muposhi et al., 2016). Also, several countries have a system of ‘fixed’ quota, where the operators are charged for a quota, regardless of whether animals are actually hunted. Such a system is likely to encourage less selective hunting and a higher probability of killing an animal upon sighting (Diekert et al., 2016).

African lions, *Panthera leo* attract the highest mean price for all tropic species and are estimated to generate 5-17% of gross trophy hunting income (Lindsey et al., 2012). At the same time, hunting pressure has declined the abundance of lion populations with the most severe contraction occurring in West Africa (Lindsey et al., 2013; Packer et al., 2011). A key element of sustainable use is to incentivize users to hunt more selectively, e.g., by sparing younger animals. In Niassa National Reserve, Mozambique, a system was introduced to incentivize hunters to select older individuals, reducing overall harvesting pressure to sustainable limits (Begg et al., 2018). Also, the way hunting concessions are handed out affects sustainable use. Usually, hunting blocks are allocated with a tender process with limited benefits for local communities (Lindsey et al., 2013). An exception is Namibia, where user rights were given to communities, resulting in larger local benefits and also increases in wild species populations (Lindsey et al., 2013). In Tanzania, hunting concessions are leased in block to companies. Shorter leased blocks tend to generate higher revenues for the government (133 United States Dollars per km²) compared to 62 United States Dollars per km² from long-term tenure blocks. However, long-term blocks had a significantly lower hunting offtake, which were also closer to the sustainable limits (Brink et al., 2016).

Also, if monitoring, quotas, and age-based harvesting are difficult to enforce, a full moratorium or a complete ban may be a good option to ensure sustainability (Mweetwa et al., 2018). Finally, while conservation and management are often done on a single species level, there may be important interactions when it comes to the financial viability of trophy hunting (Lindsey et al., 2012). Banning hunting of single species, for example lions, may imply that trophy hunting as a whole may become unviable. As a result, local communities that depend on trophy hunting for income, as well as funding for anti-poaching activities, may be adversely affected, having repercussions on sustainable use of wild species (Lindsey et al., 2012).

Sportfisheries create income and hold the potential to provide alternative and diversified livelihoods for coastal villages (Barnett et al., 2016). At the same time, they can generate significant environmental benefits by creating incentives to conserve targeted species and their key habitats. However, a truly sustainable sportfishery in the developing world should produce benefits for, and be supported by, local people (Barnett et al., 2016). Potential conflicts may arise if historically important fishing spots for locals are used as tourism sites, creating a conflict overfishing space. One example comes from the Alligator Rivers Region of Kakadu National Park in Northern Territory of Australia where Aboriginal people indicated that tourist activity limited access to their favorite hunting and fishing sites and aggravated fishing pressure, leading to population decline (Ligtermoet, 2016).

4.2.4.5 Consumer values, behaviors, choices

Sustainable use of wild species implies that consumption takes place within sustainable limits. Therefore, overconsumption can be considered one of the key factors undermining or preventing a regime of sustainability. Consumption of wild species varies by country, socio-

economic and demographic factors as well as by species. To understand the trends in the use of wild species, thus requires consideration of other economic and sociocultural trends. By virtually any measure—household expenditures, number of consumers, extraction of raw materials—consumption of goods and services have risen steadily in industrial nations for decades, and it is growing rapidly in many developing countries (Gardner et al., 2014; UNCTAD, 2013). Consumption is one of the determining factors of global impacts, surpassing other socio-economic-demographic factors, such as age, household size, qualification or dwelling structure (Wiedmann et al., 2020). A lifestyle and culture that became common in Europe, North America, Japan, and a few other pockets of the world in the twentieth century is going global in the twenty-first century. While the consumer class thrives, great disparities remain. In the beginning of the twenty-first century the 12% of the world's population that lives in North America and Western Europe accounted for 60% of private consumption spending, while the one-third living in South Asia and sub-Saharan Africa accounted for only 3.2% (Gardner et al., 2014). However, rapid growth in many of the developing countries over the past decades may well have changed the situation (United Nations 2019; UNCTAD 2013).

In a globalized world and with increasing demand for food and changing consumption patterns the strain on ecosystem and biodiversity is growing substantially. The consumption of goods and services has become a defining characteristic of modern-day (industrial) societies and is accompanied by an enormous and continuously increasing use of natural resources. Consumption also has a significant impact on the provision of ecosystem services worldwide. This section analyzes and illustrates the impacts of consumption patterns on sustainable use of biodiversity.

Despite the high level of concern and awareness among the general public about the need for conservation, there have not been considerable changes in personal actions or widespread patterns of behavior and so individuals in developed nations continue to consume high levels of resources in unsustainable way (Schultz, 2011). The conditions for conservation can only be achieved by changing behavior. Nevertheless, the driver for this behavior change is not proportional to increasing knowledge through education, but rather motivation, or a reason for action, such as self-interest, social responsibility, and self-transcendent values.

Consumer behavior is related to how individual customers, groups or organizations select, buy, use, and dispose of ideas, goods, and services to satisfy their needs and wants. It refers to the actions of the consumers and their main motivations. Individual, social and situational factors influence this decision process. Concerning social factors, societal norms, cultural context and mass media can influence consumer behavior and choices (Terlau & Hirsch, 2015). In the case of experiences of sustainable use of wild fauna that, as a necessary condition for profitability of local communities, require their conservation in order to be successful, it is essential that consumers be able to identify, distinguish and give preference to products that meet the condition of sustainability at the expense of those who do not, thus reducing the development of other productive activities that generate negative impacts on wild species (Banchs & Moschione, 2006). An emblematic example is the case of talking parrot (*Amazona estiva*) in Argentina, where the ban on exporting the animal to the European Union, its main buyer, increased illegal trade and did not have the resources to carry out controls on the management of the parrot, resulting in a genuine loss of income for the local population, a decline in the population of the parrot and the loss of forests (Coconier & Lichtenstein, 2014).

4.2.4.5.1 Media and consumer behavior

Media vehicles (press, television, cinema, radio and internet) may have a positive or negative influence on consumer behavior. Considering the influence of the media on consumer behavior with regard to wild species, there are more cases related to animal species, such as advertising campaigns to reduce consumer demand on wild species in general, or for exotic pet more specifically (Wallen & Daut, 2018). On the other hand, media may also stimulate demand for wild species, by creating awareness about its existence and highlighting positive health benefits of consumption, as in the case of products known as superfoods (Sikka, 2019) or with wild mushrooms (Barroetaveña et al., 2020; Peris et al., 2021). This is especially relevant for plant species that have been traditionally used as medicinal herbs by rural communities who gather wild native species. Those plants may now also be demanded by urban consumers that rarely are informed about the risks of extinction or biodiversity losses due to high consumption and demand of those products.

Consumer demand is a significant and inherent driver of illegal wild species trade and biodiversity conservation depends on the management of consumer behavior as well as changing behavior as well as changing behavior of other actors, such as in the case of marine recreational fishery, where efforts should be also oriented towards the preferences, motivations and demands of fishers regarding fisheries (Guidi et al., 2021; Llompart et al., 2012).

In the context of illegal trade, behavior change methods are rarely applied and usually not well-documented. However, some organisations are emphasising application of behavior change methods, as the example of TRAFFIC, a wild species trade-monitoring network of researchers and practitioners hosted by World Wildlife Fund (WWF) and the International Union for Conservation of Nature (IUCN). They developed a Wild species Consumer Behavior Change Toolkit, which has been made widely available (Wallen & Daut, 2018). Another example of media as a communication tool to address awareness regarding wild species conservation concerns consumption of palm oil and orang-utan threatening, where an education video presentation played at the Melbourne Zoo, Australia, as well as on the YouTube platform, mobilized celebrity ambassadors and social media (Pearson et al., 2014).

Although there is no regulation about selling and buying some wild species, such as marine ornamental fishes online (Borges et al., 2021), social media and social networks are gaining more and more importance and are being used to influence consumer behavior in many situations. On the one hand, this may promote demand of products related to wild species, as the internet increases exposure to those commodities and facilitate its consumption by suggesting suppliers, including related products or recommending on modes of consumption, such as with wild mushroom species (Barroetaveña et al., 2020; Peris et al., 2021). On the other hand, social media helps to inform consumers about potential negative effects of certain commodities, such as palm oil (Carrasco et al., 2017). If there is sufficient critical mass among consumers, a societal tipping point may be passed, changing social norms and affecting business practices (Gladwell, 2006; Nyborg et al., 2016).

Although not typically considered to be part of the conservation science toolbox, but also related to media vehicles, are marketing techniques to influence human preferences and behavior. Marketing professionals use techniques to influence the public to buy particular

products by developing relationships or creating positive associations with that particular item or service. While marketing is ubiquitous in commerce, the same techniques can be used to positively influence public behavior regarding conservation matters (Wright et al., 2015).

The purchase decisions of green consumers, for example, can be influenced by factors that are intrinsic and extrinsic to the consumers. The actual behavior is a result of consumers' regular habits, their product knowledge and the situational factors such as promotional campaigns (Kumar & Ghodeswar, 2015). Nevertheless, it is observed that attitudes towards sustainable consumption deviate from the actual consumption behavior. Closing this attitude-behavior-gap (or attitude-intention behavior gap) remains a challenge (Terlau & Hirsch, 2015). Also, gaps between best practice in social marketing and current practices in the design of demand reduction campaigns are frequent (Greenfield & Veríssimo, 2019). Understanding the impacts of different outreach efforts remains limited and it is a challenge for conservation scientists and practitioners to apply the same scientific rigour as in other parts of conservation practice (Veríssimo & Wan, 2019). MacFarlane et al. (2020) found that mass-media campaigns and incentive programs were ineffective or short-lived, while advertising bans, social marketing, and locations bans seemed to be more promising approaches, but need more high-quality evidence to draw firm conclusions. Finally, demand reduction can play a role in reducing unsustainable use, but to be impactful it requires thinking about wider systemic effects (Thomas-Walters et al., 2020).

4.2.5 Cultural drivers, value systems, customs and beliefs

Key Messages:

- World views, religions, customs and belief systems have direct and indirect influence over the practices and uses of wild flora and fauna (*established but incomplete*) {4.2.5}.
- Indigenous and local knowledge includes cultural norms and ethics support sustainable use (*established but incomplete*) {4.2.5}.
 - Observation is central to sustainable use, allowing indigenous peoples and local knowledge to closely monitor and assess resources over time and providing a strong foundation on which to build sustainable management plans (*well established*) {4.2.5.2.5}.
 - Indigenous and local knowledge is poorly documented when compared to other knowledges; where it has been documented and embraced there are greater sustainable use outcomes. It also offers a crucial foundation for sustainable use in and beyond indigenous peoples and local communities. Realizing its full benefits will require enhanced documentation as well as greater recognition of Indigenous rights (*well established*) {4.2.5}.
- Cultural norms often mediate practices and uses of wild species; where there are long term relationships between people-nature, norms around stewardship and care of wild species are more common (*well established*) {4.2.5.2}. Cultural taboos against harvest, consumption and other uses of wild species, play an important role in the conservation of some key species (e.g., sacred groves) (*well established*), {4.2.5.2.2}.

- Beliefs about the perceived medicinal value of wild species (coupled with clinical evidence about improved health outcomes) are a driver of the harvest and use of some flora and fauna (*well established*) {4.2.5.7}.
- Spiritual beliefs that wild species have equal value to humans (e.g., are relatives, or are gifts from the spirit world), are common in some cultures, particularly those of indigenous peoples. These beliefs often include recognitions or demonstrations of respect (e.g., ceremonies) when flora-fauna are harvested or used (*well established*) {4.2.5.2.5}.
- In many indigenous cultures, practices that facilitate good relationships with wild species (e.g., take only what you need) are interconnected with cultural values norms of community well-being of communities (*established but incomplete*) {4.2.5.2}. Take only what you need, is not a common principle or value in cultures tied to globalization and industrialization tend to focus more on accumulation of wild species for profit.
- Many indigenous peoples and local knowledge have traditional norms and practices to ensure appropriate, or sustainable, relationships with wild species. These norms and practices are based in indigenous and local knowledge and frequently central to spiritual practices. Often, they include significant sanctions or punishments when violated (*established but incomplete*) {4.2.5.2.7}.
- Human treatment of wild in a humane way is also highlighted in the Convention on Biological Diversity's Addis Ababa Principles and Guidelines for the sustainable use of components of biodiversity (*established but incomplete*) {4.2.5.2.4}.

4.2.5.1 Overview

Human societies are distinguished by their culture, which affects their behavior, consumption and attitudes towards nature and its constituents. Though the definition of culture has been long debated by anthropologists, 'culture' or "cultural diversity" is generally defined by the variety of religion, language, knowledge, food habits, values and philosophies in human societies (Maiero & Shen, 2004). Since time immemorial, culture has played a pivotal role behind nature conservation and sustainable use of wild species; including both extractive and non- extractive uses, and in general, shaped a symbiotic and harmonious relationship with nature. The concept of sacred groves, where a small patch of forest is worshipped, exists worldwide and possibly dates back to millennia (Alves, 2014; Negi, 2005). Traditional, resource-reliant communities engaged in an intimate relationship with nature, which is reflected in the multitude of myths, legends and lore linked to the flora and fauna surrounding them. In fact, indigenous knowledge and practices are considered to represent '*the oldest form of conservation known to mankind*' (Pretty et al., 2009; Wild et al., 2008). For example, places that are regarded as sacred by local indigenous people are protected as sanctified locations and species are protected through beliefs in totem or taboo species (e.g., Posey, 1999; Sheridan & Nyamweru, 2008; Verschuuren et al., 2010). Similarly, human use of wild animals (e.g., totem species or tabooed species) for a variety of ethnic and religious purposes has been an integral part of many cultures and traditional societies (Alves, 2012). At the same time, pervasive animism is also practiced in many traditional societies, which, at times, resulted in unsustainable use of wild species.

The concept of biocultural diversity was originally proposed to denote this intimate link between nature and culture in relation to indigenous communities, especially those living in areas of high biodiversity (Maffi, 2005; Maffi & Woodley, 2012; Posey, 1999). Biocultural diversity recognizes “the interweave of biological and cultural diversity, people and places, and the continuing adaptation and co-evolution between landscapes and ways of life” (Laird et al., 2011). In the broader sense, it encompasses coding for knowledge, values, norms and protocols. The concept has been used to successfully promote the value of local indigenous knowledge and to curb the loss of biodiversity and the decline of intergenerational transmission of traditional knowledge, practices, and languages (Rapport & Maffi, 2010). It further increased the understanding of how relationships with nature are informed by different worldviews (Descola, 1994, 2005; Mathez-Stiefel et al., 2007; Posey, 1999) and how they contribute to a sense of personal and collective identity and heightened states of mental, physical and spiritual wellbeing (Pretty et al., 2009; Russell et al., 2013) and promote sustainable use and harmonious existence. Engagement in biocultural relations also elicit emotions of happiness, enjoyment, inspiration, love, belonging and connectedness, among others. Conversely, feelings of sadness, pain and loss are experienced when culturally relevant nature is no longer accessible (Cocks & Shackleton, 2020).

Many traditional practices, nonetheless, have faded in time and continue to erode under multiple pressures including globalization, human migration, urbanization, scholarization, changes in religion, and state control of land and resources. Still different elements of nature, including both biotic and abiotic components, continue to inspire and enrich people's cultural and ceremonial lives. They provide rich symbolic values and compassion for nature, and in a way, generate a positive affinity for nature and encourage sustainable use of wild species.

This section looks into the role of cultural drivers, including cultural diversity, religion and other belief systems, indigenous local knowledge and different customary values which contributed to the sustainable use of wild species, and how changes in these drivers have resulted in unsustainable and/or uncontrolled exploitation of wild species. The following four sub-sections are developed following systematic review methodology with specific search terms and engines specified in each sub-section.

4.2.5.1.1 Methodology

The following four sub-sections were developed following different types of literature review methodology. The sub-section on cultural diversity, religion and belief system is derived from the three specific Scopus database searches, i.e., understanding of the relationship with language diversity with sustainable use of wild species, the experts administered the search terms (TITLE-ABS-KEY (cultural AND diversity) AND TITLE-ABS-KEY (language AND diversity) AND TITLE-ABS-KEY (wild AND food) OR TITLE-ABS-KEY (hunting) OR TITLE-ABS-KEY (fishing) OR TITLE-ABS-KEY (logging)) in Scopus database. The search produced 22 articles, therefore, additional search for grey literature, including important reports and books were performed. For the section 4.2.5.1.2 on religious belief and sustainable use of wild species, the experts made a search using TITLE-ABS-KEY (religio) OR TITLE-ABS-KEY(belief) AND TITLE-ABS-KEY(species) AND TITLE-ABS-KEY(wild)). The search yielded a list of 195 articles, of which 55 articles were found relevant. The section on

sacred groves was further developed based on an additional Scopus database search using the following search terms (TITLE-ABS-KEY (sacred AND groves) AND TITLE-ABS-KEY (hunting) OR TITLE-ABS-KEY (fishing) OR TITLE-ABS KEY (meditation) OR TITLE-ABS-KEY (gathering) OR TITLE-ABS-KEY (medicine) OR TITLE-ABS-KEY (healing) OR TITLE-ABS-KEY (tourism)). This search yielded 56 articles, out of which, 49 papers were considered appropriate. For the section 4.2.5.1.3. on the role of taboos and traditional belief systems on sustainable use of species, the experts used the publish and perish search engine. A total of 37 papers were considered for writing this sub-section.

Bibliographic search engines, cross-referencing keywords, are useful but the results are not perfectly satisfactory always, because they privilege 1) scientific articles from English-speaking journals, 2) recent publications, often pointed or targeted, to the detriment of reference and/or more synthetic publications, as the concepts and search terms change over time, and 3) do not sufficiently consider non-academic productions (grey literature, government reports, conference proceedings, indigenous and local knowledge productions or reports, indigenous and local knowledge dialogue workshops, media, etc.), which are nonetheless essential for taking into account local knowledge and cultural drivers.

To counterbalance these biases, the experts used other research methods for reviewing literature. The experts have mobilized partners and networks (students, colleagues, field workers), and have relied on diversified bibliographical resources, searching for relevant, synthetic or major references to the subject; some old, some not yet published (and graciously made available by the authors). The 54 cited references for the customary values section have been analysed and integrated in databases.

4.2.5.1.2 Gaps and limitations

Although biocultural diversity, indigenous and local knowledge, and customary values have been identified as a key component for the sustainable use of wild species, methods to document these and complement scientific studies, are not yet widely used and need to be further explored and implemented. There is still a clear dearth of quality documentation on the diverse indigenous and cultural use of wild species. For example, academic research has not understood well how languages changed certain practices and how they influenced their relationship with the sustainable use of wild species. Likewise, while the proportionate relationship between language and biodiversity is well-documented, underlying mechanisms remain unexplored. Similarly, academic efforts have focused on documenting the loss of systems knowledge indigenous systems and not on understanding the processes that drive those changes and their effects on society's capacity to generate, apply, and transmit knowledge to maintain living systems knowledge indigenous systems. There is a requirement to connect these dots via qualitative analysis to understand the impact of cultural factors on the sustainable use of wild species. Besides, it will be crucial to understand the enabling conditions that contribute to the effective transmission of indigenous and local knowledge. This will entail a critical analysis of current educational curricula that minimize contact with local flora, fauna, and land, contributing to the erosion of local knowledge. By contrast, it will be essential to analyze the factors that support local cultural, political, educational, and economic institutions which lead to enduring connections to the land among youth, collectors, and citizens, even amid modernity.

For use of wild species to truly be sustainable over time, analysis is required to understand how to stem the tide of rural abandonment, to raise the status of careers linked with wild harvest and natural resource management, and to attract youth to environmentally oriented vocations. while recognising/ valuing the existing knowledge of indigenous people and local communities.

4.2.5.2 Cultural diversity, religion and belief systems

4.2.5.2.1 Cultural diversity

The variety in religion, language, food habits and philosophies principally distinguish human societies from one another. Although biological and cultural dimensions of diversity have long been dealt with separately, there is an increasing recognition that cultural diversity plays a pivotal role in sustainable use of wild species and their conservation (Anthony et al., 2011). For example, research conducted across countries and continents identified patterns of co-occurrence of linguistic and biological diversity (Gorenflo et al., 2012; Harmon, 1996; Oviedo et al., 2000). Evidence indicates that areas with high language diversity are strongly correlated with biodiversity, in particular high bird and mammal diversity (Frainer et al., 2020; Gorenflo et al., 2012; Sutherland, 2003). According to Gorenflo et al. (2012), a total of 3,202 languages, which accounts for nearly half of the existing 7000 languages, are found in the 35 global biodiversity hotspots. Languages encode non-transferable knowledge bases which serve as rich repositories of diverse uses of plant and animal species. Within these languages exist several thousand years of undocumented indigenous scientific knowledge of biodiversity inventory (e.g., folk taxonomy) and instructions (folklores, stories, proverbs). Languages often underpin the preference for species which are subjected to hunting or fishing (Established but incomplete). For example, in Senegal, “Essegnaille” refers to three commonly consumed species from the Carangidae taxonomic family, namely, *Caranx hippos*, *Caranx senegallus*, and *Hemicaranx bicolor*. The local fishers, however, do not have a name for *Chloroscombrus chrysurus* despite belonging to the same family. This is because it is usually rejected when caught (Frainer et al., 2020). Folklores often prevent harming animals, foster positive environmental attitudes and teach harmonious coexistence. It symbolizes myths, tales, riddles, proverbs which are generally unwritten but passes through oral traditions. Historically, most indigenous folklores influenced the sustainable use of species, although with a few exceptions. Evidence indicates that folkloric or religious associations have particularly protected primates, predominantly in Asia and Africa, due to the physical and behavioral resemblances with human (Baker et al., 2013; Riley, 2010; Waters et al., 2018). In central Sulawesi, for instance, indigenous folklores prevented harming the macaques (*Macaca tonkeana*) despite the species’ frequent crop-raiding behavior (Riley & Priston, 2010). However, folklores also contributed to unsustainable use and indiscriminate killing. In Portugal, indigenous folklores negatively portrayed the wolf’s image as demon which resulted in strong apathy for the species (Ceríaco, 2013). As such, reptiles and amphibians are generally least appreciated in the indigenous folklores despite their high ecological and economic importance. Reptiles, in particular, epitomises many negative values within traditional folklores. Nonetheless, as cultures and languages are lost, precious information about species, their uses, as well as the philosophies’ meanings are also lost. Of the estimated 7,000 languages, nearly half is already lost, while some

studies predict up to 90% of the existing language may well disappear by the end of this century (Gorenflo et al., 2012). Africa, in particular, is losing a great amount of linguistic diversity. It is estimated that one language gets extinct every 3.5 months (Rogers & Campbell, 2015). This poses an imminent threat to biocultural diversity, in particular, loss of traditional knowledge, including folklore, traditional music, literature and songs etc. (see section on local practices and indigenous knowledge). There is, however, a dearth of quality documentation on how the annihilation of languages changed certain practices and their relationship with sustainable use of wild species. More so, while the proportionate relationship between language and biodiversity is well-documented, the underlying mechanism of sustainable use remain fairly unexplored.

4.2.5.2.2 Religion and belief systems

Human societies are governed by both formal and informal set of belief systems, including religious beliefs, principles and moral values such as kindness and compassion. Of these, religious belief is defined as a unified system of practices relative to sacred things, aiming to answer the quest and purpose of human life and beyond. Throughout history, every human society has followed certain religious narratives, symbols, and commitments in their public and personal life. Religious practices also include a significant part of ceremonial life, including different festivals, marriage and funeral. All major world religions, irrespective of their geographic occurrence, envision a symbiotic relationship between humans and nature (Negi, 2005). While some religions symbolize nature as ‘God’ or ‘Godly’, some believe nature as the creation of God, which deserves sympathy and respect. Today, nearly 80% of the world population follows a specific religion, which includes 2 billion Christians, about 1.34 billion Muslims, 950 million Hindus, and over 200 million Buddhists. In Africa, and Latin America, frequent syncretism occurs between ancient religion (animism) and revealed religion (Islam, Christianity), with ongoing engagement of ancient rites to preserve the heritage of the ancestors. In addition, there are more than 4000 religions, including animism, totemism with many believers belong to traditional indigenous communities.

According to (Berkes et al., 2001), religious traditions, as such, have a fairly limited role in biodiversity. However, they provide critical values, worldviews, and beliefs, which determine how a society perceives it should interact with biodiversity (Negi, 2005). Religious beliefs can directly influence or mediate sustainable use in mainly two ways, firstly by providing effective protection to wild species in sacred natural sites, and secondly, by altering the attitude towards wild species by declaring it potentially sacred or important for ceremonial life (Pretty et al., 2009). In fact, all traditional societies, to a meaningful extent, were able to conserve the functions of productive ecosystems, which were supported by various kinds of animism, rituals, magico-religious practices and taboos (Negi, 2005; Pretty et al., 2009). Religious sanctions, in particular, played a significant role in conserving threatened species, while also reducing animosity towards wild species (McKay et al., 2018). This is particularly prominent in the Asian sub-continent and in parts of Africa. Religious sanctions facilitated conservation in multiple ways, e.g., through the prohibition of entering certain areas or killing certain species and through instigating a fear of repercussions from doing dreadful things (Negi, 2005). For example, Islam prohibits the hunting and killing of wild animals for sports or for

sale but permits hunting when meat is consumed as food. In this way, Islam prohibits unnecessary killings of animals (Negi, 2005). In Hinduism, several wild animals are considered sacred and the followers are generally not allowed to kill or harm those animals (Kandari et al., 2014). In Hindu theology, God exists in every living being and every animal has the equal right to live. Likewise, in Buddhism, certain wild species, like elephants, enjoy special privilege and recognition. Other religions too, such as Jainism, promote the idea of *ahimsa* (nonviolence) toward human beings and all creations, and harming or hunting wild species is strictly prohibited.

There is strong evidence that religious beliefs and animism promoted sustainable use of wild resources by mainly controlling human practices of extractive use of wild species, especially hunting of animals even in the most unfavorable situations. For instance, according to the local belief, a giant crocodile formed the island of Timor in Timor-Leste, which restricts the killing of saltwater crocodile in the islands despite recurring attacks and crocodile hunting in near-by islands (Brackhane et al., 2018). In Sumatra, despite hostile human-wild species conflicts, local communities do not kill or harm tigers as the communities consider tigers as spirit tigers or as an enforcer of moral rule (McKay et al., 2018). In coastal Bangladesh, local religious beliefs have protected the Black Soft-shell Turtle, Mugger Crocodile, Rock Pigeon and Rhesus Macaque (Mukul et al., 2012). In Ghana, local religious beliefs consider monkeys as ‘untouchable children of God’ and communities refrained from the killing of monkeys, while other species significantly declined (Attuquayefio & Gyampoh, 2010). In Golestan National Park, Iran, a sharp decline of mammals was reported due to illegal hunting. Only wild boar (*Sus scrofa*) showed a population increase because of religious sanctions not to hunt or eat those (Ghoddousi, 2019). Strong evidence is available that religious sanctions can prevent poaching and uncontrolled exploitation of wild species, and thus promote sustainable use. For instance, in 2014, Indonesian Islamic clerics issued a fatwa against the illegal hunting or harvesting of wild species, which immensely helped in the conservation of Asian Elephant. Broader religious efforts such as, Sacred Earth: Faiths for Conservation, engage religious leaders to collaborate in the protection of biodiversity. However, some religious beliefs can also drive unsustainable use of wild species. For example, a study in Singapore indicated that certain beliefs attached to traditional Chinese medicines facilitated unsustainable wild species trade for Saiga – a critically endangered antelope from Central Asia (Doughty et al., 2019). Most of the Saiga users were characterized as middle-aged Buddhists and Taoists, who believed in miracle cures. Nonetheless, literature indicate a generally positive role of religion in promoting sustainable use of wild species.

The importance of religious beliefs in promoting sustainable use of wild species is incomplete without the mention of sacred groves. Sacred natural sites are identified as sites that protect nature and wild species by restricting anthropogenic disturbances due to religious sanctions. Sacred sites are religiously protected territories, the oldest form of conservation, which also find its mention in all the major religious scriptures, including the Holy Vedas and the Holy Quran. Consequently, a large number of self-imposed bio-divinity directives work in these sites. There is substantial evidence that religious beliefs associated with sacred sites halted deforestation of primary forests and in general, promoted non-extractive use of both flora and faunal species. Communities have traditionally attached great importance to sacred forests, and principally used these forests for religious tourism, watching, praying, meditation and healing

purposes. Examples of sustainable use of sacred groves and its floral and faunal species can be found throughout the world, starting from Sub-Saharan Africa, parts of Europe, South America, South and Southeast Asia (Kandari et al., 2014; Negi, 2005; Pungetti et al., 2012). However, sacred groves are predominant in some countries, for example, in India, Ghana and Nigeria. Over 13,270 sacred groves have been reported from India alone, representing different faiths, including both traditional and temple forests (Ormsby & Bhagwat, 2010). Ghana, on the other hand, has more than 1900 sacred groves, along with a long history of cultural forests (Ormsby, 2012). Commensurate with these numbers, the number of peer-reviewed articles reporting multiple use of sacred groves from these countries are considerably high. As such, religious sanctions, beliefs, myths and taboos pertaining to the use of certain plants and hunting ban of animals, are the primary determinant behind sustainable use within the sacred groves. For instance, in Ethiopia, Orthodox Tewahido Church communities have ensured the protection of church forests over centuries despite widespread deforestation in adjacent forests (Aerts, 2016; Klepeis, 2016). Similarly, Bishnoi cult of western India protect sacred groves and its species, locally known as ‘Orans’, which are dedicated to the local deity (Kala & Sharma, 2010). In Ghana, sacred groves were used as the refuge for wild species breeding (Robinson & Sasu, 2013). It is evident that religious protection significantly enhanced biodiversity, in particular plants diversity within sacred groves as compared to adjacent forests and protected areas. Informal networks of sacred groves also played a critical role in maintaining plant diversity (Bhagwat et al., 2005). For instance, the sacred natural site in Jaintia Hills in India gained widespread attention when just 0.5 ha of sacred grove was reported to have 82 tree species, out of which 54 are endemic species and 31 are rare species (Jamir & Pandey, 2003; Upadhyay et al., 2019). Some floral species, however, are typically favoured for sacred groves. For instance, in India, banyan tree (*Ficus bengalensis*), Peepul (*Ficus religiosa*), wood apple (*Aegale marmelos*) and the neem tree (*Azardirachta indica*) are typically considered highly sacred and often used for ceremonial purposes. Felling of these trees are often considered amongst heinous religious crimes. In particular, large old trees are often considered keystone ecological entities within the sacred groves. Sacred groves have contributed to improve the quality of life for people not only in the traditional communities, but also many people used these areas as refuge from stressful urban life. Within the extractive use, sacred groves worldwide continue to serve as rich repositories for traditional medicines (well-established). Medicinal and therapeutic uses of sacred groves are particularly common in Asia and Africa, where several trees and their parts are used as traditional medicine. For the traditional societies, the need for traditional medicine is one of the primary causes of maintaining sacred groves (Adeniyi et al., 2018). Apart from medicinal plants, these also serve as natural pesticides and sacred ingredients widely used in cultural and ceremonial activities. Yet, despite their bio-cultural significance, the spatial extent of sacred groves is rapidly shrinking. A number of factors, including rapid urbanization, globalization and transition to a market-based economy (e.g., rising land prices, land demand) have changed the core religious values and perceptions of local communities, eroding the emotional affinity and appreciation for wild species. Furthermore, current priorities supporting rapid economic development have conferred lesser importance to sacred sites (Xu et al., 2006). In addition, many of the traditional religious practices are rapidly diminishing, due to conversion and changes in religion; religions with smaller number of followers are vanishing quickly. In fact, formal world religions are also experiencing losses of population share and this

might have caused annihilation of several ethno-religious practices. There is also a frequent syncretism, for instance in Africa, between “ancient” religion (animism, totemism, etc.) and revealed religion (Islam, Christianity). If the maintenance of customary rites and preservation of the ancestors’ heritage are guaranteed, the links to wild species could be reinforcing (Bassett & Cormier-Salem, 2007; Dugast, 2002). Information pertaining to these are not rigorously documented (Figure 4.12), however, significant evidence suggests that religious beliefs are vanishing due to the materialistic transitions of human societies, while global mobility and technology has led to cultural homogenization of human societies.

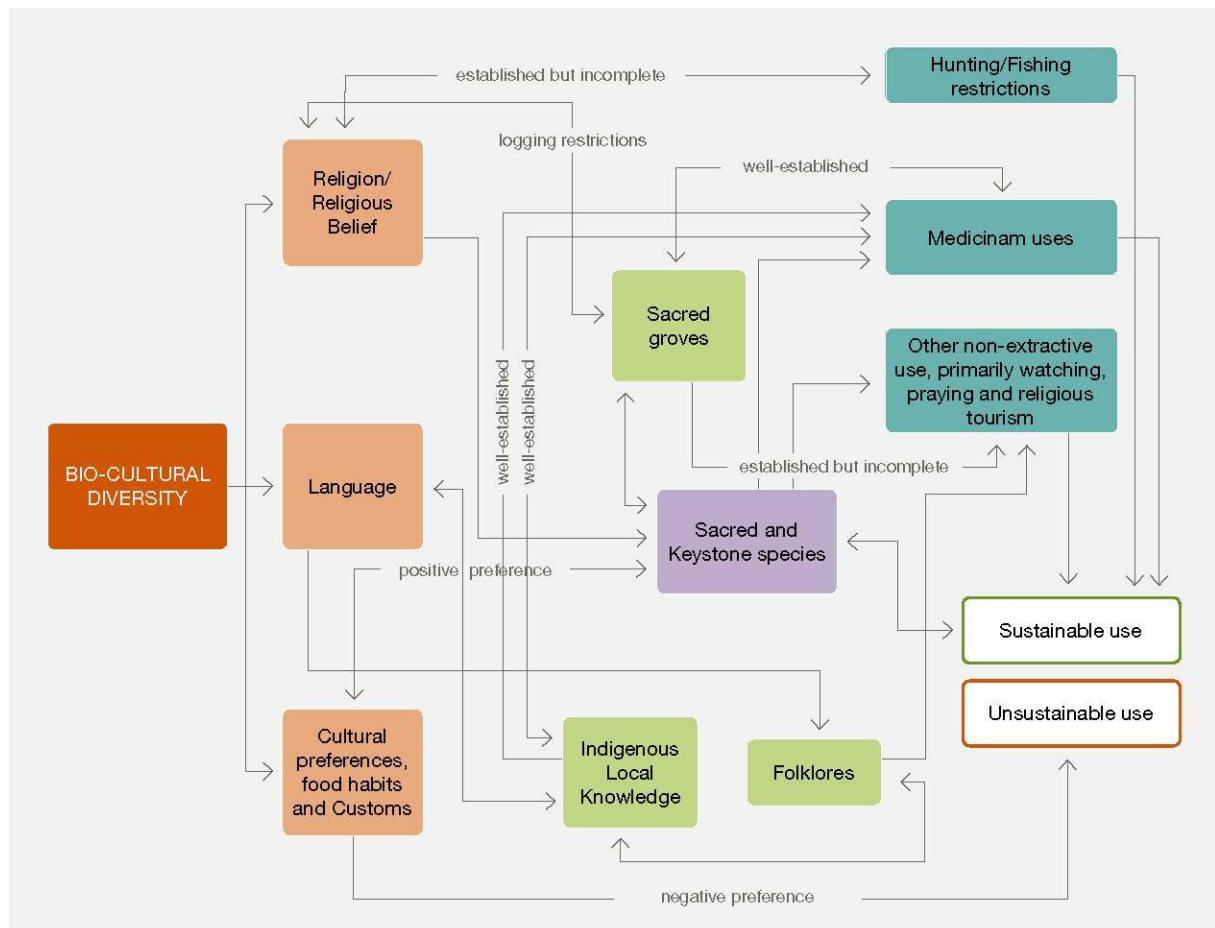


Figure 4.12 The figure summarizes different feedback loops that emerge from the specific literature review conducted for section 4.2.5.2.2. It outlines the three pillars of bio-cultural diversity and how it promoted sustainable/unsustainable use of wild species. The darker lines signify strength of the relationship. Confidence levels are mentioned wherever possible.

4.2.5.2.3 Taboos and traditional belief systems

Taboos are usually social rules that are not written but regulate human behavior (Adler, 1998; Lévi-Strauss, 1962). Such limitations not only govern human social life, but also may affect, and sometimes even directly manage, many constituents of the local natural environment. Whatever the reason for such constraints, taboos, at least locally, play a major role in the protection of natural resources, species, and ecosystems (Begossi et al., 2004; Gadgil, 1987; Gadgil et al., 1993; Johannes, 1978, 1981, 1982, 1984). Taboos resemble mechanisms for the

protection of species and habitats in present-day society, but they have other social rules and sanctions, rooted deep in traditional belief systems. In marine ecosystems, taboos are imposed on specific marine areas to prevent overexploitation of aquatic resources (Chapman, 1985; Johannes, 1978). Taboos are not always permanent in time and space but can be removed when food resources are plentiful. Taboos that directly result in management of natural resources are reportedly found among traditional groups from several parts of the world (Begossi & Souza Braga, 1992; Kwapena, 1984; Reichel-Dolmatoff, 1971; Sankhala, 1993; Sarkar, 1984). These regulations may have been the outcome of a trial-and-error process of resource management strategies like those of the contemporary practice of adaptive management (Holling, 1978; Walters, 1986). For example, Berkes (1997) argues that periods of mismanagement of North American caribou among the Cree in the 1900s resulted, in part, from a neglect of traditional hunting rules. After a change in Cree hunting behavior, the caribou population returned to previous levels. In the same manner, taboos may be employed as a social mechanism for the enforcement of ecologically adaptive behavior, even though different cultural contexts are attached to them. Taboos protect not only threatened and endemic species, but also keystone species (Colding & Folke, 1997).

A study conducted by Colding & Folke (1997) identified 70 species-specific taboos which included both flora and fauna throughout the world. They found that nearly 30% of the identified taboos ban any use of species listed as threatened by the International Union for Conservation of Nature. Of the species-specific taboos, 60% are directed at reptiles and mammals. In these two classes, nearly 50% of the species are threatened, representing all the threatened species in analysis, except for one bird species. Both endemic and keystone species that are important for ecosystem function are avoided by species-specific taboos (Figure 4.13). These reviews indicate that species specific taboos have significant ecological ramifications for the protection of threatened and ecologically important populations of species (Colding & Folke, 1997).

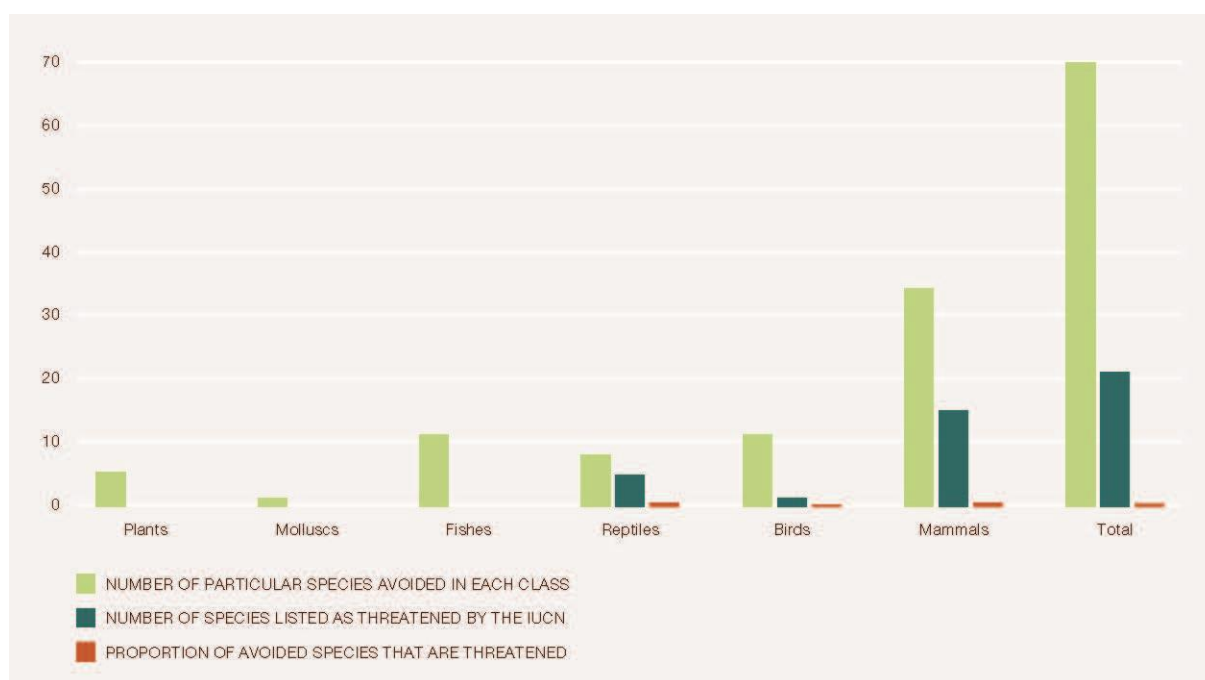


Figure 4.13 Class distribution of avoided and threatened species. Source: adapted from Colding & Folke (1997). © 1997 by The Resilience Alliance. License: CC BY-NC 4.0.

Box 4.31 The fading taboos

Bonobo (*Pan paniscus*), endemic to the Democratic Republic of Congo (Zaire) (Badrian & Malenky, 1984; Thompson et al., 2008) is an endangered species, included under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, and is protected by the Democratic Republic of Congo government. Not hunting or and eating bonobo has been a traditional taboo held by the ethnic group (Bongando) that live in Wamba region of Democratic Republic of Congo. In Bongando folk taxonomy, bonobos are considered not as wild species, but as human beings. The resemblance of bonobo bodily characteristics and behaviors to those of humans is the key reason for this categorization and this similarity has helped to conserve this endangered species. Social and cultural interchanges with other ethnic groups are altering the tradition of “folk conservation.” Research indicates that although this taboo is persisting in older generations, some youth have begun to eat bonobo meat (Lingomo & Kimura, 2009). The taboo is weakening due to numerous influences including, economic incentives, foreigners who choose to eat bonobo meat, decrease in the availability of other game, and the influence of, and hardships caused by, the civil war. To avoid incurring the wrath of God and the ancestral spirits, people make food offerings in the hopes of obtaining game and other wild meat (Lingomo & Kimura, 2009; Tashiro, 1995).

4.2.5.2.4 Local practices and indigenous and local knowledge

Worldwide, indigenous people number over 370-500 million (UNESCO, 2021). They live in about 75 of the world's 184 countries and are inhabitants of practically each main biome of the earth, with a remarkable overlap between indigenous territories and world's remaining areas of high biodiversity. According to the United Nations, “indigenous peoples are inheritors and practitioners of unique cultures and ways of relating to people and the environment. They retain social, cultural, economic and political characteristics that are distinct from those of the dominant societies in which they live.” Despite their cultural differences, indigenous peoples of the world share common challenges and are among the most people in vulnerable situations in the world.

The term indigenous and local knowledge is broadly defined as the local knowledge held by indigenous peoples (Posey, 1999). Indigenous peoples with a historical continuity of resource-use practices often possess a broad information base of the workings of complex ecosystems in their own localities. This accumulated knowledge is passed from generation to generation and generally distilled through their world views, religious affiliations, and customary experiences with nature. Such observations can be of great value and complement the observations on which science is based. The discoveries and inventions of traditional science may not be fully understood by science and, as Lévi-Strauss (1962) suggests, traditional science may be able to perceive and anticipate the discoveries of science. As indigenous peoples have depended on the local environments for a long expanse of time for a variety of resources, they have developed a stake in conserving, and in many cases, enhancing biodiversity. Their practices for the preservation of biodiversity were grounded in a progression of general guidelines, which emerged through experimentation over a lengthy timespan (Lévi-Strauss,

1962). This implies that their knowledge base is specific, and their implementation involves an intimate relationship with their belief system.

Due to the influence of different world views and a belief system of cosmovision, such knowledge is often difficult to fit into the parameters of science. While modern hegemonic science is based in concepts, traditional science is based on perception. To realize sustainable use of wild species, it is critical however, that the value of the knowledge-practice-belief systems of indigenous people are recognized, respected and utilized in the design and implementation of land use and resource management systems. Some societies, such as the Peruvian Yagua, are considered cultural conservationists. Their ideology involves limited exploitation of natural resources, as human beings are perceived as sustainers of the equilibrium of the universe, including the natural and supernatural. Their values, interdictions on food and hunting, and institutional or supernatural sanctions, guide them to act according to their ideology (Cunha & Almeida, 2000).

Rituals and offerings are a way to establish communication and a relation of reciprocity with nature. When community members in the Yucatan region of Mexico prepare the land for cultivation, for example, they touch the soil and ask for permission to plant. They engage in rituals as a demonstration of respect for the earth. Their actions and prayers ensure that soil quality is maintained and that good relations are kept with the deities associated with the soil and land. Such rituals of reciprocity echo those of cultures worldwide and reflect a world view of being one with the earth, rather than separate from it. This is not a demonstration of dominion over the earth, as is common in western societies and agribusiness, but a sense of belonging to, and kinship with, the natural world. In this way, reciprocity and sustainable management practices are ensured. According to Barabas (2003) reciprocity occupies a range of behaviors from altruism to deferred exchange. A force in all aspects of indigenous life, reciprocity is central to a value system that envisions humans in relationship with both the tangible and intangible worlds.

4.2.5.2.5 Management and indigenous and local knowledge

Effective and sustainable management of populations of flora and fauna needs quantifiable information on rates of harvest, survival, and reproduction, as well as data on population size, habitat, and demographics to ensure that harvest does not endanger the survival of populations (Lebreton et al., 1992; Ludwig et al., 1993). For many populations of wild species, however, scientific information required to gauge sustainable management practices is lacking. Over the last few decades, there has been growing recognition by the research community, that traditional and local ecological knowledge (see Chapter 1) offers a valuable source of information to complement “western scientific approaches” to resource management (e.g., Berkes et al., 2000; Chemilinsky, 1991). Because local ecological knowledge is typically derived from people who have lived with, hunted, and gathered wild species over decades, their role in resource management is analogous to “expert opinion” used in population modeling (e.g., Walters & Holling, 1990; Zabel et al. 2002). Ecological knowledge has been applied to various scientific disciplines (Gadgil et al., 1993; Johannes et al., 2000; Krupnik & Jolly, 2002), and, in managing wild species, it may be primarily useful when managing populations that occur in isolated locations where widespread scientific studies may be impractical (Barsh, 1997). Despite the

profound utility of local ecological knowledge, it has been received skeptically by some wild species managers and conservation biologists.

The coexistence of different forms of plant management and manipulation is particularly important in the case of edible plants. Multiple forms of management result in the persistence of diverse cultivars including those that combine superior flavor and better medicinal properties, with resistance to pests, floods, droughts, and the impacts of climate change (Mastretta-Yanes et al., 2018). As (Maxted et al., 2013) establishes that wild relatives have been found to have higher genetic diversity in terms of drought, pest, and disease resistance than their cultivated counterparts.

Box 4.32 Cosmovision, transformation and fallow - Milpa management in the Yucatan

Among the Mayans in the state of Yucatan in Mexico, specialized milpa production systems termed, the 'monte', are fallow areas where secondary vegetation grows. According to Maya cosmovision the vegetative growth undergoing regeneration is on its way to resurrection. Therefore, Maya campesinos do not abandon the milpa but instead return it to the owners. the *Yumilo'ob K'axo'ob*, the Lords of the Mountains. These powerful inhabitants ensure the continuity of life and supernatural force circulates through them, giving permanence to the milpa and the milperos. In the cosmovision of the native peoples, the phases which are not cultivated or intensively managed at the species and landscape level, are part of the transformation of the elements of nature and their symbolic forces (Quintanilla, 2000).

In the milpa, a wide variety of wild species are collected for food use, among them 20 species of wild sweet potato. These wild sweet potatoes have been crucial for survival during times of famine, even within the living memory of the elderly. Archeological evidence, and historical records show that since pre-Hispanic times, locusts (*Schistocerca piceifrons*), have periodically caused plagues with widespread destruction and fatality. Having an underground source of food such as sweet potatoes, has been especially important during such disasters. The cultivated and wild sweet potatoes are key, as the tortilla mixed with ground sweet potatoes was the main food source.

The sweet potato is collected in the young or mature growth, which is left fallow after its use for the production of the milpa. The cultivated and wild sweet potatoes are key, the tortilla mixed with ground sweet potatoes was then the main food.

4.2.5.2.6 Indigenous and local knowledge and wild food plants

Food is central to the culture, health, and well-being of society. Maintaining traditional food systems is important to revitalization of indigenous peoples and conservation of local knowledge. Traditional use of wild plants, utilized as food or medicines is common to both rural and urban societies (Aziz et al., 2018; Meragiaw, 2016). Ethnobotanical studies have documented medicinal and other traditional uses of wild plants, employed for human health, nutrition and veterinary use (Aziz et al., 2018; Halmy, 2017; Heneidy et al., 2017; Meragiaw, 2016). Nutritional values of wild foods and their key place in sustaining indigenous peoples and local communities' culture is important to be considered when designing sustainable use systems. Traditional practices of collection, preparation and consumption of wild plants are widely practiced in both rural and urban settings. Wild plants contribute to the nutritional wellbeing of families as well as offering a source of income generation. However, in situations of increased demand for a particular species, some traditional practices may become threatened

by local populations, as well as by third parties (see Box 4.33), interested in generating income from increased exploitation of the natural resource (Chauhan et al., 2018).

Box 4.33 Native maize: A protected cultural heritage

In the new Mexican political context, a set of conflicting public policies are emerging that may impact wild plant management and consumption. On the one hand, there is the April 13 agreement arrived at after a long negotiation between decision makers and collectives and rural communities with the goal of protecting local varieties of maize in Mexico. This Federal Law for the Development and Protection of the Native recognizes that the production, marketing, consumption, and diversity of native maize are cultural manifestations of Mexico. The preservation of native maize in all its variety places an implicit obligation on the State to guarantee a nutritious, sufficient and high-quality food free of genetically modified organisms. It is important to emphasize that even though maize has been domesticated since pre-Hispanic times, populations of the closest wild relatives of maize (*Zea mays* cultivated), known as teocintles (*Zea parviglumis*, *Zea diploperennis*, *Zea luxurians*, etc.) and *Tripsacum* species, continue to live together in the environments of the Mexican maize fields and contribute to enriching the genetic variability of native or creole maize cultivated via free pollination (Kato et al., 2009). This law will favor the permanence of traditional milpa management practices, which include maintaining wild relatives of maize and other species with local uses.

At the same time, the national Plant Variety Law is under discussion. This law would prohibit the free exchange of seeds, which has been essential for the protection of biocultural wealth and food sovereignty in Mexico. In addition, it would allow companies and external agents to obtain the intellectual property rights for seeds from the rural towns and communities that have maintained the great diversity of native species of multiple use in the country.

Great emphasis has been recently placed on the role of traditional food in human health and nutritional status. Many traditional foods, particularly wild variants, are nutrient dense, making a substantial contribution to daily nutritional intake, especially for marginalized social classes. Additionally, traditional food as well as condiments, constitute an essential aspect of cultural heritage. Since foodways are highly ingrained and part of the evolution of human behavior they are developed by the interaction between the ecological environment, cultural institutions, and family dietary patterns (Contreras & Gracia, 2005). Studies in Mexico have found that an especially important set of condiment species with unique flavors and properties are found in wild populations and missing in cultivated populations. Wild collection of these species is the most common way of managing them. Notably, in recent years, as migrant populations from Mexico move to the United States of America, demand for these plants have increased in North America. Worldwide, the large number of immigrants with a significant amount of traditional communities' influences consumption in the countries where they settle. Demand for wild plant species by immigrants has strongly influenced local and national cuisines, increasing the marketing of imported wild products which are often transported by immigrants themselves.

The Ethnobotanical Database of Mexican Plants of the Botanical Garden of the National Autonomous University of Mexico, records 16,000 uses for a total of 4,000 plant species which corresponds to more than 50% of the total estimated useful plant species in Mexico. According to Caballero et al. (1998) two patterns of usage emerge. First, the majority of utilized plant

species are wild, and second, the main uses are for food and medicine. Although the basic diet in rural populations consists of a set of cultivated and domesticated species, the diet is significantly supplemented by a large number of other plant resources, most of them wild or under “incipient management”. These supplemental species provide essential vitamins, minerals, and other important nutrients. Although traditional food is being studied for nutritional composition and cultural food use, there is still a significant research gap (Heinrich, 2006), which could endanger food and health security as traditional knowledge erodes.

Local traditions rely on information being passed on from one generation to the next in one community or in a small region. Traditional food knowledge and traditional ecological knowledge (Heinrich, 2006) are strongly influenced by socioeconomic and cultural determinants, religion and history and their dissemination differs in local or national languages. However, transmission of indigenous and local knowledge is being interrupted in many communities. This trend represents a challenge to indigenous peoples and local communities and their traditional ways of living, including spiritual practices and relationships to land, waters, and other beings. Among the adverse consequences are a shift away from nutritious wild foods. The loss of a traditional languages is closely tied to the erosion of practices and uses related to wild species.

Traditional ecological knowledge is both cumulative and dynamic, building upon the experience of early generations and adapting to new technological and socioeconomic changes of the present. Although less attention has been paid to the situation of traditional ecological knowledge within Europe and highly industrialized countries, there are many cases of traditional use and consumption of species in specific and isolated regions (Heinrich, 2006), as well as in urban areas, which are important for biodiversity conservation, local cultures, and the maintenance of a healthy life for coming generations.

Box 4.34 Apatani’s and their indigenous knowledge – A classic tale from Eastern Himalayas

The Apatani eco-cultural landscape in Ziro Valley of Eastern Himalayas represents as an excellent example of a uniquely distinct natural resource management practice which involves local and traditional knowledge systems. Apatani (earliest ancestors are termed as Abotani), is a small hill tribe that resides in the Eastern Himalayan region rich traditional knowledge. They have rich knowledge of medicinal plant use (45 species are listed) and some of these are nutrient-rich plant species supporting food security (Rai, 2005; Srivastava et al., 2010). The Apatani practice a unique, advanced agricultural practice called, the paddy-cum-fish cultivation. The main advantage from the practice is that the land gives sustained yield year after year, unlike the Jhum system, that is under cropping only once in a few years of fallow interval, depending upon the Jhum cycle. The economic and energy efficiency of this agro-ecosystem is exceptionally high, and, after meeting local needs, rice is exported. Rain fed cultivation of millet and mixed cropping contributes toward meeting the diverse needs of the people. Mithun (*Bos frontalis* Lam.), Swine and poultry husbandry are an important link with agro-ecosystems (see Rai, 2005 for further reading). This indigenous knowledge system helps reduce the pressure and dependency on the surrounding biodiversity.

There are cases where despite difficult conditions, indigenous peoples and local communities are drawing on indigenous and local knowledge and customary rules and norms to revitalize traditional practices, restore disturbed environments, recover wild species

populations, and reinvigorate more traditional ways of living, as in the case of the Xingu Seeds Network in Brazil (Antoniuzzi, et al., 2011).

Ethno-veterinary use of plants also remains very important, because many indigenous peoples depend on their livestock on a daily basis. Several animal diseases are treated through the use of indigenous knowledge on the use of parts of fruit trees and other herbaceous plants and trees (Cheikhoussef & Embashu, 2013; Khan et al., 2019; Maroyi, 2017). Conventional remedies for animal health care are inaccessible or unaffordable to indigenous people, incentivizing local communities to maintain traditional treatment practices.

There is much evidence that traditional knowledge systems contribute significantly to wild species conservation globally (i.e., Table 4.5 on practices and customary laws). Traditional knowledge systems are under stress in many parts of the world due to many factors associated with colonization, globalization (i.e., economic stress and socio-political marginalization (Gómez-Baggethun et al., 2013). These broad patterns are compounded by land use change associated with industrialization and globalization forces and westernization (Harmon & Loh, 2010; Turner & Turner, 2008). Historically, academic efforts have focused on documenting the loss of traditional knowledge systems (e.g., salvage paradigm) and not in understanding the processes that drive those changes. Moreover, there is less focus on how to support and nurture traditional knowledge in ways that ensure its continued use and value in wild species stewardship (Gómez-Baggethun & Reyes-García, 2013).

However, during changing, challenging conditions, indigenous peoples and local communities can draw on indigenous and local knowledge and customary rules and norms to revitalize traditional practices, restore disturbed environments, recover populations of wild species, and reinvigorate more traditional ways of living, as in the Mapuche communities in northwest Patagonia of Argentina, where regional knowledge about fungi is an important aspect of their tradition but process of changes also responds to complex and dynamic socioeconomic and ecological contexts (Morales et al., 2019). Other activities, such as gathering ‘gum breá’, an exudate of the *Cercidium praecox* tree in the Province of Salta, Argentina, despite not being traditional, can contribute to the generation of moments of cultural transmission, intergenerational learning and the strengthening of local identities and links between communities and territories (Olivera, 2018).

4.2.5.2.7 Customary values of wild species and policy-making challenge for sustainable use

The complex links, that bind indigenous peoples and local communities to wild species, are based on multiple values, uses and institutions, that change regarding the actors and the historical and geographical context. In this section, the purposes are to highlight first, in what way the customary values attached to wild species are (or not) a driver of sustainable use; second, to what extent changes in customs, positively or negatively, impact the use of wild species; third, to what extent policies consider customs and associated values for sustainable wild species governance.

- **Customary values of wild species as driver of sustainable use**

The customary values of wild species encompass a set of anthropocentric values (Chan et al., 2016; Maitre d'Hôtel & Pelegrin, 2012; Skubel et al., 2019; Stålhammar & Thorén, 2019) , either instrumental, either relational, either intrinsic, defined by a group. This group, at multiple scales (clans, lineages, villages, collectivity, community, associations), is the main player for the management and the governance of the species, which implies the set-up of local institutions or customary rules.

The close and deep relationships between a group and a species (or a space/ a site) are anchored in the local culture and the feeling of identity and/or dependence for the subsistence and the well-being (Borrini-Feyerabend, 2010; Garibaldi & Turner, 2004). Those relations are mediated by customary institutions, among others: totemic species, sacred sites, ancestral sites and meeting places, ancestral shrines (pioneer settlers/ land use in and around the shrine sites), animal taboos, spiritual practices and ceremonies (songs, dances, initiation), traditional calendar, village lands (“terroirs”) and territories, etc. (Adler, 1998; Artaud, 2021; A. Begossi et al., 2004; Lévi-Strauss, 1962). Indigenous peoples and local communities depend on those institutions for their livelihoods, with which they identify and which they control through ritual offices. These customary institutions are more or less formalized and recognized by official institutions (cf. chap 6) or combined with official systems of governance (positive law) in a context of legal and institutional pluralism. Therefore, custom systems (values, norms, institutions and rules) are recognized to play a major role in the development, management and control of wild species (Armitage et al., 2017; Artaud & Surrallés, 2017; Bennett et al., 2017; Cinner, 2009; Clark, 2011; Frangoudes & Gerrard, 2018; Hulme & Murphree, 2001; Johannes et al., 2000; Pascual et al., 2017).

Box 4.35 Use of “chaguar” by Wichi women

In Argentina's dry Chaco eco-region, local communities depend on the integral use of the forest for terrestrial animal harvesting, and obtaining food, fiber, shelter, and medicine from timber and non-timber forest products. In the context of increasing deforestation, expanding agribusiness and the loss of communal lands, traditional territories and resources are rapidly diminishing with negative repercussions for rural families (Paolasso et al., 2012). The Wichi people give special importance to the collection, processing, spinning, dyeing, and weaving of chaguar (*Bromelia hieronymi*), an herbaceous plant with succulent leaves. Both the fiber of “chaguar” and the products derived from it are not considered as mere objects of use to be eventually discarded by the communities, but hold a strong symbolic meaning giving identity and character to local communities (Sastre-Merino et al., 2013). The myth "The Advent of Women" conveys that the first women who descended from heaven into the world of men did so using braided ropes of chaguar. The plant has a prominent symbolic role in the female rite of initiation, in which women begin to spin and weave from adolescence. Beginning in childhood, girls accompany their mothers and female elders to the forest to collect chaguar, and learn the processes of spinning, coloring, and weaving that become central to their lives as adults. In the courtyards of their homes, grandmothers, mothers, and daughters come together to make textiles. These shared activities serve to transmit knowledge to new generations and integrate young women and girls into the community (Sastre-Merino et al., 2013). Appropriation of land by the agribusiness sector and forest clearing and degradation have resulted in diminished access for women to the chaguarales, as well as other resources necessary for food, shelter, and medicine. In this way, women lose not only the material resources needed to sustain daily life, but their socio-cultural and economic role in contributing to the community economy. The disappearance of these activities also contributes to the loss of knowledge

and symbologies that the Wichi peoples have developed for centuries. Therefore, it is important to encourage more sustainable forms of resource use, the addition of value to forest products through processing, and access to fair trade markets. In this context, the USUBI (Sustainable Use of Biodiversity) project, carried out by the Ministry of Environment and Sustainable Development of Argentina, works with Wichi women from the communities of Los Baldes, La Cortada, and Pozo El Chañar surveying chaguarales, promoting enrichment practices with chaguar in experimental plots, and hosting training workshops to improve artisanal products. These community-driven actions are aiming to generate locally derived, socially and environmentally sustainable solutions to prevent the loss of biodiversity and shore up centuries-old traditional knowledge.

There are a number of scientific-based evidence (or extensive literature) on the subject. Customary institutions, social practices, and cultural values participate, intentionally or not, in natural resource conservation (Dounias, 2007; IPBES, 2019b; Lizet & Millet, 2012; Ruddle et al., 1992) indigenous peoples and local communities, by virtue of their proximity to natural resources, are the most capable of preserving them (Agrawal & Gibson, 2001; Bouamrane et al., 2016; Dugast, 2002; Posey, 1999).

From a vast literature review and critical analysis, three categories currently are identified, namely instrumental, relational and intrinsic (Figure 4.14). These norms and values exclude or combine, succeed one another, or are superimposed on one another, mediated by institutions and customary rules, which regulate practices (hunting, fishing, gathering, etc.). As a matter of fact, the convergence of a species as “good for using (eating, clothing, healing...)”, “good for preserving” and “good for thinking” most often assure more efficient conservation of wild species.

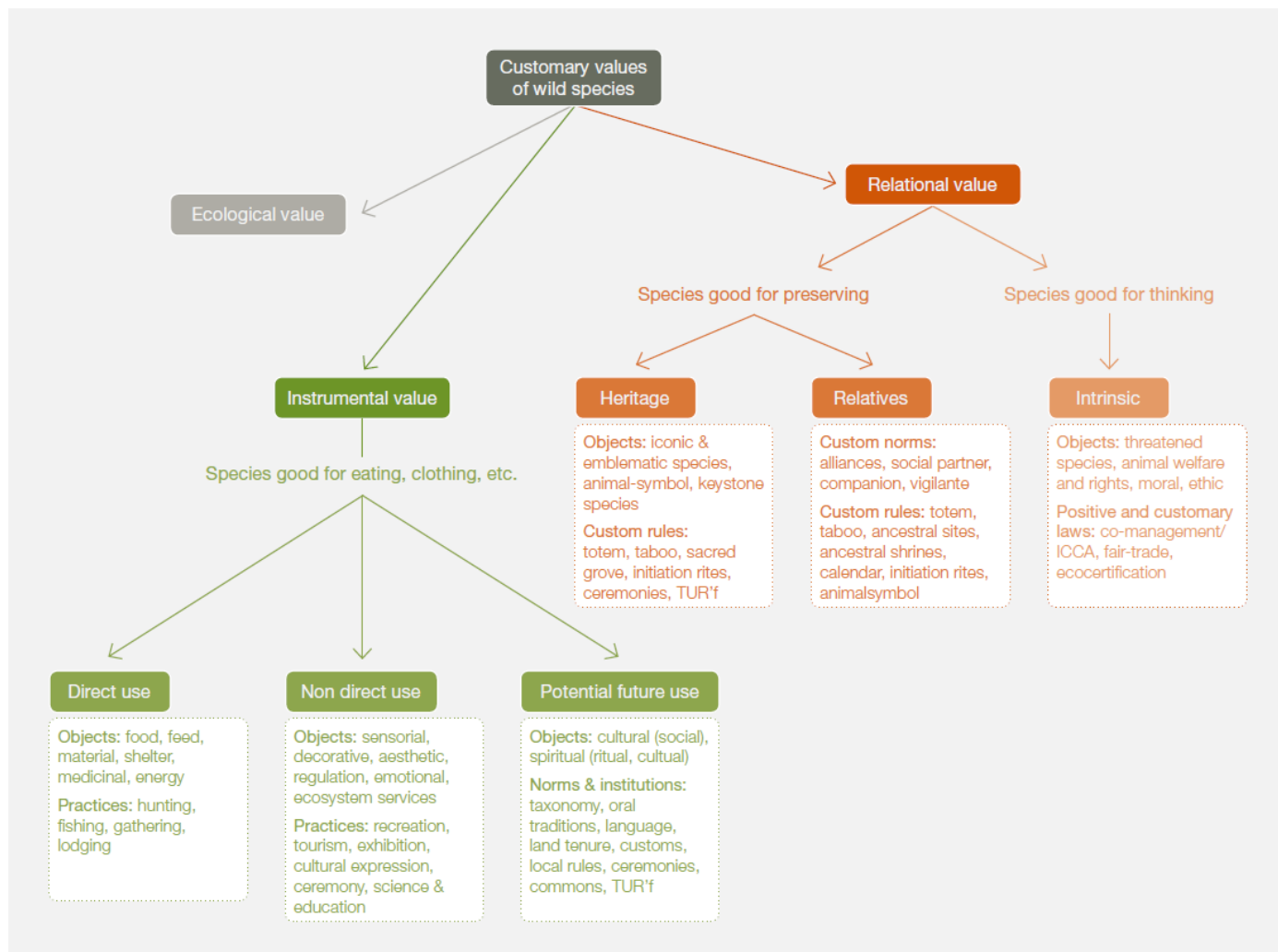


Figure 4.14 Set of customary values of wild species. Source: adapted from Skubel et al. (2019) © 2019 under license CC BY.

Thus, the capture of an animal, its killing and the sharing of its body are subject to customary rules of respect, reciprocity, and sobriety. The indigenous and local knowledge report cites many examples of such customary rules including the relationship of Maasai with wild species.

Many indigenous peoples and local communities have rules for sharing the catch, with a special sin granted to the genitals of animals, endowed with aphrodisiac virtues and most often intended for the "big chief" or lineage elder (Agrawal & Gibson, 2001; Artaud, 2014; Benitez-Capistros & Couenberg, 2019; Johannes, 1981).

Moreover, the construction of wild species as iconic, and its transmission from generation to generation – is often deemed a tool for sustainable natural resource management and are susceptible to gaining heritage status (Bassett & Cormier-Salem, 2007).

The relations between people and wild species are complex and dynamic: they are complex, in so far as there are differential relations between species and what they reveal about the differential relations between social groups; one species can be considered by a group or certain members of that group (female or male initiated, priests, intercessors, etc.), at the same time and in the same place or according to the period and to the place, good for eating,

preserving and/or thinking. The relations are dynamic in the same way that the social structures should adapt to the change. Human societies look to animal and plant species in their environment as a means to structure their social world (Lévi-Strauss, 1962). The reproduction of the social system (the establishment and maintenance of human interactions) requires a permanent reorganization of these relations between humans among themselves and between humans and nature regarding the links between tradition and innovation and resilience (Berkes et al., 2003; Cinner & Barnes, 2019; Cosens, 2013; Matin et al., 2018; Prado et al., 2015; Yadav et al., 2019; Young et al., 2006).

The following sub-section will have two lenses: first on wild plants and medicinal values; second on wild fauna and animal symbolism.

- **Customary (traditional) medicinal values of wild plants**

Medicinal values of wild species, especially wild plants have been extensively studied in recent years. For example, a study by (Shinwari & Qaiser, 2011) in Margalla hills National Park in Islamabad, Pakistan provides a list of wild plant species that are used by local people and *Hakims* (local practitioners) to treat several ailments. For instance, *Achyranthus aspera* is used for seasonal cough leaves of *Calendula arvensis* to heal wounds, leaves of *Achyranthus aspera* with the fruit of *Rubus fruticosus* for eye diseases, *Chenopodium ambrosoides* for piles, etc. However, widespread recognition of such values, as well as population growth, promote overexploitation. The regeneration and propagation of the above-mentioned species are of concern in the region due to their unsustainable use, which includes untimely plucking of leaves, and flowers or uprooting the whole plant without considering its further propagation. Similarly, local communities living around Queen Elizabeth National Park, Maramagambo Central Forest Reserve and Ihimbo Central Forest Reserve in Southern Uganda identified nearly 302 medicinal plants, many which are used to treat several ailments including digestive disorders and allergy (Gumisiriza et al., 2019). In addition to medicinal values, 47 wild plants species are also consumed as food, highlighting the nutraceutical value of the species. Out of 302 plant species identified, 91 were reported to be rare. In some cases, the use of roots, or several parts of the same plant for medicinal use results in killing the plant, thus destroying the chances of survival and propagation. In another study, 79 wild medicinal plant species were listed from Jordon (Al-Qura'n, 2009). Though the medicinal values of wild species are generally well-acknowledged, a lack of ethnobotanical, ecological, as well as ethno-pharmacological information on wild species often leave them vulnerable to overexploitation. In addition, indiscriminate and commercial use is also resulting in the loss of various wild plant species making them rarely available.

Communities value wild species not only for their medicinal or market values but also for a combination of criteria, including socio-cultural and environmental values. An ethnic group in Bénin, for instance, used a range of criteria including the plant's nutritive value, popularity, absence of taboos, its availability, and the energy input necessary for processing (N'Danikou et al., 2015). The community also considered the perceived value of the species over their rarity for conservation. Wild species, especially wild edible plants, are considered important to maintain cultural identity (Schunko & Vogl, 2018; Seeland & Staniszewski, 2007), and spirituality (Hummer, 2013). Wild food is considered as a mark of local and regional traditions and is an irreplaceable expression of natural and cultural heritage (Pardo de Santayana

et al., 2012; Seeland & Staniszewski, 2007). For instance, wild foods have been part of traditional cuisines across the world, thus imparting cultural identities to various communities.

Box 4.36 Generational transmission of ancient healing knowledge – Tibetan Amchis

Traditional Tibetan medical doctors and the traditional practitioners called Amchis, who use herbal remedies and analyze pulse, urine, and tongue to diagnose disease and are one of the oldest surviving medical traditions of the world. It has been popular throughout the central Asian regions of Mongolia, Bhutan, some parts of China (Tibet Autonomous Region), Nepal, the Himalayan regions of India, and a few areas of the former Soviet Union. In the trans-Himalayan district, Dolpa of Nepal, Amchi knowledge is passed down through dedicated apprenticeships under the tutelage of senior Amchi (Bhattarai et al., 2009). In Dolpa – a northern and remote district of Nepal, more than 400 plant species were documented, and the area was found to be exceptionally rich in ethno-medicine and indigenous knowledge (Ghimire et al., 1999, 2001), including use of caterpillar fungus (*Ophiocordyceps sinensis*) for the treatment of various diseases (Devkota, 2006). According to the Tibetan concept of illness, disease arises when the dynamic equilibrium between the three psycho-physiological conditions or ‘humors’ (nyepa-sum) translated as wind (lüng), bile (tripa) and phlegm (beken) are disturbed (Khang, 1981; Lama et al., 2001; McGehee, 2012). Amchis diagnose the disease without any sophisticated instruments by determining whether the nature of the disease is ‘hot’ (tsa) or ‘cold’ (dang) (Lama et al., 2001). The basis of their diagnosis is analysis of pulse, urine, and tongue. The treatment of disease involves the use of herbal medicines as well as moxibustion and bloodletting (Ghimire et al., 1999, 2001; Lama et al., 2001). In Amchi medicine animal parts, and various minerals, stones, such as alum, calcium, camphor, copper, emerald, gold, granite, iron, lead, limonite, magnesium, mercury, sapphire, quartz, talcum, zinc, etc. (Khang, 1981), are also used for the preparation of medicine. However, Amchis face great difficulties in getting some of these products because of legal restrictions (Rokaya et al., 2005). Training and less restrictive guidelines for the collection of medicinal resources, would assist local people in scaling up production, generating income, and preserving an age-old healing practice (Rokaya et al., 2005).

A study by Ali-Shtayeh et al. (2008) of 15 communities living under the Palestinian Authority, communities were found to gather nearly 100 wild edible plant species and to consume many of them cooked. For example, the leaves of *Rumex acetosa* are used as filling for a traditional pie called 'sambosek' or *Majorana syriaca* is used for preparing a traditional recipe that is popular in Palestinian communities called 'za'tar'. A few of these wild plants are mentioned in local folk songs and proverbs (*Malva sylvestris*, *Gundelia tournefortii*, *Salvia fruticosa*). The study also highlighted how some wild plants are considered sacred as they are mentioned in holy books (e.g., *Majorana syriaca* in the bible), or blessed for being mentioned in legends linked with holy people (e.g., *Salvia fruticosa* and Virgin Mary). In Northern India, similar findings are reported (Chandra, 2013) where wild species of temperate Himalaya, like *Dioscorea belophylla* (locally known as Tairu) are used in traditional recipes to be consumed during winter, especially at festivals (Chandra, 2013).

Indigenous peoples and local communities in many regions depend on flora and fauna for food provisioning and cultural uses. In many cases, these uses are non-commercial (i.e., subsistence); in other cases, flora and fauna are shared through commercial markets (i.e., products sold commercially); in both instances, flora and fauna make important contributions to the health and welfare of communities (Cheikhyoussef & Embashu, 2013).

The contributions of flora and fauna to improved health outcomes are essential for many Indigenous Peoples and local communities. Clinically proven and perceived health benefits are also driving broader use of flora and fauna. In many countries common ailments, are treated at the household level, since diseases are considered to be connected with natural causes and hence their symptoms. This, in turn, can trigger unsustainable use. Moreover, large number of wild animals are consumed as ornaments, medicines, cosmetics, weapons, leather, and luxury lifestyle products (e.g., fur, wool...etc.). From large mammals to amphibians, unsustainable exploitation of wild species is often driven by social status and lifestyle, leading to uncontrolled exploitation of wild species. For instance, luxury seafood such as sharkfin soup, live reef food fish...etc. are often associated with traditional Chinese culture and medicine (Dell'Apa et al., 2014; Fabinyi, 2012). Although in most cases such perceptions are misguided, the perceived benefits trigger high demand and consequently unsustainable exploitation of wild species.

4.2.5.2.8 Relational values of wild fauna

Nature occupies a privileged place in the symbolism produced by cultures around the world. Among all the elements of nature, animals are considered privileged communication partners in the processes of knowledge of humans. As expressed by (Dounias et al., 2007), the animal symbol is the means by which man constantly strives to distinguish himself from or, on the contrary, to resemble, hoping to acquire its ability to liberate himself from certain human constraints. This animal is usually a real, tangible animal, and often a wild one. The species chosen differ from culture to culture and according to environmental, geographical, social, and historical contexts, as well as the psychological context, because all relations with animals call upon people's sensitivities and shared emotions. The formation (birth, with its reasons, choice modes, etc.), form (universe of signs, dialogue between concrete inventions, oral traditions, and writing), meaning (cosmogonies, myths, taxonomies), function (of mediator, unifier, pedagogue, socializer...) of animal-symbol (Dounias et al., 2007) illustrate the complex nature of the relationships between humans and wild species, the variability (sometimes of contradictions), multiplicity (of the layered levels of meaning), ambivalence, and also their constant reactivation or recreation.

The analysis of the local taxonomies is recognized as particularly efficient in documenting the place or the customary value that different species occupied for the indigenous peoples and local communities. The process of categorization is also considered as one of the most powerful solutions used by human to break up the world's complexity and there are a number of examples to illustrate this. A key finding from the indigenous and local knowledge workshop is that there can be sanctions or punishments for violating customary rules and norms designed to assure good relations with species and with nature.

4.2.5.2.9 Iconic species for indigenous peoples and local communities

Two major types of iconic species designation processes can be identified:

- **exogenous ones** that originate at the international scale: foreign actors, environmental lobbies, large non-governmental conservation organizations, and scientific experts. One only has to cite it in the International Union for Conservation of Nature red list or at the

Appendices of the Convention on International Trade of Endangered Species. The history of these exogenous designations is well documented (Adams, 2006; Grove, 1996; Mackenzie, 1998; Neumann, 1998). They date from the late nineteenth century with the establishment during the colonial period of game reserves for hunting by foreigners and continue today in the creation of national parks by modern states (Rodary et al., 2003). This history is replete with exactions made on the peoples living in or adjacent to the protected areas who have frequently been expelled, displaced and deprived of access to and use of their customary resources. It also provides many examples of imbalanced land-use patterns between protected areas that are little more than private reserves of a foreign elite engaged in trophy hunting or nature-based tourism and non-protected areas that are subject to intense demographic pressure and overuse of resources.

- **endogenous ones** (indigenous peoples and local communities and their organizations) that are more locally derived. In many instances, the two merge and thus become indistinguishable in origin (Fairhead & Leach, 2003; Luning, 2012). The Paris Convention, for example, takes into consideration the aesthetic, symbolic and historical value of retained sites.

4.2.5.2.10 Changes in customary values and status and effect on the use of wild species

Certain elements can lose their customary (or privileged) status while others might acquire it. The content of a custom is thus susceptible to alterations in the context of religious and political change, environmental transformations or diffusion of new ideas, products and peoples (through migration, for example). In Africa the erosion or transformation of ancestral cults by the spread of Islam and Christianity has turned sacred groves into profane places that are no longer protected from the axe (Dugast, 2002; Juhé-Beaulaton & Roussel, 2002). Thus, certain elements that were previously the object of implicit or explicit conservation measures have now lost their meaning and value and are no longer preserved. Such is the case with formerly taboo animals. Conversely, new natural elements can be invested with a patrimonial or identity dimension. For example, in Sub-Saharan Africa, indigenous peoples and local communities link land degradation to the erosion of customary institutions and knowledge, ritual neglect, and the diminished authority of land priests. While the Maane (Burkina Faso) recognize that demographic pressure has produced a demand for arable land on the Moose (Mossi) plateau, they ultimately interpret the disappearance of the bush as a consequence of a breakdown in their socio-cultural system Luning (2012). In Mauritania, Imraguen fisherfolk (Artaud, 2021): cultural values attached to 2 species (turtle and manatee): it's to-day loss of strength or its rebirth. While the manatee has lost its cultural relevance with the end of relations between herders and coastal communities, the importance of the turtle has doubled since the development of the National Park of Banc d'Arguin.

Box 4.37 The changing status of shark

From the (artisanal) fisherfolk knowledge, the shark is neither a predator nor a prey, but rather a social partner, with various protective, vigilante or even totemic status for certain lineages in Pacific islands (Bataille-Benguigui, 1988) or in Africa (M.-C. Cormier-Salem, 2006). The shark only became a target species with the removal of fins, which has resulted in many social and spatial changes on tropical coasts (Africa, Madagascar, Asia)

Regarding the customary values of the shark within West African communities, three main relations can be schematically identified:

1) in some communities, estuarine, lagoon and island, the shark is game, the capture of which gives rise to collective hunting and meat is a delicacy. Smoked or salted-dried shark flesh constitutes an essential source of protein for certain forest and Sahelian populations; in certain coastal communities, it is a sought-after dish, and even locally, with a strong identity burden as among the Aïzi Ivorian lagoons (Verdeaux, 1981).

2) In others, on the contrary, among peasant-fisherfolk, it is an iconic animal, which gives rise to many myths and rites (see below initiation rituals of Bijjogo people, Bissau Guinea). Among the Bijagos, in Guinea Bissau, sharks are an emblematic species, as evidenced by the sumptuous prows of the Bijagos canoes bearing the image of this animal, ritual dances with masks dominated by shark (or rather fish) saws. Sharks are also involved in the initiation of rites as young boys, to reach adulthood, should capture a shark and present its liver to the elders. These rites are very similar to that practiced among the Maasai populations of Kenya, which the writer J. Kessel helped to magnify: the Morane is considered by the tribe a man capable of marrying a woman when he kills a lion with a knife and a javelin. For this hunt, he is adorned with hair similar to the lion's mane. This parallelism between the lion and the shark is also noted in certain coastal communities: in Wolof (Senegal), the generic name for the shark is *gainde gejj*, that is to say literally "lion of the sea. Like the lion, who owes his power, his strength and his majesty, to be the king of the jungle, the shark, sea monster, is the king of fish, or more precisely the king of marine fauna. We don't fish it, but we hunt it like all great predators. The liver sample is not surprising because, with the heart, it is the most valued part of the body.

In the animistic pantheon of Diola de Casamance, marine animals are widely represented. Sharks, alongside manatees, dolphins and caimans, often have the status of totem animals. The origin myths of certain clans, for example in Kabrousse, clearly refer to the sea and a sea monster, cousin of the shark. In addition to its symbolic and cultural value, it should also be emphasized its nutritional and utilitarian importance. Investigations carried out in Casamance in the 1980s (M.-C. Cormier-Salem, 1992) showed that incidental catches of sharks were "traditionally" remarkably valued: both the flesh (consumed smoked, in sauce, with rice) and the fat (processed in oil, soap, cosmetics and pharmaceuticals 15, etc.), the skin (flaking and tanned like leather), teeth and bones (various tools, such as hooks, jewelry, weapons) were used.

3) In most of the artisanal fisherfolk, the professional of the sea, who have knowledge of the sea, the shark has a privileged status, like all sea monsters, the consumption of which is prohibited. Shark is considered as an avenger, protector and repairer. In Senegal, among the migratory fisherfolk (Guet-Ndariens, Wolof, Lebu, Serer), the tradition recognizes various categories within sea creatures, distinguishing in particular good-luck or bad-luck fish. The shark capture is avoided. Its flesh, red and bloody, is poorly valued (this ban also affects tuna). If a fisherman is wounded by a shark, it is considered as the fair punishment for his fault. The "victim" has transgressed a prohibition, justifying the manifestation of the sea monster and the necessary intercession of the priest, whose incantatory formulas will make it possible to be reconciled with the sea and its creatures.

The shark's status has changed from that of a respected, feared, and avoided social partner to that of a target species with the globalization of the market and the arrival of new actors in the fisheries sector. The fining is a fishing system that targets the capture of selacians for their fins and has developed considerably since the 1980s in all coastal countries of the world to meet the demand of the Southeast

Asian market. Shark fins are the basis of a Chinese soup appreciated for its gastronomic and healing properties. In West Africa, the specialization of certain fisherfolk in the “fining” is first of all due to the “old” shark fishermen, such as the Ghanaians (Fanti and Ahena) who, from the 1970s, controlled the salt-dried shark meat sector. Nowadays, they constitute important communities of migrants in Ivory Coast, but also in Senegal, Gambia, Guinea-Bissau, Republic of Guinea, playing a major role at all stages of the sector (fisherman, processor, trader). On their model, other actors, originating from the circles of fisherfolk – guet-ndarien, lebu, serer, niominka - specialize in fining. Finally, this sector is attracting a growing number of actors from the interior regions, foreign to the sector, farmers, and breeders, who convert to fishing but are above all very present in the marketing and processing of sharks. With the development of fining, from the 1980s, the shark became a target species with high market value, and consequently, some species of shark would have disappeared, others would have become rare. This is the case with sawfish (*Pristis pristis*), represented on all the coins. The main socio-cultural drivers of the unsustainable uses are the attractiveness of this sector for new actors, coming from the hinterland with their uses and knowledge, the loss of traditions, a dysfunction of the customary institutions and of the old systems of control over the coast and its resources, a questioning of the knowledge and powers of the elders. Islamisation, the marginalisation of former customary chiefs, the loss of control of the elders over fishing grounds, non-compliance with prohibitions lead also to unsustainable practices.

4.2.5.2.11 Iconic species and the policy-making challenge for sustainable use

The evolution of representations and their impact on the responsibilities and duties that indigenous peoples and local communities impose upon themselves as regards certain species, as well as their consequences, particularly in the domain of sustainable use and conservation are pretty well documented (Artaud, 2021; Dounias et al., 2007). Besides, differences in wild species norms and values (*cf.* fig below with 3 categories of values): ecological, economical, anthropocentric, or customary, between stakeholders (indigenous peoples and local communities, non-governmental organizations, managers, decision-makers, etc.), locally, nationally and internationally, and even within local populations (between farmers and fisherfolk, herders and collectors, but also according to gender, origin, status, etc.) are at the root of environmental violence around the world, which have also given rise to many accounts (Neumann, 1998, 2015; Peluso, 1993; Peluso & Watts, 2001). The divergence of values regarding wild species (ecological versus anthropocentric, economical versus socio-cultural) most often are at the root of inefficient policies, environmental injustice, and unsustainable use (Figure 4.15).

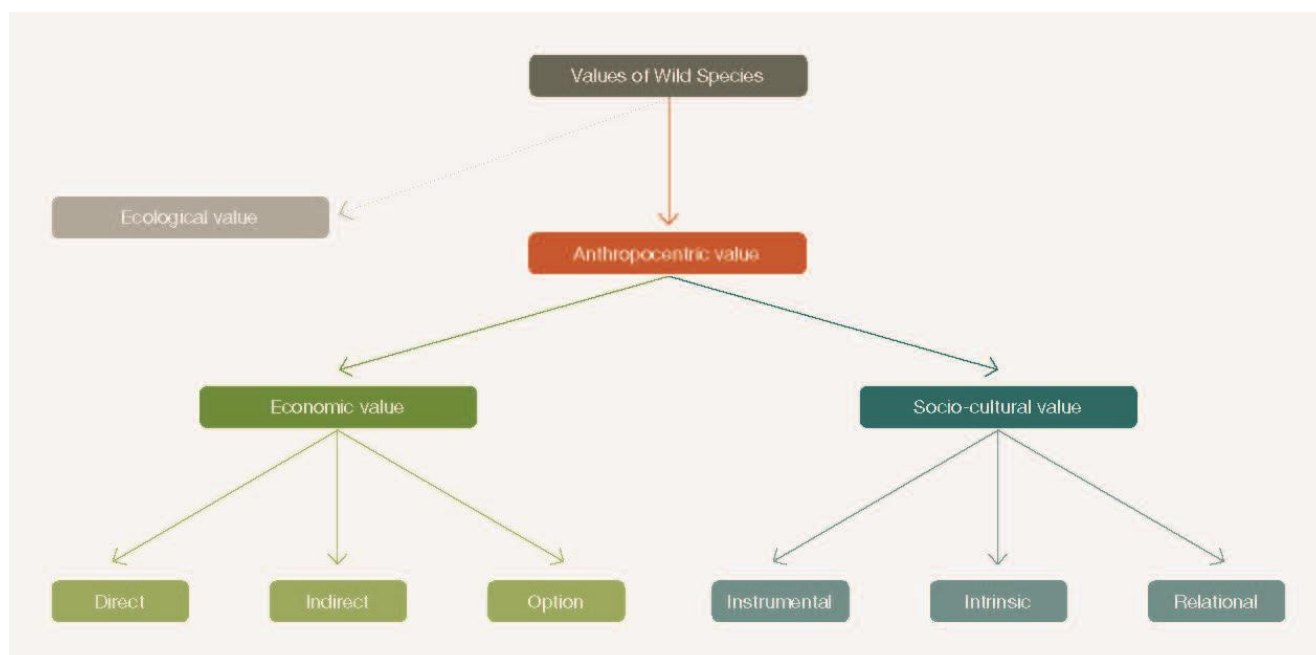


Figure 4.15 Values of wild species

These conflicts accompanied the colonization of the Southern part of the globe (colonial imperialism), then from the end of the 19th century onwards, what some call « green imperialism » with the rise of environmental lobbies (Grove, 1996), and finally the neoliberalism and the commodification of nature (Fletcher et al., 2015). The debates are always vehement (cf. in France regarding the reintroduction of large predators, wolves, lynx, bears, etc.).

There are examples and counter-examples of sustainable and unsustainable use of iconic species (or customary lands), notably due to the changes in policymaking regarding land tenure or the enclosure of the commons during the colonial period. Customary claims on land within national park boundaries are pointed out by Neumann and others. Heritage claims in Africa often serve to mediate territorial and identity claims (Berry, 1993; M.-C. Cormier-Salem et al., 2005; Zerner, 2000). The changes in governance from customary laws to formal laws contributed to the decline of the traditional chief, and the appearance of new elites (Agrawal & Gibson, 2001a; Bassett & Cormier-Salem, 2007)

As highlighted above, the convergence of a species as «good for eating », « good for thinking » and «good for preserving» most often assure more efficient conservation of wild species. Nevertheless, there are counter-examples of « false convergence » with a risk of freezing the tradition, which can actually lead to weakening conservation attempts. Artaud (2021) highlights the limits of these “hybrid” models, which wish to integrate the cultural values attributed to a species, but which do so only partially, without considering the complexities and the dynamics (studied case: Fish co-management in two marine protected areas in Guadeloupe and in Mauritania).

Although the existence of indigenous conservation territories and areas conserved by indigenous peoples and local communities is as old and widespread as human civilization itself, they have emerged only recently as a major phenomenon in formal conservation circles. International policies and programmes, notably those of the International Union for the

Conservation of Nature and the Convention on Biological Diversity, encourage today all countries to recognize and support indigenous peoples and local communities as examples of « effective governance of bio-cultural diversity ». It is clear, however, that such recognition and support need to be carefully tailored, and cannot be improvised (Borrini-Feyerabend, 2010).

- **Changes: shifting or porous frontiers between human and animal**

Recently, the divide between humanity and animality has started to be less radical, new horizons are opening to philosophical and anthropological thoughts (Dounias et al., 2007). For example, whale (Kalland, 2009) metonymic relationship to nature (i.e., whales represent nature at large) and, at the same time, a metaphoric relationship to society (i.e., whales symbolize human relations.). In the case of the chimpanzee, the biological relationship with humans is closer. Scientific research and the observation of language, but also aesthetic sensitivity and cognitive anthropology lead to a blurring of the frontiers, making them more labile (Dounias et al., 2007; Leblan, 2017). In the case of the Landouma people in Republic of Guinea, they can hunt chimpanzees but not for consumption. There is no competition between them; they can coexist and therefore there is no reason to separate humans and animals by creating protected areas (Leblan, 2017).

A growing challenge facing science-based policymaking on sustainable use is the growth in dominance of intrinsic (and ecological) values and morals opposing the sustainable use, particularly of iconic species such as elephants, lions, and rhino (Bauer et al., 2018; Biggs et al., 2017; Di Minin et al., 2016; Lindsey et al., 2016). In particular, there has been a growth in mutualist orientations toward wild species (Manfredo et al., 2017), which dictate that wild species should be treated in the same way as people and should have the same rights (Maris & Bechet, 2010). Therefore, sustainable use of wild species is perceived as immoral (Biggs et al., 2017). Examples of policies on sustainable use and real impacts on human livelihoods and wild species can be seen in the outbursts in response to the hunting of Cecil the Lion (Lindsey et al., 2016) and the restrictions on transporting wild species trophies by numerous airlines. These developments point to a main challenge for science-based decision-making regarding sustainable use. Underlying this challenge are the different values that individuals and groups hold over the moral acceptability of sustainable use of iconic species as a source of conservation revenue (Biggs et al., 2017). Drawing on experience and evidence from other areas of conflict resolution, Biggs and others propose a structured iterative process that incorporates differences in values together with scientific evidence (Biggs et al., 2017).

4.2.6 Scientific and technological innovation and education

Key messages:

- Rapid transformations in the life sciences and modern biology have changed the way the natural world is studied and understood, with enormous implications for the management of wild species and conservation across all sectors and practices including fishing, gathering, terrestrial animal harvesting, logging, and non-extractive practices like observing. Genomic technologies and bioinformatics have generated an enormous amount of data and analysis, and the trend is a continued and accelerated expansion of scientific understanding (*well established*) {4.2.6.2}.

- Advances in science and technology can both contribute to, and undermine, the sustainable use of wild species. Positive contributions include an enormous expansion of invaluable scientific understanding and knowledge directly useful for the sustainable use and conservation of species, including new ways to identify, characterize, manage, and monitor species, and set priorities for conservation. This knowledge and resulting tools are employed across practices including fishing, gathering, terrestrial animal harvesting, and logging, as illustrated in hundreds of studies in recent years (*well established*) {4.2.6.2}.
- Positive contributions of advances in science and technology also include information/knowledge and technical support for the implementation of policies and laws that regulate the use and trade of wild species. Conservation and sustainable use laws based on a deep understanding of species, populations, and ecosystems have proven to be more effective, as documented in numerous studies and policy evaluations. The indirect and direct negative impacts of destructive laws and policies are also illustrated by advanced scientific research (*established but incomplete*) {4.2.6.2}.
- Fishing, gathering, terrestrial animal harvesting, logging and non-extractive uses all take place within the context of broader ecosystems, the health of which impacts sustainable use of species and populations. Advances in science and technology also have direct impacts on sustainable use by impacting ecosystems from which species are harvested, including erosion and degradation of ecosystems, and nature's contributions to people, resulting from feedstocks for new 'biological factories', as well as the positive impact of bioremediation (*established but incomplete*) {4.2.6.2}.
- Science and technology create conditions that support or undermine sustainable use and local livelihoods, indirectly or directly. Biotechnology and 'biological factories', for example, can provide substitutes for unsustainably harvested plants, animals, and marine species, -thereby taking pressure off wild populations, but they can also negatively impact small-scale producers and harvesters who depend on those species to make a living in a range country (*established but incomplete*) {4.2.6.2}.
- Information and communication technologies improve managers' decision-making processes through improving their ability to acquire timely and relevant data related to the population movement, scale, and management of wild species (*established but incomplete*) {4.2.6.3}.
- Information and communication technologies support managers and decision-makers' ability to collaboratively analyze, access, and share data, and to work in partnership in these processes with colleagues, peers, decision-makers, and members of the public (*well established*) {4.2.6.3}.
- It is well established that technology and urbanization contribute to decreased contact with biodiversity, leading to a decline in biodiversity-related knowledge and lack of awareness of its loss, unsustainable use, and importance in the lives of humans (*well established*) {4.2.6.4}.
- Global trends toward standardization of education are resulting in decreasing attention to, and understanding of, local biodiversity, and a decline in community resilience (*well established*) {4.2.6.4}.

- Research and practice demonstrate that indigenous, place-based, and experiential learning build bonds between community members and their ecosystems, leading to a stronger environmental ethic (*established but incomplete*) {4.2.6.4}.
- Institutional disincentives within academic and research organizations discourage the communication of relevant research results about biodiversity to broad audiences. Reform of academic incentive structures is needed that reward on-the-ground engagement with local groups and in biologically and culturally diverse regions, and broader communication of findings beyond the scientific community (*established but incomplete*) {4.2.6.4}.
- Initiatives such as communication for social change, social learning, citizen science, and health-related sciences demonstrating links between human health and biodiversity can serve as a model; these fields are building bridges between science and the public, and their methods could improve understanding of the value of biodiversity and promote sustainable use of wild species (*well established*) {4.2.6.4}.
- Many local and indigenous groups are calling for systemic changes in educational systems to respect the traditions, knowledge, languages, values, history, and identities of their cultures. Formal recognition by national educational systems of cross-generational knowledge transmission and a wider range of approaches to learning would support local stewardship and sustainable use of wild species (*established but incomplete*) {4.2.6.4}.
- Biodiversity education and communication can nurture a conservation consciousness which is fundamental to supporting sustainable use of wild species. There is an emerging consensus that effective education programs respect local cultures, languages, and land, involve women, elders, and youth, and promote inter-generational transmission of knowledge (*established but incomplete*) {4.2.6.4}.

4.2.6.1 Overview

This section addresses scientific and technological innovations in the life sciences, and information and communication technology, with direct and indirect impacts on the sustainable use of wild species, as well as the critical role that education and awareness can play in changing behavior and practices. These elements are combined into a single section because they contribute to shifting paradigms, and to solutions. All are drivers of change at the levels of both specific sustainability challenges (e.g., over-harvesting, hunting, grazing, etc.), as well as broader, transformative social, economic, and ecological change.

Scientific and technological innovations, characterized by new ideas, creative thoughts, and imagination in the form of a device or method, can have both positive and negative impacts on sustainability, and this section addresses both the challenges and opportunities they present. Recent scientific and technological advances have transformed how people interact with, and learn about, the natural world. The understanding of biodiversity has expanded through scientific advances, as at the same time, human-nature interactions, among vast proportions of the world's population, have drastically diminished. Information and communication technologies have also revolutionized education, as has the rise of citizen science across the globe. This section will explore the positive contributions education and awareness-raising can

contribute to sustainability of wild species use, as well as the challenges to enacting appropriate education and outreach, including institutional disincentives for researchers, governments, and others to incorporate education and awareness-raising into their work.

Developments in the life sciences, modern biology, and information technologies have both contributed to, and undermined, the sustainable use of wild species. Benefits include improved identification, characterization, management and monitoring of species, and technical support for the implementation of policies and laws that regulate sustainability and trade of wild species. Information and communication technologies play a central role in influencing and shaping the public's perception of the value, management, and use of wild species. Information and communication technologies and global trends towards homogenization and standardization of education, have also contributed to a decline in direct contact with, and knowledge of, biodiversity. There is emerging consensus that effective education programs respect local cultures, languages, and land, involve women, elders, and youth, and promote place-based learning and inter-generational transmission of knowledge.

Evidence-based knowledge from academic literature has been searched extensively using unique and cross-referencing keywords to find information relating to the main questions of this sub-chapter (science, information and communication technologies, and education) regarding sustainable utilization of wild species in local, regional, and global scenarios. In addition to scientific findings, from bibliographic search engines, non-academic publications (grey literature, reports, working papers, government documents, white papers, and evaluations) were similarly reviewed. Furthermore, to broaden the range of information on indigenous and local knowledge, the experts conferred with individuals with decades of experience living in and working with, rural and indigenous communities. Critical evaluation of the state of knowledge was performed by independent team members to ensure the legitimacy, relevance, and credibility of the presented evidence.

4.2.6.2 Developments in the life sciences and modern biology with a bearing on the sustainable use and management of wild species

Rapid transformations in the life sciences and modern biology have changed the way people study and understand the natural world, with enormous implications for the management of wild species and conservation across all sectors and uses – including hunting, fishing, wild plant gathering, logging, and non-extractive uses like recreation and tourism. Genomic technologies and bioinformatics have generated an enormous amount of data and analysis, and the trend is a continued and accelerated expansion of scientific understanding including quantifications of three genetic indicators in the context of international policy and regulation related to the sustainable use of biodiversity (Hoban et al., 2020).

Almost every branch of the life sciences and modern biology today are undergoing rapid change. Genetic, or DNA, sequencing techniques have become faster, cheaper and more accurate in recent years, helping us to understand the molecular basis of life, and transforming scientific practices and understanding (Heather & Chain, 2016). Linked to genomic technologies is the parallel development of the field of bioinformatics. Genomic technologies used to study genes and their functions generate an unprecedented amount of information, and

require bioinformatics to manage the collection, classification, storage and analysis of vast and complex biological data (National Academy of Sciences, Engineering and Medicine, 2017).

Advances in genomics and bioinformatics have in turn spawned metagenomics, also known as environmental genomics, in which researchers sequence and analyze genetic material found in environmental samples, usually from soil or water. Thousands of microorganism species might be represented in a single sample. This technique has vastly increased the knowledge of genetic and biological diversity (Escalante et al., 2014). In another advance, DNA barcoding focuses on the ‘genetic fingerprint’ of a species, allowing for the identification of species from short fragments (standardized region between 400 and 800 base pairs) of DNA (Schindel et al., 2015).

4.2.6.2.1 Advances in science and technology can both contribute to, and undermine, the sustainable use of wild species.

Positive contributions include an enormous expansion of invaluable scientific understanding and knowledge directly useful for the sustainable use and conservation of species, including new ways to identify, characterize, manage, and monitor species, and set priorities for conservation. This knowledge and resulting tools are employed across sectors including terrestrial animal harvesting, fishing, wild plant gathering, and logging, as illustrated in hundreds of studies in recent years.

Advances in science and technology can both contribute to, and undermine, the sustainable use of wild species (IUCN, 2019; Laird & Wynberg, 2018). Positive contributions include the indirect, but extremely important bedrock of scientific understanding that supports sustainable use and conservation of wild species, including providing invaluable information and understanding to conservation planning and management. Scientific advances have transformed the understanding of the natural world in recent years, providing researchers and conservationists with important tools and approaches to management and policy, which continue to advance with time (Supple & Shapiro, 2018).

Examples of conservation understanding and management gains from advances in science and technology include, for example: a discovery of additional components of lichenicolous fungi together with mycobiont and photobiont symbionts (Lawrey & Diederich, 2003; Millanes et al., 2016; Spribille et al., 2016) new ways to identify and characterize biodiversity (Mosa et al., 2019; Palomares & Adrados, 2014); better understand genetic variability in populations of highly abundant or rare wild species (Ayala-Burbano, 2020; Drury et al., 2016; Xue, 2015) and the critical role of pollinators (Lopez-Maldonado & Berkes, 2017); monitor environmental change (Thomsen & Willerslev, 2015); manage invasive species (Hand et al., 2015); sequence and taxonomically identify understudied taxa like lichens (Mark et al., 2016) and edible/poisonous wild mushrooms (Khaund & Joshi, 2014; Parnmen et al., 2016) and set priorities for *ex situ* (Castañeda-Álvarez et al., 2016) and *in situ* (Kell et al., 2012) conservation. A range of technologies - including miniaturized satellite tags deployed onto animals, smartphone apps, camera and audio traps, and drones – as well as the work of citizen scientists, have considerably increased the ability to collect huge volumes of new data, which people can now analyze with news analytical methods, allowing a much better understanding

of wildlife and plant behavior and population dynamics, and the consequences of their exploitation.

Some groups are working to sequence genomes and catalogue species, to build libraries and datasets to support sustainable use and conservation of species. For example, the Earth BioGenome Project is working to sequence, catalog, and characterize the genomes of all of Earth's eukaryotic biodiversity over a period of 10 years (Lewin et al., 2018). (Mosa et al., 2019) report on global efforts to generate DNA barcode libraries for vascular plants, and the contribution of herbaria specimens - preserved and already identified - as a complement to wild samples as groups develop reference DNA barcode libraries for plants from different regions. (Marthinsen et al., 2019) describe the OLICh Project, an authoritative reference library of DNA barcode sequences of Nordic lichens.

4.2.6.2.2 Positive contributions of advances in science and technology also include information/knowledge and technical support for implementation of policies and laws that regulate sustainability and trade of wild species.

Conservation and sustainable use laws based on a deep understanding of populations, species, and ecosystems have proven to be more effective, as documented in numerous studies and policy evaluations. The indirect and direct negative impacts of destructive laws and policies are also illustrated by advanced scientific research. In addition to expanding the understanding of populations, ecology and conservation status of useful species, new technologies also support the sustainable use of wild species more directly by assisting with the implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora and national laws intended to regulate trade in wild species (Ghorbani et al., 2017; Subedi et al., 2013). This includes tracking illegally harvested and traded species, and identifying those intentionally mislabeled (Feitosa et al., 2018). DNA sequence markers make it possible to distinguish between wild and cultivated species, geographic origin, and assist with the Convention on International Trade in Endangered Species of Wild Fauna and Flora enforcement (Hassold et al., 2016). Enforcement is clearly an essential part of compliance, and of ensuring sustainable use of wild species, and increasingly this involves scientific analytic techniques and DNA profiling and barcoding. The key areas this is done to support the Convention on International Trade in Endangered Species of Wild Fauna and Flora compliance include: *species identifications*, including using DNA markers when wild species samples are heavily processed or multiple species are mixed as in traditional medicines; *matching a DNA sample to an individual plant or animal* using DNA profiling that relies on reference databases; *verifying captive breeding origins* and parentage; and *identifying geographic origins of samples*, assigning them to genetic populations of origin, which also requires comprehensive data profiles from possible source populations; and *forensic scientific standards* to prosecute the Convention on International Trade in Endangered Species of Wild Fauna and Flora offenses (UNEP-WCMC, 2013).

Chang et al. (2018) used DNA barcoding based on government-seized Chelonian (turtle and tortoise) specimens deposited at Taipei Zoo as a shortcut to traditional morphological identification and found that a “fast and accurate method to authenticate seized samples could

assist law enforcement agencies to prosecute criminals and restrict illegal exploitation of wild chelonian resources.” DNA barcoding approaches would make applying the Convention on International Trade in Endangered Species of Wild Fauna and Flora more practical and accessible. Aubriot et al. (2013) used DNA barcoding for the genus *Euphorbia* in Madagascar, with 170 native species almost all endemic and threatened by habitat loss and illegal collection of wild plants. Almost all Malagasy *Euphorbia* are listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora Appendices I and II, but an absence of reliable taxonomic information means that these species are difficult to identify, even when fertile with flowers and fruits, and this makes implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora difficult. DNA barcoding can also be used in border security programs to intercept potential invasive species at ports-of-entry and is particularly useful because identification of immature arthropods is challenging when identification characters are based on adult morphology and reproductive structures (Madden et al., 2019).

Johri et al. (2019) report on recent innovations to increase the affordability, accessibility, accuracy, speed and breadth of ecological investigations of threatened Chondrichthyes - sharks, rays, skates and chimeras - through genome sequencing. Global markets for these species have resulted in unsustainable fishing practices, which are facilitated by a lack of regulations and ecological data required for conservation. Using a Next Generation Sequencing (non-Sanger-based high-throughput DNA sequencing technologies) method, MinION, a hand-held portable sequencing device, allows more widespread and accurate identification of shark species listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora Appendices, and produces invaluable ecological data.

4.2.6.2.3 Terrestrial animal harvesting, fishing, gathering, logging and non-extractive uses all take place within the context of broader ecosystems, the health of which impacts sustainable use of species and populations.

Advances in science and technology also have direct impacts on sustainable use by impacting ecosystems from which species are harvested, including erosion and degradation of ecosystems, and ecosystem services, resulting from feedstocks for new ‘biological factories’, - that use biotechnology to produce biofuels, biochemicals, bioplastics and other products, as well as the positive impact of bioremediation.

In addition to the contributions of science and technology to species conservation and management, commercial applications of knowledge and technologies also have positive and negative direct impacts on the sustainable use of wild species through the ecosystems of which they are a part. This impact is increasing, as science and technology rapidly advance, and one area with direct impacts on the sustainable use of wild species is synthetic biology, and biotechnology or biological factories.

Using ‘synthetic biology’ - the design and construction of new biological parts, devices, and systems, and the redesign of existing, natural biological systems for useful purposes - researchers now design cells to replicate products or compounds found in nature, or new chemicals, drugs, biofuels, food and flavorings, and a myriad of other products (Eisenstein,

2016) Synthetic biology is a departure from earlier science because of the focus on design and construction of core components (parts of enzymes, genetic circuits, metabolic pathways, etc.) that are modelled and tuned to meet specific performance criteria (<https://ebrc.org/synberc>). Synthetic biology was defined by the Convention on Biological Diversity *ad hoc* technical expert on synthetic biology, as “a further development and new dimension of modern biotechnology that combines science, technology, and engineering to facilitate and accelerate the understanding, design, redesign, manufacture and/or modification of genetic materials, living organisms and biological systems” (UNEP/CBD/SBSTTA/20/8, March 2016).

One implication of these new technologies for wild species is that production and manufacturing have been ‘decoupled’ from finite, non-renewable resource consumption. Some argue that this is a positive development for sustainability since biological factories – that use biological systems to produce commercial materials - can replace petroleum-based products and those over-harvested from the wild and are cleaner and more efficient manufacturing processes that pollute less and reduce waste (Piaggio et al., 2017; D. Scott et al., 2015). The commercial growth of *Cordyceps militaris* a caterpillar fungus as a substitute of highly priced and well demanded *Ophiocordyceps sinensis* is also an important outcome of technological enhancement (Lin et al., 2018).

Others are concerned that the supply of feedstocks - raw materials used to produce sugar for the biological factories - is itself unsustainable. Feedstock crops can replace food crops, and forests, and ‘marginal’ or ‘degraded’ areas are cleared to grow agricultural feedstocks, in some cases through land grabbing and the violation of the rights of indigenous peoples and local communities (Bagley, 2017; Scott et al., 2015; Webb & Coates, 2012). Many of these so-called “marginal” and ‘degraded’ areas might contain wild species of value to local communities, or regional or global markets, and might also be biologically diverse and important habitats.

Positive contributions of advances in science and technology to ecosystem health include bioremediation. Bioremediation uses decomposers or their enzymes – mainly microorganisms, plants, and microbial or plant enzymes – to clean pollution, and remove or neutralize contaminants in the soil, ocean, and other environments.

4.2.6.2.4 Science and technology create conditions that support or undermine sustainable use and local livelihoods, indirectly or directly.

Biotechnology and ‘biological factories’, for example, can provide substitutes for unsustainably harvested plant, animals, and marine species — thereby taking pressure off wild populations, but they can also negatively impact small-scale producers and harvesters who depend on this income. This is liable to reduce local motivation to conserve the ecosystems on which those species depend.

For species currently overharvested in the wild, the production of substitute chemicals and products in biological factories could provide a non-destructive alternative. For cultivated raw materials insufficient to supply the demand of markets, with resulting unstable markets producing shortages or wide price fluctuations, biological factories – which use synthetic biology methods and biological systems to produce useful commercial biomaterials or biomolecules – can help address supply challenges (Kung, 2018; Paddon et al., 2013). This includes medicines like artemisinin, an important life-saving drug used to treat malaria.

However, for species that are grown sustainably in small-scale agriculture, products produced in biological factories and labelled ‘natural’ – like vanilla, saffron, stevia – could displace the products of small farmers, damaging local livelihoods (Bagley, 2017; Laird & Wynberg, 2018), although a wide range of factors contribute to supporting or undermining community livelihoods tied to commodity sales of bulk raw materials.

4.2.6.3 Developments in the information and communication technologies with a bearing on the sustainable use and management of wild species

Rapid development and increasing access to information and communication technologies are changing how policymakers, managers, local communities, and organizations communicate about, collaborate and administer the sustainable use and management of wild species.

Information and communication technologies refer to all digital communication tools including the internet, wireless networks, mobile phones, computers, software, instant messaging, video-conferencing, social networking, and other media applications and services that enable users to access, retrieve, store, transmit, and manipulate information in a digital form. Progresses in mathematics, computer science (big data) and other kinds of technology (e.g., miniaturized satellite tags deployed onto animals) have considerably increased the ability to collect and analyze huge volumes of new data, allowing a much better understanding of wildlife and plant behavior and population dynamics, and the consequences of their exploitation. Globally people now live in an increasingly ‘networked society’ where there is ‘growing convergence of specific technologies into a highly integrated system, within which old, separate technological trajectories become literally indistinguishable’ (Castells, 2011).

The importance of information and communication technologies in the sustainable use and management of wild species cannot be overstated. They are changing nature conservation and the understanding of biodiversity in both novel and profound ways (Arts et al., 2015). Information and communication technologies directly shape the public's perception of the management and use of wild species; improve managers' decision-making processes through improving their capacity to collaborate with peers and to access timely and state-of-the-art information related to wild species; support decision-makers ability to create and disseminate effective and contemporary policy; as well as promote collaboration between decision makers, researchers, and members of the public through citizen science data collection and knowledge dissemination projects. Information and communication technologies are vital tools in achieving the global long-term sustainability of critical wild species. However, people need to recognize that their diffusion remains starkly uneven across different generations, scales, and geographies.

However, not all examples of information and communication technologies usage are positive. Information and communication technologies are a fundamental tool in maximizing resource extraction efficiencies and cost-effectiveness and can lead to predatory extraction. For example, Geographic Information Systems (GIS) are integral to predicting the location of precious materials for mining exploitation, often degrading landscapes with irreversible consequences for traditional communities. Yet, they are also used to secure land rights for indigenous communities. It is not that information and communication technologies are inherently destructive or negative, rather it is the purpose to which they are put. Similarly,

poachers use GPS locality data taken from wildlife photography, including camera traps, and other sources to locate populations of rare and local species. Many descriptions of new species in recent years have had to exclude precise locality data for the same reason (Choo et al., 2020).

Drones are increasingly used to monitor terrestrial animals and plants. In another example, researchers have effectively used drones to gather data on schooling juvenile Atlantic bluefin tuna in the Gulf of Maine. Very little is known about the movement and foraging of the fish, so this data is an important resource to better understand, and thus sustainably manage the species (Fisheries, 2021). Furthermore, drones are increasingly being used as a surveillance tool to collect spatially referenced data on the location of fishing vessels and gears to eradicate illegal, unreported and unregulated fishing activity (Toonen & Bush, 2020). Yet drones have also been used to turn aquatic refuges into popular fishing spots and to lead to overfishing in these areas.

4.2.6.3.1 Because of their growing global uptake, information and communication technologies play a central role in influencing and shaping the public's perception of the value, management and use of wild species.

The internet is the overarching technology that permits the access, sharing and storage of digital data. Broadening bandwidth, lowering prices, and general public acceptance are fueling the near global access to information and communication technologies. Individuals, organizations, governments and communities increasingly communicate using 'horizontal networks of communication' that are built around peoples' shared interests, initiatives and needs (Castells, 2011). People progressively seek out and share information (for example the cost of products at the market, access to services or weather forecasts), skills (for example how-to videos or brochure information required for completing tasks) and news (thus stimulating the decrease in accessing traditional media such as newspapers) using web-dependent social media and associated technologies.

Because of this growing reliance on information and communication technologies to mediate, augment, and inform the understanding of the world, they assume a growing role in shaping the way that people perceive, understand and articulate their own, as well as other peoples', relationship to wild species and their use and management (Kahn et al., 2009). New visual technologies are increasingly being employed by wild species conservation-related organizations in their science communication and public engagement efforts (Cox, 2013). They can sensitize the public's perception of conservation initiatives as well as help generate an emotional response perceived as being necessary for motivating a sense of caring about wild species (Verma et al., 2015). Similarly, social networking platforms allow stakeholders from around the world to remain in contact and communicate about different aspects of the natural world, unfettered by their geography, the time of day or their native language. Furthermore, there are a growing number of examples that suggest that information and communication technologies not only play an important role in fighting against deforestation, but that they also actively help decrease deforestation through increasing management efficiencies, monitoring risks, preventing illegal activities and amplifying the voice of indigenous peoples land rights (Yilmaz & Koyuncu, 2019).

Despite the importance of information and communication technologies ability to influence public perceptions of the natural world, it is necessary to recognize that many communities, and especially those living within or beside areas rich in wild species, are still limited by the partial penetration of information and communication technologies and the concomitant benefits they bring. Inadequate access to the appropriate communication technology for the dissemination of knowledge and information is believed to be an important cause of poverty and also the pushing factor for natural resources degradation in the remote mountains of the Hindu Kush Himalayan region (Maikhuri et al., 2011). For example, the lack of access to suitable information and communication technologies among wild species collectors, harvesters, local brokers, retailers and traders have led to those involved in the trade being deprived of getting a fair price for their products (Olsen & Larsen, 2003).

4.2.6.3.2 Information and communication technologies improve managers decision-making processes through improving their ability to acquire timely and relevant data related to the population movement, scale, and management of wild species.

It is well supported that the regular monitoring of animal populations and natural habitats should be implemented to ensure wild species protection, especially when pressure on animals is high (Linchant et al., 2015). A central contribution of information and communication technologies to the sustainable use and management of wild species are their ability to acquire data, to transform this data into information, which in turn becomes central in informing decision-making processes. Legacy information and communication technologies such as satellite imagery acquisition and Geographic Information Systems continue to play an important role in spatial decision-making processes and wild species management. However, they are increasingly augmented with data captured using automated, miniaturized, low-cost and readily available hardware sensors that are capable of measuring heat, temperature speed, pressure sensor (e.g., to study diving depth in penguins etc.), and location. This includes the growing use of radio frequency identification tags and camera traps to record the movement of birds, fish and animals, the use of unmanned aerial vehicles, or drones, as well as the increasingly prominent role of mobile devices to support citizen monitoring and reporting on wild species.

Radio frequency identification is a wireless communication technology that permits computers to read the identity of inexpensive electronic tags from a distance without requiring a battery (Nath et al., 2006). This allows users to identify, track and monitor the objects attached with tags globally, automatically, and in real-time (Jia et al., 2012). This relationship between physical technologies (such as the radio frequency identification tags) and computer automation is now commonly referred to as the Internet of Things. Radio frequency identification tags have already been used for some time in commercial livestock identification and tracking (Ruiz-Garcia & Lunadei, 2011), even for monitoring cattle rustling activities in Eastern Africa (Siror et al., 2009). Increasingly they are being used to monitor wild species. One example is the use of radio frequency identifications, to better understand how bird feeders in urban environments in the US impact the survival, range extension and species conservation of hummingbirds (Bandivadekar et al., 2018; Choo et al., 2020).

Camera traps have become a ‘preferred tool’ for monitoring and sampling animal populations; this in turn has greatly improved science’s understanding of ecological relationships and population dynamics (O’Connell et al., 2010).

Unmanned aerial vehicles can be remotely controlled or fly autonomously through software-controlled flight plans that work in conjunction with their onboard sensors and GPS. These vehicles provide a safe, inexpensive, user-friendly, and statistically robust option for a variety of wild species survey applications (Jones et al., 2006). Unmanned aerial vehicle technology continues to develop rapidly and dropping prices and their ability to synchronize with mobile device applications are making them more and more prevalent in civilian markets. The future role of unmanned aerial vehicles for monitoring will include the growing number of semi-autonomous robots.

Globally, thousands of research projects are engaging millions of individuals—many of whom are not trained as scientists in the collection, categorization, transcription and analysis of scientific data (Bonney et al., 2014). This contemporary trend in science is referred to as Citizen Science and is being used to support a broad range of projects that require vast quantities of data to better understand large-scale patterns in nature (Bonney et al., 2009). These projects range from supporting the Christmas bird count (Silvertown, 2009) to studying new galaxies (Raddick et al., 2013). Information and communication technologies play a central role in supporting Citizen Science projects, which tend to focus on enabling members of the public to capture data in the field using specialized mobile device apps, camera and audio traps, which can now be explored more in-depth by new analytical methods (deep learning, advanced mathematical models, etc.).

4.2.6.3.3 Information and communication technologies support managers and decision-makers ability to collaboratively analyze, access and share data, and to work in partnership in these processes with colleagues, peers, decision makers and members of the public.

Data is a vital commodity in the sustainable use and management of wild species. How managers access, disseminate and share data is vitally important in supporting effective decision-making. Fifteen years ago, there was little sharing of data. Today governments, organizations and businesses are more prepared to see the value of sharing data in order to enable making the best decisions. The ability to share data is supported by the rapid transformation of cloud computing, access to big data and a willingness to share through open data classifications and agreements.

Cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services (Armbrust et al., 2010). Cloud computing gives the appearance of infinite computing resources available on demand, and it enables organizations to no longer invest in hardware or software – they pay for it as they use these resources. As research in wild species management increasingly relies on quantitative population modelling, cloud computing is playing an increasingly important role in providing managers the tools to analyze large datasets on demand, but also to provide a means for members of the public to interact with and access large and complex datasets to simplified user interfaces that are no longer software dependent (Chapron, 2015).

The past twenty years has witnessed an explosion of digital data. The term big data is used to describe the enormous, often unstructured, datasets that have emerged through cloud computing, the internet of things and other devices that capture data. This explosion is represented by an increase in the volume of data, the velocity to which it is created, as well as the variety of data (McAfee & Brynjolfsson, 2012). These datasets provide a huge opportunity for understanding complex values and behaviors that in the past have remained invisible, and for improving to decision-making ed about the sustainable management and use of wild species. In addition to an increase in the volume of data, it should also be stated that the ability to analyze the data in depth has considerably improved thanks to progress in mathematics and biostatistics. Knowledge and science in this field are also more readily accessible nowadays (e.g., most scientists now rely on the R software for statistical analyses, which is a collaborative, open source and free system constantly being improved by the users themselves; <https://www.r-project.org/>).

The information society changes the conditions and resources which are involved in environmental management and governance: old modes and concepts are increasingly being replaced by new, informational ones (Mol, 2008). Information and communication technologies in their essence are involved with the communication of information, in the realm of environmental governance; they can play a significant role in making environmental decision-making transparent, and in doing so. Furthermore, scholarship in global environmental politics increasingly recognizes the role of “information as influence” whereby it creates the conditions under which informational governance may stimulate environmental reform (Gupta, 2008).

The MapBiomass initiative, which originated in Brazil in 2015, provides an important example of the collaborative use of technologies to improve the monitoring and management of changes in land cover. This project has developed innovative and low-cost methods using Landsat imagery of 30-meter resolution and machine learning supported by Google Earth Engine to generate annual maps showing land cover change over time. For Brazil and much of South America, MapBiomass has produced annual land cover maps for the period, 1985-2020, and these are made publicly available on a user-friendly web-based platform. In Brazil, project partners have also incorporated high resolution satellite imagery to create a system of alerts to detect deforestation in near-real time. Images are then rapidly validated and shared with government law enforcement agencies to hold landowners accountable for illegal deforestation. MapBiomass has been pioneered by a collaborative network of non-governmental organizations, universities, and technology companies, enabling the initiative to harness local knowledge and to building capacity among national scientists and civil society organizations. The project has trained collaborators throughout Latin America and is currently bringing this innovative use of technologies to environmental and social movement organizations in Indonesia and other parts of the tropics.

A wide range of political, social, cultural, ecological and economic factors determine the way new innovative technologies are developed and used (Trace, 2016). It is not always possible to anticipate trends into the future for science and technology since unintended consequences or unanticipated gains, are often difficult to determine in advance. It is important that global policy processes monitor and regulate dramatic scientific and technological advances to ensure that they support sustainable use of wild species, and the conservation of biodiversity.

4.2.6.4 Education and awareness tools and approaches with a bearing on the sustainable use and management of wild species

It is well-established that direct contact with, and knowledge of, biodiversity has been declining among populations worldwide (Gadgil et al., 1993). Major factors contributing to this decline include technology and urbanization, leading to less interaction with, and understanding of, wild species (Cox & Gaston, 2018). In the face of unprecedented levels of declining biodiversity coupled with a lack of human contact with nature, it is important to understand the role education plays in supporting sustainable use of biodiversity, and the elements of education, both formal and informal, that support and drive sustainable or unsustainable use.

According to a global survey carried out on behalf of the Secretariat of the Convention on Biodiversity, efforts to communicate the importance of biodiversity have not made clear the value and relevance of nature to citizens' daily lives (Airbus, 2010; J. R. Miller, 2005). Survey results from across 10 countries sampling 10,000 children between the ages of five and eighteen indicate that 40% ranked watching TV or playing computer games as a priority, compared to 4% who considered the environment to come first (CBD, 2010). Results highlight the need for increasing efforts to inform future generations about the importance of biodiversity conservation and sustainable use of species (Airbus, 2010).

This section explores three questions: 1) How are educational systems addressing biodiversity in the face of urbanization and the expansion of technology, alongside biodiversity loss? 2) What barriers exist to effective education and awareness-raising about biodiversity and the sustainable use of wild species? 3) What are common elements of effective biodiversity education and communication programs?

4.2.6.4.1 The impact of technology and urbanization on biodiversity education and awareness

It is well-established that technology and urbanization contribute to decreased contact with biodiversity, leading to a decline in biodiversity-related knowledge and the lack of awareness of its loss, unsustainable use, and importance in human lives.

The United Nations projects that by 2050, 68% of the world's population will be urban, with diminished contact with nature, resulting in a significant loss of associated health benefits (United Nations, 2019). It is well established that due to demographic shifts, the number of people with first-hand experience of biodiversity diminishes each year (Orr, 2004). Limited transmission of knowledge regarding wild species brings to light the paucity of daily human interaction with plant species.

Studies illustrate the erosion of children's knowledge not only of plant names, but where to find and how to prepare them, highlighting how children's knowledge is detached from hands-on knowledge and practice (Setalaphruk & Price, 2007). Children from rural areas who migrate to cities no longer take part in helping their parents in farm fields and forests (Barreau et al., 2016). As a Mapuche woman reflected, "How can we teach our children if we cannot access the forest?" This sentiment underscores how critical forests are for intergenerational

environmental learning as for centuries they have been a place for children to gain ecological knowledge (Barreau et al., 2016).

Increasing urbanization leads to a break in the transmission of local knowledge regarding seasons, geography, botany, ecology, and culture needed to gather wild species sustainably. Today, within the educational, socio-economic, and political systems in which urban and suburban populations live, biodiversity “is considered expendable and the ecological processes which sustain us are hidden from view” (Miller, 2008).

Research across the globe also demonstrates that many youths currently spend from 2 to more than 7 hours a day on technological devices, with a negative association between screen time and psychological well-being (Aitken, 2001; Twenge & Campbell, 2018), and a corresponding decline in time spent in nature and in contact with biodiversity (S. Adams & Savahl, 2017). The result of diminishing contact with biodiversity, and time outdoors, that result from urbanization and technology, has been shown to lead to a lack of knowledge and/or interest in nature. As Pyle (2002) states, “Collective ignorance inexorably leads to collective indifference, and from there it is not many more steps to ecological depreciation and collapse.” Decades of studies on the impact of nature on health clearly demonstrate that detachment from nature also leads to a decline in mental and physical health. Conversely, time spent in nature is not only central to improving human health and well-being but can also motivate people to make more informed decisions and take actions to protect the environment (Capaldi et al., 2015; Dasgupta, 2021).

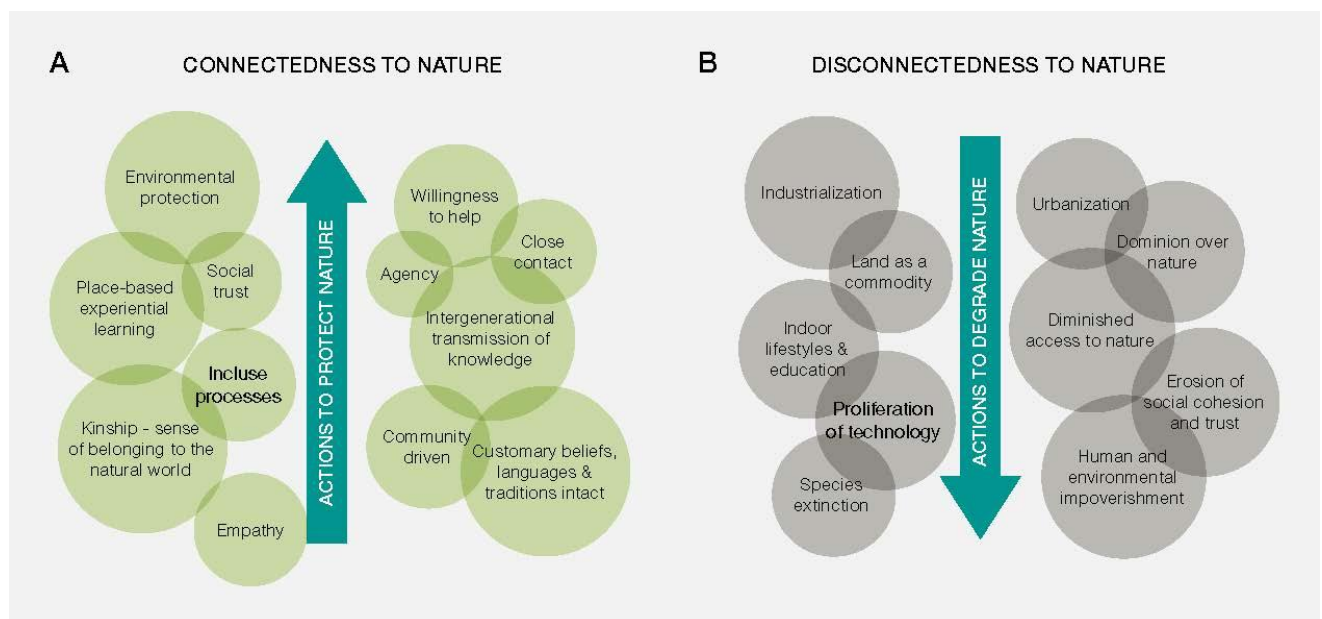


Figure 4.16 Effects of connectedness and disconnectedness to nature. Source: Shanley & Lopez, (2009) © 2009 by The Association for Tropical Biology and Conservation. License CC-BY.

4.2.6.4.2 The role of formal educational systems

Global trends toward standardization of education are resulting in decreasing attention to, and understanding of, local biodiversity, and a decline in community resilience.

Currently, over 50% of *Homo sapiens* live in urban centers, and the majority lack basic knowledge regarding flora, fauna, water, and weather (Orr, 2004). Scholars describe the current chasm between people and nature as the “extinction of experience” (Miller, 2005; Pyle, 1979). Concern about the sharp decline in nature-based knowledge, coupled with intensifying environmental degradation, has led to the development of global biodiversity educational initiatives that seek to counter the effect of these trends.

For example, the United Nations called for a Decade of Education for Sustainable Development (2004-2014), focusing on the interconnectedness of nature, culture, society, and economics. The biodiversity education goals of the United Nations Environment Program (UNEP) encourage individual and collective work to maintain and enhance biodiversity at local, regional, and global levels. The United Nations Education Science and Cultural Organization (UNESCO) is a lead agency promoting the inclusion of sustainability and conservation in national education systems. Furthermore, in 2015, Pope Francis released an encyclical entitled “On care for our common home”. Lamenting environmental degradation and loss of biodiversity, he calls for people worldwide to take, “swift and unified global action” (Catholic Church & McDonagh, 2016).

Despite efforts by leading international figures and agencies to intensify biodiversity education, over the last few decades a divergent trend has gained momentum - globalized and nationalized educational systems – which work against the uniquely local and endemic and undermine connection to biological and cultural diversity. These widely used systems are characterized by homogenization, consolidation, corporatization, institutionalization, testing, and competition in the global economic sphere (Spring, 2015). Critics describe the internationalization of education as being founded upon vestiges of colonial structures intended to eradicate indigenous cultures, land-based knowledge, and languages (Anderson-Levitt, 2008; Sloan, 2008).

The International Council of Science established that universal education programs, characterized by standardization and testing, and divorced from local cultural and environmental conditions, weaken the transmission of traditional knowledge, contributing to an erosion of both indigenous knowledge and languages (ICSU, 2002). In the Australian context, (Ditchburn, 2012) notes there has been, “swift and unquestioning acceptance of the National curriculum, with long term implications.” Within such homogenized curriculum, students may graduate with literacy in mathematics and language, but without knowledge of their ancestry, culture, land, plants, and animals. School regimes are cited as causal in children’s lack of knowledge of and interest in wild plants (Barreau et al., 2016; Dounias & Aumeeruddy-Thomas, 2018; Saynes-Vasquez et al., 2013). Studies indicate that children’s knowledge of wild plants decreases with their age and that forest-based knowledge, suffers the greatest rate of loss as compared to gathering in other types of locations (e.g., (Caniago., 1998; Setalaphruk & Price, 2007).

In the past, many children attended local schools during their first 12 years of life. Today, many children leave rural communities at a young age, becoming disconnected from traditional practices and land, and experience a gradual transformation in their values, attitudes and food habits. The trend toward consumption of processed foods is substantially altering outlooks and tastes worldwide and has been termed, “gustatory subversion” whereby the introduction of industrialized foods undermines local cuisine, eroding nutrition and resulting in

economic dependence (Dounias & Aumeeruddy-Thomas, 2018; Garcia, 2006; Ladio & Lozada, 2004; Lewis, 1998). As populations of, and access to, forest plants diminish, knowledge erodes more readily (Cruz-Garcia et al., 2018). Such profound erosion of knowledge regarding wild plant gathering among youth can have a significant impact on the resiliency of communities to absorb and buffer changes (Begossi et al., 2002; Berkes & Folke, 1998).

In addition to schooling that distances children from contact with nature, international child rights laws insist on both access to formal education and a ban of child labor, reinforcing the notion that children should not be involved in agroecological activities (Dounias & Aumeeruddy-Thomas, 2018). Such a global perspective discounts local realities in rural villages where children's participation in subsistence economies contributes to the resilience of local knowledge and where the well-being of children is tightly woven into community practices.

Subsequently, as rural children finish school and embark upon careers, their interests are increasingly geared toward jobs in urban centers, with youth less interested in studying biology, ecology, and whole organisms. Furthermore, within the biological sciences, there is a tendency to choose lucrative careers in biotechnology and related areas, rather than the environmental sciences. In response to the wave of rootless and globalized education and work prospects, there is a growing trend in alternative schools and programs to restore educational initiatives which draw from local and indigenous cultures, traditional knowledge, and environmental and social justice.

4.2.6.4.3 Place-based education: Indigenous, outdoor, environmental, and experiential learning

Research and practice demonstrate that indigenous, place-based, and experiential learning build bonds between community members and their ecosystems, leading to a stronger environmental ethic.

For 99% of the time *Homo sapiens* have inhabited the earth, they accumulated relevant knowledge and learned complex skills and expertise related to geography, astronomy, biology, ecology, and other aspects of the natural world when engaged in outdoor activities such as fishing, hunting, and gathering. Children learned less through direct “teaching” and more through individual observation, imitation, stalking, games, stories, practice, and time accompanying a parent, friend, or relative (Lew-Levy et al., 2017). By age ten, “children in hunting and gathering communities identify, locate, and know about the behavior of many plants and animals in their environment” (McDonald, 2007).

Until recently, such a deep, multi-faceted understanding of biodiversity for the provision of food, water, shelter, and medicine has been fundamental to human survival. The environmental movement of the 1970's - a response to rapid and alarming environmental damage - renewed interest in outdoor and environmental education in which learning is based on a combination of experiences in nature, community, and/or culture (Gruenewald & Smith, 2008). Current educational movements also include indigenous, and place-based education centering around stories, ecologies, languages, histories, and politics embedded in place (Bartlett et al., 2012; Cajete, 2010; Orr, 2004).

4.2.6.4.4 Research and academic incentive structures

Institutional disincentives within academic and research organizations discourage the communication of relevant research results about biodiversity to broad audiences. Reform of academic incentive structures is needed that reward on-the-ground engagement with local groups and in biologically and culturally diverse regions, and broader communication of findings beyond the scientific community.

In addition to the standardization of education, another significant barrier to successful education and awareness raising about biodiversity and sustainable use of species includes entrenched institutional disincentives within academia (Edwards & Roy, 2017); infusion of corporate funding into research (Nestle, 2016); and a flawed peer review process leading to impoverishment of science (Smith, 2006). Over the last 30 years, excessive performance measurement, based narrowly on the quantity rather than the substance of publications, has led to an increase in conformity and superficiality, reducing the motivation of researchers to engage in original thinking (Gendron, 2007). These trends have resulted in what is being termed, “blind science” in which positive feedback loops within research institutions, reinforce self-promoting forms of science as opposed to contextualized, impact-oriented research (Morin, 2005).

Prioritizing the production of peer-review journal articles has also discouraged applied research, and activities such as public education, outreach, and extension. Successful educational tools such as plain language communication, the synthesis and application of knowledge to address problems, partnerships with civil society organizations, and artistic expressions, are generally not accepted as legitimate forms of academic communication (Jacobson et al., 2004). Knowledge generation is instead occurring at the periphery, where multiple voices, diverse lenses and languages converge (Gendron, 2007).

In a survey of 3,748 members of the American Association for the Advancement of Science (AAAS), 77% indicated that it is not important for career advancement to promote their findings on social media (M.O.R.I./Wellcome Trust, 2001). In a Center for International Forestry Research (CIFOR) study of 268 researchers in the field of conservation biology from 29 countries, less than 5% of respondents engaged with the media, produced training and educational materials, or popular publications (Shanley & Lopez, 2009). Respondents considered local initiatives and training likely to lead to success in conservation but, due to institutional disincentives, few invested in these activities. The result is inadequate communication, which in turn means that governments and the public rarely understand the value of, and threats to, biodiversity, and the urgent need for action.

To improve biodiversity research and communication, changes in academic incentive structures and resource allocation are needed that reward communication and action (Bawa et al., 2004; Edwards & Roy, 2017) as well as participatory research processes that include local communities in the co-production of knowledge and share its benefits (Grasser et al., 2016). Research and academic institutions need to recognize public education and outreach as important professional endeavors, and such efforts should be considered positive in merit evaluations (Hampton et al., 2010).

4.2.6.4.5 Equitable trends in communication and education: Social learning, two-eyed seeing and citizen science

Initiatives such as communication for social change, social learning, citizen science, and health-related sciences demonstrating links between human health and biodiversity can serve as a model; these fields are building bridges between science and the public, and their methods could improve understanding of the value of biodiversity and promote sustainable use of wild species.

Communicating with and for marginalized people reflects a movement that has been led largely by social scientists. The Brazilian educator Paulo Freire and his colleagues (Freire & Macedo, 1987) conceived of communication for social change as participation for the purpose of empowering the voiceless and strengthening cultural identity. Understanding through dialogue creates a cyclical model of social and environmental transformation that is built on relationships and mutual change (Figueroa et al., 2002; Pretty & Smith, 2004).

Behavioral psychology, communication for social change, social learning, and the health-related sciences have developed methodologies to link science and public understanding, and these methods can inform sustainability initiatives by building bridges between knowledge and action (Garzón-Galvis et al., 2019). To varying degrees, participatory processes and inclusive communication are present in biocultural research and development, such as sustainability science (Cash et al., 2003), knowledge systems, integrated natural resource management (INRM; Sayer & Campbell, 2003), and adaptive collaborative management (ACM; Colfer, (2008). INRM and ACM are attempts to include end users in all stages of research and to move from a scientist-dominated research focus to action research that includes social learning and adaptive processes (Shackleton et al., 2009). An extensive recent study analyzing the impacts of environmental education concludes that inclusive, creative, hands-on, action-based projects which address local community needs through collaborative processes can be highly effective in achieving education and conservation outcomes (Ardoin et al., 2019).

Two-eyed seeing and collaborative research also strive to take an equitable approach to research and communication (Cajete, 2010). Two-Eyed seeing entails methods whereby indigenous and western scientific ways of viewing the world are respected and woven together for the benefit of all (Wright et al., 2019). In methodologies, implementation, and outputs, collaborative approaches and Two-Eyed Seeing contrast starkly with, ‘blind science’, in which the process rarely includes input from local communities or end-users, and primarily produces peer-review publications (Morin, 2005) (Figure 4.17).

A recent initiative establishing a bridge between the public and the world of research and education is citizen science, in which members of the public collect substantial quantities of data at unprecedented spatial and temporal scales that would otherwise not be possible or affordable (Dickinson & Bonney, 2012). Citizen science authenticates place-based nature experiences while enhancing understanding of and support for sustainable stewardship (Shirk et al., 2012). As contributors become engaged in resource management issues that impact their lives, participation can initiate democratization of the research process (Dickinson & Bonney, 2012). Furthermore, the inclusive nature of working with diverse collaborators more readily sparks innovation (Woolley et al., 2010).

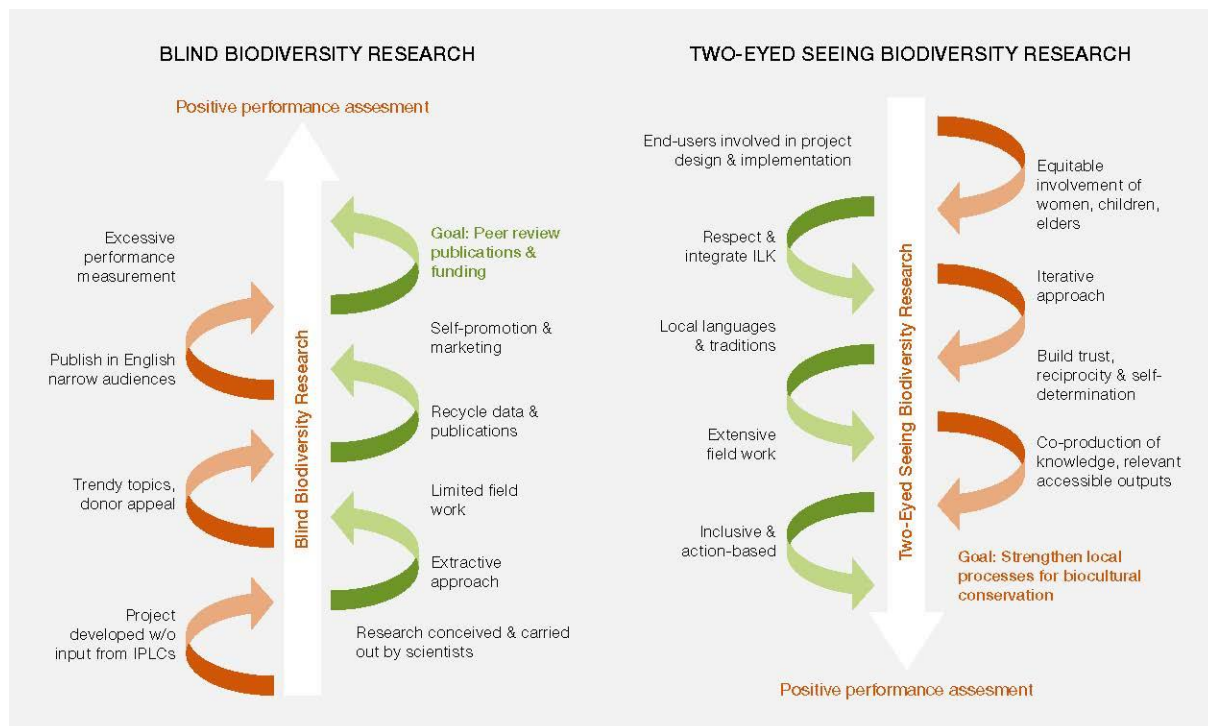


Figure 4.17 Blind vs two-eyed seeing biodiversity research and education. Source: Shanley & Lopez, (2009) © 2009 by The Association for Tropical Biology and Conservation. License CC-BY.

4.2.6.4.6 Movements toward indigenous, culturally inclusive, and place-based education

Many local and indigenous groups are calling for systemic changes in educational systems to respect the traditions, knowledge, languages, values, history, and identities of their cultures. Formal recognition by national educational systems of cross-generational knowledge transmission and a wider range of approaches to learning would support local stewardship and sustainable use of wild species.

Examples of case studies highlighting trends in education and awareness-raising which support sustainable use of wild species are described below.

The Philippines, the Negritos: An example of a systemic change in formal education, policy and resource conservation has occurred among the Negritos in the Philippines. Over 70 Negrito communities are currently using culture, education, and awareness-raising as effective tools to change public perception of indigenous peoples and promote conservation. Once denigrated, the Negritos now host cultural revival festivals, boosting their societal status, as well as improving relationships with policymakers. Wild plant foods, crafts, herbs, songs, and dances are shared to celebrate biodiversity and the knowledge of the elders in managing forests sustainably. The revivals have helped lead to a reform of elementary and secondary education whereby traditional ecological knowledge, values, and skills are integrated into school curricula and bi-lingual learning materials (Quierrez & Beer, 2014). School credit is being granted to youth for time spent outside with elders learning about nature first-hand. To expose urban families to the Negrito lifeways, the National Museum of the Philippines has created a permanent exhibit and programs, which along with newspaper and television broadcasts,

highlight the positive contributions of Negritos to the nation. Negritos are currently engaging with government agencies in multi-stakeholder symposiums to conserve biodiversity and enact policies favorable to rural livelihoods (Beer, 2014; Jenne, 2011).

In Sulawesi, Indonesia, an extensive awareness programme to promote biodiversity protection at the Nantu Wild species Sanctuary has been carried out over the last three decades by the Adudu-Nantu Conservation Foundation (“YANI”). This has included the construction of a Biodiversity Field Training Center, conservation workshops for all sectors of local society, and the creation and distribution of 5,000 copies of a children’s storybook about the endangered Babirusa, an endemic mammal in Sulawesi. In addition, live “Conservation Concerts” by local entertainers, Nantu Forest scholarships providing secondary school education to local children, and the development of a Biodiversity Curriculum Materials Manual (Kartikasari & Clayton, 2015) have helped to conserve 62,000 hectares of the threatened rainforest at one of Southeast Asia’s five most significant sites for biodiversity (Clayton et al., 2007).

Box 4.38 Case Study: Key drivers of wild resource use and how interactions amongst them can dramatically change outcomes

The Amur Falcon is a fascinating migratory raptor. Every year, the small, resilient birds make the voyage from breeding grounds in Russia, Mongolia, and northern China to winter in southern Africa. Because of the long journey, approximately 22,000 km, the longest sea crossing of any raptor, stopover sites are important to stock up on food for the ensuing journey. It feeds on dragonflies, grasshoppers, locusts, and termites. Pangti is a small village in Nagaland, northeastern India. Nagaland is rich in natural resources, but the hilly terrain, landlocked location and poor infrastructure are key reasons for underdevelopment, and poverty. Until 2012, hunting of the Amur falcon used to provide meat as well as cash income for large numbers of local people. In 2012 an estimated 120,000 to 140,000 birds were trapped in nets and killed while passing through Pangti. Video images of the slaughter resulted in a national outcry. The Government of India and the State of Nagaland imposed bans on hunting. However, the role of non-governmental organizations working with the local indigenous community was key in ensuring compliance. Local adults were trained in natural history education and employed as teachers, strengthening local capacity and indigenous pride in managing the resources. Eco-clubs and engaging the local youth further motivated them to stop hunting. After the initiative was taken to conserve the falcon, local communities also benefited economically with homestay lodges opening up for visitors to the “*amur falcon capital of the world*”. Locals were trained as tourist guides, the youth recruited by the forest department for patrolling and monitoring the roosting areas. The actions taken were not top-down and prescriptive, but the spectacular change was possible through the empowerment of local communities, and recognition of indigenous knowledge as well as skill development for alternative income generation.

Source: Murali Chatakonda and Ganesan Balachander; Compiled from publicly available information and as reported by Mr. Phanteo Kittan, Secretary, Amur Falcon Roosting area Union, Pangti village.

In Mexico, at the State University of Veracruz, indigenous villagers can enroll in a certified diploma course covering themes such as community development, silviculture, and multiple-use management. Experiential, peer-to-peer, field-based learning leads to individual and collective transformation, building resilience and sustainable means of facing land use challenges. The project has led to retaining tree diversity, production of native dyes,

management and consumption of indigenous foods, curriculum reform, and hands-on teaching methods. It has also led to the protection and consolidation of the socio-ecological system underlying traditional weavers, which serves as a cornerstone of community-based landscape management (Binnqüist et al., 2017). As an original, transdisciplinary approach to solving complex problems, indigenous education holds the profound potential to address the array of sustainability challenges facing the planet (Cajete, 2010).

In the Brazilian Amazon as part of a decades-long initiative, over one hundred Brazilian researchers shared relevant ecological and economic data on 30 fruit, medicinal and wild species-attracting tree species with a wide distribution throughout Amazonia, and integrated these with traditional knowledge, recipes, stories, songs, and management tips from scores of local people. The resulting illustrated book in Portuguese, *Fruit Trees of the Forest in the Lives of Amazonians*, has been translated into English and Spanish, and has served as a template to share local and scientific knowledge for community benefit. Throughout the Amazon Basin the information has been used to enhance the management of medicinal plants and fruit trees, increase women's participation in decision-making, create forest reserves, and train foresters. Radio programs, a film, and workshops complement the manual and have resulted in improved forest practices and policies, and more sustainable use of wild species (Shanley & Medina, 2006).

4.2.6.4.7 Elements of effective biodiversity education and awareness initiatives – mediating factors

Biodiversity education and communication can nurture a conservation consciousness which is fundamental to supporting sustainable use of wild species. There is an emerging consensus that effective education programs respect local cultures, languages, and land, include women, elders, and youth, and promote inter-generational transmission of knowledge.

The relationship between education of various kinds and behavioral change is complex (Liu et al., 2016). Interests and motivations are impacted by socioeconomic variables such as income, gender, religion, age group, schooling, and place of residence (de Oliveira et al., 2019). However, in the examples above some commonalities can be identified. First, these examples focus on issues related to wild species of direct relevance to local populations. Second, the challenges are approached respectfully, taking into consideration local traditions, customs, and intergenerational world views. Third, in these cases, the action was not prescriptive, but through education, empowerment, and skill development for alternative management practices and/or income generation. In addition, change was instilled through a cyclical, collaborative process whereby perspectives of local and regional people and policymakers were considered. Furthermore, in each case, unique aspects of local and regional flora, fauna, and culture were celebrated, engendering in villagers, urban residents, and policymakers, a feeling of pride, and a connection to species other than themselves. Finally, these case studies reveal a renewed sensitivity to the plight and perspectives of birds, mammals, and trees, which led to systemic changes in education, policy, and practice.

These elements of biodiversity education highlight components of effective local initiatives less frequently recognized or documented by scientists -- appreciation of people's cultural, emotional, and spiritual connections to nature. Understanding the emotional

connection to, and cultural importance of, biodiversity is essential to developing collectively acceptable forest management and restoration strategies (Posey, 1999; Wehi & Lord, 2017). Additionally, the extent to which a person feels a part of nature is vital to how they act towards nature. Such values and belief systems are reflected in linguistic and cultural identities which convey respect for nature and which constitute a strong foundation for the sustainable use of wild species (Cocks & Shackleton, 2020).

Case studies indicate that education and communication leading to sustainable use of biodiversity are characterized by some of the following features:

- Support cultural inclusion and linguistic identity
- Foster intergenerational transmission of knowledge
- Include elders and youth
- Promote gender equity
- Advance place-based initiatives
- Recognize parents and community as primary teachers
- Uphold respectful communication and interactions
- Employ experiential learning techniques
- Advocate creative use of technologies when appropriate
- Stimulate cross-sectoral initiatives
- Reflect the input of local people

4.3 Interactions among Drivers

Key messages:

- In most, if not all instances of resource use, there is interaction amongst drivers leading to either synergistic or antagonistic effects. Interactions among the various drivers make use of a species sustainable or unsustainable and are common. The level of interaction is often case-specific and depends on whether:
 - use is restricted to a single jurisdiction versus being regional or transboundary.
 - technology is relatively simple and stable versus highly mechanized and frequently innovated.
 - alternative sources of food or livelihoods are of limited or ample availability.
 - governance processes are robust or contested.
 - there are multiple competing uses, or
 - little is known about the species.
- Whether a practice of using wild species is sustainable or not is highly complex and may be influenced by how drivers (i.e., environmental, social, economic, cultural, political, and science and technology and education) interact, which is often also influenced by mediating factors such as species ecology, value systems, indigenous and local knowledge and context (*well established*) {4.3.2, 4.3.4}.
- The sustainability of fishing and fisheries is widely driven by the complexity of the web of interactions among environmental, social, economic and technology drivers, where species biology, ecosystem and multi-species interactions also matter significantly (*well established*) {4.3.2.1}.

- The economic trade driver interacts with environmental, cultural, and social drivers to have an effect on the sustainability of gathering and collection of wild species. Such effects may be mediated by the use of technology and tools to further impact the collection of wild resources (*well established*) {4.3.2.2}.
- Cultural and social drivers often interact with economic drivers which are further mediated by factors such as species biology to shape the sustainability outcome of hunting, with the bulk of the studies coming from the tropics (*well established*) {4.3.2.3}.
- Political and economic trade drivers and mediating factors such as species management interact to determine if logging practices are sustainable, but regional differences are apparent (*well established*) {4.3.2.4}.
- Compared to other practices, the non-extractive use of wild species is relatively sustainable, though not as widely studied. Multiple drivers have been documented to interact to affect the sustainable management of species (*established but incomplete*) {4.3.2.5}.
- The ecological settings, species rarity, and the resilience of ecosystems can influence the sustainability of the practices. Understanding species biology and ecology and how they interact with drivers can affect the management and sustainability outcome of the practice (*established but incomplete*) {4.3.3}.
- Long-term, spatially explicit studies are important for the assessment of the sustainability of the use of wild species. The interactions of drivers change with time and conditions, particularly when subjected to external shocks (e.g., economic or environmental) and perturbations, which may impact the sustainable use of a species in the future (*established but incomplete*) {4.3.4}.

4.3.1 Overview

The section addresses the relationships among different primary drivers (e.g., environmental vs social) and the synergies among the different combinations of drivers. In the previous sections, the experts recognized a total of six key drivers namely environmental, social, political, economic, value systems, customs and beliefs, scientific and technology innovation and education. Within each primary driver, secondary drivers often interact leading to unintended wild species use outcomes (see each driver section for examples). In many instances, different drivers interact to give unexpected hunting, extraction and harvest outcomes. Three possible ecological outcomes that may change dynamically over time upon further interactions. Wild species sustainable use may either be positive (+), negative (-) or no net change (=).

In this section, the focus is on inter-driver interaction and how they influence the ecological outcomes. This section highlights cases with different combinations of drivers under a variety of ecological context and settings, species rarity, and resilience of ecosystems. Temporal and spatial scale issues may also influence the interactions among drivers, providing a mapping of these relationships and identifying possible indicators of each driver (or group of drivers). This section draws on examples to illustrate the nature of the interactions among drivers and how the sustainable use of wild species can change.

- **Methodology**

Chapter 4 has compiled a database of relevant papers partitioned into the five different practices and their drivers for in-depth analyses. The interactions among the drivers for a practice (i.e., terrestrial animal harvesting) will be quantified and elucidated during this process. The Sankey diagram below illustrates the complexity and interactions among the five key drivers in producing sustainability outcomes of the use of wild species throughout the world for selected key papers associated with the hunting practice. In addition, this section delves into details for each practice to look at interactions within and across drivers separately.

- **Analysis of literature and cases on sustainable use of wild species**

As a first pass analysis in understanding the influence of drivers, mediating factors on the sustainable use of wild species focusing on the published literature related to the hunting practice. From the selected 20 studies based on a pre-determined set of criteria, the 74 sets of drivers and mediating factors and associated outcomes were identified, as well as the concluded author-assessed use. In many cases, they have listed multiple and interactive drivers and mediating factors when evaluating whether a hunting practice is sustainable or not. The listed drivers and mediating factors were categorized based on the proposed structure set shown in Figures 4.18.

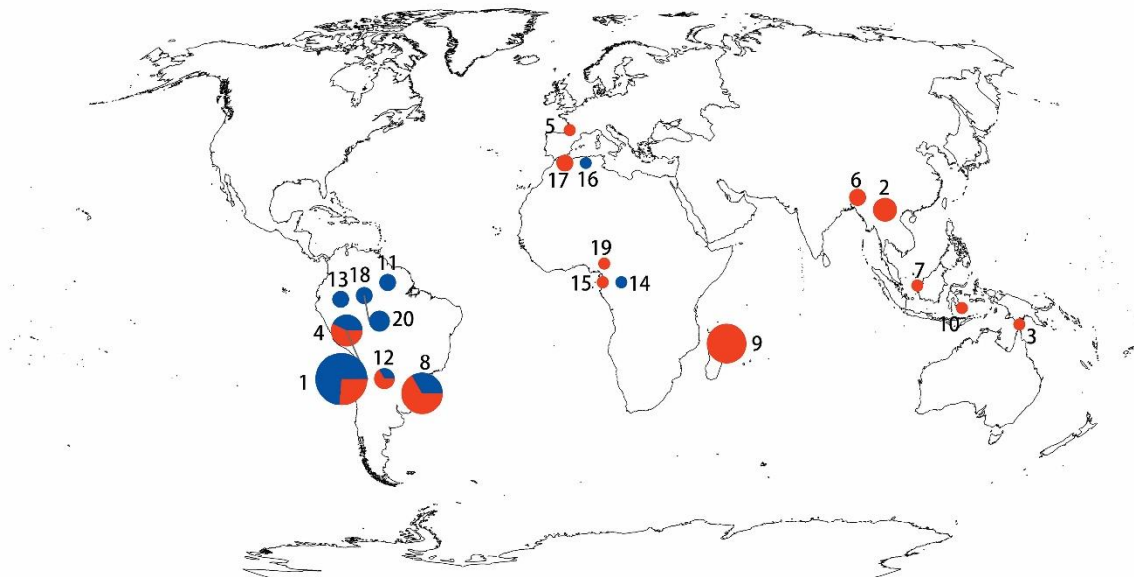


Figure 4.18 The global geographical locations of selected 20 studies (a subset of available literature) comprising 74 cases on the sustainable use of wild species based on hunting. Author-assessed sustainable and unsustainable use of wild species represented in blue and orange, respectively. The size (not to scale) of the circle represents the number of cases per study. The proportion of cases that are sustainable or not is indicated for each study. An orange circle means that all cases are unsustainable for the study. See data management report (doi: 10.5281/zenodo.6453169).

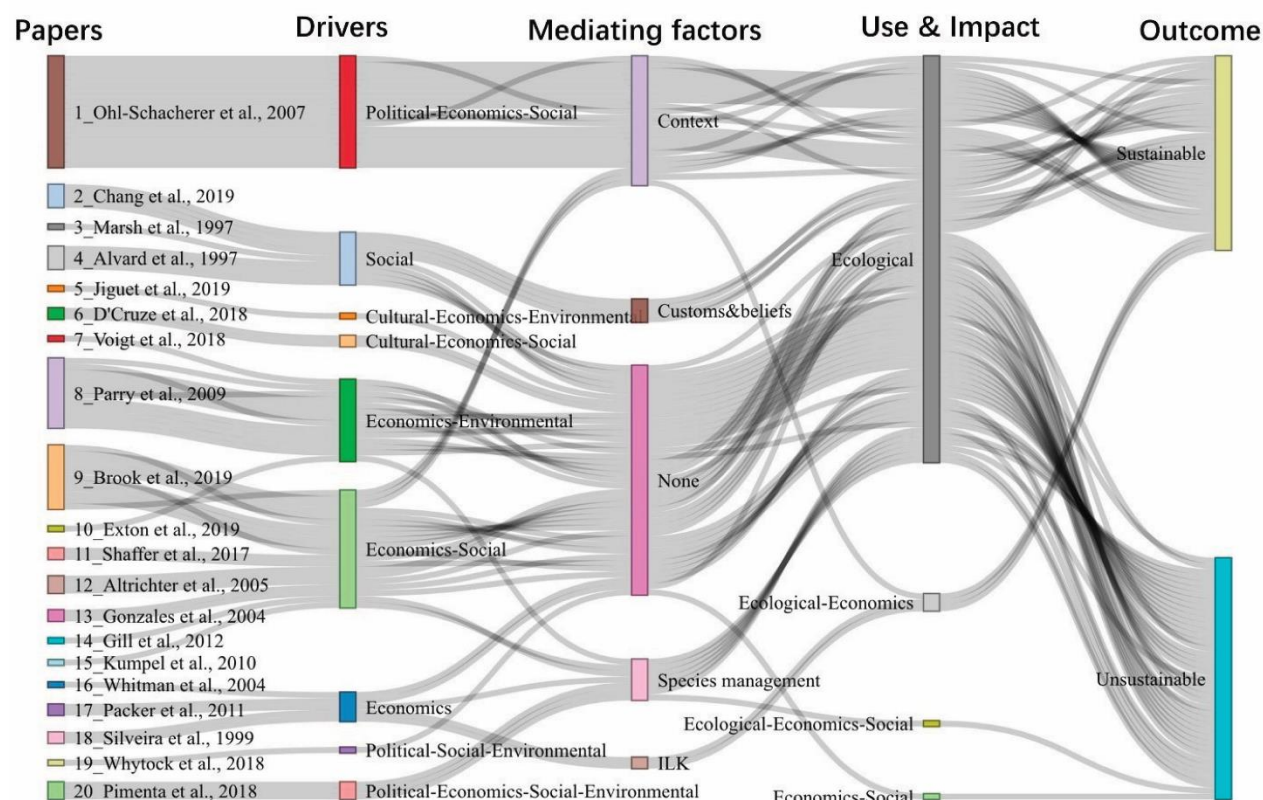


Figure 4.19. Preliminary analysis of the factors driving the sustainable use of wild species based on hunting as a practice (number of cases = 74; from 20 papers). The data is presented in the form of a Sankey diagram. The leftmost column shows the paper, the second from the left column shows the combination of five main drivers, the third from the left the mediating factors, the fourth from the left column provides the identified impact measures (i.e., ecological, social, economics, or combinations), and the rightmost column indicates if a certain driver leads to a sustainable or unsustainable use based on the authors' evaluation. See data management report (doi: 10.5281/zenodo.6453184)

From Figure 4.19, when it comes to hunting, all five types of drivers are listed, with the economic and social drivers being the most common solo ones (first column). While interactive and combination of drivers are recorded frequently, many cases only considered two to three drivers (e.g., Economic-Social). Similarly, while mediating factors are seen in many cases, over half of them has none. The most frequently seen mediating factors include species management and context. In addition, the most dominant use and impact measure is related to a single ecological dimension, although other combinations of outcome measures (combinations of ecological, social, and economic) have been found. Economic-related and combination drivers are more commonly observed than others in driving outcomes in hunting. Context matters in influencing the sustainability outcome of the use of wild species. Overall, based on the first pass analysis, the author-assessed evaluation of sustainable use is slightly skewed towards unsustainable use, although sustainable use cases have been reported.

4.3.2 Interactions between drivers across different practices

4.3.2.1 Interactions between key drivers for fishing

Complex ecological (e.g., interspecies interaction), economic and technology drivers interact to influence if fishing levels are sustainable or not (Aura et al., 2019; Bertocci et al., 2018; Biggs et al., 2016; Campos-Silva et al., 2020; Filous et al., 2019; Gianelli et al., 2019; Irvine et al., 2019; Kluger et al., 2019; Lee & Perry, 2019; Maravelias et al., 2018; Muallil et al., 2019; Paesch et al., 2014; M. N. Peterson & Nelson, 2017; Puente-Rodríguez et al., 2015; Stephenson et al., 2018). In Galicia (Northeast Spain), cetacean depredation on catches and damage to fishing gear can cause substantial economic loss for fishers, while cetacean bycatch raises conservation concerns. Fishers report that economic loss can result from common bottlenose dolphins (*Tursiops truncatus*) damaging coastal gillnets and from short-beaked common dolphins (*Delphinus delphis*) scattering fish in purse-seine fisheries. The main problem, however, was that cetacean bycatch mortality was reported to be highest for trawls and set gillnets, and likely exceeds sustainable levels for local dolphin populations. To minimize cetacean fishery interactions, there is a need to implement case-specific management strategies with the active participation from fishers. For set gillnet and purse-seine fisheries, the use of acoustic deterrent devices (e.g., pingers) may stop cetaceans from going near and getting trapped in the nets. For trawl fisheries, where bycatch appears to be particularly high at night in water depths of 100-300 m, possible solutions include the implementation of time/area closures and the relocation of some fishing effort to deeper waters (Goetz et al., 2014). Improvising the use of technology and considering the species behavior will reduce the cetacean by-catch mortality which will make the harvesting more sustainable.

Social, economic, and ecological drivers often interact in the sustainability of fishing and fisheries. There is a need to understand the fishing process to understand and manage fisheries. A quantitative, mechanistic understanding of the opportunities fishers encounter, the constraints they face, and how they make decisions within the context of opportunities and constraints will enhance the design of fisheries management strategies to meet linked ecological and social objectives and will improve scientific capacity to predict impacts of different strategies. Spearfishing in a Caribbean coral reef fishery was examined. There are differences among taxa in this multispecies fishery, as some taxa are known to be ecologically or economically more valuable than others. Parrotfish are ecologically indispensable for healthy coral reefs, and they were encountered and captured more frequently than any other taxon. Fishers made decisions about which fish to target based on a fish's market value, proximity to the fisher, and taxon. The information uncovered on fishers' opportunities, constraints, and decision making has implications for managing this fishery and others sustainably (Pavlowich & Kapuscinski, 2017).

4.3.2.2 Interactions between key drivers for gathering

Economic trade driver may interact with environmental and biological, and/or cultural and social drivers to have an effect on the sustainability of gathering and collection of wild species (Brooks & Tshering, 2010; Gaoue & Ticktin, 2009; Huber et al., 2010; Jensen & Meilby, 2010).

Humans compete directly with native dispersers/predators (e.g., agouti) for *Bertholletia excelsa* seeds traded internationally as Brazil nut, and hence timing and intensity of harvests following fruit-fall determine the availability of this resource for dispersers. Research has revealed that agouti is particularly important for *B. excelsa*, because it disperses and often buries seeds into spatially scattered caches, facilitating seed germination and early seedling establishment. By tracking and monitoring the timing of the rodents' dispersal behavior and human harvesting behavior, local people could safely collect, and dispersers would have periods of unlimited resource access. Considering the collective understanding of the dynamic *Bertholletia*-*Dasyprocta*-*Homo sapiens* interactions, properly timed harvests across the sites in the region could boost rural people incomes and probably not threaten Brazil nut recruitment or maintenance of agouti populations (Wadt et al., 2018).

Commercial gathering of selected medicinal plant species in the Himalayas to meet increasing national and international demand can lead to overexploitation. Sustainable management of medicinal plants requires a clear understanding of the respective roles, responsibilities and viewpoints of the various stakeholders involved, which could be drastically contrasting. Perceptions on market availability and threat status of medicinal plants differed between representatives from the district and national organizations and local people. Nevertheless, both stakeholder groups agreed that key threat drivers are over-harvesting, habitat loss due to land-use change and deforestation, and livestock over-grazing which could undermine the sustainable use of important plant resources (Upreti et al., 2011).

Cultural and social factors may interact with technology use to impact the collection of wild species resources. Cultural and socio-economic factors influence the collection practice and resource use of indigenous wood carvers in the Maningrida region of central Arnhem Land, Darwin, Australia. Local woodcarvers use a small amount of carving timbers from two species but many cultural differences in harvest practice exist with artists from a different (i.e., Kuninjku/Kunibeidji) language community, where they harvest a greater number of tree species, larger quantities per harvest trip and thinner stems. Artists owning a vehicle are known to acquire more stems than those who did not. Not surprisingly, such influences on harvest practice can have significant implications for the ecological sustainability of logging in the region, highlighting the need to examine localized factors when assessing the sustainability of indigenous wild species harvests (Koenig et al., 2011).

Social and economic factors may interact to determine if communities can sustainably gather wild species resources. Surveys of actual resources suggest that for poorer resource-dependent communities without access to markets, plants, algae and fungi can only be a safety-net activity and a supplementary income source. Resource availability, in terms of the diversity and productivity of the forest, has been argued to be key in contributing to well-being. Data from an area of tropical rainforest in Peru show that non-timber forest products provide only a relatively small portion of income and that only a small proportion of available products are in fact commercialized, even when markets are available. The observed low rates of commercialization can also be explained by unequal access capital assets used for extraction, to natural resources themselves, and to product markets, as well as due to the concentration of capital-poor households on subsistence gathering activities. As a result, unsustainable and destructive uses of forests (e.g., logging), generate more returns than those from plants, algae, and fungi. While plants, algae and fungi may have the potential to be an important livelihood

source for poorer communities, market integration and commercialization, two critical enablers, may not be omnipresent (Pyhälä et al., 2006).

4.3.2.3 Interactions between key drivers for terrestrial animal harvesting

For political drivers to be effective in making the use of wild species sustainable, it is crucial to consider the circumstances of local communities, be complementary and coordinated with other secondary drivers, and be well implemented. Furthermore, people may consider the impacts and interaction of political drivers with other drivers such as those economic in nature. For example, effective programs to manage wild species trade sustainably should be instituted not just at source populations but also at the point of sale and consumption (Nasi et al., 2008). This is in addition to considering other economic and livelihood activities such as agriculture and market trends (Hakimzumwami, 2000), coupled with economic incentives (Abensperg-Traun, 2009). Similarly, political drivers need to be considered at different scales. For example, developing institutions at local levels to promote sustainable use of species need to be supported by other institutions and across different levels (such as devolution of land ownership or use rights) (Abensperg-Traun, 2009), also considering impacts policies at the international level can have at the local level. For instance, what are the impacts of trade barriers on local prices of wild species (Giller et al., 2008). Sustainable use is thus conditional on a wide range of political, economic, environmental, and other drivers, and with a full understanding of the interaction of these drivers across multiple levels.

Cultural, social, and other drivers interact and are mediated by other factors to influence the sustainability of hunting (Brook et al., 2009; Brooks et al., 2007; Etnier, 2007; Golden, 2009; McAllister et al., 2009; Naranjo & Bodmer, 2007; Ohl-Schacherer et al., 2007; Zapata-Ríos et al., 2009). In Latin America, campesino hunters are identified as peasants-cultureless, uneducated, and uncaring toward wild species sustainability, but knowledge from this largest group of hunters is underrepresented in the literature. Existing studies spanned 17 countries, 7 ecosystems, and >75 indigenous and nonindigenous demographics in 30 research contexts, where the focus is on nonindigenous campesinos for species-specific conservation and protected area management in tropical broadleaf forests of Mexico, Peru, and Colombia. The synthesis revealed that factors subsistence, income, ethics, regulations, and crop or livestock protection and their interactions shaped whether these hunters hunt nearly 800 species, most of which are the International Union for Conservation of Nature least concern species, and if they do so sustainably (Petriello & Stronza, 2020).

Economic and social drivers may interact to affect wild meat hunting sustainability. In the Democratic Republic of Congo, artisanal and small-scale mining is a source of livelihood for up to million people and is one of the main threats to large mammal species and their habitats, including forest elephants and great apes. Wild meat hunting is a consequence of mining. Minerals exploited at the sites included cassiterite, gold, coltan and wolframite, and most mines were controlled by armed groups. On average, miners earned significantly higher revenue than non-miners. Because mining was seen as a short-term activity, most miners were in favour of leaving the sector for better jobs. Almost all respondents consumed wild meat regularly due to the lack of alternatives and they believed that wild meat hunting had caused declines and local extinctions of some large mammal populations, including great apes.

Nevertheless, the respondents indicated that they would reduce their consumption of wild meat provided that domestic meats became more available. To remove the threat of unsustainable hunting by miners, access to sustainable meat sources should be made, micro-financing mechanisms should be established to help miners leave the mining sector, and de-militarizing the mining sites should be prioritized to facilitate law enforcement (Spira et al., 2019).

4.3.2.4 Interactions between key drivers for logging

Political and economic trade drivers and other mediating factors interact to determine if logging practices are sustainable (Houehanou et al., 2011; Medjibe et al., 2013; Robiglio et al., 2013; Scabin et al., 2012). Illegal timber trade is a global issue, with highly prized rosewoods from Madagascar providing an example. Corruption and political instability facilitated illegal rosewood exploitation in recent decades. At present, there exists no non-detriment findings (where the exporting State ensures that a proposed action will not be detrimental to the survival of a species) to enable the sustainable use of standing populations. The Malagasy government, with support from the World Bank, is promoting the sale of stocks of confiscated precious woods. Such sales could encourage further illegal harvest because tools to identify, control and monitor standing trees and cut timber are lacking. Taxonomic confusion and substantial knowledge gaps regarding species limits and population sizes may also increase the difficulty of detecting and addressing unsustainable levels of the harvest of rosewoods (Waeber et al., 2019).

Social drivers interact with species management to mediate the sustainability of logging. Implementation of forestry best management practices protects water quality during and after logging operations. Effective best management practices are site or region specific and address the full course of logging operations from planning and site preparation to felling and removal of trees, to the closure of logged sites. Throughout logging, sediment control and road construction and maintenance are especially important to assure water quality. In the United States of America, over 50 years of research in three regions of the United States of America demonstrate that well-designed forestry best management practices can reduce erosion and sedimentation of surface waters. However, their effectiveness is dependent upon the quality of their implementation (Richard Cristan et al., 2016). In the case of logging on private forest lands, loggers, landowners and professional foresters each play a role in the implementation of forestry best management practices. With their differing interests in the logging process and its outcomes, as well as variable levels of knowledge about forest ecology and management, implementation of best management practices can be enhanced by training programs for young loggers, educational programs for landowners, and discussion platforms for all stakeholders (Tumpach et al., 2018).

Legacies of past logging practices and climate change may interact to influence the behavior of rural communities in harvesting forest timber products. Rural households in southern Africa need fuelwood to meet daily domestic energy requirements. Unsustainable fuelwood harvesting arising from the increasing demand due to growing human populations may lead to environmental degradation. The impacts of fuelwood harvesting from 1992-2009 on the woodland structure and species composition surrounding two rural villages, with similar socioeconomic characteristics, located within the Kruger to Canyons Biosphere Reserve

(Mpumalanga Province, South Africa) were assessed. The total wood stock in the communal woodlands of both villages declined overall, with adverse changes in woodland structure and diversity of species commonly harvested for fuelwood in one village. The latter site became degraded, and no longer produced fuelwood of preferred species and stem size in sufficient quantity or quality. More sustainable harvesting regimes probably existed at the other site because of the lower human population and lower fuelwood extraction pressure. However, both communities harvested from neighbouring unoccupied private land in a social response to fuelwood scarcity due to either degradation or drought periods (Matsika et al., 2013).

4.3.2.5 Interactions between key drivers for non-extractive use

Multiple drivers may interact to affect the sustainable management of iconic species, particularly for those of non-extractive (e.g., cultural) and economic use. The Murray crayfish (*Euastacus armatus*) is a freshwater species valued by the Aboriginal Owners and threatened by landowners, tourism businesses, scientific researchers, non-governmental organizations, and government agencies across southeast Australia (Noble et al., 2018). Research showed that *E. armatus* is a culturally significant species, targeted for fishing, but is also highly valued for a range of non-extractive reasons that support social-ecological linkages between local people and freshwater ecosystems. Regarded as an iconic species by most stakeholders in SE Australia, there was general support for *E. armatus* to be used as a flagship species for conserving a spectrum of social-ecological values (e.g., Aboriginal Traditional Owner totem species) in local freshwater ecosystems. General calls for increased public education, co-management with non-government stakeholders, federal government coordination, and spatial protection of critical areas could feature for more equitable conservation and management strategies.

Wild edible mushrooms offer us a system that illustrates how economic, cultural, and social drivers may interact to produce potentially sustainable forest production and management. The diverse use of mycological resources may include tourism, where recreational and non-extractive activity is largely based on knowledge, identification, gathering, and tasting of mushrooms. By productively restructuring the forest spaces in Mexico, for example, developing mycological tourism could aid in generating income and social transformation of rural communities and provide incentives for optimal resource management and spatial planning (Jimenez-Ruiz et al., 2017).

4.3.3 Effect of ecological settings, rarity & resilience of ecosystem

Wild species hunting and harvesting is often unsustainable in the tropics. This is in part due to a burgeoning human population and shrinking forests, and weak enforcement and regulation of protected areas and protected species, respectively (Bennett & Rao, 2002; Brodie et al., 2015; Corlett, 2007; Harrison et al., 2016; Kamp et al., 2015; Lavery & Fasi, 2019; Milner-Gulland & Bennett, 2003; Nasi et al., 2008; Ripple, Abernethy, et al., 2016). Drivers of recent overhunting include deforestation, improved access, including road infrastructure, to forests and markets, improved hunting technology, and their interactions and escalating demand for wild meat, and wild species-derived medicinal products (Corlett, 2007; Harrison et al., 2016; Lima Constantino, 2016).

For example, there is a need to understand the complex and dynamic relationships between the hunting ground, its resources, the stakeholders, and the different exogenous drivers of change that affect the components of the system at different scales. Using the resilience theory in the context of wild meat hunting people may considering shifting from the need to assess stocks with imprecise measures to the incorporation of the uncertainty and stochasticity inherent to complex systems in participatory and adaptive management processes. Such an approach can provide an opportunity for the sustainable use of wild meat and allows the identification of strategies to strengthen resilience when the system is found to be close to a given threshold (van Vliet, Quiceno, et al., 2015).

Conservation and management design of threatened aquatic species, such as Murray crayfish in SE Australia, should include their entire range of cultural, economic, and ecological values using more stakeholder-led approaches (including from locals, non-governmental organizations, and tour operators). In doing so, broader stakeholder engagement and co-management could increase the capacity and confidence of managers to implement strategies that bolster both the social and ecological resilience of aquatic ecosystems (Noble et al., 2018).

The non-extractive value of certain marine species may have important impact on the economic viability of marine protected areas that are highly dependent on marine-oriented nature tourism. Some marine protected areas in the Turks and Caicos Islands have recorded increases in spiny lobster (*Panulirus argus*) size and abundance leading to more sustainable fisheries. While these economic benefits of these changes have been linked to the effects of emigration of adult lobster to adjacent fishing grounds and/or increased larval export to downstream nurseries, non-extractive economic value resulting from viewing wild species from recreational divers may also have an important impact on the overall economic viability of Marine Protected Areas (Rudd, 2001).

Looking at a sample of 27,600 vertebrate species assessed by the International Union for Conservation of Nature Red List, slightly over 30% of them are decreasing in terms of both population size and range (IUCN, 2017). In the last one hundred years, vertebrate species have been lost at 100 times the normal background rate. Specifically, of the 177 evaluated mammal species, all have lost over 30% of their range since the year 1900, while >40% have experienced severe population declines (i.e., over 80% range shrinkage) during the same time (Ceballos et al., 2017). The Living Planet Index estimates that the global wild species abundance has dropped by up to nearly 60% between 1970–2012 (WWF, 2018). Species with larger body sizes are suffering the worst declines (Dirzo et al., 2014; Ripple et al., 2014, 2015), indicating the influence of ecological traits (body size), which may be related to rarity. Because wild meat harvesting can contribute directly to wild species losses, particularly for large mammals (Ripple, Chapron, et al., 2016), understanding of the myriad of interacting factors that drive such unsustainable harvests to better tailor interventions to curtail such losses.

As depicted in Figure 4.20, the reasons for wild meat overexploitation or unsustainable harvesting are many and these often vary significantly between regions (i.e., spatial variation). Take for instance, how escalating human populations via new immigrants (transmigration) and refugees (due to war and conflict) in villages, coupled with drought conditions and widespread economic and social inequalities could lead to ongoing decimation of wild species populations. Figure 4.20 illustrates the tangled web of some of these inter-driver interactions that typically

catalyze wild species overexploitation. For example, Figure 4.20 shows how the extensive and complex interactions among many of the primary drivers such as environmental, social, economic and political drivers can critically affect the sustainable harvesting of wild meat.

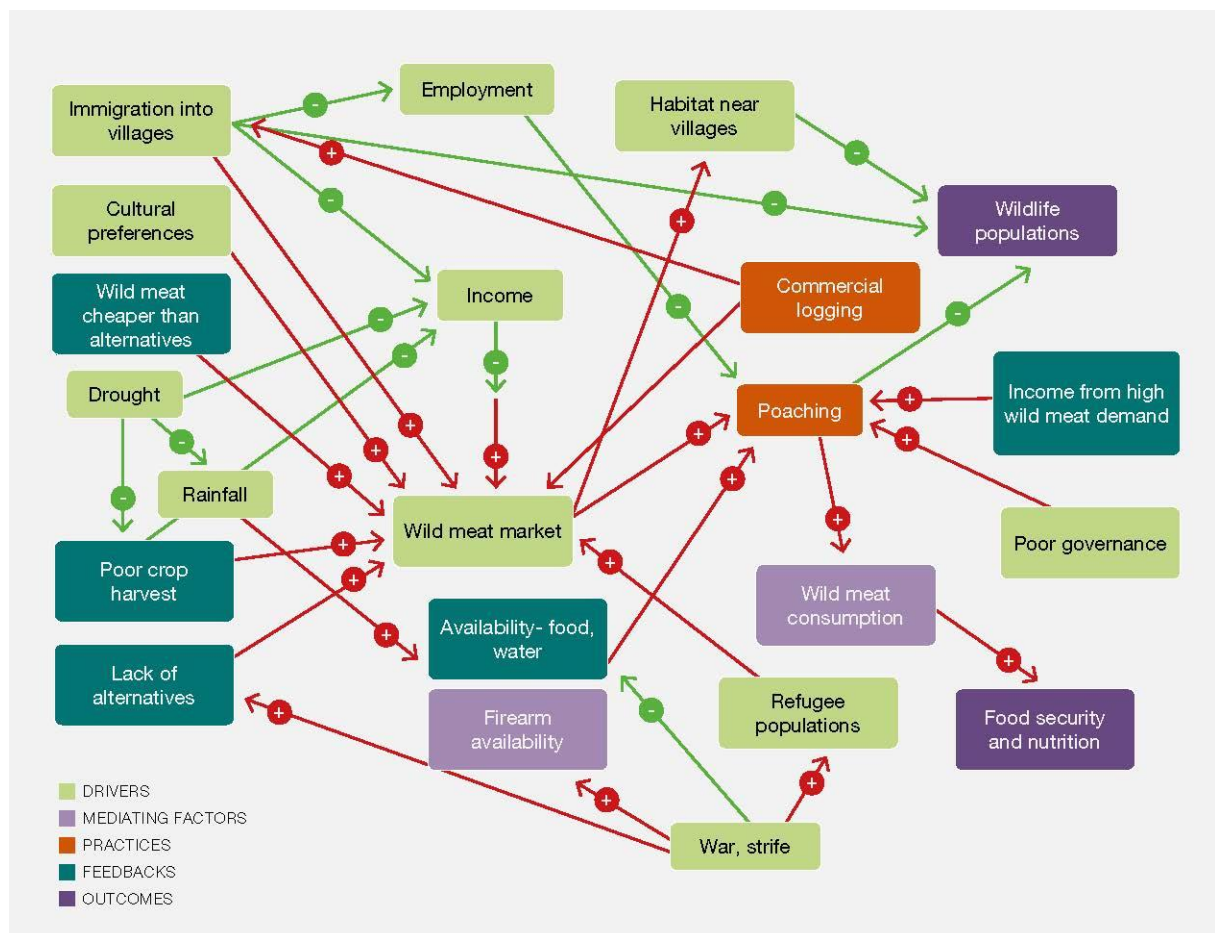


Figure 4.20 Inter-related and interacting drivers contributing to rising wild meat demand, for example, and consequent resource overexploitation (arrows with + signs denote positive relationships between drivers; arrows with – signs denote negative relationships between drivers). Each node is also classified as either a driver, a mediating factor, a practice, a feedback, or an outcome). Source: adapted from Cawthorn & Hoffman, (2015) © 2015 Elsevier Ltd. License number 5300701475716.

4.3.4 Pattern of interaction among drivers across time and space

Hunting may also be indiscriminate, with offtake determined largely by relative abundance rather than intrinsic preference or legislation. As such, specific management and policy options include the need to monitor the hunting impacts on vulnerable species, the delineation of no-take areas, and modification of the legal framework for wild species conservation over time (Rao et al., 2005).

Box 4.39 Multiple-use system and sustainability

The diversity of wild species used, the complementarity in space and time of diversified practices, the fair regulation of access to resources – and notably the gender equity - are all elements that contribute to the co-viability of ecological and social systems, that means their adaptability to the global change and their sustainability (Armitage et al., 2017; Berkes et al., 2003; Cinner & Barnes, 2019; Cruz-Torres & McElwee, 2017; Gillon et al., 2000; Matin et al., 2018; Prado et al., 2015). Mangrove (socio-ecosystem) is a good example for illustrating in what way a multiple-use system is more sustainable than a single-use system (Sarr et al., 2011) (Table 4.7). Forest in the sea, mangrove combines diverse facets of seascape and landscape – from hinterland to open sea, from tidal channels to backwaters and barren land or tanne areas. Depending on the seasons, the places/sites of uses and the labor forces mobilized (women/men, senior/junior, resident/migrant, etc.), various practices are associated: fishing (fish, crustaceans, shellfish), wood cutting, logging, salt gathering, bee hunting, rice growing, etc.).

Along West African coast, from Senegal to Sierra Leone, the communities of peasant-fishermen, used all the facets of the mangrove, that is not only a resource support or a source of income, on which they depend for their livelihood, but even a more collective heritage. (Figure 4.21: transect of mangrove -zones, species, uses and actors). That means the mangrove socio-ecosystem, with the biological and cultural diversity associated, is inherited from the ancestors, managed thanks to diversified technical systems, controlled over time by means of traditional rules, in such a way that it can be passed on to the next generations. This traditional multiple-use system, which prevailed until the 1960s, has been profoundly affected by a set of interacting factors, including climate change (severe Sahelian drought of the 1970-80s, rain variability since the 1990s), rural exodus (notably inked to urbanization and schooling), globalization of market and also insecurity, political instability and civil war. Local communities cope with these drastic changes in re-arranging the interactions between species/places/uses and actors. Also, the reorganization of the mangrove multiple-use system is based on 3 main trends: the abandonment of mangrove rice fields, the revalorization of traditional uses, the conversion of peasant-fishermen to sea fishing. Long been considered as a secondary or marginal practice, in comparison with rice cultivation, the oysters gathering, under the hands of the women, have become a major resource to face the crisis of the farming system; that means a key source of animal protein for the household consumption, but beyond, a major source of income, through their smoking and long-distance selling on the urban markets. The women gatherers, thanks to the oyster value-chain they control, now cover the essential need of the household (provision of rice, food, medical and education expenses) and have gained new (economic and social) power. This recombination of practices, the rearrangement of uses within the system (included the gender balance within the household and in the whole society), ensures its long-term maintenance. The resilience of the mangrove socio-ecosystem largely is due to the diversity of its components, at all levels, genetic (several varieties of rice), population (several groups of exploited wild species), sea/landscape (from the plateau to the sea). The complementarity between species/practices/actors, with their strategies and institutions, is a key driver of flexibility and adaptability to the changes. On the opposite, when a single use is privileged, whether it is oriented towards production (such as the shrimp aquaculture) or protection/restoration (reforestation with a single species of *Rhizophora* for carbon sequestration), when a component or a facet of the mangrove is overvalued (e.g., the mangrove trees to the detriment of the aquatic component), there is a high risk of biodiversity loss and unsustainability (M.-C. Cormier-Salem, 2017a). Clearly, multiple-use systems in the hands of local communities based on the sustainable management of multiple resources and their redistribution for the benefit of all community members are opposed on the one hand to specialized systems, assigning a use to a space and aiming to intensify production, increase yields and maximize private profits, and on the other hand to protected areas, spaces under severe constraints. These models of environmental management are based on radically different practices, knowledge and relationship to place.

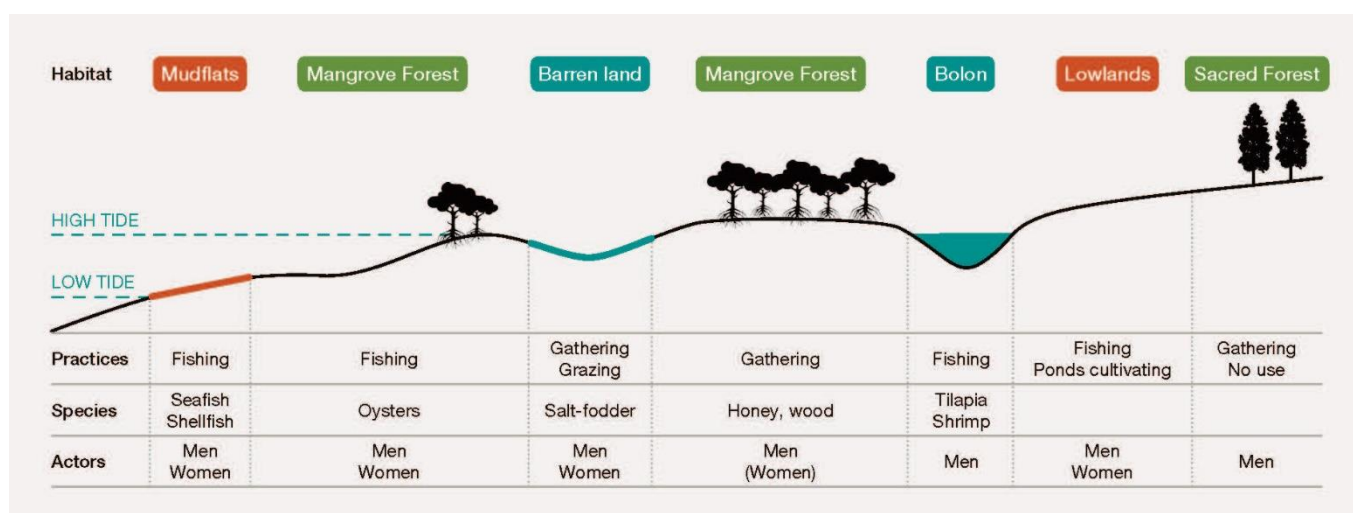


Figure 4.21 Transect of mangrove - zones, species, uses and actors.

Table 4.7 Mangrove services

| Services | Services from mangroves | Main functions (examples) |
|----------------------------|-----------------------------------|--|
| Regulation | Erosion control | Stabilization of shorelines, trapping of sediments by mangrove roots |
| | Protection against storms | Dam consisting of mangrove forests against storms, cyclones and tidal waves, damping of the waves |
| | Flow regulation | Circulation and water exchange through tidal, the river systems, coastal currents |
| | Waste treatment | Waste assimilation by the plant biomass, wastewater |
| Self-production or support | Air and water purification | Carbon export or sequestration by mangrove (carbon sink or source depending on the year) |
| | Water purification | Processing and storage of energy via biomass; sequestration of metal contaminants from the soil |
| | Constitution of the soil | Reclamation and colonization of soft substrate and low oxygen by the root system |
| | Nutrient cycling | Processing and storage of energy and materials (e.g., photosynthesis biomass of mangrove trees, bioturbation and landfill litter by crabs burrowing, litter mineralization by the benthic macrofauna) |
| | Enrichment of coastal waters | Direct transfer of the productivity of mangrove forests to coastal waters via tidal channels and flood; decomposition and mineralization of detrital organic matter, mixed continental water - ocean water; export of materials by migration of macrofauna |
| | Nutrient cycling and Biodiversity | Refuge habitat for birds |
| | | Nursery for fish fauna (retention area, feeding and growth for aquatic life) |
| | | Spawning ground for many species (fish, shrimp) |
| | | Refuge from predators with shade trees, tangle of mangrove roots, turbidity |
| Provision | Food | Mangrove forests, tidal channels and associated ecosystems, agro-silvopastoral resource support, fisheries and food (rice, salt, honey, fish, shellfish, etc.). |
| | Drinks and alcohol | Wood, flower, leaf and fruit fermented beverage, alcohol, vinegar, tea |

| | | |
|---------|-------------------|--|
| | Wood fuel | Firewood and charcoal (fish smoking, heating the brine to manufacture salt) |
| | Health | Leaves and fruits at medicinal and cosmetics uses |
| | Material | timber: poles, wood for house (piles), boat, farm tools (round, plow, dam), fishing gear (dam fence, trap and scoop nets); kitchen (mortar and pestle), tannin and dye (bark), lime shells, sticks |
| | Trade | Commercial and small-scale fishing, coastal and estuarine (fish - mullet, captain, carp and shrimp); collection of crabs, clams, oysters; aquaculture |
| | Livestock feeding | Forage and grazing herds of cattle, goats and other, salt cure |
| Culture | Spiritual | Sacred sites, totemic species: shell middens as tumulus in Saloum |
| | Recreation | Tourism and nature-based tourism (boat ride, wild species viewing); fishing, etc.); terrestrial animal harvesting |
| | Aesthetic | Oral traditions (myths, songs and poems), directed by the mangrove |

Long-term, spatially explicit studies are important for the assessment of the sustainability of the wild species trade, as they provide the potential for disentangling the influences of market dynamics from population declines and contribute to interpreting changes in prices and quantities on sale in end-markets, for example (Milner-Gulland & Clayton, 2002).

When drivers interact and progress over time, the (un)sustainable use of a species may change in the future. Sea trout is one such species. It is a key species in both freshwater and marine ecosystems, providing important demand-driven ecological provisioning and socio-cultural services. As a salmonid species, the sea trout is sensitive to negative environmental conditions in both freshwater and marine coastal areas and is in general decline. Historically, the sea trout professional and subsistence fishery was important but unsustainable. However, in recent times recreational fishing for sea trout in the near shore coastal areas and rivers became more popular and accessible activity and that helped generate primarily socio-cultural services. The progressive growth of the recreational fishery may contribute to local cultural heritage, its folkways and lore, to the development and transfer of local ecological knowledge and fishing experience to the young and to human well-being, which may pave the way for more sustainable management (Liu et al., 2019).

How environmental drivers and species management interact to affect practices over time remains data limited. Selective logging, a prominent land use in tropical forests, harvests a limited number of trees, but the impact on forest structure, composition and aboveground biomass can be significant. While these impacts are well noted, the extent to which selective logging practice affects tree floristic composition and its recovery process is poorly known. Data from the effect of logging on long-term recovery trends of species composition in a tropical forest with yearly measurements were taken over 25 years. In the first years, post-logging, floristic composition differed widely between intact and selectively logged forests, with exploited areas diverging from pre-logged composition. Gradually, exploited areas shifted towards the original composition, with clearer changes in this trend after 13 years. Shifts in floristic composition were caused by a significant increase in light-demanding fast-growing pioneer species and their subsequent continuous high mortality rates after 13 years of the recovery process. In contrast, the control permanent plots showed similar shifts in composition over time, suggesting that external factors such as long-term climate changes may be driving these shifts. After 25 years, floristic composition tends to recover closer to the pre-logged status if the forest had undergone selective logging. Without additional human disturbances,

experimental selectively logged forests in low-to-moderate intensities may be favorable for biodiversity conservation, at least during the first harvesting cycle. Reconciling conservation strategies with the recovery of stocks of commercial timber species could lead to more sustainable forest management plans (Gauti et al., 2019).

Environmental changes over time and the impact of rare events (such as droughts) may interact with extractive and management practice to influence if the harvest of wild species is sustainable or not. Over 20 years in Paragominas, Para, Brazil, previously unlogged forest was experimentally subjected to three different logging practices: conventional logging; reduced-impact logging; and unlogged control. Above-ground biomass and bole volumes of commercial species were tracked based on ten inventories (between 1993 and 2014). One year after logging, biomass, compared to pre- logging numbers, was reduced 14% by reduced-impact logging and 24% by conventional logging with corresponding merchantable species volume reductions of 21% and 31%. By 2014, biomass and bole volumes of commercial species had recovered 95% and 98% of their pre- logging stocks in the reduced-impact logging plot but only 76% and 72% in the conventional logging, plot, respectively; timber volumes from large trees (≥ 50 cm diameter at breast height) were only recovered to 81% in the reduced-impact logging plot and 53% in the conventional logging plot. Twenty years after logging, average volume increments from commercial species were substantially higher in the reduced impact logging plot than in the conventional logging plot. The probable impact from the 2010 extreme drought temporarily reversed the biomass and timber volumes between 2009 and 2014 because of a 3-5.5-fold increase in annual mortality rates across the plots. This research shows that logging practices can interact with extreme events to affect the recovery of forests and hence the sustainable harvest of timber species (Vidal et al., 2016).

Multiple drivers (e.g., cultural, social, technology) and mediating factors interact in a complex manner to determine if hunting is sustainable. Hunting in villages of northeast Gabon is practiced for both local consumption and cash income to cover basic family expenses. Cultural and socioeconomic factors could explain the temporal and spatial variation in hunting activities. Hunting increases in the dry season during circumcision ceremonies at > 10 km from villages and decreases during the rainy season because hunters are engaged in other economic activities. Degraded forest accounts for 20% of the animals killed and the greatest diversity of species nearest to villages. Mature forest supplies the species with the greatest commercial value, e.g., red river hog (*Potamochoerus porcus*), and is the preferred source of meat for traditional ceremonies. In the last 15 years, hunting patterns have evolved rapidly, mainly because of the use of gun, which had serious implications for the sustainability of offtakes. However, hunting resilient species such as blue duiker (*Cephalophus monticola*) should be possible, but not sensitive species such as red river hog and small diurnal monkeys. As such, specific management systems are needed to identify possible solutions to sustain the population levels of the critical species (Van Vliet & Nasi, 2008).

4.4 Conclusions and options

Given the multiplicity of drivers and the contexts in which they operate through the human agency, achieving sustainable use of wild resources may appear to be a tall order and classified as a “wicked problem”. Wicked problems are difficult to solve. They require multidimensional

and adaptive responses involving governments, the private sector, civil society, and indigenous peoples and local communities to address drivers and find solutions that are appropriate in the local context.

Various demographic and social factors influence the sustainable (or unsustainable) use of wild species: migration and urbanization, social organization and reproduction, empowerment, effective participation and accountability, poverty and process of marginalization, gender equity and, rural development (roads, infrastructure, access to material assets and immaterial goods-market, credit, internet). Population growth, aging populations in some countries and youth bulges in others is affecting patterns of use of wild species, the greatest of which is an increasing demand for wild species as food resources as well as expanding use of wild species habitats.

Increasing urbanization has led to perverse values of wild species that privilege some uses such as tourism - (e.g., polar bear viewing) over rural and indigenous uses (e.g., bear harvest), which is creating unintended consequences (e.g., polar bears are becoming acclimatized to human interaction with tourists and creating risks/safety, human-wild species conflicts for Inuit communities; other examples in east-Africa /China)

Economic forces are considered among the most critical in addressing rapid declines in biodiversity including the use of wild species; economic systems directly impact species but also shape perceptions and norms about the importance of particular species and their value within society. Global markets and consumer behavior patterns (particularly in the Americas) are drivers of demand for wild species and unsustainable uses (e.g., wild salmon harvest).

Rights of access to and use of common property wild resources by local communities along with social capital, participation in governance mechanisms and accountability greatly influence the sustainability of wild resources. Equitable distribution of benefits from the sustainable use of wild species is a stated goal of many governance and institutional frameworks. However, the implementation of these goals is often flawed. This has a direct impact on sustainability, creates incentives to over-harvest species, undermines long-term management of species, and can support unsustainable commercial extraction. Equal rights of access and use of resources on one side, social alliances and solidarity on the other side are recognized as key drivers for sustainable use.

Indigenous people and local communities are often at the front line of where the problems (unsustainable use) occur as they live close to wild resource-rich areas, though the ultimate causes of the change may lie far away in board rooms, government policies and, imperfect markets. So, it is imperative that if equitable solutions are to be found that indigenous communities and their local knowledge honed over centuries of resource use, are recognized and used judiciously.

Understanding of wild species as relatives, with whom humans should have a relationship of respect and reciprocity is common across cultures, continents, and oceans. Good relationships with wild species (the relationship between people and wild animals and plants) is understood as akin to a family relationship. All actions should assure the long-term wellbeing of that family and community.

Inequality and poverty are major drivers of unsustainable use of wild species. Eradicating poverty requires a multidimensional approach. Policies that maintain access to resources and opportunities for those marginalized and/or living in poverty (especially

Indigenous Peoples and local communities) are key to sustainable use of wild species. Given that poverty is multidimensional, eradicating it requires a multidimensional approach. Access to food, shelter, education, employment, and healthcare can lift people out of poverty and make them less dependent on unsustainable use of wild species. The subsistence uses of wild species by women and Indigenous Peoples, are under-recognized and poorly protected. Such lack of recognition creates and aggravates problems of food insecurity and poor health for vulnerable populations (e.g., poor nutrition) and increases dependency on commercially produced food resources.

There is progress, however, in understanding the outcomes of single drivers (cause and effect) and in some instances, multiple drivers on wild species uses and outcomes, including synergistic, or antagonistic effects. Accounting for the interactions among the multiple drivers can ensure sustainable use.

4.5 Gaps and challenges

One of the main challenges faced by the authors of the current chapter was in accessing the information presented by sources written in languages other than English. Also, there was difficulty in accessing non-academic sources of information such as the grey literature, government reports, and conference proceedings. Authors struggled to achieve balance between the conventional scientific knowledge and the knowledge of indigenous peoples and local communities. To be able to overcome these biases, authors engaged with reports from indigenous and local knowledge dialogue workshops, and contacted experts working closely with indigenous peoples and local communities; some authors reached out directly to members of indigenous peoples and local communities. Authors aimed to present a diversity of bibliographical resources; in some cases, this involved searching for information by directly contacting experts and those involved in fieldwork.

The following list reflects some of the main gaps in knowledge identified in this chapter:

Environmental drivers

- There is insufficient information on how climate change will affect wild species use through gathering and non-extractive practices.
- The assessment revealed that there is a significant gap in knowledge on the ecological impact of invasive species in the marine ecosystem globally.
- A more elaborate assessment of the contribution of air pollution and climate change to the global decline of insects, especially pollinators, is needed for effective intervention. This is important in view of its huge implications for horticulture and agriculture sectors that comprise the backbone of economies of the global south.
- There is a lack of focused in-depth studies on the impacts of pollution on keystone wild species (their biology, ecology, and conservation in the context of growing pollution), especially in the global south.
- There is a paucity of in-depth studies assessing the interactions among states, indigenous peoples and local communities, different forms of conservation bodies (international non-governmental organizations, non-governmental organizations, community-based

organizations, and other stakeholders) particularly as it relates to minimizing causes and threats posed by pollution on wild species. This is particularly problematic in the global south.

- Acts and regulations are often inadequate or poorly addressed in terms of local impacts and evaluation methods (e.g., environmental assessment).
- Regulations in managing the impacts of pollution on wild species are poorly understood.
- More understanding of pollution-induced changes in wild species dynamics is needed.
- There are gaps in information about effective implementation of regulations.
- More information is needed about building capacity and awareness

Social drivers

- Urbanization tends to lead to decreased consumption of wild species, however there are some gaps in the assessment of how the influence of urbanization may differ particularly in lower-income countries where there are strong drivers for the consumption of wild species.
- Social systems, like many aspects of ecosystems, are highly complex and there are many factors, which affect sustainable use that are not well-documented.
- There are gaps in literature related to governance of gathering and non-extractive practices (including viewing) when compared to the extractive practices of terrestrial animal harvesting, fishing, and logging.
- Regional gaps exist concerning social norms, perceptions, and gendered dimensions of sustainable use in most parts of the globe, particularly for Latin America, and Asia, especially regarding informal institutions and governance systems of indigenous peoples and local communities.

Economic drivers

- There were some challenges regarding the availability of data, whether due to insufficient official trade statistics (that trace the status of threatened species) or due to the inconsistencies in the official statistics and trade surveys for wild species. The lack of systematic collection of data was another challenge, which curbs the quality and quantity of evidence concerning the sustainability outcomes.
- There is no clear definition of ‘economic sustainability’ and a lack of quantitative measures that can be used to evaluate which outcomes would be considered sustainable, which may change over time, and which specific drivers cause changes in outcomes over time.
- There are no guidelines for assessing economic sustainability, including tools to facilitate comparison among different regions/cases .
- There is insufficient quantitative data that can be compared across geographic regions regarding subsistence and indigenous economies, especially in relation to economic impacts and drivers of cultural, spiritual, and social uses of wild species.
- There are significant gaps in the availability of documented Indigenous and local knowledge related to economic drivers at all scales and in relation to all species.

- There is regional disparity in respect of understanding the economic drivers of sustainable use issues.

Cultural drivers

- Methods to document Indigenous and local knowledge, and customary values are not yet widely used and need to be further explored and implemented.
- There is a clear dearth of quality documentation on the diverse indigenous and cultural use of wild species. Documentation of the importance of languages in changing certain practices and that influenced the sustainable use of wild species is also limited.
- The underlying mechanisms that control the relationship between language and biodiversity remain unexplored.
- While academics have concentrated their efforts on documenting the loss of [Indigenous Knowledge systems, they overlooked studying the processes and the factors that drive this loss and the effect that has on society's capability to produce, employ, and transfer knowledge to sustain traditional ecological knowledge systems.

Interaction among drivers

- Lack of in-depth studies on ecosystem resilience and how it relates to non-fishing practices.
- Long-term temporal and spatial studies are few, particularly for non-fishing practices.

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