Chapter **3.**

ASSESSING PROGRESS TOWARDS MEETING MAJOR INTERNATIONAL OBJECTIVES RELATED TO NATURE AND NATURE'S CONTRIBUTIONS TO PEOPLE

IPBES GLOBAL ASSESSMENT REPORT ON BIODIVERSITY AND ECOSYSTEM SERVICES
CHAPTER 3. ASSESSING PROGRESS TOWARDS MEETING MAJOR INTERNATIONAL OBJECTIVES RELATED TO NATURE AND NATURE'S CONTRIBUTIONS TO PEOPLE

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COORDINATING LEAD AUTHORS:
Stuart H. M. Butchart (United Kingdom of Great Britain and Northern Ireland/BirdLife International), Patricia Miloslavich (Venezuela/Australia), Belinda Reyers (South Africa), Suneetha M. Subramanian (India/United Nations University)

LEAD AUTHORS:
Cristina Adams (Brazil), Elena Bennett (United States of America), Bálint Czúcz (Hungary), Leonardo Galetto (Argentina), Kathleen Galvin (United States of America), Victoria Reyes-García (Spain), Leah R. Gerber (United States of America), Tamrat Bekele Gode (Ethiopia), Walter Jetz (Germany/Future Earth), Ishmael Bobby Mphangwe Kosamu (Malawi), Maria Gabriela Palomo (Argentina), Mostafa Panahi (Islamic Republic of Iran/ECO-IEST), Elizabeth R. Selig (United States of America/Norway), Gopal S. Singh (India), David Tarkhnishvili (Georgia), Haigen Xu (China)

FELLOWS:
Abigail J. Lynch (United States of America), Tuyeni Heita Mwampamba (Mexico/Tanzania), Aibek Samakov (Kyrgyzstan)

CONTRIBUTING AUTHORS:
Tris Allinson (United Kingdom of Great Britain and Northern Ireland), Shankar Aswani (South Africa), Alpina Begossi (Brazil), Petra Benyei (Spain), Jake Berger (United States of America), Sébastien Boillat (Switzerland), Rainer Bussmann (Georgia), Fulvia Calcagni (Spain), Cristina O'Callaghan (Spain), Joji Carino (Forest Peoples Programme/Philippines), Steve Chignell (United States of America), Sara Diamond (United States of America), Álvaro Fernández-Llamazares (Finland), Wendy Foden (South Africa), David García-del-Amo (Spain), Sara Guadilla (Spain), Anne Guerry (United States of America), Natalia Hanazaki (Brazil), Samantha Hill (United Kingdom of Great Britain and Northern Ireland), Ankila Hiremath (India), Sander Jacobs (Belgium), Nicolas Kosoy (Canada), Johannes Langemeyer (Spain), Margarita Lavides (Philippines), Ana C. Luz (Portugal), Pamela McElwee (United States of America), Vicky J. Meretsky (United States of America), Carla Morsello (Brazil), Jeanne Nel (Netherlands), Teresa Lynn Newberry (United States of America), Diego Pacheco (Bolivia), Aili Pyhala (Finland), Sergio Rossi Heras (Spain), Joyashree Roy (Thailand), Isabel Ruiz-Mallén (Spain), Matthieu Salpeteur (France), Fernando Santos-Martin (Spain), Kirk Saylor (United States of America), Anke Schaffartzik (Spain), Nadia Sitas (South Africa), Chinwe Ifejika Speranza (Switzerland), Helen Suich (Australia), Derek Tittensor (Canada), Patricia Carignano Torres (Brazil), Elsa Tsioumani (United Kingdom of Great Britain and Northern Ireland), Sarah Whitmee (United Kingdom of Great Britain and Northern Ireland), Sarah Wilson (United States of America), Sylvia Wood (Canada), Felice Wyndham (United Kingdom of Great Britain and Northern Ireland), Francisco Zorondo-Rodriguez (Chile)

REVIEW EDITORS:
Fikret Berkes (Canada), Thomas M. Brooks (United Kingdom of Great Britain and Northern Ireland/United States of America)

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CHAPTER **3**

ASSESSING PROGRESS TOWARDS MEETING MAJOR INTERNATIONAL OBJECTIVES RELATED TO NATURE AND NATURE'S CONTRIBUTIONS TO PEOPLE

EXECUTIVE SUMMARY

In recognition of the importance of nature, its contributions to people and role in underpinning sustainable development, governments adopted a Strategic Plan on Biodiversity 2011–2020 through the Convention on Biological Diversity (CBD) containing 20 'Aichi Biodiversity Targets' and integrated many of these into the Sustainable Development Goals (SDGs) adopted through the United Nations in 2015. Additional multilateral environmental agreements (MEAs) target particular aspects of nature (e.g., Ramsar Convention on Wetlands; Convention on Migratory Species), drivers of biodiversity loss (e.g., Convention on International Trade in Endangered Species of Wild Fauna and Flora), or responses (e.g., World Heritage Convention). These various MEAs provide complementary fora in which governments strive to coordinate efforts to reduce the loss and degradation of nature, and to promote sustainable development. In this chapter, we assess, through a systematic review process and quantitative analysis of indicators, progress towards the 20 Aichi Targets under the Strategic Plan (and each of the 54 elements or components of these targets), targets under the SDGs that are relevant to nature and nature's contributions to people (NCP), and the goals and targets of six other MEAs. We consider the relationships between the SDGs, nature and the contributions of Indigenous Peoples and Local Communities (IPLCs) to achieving the various targets and goals, the impact of progress or lack of it on IPLCs, the reasons for variation in progress, implications for a new Strategic Plan for Biodiversity beyond 2020, and key knowledge gaps.

1 **There has been good progress towards the elements of 4 of the 20 Aichi Biodiversity Targets under the Strategic Plan for Biodiversity 2011–2020. Moderate progress has been achieved towards some elements of another 7 targets, but for 6 targets poor progress has been made towards all element. There is insufficient information to assess progress towards some or all components of the remaining 3 targets (*established but incomplete*) {3.2}. Overall, the state of nature continues to decline (12 of 16 indicators show significantly worsening trends) (*well established*) {3.2}.** Of the 54 elements, we have made good progress towards five (9%), moderate progress towards 19 (35%) and poor progress or movement away from the target for 21 (39%). Progress is unknown for nine elements (17%). The strongest progress has been towards identifying/prioritizing invasive alien species (Target 9), increasing protected area coverage (Target 11), bringing the Nagoya Protocol into force (Target 16), and developing national biodiversity strategy and action plans (Target 17). However, while protected areas now cover 15 per cent of terrestrial and freshwater environments and 7 per cent of the marine realm, they only partly cover important sites for biodiversity and are not yet fully ecologically representative, well-connected and effectively or equitably managed *(well established)* {3.2}. While some species have been brought back from the brink of extinction (contributing towards Target 12 on preventing extinctions), species are moving towards extinction at an increasing rate overall for all taxonomic groups with quantified trends (*well established*) {3.2}. Least progress has been made towards Target 10 (addressing drivers impacting coral reefs and other ecosystems vulnerable to climate change); *(established but incomplete)* {3.2}.

2 **In addressing the Aichi Biodiversity Targets, more progress has been made in adopting and/or implementing policy responses and actions to conserve and use nature more sustainably (22 of 34 indicators show significant increases) than has been achieved in addressing the drivers of biodiversity loss (9 of 13 indicators show significantly worsening trends) (*well established*) {3.2}. As a result, the state of nature overall continues to decline (12 of 16 indicators show significantly worsening trends) (*well established*) {3.2}.** Indicators for the Targets under Goal B

addressing anthropogenic drivers of biodiversity loss, including habitat loss (Target 5), fisheries (6), agriculture, aquaculture and forestry (7), pollution (8) invasives (9) show that many of these drivers are increasing despite efforts to meet the Targets (*established but incomplete)* {3.2}. Trends over time in the magnitude of nature's contributions to people are less well known, but four of five indicators show significantly worsening trends (*established but incomplete)* {3.2}.

3 **In some cases, it is possible to quantify what the trends would have been in the absence of conservation action and policy responses to the Aichi Biodiversity Targets {3.2}, but in most cases there is insufficient information.** For example, for Target 12, extinction risk trends shown by the Red List Index for birds and mammals would have been worse in the absence of conservation, with at least six ungulate species (e.g., Arabian Oryx and Przewalski's Horse) likely to now be extinct or surviving only in captivity without conservation during 1996–2008. For Target 9, at least 107 highly threatened birds, mammals, and reptiles (e.g., Island Fox and Seychelles Magpie-Robin) are estimated to have benefited from invasive mammal eradications on islands {3.2}. A recent model estimated that conservation investment during 1996–2008 reduced biodiversity loss (measured in terms of changes in extinction risk for mammals and bird) in 109 countries by 29% per country on average {3.2}. However, there are few other counterfactual studies assessing how trends in the state of nature or pressures upon it would have been different in the absence of conservation efforts, meaning that it is often difficult to quantify the impact of actions taken towards the Aichi Biodiversity Targets (*well established*) {3.2}.

4 **Nature is essential for achieving the Sustainable Development Goals, either directly through clean water, climate action, life below water and life on land (Goals 6, 13, 14, 15, respectively) or through more complex relationships and contributions to ending poverty and hunger, improving health and well-being, and sustainable cities (Goals 1, 2, 3, 11, respectively) *(established but incomplete)* {3.3.2.1; 3.3.2.2}.** For several targets to end poverty and hunger and enhance health and well-being; nature and its contributions play an important role (e.g., through reducing vulnerability, increasing agricultural productivity and nutrition, as a source of traditional medicine or novel compounds, or by regulating water and air quality). However, the role of nature's contribution for specific targets is variable across regions, societies and ecosystems, and strongly dependent on governance and other inputs / assets. Improved understanding of these interactions and associated positive and negative feedbacks across space and time, is a key knowledge gap.

5 **For the 44 SDG targets assessed, including targets for poverty, hunger, health, water, cities, climate, oceans and land (Goals 1, 2, 3, 6, 11, 13, 14, 15), findings suggest that current negative trends in nature will substantially undermine progress to 22 SDG targets and result in insufficient progress to meet 13 additional targets (i.e. 80 per cent (35 out of 44) of the assessed targets) {3.3.2.1; 3.3.2.2} *(established but incomplete).*** Across terrestrial, aquatic and marine ecosystems, current negative trends in nature and its contributions will hamper SDG progress, with especially poor progress expected towards targets on water security, water quality, ocean pollution and acidification. Trends in nature's contributions relevant to extreme event vulnerability, resource access, small-scale food production, and urban and agricultural sustainability are negative and insufficient for achieving relevant targets under SDGs 1, 2, 3, and 11. This has negative consequences for both the rural and urban poor who are also directly reliant on declining resources for consumption and income generation {3.3.2.2}. For a further 9 targets evaluated in SDGs 1, 3 and 11 a lack of knowledge on how nature contributes to targets (4 targets) or gaps in data with which to assess trends in nature (5 targets) prevented their assessment.

6 **Important positive synergies between nature and goals on education, gender equality, reducing inequalities and promoting peace and justice (Sustainable Development Goals 4, 5, 10 and 16) were found {3.3.2.3} (*established but incomplete*). Despite overwhelming evidence of the linkages between nature, NCP and development, the current focus and wording of targets in these goals obscures or omits their relationship to nature, thereby preventing their assessment here.** Important positive synergies at the goal level were found to exist for Goals 4, 5, 10, 16 from studies of access to nature and educational outcomes, land or resource tenure and gender equality, and the availability of nature's contributions and conflict resolution. There is a critical need to include these linkages in future policy targets, as well as to develop more fit-for-purpose indicators and datasets, especially socially disaggregated data to capture impacts on equity related to SDGs and the Agenda 2030 aim to "leave no one behind".

7 **In assessing the impacts of SDG achievement on nature and its contributions, Goals 7, 8, 9, 12 (relating to energy, economic growth, industry and infrastructure, and consumption, and production) could have substantial positive or negative impacts on nature and therefore on the achievement of other Sustainable Development Goals. The nature and magnitude of this impact will depend on approaches chosen to achieve these goals {3.3.2.4} (*well established*). This is also the case for aspects of Goals 1 (ending poverty), 2 (ending hunger), and Goal**

11 (sustainable cities) and their potential impacts on nature. Across SDGs assessed, some evidence suggests that approaches that enhance nature and its contributions, in combination with investments in anthropogenic assets, can help meet multiple SDGs, often simultaneously {3.3.2.2} *(established but incomplete).* New agroecological farming approaches, certain clean energy technologies, improvements in grey and green infrastructure, and improved management of marine ecosystems and fisheries are among approaches found to have positive impacts across multiple SDG targets. While we have good evidence on the impacts on nature of previous efforts to achieve development goals, lack of information on the approaches to be used to achieve the SDGs makes it not currently possible to assess their impacts on nature, nature's contributions to people and other SDGs. Efforts to achieve Goals 6, 13, 14, 15 will likely have positive effects on nature and NCP. However, if these efforts do not consider factors such as access, equity or power they can have negative impacts on the poor and several other SDGs related to poverty and equity. Issues of land and resource tenure, water security and entitlements, and secure access to resources are likely to increase in importance for efforts to reduce vulnerability and prevent worsening poverty, particularly in regions impacted most strongly by climate change.

8 **There has been mixed progress towards achieving the goals of the Convention on Migratory Species, Convention on International Trade in Endangered Species of Wild Fauna and Flora, International Plant Protection Convention, United Nations Convention to Combat Desertification, the Ramsar Convention on Wetlands, and the World Heritage Convention (*established but incomplete*) {3.4}.** In addition, only one in five of the strategic objective and goals across six global agreements relating to nature and its contributions to people are demonstrably on track to be met. For nearly one third of the goals of these conventions there has been little or no progress towards them or, instead, movement away from them (*established but incomplete*) {3.4}. Progress has been most positive for the World Heritage Convention {3.4}.

9 **Given their direct material and cultural links to the environment, Indigenous Peoples and Local Communities (IPLCs) are and will continue to be disproportionately impacted if the Aichi Biodiversity Targets and SDGs are not met (*well established*) {3.2, 3.3}. Furthermore, formal incorporation of IPLCs, their many locally attuned management systems, and indigenous and local knowledge (ILK) into environmental management has been shown to offer effective means to reduce environmental degradation (*well established*) {3.2, 3.3}.** Examples of negative impacts on IPLCs from insufficient progress towards meeting the Aichi Biodiversity Targets and SDGs include continued loss of subsistence and livelihoods from ongoing deforestation (Target 5, SDG 15) and unsustainable fishing practices (Target 6, SDG 14), and impacts on health from pollution and water insecurity (Target 8, SDGs 6 and 12). Examples of the contributions of IPLCs to sustainable environmental management include community forestry initiatives (Target 7, SDG 12), traditional agriculture and aquaculture systems (Target 7, SDG 12), 'Indigenous Peoples' and community conserved territories and areas' (ICCAs; Target 11, SDGs 14 and 15), integration of indigenous and local knowledge into invasive and threatened species' management (Targets 9 and 12; SDGs 14 and 15), and conservation of wild and domestic animal and plant genetic diversity through market and non-market exchanges (Target 13, SDG 2) {3.2, 3.3}.

10 **Progress towards Aichi, SDG and other MEAs' targets related to marine and terrestrial conservation and restoration has mostly been poor to moderate (*well established*) {3.2, 3.3, 3.4}.** While good progress has been made in the implementation of some actions and policy responses, marine biodiversity continues to face multiple threats from human activities, including habitat loss and degradation, unsustainable fisheries, invasive alien species, pollution, and climate change, with consequent biodiversity loss (*well established*). Coastal fishery stock depletion and ecosystem degradation has had negative consequences for the well-being of both low-income populations and Indigenous Peoples and Local Communities in terms of food security, spiritual and social integrity, vulnerability to climate change, and livelihoods (*well established*) {3.2, 3.3}. Progress towards targets relating to conservation and restoration of terrestrial and freshwater ecosystems is varied across different target elements. While trends in some responses have been positive, there has been poor to moderate progress towards key aspects of protected areas, sustainable production/ management systems (particularly in agriculture, aquaculture and forestry), and in restoring ecosystems, preventing extinctions, addressing species declines, ensuring health, food and water security, and building resilience amongst vulnerable populations (*well established*) {3.2, 3.3, 3.4. 3.5}.

11 **A number of drivers and threats are hindering progress towards achieving conservation of nature, sustainable delivery of nature's contributions, and achievement of the Aichi Biodiversity Targets, SDGs and objectives of other MEAs.** Ecosystem loss and degradation—driven in particular by agricultural expansion and intensification, unsustainable forestry and commercial and residential development— is the major driver of deteriorations in the state of nature that hinder progress to targets aiming to sustain life on land and preventing extinctions (*well established*) {3.2, 3.3}. Unsustainable use and trade in species, including illegal poaching and trafficking, is a particular driver for exploited terrestrial and

freshwater species and ecosystems, (*well established*) {3.2, 3.3}. Marine species and ecosystems are also substantially impacted by unsustainable harvest, both for targeted species and those impacted indirectly through bycatch or effects on food supply (*well established*) {3.2, 3.3}. Insufficient progress has been made to targets addressing the spread of invasive alien species and to mitigate their impacts on native species (*well established*) {3.2, 3.3}. Pollution continues to negatively impact ecosystem integrity, species populations and human well-being, with plastics emerging as a particular issue, especially in the marine realm (*well established*) {3.2, 3.3}. Despite availability of appropriate technologies and public awareness of the impact of pollution on nature and human well-being, only moderate progress has been made in reducing/abating different forms of pollution (*well established*) {3.2, 3.3}.

12 **To meet the Sustainable Development Goals and achieve the 2050 Vision for Biodiversity, future targets are likely to be more effective if they take into account the impacts of climate change. Climate change is exacerbating other threats and hindering our ability to meet many Sustainable Development Goals and Aichi Biodiversity Targets including those related to fisheries, invasive alien species, reefs, protected areas, preventing extinctions, and ecosystem resilience (6, 9, 10, 11, 12 and 15, respectively) (*well established*) {3.2, 3.3}.** Shifts in species' distributions, changes in phenology, altered population dynamics, and other disruptions scaling from genes to ecosystems are already evident in marine, terrestrial and freshwater systems (*well established*) {3.2}. Almost half (47%) of terrestrial non-volant threatened mammals and 23.4% of threatened birds may have already been negatively impacted by climate change in at least part of their distribution (*established but incomplete*) {3.2}. Projected impacts suggest that climate change will increase the number of species under threat, with most studies concluding that there are likely to be fewer species that expand their ranges or experience more suitable climatic conditions than the number that experience range contraction or less suitable conditions (*established but incomplete*) {3.2}. Few protected areas are currently taking into account climate change in their objectives or management, but the effects of climate change on protected areas will continue exacerbating existing threats (*established but incomplete*). These trends, combined with the direct impacts of climate change, will negatively affect the achievement of SDGs including those related to poverty, health, water and food security, affecting in particular low-income populations and IPLCs.

13 **Progress to different goals and targets, as well as between regions, was variable {3.6}. Good progress on goals related to policy responses and actions to conserve nature and use it more sustainably were countered by substantial negative trends in drivers of change in nature and NCP, producing generally negative trends in the state of nature and many aspects of NCP (*well established*) {3.2, 3.3, 3.4}.** Reasons for this variation are multiple and interacting, including the sectoral, spatial and temporal mismatches between the responses assessed (e.g., protected areas) and drivers of change (e.g., agricultural expansion). Furthermore, evidence suggests that trends in drivers and nature would be worse without the responses implemented. Poor to moderate progress in effectively implementing some responses is an important constraint, including reducing harmful subsidies, providing positive incentives, sharing technologies, mobilizing financial resources, sustainably managing natural resources, ensuring equity, and strengthening the role of nature and NCP in reducing impacts from disasters. Regionally, there were no consistent patterns, with some regions showing greater progress towards some targets but not for others. Ensuring that policies are coherent between different sectors would enable better alignment of targets and goals (mainstreaming) relating to biodiversity in national and regional planning.

14 **Future targets in a new post-2020 global biodiversity framework may be more effective if they: have clear, unambiguous, simple language, with quantitative elements; take account of synergies and trade-offs between targets, are formulated to capture aspects of nature and NCP relevant to GQL, take greater account of socioeconomic and cultural contexts and values; take account of climate change impacts and responses; and integrate insights from the conservation science community as well as social scientists, indigenous and local knowledge, and non-academic stakeholders and take account of the availability of existing indicators and the feasibility of developing new ones (*established but incomplete*) {3.7}.** Identifying and securing synergies between targets, and minimizing trade-offs, would maintain options for co-benefits before they are reduced by increasing human impacts (*established but incomplete*) {3.7}. Increasing consideration of values and drivers in the context of policies and decision-making when setting targets may help to reduce lack of political cooperation, inadequate economic incentives, and inadequate involvement of civil society. Future targets will be more effective if they take climate change into account, considering both the potential consequences for biodiversity of climate change mitigation policies and actions, and the need to integrate adaptation. Alternative approaches to the process of target-setting (e.g., nationally determined contributions) may also be considered {3.7}.

15 **Key knowledge gaps make it more challenging to determine progress towards the Aichi Biodiversity Targets and Sustainable Development Goals and limit our ability to implement responses more effectively**

(*well established*) {3.8}. We lack quantitative indicators to judge progress towards some elements of 13 Aichi Biodiversity Targets, and over one third (19/54, 35%) of all elements across all Targets *(well established)* {3.2}, meaning that assessment of these elements relies on more qualitative assessment of the literature. For Target 15 (ecosystem resilience and contribution of biodiversity to carbon stocks), the lack of both quantitative indicators and qualitative information means that no assessment of progress was possible {3.2}. Key knowledge gaps include trends in harmful subsidies, patterns in the intensity of unsustainable exploitation of species and ecosystems, effectiveness and equity of management of protected areas and other area-based conservation mechanisms, extinction risk and trends of many species (particularly invertebrates, plants and fungi), trends in the genetic diversity of utilised species, ecosystem resilience, Access and Benefits-Sharing of genetic resources, integration of indigenous and local knowledge in assessment and monitoring, extant and effectiveness of participation of indigenous and local communities in governance, trends in many categories of nature's contributions to people, and regional patterns of progress (*established but incomplete*) {3.2, 3.3, 3.8}. Gaps in knowledge also precluded assessment of 9 out of 44 targets under the SDGs reviewed, and there is inadequate understanding of the relationships between nature (and its contributions to people) and the achievement of some SDGs, and vice versa (*established but incomplete*) {3.3, 3.8}.

3.1 INTRODUCTION

3.1.1 Premise

Evidence shows that in the past 50 years, human development gains have been substantial but largely achieved at growing costs to losses in biodiversity, degradation of many of nature's regulating and non-material contributions to people (NCP), displacements of indigenous and local populations, exacerbation of poverty for certain groups of people, and extensive human rights and social justice violations. The level of planetary change is unprecedented and may push the Earth system into a new state (Steffen *et al*.,2015).

In light of the importance of nature and NCP, governments have developed many multilateral environmental agreements (MEAs) to motivate actions to sustain nature and its contribution to the promotion of long-term equitable human well-being and sustainable development. Notably, the Aichi Biodiversity Targets, and a range of other related agreements (see section 3.1.4 below). These provide a foundation to implement actions at the national, regional, and international level. While there are many synergies and shared goals between these environmental agreements and global development policies, their execution is largely uncoordinated requiring efforts to better align them (UNEP 2016c). In response, the United Nations Agenda 2030 and its Sustainable Development Goals (SDGs) have been developed as a comprehensive policy framework which unifies multiple agreements including goals related to nature and nature's contributions to people. It is therefore an important policy framework for IPBES in its ability to contribute to the conservation and sustainable management of nature and NCP.

In this chapter, we review evidence available for assessing progress towards meeting major international objectives related to nature and NCP. We focus specifically on the Aichi Biodiversity Targets and relevant SDGs, as well as relevant objectives of other agreements. This includes an assessment of both regional and distributional patterns as well as indigenous and local knowledge. We then synthesize the patterns across goals and targets, review the implications of our results for a new Strategic Plan for Biodiversity and the post-2020 agenda, and finally summarize knowledge gaps and needs for further research and capacity-building.

Below, we briefly summarise some of the agreements with relevance to IPBES and outline our approach to their assessment. These agreements include the Aichi Biodiversity Targets agreed through the Convention on Biological Diversity (CBD), the SDGs, other relevant conventions. We also consider the role of Indigenous Peoples and Local Communities (IPLCs) in achieving these agreements. We intentionally focus in more detail on IPLCs (compared with other sectors of society such as business, NGOs, women, civil society) because of the mandate of the IPBES global assessment; however, we acknowledge the critical importance of these other sectors in relation to meeting targets of these agreements.

3.1.2 Aichi Biodiversity Targets

In October 2010, the tenth meeting of the Conference of the Parties of the Convention on Biological Diversity (CBD) adopted a revised and updated Strategic Plan for Biodiversity, including the Aichi Biodiversity Targets, for the 2011–2020 period (CBD, 2010a). The Plan provides an overarching framework on biodiversity, including for the biodiversity-related Conventions as well as the entire United Nations system. The vision of this Plan is of a world 'living in harmony with nature' where 'by 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people'. A central element of this framework is facilitating the implementation of coherent National Biodiversity Strategies and Action Plans (NBSAPs), instruments for translating the global Strategic Plan to national circumstances, including through national targets, and a deep integration of aspects of biodiversity conservation into sectoral policies.

As presented in **Table 3.1**, the 20 headline targets of the Strategic Plan for 2015 or 2020 (the 'Aichi Biodiversity Targets'), are organized under five strategic goals.

To help monitor progress towards achieving the Aichi Biodiversity Targets, the CBD developed an indicative list of indicators (CBD, 2012a), building on those used to assess whether the 2010 Biodiversity Target was met in the Global Biodiversity Outlook 3 (GBO-3) (Butchart *et al*., 2010; Secretariat of the Convention on Biological Diversity, 2010). A mid-term evaluation of progress against the Aichi Biodiversity Targets using some of these indicators (Tittensor *et al*., 2014) formed the basis of the assessment published in the Global Biodiversity Outlook-4 (Secretariat of the Convention on Biological Diversity, 2014). This list of indicators was further considered and revised by the CBD COP in 2016 (see Decision XIII/28; CBD, 2016a). In this chapter, we extend and expand the analysis of Tittensor *et al*. (2014), using updated time series for most indicators, and incorporating additional indicators to fill gaps. We also review the literature more generally for information on progress towards the Targets and draw on assessments of countries' National Reports to the CBD.

3.1.3 SDGs

In 2015, the United Nations' 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals

Table 3 1 **The Convention of Biological Diversity 2011-2020 Aichi Biodiversity Targets.**

Target	Description
Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society	
1	By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.
2	By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.
3	By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.
4	By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.
Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use	
5	By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.
6	By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.
7	By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.
8	By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.
9	By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.
10	By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.
Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity	
11	By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.
12	By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

13	By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socioeconomically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.
Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services	
14	By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.
15	By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.
16	By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.
Strategic Goal E: Enhance implementation through participatory planning, knowledge management and capacity-building	
17	By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.
18	By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.
19	By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.
20	By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.

was adopted at the UN Sustainable Development Summit (UN, 2015; **Table 3.2**). This agenda built on the previous Millennium Development Goals (MDGs) but went further in making the goals universal to apply to all countries and all people – not just developing countries as was the case with the MDGs. Furthermore, they integrate all three dimensions of sustainable development: social, economic and environmental into a unified ‘plan of action for people, planet, and prosperity’. The 2030 Agenda and its SDGs goes beyond the poverty alleviation focus of the MDGs to address inequalities, economic growth, decent jobs, cities and human settlements, industry and infrastructure, oceans, ecosystems, energy, climate change, sustainable consumption and production, peace and justice.

In this more integrated approach, nature and its contributions to people are clearly critical to achieving many SDGs (Balvanera *et al*., 2016; Pascual *et al*.,2017; Pérez & Schultz, 2015; Smith *et al*.,2017 ; Wood *et al*., 2018). Furthermore, approaches to achieve the SDGs will have positive and/or negative impacts on nature and NCP. These relationships and feedbacks between nature, NCP and SDGs, as well as feedbacks between attempts to meet the SDG targets, and nature and NCP, are complex, often cross-scale and are typically overlooked (Guerry *et al*., 2015).

In this chapter we focus on the assessment of how trends in nature and its contributions to people affect our ability to achieve particular SDGs. We further assess how the achievement of SDGs affects nature and its contributions to people. In recognizing that the SDGs are complex and interrelated, we adopt an integrated approach to assessment as outlined in section 3.3 below.

Table 3 2 **The United Nations 2030 Sustainable Development goals.**

1 NO POVERTY	End poverty in all its forms everywhere	10 REDUCED INEQUALITIES	Reduce inequality within and among countries
2 ZERO HUNGER	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	11 SUSTAINABLE CITIES AND COMMUNITIES	Make cities and human settlements inclusive, safe, resilient and sustainable
3 GOOD HEALTH AND WELL-BEING	Ensure healthy lives and promote well-being for all at all ages	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Ensure sustainable consumption and production patterns
4 QUALITY EDUCATION	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	13 CLIMATE ACTION	Take urgent action to combat climate change and its impacts
5 GENDER EQUALITY	Achieve gender equality and empower all women and girls	14 LIFE BELOW WATER	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
6 CLEAN WATER AND SANITATION	Ensure availability and sustainable management of water and sanitation for all	15 LIFE ON LAND	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
7 AFFORDABLE AND CLEAN ENERGY	Ensure access to affordable, reliable, sustainable and modern energy for all	16 PEACE, JUSTICE AND STRONG INSTITUTIONS	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
8 DECENT WORK AND ECONOMIC GROWTH	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	17 PARTNERSHIPS FOR THE GOALS	Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation		

3.1.4 Other global agreements related to nature and nature's contributions to people

Conserving nature, and hence nature's contributions to people, is the goal of many other Conventions and agreements. More than 700 Multilateral Environmental Agreements (MEAs) have been adopted between 1868 and 2011 (Gomar, 2016; Kim, 2013), around 150 of which are related to nature (Gomar, 2016). Most of these nature-related MEAs focus on specific issues and geographic regions. In 2004, seven MEAs operating at a global scale created the Liaison Group of Biodiversity-related Conventions (Caddell, 2012) to improve 'implementation of and cooperation among the biodiversity-related Conventions' (CBD, 2018g). The group consists of the following set (abbreviations and year in which each one entered into force are given in parentheses): the Convention on Biological Diversity (Convention on Biological Diversity, 1992), Convention on the Conservation of Migratory Species of Wild Animals, also known as the Convention on Migratory Species (CMS), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1975), International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA, 2004), Ramsar Convention on Wetlands (Ramsar, 1971), World Heritage Convention (WHC, 1972), and the International Plant Protection Convention (IPPC, 1952).

In this chapter, we assess progress towards the goals and targets of these MEAs, plus the United Nations Convention to Combat Desertification (UNCCD, 1994) (section 3.4). Although UNCCD does not have nature as its core goal, its mission and vision include nature-based solutions and sustainable actions and its implementation has a significant impact on nature, nature's contributions to people, and livelihoods. Given that none of these Conventions explicitly focuses on the marine realm, we consider progress towards elements of articles 61–66 of the United Nations Convention on the Law of the Sea (UNCLOS) that relate most closely to the conservation of nature **(Box 3.1)**. Finally, given the global importance of conserving polar regions, we also review progress towards achieving the objectives of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF, **Box 3.2**). While we acknowledge that other agreements, including United Nations Framework Convention on Climate Change, contribute to this sphere, they are beyond the scope of this exercise.

The 11 global multilateral environmental agreements covered by this chapter together address both fauna and flora in all biomes including agricultural lands, cities, and rangelands. For each goal under each MEA, we assess progress through reviewing relevant indicators from sections 3.2 (on the Aichi Biodiversity Targets) and 3.3 (on the SDGs), systematically reviewing the available literature, and drawing on assessments of countries' reports to Convention secretariats. Hence, we use a broad evidence base, both quantitative and qualitative to assess progress. We score progress to each goal or objective against a three-point scale (good, moderate, little/no; see below for definitions). The breadth of these categories allows for greater accuracy in categorizing progress, given the subjective nature and incomplete information for many of the goals and objectives.

3.1.5 Why the Aichi Biodiversity Targets and Sustainable Development Goals are important from the perspective of Indigenous Peoples and Local Communities

A growing body of research shows that biodiversity loss and unsustainable use have led to severe hardship among IPLCs and that Indigenous Peoples lag behind on virtually every social and economic indicator addressed in the SDGs, including health, education, employment, human rights, right to access lands and natural resources (Thaman *et al*., 2013). For example, using the scarce available national data, the 2009 and the 2015 United Nations Reports on the 'State of the World's Indigenous Peoples' (UNPFII, 2009; UNPFII, 2015) noted that while there are 370 million Indigenous Peoples (5% of the world's population), they represent about one third of the world's 900 million extremely poor rural people (UNPFII, 2009). While estimates about the number of people that could be classified as local communities are not available, estimates based on customary tenure or community-based regimes (often overlapping with government land) suggest that over 1 billion people could fall in such category (see chapter 1), a significant share of which are considered rural poor. Similarly, IPLCs experience poorer health and social outcomes than non-indigenous populations, although the magnitude of the differences vary according to the indicator (Anderson *et al*., 2016; Coimbra *et al*., 2013; Gracey & King, 2009). On the other hand, IPLCs manage or have tenure rights over at least 28% of the global land area, including at least 40% of the area that is formally protected, and about 37% of ecologically intact landscapes. Consequently, adequate progress to both the SDGs and Aichi Biodiversity Targets are crucially important to IPLCs, and a major international effort is also needed to increase the recognition of IPLCs at national and international levels so as to provide a strong base for policy development and monitoring (Madden *et al*., 2016).

Conventions to ensure biodiversity conservation (i.e., the CBD) and to achieve sustainable development (i.e., the SDGs) are of great relevance for IPLCs worldwide (CBD, 2016a; UNPFII, 2009). Indeed, both policy instruments explicitly address issues related to IPLCs in some of their targets and goals. For example, Aichi Target 18, under Goal E, is of central importance to IPLCs because it deals directly with traditional knowledge and customary sustainable resource use. It is worth noting, though, that Aichi Target 18 is one of the only Aichi Biodiversity Targets not reflected in the SDGs (see CBD, 2017a). However, there are six direct references to IPLCs in the SDGs, including in SDG 2 related to agricultural output of indigenous small-scale farmers, and SDG 4 on equal access to education for indigenous children. Furthermore, the framework calls on IPLCs to engage actively in implementing the SDGs, including implementation on the national level to ensure that progress for Indigenous Peoples is reflected. However, the indicators used by these policy instruments do not necessarily reflect how progress in achieving goals and targets affect IPLCs, either in positive or in negative ways. This is even more important, as evidence suggest there is a gap between indicators defined in public policies and those that are locally important (Zorondo-Rodriguez *et al*., 2014). Indigenous Peoples have advocated for data disaggregation and the inclusion of an 'indigenous identifier' in official statistics, to capture the inequalities Indigenous Peoples face across all of the SDGs. Moreover, targets and goals scarcely reflect the heterogeneity of IPLCs and how the drivers/conditions described above are manifested in different regions. In this chapter, as well as assessing progress to the Aichi Biodiversity Targets, SDGs, and other MEAs, we report a) the contributions of IPLCs to achieving the goals and targets, and b) how progress (or lack of it) might specifically affect IPLCs.

3.2 PROGRESS TOWARDS THE AICHI BIODIVERSITY TARGETS

3.2.1 Assessment of progress globally

To assess progress towards the Aichi Biodiversity Targets we assembled a broad suite of indicators building on those used by Tittensor *et al*. (2014) and Secretariat of the CBD (2014), which in turn drew on the list of indicators identified by CBD (2012a), and we also utilized relevant additional indicators among those compiled by the Biodiversity Indicators Partnership, the IPBES Knowledge and Data Task Force and other sources. A total of 68 indicators **(Table 3.3)** were selected from more than 160 potential indicators using five criteria: (i) high relevance to a particular Aichi Biodiversity Target and a clear link to the status of biodiversity; (ii) scientific or institutional credibility; (iii) a time series ending after 2010; (or, if the indicator fills a critical gap, the time series ends close to 2010); (iv) at least five annual data points in the time series; and (v) broad geographic (preferably global) coverage. Of these, 30 correspond to the Core Indicators developed for the IPBES regional assessments (see chapter 1 and Supplementary Materials 1.5). Following Tittensor *et al*. (2014), we fitted models to estimate underlying trends using an analysis framework that was adaptive to the variable statistical properties of the indicators. Dynamic linear models (Durbin & Koopman, 2001) were fitted to high-noise time series, while parametric multimode averaging (Burnham & Anderson, 2002) was used for those with low noise. We projected model estimates and confidence intervals to 2020 to estimate trajectories and rates of change for each indicator, scoring each indicator as showing a significant increase, non-significant increase, significant decrease or non-significant decrease. Further details of the methods are provided in the Supplementary Materials.

To complement the indicator analysis and to broaden the evidence base for our assessment, we then carried out a systematic review of the literature relevant to each Aichi Biodiversity Target (see Supplementary Materials for details), including on countries' commitments to implement actions by 2020 (e.g., planned protected area designations). We also draw on assessments of progress towards the targets described in countries' National Reports to the CBD (section 3.2.3). We used the full set of evidence to assign a score of progress towards each element of each target and summarize this in **Figure 3.6**. Progress towards each target element was defined as Good (substantial positive trends at a global scale relating to most aspects of the element), Moderate (overall global trend is positive, but insubstantial or insufficient, or there may be substantial positive trends for some aspects of the element, but little or no progress for others, or the trends are positive in some geographic regions but not in others) or Little/no progress or movement away from target (while there may be local/national or case-specific successes and positive trends for some aspects, the overall global trend shows little or negative progress). Where multiple indicators with different trends were available for a particular target element, we gave greater weight to indicators that are of higher alignment (i.e. metrics that relate more directly to the target element rather than indirect proxies), greater geographic coverage, longer time series, and greater relevance to the state of biodiversity that the target aims to address. Where there were no indicators for a particular target element, or only indicators with low alignment and/or low geographic coverage and/or lower relevance to the state of biodiversity that the target aims to address, we used or gave greater weight to the results of the literature review.

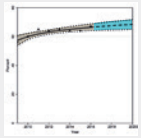
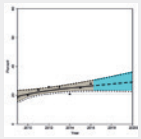
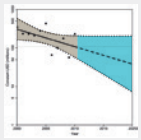
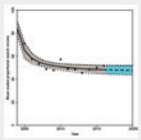
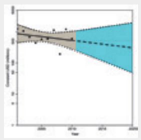
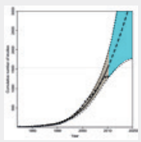
Below, we summarize progress towards each target, drawing on the analysis of indicator extrapolations shown in **Table 3.3** augmented by other available information derived from a literature review. The results are summarized in **Figure 3.6**. We then review the contributions of IPLCs to efforts towards achieving each Aichi Biodiversity Target, and the significance of each target to IPLCs.

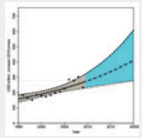
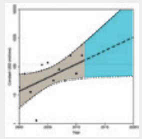
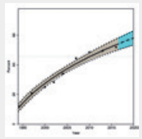
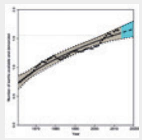
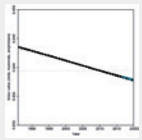
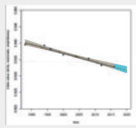
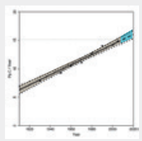
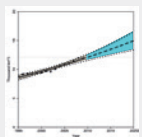
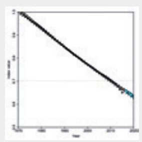
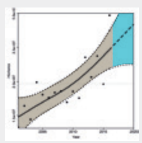
Aichi Target 1: Increasing awareness of biodiversity

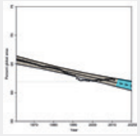
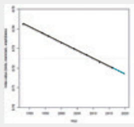
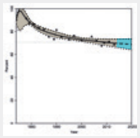
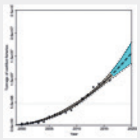
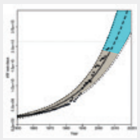
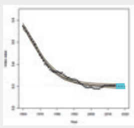
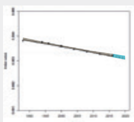
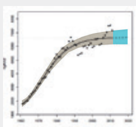
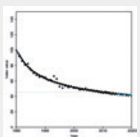
Moderate progress has been made towards Aichi Target 1, on increasing awareness of biodiversity and the steps needed to conserve and use it sustainably. The 'biodiversity barometer' shows that knowledge of the values of nature has increased in recent years, at least for a sample of 16 countries with data **(Table 3.3)** but varies substantially (e.g., 40% of people in India have heard of biodiversity, compared with ≥90% in France, Mexico, Brazil, Peru, China and Vietnam; UEBT, 2017). The proportion of people able to correctly define biodiversity shows similarly high variation between countries (e.g., from 1% in India to 72% in Peru; UEBT, 2017). However, people's interest in biodiversity varies over time in relation to economic cycles and other drivers of public interest (Troumbis, 2017). Globally, tourism in National Parks and World Heritage Sites is growing (UNEP-WCMC & IUCN, 2016), and tourism in protected areas helps to raise awareness of the values of biodiversity and provides the opportunity to educate visitors, thereby contributing to this target. Zoos and aquaria can also play a role in raising awareness (Moss *et al*., 2015), as can digital games (Sandbrook *et al*., 2015). Most efforts towards this target have had a local or regional focus, but there are also several global programs to increase awareness of the benefits of nature to people (e.g., www.panorama.solutions, www.bluesolutions.info; www.iucn.org/theme/protected-areas; UNEP-WCMC & IUCN, 2016; Whitehead *et al*., 2014). Global investment in environmental education appears to be decreasing **(Table 3.3)**. In some cases, education has a positive link with the perception

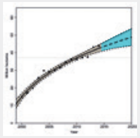
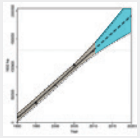
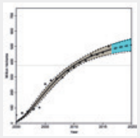
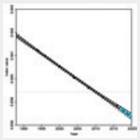
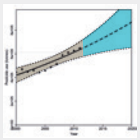
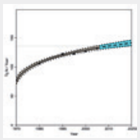
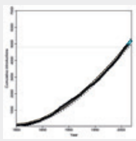
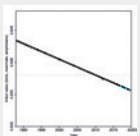
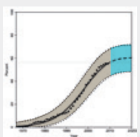
Table 3 3 **Trends of indicators used to assess progress towards the Aichi Biodiversity Targets.**

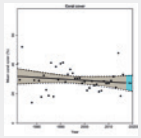
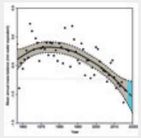
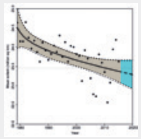
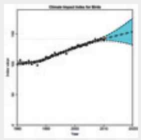
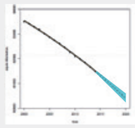
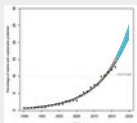
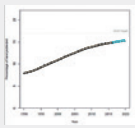
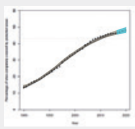
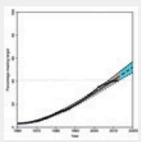
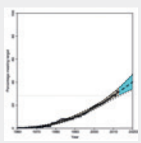
For each element of each of the 20 Targets, relevant indicators are shown along with their alignment to the Target element (i.e. their relevance to the element and the degree to which they are a good proxy, scored as 'low', 'medium', or 'high'), the direction and significance of their projected trend to 2020, and a thumbnail graph (solid line and brown shading show modelled trends with confidence intervals; dotted lines and blue shading shows projected trends with confidence intervals; horizontal line shows 2010 value). Target elements lacking indicators with suitable data for extrapolation are shown in red. Asterisks identify those indicators for which positive trends are generally have negative consequences for biodiversity. Larger format versions of the thumbnail graphs, which include y-axis labels and background information on each indicator, are provided in Table S3.1.2, while the methods to extrapolate and assess the significance of trends to 2020 are provided in the Supplementary Online Materials. The interpretation of the indicator trends in relation to each Aichi Biodiversity Target is given in the text below.

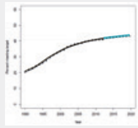
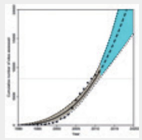
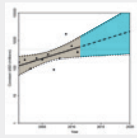
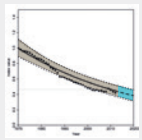
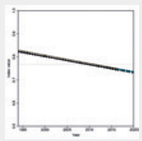
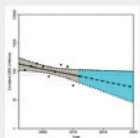
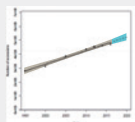
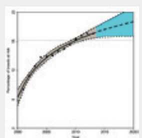
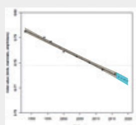
Aichi Target	Target element	Indicator name	Alignment	Projected trend (2010-2020)	Graph
	1.1 People are aware of the values of biodiversity	Biodiversity Barometer (% of respondents that have heard of biodiversity)	High	Significant increase	
		Biodiversity Barometer (% of respondents giving correct definition of biodiversity)	High	Significant increase	
		Funding for environmental education ($)	Low	Non-significant decrease	
	1.2 People are aware of […] the steps they can take to conserve and use it sustainably.	Online interest in biodiversity (proportion of google searches)	Medium	Non-significant decrease	
	2.1 Biodiversity values have been integrated into national and local development and poverty reduction strategies				
	2.2 Biodiversity values have been […] integrated into national and local planning processes	Funding for Environmental Impact Assessments ($)	Low	Non-significant decrease	
	2.3 Biodiversity values […] are being incorporated into national accounting, as appropriate				
	2.4 Biodiversity values […] are being incorporated into national […] reporting systems	Number of research studies involving economic valuation	Low	Significant increase	
	3.1 Incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts				

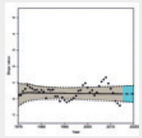
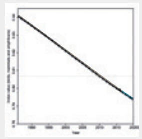
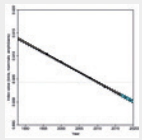
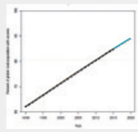
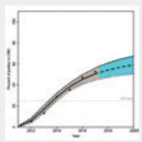
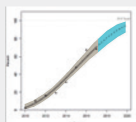
Aichi Target	Target element	Indicator name	Alignment	Projected trend (2010-2020)	Graph
	3.2 Positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.	World Trade Organization greenbox agricultural subsidies ($)	Medium	Non-significant increase	
		Funding towards institutional capacity-building in fisheries ($)	Low	Non-significant increase	
	4.1 Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption	Percentage of countries that are Category 1 CITES Parties	High	Significant increase	
	4.2 Governments, business and stakeholders at all levels […] have kept the impacts of use of natural resources well within safe ecological limits.	Ecological Footprint (number of earths needed to support human society)*	High	Non-significant increase	
		Red List Index (impacts of utilization)	High	Significant decrease	
		Red List Index (internationally traded species)	Medium	Significant decrease	
		Human appropriation of net primary productivity (Pg C)*	Low	Significant increase	
		Human appropriation of fresh water (water footprint; thousand km³)*	High	Significant increase	
	5.1 The rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero	Wetland Extent Trends Index	Medium	Significant decrease	
		Area of tree cover loss (ha)*	High	Significant increase	

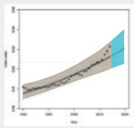
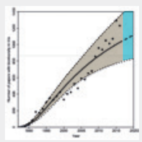
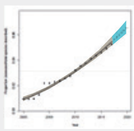
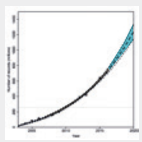
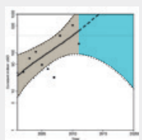
Aichi Target	Target element	Indicator name	Alignment	Projected trend (2010-2020)	Graph
		Percentage natural habitat extent	High	Significant decrease	
	5.2 Degradation and fragmentation [of natural habitats] is significantly reduced	Wild Bird Index (habitat specialists)	Low	Significant decrease	
		Red List index (forest specialists)	Low	Significant decrease	
6	**6.1** All fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, overfishing is avoided [… and] the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits	Proportion of fish stocks within safe biological limits	High	Non-significant decrease	
		Marine Stewardship Council certified fisheries (tonnes)	High	Significant increase	
	6.2 Recovery plans and measures are in place for all depleted species				
	6.3 Fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems	Global effort in bottom-trawling (kW sea-days)*	Medium	Significant increase	
		Marine trophic index	High	Non-significant decrease	
		Red List Index (impacts of fisheries)	Medium	Significant decrease	
7	**7.1** Areas under agriculture […] are managed sustainably	Nitrogen use balance (kg/km^2)	Low	Non-significant increase	
		Wild Bird Index (farmland birds)	Medium	Significant decrease	

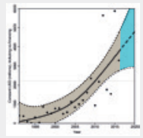
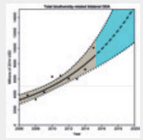
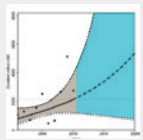
Aichi Target	Target element	Indicator name	Alignment	Projected trend (2010-2020)	Graph
		Area of agricultural land under organic production (million ha)	High	Significant increase	
		Area of agricultural land under conservation agriculture (thosuand ha)	High	Significant increase	
	7.2 Areas under aquaculture […] are managed sustainably				
	7.3 Areas under forestry […] are managed sustainably	Area of forest under FSC and PEFC forest management certification (million ha)	High	Significant increase	
	8.1 Pollution […] has been brought to levels that are not detrimental to ecosystem function and biodiversity.	Red List Index (impacts of pollution)	High	Significant decrease	
		Pesticide use (tonnes)*	Medium	Significant increase	
	8.2 Pollution […] from excess nutrients has been brought to levels that are not detrimental to ecosystem function and biodiversity	Nitrogen surplus (Tg N)*	Medium	Significant increase	
	9.1 Invasive alien species are identified and prioritized	Number of invasive alien species introductions	Medium	Significant increase	
	9.2 [Invasive alien] pathways are identified and prioritized				
	9.3 Priority [invasive] species are controlled or eradicated	Red List Index (impacts of invasive alien species)	Medium	Significant decrease	
	9.4 Measures are in place to manage pathways to prevent their introduction and establishment	Percentage of countries with invasive alien species legislation	High	Non-significant increase	

Aichi Target	Target element	Indicator name	Alignment	Projected trend (2010-2020)	Graph
10	**10.1** The multiple anthropogenic pressures on coral reefs […] are minimized, so as to maintain their integrity and functioning	Percentage live coral cover	High	Non-significant decrease	
	10.2 The multiple anthropogenic pressures on […] other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning	Glacial mass balance (mm water equivalent)	Medium	Significant decrease	
		Mean polar sea ice extent (million km²)	Medium	Non-significant decrease	
		Climatic Impact Index for birds	Low	Non-significant increase	
		Area of mangrove forest cover (km²)	Medium	Significant decrease	
11	**11.1** At least 10 per cent of coastal and marine areas […] are conserved	Percentage of marine and coastal areas covered by protected areas	High	Significant increase	
	11.2 At least 17 per cent of terrestrial and inland water areas […] are conserved	Percentage of terrestrial areas covered by protected areas	High	Significant increase	
	11.3 […] Areas of particular importance for biodiversity and ecosystem services, are conserved	Protected area coverage of Key Biodiversity Areas	High	Significant increase	
	11.4 [Areas are conserved through] ecologically representative […] protected areas and other effective area-based conservation measures	Percentage of terrestrial ecoregions covered by protected areas	High	Significant increase	
		Percentage of marine ecoregions covered by protected areas	High	Significant increase	

Aichi Target	Target element	Indicator name	Alignment	Projected trend (2010-2020)	Graph
		Protected area coverage of bird, mammal and amphibian distributions	High	Significant increase	
	11.5 [Areas are conserved through] effectively and equitably managed […] protected areas and other effective area-based conservation measures	Number of protected area management effectiveness assessments	Medium	Significant increase	
		Funding towards nature reserves ($)	Low	Non-significant increase	
	11.6 [Areas are conserved through] well connected systems of protected areas and other effective area-based conservation measures and integrated into the wider landscapes and seascapes				
12	**12.1** The extinction of known threatened species has been prevented				
	12.2 The conservation status [of known threatened species, particularly of those most in decline] has been improved and sustained	Living Planet Index	High	Significant decrease	
		Red List Index	High	Significant decrease	
		Funding towards species protection ($)	Low	Non-significant decrease	
13	**13.1** The genetic diversity of cultivated plants […] is maintained	Number of plant genetic resources for food and agriculture secured in conservation facilities	High	Significant increase	
	13.2 The genetic diversity of […] farmed and domesticated animals […] is maintained	Percentage of terrestrial domesticated animal breeds at risk*	High	Significant increase	
	13.3 The genetic diversity of […] wild relatives […]is maintained	Red List Index (wild relatives of farmed and domesticated species)	High	Significant decrease	

Aichi Target	Target element	Indicator name	Alignment	Projected trend (2010-2020)	Graph
	13.4 The genetic diversity of […] socio-economically as well as culturally valuable species, is maintained				
	13.5 […] Strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity				
14	**14.1** Ecosystems that provide essential services, including services related to water, and contributing to health, livelihoods and well-being, are restored and safeguarded	Percentage change in local species richness	Low	Non-significant	
		Red List Index (species used for food and medicine)	Medium	Significant decrease	
		Red List Index (pollinator species)	Low	Significant decrease	
	14.2 […] Taking into account the needs of women, indigenous and local communities, and the poor and vulnerable	Percentage of global rural population with access to improved water resources	Low	Significant increase	
15	**15.1** Ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration […] thereby contributing to climate change mitigation and adaptation and to combating desertification				
	15.2 […] Including restoration of at least 15 per cent of degraded ecosystems […]				
16	**16.1** The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force [by 2015]	Percentage of countries that have ratified the Nagoya Protocol	High	Significant increase	
	16.2 The Nagoya Protocol […] is operational [and] consistent with national legislation [by 2015]				
17	**17.1** Each Party has developed[…] an effective, participatory and updated national biodiversity strategy and action plan (NBSAP)	Percentage of countries with revised NBSAPs	High	Significant increase	
	17.2 Each Party has […] adopted as a policy instrument […] an effective, participatory and updated national biodiversity strategy and action plan (NBSAP)				

Aichi Target	Target element	Indicator name	Alignment	Projected trend (2010-2020)	Graph
	17.3 Each Party has […] commenced implementing an effective, participatory and updated national biodiversity strategy and action plan (NBSAP)				
18	**18.1** The traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations [...] at all relevant levels.				
	18.2 The traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are [...] fully integrated and reflected in the implementation of the Convention [...] at all relevant levels.				
	18.3 The traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, [are respected, integrated, and reflected] with the full and effective participation of indigenous and local communities, at all relevant levels.				
19	**19.1** The science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred […]	Species Status Information Index	High	Non-significant increase	
		Number of biodiversity papers published	High	Non-significant increase	
		Proportion of known species assessed through the IUCN Red List	High	Significant increase	
		Number of species occurrence records in the Global Biodiversity Information Facility	Low	Significant increase	
		Funding committed to environmental research ($)	Low	Non-significant increase	
	19.2 The science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are […] applied.				

Aichi Target	Target element	Indicator name	Alignment	Projected trend (2010-2020)	Graph
20	**20.1** The mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels [...]	Funding provided by the Global Environment Facility ($)	High	Significant increase	
		Official Development Assistance provided in support of the CBD objectives ($)	High	Significant increase	
		Global funding committed towards environmental policy, laws, regulations and economic instruments ($)	Medium	Non-significant increase	

about biodiversity conservation and the steps needed to conserve and use it sustainably. For example, Vodouhê *et al*. (2010) found that when local communities were trained to participate in park management and gained economic benefits from this, their willingness to engage in biodiversity conservation increased. Similarly, positive messages about marine conservation projects are more effective at motivating conservation actions of the public than messages focusing on the negative impact of their behaviours (Easman *et al*., 2018).

Aichi Target 2: Integrating biodiversity values into development, poverty reduction, planning accounting and reporting

Poor or moderate progress has been achieved towards Aichi Target 2. Some international initiatives have contributed to reducing poverty by supporting natural capital accounting and use of the results in national strategies. According to a report from the International Fund for Agricultural Development (IFAD, a UN specialized agency), it helped to move 24 million people out of poverty during 2010–2015 by transforming agriculture and rural communities, empowering women, improving nutritional status of poor people and building institutions. By strengthening sustainability and resilience in the rural sector and by integrating biodiversity values through sustainable agriculture, IFAD also contributes to the conservation of biodiversity (IFAD, 2016). Investment in environmental impact assessments showed no significant increase since 2010, while no other global indicators are available to assess progress in integrating biodiversity values in national and local planning processes **(Table 3.3)**. The number of scientific publications assessing the economic value of biodiversity increased significantly in recent years **(Table 3.3)**, but few report results from developing economies (Christie *et al*., 2012), and it is unclear to what extent these values are integrated into national accounting and reporting systems (e.g., the Wealth Accounting and Valuation of Ecosystem Services Partnership; WAVES, 2014). One obstacle to incorporating biodiversity values into national accounting and reporting systems is the lack of agreement on what these values are. A tool to facilitate this is the System of Environmental and Economic Accounting (SEEA) adopted by the United Nations Statistical Commission. However, there has been limited integration of this framework into national accounting systems (Vardon *et al*., 2016).

Aichi Target 3: Eliminating harmful incentives and developing and applying positive incentives for biodiversity conservation and sustainable use

There has been poor progress at a global scale towards Aichi Target 3. No global indicators suitable for extrapolation are available to assess progress in eliminating subsidies or other harmful incentives **(Table 3.3)**. In Europe in 2015, significant steps were taken to scale back 'first generation' biofuels, such as rapeseed biodiesel, which have negative consequences for biodiversity because their cultivation in existing agricultural areas displaces food production elsewhere, leading to loss of natural habitats (Oorschot *et al*., 2010; Searchinger *et al*., 2008). Substantial investment in biofuels followed the establishment of EU targets in 2009 in the transport sector for renewables and the de-carbonization of fuels (Valin *et al*., 2015).

There has been poor progress in applying positive incentives for conservation. While agri-environment schemes (in which farmers receive payments to implement biodiversity-friendly agricultural techniques) have been applied in many countries worldwide, and REDD+ schemes have been implemented to reduce greenhouse gas emissions from deforestation and forest degradation, these initiatives are insufficient in scale to deliver substantial progress towards Target 3 (Armsworth *et al*., 2012). Similarly, local approaches to fisheries management, such as cooperatives or individual transferable quotas, often help to improve sustainability, but have been insufficiently implemented (Gelcich *et al*., 2012; Wilen *et al*., 2012). By 2018, only 43 countries had introduced biodiversity-relevant taxes (OECD, 2018).

Aichi Target 4: Implementing plans for sustainable production and consumption

There is a poor progress towards Aichi Target 4. While the proportion of countries that are category 1 signatories to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has significantly increased, this represents only half of the 183 Parties (CITES, 2018b). This is a very narrow measure in relation to the first part of Aichi Target 4, and unfortunately no other indicators are available to assess progress towards the aim of governments, business and other stakeholders to achieve sustainable production and consumption **(Table 3.3)**, noting that the sustainability of agriculture, aquaculture and forestry specifically are addressed under Aichi Target 7.

The second part of Aichi Target 4 relates to keeping the impacts of the use of natural resources well within safe ecological limits. Progress is being made for several responses aiming to address this **(Table 3.3)**. Growth in human appropriation of net primary production (HANPP) has been slower than human population growth during the twentieth century (Haberl *et al*., 2014), indicating increasingly efficient use of resources. However, projected increases in global population and potential increases in bioenergy use are likely to increase HANPP (Krausmann *et al*., 2013). Similarly, the ecological footprint and water footprint are growing more slowly **(Table 3.3)**. However, species continue to be driven towards extinction through unsustainable use, as shown by a version of the Red List Index showing trends driven by utilization (**Table 3.3**, Butchart, 2008). Demand for greener products and services is increasing and leading to improvements in labeling (Marco *et al*., 2017), but green consumption represents less than 4% of global consumption, and efforts to increase this proportion are needed, particularly in emerging economies (Blok *et al*., 2015). A recent modelling study on internationally traded goods and services concluded that biodiversity loss per citizen is highly variable across countries, but is higher in countries with higher per capita income, with more than 50% of the biodiversity loss associated with consumption in developed economies occurring outside their territorial boundaries (Wilting *et al*., 2017). Two thirds of global biodiversity loss was due to land use and greenhouse emissions, followed by food consumption. However, in rich countries with higher income per capita, consumption of non-food goods and services are the main causes of biodiversity losses (Wilting *et al*., 2017).

Aichi Target 5: Reducing the loss, degradation and fragmentation of natural habitats

The annual rate of net forest loss halved during 1990–2015 according to one assessment (Keenan *et al*., 2015; Morales-Hidalgo *et al*., 2015), but annual tree cover loss derived from globally consistent analysis of remote sensing data increased from 17.2±0.63 million ha/yr in 2001–2010 to 21.3±1.78 million ha/yr in 2011–2016 (globalforestwatch.org; Harris *et al*., 2016). For other natural habitats there is little evidence that rates of loss been brought close to zero, or even halved, indicating that overall, there has been poor or mixed progress towards meeting Aichi Target 5. While there has been growth in the area of land worldwide under timber plantations and afforestation (FAO, 2015a), the former typically do not represent natural habitats, while much of the latter would not yet qualify as forest under stricter definitions (Ahrends *et al*., 2017) and hence are of lower biodiversity significance. Regional assessments in 2016 found that forest loss was continuing across Africa, the Asia-Pacific region (particularly in South-East Asia), and in West Asia, but that there had been significant reduction in rates of forest loss in Latin America and the Caribbean, with mangrove cover increasing in that region (UNEP-WCMC, 2016a, 2016b, 2016c, 2016d). Commercial agriculture is estimated to be the proximate driver for 80% of deforestation worldwide (Kissinger *et al*., 2012), although subsistence agriculture is almost as significant as commercial agriculture in driving deforestation in developing countries (Hosonuma *et al*., 2012), while the key drivers of forest degradation in the tropics include unsustainable logging, fuelwood collection and uncontrolled fires (Kissinger *et al*., 2012). Globally, 27% of global forest loss during 2001–2015 was driven by conversion for commodity production, 26% by forestry, 24% by shifting agriculture and 23% by wildfire (Curtis *et al*., 2018). Despite corporate commitments, the rate of commodity-driven deforestation has not declined (Curtis *et al*., 2018).

The global rate of loss of natural wetlands during the 20th and early 21st centuries averaged 1.085%/yr according to one recent analysis of a sample of wetlands (Davidson *et al*., 2014), while the decline in wetland area averaged 30% during 1970–2008 based on another sampled study (Dixon *et al*., 2016). Permanent surface water was lost from an area of almost 90,000 km^2 between 1984 and 2015, with 70% of this being located in the Middle East and Central Asia, resulting from drought and human actions including damming and diverting rivers and unregulated withdrawal (Pekel *et al*., 2016). While new permanent bodies of surface water covering 184,000 km^2 have formed elsewhere during this period, most are artificial reservoirs (Pekel *et al*., 2016) which are of lower biodiversity significance. Rivers are becoming increasingly fragmented: of the 292 large river systems globally, only 120 (41%) were still free-flowing in 2014, of which 25 (9%) will be fragmented by ongoing or planned construction of dams

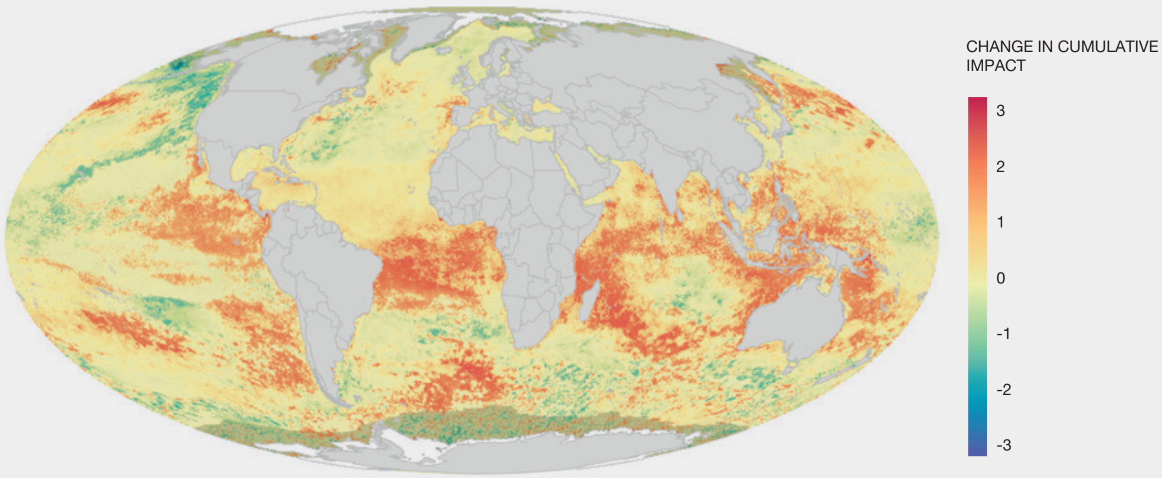


Figure 3 1 **Change in cumulative human impact on marine ecosystems between 2008 and 2013 based on 12 anthropogenic stressors.**

Positive scores represent an increase in cumulative impact; the maximum cumulative impact score for both periods = 11.1. Source: Halpern *et al.* (2015a).

(Nilsson *et al.,* 2005; Zarfl *et al.,* 2014). Reservoirs together with other human activities affect land-ocean sediment and water fluxes, causing impacts on river deltas and loss of coastal habitats (Ericson *et al*., 2006; Syvitski *et al*., 2009; Tessler *et al*., 2015). Overall, an estimated 3.3 million km^2 of wilderness (9.6%) has been lost since the early 1990s, with the most loss occurring in South America (29.6% of wilderness lost) and Africa (14% of wilderness lost) (Watson *et al*., 2016a). Sixty-six per cent of the ocean experienced increases in cumulative human impact during 2008–2013, especially in tropical, subtropical and coastal regions, while only 13% experienced decreases (Halpern *et al*., 2015a; **Figure 3.1**).

Aichi Target 6: Managing and sustainably harvesting aquatic living resources

Overall, we have made poor progress towards meeting Aichi Target 6, with trends in some aspects moving in the opposite direction. World catches increased steadily from the 1950s, peaking between 86 million tonnes (FAO) and 130 million tonnes (Pauly & Zeller, 2016) in 1996. Although trends since have been considered fairly stable by FAO (-0.38 mt.per year), inclusion of other types of catches omitted from FAO data suggests that catches (particularly industrial catches) might be declining significantly (-1.22 mt. per year; Pauly & Zeller, 2016; chapter 5), despite geographic expansion and fishing ever-deeper waters (Maribus, 2013; Pauly & Zeller, 2015). No significant progress has been made on keeping stocks in safe biological limits, while unassessed stocks, mostly in developing countries or small-scale fisheries, are likely to be in substantially worse condition than assessed stocks (Costello *et al*., 2012). Bottom trawling effort is increasing, and the survival probability of marine species is decreasing as a consequence of the impacts of this and other types of fisheries (shown by a version of the Red List Index; **Table 3.3**). Although fishing was rated as the most important anthropogenic driver of biodiversity change in the marine environment (Joppa *et al*., 2016; Knapp *et al*., 2017; Österblom *et al*., 2015), there is no comprehensive global agreement on marine conservation and management (although the United Nations Convention on the Law of the Sea is very relevant, and there are many regional agreements; see **Box 3.1** below). Although the ecosystem approach to fisheries management was proposed in the 1990s to enable more sustainable production, ecosystem drivers of fish stock productivity have rarely been included in management advice (Skern-Mauritze *et al*., 2016). Full biodiversity of stocks is crucial for long-term yields (Worm, 2016). Uncertainties in how climate change will impact the abundance and distribution of fish stocks renders it even more challenging to ensure that harvests are sustainable (Chown *et al*., 2017). Although CBD (2018e) concluded that most countries seem to have taken steps in the right direction to enable sustainable fisheries, in terms of legal, policy and management frameworks, it also projected that at least 30% of fish stocks will be overfished by 2020 under business as usual projections. Recent regional assessments concluded that there is heavy pressure on many fisheries in Africa, sustainable fisheries management is highly variable across Asia-Pacific, there is little information available for West Asia, and there has been poor progress towards sustainability in Latin America and the Caribbean (UNEP-WCMC, 2016a, 2016b, 2016c, 2016d).

The failure of fisheries regulation to prevent overexploitation of fish stocks (Knapp *et al*., 2017) has happened despite the implementation of new legislation and governance systems to enhance protection and management of marine fisheries (Boyes *et al*., 2016; Marchal *et al*., 2016; Vasilakopoulos & Maravelias, 2016), such as the incentivization of illegal, unregulated and unreported fishing in Antarctica by enhancing traceability (through a catch documentation scheme), sanctioning (through an 'illegal unregulated and unreported' vessel blacklist), surveillance (through vessel monitoring systems) and other rules (Abrams *et al*., 2016; CCAMLR, 2016; Chown *et al*., 2017).

The use of market-based instruments such as Marine Stewardship Council certification is increasing **(Table 3.3)**, with about 10% of global wild-caught seafood in some stage of the certification process by March 2015 (MSC, 2015 per Pérez-Ramiréz *et al*., 2016). Co-management between government and local users is increasingly being implemented to achieve more sustainable fisheries (Defeo *et al*., 2016). Many IPLCs have customary sustainable fishery systems that limit harvest levels and impacts to ensure that resources can continue to be used by future generations. Such practices have the potential to contribute to national and international marine biodiversity policies (FPP *et al*., 2016). IPLCs' high reliance on marine ecosystems, including aquatic animals and plants, for food and cultural purposes, results in them being disproportionately affected by unsustainable fishing practices (Cabral & Alino 2011; Cisneros-Montemayor *et al*., 2016), while social responsibility issues in fisheries have only recently began to receive significant attention (Kittinger *et al*., 2017).

CBD (2018e) noted that although there are encouraging signs of reduced pressure on vulnerable seafloor ecosystems, trends in exploitation of sharks and threatened marine fish, and bycatch of seabirds suggest that progress on reducing fisheries pressure on threatened species needs to accelerate. Although there have been some successes in reducing seabird bycatch from long-line and trawl fisheries (e.g., by 90% during 2008–2014 in the South African trawl fishery; BirdLife International, 2016a), seabird bycatch remains an issue in many fisheries, with around 300,000 individuals estimated to die in longline and trawl fisheries each year (Anderson *et al*., 2011), and a further 400,000 in gillnets (Zydelis *et al*., 2013). Bycatch is also major issue for turtles and a number of fish and invertebrate species (Kelleher, 2005).

Since the mid-1990s, total fish production has been increasingly influenced by aquaculture production (**Figure 3.2a**; Granada *et al*., 2016). During 1974–2004, there was a 32% increase in the percentage of fish provided by aquaculture for human consumption (FAO, 2016: 30). However, aquaculture may cause negative environmental impacts including the discharge of effluents and chemical contaminants (antibiotics, parasiticides, metals etc.), the spread of potential invasive species (Granada *et al*., 2016), and increased pressure on other species used as fishmeal. One-sixth of global landings from marine capture fisheries are used to produce fishmeal and fish oil, mainly for aquaculture (Cashion *et al*., 2017; Pauly & Zeller, 2017).

No data are available on the proportion of depleted species with recovery plans and measures in place. CBD (2018e) concluded that although 87% of Parties responding to a survey have plans to allow depleted stocks to recover, specific stock rebuilding plans (that specify not only a rebuilding target but also a deadline for rebuilding with a given probability) are not widely used.

Aichi Target 7: Managing agriculture, aquaculture and forestry sustainably

While some efforts to manage areas under agriculture, aquaculture and forestry sustainably (such as organic agriculture and forestry certification schemes) are increasing, biodiversity in production landscapes continues to decline, meaning that we are moving further away from achieving Aichi Target 7. Regional assessments in 2016 concluded that efforts have been made to improve forestry sustainability in Africa, rates of unsustainable timber harvesting, aquaculture and fisheries are high in Asia, but there has been some (albeit slow) progress in developing schemes for sustainable agriculture, aquaculture and forestry Latin America and Caribbean; all regions lack sufficient data to quantify accurately the trends in sustainability of production systems (UNEP-WCMC, 2016a, 2016b, 2016c, 2016d).

Agricultural expansion is one of the main drivers of global biodiversity loss (Eisner *et al*., 2016; UNCTAD, 2013). In the period 2007–2012, 290,000 km^2 of land were cleared for agriculture, a net increase of 29% compared with 2000–2006. The main drivers of agricultural expansion are global population growth and demand for grain-fed meat (Eisner *et al*., 2016) and production of biofuels (Sachs, 2007). Impacts from unsustainable monoculture-based agriculture with high levels of external inputs include soil degradation and erosion, impoverishment of soil biota (Gianinazzi *et al*., 2010), biodiversity and crop genetic diversity loss, nutrient and water depletion, soil and water contamination, emergence of new pests and diseases (Bubová *et al*., 2015; Reynolds *et al*., 2015; Rusch *et al*., 2016; Thompson *et al*., 2015; UNCTAD, 2013; United Nations Human Rights Council, 2017), and possible ecological risks associated with the use of genetically modified organisms (Wolfenbarger & Phifer, 2000). Simplification of agricultural landscapes through removal of linear habitats and reduction of landscape-scale heterogeneity also impacts farmland biodiversity (e.g., Lee & Martin, 2017). As agricultural land becomes degraded (15–80% is estimated to be currently degraded; Gomiero, 2016), this drives further agricultural

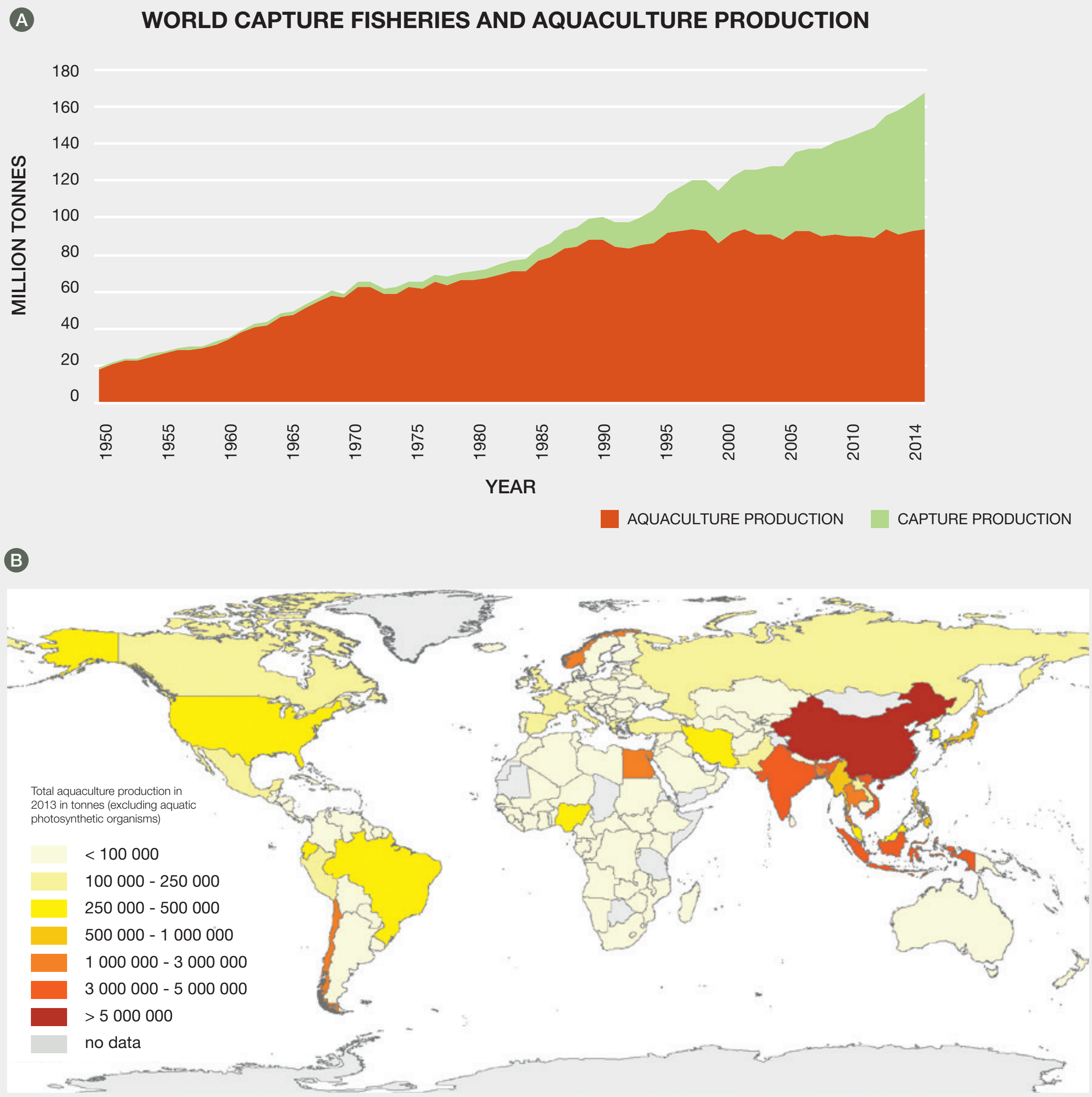


Figure 3 2 **A Global trends in aquaculture production compared with capture fisheries; and B global distribution of aquaculture production in 2013.**

Source for A: FAO (2016a); for B: Ottinger *et al.* (2016: 246).

expansion. While the area of land under organic or conservation agriculture has increased (by 20.7% during 2000–2014), for those regions and taxa with available data, farmland biodiversity continues to decline, as shown by the Wild Bird Index for farmland species **(Table 3.3)**. A global effort has been initiated to enhance biodiversity conservation through the revitalization and sustainable management of "socio-ecological production landscapes and seascapes" (the Satoyama Initiative) (UNU-IAS & IGES, 2015).

While the area under forest certification schemes has increased rapidly (by 37.2% during 2010–2016; **Table 3.3**), much forestry remains unsustainable; local species loss increases from conventional selective logging (13%) and clear-cutting (22%), to timber and fuelwood plantations (40%) (Chaudhary *et al*., 2016). Of all food production systems, aquaculture is the fastest-growing sector worldwide, particularly in South-East Asia **(Figure 3.2b)**, expanding at 8.6% per year during 1983–2013 (FAO, 2014a; Troell *et al*., 2014). Expansion of aquaculture is causing large-scale loss and destruction of coastal wetlands (e.g., mangroves) and pollution of soil and water (Ottinger *et al*., 2015).

Conservation in production landscapes is increasingly recognized as important for maintaining local biodiversity and nature's contributions to people (Ansell *et al.,* 2016; Chaudhary *et al*., 2016; Rusch *et al*., 2016; Thompson *et al*., 2015). Agroforestry systems in Europe enhance biodiversity and the provision of nature's contributions to people compared with forestry and conventional agriculture (Torralba *et al*., 2016). IPLCs' customary sustainable use practices and management systems are increasingly recognized as effective conservation approaches (Berkes *et al*., 2000; Forest Peoples Programme, 2011). For example, protected areas overlapping Indigenous Peoples' territories in Colombia have joint management arrangements for natural and cultural conservation (Leguizamón, 2016). Community-managed forests in the tropics have lower deforestation rates than strict protected areas (Nelson & Chomitz, 2011; Porter-Bolland *et al*., 2012), while traditional management often benefits biodiversity (Cotta *et al*., 2008), and indigenous and traditional shifting cultivation systems create and maintain agrobiodiversity (Carneiro da Cunha & Lima 2017, Padoch & Pinedo-Vasquez, 2010).

Aichi Target 8: Reducing pollution

We have made poor progress towards meeting Aichi Target 8, in particular owing to increasing nitrogen pollution. Global emissions of reactive nitrogen have been increasing rapidly since the 1950s. With the exception of Europe, where nitrogen deposition rates have recently leveled off owing to decreasing emissions since the 1980s, nitrogen deposition is projected to continue to increase globally (Bobbik *et al*., 2010; Shibata *et al*., 2015). Increased reactive nitrogen addition caused by agricultural fertilization or atmospheric deposition to terrestrial ecosystems is considered one of the main drivers of global change (Erisman *et al*., 2013; Galloway *et al*., 2008), while nitrogen accumulation is the main driver of changes in species composition across a wide range of ecosystem types (Bobbik *et al*., 2010; Clark & Tilman, 2008). Nitrogen pollution causes widespread plant biodiversity loss (including through impacts on soil micro-organisms), which can lead to cascading effects (Bobbink *et al*., 2010; Clark & Tilman, 2008; De Schrijver *et al*., 2011; Dupré *et al*., 2010; Shibata *et al*., 2015). Impacts include direct toxicity of nitrogen gases and aerosols, soil-mediated effects of acidification, long-term negative effects of increased ammonia and ammonium availability, eutrophication of aquatic ecosystems, soil and surface water acidification, and reductions in air quality (Bobbink *et al*., 2010; Dupré *et al*., 2010; Phoenix *et al*., 2012; Sponseller *et al*., 2016). Furthermore, nitrogen deposition increases greenhouse emissions from tropical forests, causing a positive feedback to climate change (Cusack *et al*., 2016). Reactive nitrogen pollution also affects human health and has been linked to reduction in drinking water and air quality (Erisman *et al*., 2013). Since 2003, the International Nitrogen Initiative has attempted to improve global nitrogen management (INI, 2017). IPLCs have made important contributions to reductions in nutrient pollution through agricultural practices with little use of chemicals (Altieri & Toledo, 2011; Dublin *et al*., 2014; Wezel *et al*., 2014).

In 2010, severe organic pollution (measured by biochemical oxygen demand) was estimated to affect 6–10% of Latin American, 7–15% of African and 11–17% of Asian river stretches, with levels typically increasing (UNEP, 2016a). No overall progress has been made in minimizing pollution from insecticide use, which continues to grow **(Table 3.3)**. Plastic pollution is increasing in the marine ecosystems (e.g., the western North Atlantic Ocean; Maes *et al*., 2018; Moret-Ferguson *et al*., 2010), and recent estimates are that between 4.8–12.7 million tonnes of plastic waste are entering the oceans every year, between 1.15–2.41 million tonnes carried by rivers (Jambeck *et al*., 2015); effectiveness of plastic bag reduction strategies remains to be evaluated (Xanthos & Walker, 2017). The top 20 rivers feeding into the seas account for 67 per cent of the global total (Lebreton *et al*., 2017; UNEP, 2017). One recent study estimated that there are over 5.25 trillion plastic particles, weighing over 260,000 tons in the world's oceans (Eriksen *et al*., 2014), endangering fish (Romeo *et al*., 2015), seabirds (Croxall *et al*., 2012; Wilcox *et al*., 2015) and other taxa (Baulch & Perry, 2014; Besseling *et al*., 2015; Gall & Thompson, 2015; Wright *et al*., 2013). Coral reefs may be particularly vulnerable, with plastic debris increasing the likelihood of disease by 4–89% (Lamb *et al*., 2018).

These global patterns in pollution trends are mirrored regionally according to recent assessments (UNEP-WCMC, 2016a, 2016b, 2016c, 2016d). In Africa, nutrient pollution is particularly severe in cities and agricultural areas of South Africa and the Nile River. In Asia, nitrogen and phosphorous pollution remains a serious problem, especially deriving from fertilizer use given substantial food demands from the large population in this region. In Latin America and Caribbean, nutrient loading in agricultural areas is also a problem, but pollution is particularly severe in large urban areas, with impacts on downstream rivers and marine areas.

Finally, the negative trend in a version of the Red List Index showing impacts of all types of pollution **(Table 3.3)** indicates that the negative effects of pollution are continuing to drive species towards extinction.

Aichi Target 9: Preventing, control and eradicating invasive alien species

Good progress has been made in identifying, prioritizing and implementing eradications of invasive alien species, with substantial benefits to native species, particularly on islands. However, for most taxonomic groups the numbers of alien species are increasing, suggesting that efforts to mitigate invasions have not been sufficiently effective to match increasing globalization (Seebens *et al*., 2017). Unsurprisingly therefore, invasive alien species are increasingly driving species towards extinction (as shown by the Red List Index, **Table 3.3**), meaning that overall, we are making poor progress towards Aichi Target 9. Comprehensive data on the distribution of invasive alien vertebrates on islands and their impacts on threatened native vertebrates are now available in the *Threatened Island Biodiversity Database* (McCreless *et al*., 2016; Spatz *et al*., 2017). Dataset such as this have allowed systematic prioritization of islands for eradication of invasive species to be completed for some territories, regions or taxa (e.g., Dawson *et al*., 2014; Helmstedt *et al*., 2016; Spatz *et al*., 2014, 2017). Over 800 invasive mammal eradications have been successfully carried out, with estimated benefits through positive demographic and/or distributional responses for at least 596 populations of 236 native terrestrial insular species on 181 islands (Jones *et al*., 2016). More recent data from the *Database on Island Invasive Eradications* (http://diise.islandconservation.org/) indicate that over 85% of the >1,200 eradication attempts to date have been successful. It has been predicted that 107 highly threatened birds, mammals, and reptiles have benefitted from invasive mammal eradications on islands, e.g., island fox *Urocyon littoralis* and Seychelles magpie-robin *Copsychus sechellarum* (Jones *et al*., 2016). Less evidence is available to assess the degree to which measures have been successfully put in place to manage invasion pathways and to prevent the introduction and establishment of invasive alien species. Such efforts are likely to be more cost-effective, but better information is needed to quantify their application and cost-effectiveness. Despite these positive trends, there has been no significant growth in the adoption of national legislation in addressing invasive alien species, the rate of introductions is increasing, and the Red List Index shows that more species have deteriorated in status as a consequence of invasive alien species than have improved in status following successful eradication or control measures **(Table 3.3)**. On continents, there are far fewer examples of successful efforts to manage invasive alien species. In aquatic environments, particularly in the marine realm, more effort is needed to update inventories of invasive alien species and pathways (Tricarico *et al*., 2016). The rate of establishment of alien species appears to be growing across all animal, plant and microbial groups with sufficient information: only mammals and fishes show signs of a slowdown (Seebens *et al*., 2017). Regional assessments reveal a similar pattern, with poor overall progress towards eradicating, controlling and preventing the spread of invasive alien species in Africa, West Asia, Asia-Pacific, Latin America and the Caribbean (UNEP-WCM, 2016a, 2016b, 2016c, 2016d).

Aichi Target 10: Minimising pressures on ecosystems vulnerable to climate change

We have made poor progress on minimizing the multiple anthropogenic pressures on coral reefs and other vulnerable ecosystems impacted by climate change or ocean acidification owing to growing anthropogenic pressures on vulnerable ecosystems and the accelerating impacts of climate change, ocean acidification, and interactions with other threats. This global assessment is reflected at the regional scale too (Jackson *et al*., 2014; UNEP-WCMC, 2016a, 2016b, 2016c, 2016d). More than 60% of the world's coral reefs face immediate direct threats, with overfishing being the most pervasive immediate driver (Burke *et al*., 2011; Mora *et al*., 2016), combined with climate change (Hughes *et al*., 2017a, 2018). Threats to coral reefs increased substantially during 1997–2007, with a 30% increase in the percentage of coral reefs rated as threatened (Burke *et al*., 2011). Corals have shown the steepest declines in status of all groups for which Red List Indices are available **(Figure 3.4b)**. Coral bleaching due to anthropogenic temperature change and ocean acidification affects >90% of coral reefs (Frieler *et al*., 2013), and is becoming more frequent, with further mass-bleaching events in 2015–2017 (Hughes *et al*., 2017a, 2018). Despite these negative trends, the global indicator of percentage of live coral cover showed only a non-significant decline during 1972–2016 **(Table 3.3)**, because individual reef trajectories are hugely variable and only a small proportion of reefs show high or severe mortality (e.g., 10% in the Western Indian Ocean; Obura *et al*., 2017). Given that the pressures on corals are expected to increase in the coming decades, this indicator is expected to decrease significantly in future.

Benthic communities, cold-water corals and seamount communities, among others are also at risk from climate change and ocean acidification (Burke *et al*., 2011; Mora *et al*., 2016; Ramirez-Llodra *et al*., 2011). Responses that have already been observed include hypoxia, distributional shifts, bleaching, and reduced body size, with greater impacts expected owing to synergistic interactions between ocean acidification and warming (Harvey *et al*., 2013; Wilkinson *et al*., 2016). Interactions with other threats, such as eutrophication, pollution, coastal development and overfishing exacerbate the situation (Burke *et al*., 2011, 2016; Mieszkowska *et al*., 2014; Ramirez-Llodra *et al*., 2011). Observed increases in the frequency of outbreaks of seastar *Acanthaster planci* related to nutrient loads have had massive destructive effects (Fabricius *et al*., 2010). Ocean acidification and warming increase the potential for reduction in diversity and abundance of key species in marine ecosystems, and lower ecosystem resilience to future stress (Burke *et al*., 2016; Dupont *et al*.,2010; Nagelkerken & Connell 2015). Plastics have also been recently identified as another major cause of coral reef loss due to light interference, toxin release, physical damage, anoxia and increasing the likelihood of pathogen disease 20-fold (Lamb *et al*., 2018; see also **Box 3.1**).

Climate change impacts on other vulnerable ecosystems, such as mountains and glaciers, including on water storage and run off regulation (Houghton *et al*., 2001), have been widely reported, e.g., Mount Kilimanjaro (Tanzania; UNEP-WCMC 2016a), the Andes (Veettil *et al*., 2017) and in Asia (Kraaijenbrink *et al*., 2017). Polar regions have been particularly affected by climate change and impacts on marine mammals (Laidre *et al*., 2015), birds (Stephens *et al*., 2016), other marine biota (Constable *et al*.,2014), and arctic marine ecosystems in general (Wassmann *et al*., 2013) have been reported. In Antarctica and the Southern Oceans, fisheries and tourism are impacting vulnerable ecosystems (Chown *et al*., 2017). Overfishing, pollution and inappropriate coastal development in coral reef ecosystems are driving declines in diversity and biomass of fish and other organisms, and loss of spatial dominance of corals (Sale 2015). Continental-scale estimates of the magnitude of climate change impacts on species' population trends are available only for birds, for which a Climatic Impact Index shows a growing signal of climate change on population trends since the 1980s across Europe and North America (the only regions with available information; Stephens *et al*., 2016), while other anthropogenic threats continue to drive declines in these species, particularly in farmland habitats (BirdLife International 2018). Climate change impacts on vulnerable ecosystems and species are discussed further under Aichi Target 12: see below.

Aichi Target 11: Conserving terrestrial and marine areas through protected areas and other area-based measures

While the world's protected area network continues to expand and may exceed numerical targets for coverage of terrestrial and marine environments by 2020, there has been only moderate progress towards other aspects of Aichi Target 11 in both the terrestrial and marine environment. This pattern is reflected regionally too (UNEP-WCMC, 2016a, 2016b, 2016c, 2016d). By September 2018, the *World Database on Protected Areas* showed that 14.9% of the world's terrestrial and freshwater environments was covered by protected areas, with 7.44% of the marine realm area covered (17.2% of marine areas within national jurisdiction, and 1.18% of marine areas beyond national jurisdiction (Gannon *et al*., 2017; UNEP-WCMC & IUCN, 2018). In Antarctica, <4% of the ice-free terrestrial area is protected (Chown *et al*., 2017). Specific commitments made by particular countries for new/expanded protected areas through National Priority Actions, National Biodiversity Strategies and Action Plans or projects from the fifth and sixth replenishment of the Global Environment Facility total over 3.9 million km^2 on land and over 13 million km^2 in the oceans (CBD, 2018b). If these are fulfilled before 2020, coverage is expected to exceed 10% of the global ocean and 17% of terrestrial and inland water (**Figure 3.3a**; CBD, 2018b).

Recent growth in the global protected area network has been greatest in the marine environment, with the coverage of marine protected areas increasing from 2 million km^2 (0.7% of the ocean) in 2000 to 26.9 million km^2 (7.44%) at present. This increase has resulted in particular from the establishment of some extremely large marine protected areas (Gannon *et al*.,2017; Thomas *et al*., 2014), such as the Marae Moana Marine Park in the Cook Islands in 2017 (1.97 million km^2) and the expansion in 2016 of the Papahānaumokuākea Marine National Monument in the Hawaiian Islands (1.5 million km^2), representing the second and fourth largest marine protected areas worldwide respectively. The establishment of marine protected areas in Areas Beyond National Jurisdiction has mostly been driven by the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) and the Convention for the Conservation of Antarctic Marine Living Resources (CCMALR) (UNEP-WCMC & IUCN, 2016). Protection of biodiversity in the high seas has considerable governance challenges. The organizations with the authority to protect and manage the marine resources in the high seas are: (1) the International Maritime Organization, which can designate Particularly Sensitive Sea Areas to control shipping activities, (2) the International Seabed Authority, which can designate Areas of Particular Interest to control deep seabed mining, and (3) the Regional Fisheries Management Organizations, which can designate closure for certain fisheries or protect Vulnerable Marine Ecosystems as defined by the UN (Wright *et al*., 2016), but protection of the high seas is still uneven and cooperation is weak across the existing agreements (Ardron & Warner, 2015; Ardron *et al*., 2014). In response, two major initiatives are underway to strengthen conservation of the marine environment, in particular through establishment of marine protected areas in the high seas. The CBD has developed criteria and processes to describe Ecologically or Biologically Significant Areas (EBSAs) to support national and international management of ocean habitats and resources (Dunn *et al*., 2014; Dunstan *et al*., 2016), 279 of which have been described to date (Bax *et al*., 2016; CBD, 2017b). The second initiative has been driven by the United Nations General Assembly, with countries agreeing in 2015 to open negotiations for a new legally binding instrument on the conservation and sustainable use of marine biodiversity in Areas Beyond National Jurisdiction under the United Nations Convention on the Law of the Sea (Rochette *et al*., 2015; Wright *et al*., 2013, 2016).

The extent and distribution of 'other effective area-based conservation measures' (OECMs, as referred to in Aichi Target 11, such as some privately managed areas and territories and areas managed by Indigenous Peoples and Local Communities) is not well documented (Gannon *et al*., 2017; UNEP-WCMC & IUCN, 2016). This is partly because a definition of such areas has only recently been developed (CBD, 2018h). Once documented, inclusion of such areas will likely also substantially increase the estimates above of terrestrial and marine coverage by protected areas and conserved areas. The contribution of IPLCs to protected area growth, and the impact of this on IPLCs, is discussed in greater detail in section 3.2.4.

Moderate progress has been made towards ecological representativeness, effective management and protection of areas of importance for biodiversity. Although ecological representation of protected area networks has increased (Kuempel *et al*., 2016), by April 2018, only 43.4% of the world's 823 terrestrial ecoregions have at least 17% of their area covered by protected areas and 42.7% of the 232 marine ecoregions (and 10.8% of pelagic provinces) have at least 10% of their area covered (CBD, 2018b; EC-JRC, 2018). One quarter of terrestrial ecoregions (207, 24%) have been identified as 'imperiled', where the area of protected and unprotected natural habitat remaining is less than or equal to 20% (and averages only 4%) (Dinerstein *et al*., 2017). Protected area coverage of species distributions also remains insufficient (Goettsch *et al*., 2018; Venter *et al*., 2017), and over half (57%) of 25,380 species assessed to date have inadequate coverage of their distributions by protected areas (Butchart *et al*., 2015). Recent protected area expansion has failed to target places with high concentration of threatened vertebrate species: if protected area growth during 2004–2014 had strategically targeted unrepresented threatened vertebrates, it would have been feasible to protect over 30 times more threatened species for the same area or cost as the actual expansion that occurred (Venter *et al*., 2017).

Only 20.7% of Key Biodiversity Areas ('sites contributing significantly to the global persistence of biodiversity') are completely covered by protected areas (BirdLife International *et al*., 2018; Butchart *et al*., 2012, 2016). The global mean percentage area of terrestrial Key Biodiversity Areas covered by protected areas increased from 35.0% in 2000 to 46.6% in 2018, with the equivalent figures being 31.9% to 43.5% for freshwater Key Biodiversity Areas and 31.7% to 44.3% for marine Key Biodiversity Areas (**Figure 3.3b**; BirdLife International *et al*., 2018). Of the protected areas that overlap Key Biodiversity Areas and that have data available on governance, just 1.01% are managed by Indigenous Peoples and Local Communities, or are nationally designated as indigenous, local, or community lands, covering 2.37% of the overlapping area (based on spatial analysis of data from BirdLife International, 2016b and IUCN & UNEP-WCMC, 2016). A significant but unknown proportion of Key Biodiversity Areas are also likely to be covered by OECMs (BirdLife International, 2014). Recent protected area expansion has disproportionately targeted area outside Key Biodiversity Areas (Butchart *et al*., 2012), meaning that insufficient attention is being paid to the element of Aichi Target 11 addressing 'areas of particular importance for biodiversity'.

Currently, there is no global indicator measuring the extent to which areas of importance for ecosystem services are protected or the effectiveness of such protection (Spalding *et al*., 2014), while national studies typically show a mismatch between the distribution of protected areas and locations of importance for ecosystem services (e.g., protected areas cover 15.1% of China's terrestrial surface, but only 10.2–12.5% of the source areas for four key regulating services; Xu *et al*., 2017). Similarly, there is a mismatch between marine protected areas and locations of importance for ecosystem services (Lindegren *et al*., 2018).

Although there are positive trends in the number of protected areas with assessments of management effectiveness **(Table 3.3)**, as of May 2018, only 21% of countries have assessed management effectiveness for at least 60% of their terrestrial protected areas (and 16% of countries had done so for at least 60% of their marine protected areas): the target under the CBD Programme of Work on Protected Areas (CBD, 2010b; Coad *et al*., 2015; UNEP-WCMC, 2018b). The *Atlas of Marine Protection* (an independent attempt to track the adequacy of protection of marine protected areas) estimates that as little as 3.6% of the global ocean is covered by fully implemented and actively managed protected areas (Marine Conservation Institute, 2017). In many countries, less than half of protected areas are effectively managed, having the same level of modification as non-protected lands (Clark *et al*., 2013), while only 10% of protected areas are free from human pressure (Jones *et al*., 2018). A main driver of ineffectiveness is the unsustainable use of biological resources (Shulze *et al*., 2018), while some protected areas may be too small to conserve the target species they aim to protect (Mallari *et al*., 2016). Without a comprehensive global dataset on protected area management effectiveness, it is difficult to estimate what percentage of the terrestrial/freshwater and ocean environments is effectively protected, but it is likely to fall far short of the percentages for absolute coverage reported above. One recent assessment found that only 21% of a sample of marine protected areas met more than half of nine thresholds for effective management, although 71% of marine protected areas showed positive responses in fish biomass, which averaged 1.6 times higher than in matched unprotected areas (Gill *et al*., 2017). There is significant evidence, especially from "no-take" marine reserves, that protecting marine biodiversity and ecosystems delivers benefits (e.g., Aburto-Oropeza *et al*., 2011; Mellin *et al*., 2016). A recent meta-analysis found that most studies showed that protected areas helped to reduce declines in both species' populations (74% of 42 relevant counterfactual studies) and habitat (79% of 60 studies) (Geldmann *et al*., 2013). Similarly, analysis of studies of biodiversity responses to land-use change found that protected areas were effective at retaining species richness and local abundance (Gray *et al*., 2016).

No agreed methodology exists for tracking progress towards equitable management of protected areas (Corrigan *et al*., 2017; Spalding *et al*., 2014), although indicators

(Zafra-Calvo *et al*., 2017) and frameworks have been proposed (Schreckenberg *et al*., 2016). The proportion of sites in the *World Database on Protected Areas* reporting shared governance increased from 1.8% in 2016 to 3.3% in 2018 (CBD, 2018b). Protected areas that explicitly integrated local stakeholders are significantly more effective at achieving conservation and socioeconomic outcomes (Oldekop *et al*., 2016), but data on protected area socio-ecological effects are generally lacking (Pendleton *et al*., 2017).

Adequately connected protected areas cover only 9.3–11.7% of the terrestrial realm, with only about a third of the world's ecoregions and 30.5% of countries currently having 17% of their area covered by well-connected protected areas, indicating that the spatial arrangement of protected areas is only partially successful in ensuring connectivity of protected lands (Santini *et al*., 2016; Saura *et al*., 2017, 2018). Connectivity of marine protected areas has not yet been assessed (Gannon *et al*., 2017). Protected area management strategies would be more effective if they took greater consideration of connectivity (particularly in freshwater ecosystems), contextual vulnerability, and required human and technical capacity (Juffe-Bignoli *et al*., 2016b), and were better embedded within integrated spatial planning. While uptake of the latter appears to be accelerating in the marine realm, only c.10% of jurisdictional waters are currently under some level of marine spatial planning (Spalding *et al*., 2014).

Finally, few protected areas are currently taking into account climate change in their management (Poiani *et al*., 2010), but the effects of climate change on protected areas will be profound (e.g., Araujo *et al*., 2011; Bagchi *et al*., 2012; Baker *et al*., 2015; Hole *et al*., 2009; Zomer *et al*., 2015), and addressing them will require the development and implementation of coherent, network-scale, adaptation plans (Dudley *et al*., 2010; Hole *et al*., 2011; Wiens *et al*., 2011). This is particularly important given that effectively managed protected areas can help to buffer the negative impacts of climate change, reduce disaster risks, and contribute to climate change mitigation and adaptation (Hole *et al*., 2011; Lawson *et al*., 2014; Nogueira *et al*., 2018; Virkkala *et al*., 2014).

Aichi Target 12: Preventing extinctions and improving the conservation status of species

Poor progress has been made overall towards Aichi Target 12, although trends would have been worse in the absence of conservation action. A total of 25,062 species are listed as threatened on the IUCN Red List, the global standard for assessing extinction risk (IUCN, 2017). It is important to note, however, that only 87,967 species have been assessed for the Red List, with 95% of described species not yet evaluated (IUCN, 2017). Best estimates (with upper and lower bounds) of the proportion of species threatened with extinction average 23.7% (20–34%) across comprehensively assessed taxonomic groups, ranging from 7% (7–18%) for selected families of bony fishes, to 13% (13–14%) of birds, 25% (22–36%) of mammals, 31% (18–60%) of sharks and rays, 33% (27–44%) of reef-forming corals, 34% (34–35%) of conifers, 36% (32-44%) of selected families of dicots (magnolias and cacti), 41% (32–55%) of amphibians, and 63% (63-64%) of cycads (**Figure 3.4a;** IUCN, 2017). Among those groups in which not all species have yet been assessed, a sampling approach suggests that the proportion of species that are threatened ranges from 14% (9–44%) for dragonflies and damselflies (Clausnitzer *et al*., 2009) to 19% (15–36%) for reptiles (Böhm *et al*., 2013) and 22% (20–26%) for plants (Brummitt *et al*., 2015). Considering phylogenetic diversity together with extinction risk elevates the conservation priority of many mammal and bird species (Isaac *et al*., 2007; Jetz *et al*., 2014; Safi *et al*., 2013).

Concentrations of threatened species occur in South-East Asia, the Andes, the Caribbean, Madagascar, New Zealand, and other oceanic islands (IUCN, 2009; Pereira *et al*., 2012). Primary threats to threatened species are unsustainable agriculture, biological resource use, invasive species, land use, and residential and commercial development (Joppa *et al*., 2016). Recent extinctions include Bramble Cay melomys *Melomys rubicola* in Australia (last seen in 2007, declared extinct in 2016; Gynther *et al*., 2016; Woinarski & Burbidge, 2016; Woinarski *et al*., 2014), Western black rhinoceros *Diceros bicornis longipes* in Cameroon (last reported in 2006, declared extinct in 2011; Emslie, 2012), Javan rhinoceros *Rhinoceros sondaicus annamiticus* in Vietnam in 2011 (Kinver, 2011), the Pinta Giant Tortoise *Chelonoidis abingdonii* in Galapagos in 2012 (Cayot *et al*., 2016) and the Alagoas Foliage-gleaner *Philydor novaesi* in 2011 (Lees *et al*., 2014; Butchart *et al*., 2018). However, extinctions per se are extremely difficult to detect (Butchart *et al*., 2006, 2018), so a more useful metric of relevance is the Red List Index, which shows that, overall, species are continuing to move towards extinction rapidly, with cycads, amphibians and particularly corals declining most rapidly **(Figure 3.4b)**. This global trend is repeated across all regions (UNEP-WCMC, 2016a, 2016b, 2016c, 2016d). Among carnivores and ungulates, one quarter of all species moved one or more categories closer to extinction globally since the 1970s. For each species that improved in status (towards less threatened categories), eight species deteriorated in status during this period (Di Marco *et al*., 2014). Rodrigues *et al*. (2014) found that 50% of the global deterioration in the extinction risk status of vertebrates is concentrated in 1% of the surface area, 39/1,098 ecoregions (4%) and 8/195 countries (4%): Australia, China, Colombia, Ecuador, Indonesia, Malaysia, Mexico, and the United States.

It is notable that extinction risk trends would have been worse in the absence of conservation: for birds,

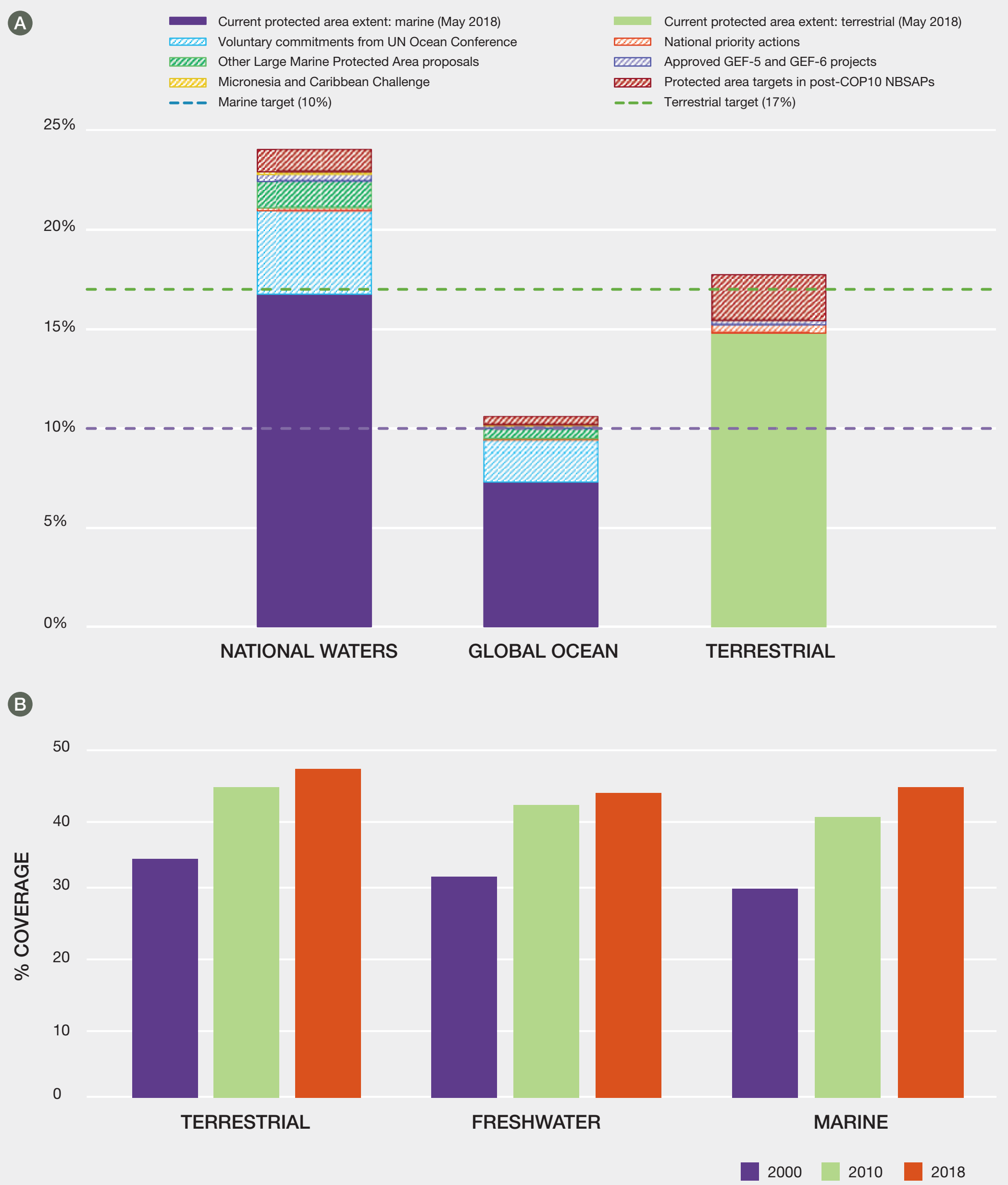


Figure 3 3 **Progress towards elements of Aichi Target 11.**

A Current and projected coverage of marine and terrestrial areas by protected areas, showing the potential contributions of approved projects through 5th and 6th replenishments of the Global Environment Facility (GEF-5 and GEF-6), national targets defined in National Biodiversity Strategies and Action Plans, and other national commitments, in addition to coverage documented in the May 2018 release of the *World Database on Protected Areas* (dotted lines indicate the thresholds of 10% of coastal and marine areas and 17% of terrestrial and freshwater areas, as specified in Target 11); B Increase in mean percentage of Key Biodiversity Areas covered by protected areas in different ecosystems. Source for A CBD (2018b); for B BirdLife International, IUCN and UNEP-WCMC (2018).

conservation action reduced the decline in the Red List Index equivalent to preventing 39 species (2.8% of threatened species) each moving one IUCN Red List category closer to extinction between 1988 and 2008, while for mammals the figures were equivalent to preventing 29 species (2.4% of threatened species) moving one category closer to extinction between 1996 and 2008 (Hoffmann *et al*., 2010). A subsequent analysis focusing on ungulates estimated that without conservation, at least 148 species would have deteriorated by one IUCN Red List category during 1996-2008, including six species that now would be listed as extinct (Javan Rhinoceros *Rhinoceros sondaicus*, Greater One-horned Rhinoceros *R. unicornis* and Kouprey *Bos sauveli*) or extinct in the wild (Arabian

Oryx *Oryx leucoryx*, Przewalski's Horse *Equus ferus* and Bawean Deer *Axis kuhlii*). For birds, 16 species would have gone extinct during 1994–2004 without conservation action, and another 10 species would have gone extinct prior to 1994 without conservation action (Butchart *et al*., 2006). The overall decline in the status of ungulates would have been nearly eight times worse than observed without conservation efforts (Hoffmann *et al*., 2015). A recent model estimated that conservation investment during 1996–2008 reduced biodiversity loss (measured in terms of changes in extinction risk for mammals and bird) in 109 countries by 29% per country on average (Waldron *et al*., 2017). Finally, a recent analysis concluded that five species of pheasants and partridges in Sundaland (the Malay Peninsula to Bali) survive only in protected areas and have been entirely extirpated in unprotected areas (Boakes *et al*., 2018). These studies provide rare comparisons of how trends in the state of nature would have been different in the absence of conservation efforts.

From 1970 to 2012, global populations of vertebrate species declined by 58% (48–66%), on average, according to the Living Planet Index. Overall declines were higher in the freshwater realm (81%; 68–89%) than the terrestrial (38%; 21–51%) and marine realms (36%; 20–48%) (McRae *et al*., 2017; WWF, 2016). In a sample of 27,600 vertebrate species, 32% were found to be decreasing in population size and range, while for 177 mammals with detailed data, all have lost more than 30% of their range, and over 40% have lost over 80% of their range (Ceballos *et al*., 2017).

Insufficient data are available to assess trends in genetic diversity (Pereira *et al*., 2012). Protected areas have a key role in conserving threatened species but while the total extent of protected areas has grown, many important sites for threatened species (Key Biodiversity Areas) remain unprotected (see above). For the subset of Key Biodiversity Areas that qualify as Alliance for Zero Extinction sites (because they hold effectively the entire global population of at least one Critically Endangered or Endangered species), the global mean percentage area of these sites covered by protected areas increased from 33.4% in 2000 to 42.6% in 2017.

Progress towards Aichi Target 12 is being hampered by the increasing impacts of climate change, which is exacerbating the challenge of conserving species. Most ecological processes (82%) in marine, terrestrial and freshwater environments that underpin ecosystem functioning and support services to people now show evidence of impact from climate change (Poloczanska *et al*., 2016; Scheffers *et al*., 2016; Settele *et al*., 2014). Examples of observed impacts include shifts in species ranges, changes in phenology, altered population dynamics, and other disruptions scaling from genes to ecosystems (BirdLife International & National Audubon Society, 2015; Poloczanska *et al*., 2016; Scheffers *et al*., 2016). For example, in North American temperate forests, surges in mountain pine beetle infestations are associated with warmer temperatures, particularly in winter (Creedon *et al*., 2014), with resulting effects on survival of species such as the Whitebark Pine *Pinus albicaulis* and Grizzly Bear *Ursus arctos* in Yellowstone National Park (Saunders *et al*., 2009). Warming temperatures in Hawaii are leading to invasive mosquitoes and introduced disease spreading to higher elevations, driving rapid declines in in the populations of many native bird species (Benning *et al*., 2002; Paxton *et al*., 2016). European butterfly communities shifted an average of 114 km northwards during 1990–2008 (Devictor *et al*., 2012), while timing mismatches have been observed between butterflies and their host plants (Parmesan *et al*., 2013). Mass-bleaching of coral reefs has become a recurrent occurrence, ocurring most recently in 2015–2016 (Hughes *et al*., 2017a). In the Arctic, marine species are under threat from changes in their physical, chemical and biological environment, with a number of species shifting their ranges northwards to seek more favourable conditions as the Arctic warms (particularly mobile open-water species such as Polar Cod *Arctogadus glacialis*; CAFF, 2013) (see **Box 3.2**). Almost half (47%) of terrestrial non-volant threatened mammals and 23.4% of threatened birds may have already been negatively impacted by climate change in at least part of their distribution (Pacifici *et al*., 2017), while strong evidence suggests that bird populations in North America and Europe have been affected by climate change since the 1980s, with 'warm'-adapted species increasing in abundance, and 'cold'-adapted species either stable or declining in abundance (Stephens *et al*., 2016). One recent assessment of 987 populations of 481 terrestrial bird and mammal species found that declines in population abundance since 1950 were greater in areas where mean temperature has increased more rapidly, and that this effect was more pronounced for birds (Spooner *et al*., 2018).

Projected impacts suggest that climate change will greatly increase the number of species under threat, with most studies on birds concluding that there are likely to be fewer species that expand their ranges or experience more suitable conditions than the number that experience range contraction or less suitable conditions (BirdLife International & National Audubon Society, 2015). Large-scale redistribution of fish populations is also predicted (with consequences for fisheries too; Cheung *et al*., 2010). Species reliant on sea ice for reproduction, resting or foraging will experience range reductions if current trends continue (CAFF, 2017).

Other factors that hamper progress towards Aichi Target 12 include insufficient holistic species conservation planning, with inadequate consideration given to socioeconomic aspects, monitoring and evaluation (Mair *et al*., 2018).

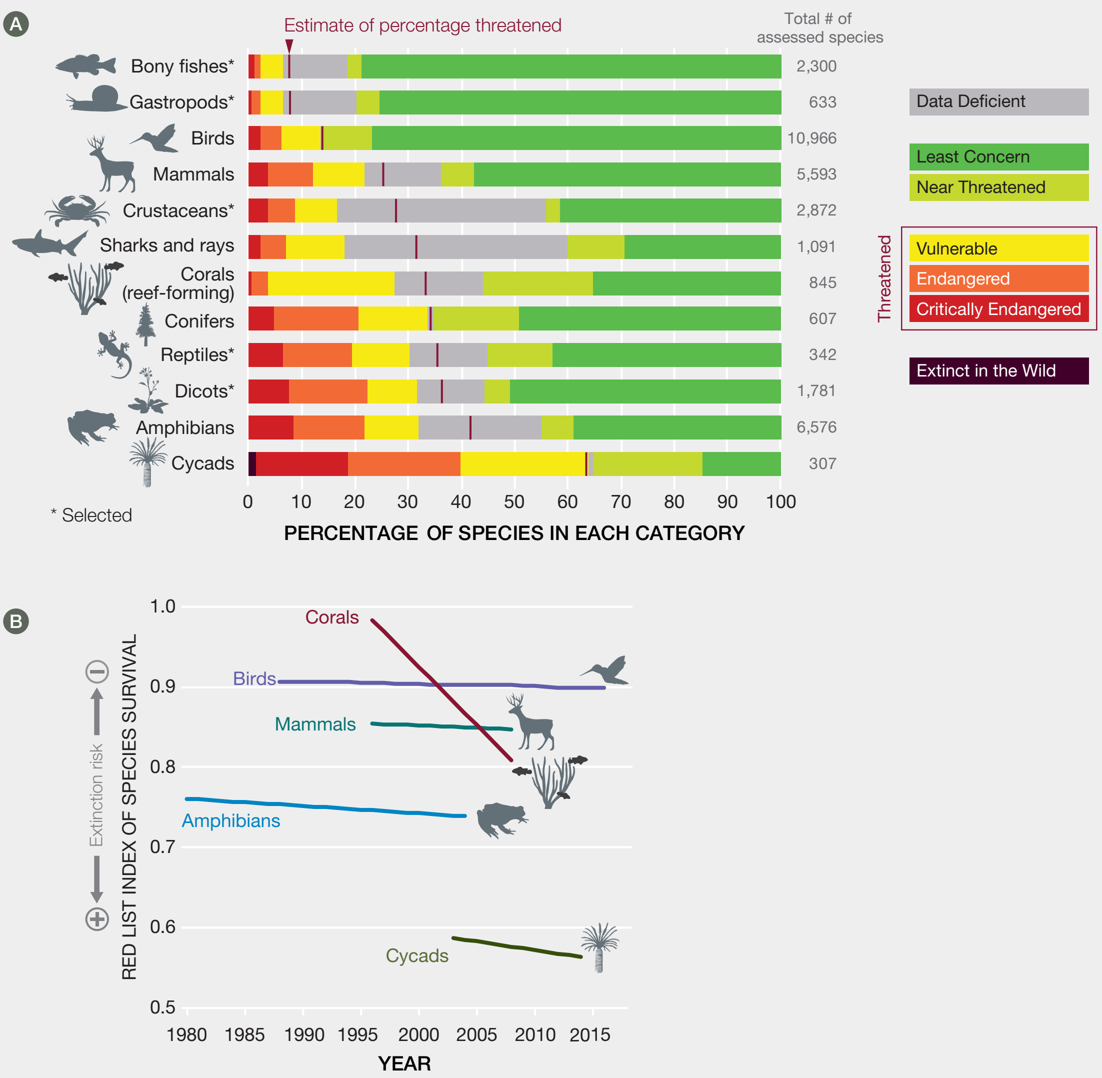


Figure 3 4 **A substantial proportion of assessed species are threatened with extinction and overall trends are deteriorating, with extinction rates increasing sharply in the past century.**

A Percentage of species threatened with extinction in taxonomic groups that have been assessed comprehensively, or through a 'sampled' approach, or for which selected subsets have been assessed, by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Species in are grouped into classes (with the exception of reef-forming corals, which includes species from classes Hydrozoa and Anthozoa). Groups are ordered according to the best estimate for the percentage of extant species considered threatened (shown by the vertical blue lines), assuming that data deficient species are as threatened as non-data deficient species. For 'sampled' and 'selected' groups, the total estimated number of described specie are as follows: bony fishes: 28,000, gastropods: 85,000, dragonflies: 3,000, ferns and relatives: 12,000, monocots: 60,000, reptiles: 10,793, crustaceans: 47,000, dicots: 208,000. The taxonomic subsets included in the 'selected' groups are listed at http://www.iucnredlist.org/about/summary-statistics. B Red List Index of species survival for taxonomic groups that have been assessed for the IUCN Red List at least twice. A value of 1 is equivalent to all species being categorized as Least Concern; a value of zero is equivalent to all species being classified as Extinct.
Data for both panels derive from www.iucnredlist.org, plus Butchart *et al.* (2016) for panel B.

Aichi Target 13: Maintaining genetic diversity

We are far from maintaining and safeguarding the genetic diversity of cultivated plants, farmed and domesticated animals, and wild relatives, and hence meeting Aichi Target 13. While many varieties of crops and domesticated animals are held in gene banks (FAO 2015c), overall genetic diversity is being eroded, and renewed approaches to the management and research on domesticated biodiversity is needed (Carvalho *et al*., 2012; Newton *et al*., 2010), particularly given the threat of climate change (Mercer & Perales, 2010). Recent initiatives are pursuing more efficient and effective conservation strategies for *ex situ* crop conservation (Khoury *et al*., 2010), but the diversity of crop wild relatives is still poorly represented: 29.1% of taxa have no germplasm accession and 23.9% are represented with fewer than ten accessions (Castañeda-Álvarez *et al*., 2016). Furthermore, 95% of taxa have insufficient representation of the geographic and ecological variation across their native ranges, with significant gaps in the Mediterranean and the Near East, Western and Southern Europe, Southeast and East Asia, and South America (Castañeda-Álvarez *et al*., 2016).

Progress towards achieving this target has been hampered by the absence of relevant inventories of crop diversity (including major and minor cereals, root and tuber crops, oil crops, vegetables, fruits, fodder and spices), declines in the cultivation of many varieties, and the absence of national institutions responsible for their conservation (Castañeda-Álvarez *et al*., 2016; Newton *et al*., 2010). Genetic pollution i.e., contamination by gene flow from conventional and biotechnologically bred crops and introduced alien species threaten cereal varieties (Carvalho *et al*., 2012), but poor progress has been made in minimizing and mitigating this threat. For non-commercial and local breed livestock there is still a paucity of indicators of genetic erosion and diversity (Bruford *et al*., 2015). The proportion of domesticated breeds categorized as at risk or extinct is increasing **(Table 3.3)**, indicating a decline in livestock diversity, but the rate of increase is slowing, potentially suggesting that countries are making some progress in safeguarding domesticated animals. The extinction risk of wild relatives of domesticated or farmed birds and mammals is increasing, as shown by declining Red List Index trends, suggesting that potentially valuable genetic diversity is being lost (McGowan *et al*., 2018). Regional assessments of progress towards this target found that trends in genetic diversity are unknown in Asia, while progress has been poor in Africa, Latin America and the Caribbean (UNEP-WCMC, 2016a, 2016b, 2016c, 2016d).

Aichi Target 14: Restoring and safeguarding ecosystems that provide essential services

Poor progress has been made towards achieving Aichi Target 14. An analysis of 21 indicators of the state of nature and 13 indicators of nature's contributions to people showed that while 60% of the latter indicators have positive trends, 86% of indicators of the state of nature show declines (Shepherd *et al*., 2016). This suggests that while good quality of life is increasing in the short-term, it is based on unsustainable use of nature. As soil fertility continues to decline, it is doubtful that good quality of life can continue to increase without negative impacts on nature's contributions to people (Shepherd *et al*., 2016).

Mangroves are a good example of an ecosystem that contribute to good quality of life, providing food and feed (including through sustaining fisheries), energy (fuelwood), materials (wood for construction), medicinal resources, regulation of coastal water quality, regulation of hazards (coastal protection), physical and psychological experiences (nature-based tourism), regulation of climate (carbon sequestration), and supporting identities (cultural services), among others (e.g., Datta *et al*., 2012). About 38% of the global extent of mangroves had been lost by 2010 (Thomas *et al*., 2017), but there has been no comprehensive assessment of trends in their global extent, and hence progress towards Aichi Target 14 for this habitat, since 2010 (Butchart *et al*., 2010), although work is underway to address this. In the western Himalayas, mountain ecosystems provide contributions to people ranging from water flow regulation to provision of materials, food and medicine, but extensive use of natural vegetation in the past has decreased the value of provisioning services (Khan *et al*., 2013), with increasing rarity of plants used for medicine by IPLCs (Díaz *et al*., 2006; Giam *et al*., 2010; Khan *et al*., 2012).

Loss of forests and native vegetation has affected smallholder subsistence systems by lowering yields, pollination, water provisioning, and access to animals and plants used as food, medicine and fuelwood, as well as aspects of human well-being including identity, autonomy, traditional lifestyles and knowledge (IPBES, 2018: 5.2.1). Deforestation and land degradation have had a negative impact on freshwater quality and quantity (IPBES, 2018: 5.2.3.). Approximately half of global population is expected to be living in water scarce areas by 2050, especially in Asia (IPBES, 2018: 7.2.4). Loss of native vegetation has also been linked to increase in flood-related disasters and soil erosion (IPBES, 2018: 5.3.2, 5.3.3).

Pollination services undertaken by feral colonies of honey bees and native insects are essential to crops and natural ecosystems (Gallai *et al*., 2009); animal pollination is directly responsible for between 5–8% of current global agricultural production by volume (IPBES, 2016). However, wild pollinators have declined in distribution and diversity (and in some cases, abundance) at local and regional scales in North West Europe and North America, the only regions with adequate data; local declines have been recorded elsewhere (IPBES, 2016). According to the IUCN Red List, 16.5% of vertebrate pollinators are threatened with global extinction, while the Red List Index for vertebrate pollinators is declining (**Table 3.3**; Regan *et al*., 2015), indicating that their extinction risk is increasing. In Europe, 9% of bee and butterfly species are threatened, and populations are declining for 37% of bees and 31% of butterflies (IPBES, 2016). Where national Red List assessments are available, they show that often more than 40% of bee species may be threatened (IPBES, 2016). These results suggest that the ecosystems upon which pollinators depend are not being sustained, and hence that we are moving away from meeting Target 14 for this component of nature's contribution to people.

Protected areas are a key mechanism for safeguarding ecosystems that provide essential services, and hence potentially play a key role in achieving Target 14 (IPBES, 2018: 7.2.2.2; Larsen *et al*., 2012). Protected areas deliver 20% of the global total of continental runoff, providing freshwater to nearly two thirds of the global population living downstream (Harrison *et al*., 2016). Positive conservation and socioeconomic outcomes are more likely to occur when protected areas are co-managed, empower local people, reduce economic inequalities, and maintain livelihood benefits (Oldekop *et al*., 2016). Co-management of protected areas by local communities and conservation agencies tends to be associated with delivery of greater local benefits than community– or state-management, according to a global meta-analysis of 171 studies involving 165 protected areas (Oldekop *et al*., 2016; see also chapter 6).

Elsewhere, restoration efforts are helping to recover nature's contributions to people, such as coastal protection from mangrove restoration (IPBES, 2018: 5.3.2), while multiple benefits are expected from forest restoration initiatives (IPBES, 2018: 6.5).

The global pattern of poor progress towards Target 14 is reflected in Asia-Pacific, but trends in West Asia, Latin America and the Caribbean are judged to be negative, while there is insufficient information to assess progress in Africa (UNEP-WCMC, 2016a, 2016b, 2016c, 2016d).

Aichi Target 15: Enhancing ecosystem resilience and the contribution of biodiversity to carbon stocks through conservation and restoration

Insufficient data are available to assess progress towards Aichi Target 15, but plausible scenarios suggest poor progress owing to increasing demands for commodities, water and energy from demographic growth and affluence gains (IPBES, 2018: 7.2). Assessing progress towards Target 15 is challenging owing to lack of agreement on how to measure ecosystem resilience, absence of baseline data on land degradation (IPBES, 2018: 7.2, 4.1.4) and lack of standardized protocols for measuring and reporting soil erosion (García-Ruiz *et al*., 2015). Additionally, evaluations of the success of reforestation programs tend to focus on short-term establishment success indicators and fail to assess long-term growth, maturation success and socioeconomic indicators (Adams *et al*., 2016; Le *et al*., 2012). Regional assessments indicate that slow progress is being made towards Target 15 in West Asia, while there is no significant progress in Africa. In Europe, there is an international agreement on the inclusion of greenhouse gases and removals from land use, land use change and forestry in the 2030 climate and energy framework. All regions suffer from a lack of data for assessing progress (UNEP-WCMC, 2016a, 2016b, 2016c, 2016d).

Historical loss of soil organic carbon due to land cover and land use change is estimated between 50 and 176 Gt C, mainly from topsoil in croplands, and future scenarios project a loss of 65 Gt C up to 2050 (IPBES, 2018: 7.2.1). In the tropics, conversion of primary forest into other land cover/use has been shown to cause soil organic carbon losses of 30% for conversion to perennial crops, 25% for other cropland and 12% for grassland (Don *et al*., 2011). Soil erosion is a global problem (IPBES, 2018: 4.2), and agricultural land use tends to be associated with the highest erosion rates (García-Ruiz *et al*., 2015). Land degradation is also the main stressor affecting freshwater ecosystems and water security (Vörösmarty *et al*., 2010). Climate change-induced droughts and expansion of drylands exacerbates the risks of land degradation (IPBES, 2018: 4.2).

Although there is no comprehensive global map of degraded lands or restoration efforts, a global analysis of forest restoration opportunities indicated that two billion hectares of degraded land are available for forest restoration (Potapov *et al*., 2011) and current efforts for large-scale forest restoration have proposed a goal of 350 million hectares to be restored by 2030 (Chazdon & Uriarte, 2016). Potential areas for restoration include carbon-rich ecosystems such as tropical peatland forests (FAO & Wetlands International, 2012).

Aichi Target 16: Operationalizing the Nagoya Protocol on Access and Benefit-Sharing

Progress has been made in the implementation of the Nagoya Protocol, but the objectives of this target have only partially been met. The protocol has been in force and operational since 12 October 2014 and has received 107 ratifications as of June 2018. With respect to the second part of Target 16, many Parties are in the process of establishing a legal framework on access and benefit-sharing in order to make the Protocol operational at the national level. As of February 2018, 50-member state Parties have made information on national ABS measures available online and 52 have made the coordinates of a competent national authority for genetic resources available online (at the CBD Access and Benefit-Sharing Clearing-House; https://absch.cbd.int). Some Parties still lack the necessary capacity and financial resources to make the Protocol operational, although several capacity-building initiatives are underway to respond to these needs. Of the Parties that had ratified the Protocol by February 2018, 75 (71% of 105 Parties) and 30 non-Parties (28%) have adopted legislative, administrative and policy frameworks for the implementation of the Nagoya Protocol (an increase from 51 Parties and 29 non-Parties in 2016). At the international level, the agreed principles of access and benefit-sharing have been considered beneficial to protecting genetic resources and traditional knowledge from misappropriation, although at the local level there are challenges (Robinson & Forsyth, 2016; Rosendal & Andersen, 2016).

Aichi Target 17: Developing and implementing national biodiversity strategies and action plans

Moderate or good progress has been made towards development, adoption and implementation of National Biodiversity Strategies and Action Plans (NBSAPs). By March 2018, 190 of 196 Parties (97%) have developed NBSAPs, and 141 of these (74%) have revised them at least once (CBD, 2018a). The vast majority (92%) of NBSAPs submitted since the tenth Conference of the Parties have taken account of the Strategic Plan for Biodiversity (CBD 2018a). An analysis of the level of ambition set in national targets within the revised/updated NBSAPs developed by 154 countries in March 2018 found that the majority of national targets in the NBSAPs were similar or commensurate with the relevant global Aichi Target (CBD 2018a). One recent analysis found that the NBSAPs of 94 countries analyzed contained a total of 1,485 priority actions addressing the elements of Aichi Target 11 and 12, and these were assessed as having positive contributions for progress towards 15 other Aichi Biodiversity Targets (UNEP-WCMC & IUCN, 2016). The number of countries implementing NBSAPs is increasing, but several countries have not yet made progress in implementation (Marques *et al*., 2014). Further research is needed to develop indicators assessing the link between policies implemented and their outcomes (Bark and Crabot, 2016).

Aichi Target 18: Respecting and integrating traditional knowledge and customary sustainable use

Poor or moderate progress has been made towards integrating traditional knowledge and customary use into implementation of the Convention, despite IPLCs managing or having tenure rights over at least 38 million km^2 in 87 countries/territories on all inhabited continents (Garnett *et al*., 2018). Local studies indicate general declines in traditional knowledge (e.g., Hidayati *et al*., 2017); analysis of management and conservation by IPLCs is more easily conducted at the national level, and global assessments are lacking. There have also been recommendations for how traditional knowledge and the practices of IPLCs could be integrated better into relevant national legislation (e.g., Barpujari & Sarma, 2017) and international obligations, such as global patent systems (Amechi, 2015). While NBSAPs may include actions that respect and integrate traditional and local knowledge into implementation of the Convention, only 20% of 98 NBSAPs examined in 2016 mentioned customary sustainable use (CBD 2016a), and 34% of NBSAPS had no targets relating to Aichi Target 18 (CBD 2016b). Furthermore, participatory mechanisms are not fully operative yet, (for example, only 18% of Parties reported involvement of IPLCs in their NBSAPS in 2016; CBD 2016a), and there is often limited capacity to engage IPLCs meaningfully in policy decisions (Escott *et al*., 2015). Exceptions include some Arctic regions, where indigenous communities have a significant voice in policy decisions at local, national and international scales (Merculieff *et al*., 2017). Elsewhere, there is often still some resistance to the idea that conventional science can be complemented by local knowledge, despite examples showing that such an approach can help address environmental problems (Tengö *et al*., 2017). In countries where there is a strong legislative and policy framework surrounding Indigenous Peoples and community conserved territories and areas (ICCAs), they cover and conserve large areas. For example, in Namibia, where community-governed areas are formally recognised, ICCAs cover over 164,000 km^2 (UNEP-WCMC & IUCN, 2016). However, in some countries the lack of financial or human resources is hampering participatory approaches, while in others, support for community-based monitoring is limited its potential contribution is insufficiently recognised (Ferrari *et al*., 2015).

Aichi Target 19 Improving, sharing and applying knowledge of biodiversity

While knowledge, science and technologies relating to biodiversity have improved and been shared and applied, there has been poor or moderate progress towards Aichi Target 19. There has been substantial growth in knowledge on biodiversity and its dissemination (as illustrated by the numbers of scientific publications on biodiversity, relevant research funding, taxa assessed for the IUCN Red List, and species with data included in the Global Biodiversity Information Facility; **Table 3.3**), although this has often not translated into conservation actions (Geijzendorffer *et al*., 2017). Some aspects of biodiversity receive significantly more attention than previously but remain underrepresented; the total proportion of scientific articles relating to biodiversity that focus on invertebrates, genetic diversity, or aquatic systems is 50%–60% higher in 2011–2015 than it was before 2010 (Di Marco *et al*., 2017). However, greater attention is still given to areas or taxa less rich in biodiversity and threatened biodiversity, e.g., 40% of studies are carried out in USA, Australia or the UK, with only 10% in Africa and 6% in South-East Asia (Di Marco *et al*., 2017). A recent analysis quantified the funding required to maintain and expand key biodiversity and conservation knowledge products (Juffe-Bignoli *et al*., 2016a). Progress has been made in transfer of scientific knowledge and technologies from countries rich in resources to countries rich in biodiversity (Vanhove at al. 2017). However, the latter often have limited capacities for biodiversity monitoring, data gathering, and integration between science and policy, despite efforts of various initiatives (Schmeller *et al*., 2017) and notwithstanding the potential for IPLCs to contribute to monitoring (Zhao *et al*., 2016a). We lack sufficient information on the consequences of biodiversity loss for people, and appropriate indicators of the application of knowledge, science and technologies **(Table 3.3)**. However, it is likely that while the amount of biodiversity information is increasing, there has been less progress in the application of such information to inform decision-making (CBD 2016f), particularly by comparison with responses to tackle climate change (Legagneux *et al*., 2018; Veríssimo *et al*., 2014).

Aichi Target 20: Increasing financial resources for implementing the Strategic Plan for Biodiversity

While financial resources for implementing the Plan have increased, these are still insufficient for its effective implementation. The first report of the High-Level Panel on Global Assessment of Resources for implementing the Strategic Plan for Biodiversity 2011–2020 estimated that US$150–440 billion per year would be required to meet the Aichi Biodiversity Targets by 2020, depending on inter-linkages, policy coherence, institutional development, and synergies between targets and other goals (CBD 2016c). As inputs to this synthesis, McCarthy *et al*., (2012) estimated that US$3.41–4.76 billion would be needed per year to reduce the extinction risk of all known globally threatened species and hence contribute to one part of Aichi Target 12, but that only 12% of needs are currently funded for threatened birds, one of the better-funded groups. Similarly, these authors estimated that US$76.1 billion per year is needed to conserve areas of particular importance for biodiversity, but that funding needs to increase by at least an order of magnitude (McCarthy *et al*., 2012).

There has been significant growth in Official Development Assistance in support of the CBD and funding provided by the Global Environment Facility, but no significant increase in global funding committed to environmental policy, laws and regulations **(Table 3.3)**. While biodiversity aid flows have been boosted by concern about climate change (Donner *et al*., 2016) and have reached up to $8.7 billion annually (including projects for which biodiversity conservation is only a secondary objective; OECD, 2017), this falls far below the levels needed to support progress toward international conservation goals (Tittensor *et al*., 2014), including for protected areas and threatened species (McCarthy *et al*., 2012; UNEP-WCMC & IUCN, 2016). The countries that are least adequately funded are typically developing nations with high biodiversity and many threatened species. Furthermore, they are often neighbors, which affects taxa across their entire ranges, increasing the risk of extinction. This latter effect is of particular concern in the Malaysia–Indonesia–Australia region and in arid and semi-arid lands across Central Asia, Northern Africa, and the Middle East (Waldron *et al*., 2013).

3.2.2 Synthesis of progress globally

Overall, we have made good progress towards elements of four of the 20 Aichi Biodiversity Targets (9, 11, 16, 17) under the Strategic Plan on Biodiversity, and moderate progress towards some elements of another seven targets (1,2,7,13, 18, 19, 20), but for six targets (3, 4, 5, 8, 10, 12) we have made poor progress towards all elements, while we have insufficient information to assess progress for some or all elements of the remaining three targets (6, 14, 15; **Figure 3.6**). Of the 54 elements, we have made good progress towards five (9%), moderate progress towards 19 (35%) and poor progress or movement away from the target for 21 (39%). Progress is unknown for nine elements (17%) **(Figure 3.6)**. The strongest progress has been towards identifying/prioritizing invasive alien species (Target 9), conserving 10% of coastal/marine areas and 17% of terrestrial and inland water areas (Target 11), bringing the Nagoya Protocol into force (Target 16), and developing National Biodiversity Strategies and Action Plans (Target 17). While protected areas now cover 14.9% of the terrestrial realm, 17.2% of marine areas within national jurisdiction and 7.44% of the ocean (as of September 2018), and prospects are very high for exceeding the area thresholds (17% terrestrial and inland waters, 10% marine and coastal) providing country commitments are fulfilled **(Figure 3.3a)**, the global protected area network only partly covers the most important sites for biodiversity, and is not yet fully ecologically representative, effectively and equitably managed or adequately resourced. Furthermore, while some species have been brought back from the brink of extinction, achieving local successes towards Target 12 (preventing extinctions), for all taxonomic groups with known trends, overall, species are moving towards extinction at an increasing rate. Least progress has been made towards Target 10 (addressing drivers impacting coral reefs and other ecosystems vulnerable to climate change).

We have made more progress towards implementing policy responses and actions to conserve nature and use it more sustainably (22 of 34 indicators show significant increases) than has been achieved in addressing the drivers of biodiversity loss (9 of 13 indicators show significantly worsening trends). As a result, the state of nature overall continues to decline (12 of 16 indicators show significantly worsening trends) **(Figure 3.5)**. Indicators for the Targets under Goal B addressing anthropogenic drivers of biodiversity loss, including habitat loss (target 5), fisheries (6), agriculture, aquaculture and forestry (7), pollution (8) invasives (9) show that many of these drivers are increasing despite efforts to meet the Targets. Trends in the magnitude of Nature's Contributions to People (NCP) are less well known, but four of five indicators show significantly worsening trends. Trends in the magnitude of nature's contributions to people are less well known, but four of five indicators show significantly worsening trends **(Figure 3.5)**. Declines in the state of biodiversity suggest that any current positive trends for other benefits from nature are likely to be unsustainable. These patterns mirror those found by Tittensor *et al*., (2014), but the larger number of indicators, and the longer time series, strengthen these conclusions **(Figure 3.5)**. Only eight indicators showed different trends between this assessment and Tittensor *et al*. (2014). Three provided a more positive assessment in terms of progress towards targets (Ecological Footprint, Mean polar sea ice extent, Official development assistance provided in support of CBD objectives), while five provided

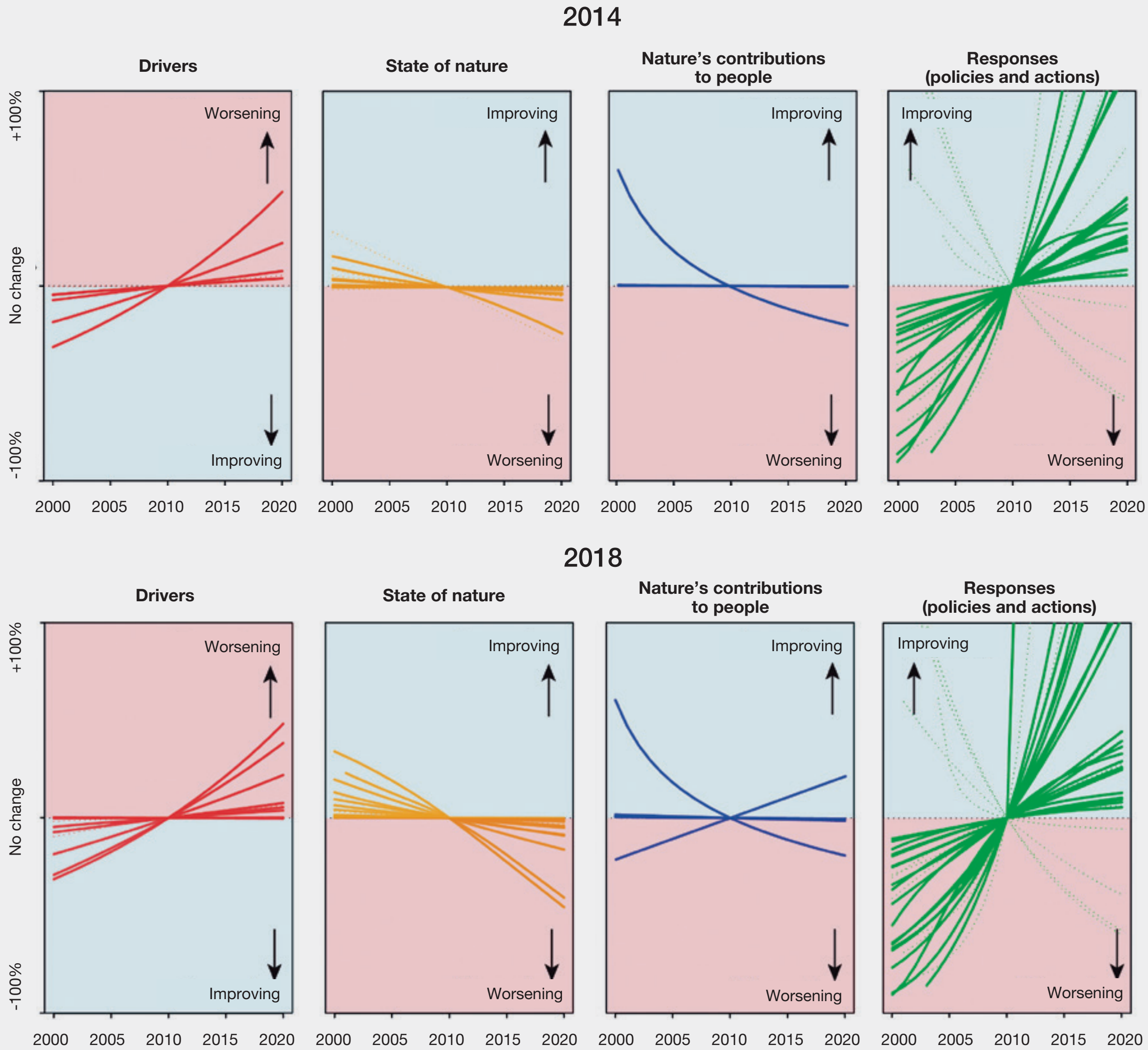


Figure 3 5 **Trends in indicators of drivers, the state of nature, nature's contributions to people, and responses (policies and actions of institutions and governance) across all Aichi Biodiversity Targets, as assessed in Tittensor *et al.* (2014), and for this assessment in 2018.**

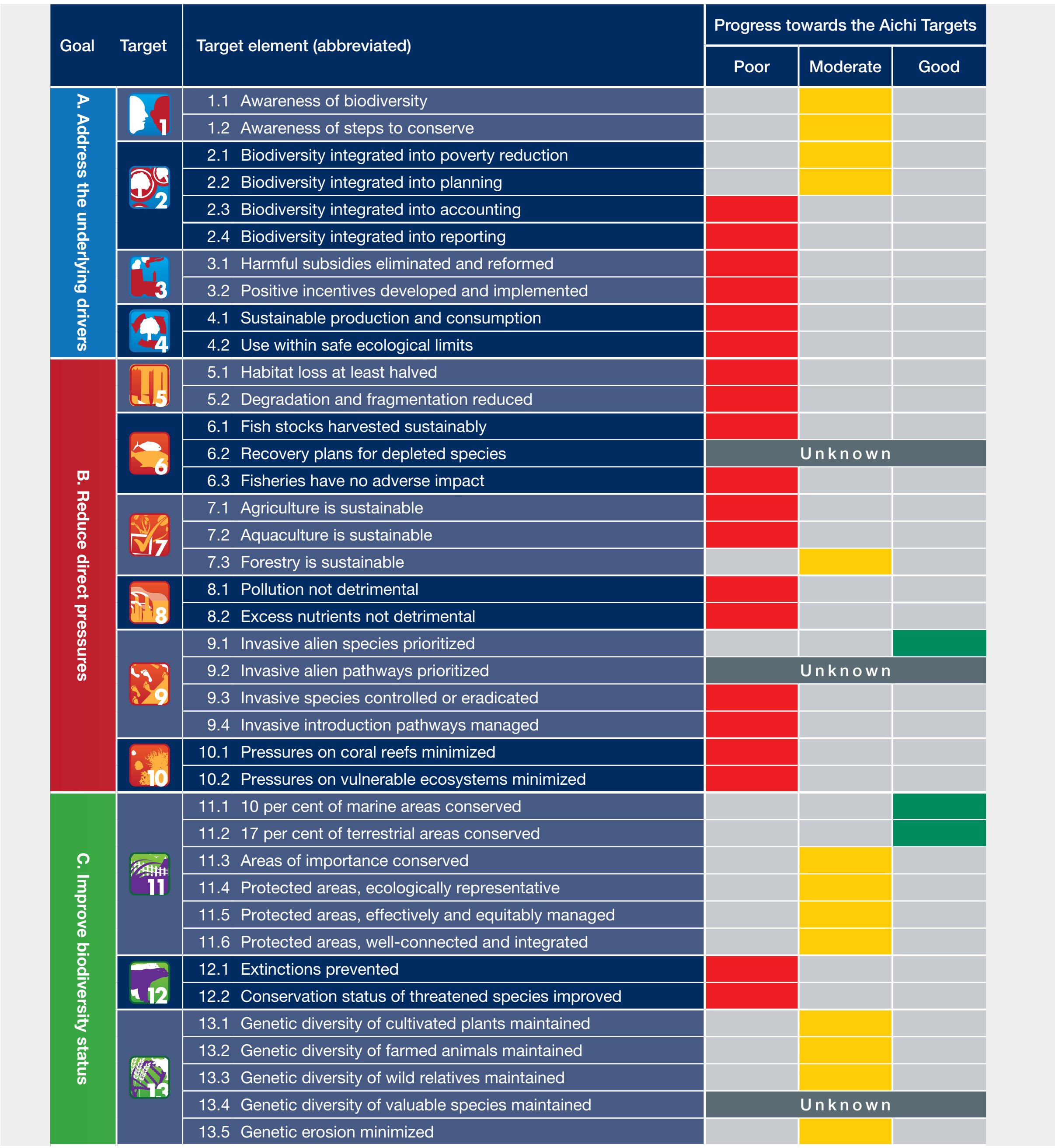
Lines represent significant (continuous) or nonsignificant (dotted) trends relative to 2010 modelled value (horizontal dotted black line). Indicators with very flat linear trends may be superimposed (e.g., two indicators of nature's contributions to people). An increase in indicators of the state of nature, nature's contributions to people, and responses, or a decrease in drivers, represents progress toward the targets. Some indicator trends (e.g., extinction rates) have been inverted to conform to this paradigm. Trends have been truncated before 2000 for visualization purposes.

a more negative assessment (World Trade Organization 'greenbox' agricultural subsidies, Percentage natural habitat extent, Wild Bird Index for habitat specialists, Pesticide use, Glacial mass balance). In almost all cases, the trends were identical but changed from significant to non-significant, or *vice versa*.

In most cases, there is insufficient information to quantify what the trends would have been in the absence of conservation action and policy responses to the Aichi Biodiversity Targets. Some evidence is available for some elements of some targets. For example, for Target 12, extinction risk trends shown by the Red List Index for birds and mammals would have been worse in the absence of conservation (Hoffmann *et al*., 2010), with at least six species of ungulate species likely to now be extinct or surviving only in captivity without conservation during 1996–2008 (Hoffmann *et al*., 2015). For Target 9, at least 107 highly threatened birds, mammals, and reptiles are estimated to have benefitted from invasive mammal eradications on islands (Jones *et al*., 2016). However, there are few other counterfactual studies assessing how trends in the state of nature or pressures upon it would have been different in the absence of conservation efforts.

We lack quantitative indicators suitable for extrapolation to judge progress towards some elements of 13 Aichi Biodiversity Targets, and over one third (19/54, 35%) of all elements across all Targets, meaning that assessment has to rely on more qualitative assessment of the literature. For Target 15 (ecosystem resilience and contribution of biodiversity to carbon stocks) the lack of both quantitative indicators and qualitative information means that no assessment of progress was possible **(Figure 3.6)**. Target 18 (integration of traditional knowledge and effective participation of indigenous and local communities) also lacked any indicators that were suitable for statistical extrapolation, while lack of both indicators and qualitative information precluded assessment of one element of each of Targets 6 (on sustainable fisheries) and 14 (on ecosystem services) **(Figure 3.6)**.

Our results mirror the pattern found by Tittensor *et al*. (2014) and the Global Biodiversity Outlook 4 (Secretariat of the CBD, 2014), but the larger sample of indicators (68 vs. 55) and updated time series of our analysis show an even clearer pattern of increasing drivers and responses, but declining trends in the state of nature and NCP **(Figure 3.5)**.



Goal	Target	Target element (abbreviated)	Progress towards the Aichi Targets: Poor	Moderate	Good
D. Enhance benefits to all	14	14.1 Ecosystems providing services restored and safeguarded	●		
		14.2 Taking account of women, IPLCs, and other groups	Unknown		
	15	15.1 Ecosystem resilience enhanced	Unknown		
		15.2 15 per cent of degraded ecosystems restored	Unknown		
	16	16.1 Nagoya Protocol in force			●
		16.2 Nagoya Protocol operational		●	
E. Enhance implementation	17	17.1 NBSAPs developed and updated			●
		17.2 NBSAPs adopted as policy instruments		●	
		17.3 NBSAPs implemented		●	
	18	18.1 ILK and customary use respected		●	
		18.2 ILK and customary use integrated	Unknown		
		18.3 IPLCs participate effectively	Unknown		
	19	19.1 Biodiversity science improved and shared		●	
		19.2 Biodiversity science applied	Unknown		
	20	20.1 Financial resources for Strategic Plan[a] increased		●	

Figure 3 6 **Summary of progress towards the Aichi Biodiversity Targets.**

Scores are based on quantitative analysis of indicators, a systematic review of the literature, fifth National Reports to the CBD, and available information on countries' stated intentions to implement additional actions by 2020. Progress towards target elements is scored as "Good" (substantial positive trends at a global scale relating to most aspects of the element), "Moderate" (the overall global trend is positive but insubstantial or insufficient, or there may be substantial positive trends for some aspects of the element but little or no progress for others, or the trends are positive in some geographic regions but not in others), "Poor" (little or no progress towards the element or movement away from it; while there may be local, national or case-specific successes and positive trends for some aspects, the overall global trend shows little or negative progress) or "Unknown" (insufficient information to score progress). IPLCs = Indigenous Peoples and Local Communities; NBSAPs = National Biodiversity Strategies and Action Plans; ILK = Indigenous and Local Knowledge. Numbers for target elements match those in **Table 3.3**.

3.2.3 Assessment of progress regionally and nationally

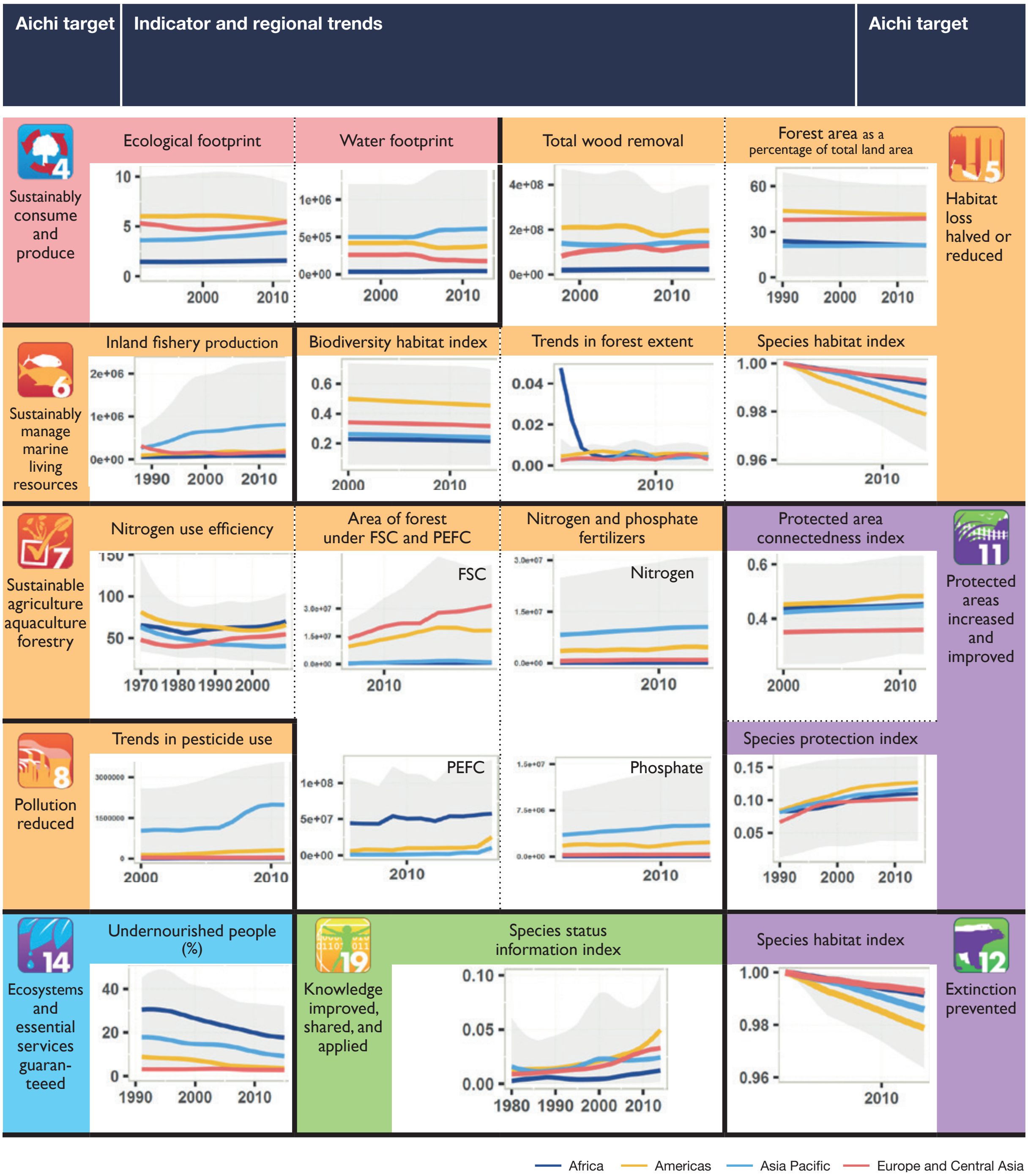
For a set of indicators addressing nine targets, observed trends for four different IPBES regions (Africa, Americas, Asia-Pacific and Europe and Central Asia) regions are shown in **Table 3.4**. For many indicators, regions differ in absolute level of progress, highlighting known historical and recent differences in the status of biodiversity and ecosystem services. Regional positions vary by target, and no region is consistently at the bottom or top. Regional differences in trends were more limited, which is not surprising given the relatively short time-frame analyzed. Notably differences existed for the Species Habitat Index where the Americas and Asia-Pacific saw a much greater deterioration and more limited progress to achieving Targets 5 and 11 than the other regions. Trends in Pesticide Use increased particularly strongly in Asia-Pacific, suggesting a potentially more limited progress to Target 8 there. As final example, the Americas stood out as making particularly strong progress toward closing biodiversity knowledge gaps (Target 19).

A separate analysis applied the methods used for **Table 3.3** and extrapolated trends to 2020 for each of the IPBES regions for six indicators for which data were available (Area of tree cover loss, Marine Stewardship Council certified fisheries, Marine trophic index, Pesticide use, Percentage of Key Biodiversity Areas covered by protected areas, and Species Status Information Index). Here, trends were similar across all regions, with the exception of Europe and Central Asia, in which trends were more positive. For example, it was the only region which experienced a significant increase in the Marine trophic index (other regions had significant or non-significant decreases), the only region with a decrease (albeit non-significant) in the area of tree cover loss, and the only region alongside Africa in which the increase in pesticide use was non-significant. However, overall there are too few quantitative results in **Tables S3.2** and **3.4** to draw robust conclusions about regional variation in progress towards the Aichi Biodiversity Targets. Qualitative information from a review of the literature also did not reveal strong and consistent regional differences in terms of progress towards the Aichi Biodiversity Targets.

The Aichi Biodiversity Targets are largely implemented nationally. Under the CBD, Parties develop NBSAPs to plan such implementation, and National Reports to document the outcomes. CBD (2016d) assessed the level of alignment of national targets set in revised/updated NBSAPs (available

Table 3 4 **Regional trends for selected indicators relevant to selected Aichi Biodiversity Targets.**

Graphs show the smoothed trend in average indicator values for each of the four IPBES regions (Africa: navy, Americas: gold, Europe and Central Asia: coral, Asia-Pacific: sky blue). Grey areas delineate the central 90% of variation among countries. Regional values account for the different sizes of countries, and lines characterize the trends of a region's average-sized country. The indicators shown are those considered by the IPBES indicators task group to be relevant to particular Aichi Biodiversity Targets, appropriate for weighting national values by country size, and for which trends are available for IPBES regions.



for 52% of Parties) to the global Aichi Biodiversity Targets, and progress towards achieving these described in the 5th National Reports (available for 90% of Parties). RSPB *et al*. (2016) synthesized the results by comparing average scores across targets **(Figure 3.7)** and found that only 10% of countries have set national targets that equal or exceed the global level of ambition, while c.40% of countries were less ambitious and 50% of countries have targets that are significantly lower in ambition. In particular, Target 2 (integrating biodiversity values into development,

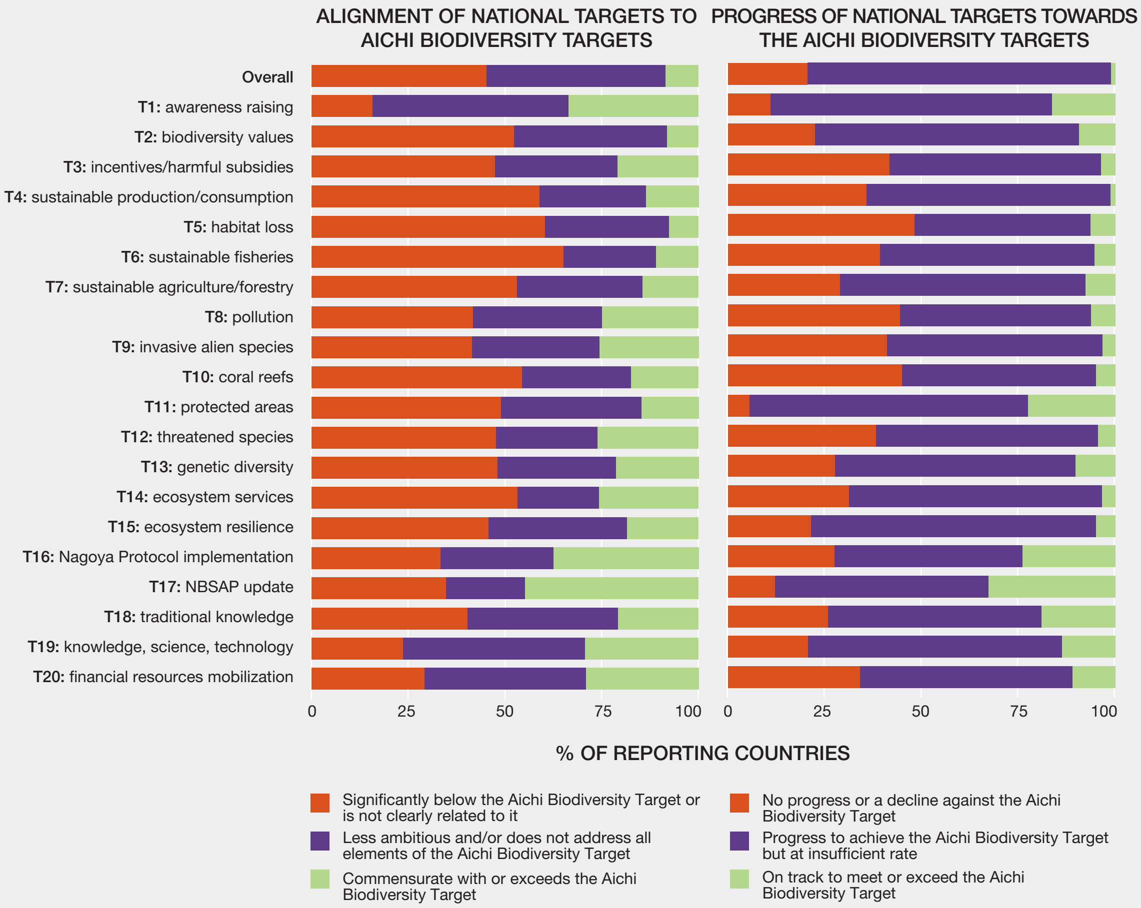


Figure 3 7 **Alignment of national targets (set in National Biodiversity Strategies and Action Plans) to the global Aichi Biodiversity Targets, and progress towards achieving them (described in 5th National Reports to the Convention on Biological Diversity).**

Source: RSPB *et al.* (2016) based on data in CBD (2016d).

poverty reduction and national accounting) and Targets 5 to 7 in Strategic Goal B (reducing direct pressures on biodiversity and promoting sustainable use) are those for which countries least ambitious. Targets 1 (awareness raising), 16 (implementation of the Nagoya Protocol), and 17 (development, adoption and implementation of NBSAPs) are those for which countries have been most ambitious compared with the global Targets (**Figure 3.7**; RSPB *et al*., 2016). An updated assessment by CBD (2018f) found similar results and concluded that the majority of national targets and/or commitments contained in NBSAPs were lower than the Aichi Biodiversity Targets or did not address all of the elements of the Aichi Target.

In relation to progress, only about 5% of countries' National Reports indicate that they are on track to meet the global targets, while 75% have made progress but insufficient to meet the global level of ambition by 2020. Of greatest concern, 20% of National Reports indicate that countries have made no progress or have moved away from the global targets. Countries report that their progress has been greatest towards Targets 1, 16 and 17, as noted above, but also Targets 11 (relating to protected areas) and 18 (on traditional knowledge and customary use of biological resources). Least progress is reported towards Target 4 (on sustainable production and consumption) and 9 (addressing invasive alien species). Underpinning these patterns, 34% of countries indicate no progress towards Target 20 (on resource mobilization), 55% have made insufficient progress, and only 11% are on track to meet or exceed the global level of ambition (**Figure 3.7**; CBD 2016d; RSPB *et al*., 2016). An updated assessment by CBD (2018f) found similar results and concluded that the majority of Parties have made insufficient progress to allow the Aichi Biodiversity Targets to be met by the deadline unless additional actions are taken, with proportion of Parties not on track to attain a given target ranging from 63% to 86%.

These results on national ambition and progress, which indicate that 95% of countries are behind schedule (CBD 2016d; RSPB *et al*., 2016) help to explain the global and regional patterns reported above.

3.2.4 The Aichi Biodiversity Targets and Indigenous Peoples and Local Communities

IPLCs are conducting many collective and on-the-ground actions that contribute to achieving the Aichi Biodiversity Targets and the SDG. The international Indigenous Forum on Biodiversity (IIFB), a platform for IPLC participation in the CBD, has published the Local Biodiversity Outlooks as a contribution to mid-term monitoring of the Strategic Plan for Biodiversity (Forest People's Programme *et al*., 2016). The report highlights the contributions of IPLCs and the challenges and opportunities for enhanced national implementation of these international commitments. It also highlights the importance of recognizing IPLCs as legitimate stakeholders and their knowledge system as valuable knowledge in achieving these goals in collaboration with other stakeholders (Sikor & Newell, 2014; Sikor *et al*., 2014; also see chapter 1).

Building upon the Local Biodiversity Outlook and based on systematic literature review, we review 1) the contribution of IPLCs' efforts to achieve the Aichi Biodiversity Targets, and 2) the significance of achieving each target to IPLCs. Detailed accounts for each Aichi Target are provided in the Supplementary Materials, section S3.3. We focus on the positive contributions that IPLCs make to achieve targets and goals but recognize that there are exceptions and note some in the text.

Aichi Target 1: Increasing awareness of biodiversity
IPLCs have played a crucial role in raising awareness of biodiversity diverse values from local to global scales (Athayde, 2017; Bali & Kofinas, 2014; Rathwell & Armitage, 2016; Singh *et al*., 2017). They have substantially contributed to initiate, maintain and strengthen initiatives (e.g., cultural events, written and audiovisual material) for communicating, educating and raising awareness about biodiversity (Horton, 2017; FPP *et al*., 2016; Janif *et al*., 2016; Veríssimo *et al*., 2018). Many of these actions have been orchestrated through IPLC organizations and networks, such as the International Indigenous Forum on Biodiversity (IIFB) and the Traditional Knowledge Information Portal (TKIP) of the CBD. IPLC-led awareness-raising campaigns often reveal conceptualizations of nature that differ substantially from Western epistemologies, promoting recognition towards the intrinsic values of nature, and acknowledging its spiritual dimension (e.g., Aniah & Yelfaanibe, 2016; Chen & Gilmore, 2015; Parotta & Trosper, 2012; also see chapter 1). IPLC narratives on the environment often build on philosophical concepts such as the mutual reciprocity between humans and nature (Kimmerer, 2011; Kohn, 2013; Nadasdy, 2007), webs of relationality and kin (Aiyadurai, 2016; Descola, 1996), lack of a nature-culture divide (Caillon *et al*., 2017; De La Cadena, 2010; Zent, 2013), promotion of relational approaches to nature (Comberti *et al*., 2015; Kopenawa & Albert, 2013), and powerful stewardship ethics (Dove, 2011; Gammage, 2011). Lack of awareness of biodiversity and its multiple values is one of the main drivers of the current conservation crisis (Balmford, 2002; Lindemann-Maties & Bose, 2008; Snaddon *et al*., 2008). There is well established evidence that many IPLCs currently face cultural and economic pressures that threaten their connections with the environment (Ford *et al*., 2010; Godoy *et al*., 2005; Luz *et al*., 2017; Reyes-García *et al*., 2014). Monetary valuation of biodiversity and NCP is increasingly emphasized in policy reports (Brander & van Beukering, 2013), whereas the intangible benefits of biodiversity continue to be largely overlooked (Boeraeve *et al*., 2015; Hausmann *et al*., 2016). Similarly, advertisement campaigns by pro-environmental NGOs have often used 'threatening' messages to raise biodiversity awareness (Weberling *et al*., 2011; Weinstein *et al*., 2015), failing to capitalize upon IPLCs cultural values and intrinsic motivation to conserve nature (Hazzah *et al*., 2014; García-Amado *et al*., 2013; van der Ploeg *et al*., 2011). Innovative art-based participatory methods are increasingly engaging IPLCs in biodiversity conservation (Bali & Kofinas, 2014; Heras & Tàbara, 2014, 2016). Education programs integrating ILK are also playing a significant role in promoting awareness of the multiple values of biodiversity amongst IPLCs (Hamlin, 2013; Mokuku, 2017; McCarter & Gavin 2011, 2014; Thomas *et al*., 2014). IPLCs are also engaging in ecotourism initiatives, the certification of local agricultural products, and initiatives to utilize forgotten traditional wild food plants (Łuczaj *et al*., 2012; Reyes-García *et al*., 2015), which help to raise awareness about biodiversity (Bluwstein, 2017; Espeso-Molinero *et al*., 2016; Mendoza-Ramos & Prideaux, 2017; Stronza & Gordillo, 2008).

Aichi Target 2: Integrating biodiversity values into development, poverty reduction, planning accounting and reporting
Despite numerous efforts from IPLCs in communicating ideas of environmental governance based upon reciprocity (Belfer *et al*., 2017; Raatikainen and Barron, 2017), little or no progress has been achieved in the inclusion of IPLCs biodiversity values into development or poverty reduction. For instance, although Standing Rock Sioux Tribe members have tried to communicate the importance of their territory in maintaining water flows and local biodiversity levels, priority has been given to the construction of an oil pipeline that crosses sacred lands (Raffensperger, 2014). In some cases, however, IPLCs biodiversity values have been mainstreamed into national development and conservation policies,

recognizing the rights of non-human actors and ecosystems (Haraway, 2016). Examples include the Ecuadorian and Bolivian Constitutions where Pachamama ('Mother Earth') has rights, and New Zealand's recognition of Te Urewa legal personhood. However, implementing such approaches in development and poverty reduction policies has proven difficult, as ecosystems do not have a voice in courtrooms when their existence is at risk (McNeill, 2017; Temper and Martinez-Alier, 2016), and IPLC's value systems are often simplified (Bidder *et al*., 2016; Griewald *et al*., 2017; Jacobs *et al*., 2016). For example, *Sumak Kawsay* is a Quechua term that means "living well". In recent years the term "*buen vivir"* has also been used by other actors with purposes that might differ from those originally intended by IPLCs (Perreault, 2017). A shift from top-down environmental policy to bottom-up inclusive socio-ecological policy requires: (i) the recognition of the importance of socially and historically contextualized scientific knowledge (Kolinjivadi *et al*., 2016; Pascual *et al*., 2017); (ii) the expansion of the value system related to biodiversity to include relational values along with utilitarian and non-utilitarian values in nature (Chan *et al*., 2006; Kosoy and Corbera, 2010); and (iii) the inclusion of non-human stakeholders as legitimate actors in social-ecological system (Culinam, 2011; Saito, 2017).

Aichi Target 3: Eliminating harmful incentives and developing and applying positive incentives for biodiversity conservation and sustainable use

Positive incentives to halt biodiversity loss, such as Reducing Emissions from Deforestation and Forest Degradation (REDD+) and Payments for Ecosystem Services (PES), can bring both opportunities and challenges for IPLCs (Aguilar-Stoen, 2017; Godden & Tehan, 2016; Larson *et al*., 2013; Loaiza *et al*., 2016). Positive incentives are more effective in halting biodiversity loss if they are grounded in the relative values people attach to environmental impacts (Babai *et al*., 2015; Baskaran *et al*., 2009) while integrating traditional management systems with scientific and institutional inputs (Chandrasekhar *et al*., 2007; Molnár *et al*., 2016; Riseth, 2007). Challenges to IPLCs from positive incentives include 'elite capture' (Calvet-Mir *et al*., 2015), increased income inequality, and motivational crowding out after economic incentives stop (Corbera, 2012). Including IPLCs in the design of positive incentives can help tackle these risks and increase the potential for securing multiple biodiversity values and contributing to community quality of life (Spiric *et al*., 2016). Perverse incentives (e.g., those awarded to extractive industries) or incentives that are not adapted to ecological and social contexts (e.g., decoupling payments from production) are not effective in reconciling conservation and development goals (Santos *et al*., 2015) and directly affect biodiversity and IPLCs (Abdollahzadeh *et al*., 2016; Acharya *et al*., 2015; Diaz *et al*., 2015; Ribeiro *et al*., 2014; Roder *et al*., 2008). Eliminating such perverse incentives is a priority from both a biodiversity and a human rights perspective (Vadi, 2011).

Aichi Target 4: Implementing plans for sustainable production and consumption

IPLCs offer many examples of how economies built on ILK can contribute to sustainable production and consumption (e.g., Cedamon *et al*., 2017; Cuthbert, 2010; Okia *et al*., 2017; Ouédraogo *et al*., 2017; Perfecto & Vandermeer, 2010; Tolley *et al*., 2015; Valente & Negrelle, 2013). IPLCs contribution to natural resources sustainable production includes water (Schnegg & Linke, 2016; Vos & Boelens, 2014), energy (Parker *et al*., 2016; Pilyasov, 2016), fisheries (Bravo-Olivas *et al*., 2014; Wiber *et al*., 2010) and ecosystems/environments (Kimmel *et al*., 2010; Rebelo *et al*., 2011) such as mountains (Gratzer & Keeton, 2017), pasture lands (Fernández-Giménez, 2000; Kis *et al*., 2017; Meuret & Provenza, 2014; Tessema *et al*., 2014), agricultural land (Barrios *et al*., 1994; Kahane *et al*., 2013; Schulz *et al*., 1994) and forests (Hajjar, 2015; Meyer & Miller, 2015). Some studies have demonstrated that such initiatives are within safe ecological limits (e.g., Bravo-Olivas, 2014 for coastal fisheries; Brown *et al*., 2011 and Faude *et al*., 2010 for forests; and Cuthbert, 2010 for hunting), but more research on the topic is needed. The examples provided by IPLCs are particularly relevant as the expansion of commodity production driven by unsustainable consumption and production patterns exerts direct pressures on IPLCs and their lands (Dell'Angelo *et al*., 2017; De Schutter, 2011; Moore, 2000; Orta & Finer, 2010), sometimes also changing their production and consumption patterns (e.g., Luz *et al*., 2017). Unsustainable production of natural resources has resulted in many conflicts involving IPLCs, including over biofuels (Amigun *et al*., 2011; Nesadurai, 2013; Pilcher, 2013; Sawyer, 2008), energy (Andre, 2012; Baumert *et al*., 2016), mining (Ncube-Phiri *et al*., 2015), industrial development (Pilyasov, 2016), agriculture (Kahane *et al*., 2013), water use (Vos & Boelens, 2014), forest management (Carter & Smith, 2017; Grivins, 2016; Ribot *et al*., 2010), marine resources (Rebelo *et al*., 2011; Thomson, 2009), sport hunting (Yasuda, 2011), and pastoralism (Yonas *et al*., 2013). The contributions of IPLCs to sustainable production and consumption are recognized mostly when the contribution of ILK systems is acknowledged (e.g., Bardsley & Wiseman, 2016; Kahane *et al*., 2013; Kumagai & Hanazaki, 2013; Lane, 2006; Queiroz, 2011).

Aichi Target 5: Reducing the loss, degradation and fragmentation of natural habitats

Many of the world's biodiversity-rich natural habitats overlap with IPLCs' lands and territories (Garnett *et al*., 2018; Maffi, 2005; Nietschmann, 1987; Sunderlin *et al*., 2005; Toledo, 2001). A growing body of literature provides evidence that IPLCs can contribute to forest conservation (Blackman *et al*., 2017; Ceddia *et al*., 2015; Nolte *et al*., 2013; Porter-Bolland *et al*., 2012), although there is less evidence for other terrestrial habitats (but see Busilacchi *et al*., 2013; Williams *et al*., 2008). IPLCs may contribute to forest conservation through customary practices such as sacred forests (Assefa & Hans-Rudolf, 2017; McPherson *et al*., 2016), taboos (Colding & Folke, 2001; Lingard *et al*., 2012), temporary restrictions (Camacho *et al*., 2012; Hammi *et al*., 2010; Khan *et al*., 2014), selective cutting or other small-scale disturbances (Rodenburg *et al*., 2012; Zent & Zent, 2004), and assisted natural regeneration (Camacho *et al*., 2012; also see chapter 2.2 section 2.2.4). As many IPLCs obtain their daily needs from the world's forests (Angelsen *et al*., 2014; TEEB, 2010), habitat loss and degradation often entail loss of subsistence and livelihood for IPLCs. Evidence also shows that policies devolving power to manage natural resources from governments to IPLCs and recognizing IPLCs' land rights may reduce rates of habitat loss (Ceddia & Zepharovich, 2017; Chen *et al*., 2012) and that integrating ILK into conservation initiatives can help to reduce biodiversity loss (Brooks *et al*., 2012).

Aichi Target 6: Managing and sustainably harvesting aquatic living resources

There are no global data on the extent of IPLC areas in the marine realm nor on how inclusion of IPLCs in MPA management affects fisheries. However, ILK has informed fisheries management in many contexts (e.g., McMillen *et al*., 2014; Thornton and Scheer, 2012), including mapping spawning grounds (Ames, 2004, 2007; Ames *et al*., 2000), understanding the structure, ecology and use of seascapes (Williams & Bax, 2003), assessing ecological and socio-economic sustainability of reef fisheries (Teh *et al.,* 2005), and documenting long-term reef fisheries trends (e.g., Daw *et al.,* 2011a; Teh *et al.,* 2007; Tesfamichael *et al.,* 2014). At the species level, fishers' ILK has been used to document long-term changes (Neis *et al.,* 1999; Spens, 2001), describe species' biology and environment (Camirand *et al.,* 2001), and assess species' cultural importance (Leeney & Poncelet, 2013). Studies drawing on IPLCs have also been instrumental in identifying marine fish species that are declining and/or at risk of extinction, and the implications for policy and management (e.g., Dulvy & Polunin, 2004; Lavides *et al.,* 2010, 2016; Maynou *et al.,* 2011; Sadovy & Cheung, 2003) and have helped to assess changes in fish diversity (e.g., Azzurro *et al.,* 2011; Castellanos-Galindo *et al.,* 2011; Saenz-Arroyo *et al.,* 2005a, 2005b). IPLCs have also supported recovery, conservation and sustainability of marine and freshwater fisheries and ecosystems around the world (Begossi, 1998; Berkes *et al.,* 2000; Hanna, 1998; UNDP, 2017). IPLCs have promoted the concept of "nature's rights" that has influenced policy at multiple levels (Burdon, 2012; Gordon, 2017; Mihnea, 2013; Sheehan, 2014). Many IPLCs are highly reliant on marine ecosystems, and especially fisheries, (Cisneros-Montemayor *et al*., 2016; Forest People's Programme, 2016), for which IPLCs are disproportionately affected by unsustainable fishing practices (Cabral & Alino, 2011). Management policies that have tried to address the issue include the UNDP-GEF Equator Initiative (UNDP, 2017) and the Ecotipping Points Project (http://ecotippingpoints.org/index.html).

Aichi Target 7: Managing agriculture, aquaculture and forestry sustainably

IPLCs are important natural resource users and managers and provide many examples of sustainable management systems (e.g., FAO's Globally Important Agricultural Heritage Systems; http://www.fao.org/giahs/en/, see also chapter 2.2 section 2.2.4). Traditional agriculture (Johns *et al*., 2013), aquaculture (Le Gouvello *et al*., 2017; Rose *et al*., 2016), and community forestry initiatives (Gbedomon *et al*., 2016) or other forms of forest conservation (Boadi *et al*., 2017; Negi, 2010) show promise for conserving local biodiversity. Locally controlled resources also provide economic opportunities while incorporating community values (Claire & Segger, 2015; Oldekop *et al*., 2016). With appropriate local oversight and resource use agreements, these practices can help conserve local biodiversity and generate sufficient resources to maintain livelihoods, particularly when in tandem with other sources of income (Barrios *et al*., 2018; Berkes and Davidson-Hunt, 2006; Gbedomon *et al*., 2016). However, IPLC management strategies respond to social and economic pressures, which often encourage unsustainable management of natural resources (Lawler & Bullock, 2017)***.*** Therefore, the sustainability of IPLCs' management practices should not be assumed but requires demonstration and regular monitoring (Montoya & Young, 2013). Economic and environmental policies that effectively promote simultaneous social well-being and conservation of biodiversity are still lacking for most IPLCs (Caillon *et al*., 2017). Interventions aimed at improving access to social services and economic institutions can have greater land-management impacts than those aimed at conservation or resource productivity alone (Bene & Friend, 2011). Effective multiscale governance is still needed to support sustainable economic and subsistence activities such as forestry, agriculture, and both fresh and marine aquaculture (Berkes *et al*., 2000; Forest Peoples Programme, 2011; Nelson & Chomitz, 2011; Ostrom, 1990; Porter-Bolland *et al*., 2012).

Aichi Target 8: Reducing pollution

IPLCs help to limit pollution through the maintenance of traditional agricultural practices with limited use of pesticides and fertilizers (Dublin & Tanaka, 2012; FPP *et al*., 2016). IPLCs' traditional management practices also include remediation techniques (e.g., phytoremediation) to restore landscapes affected by pollution (Pacheco *et al*., 2012; Sandlos & Keeling, 2016; Sistili *et al*., 2006) and contribute to pollution buffering and nutrient cycling (Ulrich *et al*., 2016; Vierros, 2017). Additionally, local observations and ILK often enable IPLCs to monitor, map and report the expansion of pollution, e.g., in water bodies (Bradford *et al*., 2017; Rosell-Melé *et al*., 2018; Sardarli, 2013). IPLCs are often disproportionally affected by the impacts of pollution, because they rely on their immediate environments (e.g., water streams, local resources) for meeting their direct livelihood needs (Nguyen *et al*., 2009; Orta-Martínez *et al*., 2017; Suk *et al*., 2004). Pollution not only directly affects the health and well-being of many IPLCs (Dudley *et al*., 2015; Gracey & King, 2009; Valera *et al*., 2011), but also their cultural integrity (Pufall *et al*., 2011; Tian *et al*., 2011). Exposure of IPLCs to pollution often comes through the consumption of traditional wild foods (Curren *et al*., 2014; Russell *et al*., 2015; Ullah *et al*., 2016). The pollutants to which IPLCs are most often exposed include heavy metals such as mercury (e.g., Lyver *et al*., 2017), lead (Udechukwu *et al*., 2015), arsenic (Sandlos & Keeling, 2016), and zinc (Ullah *et al*., 2016), as well as DDT (Reyes *et al*., 2015) and high levels of radiation (van Dam *et al*., 2002; Williams *et al*., 2017). Given this, IPLCs worldwide are engaging in community-based participatory monitoring of pollution and ecosystem health (Benyei *et al*., 2017; Deutsch *et al*., 2001; McOliver *et al*., 2015). There is well-established evidence of IPLCs' organized resistance against polluting activities, e.g., oil extraction (Orta-Martínez & Finer, 2010; Temper *et al*., 2015; Veltmeyer & Bowles, 2014), including litigation to hold polluters accountable (Benyei *et al*., 2017; Martínez-Alier *et al*., 2010, 2014, 2016; Petherick, 2011). However, the contributions of IPLCs to the prevention and reduction of pollution are seldom recognized. With few exceptions (e.g., Lyons, 2004; O'Faircheallaigh 2013), IPLCs remain largely unsupported in their legal battles against polluting corporations operating in IPLC territories (MacDonald 2015; Rodríguez Goyes *et al*., 2017). As such, they often face enormous challenges in receiving compensation for the impacts of pollution (Koh *et al*., 2017; Martínez-Alier, 2014).

Aichi Target 9: Preventing, control and eradicating invasive alien species

There are many examples of IPLCs' contributions to invasive alien species (IAS) management, control, monitoring and eradication (Bart, 2010; Bart & Simon, 2013; Fredrickson *et al*., 2006). The role of IPLCs in monitoring IAS has been documented in a range of ecosystems (e.g., (Jevon & Shackleton, 2015; Luizza *et al*., 2016; Santo *et al*., 2017; Schüttler *et al*., 2011; Sundaram *et al*., 2012; Uprety *et al*., 2012; Voggesser *et al*., 2013), including invasive fishes (e.g., Aigo & Ladio, 2016; Azzurro & Bariche, 2017) and crabs (e.g., Cosham *et al*., 2016) in marine environments, invasive plants in coastal wetlands (Bart, 2006), and invasive insects in North America (Costanza *et al*., 2017). IPLCs are directly affected by the spread of IAS through impacts on food production, water sources, time and resource loss, or damage to sacred areas (Duenn *et al*., 2017; Rai & Scarborough, 2015; Shackleton *et al*., 2007; Turbelin *et al*., 2017). However, IAS may also be integrated into IPLCs' subsistence strategies (Hall, 2009; Sato, 2013) and pharmacopeia (Philander, 2011; Srithi *et al*., 2017), given that IPLCs may not regard all IAS as 'weeds' or 'pests' (Trigger, 2008), with implications for IAS management practices (Bach & Larson, 2017), especially if IPLCs are involved in co-designing IAS-control experiments and management strategies (Ens *et al*., 2016a).

Aichi Target 10: Minimizing pressures on ecosystems vulnerable to climate change

There is clear evidence that IPLCs have contributed substantially to the management and conservation of areas particularly sensitive to climate change, such as the Arctic (Johnson *et al*., 2015), coastal wetlands, mangroves, and seagrass beds (Aburto-Oropeza *et al*., 2011; Moshy & Bryceson, 2016; Teixeira *et al*., 2013), especially when they contribute to the design of management plans (Vierros, 2017). Given that top-down marine protected areas management strategies have often excluded collaboration with IPLCs (Moshy & Bryceson, 2016; van Putten *et al*., 2016; Vaughan & Caldwell, 2015), co-management has emerged as an alternative bottom-up approach that may be beneficial for resource and landscape-seascape conservation (Aburto-Oropeza *et al*., 2011; Datt & Deb, 2017; Siregar *et al*., 2016; Vaughan & Caldwell, 2015). IPLCs have been foundational in recognizing and protecting the links between land and sea management in the coastal zones (Haggan *et al*., 2007; Johannes, 1992; Jupiter *et al*., 2014a). The preservation of the marine natural environment and ILK in coastal zones is essential for some IPLCs' food sovereignty and livelihood (e.g., Inuit Circumpolar Council, 2015; Kronen, 2004). IPLCs have developed particular forms of natural resource management that do not directly seek profit, but social and cultural compensation (Lauer & Aswani, 2009; Walters, 2004). However, increasing monetarization (e.g., through mass tourism on coral reefs or shrimp aquaculture in mangroves) can lead to the loss of sense of social value, with potential implications for ecosystem's health (Arias-González *et al*., 2017). Strenthening self-determination can contribute to improve natural resource management and food sovereignty (Inuit Circumpolar Council, 2015).

Aichi Target 11: Conserving terrestrial and marine areas through protected areas and other area-based measures

There is considerable overlap between global biodiversity hotspots and ancestral IPLCs' homelands (Garnett *et al*., 2018; Guèze *et al*., 2015; Kandzior, 2016; Porter-Bolland *et al*., 2012). Through traditional practices such as taboos, beliefs, or the establishment of sacred site guardians, IPLCs have facilitated the persistence of biodiversity important areas worldwide (Karst, 2017; Lopez-Maldonado & Berkes, 2017; McPherson *et al*., 2016; Samakov and Berkes, 2017). Moreover, IPLCs' biodiversity protection often combines multiple goals and purposes, with spatial and temporal management of species helping to maintain ecosystem function and resilience (Dominguez *et al*., 2010; Elmkvist *et al*., 2004; Ruiz-Mallen & Corbera, 2013). This has often led to the designation of protected areas within IPLCs' lands (Maraud & Guyot, 2016; Mueller *et al*., 2017; Shen *et al*., 2012; Stevens, 2014), often without obtaining the Free, Prior and Informed Consent of IPLCs (e.g., Hermann and Martin, 2016). Moreover, because biodiversity conservation is inherently spatial, displacement of IPLCs from their ancestral lands, restriction of resource access, and changing land use patterns have often been a consequence of conservation projects dominated by ideas to preserve 'wilderness' (Agrawal & Redford, 2009; Samakov & Berkes, 2017; Shultis & Heffner, 2016). This can lead to conflicts (Agrawal & Redford, 2009; Geisler, 2003; Lepetu *et al*., 2009). While c. 40% of protected areas lie on Indigenous Peoples' lands (Garnett *et al*., 2018), <1% of protected areas in the *World Database on Protected Areas* are reported to be governed by IPLCs (UNEP-WCMC & IUCN, 2016). While the percentage might be higher if other forms of protection were considered, it indicates the lack of recognition by governments of IPLCs in the formal system of protected areas. Expansion of protected areas may generate disproportionate costs to IPLCs (e.g., restricting access to hunting or grazing areas). For example, MPA expansion in the Arctic may threaten IPLCs' hunting, particularly if MPAs are planned without consultation. Some areas conserved by IPLCs, such as Indigenous Peoples' and community conserved areas (ICCAs) also contribute to conservation (see Borrini-Feyerabend *et al*., 2004) and therefore may qualify as 'Other effective area-based conservation measures' (OECMs; Jonas *et al*., 2017), although some ICCAs are treated by governments as protected areas, and hence excluded from the definition of OECMs (Jonas *et al*., 2017; UNEP-WCMC & IUCN, 2016). The contribution of ICCAs to biodiversity conservation globally has not been quantified, but the fact that they cover 20% of the total terrestrial surface (Kandzior, 2016) in a wide variety of habitats (Bhagwat & Rutte, 2006) signals their potential for contributing to ecosystem maintenance (Kothari *et al*., 2014). Moreover, safeguarding IPLCs' ownership of knowledge, respecting their laws and principles (Johnson *et al*., 2016), promoting customary management practices, and involving IPLCs as equal partners in research and monitoring may increase the effectiveness of protected areas (Brooks *et al*., 2012; Ens *et al*., 2016b; Holmes *et al*., 2016; Housty *et al*., 2014; Kandzior, 2016; Molnar *et al*., 2016; Moreaux *et al*., 2018).

Aichi Target 12: Preventing extinctions and improving the conservation status of species

The contributions of IPLCs to the conservation of threatened species includes controlling poaching (Lotter & Clark, 2014), reducing other sources of mortality (Gunn *et al*., 2010), maintaining sacred sites (Pungetti *et al*., 2012), food taboos (Colding & Folke, 2001; Jones *et al*., 2008; Pungetti *et al*., 2012), and traditional land management (Bird *et al*., 2013; Ashenafi *et al*., 2012). The number of threatened species conserved by IPLCs has not been quantified, but because IPLCs often live in areas of high biodiversity (Renwick *et al*., 2017; Sobrevila, 2008), they have the capacity to conserve disproportionately high numbers of threatened species (Beckford *et al*., 2010; Takeuchi *et al*., 2017). Culturally important threatened species conserved by IPLCs include salmon (Ween & Colombi, 2013), wolves (Ohlson *et al*., 2008), vicuñas (Arzamendia & Vila, 2014), polar bear and walrus (Meek *et al*., 2008). Such efforts may conflict with non-indigenous land owners and managers (Breslow, 2014; Findlay *et al*., 2009) and some IPLCs have to defend their rights to participate in threatened species conservation (Muir & Booth, 2012; Olive, 2012; Olive & Rabe, 2016), and the values they bring to that practice (Nadasdy, 2006). A recent assessment in Australia found that at least 59.5% of Australia's threatened species occur on Indigenous Peoples' lands (Leiper *et al*., 2018). Progress is also being made in conserving species that pose risks to humans and crops (Dolrenry *et al*., 2016; Larson *et al*., 2016; Rastogi *et al*., 2012). IPLC skills and knowledge can be used to help into threatened species' conservation (Attum *et al*., 2008; Dolrenry *et al*., 2016) and management (Gilchrist *et al*., 2005; McPherson *et al*., 2016; Vongraven *et al*., 2012). Threatened species are often culturally significant to IPLCs, and their decline impact IPLCs' diet, medicine, and other aspects (Chiropolos, 1994; Poufoun *et al*., 2016). For example, when India's vulture populations crashed (Prakash *et al*., 2003), the Parsee people were forced to develop new ways to dispose of the bodies of their dead (van Dooren, 2010). Successful recovery of threatened species may not only improve ecosystem conditions (Bottom *et al*., 2009), but also invigorate IPLCs' culture and economy (Coria & Calfucura, 2012; Hamilton *et al*., 2011; Humavindu & Stage, 2015; Yagi *et al*., 2010). However, not all cases of IPLCs' use of native species is sustainable, and some may negatively impact threatened species (e.g., Frith & Beehler, 1998; Mack & Wright, 1998).

Aichi Target 13: Maintaining the genetic diversity of cultivated plants, domesticated animals and wild relatives

It is well established that IPLCs have contributed to enhancing the genetic diversity of crops (Brush, 2000, 2004; Gepts *et al*., 2012) and domesticated animals (Yaro *et al*., 2017) through species domestication (Khoury *et al*., 2016), diffusion (Roullier *et al*., 2013) and management (Brush, 2000; Salick, 2012). IPLCs have also contributed to the in-situ conservation of such diversity (e.g., Galluzzi *et al*., 2010; Perrault-Archambault & Coomes, 2008; Thomas & Caillon, 2016; see also chapter 2.2 section 2.2.4). IPLCs have developed strategies to minimize genetic erosion through local systems that promote seed maintenance and flow (through market and non-market seeds exchanges) (Calvet-Mir & Salpeteur, 2016; Nazarea, 2006; Thomas & Caillon, 2016). Although initiatives that value IPLCs' contributions to *in situ* conservation of genetic diversity can be found worldwide (e.g., Graddy, 2013; Wilkes, 2007), IPLCs' ability to contribute further to safeguard genetic diversity is limited by the loss of knowledge, migration to cities, undervaluation of local management practices by some agricultural extension programs (Jacobi *et al*., 2017), legislation adverse to the rights to save and exchange seeds (Deibel, 2013), and the introduction of improved mass propagation methods (Jaradat, 2016) and hybrid or genetically modified seeds (e.g., (Shewayrga *et al*., 2008). *In situ* conservation and use of crop genetic resources is of prime importance for IPLCs' food security (Johns & Eyzaguirre, 2006), as it allows long-term access to locally adapted seed and planting material (Finetto, 2010; Maxted *et al*., 2002). Traditional breeds of grazing livestock (and related traditional practices) are key for managing some high biodiversity grasslands in protected areas (Kis *et al*., 2017).

Aichi Target 14: Restoring and safeguarding ecosystems that provide essential services

IPLCs have a key role in restoring and safeguarding the world's ecosystems. While not all the lands managed by IPLCs are intact, multiple examples from around the world show that, when carefully implemented with close involvement from well-organized communities, devolving control of resource management to IPLCs can produce better outcomes for conservation and ecosystem service provision than private management, and in some cases, even than strict protected areas (Bray *et al*., 2008; Chhatre & Agrawal, 2009; Paudyal *et al*., 2017; Persha *et al*., 2011; Poteete & Ostrom, 2004). IPLCs have also played an active role in restoring ecosystems to produce ecosystem services essential to human well-being (Anderson & Barbour, 2003; FAO 2015b, Hansson, 2001; Madrigal Cordero *et al*., 2012; Wilson and Rhemtulla, 2016; Wilson *et al*., 2017). IPLCs can increase the effectiveness of ecosystem restoration activities (Senos *et al*., 2006; Uprety *et al*., 2012) because they know the land and can directly benefit from restoration activities (Babai & Molnár, 2014; Schaffer, 2010; Wangpakapattanawong *et al*., 2010). For example, in the Maradi and Zinder Regions of Niger, local communities 're-greened' over five million hectares of land through farmer-managed natural regeneration, which helped reverse desertification and produced other services important for farming (Reij & Garrity, 2016; Sendzimir *et al*., 2011). Moreover, modern restoration activities increasingly involve ILPCs and make use of ILK (Marsden-Smedley & Kirkpatrick, 2000; Middleton, 2001; NOAA, 2017; Senos *et al*., 2006; Shebitz, 2005; Storm & Shebitz, 2006). Lack of progress towards this target has had serious implications for IPLCs, as they are often relatively reliant on shared or communal natural resources, such as forests (Almeida, 1996; Angelsen *et al*., 2014; Godoy *et al*., 2000). Thus, loss of access to or degradation of natural resources have a disproportionately negative effect on IPLCs (Seaman *et al*., 2014), often resulting in migration to urban areas (e.g., Alexiades & Peluso, 2015). As they often lack formal land rights, IPLCs may receive little formal recognition for environmental goods and services produced on their lands and may be unable to access specialized markets (Ollerer *et al*., 2017; Oxfam *et al*., 2016; RRI, 2015). Furthermore, remote or impoverished conditions, weak governance structures, or a lack of representation can all limit participation in programs to compensate producers of local ecosystem services (Bark *et al*., 2015; Benjamin & Blum, 2015; Zbinden and Lee, 2005).

Aichi Target 15: Enhancing ecosystem resilience and the contribution of biodiversity to carbon stocks through conservation and restoration

Through their natural resource management systems, IPLCs have contributed to conservation of carbon stocks and strengthened ecosystem resilience (FPP *et al*., 2016; Mijatović *et al*., 2012; Nakashima *et al*., 2012; Uprety *et al*., 2012; Wangpakapattanawong *et al*., 2010; see also chapter 2.2 section 2.2.4). This is because IPLCs' land management regimes tend to have lower deforestation rates than surrounding areas, thus avoiding carbon emissions and preserving other NCP (Paneque-Gálvez *et al*., 2013; RAISG, 2016; Ricketts *et al*., 2010; Schleicher *et al*., 2017; Vergara-Asenjo & Potvin, 2014). IPLCs' lands in the Amazon Basin, Mesoamerica, the Democratic Republic of Congo and Indonesia contain over 20% of the above-ground carbon in all the world's tropical forests (Walker *et al*., 2014). ILK-based land management practices are effective at enhancing carbon sequestration, preventing environmental degradation and combatting desertification (e.g., Cheng *et al*., 2011; Chirwa *et al*., 2017; Salick *et al*., 2014; Seid *et al*., 2016; Singh *et al*., 2014; Wangpakapattanawong *et al*., 2010). IPLCs' practices of soil carbon enrichment are well recognized in Amazonia (Glaser, 2007; Junqueira *et al*., 2010, 2016; Lehmann *et al*., 2003). Similarly, IPLC fire management regimes contribute substantially to greenhouse gas abatement and ecosystem resilience (Shaffer, 2010; Welch *et al*., 2013; Wilman, 2015). There is also well-established evidence of the crucial role that IPLCs play in ecological restoration efforts that help build social-ecological resilience (Egan *et al*., 2011; Kimmerer, 2000; Lyver *et al*., 2016; Storm *et al*., 2006; Wehi & Lord, 2017), although the percentage of restoration efforts globally that are currently led by or involve IPLCs is unknown. Engagement of IPLCs in community forestry has been shown to be a useful model for restoration of degraded forests (Maikhuri *et al*., 1997; Paudyal *et al*., 2015), while co-management has shown mixed success in other ecosystems (der Knaap, 2013; Hill & Coomes, 2004). IPLCs are key participants in several large-scale forest restoration efforts, particularly in Asia (Bennett, 2008; Clement *et al*., 2009; He & Lang, 2015; McElwee, 2009; Yan-qiong *et al*., 2003).

Safeguarding ecosystem resilience is critical to promote IPLCs' quality of life (Caillon *et al*., 2017; Kingsley & Thomas, 2017; Sangha *et al*., 2015; Sterling *et al*., 2017). The failure to restore degraded ecosystems in areas inhabited by IPLCs threatens their cultural well-being, undermining access to important NCP (Adger *et al*., 2005; Aronson *et al*., 2016; FPP *et al*., 2016; Golden *et al*., 2016). Where ecological restoration is participatory and attuned to local socioeconomic benefits, IPLCs gain increased access to NCP and conflicts are reduced (Baker, 2017; Gobster

& Barro, 2000; Shackelford *et al*., 2013; Wortley *et al*., 2013). Recognizing the customary institutions of IPLCs is a critical means for connecting IPLCs with policies promoting ecosystem restoration and carbon compensation schemes (Buntaine *et al*., 2015; Larson *et al*., 2013; Sunderlin *et al*., 2014). Specifically, land titles to forest can provide access to incentive programs that pay for the maintenance of forest cover (Duchelle *et al*., 2014b; Larson, 2010; Turnhout *et al*., 2017; van Dam, 2011). Overall, property rights, land availability, social organization and political networks constitute key factors for IPLCs in accessing and benefiting from carbon offsets (Boyd *et al*., 2007; Corbera & Brown, 2010; Kerr *et al*., 2006; Osborne, 2011). Current carbon forest standards have shown moderate success in protecting IPLC rights (De La Fuente & Hajjar, 2013; Larson, 2011; McDermott *et al*., 2012; Roe *et al*., 2013). Because many carbon compensation schemes intersect with IPLC sociocultural values, active involvement of IPLCs in policy design has been found to be essential for success, particularly in building partnerships and avoiding value conflicts (Davenport *et al*., 2010; Fox *et al*., 2017; Lawlor *et al*., 2010; Lyver *et al*., 2016; Richardson & Lefroy, 2016; Rose *et al*., 2016).

Aichi Target 16: Operationalizing the Nagoya Protocol on Access and Benefit-Sharing

IPLCs have contributed to the establishment of research protocols and procedures (e.g., Consortium of European Taxonomic Facilities, 2015) and they have played an important role in negotiating the Nagoya Protocol on Access and Benefit-Sharing (GEF, 2015a; Teran, 2016). The potential effects of the protocol have been assessed (Atanasov *et al*., 2015; Burton & Evans-Illige, 2014; Nijar *et al*., 2017; Rose *et al*., 2012; Welch *et al*., 2013), and a number of countries are supporting capacity-building efforts to develop community protocols to facilitate the development of Access and Benefit-Sharing arrangements with potential users of traditional knowledge associated with genetic resources (Pauchard, 2017). However, IPLCs' contributions to bring the protocol in force in national legislation are poorly documented (Robinson & Forsyth, 2015; Sanbar, 2015). The implementation of the Nagoya Protocol and the broader participation of IPLCs in research and resource management have also contributed to a shift in research practice that has been recognized at institutional (Balick, 2016), national (Bendix *et al*., 2013), and international levels (Bussmann, 2013; Bussmann & Sharon, 2014). Such a shift involves a growing recognition of IPLCs' rights to fully informed prior consent, participation in research at all levels, including authorship, and right to benefit from commercial use of research results.

Aichi Target 17: Developing and implementing national biodiversity strategies and action plans

There is clear consensus that inclusion of ILK may enhance NBSAPs (Ayesegul and Jones-Walters, 2011; Armatas *et al*., 2016; Gadamus *et al*., 2015; Sutherland *et al*., 2013; Tengö *et al*., 2014), yet these inputs are still scarce. For example, in a review of the conservation literature, Brook and McLachlan (2008) found that only about 0.4% of conservation plans included ILK. Less than half of countries reported ecological, management, regulatory or policy information on the importance of ILK and practices in the management of wild populations and near-natural ecosystems (see also FPP *et al*., 2016). In addition, only 20 CBD Parties reported the involvement of IPLCs in their NBSAPs (18%), indicating that few Parties have developed adequate participatory approaches (Adenle *et al*., 2015). Barriers to ILK inclusion into conservation plans include bridging epistemological differences between knowledge systems (Löfmarck and Lidskog, 2017), low academic recognition of ILK (Farwig *et al*., 2017), and issues of scale and power (Beck *et al*., 2017). The impact of achieving this target on IPLCs is largely dependent on land management arrangements: where the land is co-managed and ILK is incorporated into management plans, IPLCs are often positively impacted and conservation efforts are greatly improved (Berkes, 2018; Berkes *et al*., 1995; Borrini-Feyerabend *et al*., 2004; Gadgil *et al*., 2000; Rozzi *et al*., 2006). Unfortunately, the engagement of IPLCs in NBSAPs is not yet receiving sufficient attention. The extent to which IPLCs are recognized, valued, and benefit from contributing to the target is difficult to assess (Marques *et al*., 2016). The retroactive inclusion of IPLCs into an existing biodiversity plan can highlight inequities and instances where the plans have been detrimental to IPLCs (Galbraith *et al*., 2017). Conversely, the recognition of the value of ILK and the inclusion of IPLCs in the formulation of management plans can greatly benefit them (Chen & Nakamura, 2016; Shimada, 2015).

Aichi Target 18: Respecting and integrating traditional knowledge and customary sustainable use

Consideration of ILK relevance for conservation has increased since the 1980s, driven by research highlighting the potential value of ILK for sustainable resource use and biodiversity conservation (Berkes *et al*., 2000; Brokensha *et al*., 1981; Warent *et al*., 1995), the trans-nationalization of the indigenous rights movement (Benyei *et al*., 2017; Reyes-Garcia, 2015), and the realization that biological and cultural erosion could be intertwined (Maffi, 2005; Zent, 2009a; Zent & Zent, 2007). The importance of integrating ILK into biodiversity conservation efforts was first acknowledged at the 1992 CBD Conference of the Parties (Reyes-García, 2015) and has grown since then (e.g., Apostolopoulou *et al*., 2012; Cheveau *et al*., 2008; Daniels *et al*., 1993; Ferroni *et al*., 2015; Hernandez-Morcillo *et al*., 2014; Marie *et al*., 2009; Sekhar, 2004; Sibanda & Omwega, 1996; Vaz & Agama, 2013). Integrating ILK into conservation efforts in a participatory way can not only improve the local acceptance of conservation initiatives (Andrade & Rhodes, 2012; Carpenter, 1998; Grainger, 2003), but also benefit IPLCs by adding value to ILK, raising local awareness of this value, and therefore mitigating ILK erosion, strengthening IPLCs' collective action capacity, land/resource rights, health, religious freedom, self-determination, intangible heritage protection, and control over how ILK is used (Baral & Stern, 2010; Chitakira *et al*., 2012; Cil & Jones-Walters, 2011; Reyes-Garcia, 2015). Integrating ILK into conservation initiatives has been achieved through a variety of top-down approaches (e.g., Integrated Conservation-Development Projects and Participatory Monitoring Projects; Berkes, 2007; Danielsen *et al*., 2000; Hanks, 2003; Joseph, 1997; Ruiz-Mallén & Corbera, 2013; Sanjayan *et al*., 1997), with researchers and IPLCs contesting the real "participatory" nature of some of these approaches (e.g., Dressler *et al*., 2010; Khadka & Nepal, 2010; Sterling *et al*., 2017) and the real benefits for IPLCs and for conservation itself (Büscher *et al*., 2017; Nadasdy, 1999a; West, 2006). IPLCs have also led conservation and ILK revitalization initiatives, such as establishing Indigenous and Community Conserved Areas (ICCAs), maintaining sacred natural sites, language and cultural documentation, or community-based mapping (Alexander *et al*., 2016; Berdej & Armitage, 2016; Brooks *et al*., 2013; Gavin *et al*., 2015; Kothari *et al*., 2013; Nelson, 2008; Nilsson *et al*., 2016; Zent *et al*., 2016). Through these initiatives, IPLCs, in alliance with advocacy groups, have enhanced their role as environmental managers and transformed their local disputes into international claims, thus increasing pressure to be included in environmental policy for a (Hodgson, 2002) and propelling a growing recognition of ILK in environmental negotiations (Nasiritousi *et al*., 2016; Schroeder, 2010; Tengö *et al*., 2014; Wallbott, 2014). Despite these moves, IPLCs typically continue to remain politically marginalized parties in their own countries and even more so on the global stage (Corson, 2012), and are often dependant on opportunities provided by policymakers or project-designers for participation (Harada, 2003).

Aichi Target 19: Improving, sharing and applying knowledge of biodiversity

There is increasing technological cross-fertilization involving IPLCs' biodiversity-sustaining technology and knowledge being adopted and adapted to wider use and vice versa (Berkes *et al*., 2000; Jasmine *et al*., 2016; Lynch *et al*., 2010; Varga *et al*., 2017). Recent examples of technology and knowledge sharing include the use of drones (Paneque-Galvez *et al*., 2017), community mapping (Assumma & Ventura, 2014; Heckenberg, 2016) and counter-mapping (McLain *et al*., 2017), cloud computing (Valencia Perez *et al*., 2015) and other information and communication technology applications for local biodiversity conservation (Bazilchuk, 2008; Coleman, 2015), such as citizen science and knowledge network initiatives (Bortolotto *et al*., 2017; Wyndham *et al*., 2016) and projects to return control over biodiversity to heritage owners (Bolhassan *et al*., 2014; Cairney *et al*., 2017; Thompson, 1999). IPLCs' education systems and traditional institutions for knowledge transfer are also beginning to be valued in conservation research and policy (Kawharu *et al*., 2017; Walsh *et al*., 2013; Wuryaningrat *et al*., 2017), as is the value of diversity in knowledge systems, including gender (Fillmore *et al*., 2014; Wirf *et al*., 2008), age-class (Bayne *et al*., 2015), and intra- (Saynes-Vasquez *et al*., 2016) and inter-cultural diversity (Reyes-García *et al*., 2016a). The literature on IPLCs and biodiversity knowledge shows that ideology (Gorman & Vemuri, 2012; Oviedo & Puschkarsky, 2012), social organization (Elands *et al*., 2015), cultural/spiritual values (Daye & Healey, 2015; Oleson *et al*., 2015; Thondhlana & Shackleton, 2015), politics (Wartmann *et al*., 2016), local language, subsistence practices (Zent 2009b, Zhao *et al*., 2016a), and ontology (Clarke, 2016) play a significant part in structuring local ecological relations. IPLCs are particularly vulnerable to lack of progress towards Aichi 19 in that their economies and identities are often inextricably connected to local landscapes and waterscapes (Fox *et al*., 2017) and they have been historically disadvantaged in terms of information access and equal participation in decision-making (Smith, 1999; Turner *et al*., 2008). Decolonization in curricula, museums, and libraries are steps towards reducing historical power-information imbalances (Ladio & Molares, 2013; Pulla, 2017; Zolotareva, 2015). Recognizing and valuing ILK systems, biodiversity conservation practices, and transparent information and power-sharing can strengthen sustainable local food production systems (Kamal *et al*., 2015; Turner & Turner, 2007; Turreira *et al*., 2015), secure land tenure, health and well-being (Catarino *et al*., 2016; Lah *et al*., 2015; Phondani *et al*., 2013), and ecological resilience (do Vale *et al*., 2007; Leonard *et al*., 2013), thus contributing to recognize Indigenous Peoples' rights to self-determination. The valuation of biodiversity in an ecosystem services paradigm is beginning to include more local cultural values (Afentina *et al*., 2017; Sangha & Russell-Smith, 2017) and identify problems created for IPLCs (Preece *et al*., 2016). Involvement of IPLCs in environmental impact assessments (Nakamura, 2008), species management (Gichuki & Terer, 2001; Housty *et al*., 2014) and land management (Flood and McAvoy 2007; Harmsworth *et al*., 2016; LaFlamme 2007; Molnar *et al*., 2016) are increasingly standard practice.

Aichi Target 20: Increasing financial resources for implementing the Strategic Plan for Biodiversity

It is difficult for IPLCs to access the financial mechanisms established to support actions towards achieving the Aichi Biodiversity Targets (FPP *et al*., 2016). The Global Environment Facility (GEF) has supported 160 full- and medium-size projects involving IPLCs (FPP *et al*., 2016). However, despite an overall positive trend (CBD, 2016e), in 2015 only about 15% of the GEF Small Grants Programme (GEF-SGP), a scheme which specifically enables GEF to partner with IPLCs (GEF, 2015b), involved IPLCs. Of the US$4.2 billion that were disbursed by the GEF between 1991 and 2014, only US$228 million have been financed to IPLCs (CBD, 2016e). The contribution of IPLCs' collective action towards achieving the Aichi Biodiversity Targets is included in the Strategy for Resource Mobilization (CBD, 2012b). Furthermore, a methodology for measuring the contribution of IPLCs' collective action has been developed (CBD, 2014a), offering tools to assess contributions both quantitatively (e.g., impact on environmental change rates, extent, direction) and qualitatively (e.g., impact of formal and informal rules regarding resource use and management; CBD, 2014b). Local initiatives are often highly cost-effective while their outcomes often meet multiple policy objectives, including community development, biodiversity conservation and cultural well-being (CBD 2014b).

3.3 IMPACTS OF TRENDS IN NATURE ON PROGRESS TOWARDS THE SUSTAINABLE DEVELOPMENT GOALS

3.3.1 Introduction to an integrated assessment approach

In order to assess how trends in nature and NCP affect our ability to achieve the SDGs, and how SDG achievement impacts on nature and NCP, we developed an integrated approach that takes into account the complex relationships between nature and the SDGs, as well as limitations in the current articulation of SDG targets. Despite overwhelming evidence of the linkages between nature, NCP and development, the current focus and wording of most SDG targets obscures or omits their relationship to nature or NCP. For example, the role of nature in targets for SDGs 1, 3, 8 and 9 is largely absent or the SDG targets are too narrowly defined for proper consideration of the roles of

Table 3 5 **Clusters used to guide the assessment of SDG progress linked to nature and NCP.**

Clusters are based on the nature of the relationships and feedbacks between SDGs, nature and NCP. The names of each cluster are drawn from the IPBES conceptual framework to illustrate the focus of the SDGs in each cluster. Clusters also differed in terms of the level of assessment possible (goal vs. target) due to current target formulations and available data and were subjected to different types of approaches in the assessment.

Cluster	SDGs	Assessment approach	Targets assessed
Nature	6 CLEAN WATER AND SANITATION; 13 CLIMATE ACTION; 14 LIFE BELOW WATER; 15 LIFE ON LAND	Target-level assessment using indicators and evidence of trends in nature	1.1; 1.2; 1.4; 1.5; 2.1; 2.3; 2.4; 2.5 3.2; 3.3; 3.4; 3.9 11.4; 11.5; 11.6; 11.7
Nature's contribution to people (NCP)	1 NO POVERTY; 2 ZERO HUNGER; 3 GOOD HEALTH AND WELL-BEING; 11 SUSTAINABLE CITIES AND COMMUNITIES	Target-level assessment presenting evidence of links between nature, NCP and targets, and assessing trends in relevant NCP using indicators and evidence	6.3; 6.4; 6.5; 6.6 13.1; 13.2; 13.3; 13.A; 13.B 14.1-14.7 15.1-15.9; 15.A; 15.B
Good quality of life (GQL)	4 QUALITY EDUCATION; 5 GENDER EQUALITY; 10 REDUCED INEQUALITIES; 16 PEACE, JUSTICE AND STRONG INSTITUTIONS	Goal-level assessment presenting evidence of links between nature, NCP and goal	
Drivers of change in nature and NCP	7 AFFORDABLE AND CLEAN ENERGY; 8 DECENT WORK AND ECONOMIC GROWTH; 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Goal-level assessment presenting evidence of links between nature, NCP and goal	

nature and NCP (Pérez & Schultz, 2015). In an attempt to address these gaps, we used a clustering approach to SDG progress assessment, focusing on SDGs for which detailed target-level assessment of trends is possible because there are targets that directly link to aspects of nature or NCP (Cluster 1, 2; **Table 3.5**). For SDGs with targets that do not explicitly recognize the links with nature and NCP, we limit our assessment to a synthesis of the evidence of these links at a goal in order to suggest directions for future assessments (Clusters 3, 4; **Table 3.5**).

These clusters are further differentiated to acknowledge the many different relationships between nature and the SDGs (Guerry *et al*., 2015). We identified clusters of: goals with direct positive linkages between nature and SDGs (Cluster 1; Nature); goals with complex (direct, indirect, positive and negative) relationships and feedbacks between NCP and SDGs (Clusters 2; NCP), goals with some evidence of complex linkages with nature and NCP, but for which current knowledge and focus or wording of SDG targets prevents trend assessment (Cluster 3; GQL); and goals for which meeting SDG targets may have potential positive or negative feedbacks on nature and NCP (Clusters 4; Drivers). The cluster methodology is described below together with the assessment approach adopted for each cluster **(Table 3.5)**.

Cluster 1: Nature: SDGs for which there is a direct and positive relationship between nature and our ability to meet SDG targets: Goal 14 (Life below water), Goal 15 (Life on land) and aspects of Goal 6 (Clean water and sanitation). These goals focus on conserving and/or the sustainable use of nature and natural resources (or NCP) in various ecosystems. Goal 13 (Climate action), while not specifically mentioning nature, includes specific targets for combating climate change and its impacts, which have clear positive synergies with nature. In this cluster, there is a direct and typically fairly simple positive relationship, allowing us to assess trends in nature and its contributions to people relevant to these targets through the use of existing indicators, data and literature reviews. We assess all targets in Goals 14 and 15, and those targets with direct links to nature for Goals 6 and 13 **(Table 3.5)**. For each of these targets, we assess progress towards achieving them based on extrapolations to 2030 for relevant indicators, including those in the SDG Indicators Global Database (https://unstats.un.org/sdgs/indicators/database/) as well as other relevant indicators **(Table 3.7)**.

Cluster 2: NCP: SDGs for which there are complex linkages between nature, and its various contributions (material, non-material and regulating) to these SDGs targets. These relationships can be both positive and negative, thereby supporting or undermining SDG target achievement. Furthermore, we recognise that in addition to nature, anthropogenic factors including infrastructure, tenure, skills, technology, are essential to the achievement of these goals. Diaz *et al*. emphasises the co-produced nature of NCP and GQL which is key to achieving the goals in this cluster: Goal 1 (No poverty), Goal 2 (Zero hunger); Goal 3 (Good health and well-being) and Goal 11 (Sustainable cities and communities). This can make understanding and interpreting the effects of trends in nature on these goals and their achievement difficult. We therefore follow a two-phase approach to the assessment of trends in this cluster by first assessing current evidence and knowledge on the features and processes in nature relevant to these targets, and then assessing trends to targets in Goals, 1, 2, 3 and 11, in which clear links to aspects of NCP are present in current expressions of targets. Where available, we examine trends in key indicators for these SDGs (drawing on those used for assessment of progress towards the Aichi Biodiversity Targets in section 3.2). Several targets were omitted because their wording or focus does not provide clear links to NCP. We also note that approaches to achieving these SDGs will have substantial implications for nature and NCP. These impacts could be positive or negative depending on the approach used and will involve feedbacks across scales and time. We highlight evidence of these impacts where possible in our assessment.

Cluster 3: GQL: SDGs associated with GQL that feature goal-level but often complex relationships between the goal and nature. Knowledge about these linkages is currently weak but growing and will be key for future assessments and iterations of these targets. Goal 4 (Quality education), Goal 5 (Gender equality), Goal 10 (Reduce inequalities) and Goal 16 (Peace and justice) do not currently have targets that clearly link to elements of nature or NCP. We therefore do not conduct a detailed assessment of these SDGs in this chapter, but rather conduct a goal-level assessment of the evidence on aspects of nature relevant to these goals

Cluster 4: Drivers: SDGs for which the way we aim to meet the goal will have important implications for nature and NCP. Goal 7 (Affordable and clean energy) Goal 8 (Decent work and economic growth) and Goal 9 (Industry, innovation and infrastructure) in the past have had large negative impacts on nature, NCP and GQL for certain people and places. Goal 12 (Responsible consumption and production) holds particular relevance for future trends of nature and NCP. The outcomes of these goals will be nuanced by positive and negative feedbacks between SDGs operating over space and time. Some paths to achieving a given SDG may have negative implications for other SDGs, while others may have positive impacts. Similarly, certain approaches to achieving SDGs may have positive outcomes in some regions and negative outcomes in others. Further research is needed on how particular approaches to each SDG will influence nature and its contributions to people, and how this is likely to vary in different locations. Chapter 5 explores these pathways and outcomes in more detail. Here we focus on a goal-level assessment, due to a lack of clear linkages with current targets. Where relevant, we also suggest consulting chapter 2 for more details on these drivers of change and their trends.

Based on the clustering approach, we assessed trends in nature and NCP relevant to 44 SDG targets that have clear and well-evidenced linkages to nature and NCP. The SDGs are relatively new (Sustainable Development Platform, 2014), so determining the appropriate indicators for assessing how the status and trends of nature and NCP affect and will be affected by achieving those goals is still a major research effort, as is the indicator development for assessing progress to SDGs at national and global levels. In addition, local priorities or values may differ from the globally chosen indicators. Several goals have indicators identified, but global data are largely incomplete or not available to determine the status and trends in nature and NCP in meeting them. For several targets, the official SDG indicators do not adequately capture the role of nature and NCP in achieving targets. We made use of other available global indicators where possible, and complemented indicator-based assessments with literature reviews to assess the current evidence.

Below we present the findings for selected targets per goal under Clusters 1 and 2 and provide goal-level assessments for Clusters 3 and 4. We summarise the results in **Figure 3.13**.

3.3.2 Assessment findings

3.3.2.1 Cluster 1: Nature (Goals 6, 13, 14, 15)

SDG 6. Clean water and sanitation

The relationship of N and NCP with SDG 6 is direct as well as being synergistic. Achieving SDG 6 will improve water quality and quantity, thus directly benefiting many aspects of N and NCP. Likewise, natural or semi-natural freshwater ecosystems offer valuable contributions towards achieving SDG 6. Over half of global river discharge and the aquatic habitat it supports is under moderate to high threat (Vorosmarty *et al*. 2010). This is driven by deterioration of water quality and over-abstraction of water resources, which severely impact the ability of freshwater ecosystems to regulate water flows, purify water and prevent erosion. In addition, achievement of targets under SDG6 directly affect targets under SDGs 1-3, 11, 14, and 15.

Target 6.3: By 2030, improve water quality by reducing pollution, eliminating, dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

Water pollution has continued to worsen over the last two decades (UNEP 2016a) and is expected to escalate in the future (IFPRI & Veolia, 2015), causing increased threats to freshwater ecosystems, human health and sustainable development. Trends in three commonly measured pollution indicators are discussed below.

Untreated wastewater pollution is a key driver of deteriorating water quality (WWAP, 2017). On average, high-income countries treat about 70% of the municipal and industrial wastewater they generate. The proportion drops to 38% in upper middle-income countries and 28% in lower middle-income countries. In low-income countries, only 8% undergoes treatment of any kind (Sato *et al*., 2013). These figures explain the often-cited estimate that over 80% of wastewater globally is released to the environment without adequate treatment (WWAP, 2012). This is also supported by combined data and model-driven approaches that show substantial increases in the fecal coliform bacteria loadings in Latin America, Africa and Asia over the last two decades, with an estimated average 80% increase across these three continents (UNEP, 2016a). Although sanitation coverage has increased, and treatment levels have improved in some countries (UNICEF, 2014), the efforts being made have not been sufficient to reduce fecal coliform loadings in surface waters.

Organic pollution in the water is often measured using biochemical oxygen demand (BOD), nitrogen (N) and phosphorus (P) loads. BOD estimates the amount of dissolved oxygen required by microorganisms in the water to break down organic material. High BOD loads reduce dissolved oxygen levels in the river, and negatively impact freshwater fisheries and aquatic ecosystems integrity. High N and P loads can indicate organic pollution levels that risk eutrophication. Eutrophication is the addition of enough nutrients to an ecosystem to cause certain plant species such as algae to proliferate, which can lead to fish deaths because algae deplete the water of oxygen. This can lead to economic hardship for those people depending on inland fisheries and other nature and its contributions to people. Since the 1990s, organic water pollution has increased in over 50% of rivers in South America, Africa and Asia, driven largely by poor wastewater treatment (WWAP, 2017). Some positive trends are evidenced in developed regions, such as steady decline in organic pollution loads in Europe (1992–2012) (EEA, 2015), but positive trends are offset by rapid water quality degradation in developing countries, with an estimated 10–50% increase in the global average nutrient load by 2050 (IFPRI & Veolia, 2015). Increased global BOD, N, and P loads is projected for 2050 under even the most conservative of human use and climate change scenarios (IFPRI & Veolia, 2015). By 2050, an estimated one fifth of the global population will face risks from eutrophication, and one third will be exposed to water with excessive nitrogen and phosphorous (WWAP, 2017). Countries that rely on their inland fisheries as an important food source will be particularly impacted by increasing level of organic pollution.

Salinity pollution occurs when the concentration of dissolved salts and other dissolved substances in rivers and lakes is high enough to interfere with the use of these waters. In freshwaters, salinity is commonly defined and measured as the mass of "total dissolved solids" (TDS). Important human sources of salinity stem from irrigation return flows, domestic wastewater and runoff from mines. Salinity pollution can obstruct water supply for irrigation and has wide-ranging negative impacts on aquatic ecosystems (Cañedo-Argüelles *et al*., 2013). TDS concentrations have increased in 31% of the river stretches assessed in South America, Africa and Asia (UNEP, 2016a).

Improving water quality through natural ecosystems is a key ecosystem service that can be used by nations and municipalities as they plan for the use of both grey (built infrastructure such as water treatment plants) and green infrastructure (natural infrastructure such as riparian vegetation) to provide high-quality water and reduce untreated wastewater. Wetlands and other habitats can act as important biofilters for water moving through landscapes**.** Slowing the movement of water can allow pollutants and other hazardous materials to settle out, bind to sediment and decompose before entering water supply systems. Pollutants such as agricultural nutrients, pesticides, herbicides and heavy metals from mining can be reduced by landscape planning and engineering to retain and decompose pollution through riparian buffers, wetlands, aquifers and soil health (Brauman, 2015). However, there are natural limits to the assimilative capacity of ecosystems, beyond which they are threatened and can no longer perform this purifying role. Once the concentration of pollutants in runoff reaches critical thresholds, there is a risk of abrupt and irreversible environmental change (Steffen *et al*., 2015).

Target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

Global water withdrawal from dam infrastructure doubled between 1960 and 2000, with smaller increases after the 1980s in Europe and North America, and more substantial increases (>100%) for Africa, Central, West, and South Asia, Western USA, Mexico, and Central South America (Chao *et al*., 2008; Wada *et al*., 2011). Groundwater abstraction rate has at least tripled over the past 50 years and continues to increase at an annual rate of 1–2% (WWAP, 2012). There is widespread agreement that these levels of withdrawal of surface water and groundwater are unsustainable and will have ripple effects on the sustainability of irrigation for food production (Gleick, 2010; MacDonald, 2010; Vörösmarty *et al*., 2010; Wada *et al*., 2010). This trend is supported by Wada *et al*. (2014), who assessed global water use for 1960–2010 and 2011–2099, using the Blue Water Sustainability Index ((BlWSI), which incorporates both non-renewable groundwater use and non-sustainable water use that compromises environmental flow requirements. Their results reveal that ~30% of the present human water consumption is supplied from non-sustainable water resources, and this is projected to increase to ~40% by 2100.

These unsustainable water withdrawals are even more challenging in the light of water scarcity. Nearly 80% of world human population is exposed to high-level threats to water scarcity, while two thirds live under conditions of severe water scarcity at least one month per year, mostly in India and China. Half a billion people face severe water scarcity year-round (Mekonnen and Hoeskstra, 2016). Water-use efficiency improvements are therefore considered essential to address the projected 40% gap between water supply and demand, and to mitigate water scarcities by 2030 (UNEP, 2011d).

Agriculture accounts for c. 70% of total freshwater withdrawals globally and for over 90% in the majority of Least Developed Countries (FAO, 2011). Without improved efficiency measures, agricultural water consumption is expected to increase by about 20% globally by 2050 (WWAP, 2012). Given these trends, improving water-use efficiency in agriculture is a critical priority. Protecting water and using it more efficiently will be essential for sustainability of food production. Globally there is high variance in water use efficiency both within and between climatic zones (Brauman *et al*., 2013). Poor infrastructure and irrigation practices also dramatically contribute to water use inefficiencies in agricultural production. For example, leaks can create puddles and breeding grounds for disease carrying species (e.g, *Anophelese* mosquitoes, which can have health impacts relevant to targets under SDG3).

Brauman *et al*. (2013) calculated that raising crop water productivity in precipitation-limited regions to the 20th percentile of productivity would increase annual production on rainfed cropland by enough to provide food for an estimated 110 million people, and water consumption on irrigated cropland would be reduced enough to meet the annual domestic water demands of nearly 1.4 billion people. Currently, significant investments and advancements are being made in crop breeding for higher water use efficiencies (e.g., CGIAR's Seeds4Needs program), as well as shifts in crop planting patterns to track local climate (e.g., Crimmins *et al*., 2011; Kelly & Goulden, 2008; linking to SDG 2.4). Better matching crops to available water and precipitation patterns can help to reduce demand and diversion for irrigation with the co-benefit of diversifying human nutrition (e.g., SDG 2.1) and promoting local associated biodiversity if crop species are native (e.g., SDG 15.1).

Water scarcity emerges from a combination of hydrological variability, high human use, climate change and desertification, and may in part be mitigated by storage infrastructure (UNESCO, 2016). Increasingly, an environmental flow requirement is also factored into calculations of water scarcity to account for sustainability of the withdrawals (Wada *et al*., 2014). This is an important conservation and sustainability measure for nature and NCP.

Target 6.5: By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.

Water is not confined within political borders. An estimated 148 states have international basins within their territory (WWAP, 2012), and 21 countries lie entirely within them (WWAP, 2012). In addition, about 2 billion people worldwide depend on groundwater supplies, (ISARM, 2009; Puri & Aureli, 2009), which include 263 transboundary river basins and approximately 300 transboundary aquifers (UNECE, 2015). There is a growing attention to resolving the increasing competition for water between ecosystems and socioeconomic sectors, enabling progress towards better-integrated water management and more sustainable development. However, around two thirds of the world's transboundary rivers do not currently have a cooperative management framework (Samuelson *et al*., 2015). In 2012, UNEP found that 64% of countries had developed integrated water resources management plans and 34% were in an advanced stage of implementation. However, progress appears to have slowed in countries with low and medium Human Development Index (HDI) values since 2008 (UNEP, 2012).

Target 6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

Protecting and restoring freshwater ecosystems presents unique challenges due to their interconnected nature. For example, although there are approximately 2300 Ramsar Wetlands of International Importance, upstream unprotected areas often impact on the health of the downstream Ramsar Sites. The development of indicators measuring protection of water-related ecosystems should account for how this connectivity impacts on the health of protected water-related ecosystems. The Ramsar Convention, therefore, measures trends in the protection of water-related ecosystems, not only in terms of spatial extent, but also in terms of the quantity and quality of water in ecosystems, and the resulting ecosystem health (Dickens *et al*., 2017).

Although progress has been made in expanding protected area extent, shortfalls remain in coverage of areas of importance for freshwater biodiversity, ecological representation, connectivity, management effectiveness and equity (Juffe-Bignoli *et al*., 2016b). On average, only 44% of each freshwater Key Biodiversity Area is covered by protected area (**Figure 3.3b**; BirdLife International *et al*., 2018). Protection of source watersheds and their associated water supply also requires further attention. Approximately one third of the global population, living in 4000 of the world's largest cities, depend on source watersheds for their water supply, and this is projected to increase to two thirds of the population by 2050 (Abell *et al*., 2017). Forty per cent of these urban watersheds show high to moderate levels of land degradation. It is estimated that protection and restoration of mountain, forest and mixed-use lands in these urban watersheds could significantly reduce the sediment or nutrient potential for 81% of the cities studied.

Evidence suggests that many freshwater ecosystems are imperiled. Key threats to water-related ecosystems are changes to water source (land cover change), timing (flow regime), quantity (overextraction), and quality (pollution). Habitats representing 65% of continental discharge are classified as moderately to highly threatened (Vörösmarty *et al*., 2010). Approximately 46% of large rivers are affected by dams and their associated reservoirs (Lehner *et al*., 2011). In addition, freshwater species across a range of vertebrate and decapod groups are at greater threat of extinction than those in terrestrial ecosystems (Collen *et al*., 2014).

SDG 13: Climate action

Ongoing anthropogenic processes are altering the atmosphere and climate system, with forecasted increases in global average temperatures of around 1°C by 2050 and potentially 5ºC by 2100) (IPCC, 2015). The intensified hydrological cycle associated with these temperature increases includes altered precipitation patterns, amplifying droughts and flood events. Global sea-level rise is occurring and expected to increase by 20–40 cm by 2050 and 50–80 cm (or more) by 2100, increasing the exposure and vulnerability of human populations and settlements (Bedsworth & Hanak, 2010; Ketabchi *et al*., 2016) especially in the developing world (Thornton *et al*., 2014).

Conservation and sustainable use of nature and NCP depends to a great extent on progress to SDG 13, and at the same time could support progress to it. Progress toward attainment of SDG target 13.1 may be accelerated or undermined by policies laid out in SDG target 13.2. Climate change will increase tensions between the often conflicting goals of economic development and nature and NCP management (Bedsworth & Hanak, 2010). The achievement of several other SDGs depends, in part, on progress the achievement of SDG 13 targets.

Target 13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.

Progress toward attainment of SGD Target 13.1, focused on resilience and adaptive capacity, has been made in terms of general awareness and acceptance on the need for action, but limited progress in terms of coherent action, despite the extensive geographical exposure to hazards. However, it is difficult to assess mobilization and response levels beyond general characterizations at the regional level, given a lack of comprehensive reporting over time through the existing frameworks. Most analyses of climate change impacts and climate adaptation and mitigation published to date have focused on issues related to ecosystems, economies, public health, and resource management, with far less attention to issues related to disaster resilience, energy security, food security, and poverty (Deng *et al*., 2017). Most of these analyses conducted have been global in scope, and do not consider local level impacts (Deng *et al*., 2017).

By contrast, the "sustainable adaptation" (SA) approach seeks to promote development while also addressing underlying drivers of vulnerability (Eriksen and O'Brien, 2007). Social and environmental sustainability criteria have been incorporated into climate-oriented development approaches identified by various names (e.g., climate compatible development, climate-proofing, climate-resilient development, climate-smart development).

To lessen the likelihood and severity of climate-driven disasters, one SA approach that has been gaining widespread use is 'ecosystem-based approaches for adaptation' (EbA) which seeks social, environmental, and economic benefits beyond the scope of technical, engineering-based approaches planned and implemented at the local level (Bourne *et al*., 2016; Doswald *et al*., 2014; Munroe *et al*., 2012). EbA adoption efforts have been underway in various locations around the world, with examples including climate change-oriented forestry practices, dryland practices relating to farming and livestock management, and floodplain/wetlands conservation and restoration (Bourne *et al*., 2016; Iacob *et al*., 2014; Kroll *et al*., 2016; Pramova *et al*., 2012).

EbA is a set of management actions to improve the adaptation of a human-natural system. One outcome is to map systematically the production and distribution of ecosystem services to better understand the underlying bases of NCP and GQL that are by extension integral to resilience and adaptive capacity (Naidoo *et al*., 2008). This requires a better understanding of adaptive practices (Sietz & van Dijk, 2015; Sietz *et al*., 2017). Further analysis is needed to establish linkages between the biophysical provision of NCP and the socially constructed values of GQL, and how those in turn connect with resilience and adaptive capacity. This perspective fits with calls for a more "holistic ecological all-hazard inter-disciplinary risk management and capacity-building model" (Buergelt & Paton, 2014: 591).

Efforts to boost resilience and adaptive capacity advocated for this target may benefit from addressing the root causes of vulnerability at the regional and societal levels, where the degree of vulnerability is a function of adaptive capacity, exposure, and sensitivity (Sietz *et al*., 2017; Kok *et al*., 2016). Analyses at different scales can provide a more differentiated discussion of opportunities for sustainable intensification at a regional scale (Sietz *et al*., 2017).

Target 13.2: Integrate climate change measures into national policies, strategies, and planning.

Major progress towards integrating climate change measures into national policies, strategies and planning was made with the adoption of the Paris Agreement, which entered into force in 2016. As of February 2018, 174 Parties have ratified, approved, accepted, or acceded to the Agreement out of 197 Parties to the Convention. Parties develop independent Nationally Determined Contributions (NDCs) to lower their emissions. These national-level climate action and emissions-reduction contributions are prepared to reflect Parties' unique circumstances, including economic and environmental differences. NDCs or action taken to achieve NDCs include "nature-based solutions" based on sustainable management and conservation of carbon-storing terrestrial (e.g., forests and peatlands) and coastal ecosystems (e.g., mangroves, salt marshes and seagrass).

As of February 2018, only six of the top 50 countries by forest area had not ratified the Paris Agreement (Lee & Sanz, 2017). Of these, Russia has the largest forest extent (522 million hectares) (Lee & Sanz, 2017). The top three countries that have not yet ratified that have the largest CO_2 emissions associated with net forest change are Tanzania, Myanmar, and Venezuela (Lee & Sanz, 2017). The ratification, approval, acceptance, or accession of the Paris Agreement by the majority of countries represents initial progress. The majority of Parties included forests, agriculture, or other ecosystems in the mitigation components of their NDCs. Parties also indicated that they will take action to enhance adaptation in these ecosystems. NDCs do not have to specify how a country intends to meet its contributions or what specific measures it will take, including with respect to ecosystem-based actions. However, NDCs can be key in motivating countries to develop terrestrial ecosystem management and conservation strategies. Similarly, coastal ecosystems – salt marshes, seagrasses, and mangroves – have been shown to be major carbon sinks or "blue carbon", with some demonstrating higher areal carbon sequestration potential than terrestrial forests (Herr & Landis, 2016; Howard *et al*., 2017). More than 150 countries have at least one major blue carbon ecosystem. As of 2016, 28 countries specifically referenced coastal wetlands in their NDCs and 59 countries included coastal ecosystems in their adaptation strategies (Herr & Landis, 2016).

Significant challenges remain for creating greater transparency with respect to how some Parties intend to achieve their NDCs. In particular, greater detail should be provided on accounting approaches for the land sectors of NDCs, including forest-related emissions and removals, harvested wood products, and the treatment of natural disturbances within NDCs (Lee and Sanz, 2017).

Target 13.3: Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.

Climate change and its associated risks continue to be challenging to communicate to the general public. Similarly, human and institutional capacity to sustainably manage natural ecosystems for climate change mitigation and adaptation remain challenges. Progress has been made on planning and coordination, demonstration, and pilots for REDD+ readiness (Minang *et al*., 2014) and implementation. Capacity for monitoring, measurement, reporting and verification (MRV) of forests in developing countries for REDD+ as well as for NDCs is highly variable. Significant capacity-building has been carried out with respect to MRV, financing, benefit-sharing and policies, and law and institutions, although further efforts are needed (Minang *et al*., 2014).

Target 13.A: Implement the commitment undertaken by developed-country Parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible.

Progress has been made in financing climate change mitigation, although current capitalization falls far short of the $100 billion goal. Initial efforts to mobilize resources for the Green Climate Fund raised $10.3 billion, but further fundraising efforts may be more difficult following the United States' decision to withdraw from the Paris Agreement, increasing the burden for other donors, particularly in the European Union (Cui & Huang, 2018). These funding efforts remain critical because of analyses that show that in spite of the high costs associated with the implementation of climate mitigation plans, most developing countries would face even higher costs in case of inaction (Antimiani *et al*., 2017).

Target 13.B: Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.

The need for capacity-building has been recognized in many climate change-related planning and management projects including those funded by the Global Environment Facility (Biagini *et al*., 2014). However, analyses of REDD+ projects and payment for ecosystem service schemes suggests that capacity-building and benefit-sharing remain key challenges (Dougill *et al*., 2012; Cadman *et al*., 2017). A focus on gender issues within climate change adaptation planning and management is relatively nascent and there is currently scant evidence as to progress in capacity-building for women, youth and marginalized communities.

SDG 14: Life below water

Achieving the targets under SDG 14 will have direct impacts on the health of marine ecosystems and their ability to provide NCP not only in relation to this goal, but also for several other SDGs. Previous assessments of anthropogenic stressors to marine ecosystems have found that nearly all of the ocean is affected by human activities (Halpern *et al*., 2008). Updated analyses indicate that 66% was experiencing greater cumulative impact in 2013 than in 2008 (Halpern *et al*., 2015a). Increases in climate change stressors, including sea surface temperature anomalies, ocean acidification, and ultraviolet radiation, drove most of the increases (Halpern *et al*., 2015a). The intensity of these anthropogenic impacts varies by location and ecosystem, but there is widespread evidence that they are having major impacts on the health of marine ecosystems (Halpern *et al*., 2012, 2015a, 2015b).

A global assessment of the health and benefits of the oceans suggest that ocean health requires significant improvement to achieve major goals including several of the SDGs (Halpern *et al*., 2012, 2017). Global scale assessments of the health of individual marine ecosystems also generally detail major declines over the last 20–50 years, with significant regional variability. For example, kelp ecosystems have experiences declines in abundance in 38% of ecoregions, increases in 27% of ecoregions, and no detectable change in 35% of ecoregions (Krumhansl *et al*., 2016). In other ecosystems, the declines are more consistent and pervasive. Mangrove ecosystems have declined in global extent by about 38% by 2010 (Thomas *et al*., 2017), with an estimated loss of 40% of mangroves over the last 30 years in Indonesia, which has the greatest extent worldwide (Murdiyarso *et al*., 2015). Recent work suggests these deforestation rates may be slowing, but mangroves are still declining at a rate of approximately 0.18% per year on average across Southeast Asia (Richards & Friess, 2016). There is considerable variability among countries in deforestation rates, with the highest losses in Myanmar, Indonesian Sumatra and Borneo, and Malaysia (Richards & Friess, 2016). Seagrass ecosystems have experienced similar declines with historical loss rates of 30% and estimates of 7% loss per year since 1990 (Waycott *et al*., 2009). Tracking global and regional trends in the status of most marine ecosystems remains challenging, particularly for ecosystems that require regular field sampling, including benthic and pelagic ecosystems, as well as coastal ecosystems like oyster reefs, dunes and salt marshes.

Two marine ecosystems – coral reefs and polar ice-associated ecosystems – have receive increased attention as bellwethers for climate change-associated changes. As outlined in section 3.2 in relation to Aichi Target 10, coral reef ecosystems have been severely impacted by repeated major bleaching episodes. In aggregate, these episodes have caused major mortality and reduced global coral health (Hughes *et al*., 2018) even in some of the most highly protected areas in the world (Hughes *et al*., 2017a). Changing sea ice extent and thickness and warmer ocean temperatures are already having major impacts in Arctic and Antarctic ecosystems (Post *et al*., 2013; Saba *et al*., 2014). In Arctic ecosystems, ecological impacts of these conditions include changing productivity and seasonality, which affects the abundance and distribution of commercial fish and iconic species such as seals, whales, and polar bears (*Ursus maritimus*) (Post *et al*., 2013).

Compromised ecosystem health limits the ability of marine ecosystems to maximize the provision of a range of NCP, including nutritional, economic, coastal protection, cultural, and climate mitigation benefits. Nutritional and economic benefits from healthy commercial and small-scale fisheries are particularly important for SDGs 1, 2, and 3, among others. These fisheries support more than 260 million livelihoods (The & Sumaila, 2013) and generate substantial revenues for many countries, including US$ 80 billion in export revenues for developing countries in 2014 (FAO, 2016). In spite of their importance, there are significant challenges to managing both commercial and small-scale fisheries. As discussed in section 3.2 in relation to Aichi Target 6, the percentage of overexploited commercial fish stocks has continued to increase since 1990, although the trend towards more overexploitation has slowed in recent years (FAO, 2016). Analyses focusing on unassessed stocks – typically those in developing countries or small-scale fisheries – suggest that they are likely to be in substantially worse condition than assessed stocks (Costello *et al*., 2012).

The benefits from better management of marine ecosystems and fisheries are substantial. For example, if unassessed fish stocks were rebuilt, 64% of them could provide increased harvests (Costello *et al*., 2012). However, challenges remain with the implementation of many management tools including marine protected areas. Although there has been an increase in the extent of marine protected areas, benefits from these are limited by inadequate staffing and financial resources (Gill *et al*., 2017) and impacts from climate change (Halpern *et al*., 2015a; Hughes *et al*., 2017a). Achieving the SDG 14 targets will depend on finding ways to ensure that nature and NCP are managed sustainably.

Target 14.1: By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.

As human populations have grown, consumption has increased and the amount of fertilizer used for agricultural practices has increased; there has been widespread recognition that these practices have resulted in impacts on marine ecosystems (as discussed in section 3.2 in relation to Aichi Target 8). There are several types of marine pollutants, ranging from debris or "trash" to contaminants like metals, sewage and nutrient and herbicide run-off from agriculture.

Marine debris has increased in recent years and is beginning to be mapped (Cózar *et al*., 2014; Eriksen *et al*., 2014). Mortality from ingestion has been reported in some species (Baulch & Perry, 2014; Wilcox *et al*., 2015), and is a major threat to others (e.g., some seabird species, Croxall *et al*., 2012) but the extent of the problem is still being investigated. One study estimates that 192 coastal countries have generated 275 million metric tonnes of plastic waste, 4.8–12.7 million tonnes of which have entered the ocean (Jambeck *et al*., 2015). Major factors that affected how much plastic waste has entered the ocean include population size and the quality of waste management systems. Without waste management improvements, plastic waste entering the ocean could increase by an order of magnitude by 2025 (Jambeck *et al*., 2015). The impacts of plastic debris on marine plants and animals suggests that mitigation is important to the health of marine ecosystems (Rochman *et al*., 2016). Waste enters even the most remote ecosystems including the deep sea (Ramirez-Llodra, 2011). Coral reefs, in particular, seem very vulnerable to plastic debris with one study estimating that contact with plastic results in a 4–89% increase in likelihood of coral disease (Lamb *et al*., 2018).

Contaminants like metals, hydrocarbons, nutrients, herbicides and sewage have been shown to reduce species richness and abundance across marine ecosystems (Johnston & Roberts, 2009) with particular impacts on coral reefs (McKinley & Johnston, 2010). Up to 70% of studies have found negative impacts of contaminants on primary production (Johnston *et al*., 2015).

Negative impacts of land-based activites on coastal ecosystems are well documented. Nitrogen inputs from agricultural run-off and atmospheric deposition of nitrogen from fossil fuel combustion (Howarth, 2008) are major causes of coastal eutrophication and so-called dead zones (Diaz & Rosenberg, 2008; Doney, 2010) with adverse effects on coastal ecosystems like salt marshes (Deegan *et al*., 2012), coral reefs (Altieri *et al*., 2017), and temperate rocky coastlines (Strain *et al*., 2014). Recovery can be slow, with ecosystem services including fisheries and coastal protection impacted for decades (McCrackin *et al*., 2017).

Improved waste management and more sustainable agricultural practices could reduce the amount of marine pollution entering the oceans (Jambeck *et al*., 2015). Results from one analysis indicate that the perceived benefits of reducing eutrophication in European marine areas could be considerable, with the predicted annual willingness to pay per person ranging from $6 for small local changes to $235 for substantial changes covering large sea areas (Ahtiainen, & Vanhatalo, 2012).

Target 14.2: By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.

The goal of sustainable management of marine and coastal ecosystems is to ensure that they continue to deliver the multiple benefits that people rely on (Schultz *et al*., 2015). There are many examples of successful management tools for a range of ecosystems and their associated benefits (Halpern, 2003; Hilborn & Ovando, 2014; Lotze *et al*., 2011). However, management is also more than just the specific tool or tools that are implemented. Several lines of evidence demonstrate the importance of various social, cultural, and enabling conditions that may affect the ability to sustainably manage marine resources (Bodin, 2017; Schultz *et al*., 2015). For example, there is evidence that strong sociocultural institutions can such as customary taboos and marine tenure, high levels of local engagement in management, high dependence on marine resources, and beneficial environmental conditions can result in better ecosystem condition in coral reef ecosystems (Cinner *et al*., 2016). Similarly, strong leadership, the use of individual or community quotas, social cohesion and the presence of protected areas were found to be related to the successful co-management of fisheries (Gutierrez *et al*., 2011).

However, current research suggests that the condition of many marine ecosystems including kelp forests (Krumhansl *et al*., 2016), mangroves (Valiela *et al*., 2001), seagrasses (Waycott *et al*., 2009), coral reefs (Burke *et al*., 2011; Hughes *et al*., 2017a, 2018), polar ecosystems (Constable *et al*., 2014; Post *et al*., 2013; Saba *et al*., 2014; Wassmann *et al*., 2011) and deep ocean ecosystems (Ramirez-Llodra *et al*., 2011) are continuing to decline, although with regional variability. These declines indicate that sustainable management has not yet had an impact or is limited in its ability to mitigate exogenous factors like climate change (Halpern *et al*., 2015a), particularly for vulnerable ecosystems like coral reefs (Hughes *et al*., 2017a; 2017b). The effects of climate change are overwhelming even for well-managed coral reefs like the Great Barrier Reef, which has experienced recurrent coral bleaching in 1998, 2002, and 2016, leading to mass mortality (Hughes *et al*., 2017a). Local management efforts that improve water quality and promote sustainable fisheries management can help with recovery from bleaching events, but evidence suggests that they do not play a role in mitigating the severity or extent of bleaching events (Selig *et al*., 2012; Hughes *et al*., 2017a). Therefore, managing adverse impacts from both global and local stressors will be necessary for achieving healthy and productive oceans.

Target 14.3: Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.

During 2002–2011, approximately 27% of global carbon ($CO_{2)}$ emissions were absorbed by the global oceans, causing declines in surface ocean pH, also known as ocean acidification (Doney *et al*., 2014; Le Quéré *et al*., 2013). Ocean acidification poses a key threat to many species including habitat-forming species like corals, oysters and mussels. These species are expected to have decreased survival, calcification, growth, and reproduction (Kroeker *et al*., 2010; 2013; Talmage & Gobler, 2010). The vulnerability of foundation species as well as keystone species including many echinoderms to ocean acidification will result in ecosystem-level impacts (Dupont *et al*., 2010; Kroeker *et al*., 2010). Meta-analyses also suggest that ocean acidification may catalyze changes in the structure of phytoplankton communities, with potential consequences for marine food webs (Dutkiewicz *et al*., 2015). Acidification is also projected to impact deep-sea species (Levin & Lebris, 2015). In addition, there are a range of expected neurological or behavioral impacts on several commercial and non-commercial fish species, negatively affecting their ability to find suitable settlement locations, predation behaviour, and sensory functions (Branch *et al*., 2013; Stiasny *et al*., 2016). Ocean acidification rates will vary regionally, with greater rates expected in the polar and temperate oceans (Bopp *et al*., 2013). However, impacts of acidification may still be high in tropical waters because of the vulnerability of foundation ecosystem species like those forming coral reefs (Fabricius *et al*., 2011). Because ocean acidification is a result of increased CO2, progress towards mitigating it will be inextricably tied to reducing global greenhouse gas emissions.

Target 14.4: By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.

According to the Food and Agriculture Organization of the United Nations (FAO, 2018b), 33.1% of commercial fish stocks were estimated to be overfished and 59.9% maximally sustainably fished in 2015 **(Figure 3.8)**. The percentage of stocks fished at biologically unsustainable levels has increased since the 1970s, although the rate of

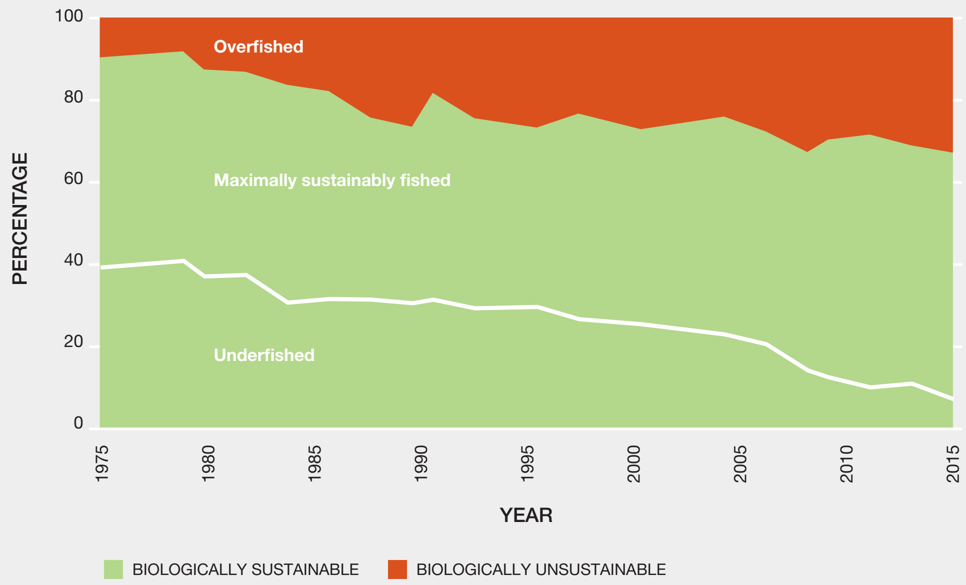


Figure 3 8 **Global trends in the state of world marine fish stocks.**
Source: FAO (2018b).

increase has slowed (FAO, 2016). Historic catch levels are difficult to estimate, but 'catch reconstructions' suggest that levels may have been higher than previously thought (Pauly & Zeller, 2016). An analysis of a larger set of stocks than those assessed by FAO suggests that 54% of stocks are below their Maximum Sustainable Yield (MSY), with 34% meeting the FAO criteria for being overfished (20% below the biomass that would support MSY) (Rosenberg *et al.*, 2017). This analysis suggests that many stocks currently classified as fully exploited could be delivering more benefits if they were more effectively managed (Rosenberg *et al.*, 2017). Small unassessed stocks are likely to be in worse condition than commerical stocks (Costello *et al.*, 2012), and would similarly benefit from rebuilding strategies.

There is significant regional variability in the status of fish stocks. For half of oceanic FAO regions, over 50% of the stocks were estimated to be below the biomass that would support maximum sustainable yield (Rosenberg *et al.*, 2017). Many of these regions were located in the northern hemisphere, which may be a result of historical exploitation patterns. Although southern stocks may appear to be in better condition, they are also generally less well-monitored, and studies suggest that stocks in data-limited regions are likely to be in poorer condition than well-monitored stocks (Costello *et al.*, 2012).

There have been considerable efforts to implement ecosystem-based management in many of the world's major fisheries. Generally, large stocks that are scientifically assessed are doing better and are generally rebuilding, rather than declining (Costello *et al.*, 2012; Hilborn & Ovando, 2014). Large, assessed stocks are likely to be outperforming small stocks or unassessed stocks because they receive more management attention, and harvesting levels can be informed by data (Hilborn & Ovando, 2014). The implementation of long-term management plans that include economic and social dimensions of fisheries have also been found to be important in achieving sustainable fisheries management (Bundy *et al.*, 2017).

Target 14.5: By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.

As outlined in section 3.2 in relation to Aichi Target 11, significant progress has been made in increasing the percentage of coastal and marine areas that are covered by protected areas, particularly since 2000. As of September 2018, the *World Database on Protected Areas* showed that 7.44% of the marine realm was covered by protected areas (17.23% of marine areas within national jurisdiction or 200 miles from the coastline and 1.18% of areas beyond national jurisdiction) (UNEP-WCMC & IUCN, 2018). Therefore, progress towards expanding protected areas in coastal areas has been greater than in marine areas beyond national jurisdiction (the High Seas). Increases in protected area coverage have been in due in large part to the establishment of a few, very large protected areas such as those in Hawaii and the Cook Islands. Therefore, in spite of progress towards the achievement of the areal element of the target, there are indications that protected areas in the marine realm may not be based on the best available scientific information and may not be protecting ecologically representative areas or areas of importance for biodiversity (Gannon *et al*., 2017; Watson *et al*., 2016b). Research suggests the current set of marine protected areas does not capture taxonomic, phylogenetic and functional diversity well and may also not protect continued delivery of NCP in marine ecosystems (Lindegren *et al*., 2018). For example, only 44% of the area of each marine Key Biodiversity Area is covered by protected areas, on average (**Figure 3.3b**; BirdLife International *et al*., 2018).

Effective MPA design and mangement is critical to their ability to deliver ecological and social outcomes (Mascia *et al*., 2010; Edgar *et al*., 2014). Previous research has identified five key features in determining the relative success of MPAs in conserving fish species: no take regulations, enforcement, MPA age, MPA size, and degree of isolation (Edgar *et al*., 2014). Connectivity between MPAs may be particularly important for biodiversity persistence (Magris *et al*., 2018). However, there are indications that management in many marine protected areas remains relatively weak due to capacity shortfalls in staffing and funding (Gill *et al*., 2017).

Target 14.6: By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation. Ilegal, unreported, and unregulated (IUU) fishing is estimated to impact 15% of the world's annual capture fisheries output (FAO, 2016), and developing countries with poor monitoring and enforcement are the most vulnerable to losing benefits (Agnew *et al*., 2009). The challenges of estimating the magnitude of IUU complicates efforts to understand the current status of many fisheries (Pauly & Zeller, 2016; Zeller *et al*., 2018). The 2009 Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA), which entered into force in June 2016 with binding obligations for foreign vessels entering ports, is aimed at increasing transparency and accountability (FAO, 2016). A key element of the PMSA is to implement traceability to reduce or eliminate access to markets for illegal fish products. Recent studies suggest that consolidation within the fishing industry results in 13 companies controlling 11–16% of the global catch and 19–40% of the largest and most highly valued stocks (Österblom *et al*., 2015). Implementing traceability and sustainable practices within these companies and the seafood industry may provide an opportunity to catalyze management changes at all ends of the value chain.

Current fisheries subsidies are estimated to total US$35 billion. There is no evidence that fisheries subsidies have undergone substantial changes between 2003 and 2009. Capacity-enhancing subsidies constitute 57% of subsidies, followed by fuel (22%), management (20%), and port and harbors (10%). Regionally, Asia had the highest subsidies (43% of total), followed by Europe (25%) and North America (16%). At a country-scale, Japan, United States and China had the highest levels of subsidies (Sumaila *et al*., 2016).

Target 14.7: By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism. There is a lack of data on the value chains of many fisheries, making it difficult to track who benefits from fisheries and other marine resources in small island developing states and least developed countries. FAO estimates that developing economies' fisheries export share has risen from 37% to 54% of total fishery export value and 60% of the quantity by 2014 (FAO, 2016). However, many countries receive a relatively small proportional share of these benefits. Information on EU fisheries agreements suggests that the EU has subsidized these agreements at 75% of their cost, while private European businesses paid roughly 1.5% of the value of the landed fish (Le Manach *et al*., 2013). Analyses of the economic returns for small-scale fisheries in international markets suggest that fishers' earnings varied depending on species, but the relative share of value they received was negatively related to end-market value. For the highest value species, small-scale fishers received approximately 10% of the retail value (Purcell *et al*., 2017). In a study of large- and small-scale fishing sectors, researchers found that small-scale fisheries received only about 16% of the total global fisheries subsidy of $35 billion in 2009, suggesting that many small island developing states and least developed countries where small-scale fisheries are important are not benefiting from subsidies. Price transparency and changes to governance structures through fisher cooperatives could improve fisher incomes (Purcell *et al*., 2017). Awareness of these issues and implementation of proposed solutions are relatively nascent.

SDG 15: Life on land

SDG 15 aims to protect, restore and promote the sustainable use of terrestrial ecosystems including freshwater ecosystems. Nature and NCP directly underpin the achievement of the targets under SDG 15. Achievement of this goal underpins many other SDGs. Some examples of the range of NCP provided by terrestrial and freshwater ecosystems and links to other goals include: the provision of freshwater for drinking, washing, and sanitation (Goal 6), hydropower (Goal 7), and habitat for fish (Goal 14), the purification of water through prevention of erosion/sedimentation and removal of excess nutrients (Goal 6), carbon storage and sequestration for climate regulation (Goal 13), provision of food and fuel from agriculture, forestry, hunting, and gathering (Goal 12), the provision of livelihoods (Goal 8), and cultural activities such as recreation, spiritual practices and their contribution to health and well-being (Goal 3), among many others.

There is a significant degree of overlap between the Aichi Biodiversity Targets and the targets that make up SDG 15. Therefore, we summarize the key findings from section 3.2 for several of the SDG targets that overlap or are identical to particular Aichi Biodiversity Targets. SDG 15.4, which focuses on mountain ecosystems, and SDG 15.7, which focuses on taking action to end poaching and trafficking of protected species, are not the specific focus of particular Aichi Biodiversity Targets and are therefore elaborated here in more detail.

As the analysis in section 3.2 suggests, progress towards meeting the SDG15 targets for the sustainable management of terrestrial and freshwater ecosystems is generally poor.

Target 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.

There has been considerable progress towards achieving the target of 17% coverage of terrestrial and freshwater ecosystems by protected areas. The *World Database on Protected Areas* indicates that by September 2018, 14.87% of the world's terrestrial and freshwater areas were in protected areas (UNEP-WCMC & IUCN, 2018). However, as outlined in section 3.2 in relation to Aichi Target 11, coverage of areas of importance for biodiversity by protected areas, and ecological representation within protected areas, and connectivity between them are insufficient. For example, only 47% of each terrestrial and 44% of each freshwater Key Biodiversity Areas is covered by protected areas on average (**Figure 3.3b**; BirdLife International *et al*., 2018), while only 9.3–11.7% of protected areas are estimated to be adequately connected (Saura *et al*., 2017, 2018; **Table 3.7**). While there are few data on management effectiveness, equity, and integration with wider landscapes, it is unlikely that the global protected area network is adequate in these respects either.

Conserving and restoring terrestrial ecosystems requires limiting their loss and actively working to recover original degraded ecosystems. As outlined in section 3.2 in relation to Aichi Target 5, natural habitats from forests to wetlands continue to be lost. Losses in services provided to people from wetlands (e.g., protection from flooding, water purification) represent significant social and economic impacts (Gardner *et al*., 2015). Many terrestrial and freshwater species are threatened with extinction (**Figure 3.4a)**, while trends in the survival probability of wetland birds, mammals, and amphibians are all negative (**Figure 3.4b**; CBD SBSTTA, 2014 in Gardner *et al*., 2015) suggesting that overall these species are moving toward extinction more rapidly (see section 3.2 Aichi Target 12).

Maintaining the sustainable use of these ecosystems and the services that flow from them in the matrix outside of protected areas is critical to achieving this target. For example, conservation in managed landscapes is important for maintaining local biodiversity and nature's contributions to people (Ansell *et al*., 2016; Chaudhary *et al*., 2016; Rusch *et al*., 2016; Thompson *et al*., 2015). In the matrix in particular, strong institutions and incentives that foster behaviours that protect the health of ecosystems and the services that flow from them are critical to the achievement of this target. As outlined in section 3.2 in relation to Aichi Target 7, while some efforts to manage areas under agriculture, aquaculture and forestry sustainably (such as organic agriculture and forestry certification schemes) are increasing, biodiversity in production landscapes continues to decline, meaning that we are not making sufficient progress towards this aspect of SDG Target 15.1.

Target 15.2: By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.

During 2000–2012, 2.3 million km^2 of forest were lost in spite of reforestation efforts (0.8 million km^2) (Hansen *et al*., 2013). As outlined in section 3.2 in relation to Aichi Target 5, although progress has been made in slowing deforestation rates (Keenan *et al*., 2015; Morales-Hidalgo *et al*., 2015), annual tree cover loss appears to be increasing (globalforestwatch.org; Hansen *et al*., 2013; Harris *et al*., 2016), suggesting that we have not yet made adequate progress on achieving sustainable forest management. For example, although Brazil has made progress in reducing deforestation, increasing forest loss in Indonesia, Malaysia, Paraguay, Bolivia, Zambia and Angola, among others, have offset those gains (Hansen *et al*., 2013). While the area under forest certification schemes has increased rapidly, much forestry remains unsustainable (see section 3.2 in relation to Aichi Target 7). Regional assessments of forest sustainability have found that unsustainable harvesting is still high in Asia, with some progress in Latin America and the Caribbean, although all regions lack data to track trends adequately in the sustainability of forest production systems (UNEP-WCMC, 2016a, 2016b, 2016c, 2016d). Efforts are underway to increase afforestation globally. For example, in May 2017, the Bonn Challenge successfully achieved pledges for the restoration of 150 million hectares of degraded and deforested lands by 2020 and 350 million ha by 2030. Achieving the Bonn Challenge could contribute an additional USD $200 billion to local and national economies and sequester enough carbon to reduce global emissions by 17% (Bonn Challenge, 2018).

Target 15.3: By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.
Desertification may result in a loss of biological and/or economic productivity, and often involves increases in bare soil and decreases in vegetation cover (D'Odorico *et al*., 2012). Desertification affects one quarter of the world's land surface (3.6 billion ha), containing one fifth of the world's population (IFAD, 2010). Approximately 12 million ha are lost to land degradation each year, contributing to an estimated US$42 billion in income lost annually (IFAD, 2010). About 135 million people in 1995 were at risk of episodic mass starvation due to land degradation (Lean, 1995). See also section 3.4, UNCCD.

Drylands (arid, semi-arid and dry sub-humid areas) are the ecosystems most at risk of desertification. They make up approximately 41.3% of the global land area and are home to 2.1 billion people. Approximately, 44% of the worlds' cultivated systems occur in these regions and they support 50% of the world's livestock (Millennium Ecosystem Assessment, 2005). Globally, only c.8% of dryland ecosystems are protected, and 24% of this land area is degrading and in danger of desertification. Nearly 20% of the degrading land is cropland, while 20–25% comprises rangeland; about 1.5 billion people directly depend on these degrading areas (GEF-STAP, 2010).

As outlined in section 3.2 in relation to Aichi Biodiversity Target 15, there is little information on trends in restoration of degraded land, but plausible scenarios suggest little progress owing to increasing demands for commodities, water and energy.

Target 15.4: By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.
Mountains make up approximately 22% of the terrestrial land area, with a human population of nearly 1 billion residents (FAO, 2018a). Alpine ecosystems provide a wide range of ecosystem services including freshwater provision, erosion prevention, timber, food, medicinal plants, and opportunities for recreation. Given their wide-ranging topography and climatic diversity, isolation, disturbance regimes, and positioning along migratory corridors, mountains are home to many endemic species, significant genetic diversity, and unique cultural heritage (Spehn *et al*., 2010). Expansion of agriculture and settlements upslope, logging for timber and fuel, and replacement of alpine systems by highland pastures, climate change, and invasive species all threaten mountain ecosystems (Spehn *et al*., 2010).

Globally, nearly one in five of the world's protected areas are in mountains (Juffe-Bignoli *et al*., 2014). During 1997–2010, the proportion of mountain area covered by protected areas increased from 9% to 16% (Spehn *et al*., 2010). Protected area coverage of Key Biodiversity Areas has also grown, but on average just 48% of the extent of each Key Biodiversity Area in mountains is covered by protected areas, ranging from 18.4% in Western Asia and Northern Africa to 68% in North America and Europe (**Table 3.7**; BirdLife International *et al*., 2018), although "other effective area-based conservation measures" may effectively conserve some of the remainder (BirdLife International *et al*., 2018). In addition to protected areas, sustainable development in montane ecosystems will require the incorporation of local livelihoods and traditional ecological knowledge to develop innovative conservation and development schemes (such as payment for ecosystem services) that can be used to protect montane ecosystems and the services they provide to people. Sustainable development in mountain ecosystems must be cognizant of climate change, deforestation from landslides, societal pressures that promote emigration from small mountain towns to larger population centers, and other dynamics.

Target 15.5: Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.
Natural habitats continue to be degraded, as noted above and in section 3.2 (in relation to Aichi Target 5). Consequently, it is unsurprising that insufficient progress has been made in efforts to halt extinction and improve the status of threatened species, with the Red List Index continuing to decline for all groups with information on trends, and indices of population abundance also showing declines in terrestrial and freshwater ecosystems (see section 3.2 on Aichi Target 12, **Table 3.7**). However, it should be noted that extinction risk trends for birds and mammals would have been worse in the absence of conservation efforts (Hoffmann *et al*., 2010, 2015; Waldron *et al*., 2017).

Target 15.6: Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed.
In October 2010, CBD Parties adopted the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization. As indicated by the analysis for Aichi Target 16 (section 3.2), progress has been made in its implementation, but its goals have only

partially been met. Operationalizing the Nagoya Protocol through political will and providing financial resources has been challenging. Continued engagement and capacity-building with Indigenous Peoples and Local Communities will also be needed to ensure effective implementation.

Target 15.7: Take urgent action to end poaching and trafficking.

Poaching, illegal killing and the illegal wildlife trade has broad implications not only for species loss (Wittemyer *et al*., 2014) and spread of invasive alien species (Garcia-Diaz *et al*., 2017), but also for human health (Karesh *et al*., 2005) and socioeconomic interests (Nielsen *et al*., 2017). There are few data on the numbers of individuals of plants and animals that are poached or hunted, trapped, collected or taken from the wild illegally. As just one example, recent assessments estimated that 11–36 million individual birds are illegally killed or taken each year in the Mediterranean region (Brochet *et al*., 2016), and another 0.4–2.1 million are illegally killed or taken per year in the rest of Europe (Brochet *et al*., 2017), while illegal capture of songbirds for the cage bird trade in Asia is now driving populations extinct (Eaton *et al*., 2015). Equivalent estimates across entire taxonomic classes are not available for other groups.

To improve tracking of illegal trade, the United Nations Office on Drugs and Crime has developed a global database of wildlife seizures ('World WISE'). Initial analyses show that nearly 7,000 species have been seized (mammals, reptiles, corals, birds, fish), with no single species responsible for more than 6% of the seizure incidents (**Figure 3.9**; UNDOC, 2016).

Suspected traffickers of some 80 nationalities have been identified, with most seizures originating in Southeast Asia (Rosen & Smith, 2010). In general, illegal imports are associated with increasing exporter GDP (Symes *et al*., 2018). One analysis found higher probabilities of underreporting for avian and reptile products, with Central Africa, Central Asia, Eastern Europe and Pacific Island states showing higher underreporting than other regions, potentially suggesting complex trade networks that could allow for illegal products to be moved through legal markets (Symes *et al*., 2018). Internationally, the wildlife trade is regulated through the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which was created to limit the illegal trade and trafficking of wildlife. Implementation of the convention has been challenging due to non-compliance, an overreliance on regulation, lack of knowledge and monitoring of listed species, and ignorance of market forces (Challender *et al*., 2015a), as outlined in section 3.4.

Target 15.8: By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.

As outlined in section 3.2 in relation to Aichi Target 9, considerable progress has been made in identifying, prioritizing and implementing eradications of invasive alien species, particularly on islands, with substantial benefits to native species. For example, over 800 invasive mammal eradications have been successfully carried out, with estimated benefits for at least 596 populations of native terrestrial species on 181 islands (Jones *et al*., 2016). There

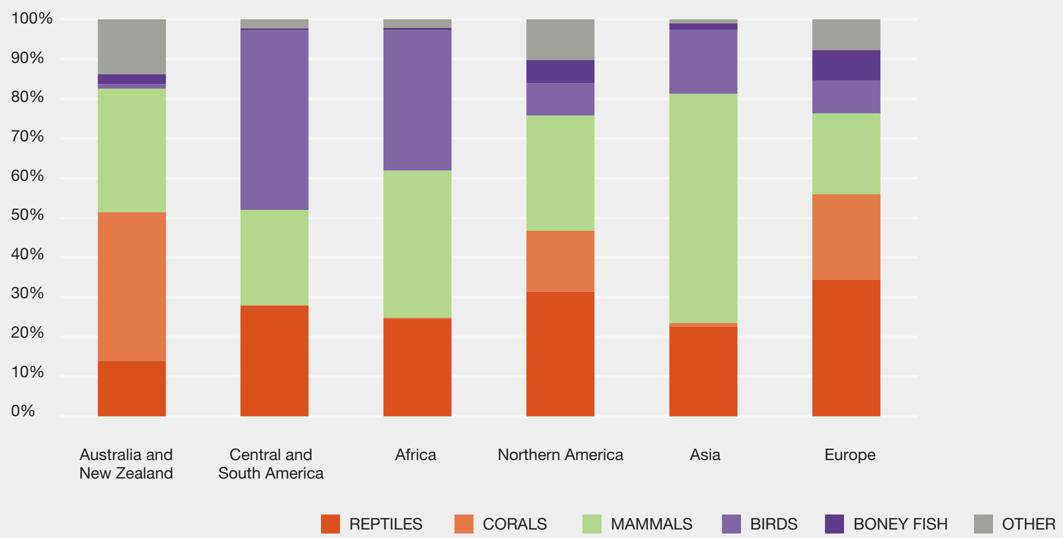


Figure 3 9 **Seizures of illegally trafficked animals, by taxonomic class and region for 1999-2015.**

Source: UNODC (2016).

are fewer data on the extent of measures to prevent the introduction and establishment of invasive alien species, but the rate of introductions is increasing (Seebens *et al*., 2017), and invasive alien species are driving more species towards extinction (see section 3.2). Globally, invasive alien species have a strong negative influence on the abundance (but apparently not species diversity) of aquatic communities, particularly macrophytes, zooplankton and fish, with invaded habitats showing increased water turbidity, and nitrogen and organic matter concentration, which are related to the capacity of invaders to transform habitats and increase eutrophication (Gallardo *et al*., 2016).

Target 15.9: By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.
As noted in section 3.2 in relation to Aichi Target 2, some progress has been achieved in integrating biodiversity values into development and poverty reduction strategies and planning processes and in incorporating biodiversity values into national accounting and reporting systems. The global community has made significant advancements in the science of ecosystem services and in communicating the importance of biodiversity and ecosystem services in policy and planning, yet implementation of responses to address the loss of nature and NCP lags (Guerry *et al*., 2015).
The System of Environmental and Economic Accounting (SEEA) has been adopted by the United Nations Statistical Commission, but integration of this framework into national accounting systems has been limited to date (Vardon et el. 2016). Examples of countries integrating ecosystem services considerations into national development planning include: China, where ecosystem service information has been incorporated into national development planning through the creation of Ecosystem Function Conservation Areas (Ouyang *et al*., 2016); Belize, where ecosystem service information has been integrated into national coastal zone planning (Arkema *et al*., 2015), and the Bahamas, where the Office of the Prime Minister has recently completed a pilot sustainable development plan for Andros Island that integrates ecosystem and biodiversity values into planning (Government of The Bahamas, 2016). These examples highlight that there is momentum to incorporate ecosystem values in national accounting (through programs like the Wealth Accounting and Valuation of Ecosystem Services Partnership) and poverty reduction strategies), but the extent to which this will be accomplished is still unclear, as are the potential impacts in policy and planning.

Target 15.A: Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems. Target 15.b. Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation.
These targets overlap considerably with Aichi Biodiversity Target 20 (see section 3.2). While financial resources for implementing the Strategic Plan for Biodiversity 2011–2020 have grown, they are still insufficient for its effective implementation. At the same time, there has been no significant increase in funding levels **(Table 3.7)**, suggesting resources are still insufficient to achieve progress toward international conservation goals (Tittensor *et al*., 2014).

3.3.2.2 Cluster 2: Nature's contribution to people (specific targets; SDGs 1, 2, 3, 11)

SDG 1: No poverty

Goal one of the SDGs calls for an end to extreme income poverty and halving of multi-dimensional poverty by 2030. The goal also aims to ensure social protection for the poor and vulnerable, to ensure equal rights to economic resources (including natural resources) and access to basic services, and to build the resilience and reduce the vulnerability of people to harm from climate-related events and other economic, social or environmental shocks and disasters.

There is a large literature examining the empirical relationship(s) between development, poverty levels (and/or human well-being) and nature (Schreckenberg *et al*., 2018). An implicit assumption is that nature and NCP can alleviate poverty, though the empirical evidence is not always available to support this, and it may be more accurate to suggest that N and NCP contribute to reducing vulnerability or preventing further declines in well-being (Balama *et al*., 2016; Suich *et al*., 2015). An increasing number of frameworks have been developed to analyse linkages between ecological and socioeconomic systems including in the context of poverty (CBD, 2010c; Fisher *et al*., 2014; Howe *et al*., 2013; Lade *et al*., 2017; Roe *et al*., 2014). These frameworks examine the links and pathways between nature and NCP and socioeconomic systems, typically examining bundles of ecosystem services (Reyers *et al*., 2013) and recognizing the multiple dimensions of poverty (i.e. not only income poverty) or well-being (Hamann *et al*., 2015). To avoid oversimplifying relationships, these frameworks typically highlight the dynamic, nonlinear and complex nature of the relationships and linkages examined, they further enhance understanding of trade-offs across disaggregated groups of beneficiaries (e.g., Daw *et al*., 2011b). In general research shows that the linkages and causality are highly context-specific, multi-scalar, subject to external factors and dynamic and need to be analyzed at the relevant scale, while looking at the appropriate elements of linked ecological and socioeconomic systems (Lade *et al*., 2017). However, knowledge gaps remain regarding causality, as well as evidence of mechanisms (Delagado & Marin, 2016; Wagner *et al*., 2015).

Empirical studies have tended to focus on the direct relationship between material needs and material contributions but focus less on the more complex relationships involving non-material and regulating NCP that underpin these relatively strong and direct links (OECD, 2013 cited in Hossain *et al*., 2017). Furthermore, factors that mediate the impacts of nature on multiple dimensions of poverty, including drivers of change, legacy effects, and contextual and external factors are also critical considerations, because of their impact on the effectiveness of management choices, and which interact with each other across multiple scales (temporally and spatially). Governance mediates the effects of interventions between nature and poverty outcomes (Swiderska *et al*., 2008); indeed, governance quality is critical to the success of policy design, implementation and subsequent outcomes. In a review of papers examining large-scale forest restoration and local livelihoods, nearly 60% of papers discussed the importance of governance to socioeconomic outcomes (Adams *et al*., 2016). This is particularly important for the analysis of high-level target-setting and reporting of achievement, as aggregated analyses may mask nuance and variation revealed by analyses conducted at scales more appropriate to the social and ecological systems being studied. Disaggregation of impacts across social groups is critical to understanding the impacts of any intervention (Daw *et al*., 2011b), though such disaggregated analyses (e.g., by ethnicity, gender, wealth categories) are infrequently presented.

Power relations also impact the ability of nature to contribute to the poor, through their effect on institutions and governance (via their mediating influence on access, use and management), with the potential to support sustainable and equitable outcomes, or produce poor outcomes, both socially and environmentally (Berbes-Blazquez *et al*., 2016). These power relations, along with local history and societal structures affect the distribution of benefits derived from the access to and utilization of NCP (Felipe-Lucia *et al*., 2015), and should therefore be explicitly assessed in order to determine whether environmental changes and resource use reinforce unequal social relations, or may be purposely used to do so (Lakerveld *et al*., 2015). In combination with power relations, the different types of values that can be held by different groups of people are also critical to outcomes, in particular through their influence on trade-offs between policy choices and desired outcomes (and these values were in turn strongly influenced by social relations, cultural norms, historical and political factors) (Dawson & Martin, 2015; Horcea-Milcu *et al*., 2016). The role of culture in determining well-being and relations between human and natural systems is also of interest (Lade *et al*., 2017; Masterson *et al*., 2016)

In assessing such high level goals as we do here, caution should be exercised given that the aggregation of data, and the use of averages can obscure the identification of winners and losers – intentionally or otherwise (see also Dawson & Martin, 2015) – and thus cement or exacerbate inequities. Thus, caution should be exercised in trying to predict the impacts of policies to achieve the SDGs; emphasis should be placed on undertaking analyses at the appropriate scale, and in incorporating consideration of local mediating and contextual factors.

Additional targets under SDG 1, not assessed here, relate to the creation of sound policy frameworks, and the mobilization of resources to implement these poverty reduction policy frameworks. The achievement of these latter targets will not necessarily directly impact on nature and NCP. However, the achievement of SDG 1 is likely to be sought through economic growth policies and through infrastructure development investments (in line with SDGs 8 and 9). Other implications include migrations of rural poor to urban areas which may result in the encroachment on agricultural land by urban areas (with knock-on effects on the achievement of SDG 2 and on management of agricultural land elsewhere) (Singh & Singh, 2016). Other impacts of the achievement of this goal are likely to be an increase in both material consumption and the generation of waste (e.g., SDG 12) and the displacement of the sites of impact on nature and NCP from the location of the consumers of goods and services (Holland *et al*., 2015; Laterra *et al*., 2016). While it is possible to design development policies to minimize and mitigate potential negative impacts on nature and NCP (Megevand, 2013; OECD, 2008; Perch, 2010; UNDP *et al*., 2009; WRI, 2005), historically this has not always occurred. Other strategies have the potential to reduce the direct utilization of nature and NCP (e.g., via job creation strategies in the services sector), though this may rather replace direct utilization with indirect utilization and/or increase consumption of certain resources. Such strategies are not always successful in their poverty alleviation objectives, as evidenced by nearly 38% of workers in developing countries living below the poverty line in 2016 (UNESC, 2017). See section 3.3.2.4.

Target 1.1: By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.90 a day.

Nature and NCP make direct contributions to the rural and urban poor, through direct consumption or the income generated by trade (e.g., food, fibre, fuel and fodder). Nature and NCP and other non-marketed goods are estimated to account for 47–89% of the 'gross domestic product of the poor' (i.e. the total source of livelihood of rural and forest-dwelling poor households), while agriculture, forestry and fisheries contribute only 6–17% of national GDP (TEEB, 2010). Studies have tended to focus on such contributions to the rural poor (e.g., Cavendish, 2000; Duchelle *et al*., 2014a; Hogarth *et al*., 2013; Schaafsma *et al*., 2014), and have considered both cultivated (Bailey

& Buck, 2016; Liu *et al*., 2010; Poppy *et al*., 2014) and non-cultivated contributions (Jagger *et al*., 2014; Shumsky *et al*., 2014), as well as some regulating contributions, such as pollination, which is critical to the continuing flow of provisioning services (Ashworth *et al*., 2009). Given large numbers of people still living in extreme poverty (especially in the rural context) for whom nature and NCP continue to provide important contributions to livelihoods, trends in environmental degradation highlighted in section 3.2 could increase the vulnerability of the poorest and undermine progress to this goal. However, high levels of uncertainty and complexity around the contribution of nature to this target, as well as unclear implications of trends in nature and NCP for this target imply we cannot current assess trends **(Figure 3.13)**. Due to the focus of this target on a poverty line of $1.90/day, changes in non-income related aspects of vulnerability and poverty could be missed.

Where opportunities for commercialization are identified as a means to increase the income that can be earned from nature and NCP, the quality of management or governance underpins any outcome. Problems have been identified in cases of newly created markets for ecosystem services, due to the potential to reinforce negative outcomes, failing to generate livelihood improvements and to achieve environmental improvement objectives, even leading to further degradation (Kronenberg & Hubacek, 2016). The equity of access to, and utilization of, nature and NCP, as well as the distribution of benefits generated (Gross-Camp *et al*., 2015; McDermott *et al*., 2013) is also of critical importance to whether the environmental and poverty goals can be simultaneously achieved.

Target 1.2: By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.

The multidimensional nature of poverty acknowledged in this target, is key to understanding the implications of changes in nature and NCP for poverty alleviation. Dimensions that have been included in international analyses include health, education and standard of living (both measured in the Human Development Index, HDI, and the Multidimensional Poverty Index, MPI; UNDP, 2016), the basic materials for a good life, health, good social relations, security and freedom of choice and action (used in the Millennium Ecosystem Assessment, 2005; Narayan & Petesch, 2002; Narayan *et al*., 2000a; 2000b). In a more comprehensive assessment, 15 non-income dimensions – food, health, water, sanitation, education, voice, relationships, violence, environment, time use, work, shelter, clothing and footwear, reproductive health and energy/fuel are included in the Individual Deprivation Measure (Bessell, 2015). Several country-level studies have also been conducted, and utilized a range of dimensions, include the provincial indices of deprivation in South Africa (income and material deprivation, employment, health, education, living environment; Noble *et al*., 2006) and Mexico, and the MPI calculated for more than 100 developing countries (using the standard MPI dimensions). Of these, several relate specifically to individual sustainable development goals, including – and especially – those related to health, food and nutrition security, water and sanitation and access to clean energy, which are discussed in the relevant SDGs below.

Evidence suggests that people in rural areas are more likely to be multi-dimensionally poor than people in urban areas (UNDP, 2016). Trends in nature and NCP highlighted in section 3.2 and in Cluster 1 SDGs will have mixed implications across these multiple dimensions, with positive outcomes for some (e.g., nutrition) and negative for others (e.g., water quality). We are therefore currently unable to report a nature or NCP related trend for this target **(Figure 3.13)**.

Target 1.4: By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.

Many studies have been undertaken to determine whether richer or poorer households use NCP to a greater extent (Narain *et al*., 2008; WRI *et al*., 2008) and the gender distribution of use and the benefits derived (Pouliot & Treue, 2013). Overall, use is highly context-specific, depending on location, resource and cultural factors, among others. In some locations, external shocks may change utilization patterns, and access to resources can help households to deal such shocks, for example, utilizing forests to harvest building materials to rebuild following floods (López-Feldman, 2014; Parvathi & Nguyen, 2018). Regardless of which groups use certain resource more, there can be no doubt that continued – and secure – access to land and other resources is essential to reducing vulnerability and to prevent worsening poverty. Clear and secure land tenure has been identified as central to many policy initiatives designed to simultaneously achieve poverty reduction and environmental conservation (e.g., payments for ecosystem services, REDD+ (Duchelle *et al*., 2014b; Tacconi *et al*., 2010) and to increasing agricultural productivity (Lawry *et al*., 2017).

Clarity and security of land and resource tenure is particularly important in the face of policies supporting the industrialization of agriculture, which can create conflict, such as that experienced with the expansion of oil palm in Indonesia (Feintrenie *et al*., 2010; Rist *et al*., 2010), and to prevent the damaging effects of 'land-grabs' (on large and small scales) which can severely compromise dimensions of poverty including (local) food security and health and can increase the inequity of land distribution (Borras *et al*., 2011; Feldman & Geisler, 2012; Visser *et al*., 2012). Inequity in land distribution has been identified as being at the root of many agrarian and environmental problems, for example across Southern Africa, and post-independence reforms have largely failed to address these, and in some cases, have reinforced threats to social, economic and environmental sustainability and security (Clover & Eriksen, 2009). While progress has been made with respect to expanding Indigenous Peoples' rights over recent decades, constraints remain on their ability to exercise these rights (RRI, 2012), and much customarily security land remain unrecognized legally (RRI, 2015). From a small set of studies, our assessment finds poor progress to this target as it applies to equal rights to nature and NCP **(Figure 3.13)**.

Land reform can threaten access to land and resources (Fay, 2009; Jagger *et al*., 2014; White & White, 2012), or can work to improve the sustainability of management practices (Ali *et al*., 2014). Though much research has focused on issues of land tenure to date, issues of water security and entitlements and secure access to other resources is likely to increase in importance (Woodhouse, 2012), particularly in regions impacted most strongly by climate change.

Target 1.5: By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.

Global disaster risk is highly concentrated in low- and lower-middle-income countries, with a disproportionate impact being borne by small island developing states (Hall *et al*., 2008; United Nations, 2003). The management of disaster risks has reportedly failed to deal with the underlying drivers of increased global risk – climate change, uncontrolled urbanization and the creation of assets in hazardous areas (Keating *et al*., 2017). In particular for the rural poor, ensuring security of access to necessary land and resources will contribute to the maintenance of livelihoods, and potentially to reducing vulnerability and building resilience, for example from the utilization of available nature and NCP to speed the recovery from shocks or disasters (Balama *et al*., 2016; López-Feldman *et al*., 2014).

Research on the role of nature and NCP in mitigating or reducing vulnerability to disasters is growing (Nel *et al*., 2014). At an aggregate level, investment in the sustainable use of nature and NCP tends to generate significant benefits and avoids having to replace nature and NCP with physical infrastructure to produce the same protection function (IUCN, 2003; Russi *et al*., 2013). Trends in coastal and marine ecosystems (section 3.2 and Cluster 1) relevant to reducing vulnerability to extreme events suggests negative trends hampering progress to this target **(Table 3.8)**. However, studies in the Global South on the role and condition of ecosystems in reducing vulnerability is a key gap (Liquete *et al*., 2013).

SDG 2. Zero hunger

Goal 2 of the SDGs, which calls for the elimination of malnutrition and the promotion of sustainable and productive agricultural systems, has significant direct reliance on nature and NCP (Wood *et al*., 2018). Food production (and by extension nutrition) is an emergent outcome of a multitude of supporting, material, and regulating contributions from nature. A typical crop depends on nutrient cycling by soil microbiota to maintain soil fertility and water holding capacity to keep crops hydrated, genetic diversity to withstand pest and diseases, as well as associated wild biodiversity to carry out basic functions (e.g., pollination, N_2 fixation).

Agriculture has also been identified as the major cause of land use change, land degradation and desertification, together leading to declines in nature and NCP (Millennium Ecosystem Assessment, 2005). As pressure rises on the food system to feed a growing, and increasingly wealthy population, there has been a global shift towards more intensive forms of agriculture. As a result, this goal is equally applicable in developing and developed countries alike, which both must improve agricultural performance while addressing issues of land degradation and malnutrition. Agriculture, and therefore SDG 2, is a critical nexus for the interaction of nature, NCP and GQL.

Over one third of our global croplands are now degraded (Millennium Ecosystem Assessment, 2005) and 12 million new hectares are lost from production each year (UNCCD, 2016), primarily in Asia and Africa (Gibbs & Salmon, 2015). Sustainable production is therefore essential and must also include equitable access to resources (i.e. financial, genetic, technological) and benefit-sharing for all actors along the value chain. Ensuring healthy diets and a healthy planet will require rebalancing both production and consumption.

How we set out to achieve targets under SDG 2 will have enormous consequences for the persistence of nature and its contributions to people (Figure S3.1). There is a high potential for trade-offs between targets 2.1–2.3 (i.e. increasing food production and reducing malnutrition) and targets 2.4 and 2.5 (improving sustainability and biodiversity within our farming systems). A continued and focused reliance on land clearing, intensive use of agrochemicals and homogenization of crop diversity to maximize productivity will continue to degrade the underlying biodiversity and regulating services upon which agriculture depends, as well as failing to deliver nutritious food. There are numerous potential pathways to achieving SDG 2 that could have strongly negative impacts on nature and NCP. Biodiversity of the soils, crops and management practices offer huge potential to address SDG 2 (see section S3.5).

Target 2.1: By 2030 end hunger and ensure access by all people, in particular the poor and people in vulnerable situations including infants, to safe, nutritious and sufficient food all year round.
Globally, total food production has been increasing at an average of 2.2% per year since the 1960s, with developing countries contributing significantly to this growth at 3.7% per year (FAO, 2002). Despite enormous gains in food production over the past half-century, 815 million people remain hungry (FAO *et al.*, 2017). Chronic hunger exists primarily in poorer countries, such as those in sub-Saharan Africa, Central Asia and the Indian subcontinent (FAO *et al.*, 2017). Chronic and acute hunger can be due to several different and compounding causes, including low yields and crop failure, but is increasingly driven by distributional issues and poor access to financial markets, as well as the breakdown of social safety nets and political strife (Sen, 1981). In many parts of the world, when food reserves or access to food is low, wild foods often provide important nutritional safety nets (Bharucha & Pretty, 2010; Penafiel *et al.*, 2011; Schulp *et al.*, 2014), particularly of rural, poor and disadvantaged groups (Kaschula, 2008). Wild foods are inexpensive and nutritionally important sources of energy, micronutrients and dietary diversity (Arnold *et al.*, 2011; Penafiel *et al.*, 2011). Although largely undocumented, wild foods represent important food intake globally (Scoones *et al.*, 1992) and reliance on wild foods has been found to be most important for meeting food security needs in areas of high biodiversity (Penafiel *et al.*, 2011). Wild species are often incorporated into home gardens and help to provide an important flow of food year-round (Freedman, 2015). For example, the Naxi people of China sustain their food supply during droughts by having a wide range of edible plants (38 cultivated, 103 wild), strong landrace crop diversity, and by eating all parts of plants (Zhang *et al.*, 2015). In addition to harvesting wild plants, it is estimated that 150,000 people in forest ecosystems of the Neotropics and 4.9 million people in the Afrotropics consume ~6 million tons of wild mammal meat every year, an important source of protein (Swamy & Pinedo-Vasquez, 2014). Insects are another important wild source for protein, with over 1700 known species consumed by traditional cultures, most from the Lepidoptera family, i.e. butterfly and moth larva (Ramos-Elorduy, 2009). However, it's likely that demand for these products will grow as populations in rural areas are set to double in size in places such as Africa and as harvesting techniques become more efficient.

Although data on bushmeat catch is patchy, current levels of harvesting are thought to be unsustainable and are likely to lead to species population crashes (Wilkie *et al.*, 2011). According to the IUCN Red List, over 1680 terrestrial animal from comprehensively assessed groups (19%) are threatened by overexploitation, 1118 freshwater and marine animals (13%) by fishing and a further 557 plants (6%) from gathering (Maxwell *et al.*, 2016). In some cases, demand for traditional and wild foods comes from wealthy and more urbanized households, rather than local communities (Brashares *et al.*, 2011). This demand can create a commodity market for wild species, increasing harvesting pressure and uncoupling the link to local diets. Policies that enforce protected areas but allow regulated access by local communities can help to preserve the flow of wild foods into diets of vulnerable communities and help achieve target 2.1. In order to do this, better and uniform metrics based on specific biological indicators are needed to evaluate the sustainability of wildlife harvests in hotspots of bushmeat consumption (Weinbaum *et al.*, 2013). To ensure that wild species continue to provide critical food sources, and that people have access to these resources, it is essential that species' habitats are protected, and harvesting is regulated to sustainable levels. Since 1990, there has been a global increase of 75% in conservation areas, which has helped to secure habitat for some populations. However, the biggest threats to wildlife remain overexploitation (46% of threatened and near threatened species) and encroaching agriculture (IUCN, 2012; Juffe-Bignoli *et al.*, 2014; Maxwell *et al.*, 2016; Swamy & Pinedo-Vasquez, 2014).

Beyond chronic hunger, this target highlights nutritious food as key to this SDG. To achieve a basic minimum level of health, people must consume both sufficient calories and sufficient macro and micronutrients. Two billion people experience micronutrient deficiencies (International Food Policy Research Institute, 2015; Rowland *et al*., 2015). A leading cause of micronutrient deficiency is a lack of sufficient diversity in the foods consumed. The widespread adoption of high yielding crops and western diets, supported by an increasingly homogenized global farming system (Khoury *et al*., 2014) has provided cheap calories to stave off hunger, but has significantly narrowed diets, replacing traditional and high micronutrient crops (e.g., Raschke *et al*., 2008) – a trend which has limited progress to aspects of this target **(Figure 3.13)**. Of the 7000 edible crops cultivated in human history, today just 12 crops and 5 animal species provide 75% of the world's food (FAO, 2015c). This has eroded the biological diversity, at both the genetic and species levels, on which our farming practices depend (Chappell & LaValle 2011). Compounding this problem, these high-yielding crops (rice, wheat, maize) tend to have lower micronutrient content than the traditional cereals they displace in local diets, e.g., millets, sorghum, barley, oats, rye (DeFries *et al*., 2015). This may be in part a result of the overuse of mineral fertilizers that can render soils devoid of micro-organisms important for making micronutrients bioavailable to plants, e.g., zinc (Cardoso & Kuyper, 2006). This has further links to the dual challenge of both high rates of chronic under-nutrition and rising adult obesity. Over 600 million people are obese, mostly in Europe, North America and Oceania, with many developing countries exhibiting this double burden of malnutrition (FAO *et al*., 2017).

There is strong scientific evidence, at the individual (Steyn *et al*., 2006) and national level (Remans *et al*., 2014), that increasing dietary diversity and food supply diversity are associated with positive health outcomes on acute and chronic childhood malnutrition, particularly for low income countries. In addition to agriculture, fish can provide important sources of protein and micronutrients to vulnerable populations (Kawarazuka & Bene, 2010). In 2015, fish accounted for 17 per cent of animal protein and provided 3.2 billion people with nearly 20 per cent of their average per capita intake of animal protein (FAO, 2018b).

Target 2.3: By 2030, double the agricultural productivity and the incomes of small-scale food producers, particularly women, Indigenous Peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.

Most farmers globally are smallholder farmers with less than 2 hectares of land, dominating agriculture across Africa and Asia, while moderate and large-scale farming dominates across much of Europe, North America, Australia and parts of South America (Fritz *et al*., 2015). Small-scale producers play a critical role in agricultural, aquacultural and capture fisheries productivity (FAO, 2016). It is estimated that approximately 500 million family farmers are responsible for producing 50–80% of our food (FAO, 2014a; Graeub et. al 2016). Meanwhile, approximately 56.6 million people were employed in capture fisheries and aquaculture in 2014 (FAO, 2016) of which small-scale fisheries constituted 90% of people employed in capture fisheries (FAO, 2016) and approximately half of the fisheries sector workforce is estimated to be women. Today, family farms still account for 98% of all farms, and are estimated to manage 53% of agricultural land (Graeub *et al*., 2016). As human populations are set to rise to 9 billion, increasing yield on existing croplands, especially smallholder farms where large yield gaps persist (Fischer *et al*., 2002), will be an essential component of achieving this target (FAO, 2009).

Increasing smallholder farmer access to improved crop varieties, high quality seed and inputs will be three important elements for achieving this target (see Supplementary Materials for review). Access to water is another significant limitation to increasing crop production. Many low-yielding regions experience water-stress due to low and variable rainfall as well as poor soil water retention (Brauman *et al*., 2013). In sub-Saharan Africa, 95% of agriculture depends on moisture from rain held in the soil or 'green moisture' (Rockstrom & Falkenmark, 2015). However, across much of the continent, most rain evaporates from the air and soil before creating run-off, meaning little recharge of lakes and rivers. This makes traditional irrigation infeasible as lakes and reservoirs quickly empty (Rockstrom & Falkenmark, 2015). Other regions in which irrigation is not viable include highly populated places such as northern China and central India where smallholder farming dominates. By 2025, it is expected that as much as 60% of the global population may suffer water scarcity and rely on non-conventional water resources to meet their water needs (Qadir *et al*., 2007) Smallholder, farmers will need to manage their fields and landscape to increase 'green water' storage in soils and the water table (Wani *et al*., 2009). Methods to improve 'green water' retention aim to increase soil organic matter, improve soil structure and reduce evapotranspiration and include mulching, minimum tillage and use of bunds among other land management techniques (Palm *et al*., 2014; see Supplementary Material S 3.5).

Assessments of global climate change which shows that 'blue' and 'green' water availability may be so severely affected in parts of Asia and Africa that these regions may no longer be able to sustain certain diets (Gerten, 2013). Taken together these trends in crop varieties, seeds, and inputs from NCP available to small-scale farmers, as well as trends in access and tenure from SDG 1, have limited progress to this target.

Tracking contributions and productivity from small-scale fisheries and aquaculture is a major ongoing research and management challenge. Nonetheless, it is recognized that the management of small-scale capture fisheries needs to improve not only for food security and nutrition, but also to ensure the equitable distribution of benefits and socioeconomic conditions of small-scale fishing communities. These goals are reflected in the Voluntary Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines), which were endorsed in 2014. The SSF Guidelines are intended to improve small-scale fisheries governance and food security. The small-scale aquaculture production sector is constrained by various factors, including access to financing, a lack of technical innovation, an absence of feed formulation and processing knowledge, and insufficient training. Public–private partnerships may provide an avenue to provide more resources and share knowledge to increase productivity (FAO, 2016).

Target 2.4: By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

Much progress in reducing hunger has been achieved through the widespread use of high yielding crop varieties (including some genetically modified organisms), increased access to fertilizers (via industrialized N_2-fixation, via the Haber-Bosch process) and expanded irrigation developed during the Green Revolution. There is also significant evidence this intensification has been accompanied by deteriorating agroecosystem health from the erosion of topsoil, loss of soil structure, eutrophication of waterways and decline in farmland and soil biodiversity (Millennium Ecosystem Assessment, 2005). In Africa, low inherent soil fertility (Aihou *et al*., 1998), insufficient fertilizers use (Druilhe & Barreiro-Hurlé, 2012) and poor soil management practices are primarily to blame for land degradation. There is clear evidence that conventional agricultural intensification, along with overgrazing of livestock, has widely contributed to loss of critical NCP and function through erosion of topsoil and loss of soil structure, which has led to widespread land degradation (Millennium Ecosystem Assessment, 2005). Today over one third of croplands (1–6 GHa) have been degraded, impairing their ability to sustain high food production (Millennium Ecosystem Assessment, 2005; Pimental & Burgess, 2013) resulting in an assessment of negative trends preventing progress to this target **(Figure 3.13)**.

Substantial trade-offs with target 2.3 to double productivity are possible if previous approaches to productivity are relied upon. Conventional approaches rely on increasing external inputs (i.e. mineral fertilizers, pesticides, irrigation) to supplement or substitute ecosystem processes such as nutrient cycling, water retention and pest control in fields to boost yields (Bommarco *et al*., 2013). Widespread and continued adoption of input-intensive forms of agriculture are dramatically altering nitrogen, phosphorus and potassium cycles as well as sediment and erosion processes (Steffen *et al*., 2015). Excess fertilizers washed into water systems can cause eutrophication and algal blooms, impacting downstream freshwater and coastal fisheries.

Between 1995 and 2011, the number of known eutrophication zones rose from 195 to over 515 worldwide (Rabotaygov *et al*., 2014). Today the total global number of reported eutrophication points experiencing large algal blooms is >760 and increasing annually (WRI dataset; Diaz, 2013). The impacts of algal blooms and the dead zones the create (i.e. areas of low oxygen or hypoxia) may be particularly important for the 10–12% of the global population who depend on coastal fisheries and aquaculture for their livelihoods, 85% of whom are small-artisanal fisher folk (FAO, 2014a). An increasing number of blooms are toxic, releasing harmful toxins that can poison aquatic species and the people consuming them, particularly shellfish (Mulvenna *et al*., 2012). These are important food sources for which provide 15–20% of protein in many coastal communities (FAO, 2014a). Over the past 50 years, nitrogen-use-efficiency has improved dramatically in some parts of the world, actually reducing inputs while maintaining or increasing yields (e.g., France, Netherlands, Greece), while other countries have continued to increase fertilizer application with diminishing returns (Lassaletta *et al*., 2014). However, major disparities worldwide exist in the application (West *et al*., 2014) and efficiency of fertilizer use for key crops (Lassaletta *et al*., 2014). It is also important to acknowledge that input-scarce farming practices can be almost as damaging as input-intensive ones. Insufficient application of nutrients, excessive tilling, overstocking of animals and low crop diversity can also lead to degradation of soils and high erosion rates, impairing food production and damaging ecosystems (Lassaletta *et al*., 2014; Liu *et al*., 2010; Rudel *et al*., 2016; Vitousek *et al*., 2009). Indiscriminate use of pesticides also contributes to problems of water quality, negative impacts on farmland biodiversity and ecological functioning (Chagnon *et al*., 2015; Simon-Delso *et al*., 2015). In particular, insecticides can negatively affect decomposition, nutrient cycling and soil respiration, in large part through their negative impact on beneficial invertebrate populations that carry out these processes (Chagnon *et al*., 2015).

Increasing intensification of agriculture in terms of both agrochemical use and landscape simplification (fewer crop types, rotations and remnant habitats) has negatively impacted farmland species critical for food production. Seventy-five per cent of major crops require some degree of pollination (Klein *et al*., 2007). Loss of adequate habitat within the agricultural matrix (e.g., grassland and forest patches, hedgerows etc.) high use of agro-chemicals and the large-scale transport of hives over great distances is thought to contribute to the widespread decline of pollinators (Simone-Finstrom *et al*., 2016). Over 40% of pollinator species are threatened (IPBES, 2016), which may lead to pollinator-limited yield declines (Basu *et al*., 2011). These crops also tend to be high-value fruits and vegetables and primary sources for key micronutrients such as vitamin A, iron and folate (Eilers *et al*., 2011), affecting efforts to achieving SDG 2.1 and 2.2 on healthy diets and malnutrition. Preservation of natural vegetation within agricultural landscapes for nesting and feeding habitat (Kremen *et al*., 2004), along with reduced use of harmful agro-chemical such as neonicotinoids can help to maintain pollinator communities in landscapes and pest control services. These findings highlight negative trends in features relevant to achieving this target **(Figure 3.13)**.

In contrast to conventional intensification, 'agroecological' intensification is a means "by which farmers simultaneously increase yields and reduce negative environmental impacts through the use of biodiversity-based approaches and the production and mobilization of ecosystem services" (Atwood *et al*., 2017). These farming approaches, are based on the integration of ecological principles and stimulation of biodiversity interactions within fields and farms to increase productivity, reduce external inputs, and build long-term fertility for healthy ecosystems (IPBES, 2016; see Supplementary Material for review).

One of the greatest threats to agriculture is climate change. Climate change projections indicate that in every decade until 2050, food production will decline on average by 1% (Porter *et al*., 2014), but in Africa and Asia major crop yields will face an estimated average decline of at least 8% by 2050 (Knox *et al*., 2012; Schlenker & Lobell, 2010). Our farm systems are vulnerable to both rising temperatures as well as weather extremes (drought, floods etc.). Ironically, agriculture is also one of the largest emitters of greenhouse gases (GHG), accounting for 24% of carbon dioxide (CO2) emissions globally (IPCC, 2014). This is a result of multiple factors including loss of carbon following the destruction of native habitat (Fearnside, 2000), massive methane (CH4) emission from rice paddies – the second most widely planted stable crop –(van Groening *et al*., 2013) and nitrous oxide (N_2O) emissions from the application of fertilizers (Gerber *et al*., 2016). In addition, significant emissions of CO_2 are emitted from the fossil fuel inputs needed to make agrochemicals and operate machinery (Verma, 2015). Judicial use of inputs, paired with improved agro-ecological management of agricultural systems can help to improve the energy-intensity of farming practices, sequester carbon and build resilience (see Supplementary Materials).

Target 2.5: By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed.

Agrobiodiversity encompassed in agricultural systems from genes to cultivar varieties and crop species, up to landscape composition, is a central element of our cultural heritage (Pautasso *et al*., 2013) and an important resource for sustainable development. The genetic diversity of both wild and cultivated species provides the basic material for crop and livestock improvement, resilience to stress and adaptation to changing conditions. The use of crop diversity in-field can improve soil function, pest control, pollination (Hajjar *et al*., 2008), yield stability (Di Falco & Chavas, 2009), resulting in improved income stability (Abson *et al*., 2013). Under an unpredictable climate, a diversity of genotypes or crops and/or livestock offers basic insurance as some varieties perform better under hot or dry conditions than others. Genetic diversity also offers the potential to develop new varieties or cultivars with beneficial traits such as resistance to emerging diseases, environmental tolerances or longevity. Wild relatives of crops that have not been domesticated provide an important genetic resource pool as they have continued to evolve under ambient environmental conditions and selection pressures, with which cultivated species can be back-crossed to acquire desirable characteristics (Dempewolf *et al*., 2014). Crop wild relatives have been and are increasingly being used in breeding programs to fight diseases and develop land races to cope with environmental stressors (Dempewolf *et al*., 2014; FAO, 2015c).

There are four types of plant genetic diversity which are important to differing degrees for breeding: wild relatives, ecotypes, landraces and cultivars (Boller & Vetelainen, 2010). Traditionally, seed exchange between farmers was central to the maintenance of agrobiodiversity (Pautasso *et al*., 2013). Modern investments and improvements in specific cultivars have led to their widespread adoption and uniformity in composition across farmlands and even between countries (Khoury *et al*., 2014). Of the 7000 crops cultivated in human history (Khoshbakht and Hammer, 2008), only 12 crops —and even fewer cultivars of those species—contribute significantly to food production and consumption today (Khoury *et al*., 2014). Such trends signal limited or mixed progress to this target **(Figure 3.13)**. Low species and genetic diversity can leave crops vulnerable to biotic and abiotic stressors (Hajjar *et al*., 2008; Zhu *et al*., 2000).

While, the genomes of the most important staple crops (e.g., rice, wheat, maize and potato) have been the subject of extensive research, conservation and development by both non-profit (e.g., International Rice Research Institute, International Maize and Wheat Improvement Center, and the International Potato Center) and agribusinesses (e.g., Syngenta, Monsanto) for decades, significantly fewer resources have gone into identifying, developing and securing the genetic diversity found in farmers' fields (FAO, 2015c). Individual country and species case studies suggest continued loss of crop genetic diversity through the widespread replacement of traditional varieties with modern high-yielding cultivars and due to land clearing, overgrazing and changing agricultural practices (FAO, 2015c). While moderate success has been made to increase the number and representation in genebanks over the past two decades, many accessions remain at risk of technical failure (FAO, 2015c). For this reason, traditional farmers who plant, maintain and exchange diverse crops, trees and wild species will remain increasingly important partners in efforts to conserve genetic resources and to identify high performing cultivars in the face of climate change and other stressors (Pautasso *et al*., 2013; Sthapit *et al*., 2014). There are substantial numbers of under-utilized and promising new species that are known to local farmers or cultivated on small scales but could benefit substantially from research investments for their promotion. The program PROTA in Africa identified 15 new cereals and 90 vegetable plants that are ideal candidates for promotion as well as protection (Lemmens & Siemonsma, 2008). Support for these efforts through agreements such as the International Treaty on Plant Genetic Resources, and the

Nagoya Protocol are critical for the conservation, exchange and sustainable use of the world's plant genetic resources in the public domain, and ensuring equitable access and benefit-sharing for all farmers.

Widespread homogenization of foods systems and genetic erosion of crop and livestock species can present a serious threat to food system sustainability (Aguilar *et al*., 2015). Much of this comes from the replacement of local and traditional land races and breeds with modern high-yielding cultivars (Biscarini *et al*., 2015), indiscriminate cross-breeding practices that leads to loss of unique species, and declining demand for animal labour with mechanization (Quaresma *et al*., 2013). Some 38 species and 8,774 separate breeds of domesticated birds and mammals are used in agriculture and food production (FAO, 2015c). However, 17% of these animal breeds are currently at risk of extinction, while the risk status of many others (58%) is simply unknown (FAO, 2015c). From 2000 to 2014, nearly 100 livestock breeds are thought to have gone extinct (FAO, 2015c). For livestock our assessment therefore shows negative trends for the target **(Figure 3.13)**. North America, Europe and the Caucasus have the greatest proportion and absolute number of breeds at risk. New efforts by groups such as the EU Globaldiv project to document goat genetic diversity across regions and continents (Ajmone-Marsan *et al*., 2014) and large genomic databases, such as the Domestic Animal Genetic Resources Information System (DAGRIS) are needed to provide systematic information on the diversity, distribution and classification of livestock, in order to properly manage and maintain these genetic resources (Dessie *et al*., 2012).

Crop wild relatives (CWR) also supply an important flow of genetic resources to support agriculture, however they are threatened by clearing and degradation of native habitats (McGowan *et al*., 2018). CWR are poorly represented with many having few or no accessions in gene banks, and over 95% insufficiently represented across their full geographic and ecological range (Castaneda-Alvazez *et al*., 2016).Wild species pollinated by insects are particularly vulnerable to loss of outcrossing and genetic erosion associated with landscape modification (Eckert *et al*., 2010) and fragmentation (Vranckx *et al*., 2012). In addition, climate change may also pose growing threat to CWR populations (Phillips *et al*., 2017). In the global protected areas network, areas of high CWR are underrepresented. Traditionally, the highest diversity of CWR occurs near the centres of origin of crop domestication (Hummer & Hancock, 2015; Vavilov, 1926), and thus incorporating CWR into *in situ* and *ex situ* conservation plans in these regions will be important for preserving wild genetic resources (FAO, 2015c). Recently, the IUCN 'Plants for People' project has set out to assess the status of 1500 priority CWR. In 2017, 26 species of wild wheat, 25 species of wild rice and 44 species of wild yam, and for the first time three species of wild rice, two species of wild wheat and 17 wild yam species have been listed as threatened on the Red List (IUCN, 2017). As more species are assessed, the IUCN Red List will become an increasingly important tool for measuring progress towards this target **(Figure 3.13)**.

SDG 3: Good health and well-being

Goal 3 of the SDGs calls for the reduction of – and end to – premature and preventable deaths associated with maternal and infant mortality, diseases (including non-communicable diseases), and deaths and illnesses from hazardous chemicals and pollution. Human health is intimately linked to nature and NCP through food, water, medicines, as well as through multiple other pathways linking nature to human well-being. For a subset of the targets listed under SDG 3 there are clear linkages between health and nature and NCP. However, there are also several more complex relationships between nature and NCP that can include positive and negative impacts on health (Oosterbroek *et al*., 2016). The links between nature and NCP to achieving the targets under SDG 3 follows several pathways which we outline below including direct impacts and ecosystem-mediated impacts.

Direct impacts of Nature and NCP on human health

Nature and NCP can have a direct impact on human health by providing nutrition (macro- and micronutrients) and as a source of traditional medicine or novel compounds for use in medicine. Large segments of the world's population depend on the consumption of wildlife for the provision of protein and micronutrients. Biodiversity declines directly threaten human nutrition and health through reduced food availability (Myers *et al*., 2013; SDG 2). It is estimated that between 1.39 and 2.9 billion people gain around 20% of their annual protein from fish (FAO, 2014a; Golden *et al*., 2016). These numbers reflect the importance of fish in the diet for vitamins and micronutrients that are essential for healthy functioning of the human body (Black *et al*., 2008; McLean *et al*., 2008). For example, deficiencies of the micronutrients found in fish (i.e. iron, zinc, vitamins A and B12, fatty acids) lead to increased risk of perinatal and maternal mortality, growth retardation, child mortality, reduced work productivity, cognitive deficits, and reduced immune function, with very large associated global burdens of disease (Black *et al*., 2008). Micronutrient deficiencies can also be ameliorated by consumption of bushmeat, ideally from sustainable sources (Rowland *et al*., 2017). A study of preadolescent children in rural Madagascar showed that consuming more wildlife was associated with significantly higher hemoglobin concentrations. Modelling suggested that loss of access to wildlife would cause a 29% increase in the numbers of children suffering from anaemia, with a much greater increase in poorer households (Golden *et al*., 2011).

Traditional herbal medicines have been defined as: "naturally occurring, plant-derived substances with minimal or no industrial processing that have been used to treat illness within local or regional healing practices" (Tilburt & Kapcuck, 2008). A few traditional medicines are now traded globally, but for many countries particularly in Africa, Asia and Latin America, locally-collected traditional medicines are a major resource for meeting primary health care needs (Dudley & Stolton, 2010). An estimated 60,000 species are used for their medicinal, nutritional and aromatic properties worldwide (UN Comtrade, 2013 analyzed in CBD, 2015) and at least 60% of medicinal plants are gathered from the wild, with some countries like India and China reportedly harvesting much higher proportion, at around 80–90% (Alves & Rosa, 2007; Muriuki, 2006). Many of these species are known to be declining in abundance due to overharvesting and habitat loss. For example, approximately 15,000 species of global medicinal plants are now classified as endangered (Schippmann *et al*., 2006). Among amphibians, around 47 species were reported to be used in traditional medicines, with a third of species belong to the family Bufonidae. Despite the number of species identified as used for traditional medicine the efficacy of most traditional medicines is not well understood, nor are the links between loss of plants and animals used in traditional cures and their concomitant impacts on human health and well-being. This is largely due to the experiential nature of most forms of traditional medicine and because they are passed on orally and so not easily harmonized with mainstream health systems or integrated in public health care (CBD, 2015).

In the last 30 years more than 2,500 different chemical compounds have been identified from marine plants and animals (Tibbetts, 2004) and between 1981 and 2010 more than 677 of the drugs approved by the US Food and Drug Administration originated in nature (Newman & Cragg, 2012). The untapped potential of the natural environment to provide novel compounds for drug development is unknown, therefore it is hard to say with certainty what impact biodiversity decline will have on the discovery of new compounds for medicinal use. There are an estimated 391,000 species of vascular plants currently known to science (RGB Kew, 2016) and of these only a small sample have been studied for their potential role in pharmacology (CBD, 2015). Of known plant species 21% are estimated as being currently threatened with extinction according to IUCN Red List (RGB Kew, 2016), while the equivalent figure for animals is 19–34% (best estimate = 22%, based on analysis of data in IUCN, 2017; see section 3.2, **Figure 3.4a**).

Amphibians have evolved a huge variety of biologically active compounds to defend against predators and infection – and many of these hold the potential to be important for the development of new medicines (Chivian & Bernstein, 2008). More than 800 alkaloids (compounds with a wide range of pharmacological uses including as non-opioid analgesics), 200 antimicrobial peptides, several hundred bioactive peptides and a range of other novel compounds such as 'frog glue' (non-toxic, high bonding strength secretions with a range of applications in industry and medicine; von Byern *et al*., 2017) have been identified within amphibian species to date (Chivian & Bernstein, 2008; Daly *et al*., 2005). Some of these unique compounds cannot, as yet, be recreated in a laboratory setting. For example, the amphibian alkaloid compounds extracted so far seem to be created through the ingestion and uptake of alkaloids from ants, mites, beetles and millipedes (Daly *et al*., 2002). The extent and severity of amphibian declines are the largest of all vertebrate taxa, with an estimated 32–55% (best estimate: 42%) of all species classified as threatened with extinction (IUCN, 2017; **Figure 3.4a**). An estimated 168 amphibian species are thought to have gone extinct in the wild in recent years (Stuart *et al*., 2004), raising the very likely probability that many compounds potentially of use in human medicine have, or will soon vanish before being discovered. Other taxa identified with a significant number of potential sources of novel medicine include bears, sharks and horseshoe crabs (Chivian & Bernstein, 2008). While bioprospecting, wild harvesting and laboratory experiments on animals all carry their own drawbacks and ethical considerations, the utility of wild species to provide templates for novel avenues of research, synthesis of artificial compounds and inspiration for drug development cannot be ignored.

Ecosystem mediated effects on health

Nature and NCP can also impact human health through ecosystem level effects on the productivity of agricultural landscapes (dependent on pollinators), freshwater and ocean water quality, air pollution, the prevalence of zoonotic diseases, mental and physical health, and protection from natural disasters. These ecosystem-mediated impacts are central to several of the targets in SDG3 (and SDG 1 and 2). For example, declines of wild and domesticated pollinators are well documented (Potts *et al*., 2010). Pollination by insects is an important form of reproduction for at least 87 types of leading global food crop which make up over 35% of the annual global food production by volume, declines in the distribution and abundance of pollinators therefore have significant repercussions for both agricultural productivity and human nutrition (Klein *et al*., 2007; Whitmee *et al*., 2015). Depending on diet composition, in South-East-Asia up to 50% of plant derived sources of vitamin A require propagation through pollination while iron and folate have lower, but still significant pollinator dependence, reaching 12–15% in some parts of the world (Chaplin-Kramer *et al*., 2014; Ellis *et al*., 2015). A recent modelling exercise calculated that if worldwide declines in pollinators resulted in a 50% loss of pollination services from the food supply chain, that the impacts of reduced availability of vitamin A and folate could increase global deaths yearly from non-communicable and malnutrition-related diseases by c. 700,000 and disability adjusted life-years (DALYs) by c.13.2 million (Smith *et al*., 2015).

Target 3.2: By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births.

Approximately 80% of diarrheal disease — the second leading global cause of death of children under the age of five — is attributable to unsafe water and insufficient hygiene and sanitation (Prüss-Üstün *et al*., 2008). This diarrheal disease burden is disproportionately experienced by low- to middle-income countries, particularly in sub-Saharan Africa, Southeast Asia, Latin America and the western Pacific (Prüss-Üstün *et al*., 2014). Addressing this problem requires a systemic approach focused on improving sanitation, hygiene and water access while also decreasing pollution from land management practices (Myers *et al*., 2013). Diarrhea is both a water-borne and water-washed disease with clear links to SDG 6 (i.e., both water quality and water quantity is key) (UNICEF, 2006).

UNICEF (2005) estimates that 3 billion people lack access to sanitation facilities and another 1.3 billion lack access to improved water sources. Inadequate access to water, sanitation, and hygiene is already estimated to cause 1.7 million deaths annually and the loss of at least 50 million healthy life years (Myers & Patz, 2009). As a result, rural populations directly rely on rivers, streams, lakes and ponds, and, therefore, on NCP to provide clean, ample water for consumption, sanitation, and hygiene. Forested watersheds play an important role in maintaining water quality, enhancing water use efficiency, and stabilizing the hydrological cycle (Lal, 1993). Natural forests may enhance river water quality by preventing soil erosion, trapping sediments, and removing nutrient and chemical pollutants, reducing microbial contamination (fecal coliform bacteria, cryptosporidium, fungal pathogens) of water resources, and preventing salinization (Cardinale *et al*., 2012; WHO & CBD, 2015 and references therein). Upstream tree cover is associated with a smaller probability of diarrheal disease downstream in rural communities (Herrera *et al*., 2017; Pienkowski *et al*., 2017).

Plant and algal species diversity enhances the uptake of nutrient pollutants from water and soil (e.g., Cardinale *et al*., 2012), and water purity is enhanced by some animal (such as the copepod *Epischura baikalensis* in Lake Baikal, Russia; Mazepova, 1998) and plant species (e.g., *Moringa oleifera* seeds and *Maerua decumbens* roots are used for clarifying and disinfecting water in Kenya; PACN, 2010). In marine ecosystems, numerous scientific studies have shown that filter feeders play an important role in water purification and elimination of suspended particles from water (Newell, 2004; Ostroumov, 2005, 2006). Bivalve molluscs of both marine and freshwater environments have the ability to filtrate large amounts of water (Newell, 2004; Ostroumov, 2005). Molluscs may also reduce pharmaceuticals and drugs from urban sewage (Binellia *et al*., 2014). One mussel species of Chilean and Argentinean freshwater habitats, *Diplodon chilensis chilensis* (Gray, 1828) plays a key role in reducing eutrophication, both by reducing total phosphorus (PO4 and NH4) by about one order of magnitude and also by controlling phytoplankton densities. Mangrove wetlands have also been shown to remove heavy metals from water (Marchand *et al*., 2012). Yet, habitat degradation and biodiversity loss often continue to hamper the ability of ecosystems to provide water purification services.

The impacts of trends in nature and NCP on water resources and therefore diarrheal disease burden depend on many ecological and socioeconomic factors, making generalizations difficult (we therefore assign mixed or uncertain status to this target in **Figure 3.13**). Natural factors include climate, topography and soil structure, while socioeconomic factors include economic ability and awareness of the farmers, management practices, and the development of infrastructure. In the case of forest systems, the precise impact of catchments on water supply varies dramatically between places and in relation to age and composition of the forest (Stolton & Dudley, 2003). There appears to be a clear link between forests and water quality, a much more sporadic link between forests and water quantity, and a variable link between forests and flow regulation (Stolton & Dudley, 2003).

Target 3.3: By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.

Infectious diseases are caused by pathogenic microorganisms, such as bacteria, viruses, parasites or fungi and can be spread, directly or indirectly, from one person to another (WHO, 2017). Most infectious diseases are zoonotic, i.e. they originate from or have a reservoir in wild or domestic animals (Redding *et al*., 2016). Zoonotic diseases are a significant source of threats to human health, with vector-borne diseases accounting for more than 17% of all infectious diseases and causing more than 700,000 deaths annually (WHO, 2017) and zoonoses originating in vertebrates such as birds, bats and dogs with a 'spillover' effect to humans have caused some of the biggest public health crises of the 21st century – for example the 2014–2015 Ebola epidemic in West Africa (Plowright, 2017) which caused a confirmed 11,310 deaths (although many more are suspected; WHO, 2016) and the H1N1 influenza outbreak (also known as swine flu) in 2009 which caused an estimated 284,500 deaths (Dawood *et al*., 2012).

Complex links between increased human disturbance, land-use change, habitat loss/degradation and biodiversity loss have all been linked to increases in the prevalence and risk of zoonotic disease for a variety of pathogens (Whitmee *et al*., 2015; WHO & CBD, 2015). Causal mechanisms are only well known for a handful of infectious diseases and it is sometimes hard to pick apart the drivers of disease to isolate the direct effects of environmental change from other human actions (Table S3.5). In addition, synergistic effects from other aspects of global environmental change such as the overextraction of water, climate change and the introduction of invasive alien species may also exacerbate disease prevalence and risk (Table S3.5; Hosseini *et al*., 2017; Ostfeld, 2017; Pongsiri *et al*., 2009). We therefore assign an uncertain status to this target indicating this knowledge gap around the trends in nature and their implications for infectious disease **(Figure 3.13)**.

Relationships between biodiversity and disease are multi-directional, with both positive and negative relationships being reported, that is, high biodiversity has been reported to increase and decrease the risk of zoonotic spillover and exposure to vector-borne zoonotic diseases (CBD, 2015; Faust *et al*., 2017). A long-held theory, known as the 'dilution effect', states that declining biodiversity increases disease transmission with the rationale that greater host diversity provides a higher proportion of low competent hosts or provides increased host regulation (aka predation) and therefore 'dilutes' the transmission chain (Faust *et al*., 2017; Keesing *et al*., 2006). Under this assumption intact habitats, high diversity and natural communities can provide protection against disease transmission. However, the impacts of species loss on disease are not straightforward (Dirzo *et al*., 2015). Following a review of recent literature, Wood *et al*. (2014) argue that "conditions for the dilution effect are unlikely to be met for most important diseases of humans. Biodiversity probably has little net effect on most human infectious diseases but, when it does have an effect, observation and basic logic suggest that biodiversity will be more likely to increase than to decrease infectious disease risk" – the so called 'amplification effect'.

Jones *et al*. (2008) found that mammalian biodiversity was a significant predictor of zoonotic spill-over, suggesting that biodiversity contributes to disease emergence risk in conjunction with other socioeconomic and environmental factors. One potential mechanism for this is that areas with high biodiversity may play host to a larger pool of pathogens with the potential to infect humans (Murray & Daszak, 2013). However, evidence supporting this assumption is variable; pathogen diversity and the ability of a pathogen to infect humans seem to differ between taxa and location (Murray & Daszak, 2013; Ostfeld & Keesing, 2013). According to Levi *et al*. (2016) some empirical examples do seem to demonstrate amplification, and certainly patterns are not simple (e.g., Young *et al*., 2013 found no evidence that biodiversity conservation generally reduces the risk of infectious disease in primates). Allen *et al*. (2017) showed globally zoonotic emerging infectious disease risk (EID) risk is elevated in forested tropical regions experiencing land-use changes and where mammal species richness is high.

As both empirical and modelling work delve deeper into these relationships it becomes clear that transmission mode, host and community relationships, host attributes relating to transmission, scaling relationships with area all have to be considered when trying to understand the mechanisms and context-dependence of biodiversity-disease relationships in order to identify how biodiversity loss will affect human disease. Recent modelling work by Faust *et al*. (2017) found evidence for dilution and amplification effects with frequency-transmitted pathogens (pathogens where the proportion of hosts or vectors infected is thought to influence transmission) and amplification effects alone were detected for density-dependent pathogens (pathogens that are transmitted through random contact among individuals or by aerial transmission). Further pathogen-specific research, studies examining suites of diseases in conjunction and placing both impacts and benefits from biodiversity within the broader context of socioeconomic driving forces are needed before these relationships are understood in enough detail to inform conservation policy (Young *et al*., 2017).

We are not able to assess a trend in nature or NCP relevant to this target **(Figure 3.13)**, but in the Supplementary Materials we explore specific diseases of relevance to the target and provide some evidence of impacts of nature and NCP trends on these diseases.

Target 3.4: By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.

The links between nature and mental health and well-being is a new area of focus for research and practice (e.g., Brattman *et al*., 2012; 2015).

The positive effects of time spent in natural environments include better mental health, stress reduction, improved cardiovascular health and social and cultural benefits such as community satisfaction, and reduced social problems (CBD, 2015 and references therein; Chivian & Bernstein, 2008). Green space and tree canopy percentage have also been found to have a positive effect on mental health in some studies, for example in Wisconsin increased green space in neighborhoods was found to be associated with significantly lower levels of depression, anxiety and stress symptoms (Beyer *et al*., 2014). Increased neighborhood green spaces reduce both morbidity and mortality from many cardiovascular and respiratory diseases and stress-related illnesses (Smith *et al*., 2014). Tree canopies have a higher albedo effect than other hard surfaces and can work to reduce the urban heat island effect, lowering heat mortality by 40–99% (Stone *et al*., 2014). Benefits of interaction with nature have been shown for relationships including domestic animals, and wild animals in wild settings in treatments for depression, anxiety and behavioural problems, particularly in children and teenagers (CBD, 2015 and references therein). A systematic review of benefits to health from exposure to natural environments reported that significantly lower negative emotions, such as anger and sadness, were experienced after exposure to a natural environment in comparison with a more synthetic environment in a subset of studies where these were measured (Figure S3.2; Bowler *et al*., 2010). But as this work is new, with limited generalized findings on the relationships between nature and mental health, we note this as a knowledge gap and do not assess progress to this target **(Figure 3.13)**.

"Solastalgia" is a type of distress associated with environmental change caused by degradation of a familiar environment (Albrect *et al*., 2007). The extent and consequences of this condition are not well researched as yet, although an "Environmental Distress Scale" has been proposed to support further quantitative studies (Higginbotham *et al*., 2007).

Target 3.9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.
Many ecosystems can act as natural filters (e.g., wetlands) to help reduce levels of certain pollutants (sediment, N, P, heavy metals) from entering and flowing downstream in our watercourse (Birch *et al*., 2004; Klapproth & Johnson, 2009). Urban air pollution is driven by the combustion of fossil fuels for transport, power generation and other human activities (Stolton & Dudley, 2010). In 2012, 3.7 million deaths were attributable to ambient air pollution with about 88% of deaths occurring in low- and middle-income countries, primarily due to respiratory and cardiovascular disease (Lim *et al*., 2012; WHO, 2014). Healthy trees can help improve air quality and reduce large particulate matter (Nowak *et al*., 2006), but pollution removal rates by vegetation differ among regions according to the amount of vegetative cover and leaf area, the amount of air pollution, length of in-leaf season, precipitation and other meteorological variables (CBD, 2015). A review of studies that looked at the estimated health effects of pollution removal by trees and found some evidence for the role of woodlands and trees in reducing pollution and thus reducing the impacts of pollution on human health, although effect sizes tend to be small, with woodlands in UK helping prevent 5–7 deaths per year, and avoided mortality of around 1 person per year per city in 10 US cities (but reaching as high as 7.6 people per year in New York City) (CBD, 2015 and references therein). There is also evidence that exposure to microbial communities in green spaces can reduce future allergy incidence (Ruokolainen *et al*., 2018).

While trends in key ecosystems such as wetlands or urban forest are relevant, the complex linkages between drivers of pollution, ecosystems as filters, and the resultant health outcomes prevent an assessment of relevant trends in nature for this target.

SDG 11: Sustainable Cities and Communities

Goal 11 of the SDGs aims to make cities safe, inclusive, resilient and sustainable. Nature and NCP will play a role in achieving this goal through the contributions they provide to city populations from local and regional areas including food, water, waste removal and other non-material contributions e.g., recreation. At the same time cities have a large impact on nature and NCP (within and outside the city) with clear linkages to multiple other SDGs. For a subset of targets under SDG 11 there are strong linkages to nature and NCP which we explore here.

Cities constitute a very small percentage of the total surface area of the planet's landscape, estimated at 2–3%, but have regional footprints that are much larger (Gaston *et al*., 2013; Schneider *et al*., 2010). This area and its footprint are projected to grow in the future, with cities holding approximately 60% of the world's population by 2030 and approximately 70% by 2050 (Seto *et al*., 2011; Sukhdev, 2013). A significant proportion of urban growth has occurred and will continue to occur in regions designated as "biodiversity hotpots" (Sukhdev, 2013).

Urban sustainability actions connected with SDG 11 to reduce pollution and increase green space availability and accessibility are relevant to nature, as well as NCP, (Schwarz *et al*., 2017). Green spaces in or near cities provide essential contributions (clean air and water, thermoregulation, and cultural benefits) (Sukhdev, 2013).

Target 11.3: By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.
Tracking progress to this target requires trends in urbanization impacts on nature and NCP, as well as trends in planning and management responses. High-density urban core areas in biodiversity hot spots increased by approximately 283,000 km², accounting for approximately 38% of the total global increase. Lower-density peri-urban areas increased by approximately 157,000 km², accounting for approximately 35% of the total global increase. This net gain in urban built-up areas in these ecologically critical zones came mostly at the expense of rural areas, which

experienced a net decrease of approximately 277,500 km^2 (31%) in area, reducing available farmlands surrounding urban cores. These trends, as well as impacts on nature and NCP due to urbanization in section 3.2, suggest that progress to this goal is negative. As for future trends, based on projected growth under a business-as-usual fossil fuel driven scenario, global urban population within designated biodiversity hotspots will increase to approximately 1.85 billion by 2030 and 2.27 billion by 2050, with the most rapid rate of growth occurring in Africa (Jones & O'Neill 2016). The dramatic expansion in the anthropogenic footprint on the landscape in critical zones creates challenges for achieving SDG 11 targets with respect to nature and NCP due to habitat conversion and fragmentation.

Sustainable urban planning is essential to meeting this target as it will not only lessen the adverse effects of urbanization (e.g., habitat fragmentation, heat island effect, impervious surfaces, invasive species, pollution, etc. (Ma *et al*., 2018)), but also preserve and restore nature and NCP (e.g., green and blue spaces and urban ecological infrastructure) (Li *et al*., 2017). Urban planning is beginning to recognize the previously discounted values of nature and NCP by identifying areas in need of preservation and restoration, but the adoption of common standards, such as the City Biodiversity Index established in 2010, appears to be lagging and uneven (Convention on Biological Diversity, 2015). From a sustainable planning perspective there is progress towards the target but at an insufficient rate**,** due in part to either not knowing how to incorporate nature and NCP into city planning or that not enough cities have made the effort to do so **(Figure 3.13)**. Recent progress remains difficult to assess objectively but appears mixed due to a general lack of assessments based on common frameworks (e.g., CBI) especially for regions projected to experience rapid urban growth in the near term. Such efforts will be increasingly important over the coming decades, as total urban area is projected to increase by as much as 60% by 2030 (Elmqvist *et al*., 2015). Urban commons are particularly under increasing pressure (Derkzen *et al*., 2017), partly due to the growing power of "those who have a less direct relationship to nature's contributions to people for their livelihoods" (Rice *et al*., 2018: 34).

The interdependence of cities and local as well as regional ecosystems therefore compels reconsideration of conventional methods and the adoption of an integrated systems perspective recognizing cities as coevolving human-environment systems (McPherson *et al*., 2016; Wu, 2014). Progress in establishing general baselines established by cities themselves is therefore difficult to assess especially for most of Africa, Asia, and Latin America.

Urban sustainability objectives can be realized through governance mechanisms (administrative, judicial, and legislative) with input from civil society organizations (NGOs, activist groups, etc.) operating locally and in some cases in coordination internationally through umbrella organizations and networks focused on sustainability issues. SDG 11 highlights the importance of inclusive urbanization and planning. The engagement and involvement of local governance in implementing sustainability-oriented measures will be critical to the attainment of Target 11.3 and requires partnerships with local stakeholders. Achieving meaningful results requires engaging local actors and groups in "initiatives informed by open, inclusive and contextually sensitive data collection and monitoring" (Klopp & Petretta, 2017: 92). Further, achieving Target 11.3 will take the integration of the perspectives of both the natural and social sciences (Niemela, 2014), as well as giving proper consideration to "informal greenspaces" and a wide range of cultural groups and demographic cohorts (Botzat *et al*., 2016).

Target 11.4: Strengthen efforts to protect and safeguard the world's cultural and natural heritage. There is underdeveloped literature connecting the preservation of cultural and natural sites of designated heritage value with nature, NCP and GQL. Safeguarding cultural and natural heritage sites enjoys widespread support as embodied in the UNESCO "Convention on World Heritage" (1972). This shared objective is reaffirmed by target 11.4 and falls within the domain of non-material contributions from nature which encompass aesthetic values, educational opportunities, nature interactions, and recreation, and promotes cognitive development. Challenges with non-material contributions (chapter 2.3) therefore apply to this target including a lack of appropriate data, indicators and evidence. Relevant proxy measures identified include aesthetics, cultural heritage, recreational/touristic value, religious and spiritual value, and sense of place (La Rosa *et al*., 2016: 74, 84–85). A "Cultural Capital framework" has been proposed by economically oriented scholars, who recognize the impossibility of quantifying such heritage sites in strictly monetary terms (Wright & Epplink, 2016).

Progress toward attainment of this target is difficult to assess but can be characterized as inadequate but uneven on the basis of geographic and socioeconomic factors **(Figure 3.13)**. Poor progress is based on the assessment of sites characterized as endangered by the UNESCO "List of World Heritage in Danger" registry - over 50 of more than 450 sites are currently highlighted (Turner *et al*., 2012). Scholars have called for the scientific community to engage with local community members to leverage traditional knowledge relevant to the preservation of such cultural and natural heritage sites (Fatoric *et al*., 2017). Doing so will be critical to developing the adaptive capacity necessary to deal with climate change effects on urban centers and may also foster capacity-building by promoting an "exploration of interactions between social and ecological processes" (Horcea-Milcu *et al*., 2016). In this sense, the social processes associated with the preservation of historic sites may function in a transitive, enabling role *vis-à-vis* the maintenance of ecosystems and ecosystem services.

Target 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.

Nature can help protect against natural disasters. Ecosystems in coastal region, mangroves, salt marshes, and coral reefs can attenuate waves and reduce damage from storm, flooding, and erosion events (Barbier *et al*., 2011; Narayan *et al*., 2016; Spalding *et al*., 2014). Coral reefs and salt marshes have highest overall wave attenuation potential. Researchers have found that intact salt marsh and mangroves can be two to five times cheaper than submerged breakwaters (Narayan *et al*., 2016). As the assessment in SDG 14 indicated, all of these coastal habitats have been found to experience declines in extent and condition (Deegan *et al*., 2012; Hughes *et al*., 2018; Richards & Friess, 2016; Valiela *et al*., 2001), suggesting that efforts to use nature and NCP to protect coastal infrastructure and people are jeopardized by degradation of these ecosystems. These trends are likely worse in cities and in areas experiencing urban growth.

Similarly, floodplains and intact river catchments can similarly protect from river flooding events by diverting and holding excess water (Royal Society, 2014). In many regions, forests improve surface soil protection and enhance soil infiltration, prevent soil erosion and landslides, protect riverbanks against abrasion, and regulate microclimate (CBD, 2012; Naiman & Décamps, 1997) Analyses of flood frequency in low-income countries have found that the slope, amount of natural/non-natural forest cover and degraded area explain 65% of variation in flood frequency (Bradshaw *et al*., 2007), and is linked to the number of people displaced and killed by such events, though associations with larger flooding events linked to extreme weather are not conclusive (van Dijk *et al*., 2009). As evidenced by the assessment is SDG 6 and SDG 15, many of these habitats are similarly declining, decreasing their potential to control inland flooding, hence progress to this target is likely negative and insufficient **(Figure 3.13)**.

Target 11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

As discussed under Target 3.9 ecosystems can act as natural filters and help to reduce levels of certain pollutants in water (e.g., heavy metals) and to improve air quality by reducing large particulate matter. Findings from US cities point to avoided mortality of around 1 person per year per city in 10 US cities (but as high as 7.6 people per year in New York City) (CBD, 2015 and references therein). Trends in air quality and waste are available and are highlighted as negative with poor progress (**Figure 3.13**; SDG 3, 6). This will have implications for the environment and hamper progress to this target's aim to reduce these impacts, also highlighted in section 3.2 (see Supplementary Materials).

As highlighted in Target 3.9, pollution removal rates by vegetation differ among regions according to the amount of vegetative cover and leaf area, the amount of air pollution, length of in-leaf season, precipitation and other meteorological variables. Particulate matter is a year-round concern but more so during the winter months, when leaf cover is lost during the autumn until it returns in the spring (Escobedo *et al*., 2011). The perceived need to address air quality has motivated informal greening initiatives at the community level (Gómez-Baggethun *et al*., 2013a). Urban greening and the deployment of green infrastructure can contribute significantly to reducing the adverse airborne impacts of cities (Pitman *et al*., 2015). Urban trees and hedges can lessen air pollution through the uptake of pollutants while providing additional regulating services relating to carbon, soil, and water that benefit both humans residing in these cities and non-human species that co-occur with certain species of trees (Roy *et al*., 2012). Reductions in PM may range from as low as 9 per cent to as high as 50 per cent (Nowak *et al*., 2006). Pataki *et al*. (2011) caution that the outcomes of green infrastructures may vary widely and therefore endorse small-scale projects for evaluation, e.g., neighborhood scale. When initial results in favorable outcomes with respect to air, water, temperature, and health effects, projects can be scaled up for further evaluation at the municipal level.

Target 11.7: By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.

This target seeks to extend green space, especially to those segments of the population considered most vulnerable. Achieving this target involves overcoming societal and spatial constraints. It also requires efforts focused on both nature and NCP within cities, with defined and measurable sub-targets that have generally been lacking in urban planning to date (Nilon *et al*., 2017). Studies conducted in Chile, Great Britain, India, Italy, Japan, Korea, and the United States, found disparities in Urban Green Space (UGS) access for different groups of people, where minorities and poorer populations tended to have lesser access. These studies employed spatial statistical methods to assess disparities in the supply of UGS relative to the level of demand by residents, where proximity affects accessibility (Comber *et al*., 2008; Dai, 2011; La Rosa *et al*., 2018; Lee & Hong, 2013; Rojas *et al*., 2016). This highlights insufficient progress to improved green space access captured in **Figure 3.13**.

The literature elaborates a wide array of benefits of green (and blue) spaces (see SDG 3, and section 3.3.2.3). The urban heat island effect, caused by the prevalence of urban materials that absorb and retain solar energy, increases exposure of residents to extreme heat and elevates the level of heat stress in all living organisms. Green space can provide relief from heat stress to those populations who otherwise lack access to intensive energy amenities such as indoor air conditioning (Gunawardena *et al*., 2017). In addition to avoiding heat-stress exposure, the promotion of green space and better access to green space is well-supported by a number of studies that identify potential health benefits associated with physical activity and social interaction (Gómez-Baggethun *et al*., 2013b; Kabisch *et al*., 2017; Lee & Maheswaran, 2011; van den Bosch & Sang, 2017). Urban settings inherently present challenges that correlate with elevated morbidity and mortality. It has been generally well established that reduced levels of physical activity associated with urban living are positively correlated with an increase in health issues such as cancer, cardiovascular disorders, chronic respiratory diseases, diabetes, obesity, and some mental conditions (van den Bosch & Sang, 2017). Challenges remain for trying to ensure access and public participation and the degree of space availability to develop them (see Supplementary Materials).

3.3.2.3 Cluster 3: Good Quality of Life (SDGs 4, 5, 10, 16)

SDG 4: Quality education

Evidence has shown that environmental education has a positive impact on the knowledge and actions required to help protect biodiversity (Moss *et al*., 2017). However, these results come from surveys of visitors to zoo and aquaria across the world and there is limited evidence to show that the same results would occur in those people with limited access and opportunities to visit such places. Many educational interventions promoting pro-environmental behaviour with children have shown positive results for enhancing stewardship behaviour and nature (Barthel *et al*., 2018; Cheng & Monroe, 2012; Grimmette, 2014) and there is increasing evidence of the role of meaningful nature experiences and pro-environmental behaviour (Ives *et al*., 2017; Miller, 2005; Raymond *et al*., 2010a). There are examples of best practice on education for sustainable development where positive outcomes have been shown (UNESCO, 2012).

Achievement of Target 4.7, which aims for people to acquire the knowledge and skills needed to promote sustainable development, should have a positive impact on nature and NCP (Leadley *et al*., 2014) and achievement of this goal should have far-reaching impacts for many of the SDGs (Figure S3.3). However, this relationship is not linear or simple as education and awareness levels increase globally (Leadley *et al*., 2014), environmental destruction over the last several decades is still occurring at a rapid rate (Cardinale *et al*., 2012; Steffen *et al*., 2017). Investment in environmental education has shown a general though non-significant decline in the last decade and Leadley *et al*. (2014) extrapolated that this will continue to 2020. Furthermore, inequality in access to quality education is a persistent problem.

At the higher level examining the relationship between nature, NCP and education, there is growing work and evidence on the role of access to nature and urban green space for achieving education outcomes (Mocior & Kruse, 2016) as well as in aspects relevant to education including cognitive function and mental health (e.g., Brattman *et al*., 2012, 2015). This is a promising area of future research, especially considering the knock-on effect of education on achievement of other SDGs (Figure S3.3).

SDG 5: Gender equality

There is increasing evidence that encouraging a gender focus on development can have positive impacts that address both gender inequalities as well enhance opportunities for nature and NCP conservation and sustainable use – which in turn can further reduce gender inequities (UNEP 2016d). There has been some progress in ensuring issues related to gender have been included in environmental policies, agreements, projects and programmes over the last several decades (e.g., the three Rio 92 Conventions on biodiversity, desertification and climate change and notably the 2030 Agenda on Sustainable Development which has achieving gender equity as a core goal (UNEP 2016d). These additions have been accompanied by increasing participation of women within these fora as country delegates, bureau members, NGO representatives; furthermore, funders of environmental projects have adopted gender mainstreaming activities in their activities.

The links between gender equality, nature and NCP are complex, context dependent and often a key knowledge and evidence gap **(Figure 3.10)**. Priority issues in promoting gender equality within this gender-and-environment nexus cut across SDGs. A priority issue revolves around access and rights to land, natural resources (NCP) and biodiversity. It has been demonstrated that secure land tenure (not necessarily ownership) is paramount to women's social, economic and political empowerment and achieving this enhances the prosperity of their families and communities (Klugman & Morton, 2013; Field, 2007; Sattar, 2012). However, despite this recognition, only 37% of 160 countries recorded in a study show that women have the same rights as men to own, use and control land (OECD, 2014) and while legislation in more than half of the countries in the study support equal rights for women, religious, customary and traditional barriers prevent gender equality, while in 4% of the countries, women explicitly have no legal right to own, use or control the land.

Another priority topic is women's participation in decision-making processes governing the use of nature and NCP

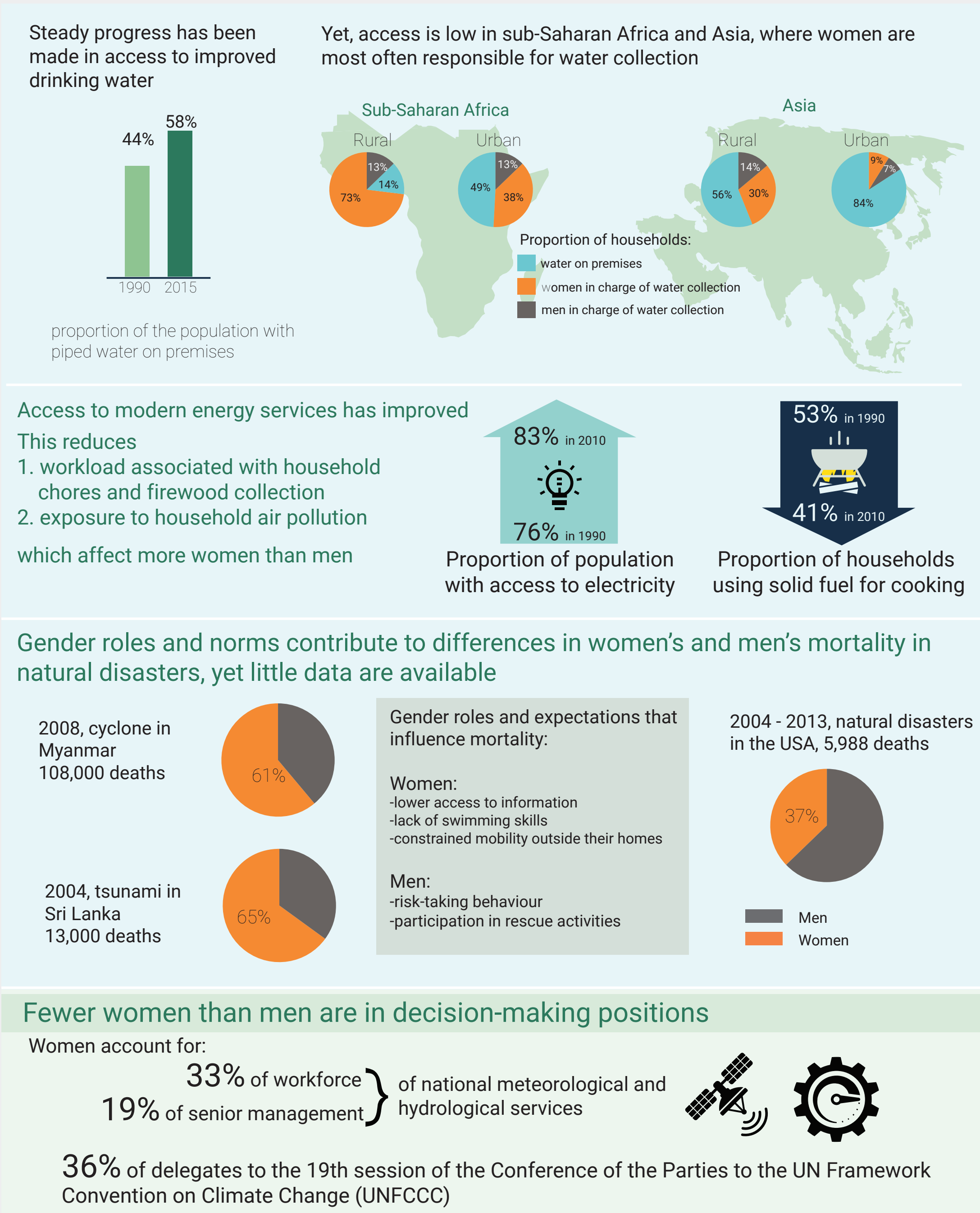


Figure 3 10 **The environment affects women and men differently due to gender inequality.**

Source: UNSD (2015).

has been shown to be fundamental for the sustainable management of those resources (Agarwal, 2010; Ray, 2007). While some studies have suggested potential win-win scenarios for women on average, there are often hidden trade-offs and negative impacts of changes in nature and NCP on women (Daw *et al*., 2015). In terms of biodiversity, notably agrobiodiversity, women play different roles to men, acting as custodians, users and adaptors of traditional knowledge which contributes to food security and seed and plant stock conservation for continued production (UNEP, 2016d). Policies regarding benefit-sharing and access to genetic resources have become increasingly important for marginalized groups as the global trend on privatization of biological resources increases which alters how women are able to use free and self-replicating seeds and the role they play in maintaining agricultural diversity, plant breeding, pest control, ecosystem management for resilience which is often undervalued and performed for free by women and girls (UNEP 2016d; Shiva 2016a).

Mainstreaming gender in development to promote access to and control over resources such land and production inputs, technology, information and innovation, has been shown to increase agricultural productivity, thereby reducing hunger and poverty with further links to many SDGs (UNEP 2016d). In both urban and rural areas, especially in informal settlements and low-income neighborhoods in the global south where basic infrastructure is often lacking, women and girls are more likely to have the primary responsibility for energy, water and sanitation management, with a disproportionate burden on them to produce and collect water, food and fuel (Grassi *et al*., 2015; UNSD, 2015). Although the role of biodiversity is indirect for this goal, it is clear that depletion of nature and NCP, increases the effort and travel distance required to access household necessities such as water, fuel wood, biomass and other forest products. The burden of this falls disproportionately on women and children. Reducing this burden through improved biodiversity management would free up time for other activities including education (Leadley *et al*., 2014).

Also, key to consider are how the impacts of global change, including climate change and biodiversity loss, exacerbate existing gender inequalities, jeopardizing future well-being opportunities with important implications for all SDGs and the intent to leave no one behind (Aguilar *et al*., 2015; Arora-Jonsson, 2011; Nightingale, 2006). A decrease in nature and NCP have gender differentiated impacts with women and girls most often being negatively impacted by these changes (UNEP, 2016d). The gender-differentiated consequences of climate change increases the burden on women to: seek alternative sources of food and income mainly from the utilization of nature and NCP (Bechtel, 2010; Momsen 2007), provide (unpaid) healthcare linked to disaster-related health risks and food and water insecurity (Babugura *et al*., 2010) and secure access to climate-smart agriculture programmes (UNEP, 2016d), often without supportive policy and enabling environments. Land degradation and water and air pollution as a result of the intensification of the use of chemicals in agriculture and industrial production has gendered impacts, with women being affected often to a larger degree than men (Prüss-Ustün *et al*., 2014; 2016). Prevailing assumptions that women control house-hold based consumption choices oversimplify power and gender dynamics related to consumption patterns and the gendering of consumer products increases demand of some products (UNEP, 2016d). This can have negative impacts on nature and NCP especially in relation to the trade of endangered species for cosmetic or medical purposes (Still, 2003). Mainstreaming a gender focus into decisions around natural resources would enable some of these gendered outcomes of local and intra-household dynamics to be more apparent, especially in light of rapid change. Institutional capacity and legal frameworks often inadequately reflect differential gender roles (UNEP 2016d).

Assessing progress to SDG 6, especially the role of nature and NCP in supporting progress, is hampered by a chronic shortage of gender disaggregated information, especially data on biodiversity access, use and control, the differential health impacts of biodiversity change, water use and sanitation, nature-based occupations and whether these occupations are carried out by indigenous women. As the term 'gender' is also often still used as a proxy for 'women' there is little analysis of power relations between men and women within households or society or how intersecting inequalities based on other social characteristics play out in natural resource governance, especially at a household level (Harris, 2011; UN Women, 2014).

SDG 10: Reduced inequalities

Reducing inequality is a cross-cutting issue underpinning the achievement of many of the SDGs in order to leave no one behind (ISSC, 2016; Oxfam, 2017; Piketty & Saez, 2014). Inequalities are multi-dimensional, multi-layered and cumulative (Figure S3.4). Furthermore, inequality, nature and NCP interact in a number of different (and often poorly understood) ways. The majority of research that has looked at these connections considers mainly one-directional linkages between inequality and nature whereas the connections between nature, NCP and inequality are complex, with multiple positive and negative feedbacks, making the achievement of this goal challenging. Most analyses of the relationship between nature, NCP and inequality have focused on economic inequality (e.g., poverty levels) and how it impacts particular environmental variables at a national scale (Berthe & Elie, 2015; Cushing *et al.,* 2015), with limited studies highlighting issues related to other manifestations of inequality such as those relating to gender, education levels, age and other social variables (Hamann *et al*., 2018). In terms of how changes in nature and NCP affect inequality, most of the studies have looked at the impacts of climate change and associated extreme events (Hallegatte *et al.,* 2016; IPCC, 2012; Mendelsohn *et al.,* 2006).

Inequality between communities and people can be amplified or reduced by both sudden and slower incremental changes in nature and NCP (Hamann *et al.,* 2018). Sudden changes in nature and NCP linked to extreme events such as floods, droughts, storms and wildfires have been shown to exacerbate existing inequalities in vulnerable and marginalized communities (IPCC, 2012; Pelling *et al.,* 2002; Turner *et al.,* 2003), especially those already living in degraded landscapes where regulating functions of nature have been eroded (Adger *et al.,* 2005). Other abrupt environmental shocks such as epidemics of zoonotic and epizootic diseases can also enhance inequality through impacting human and livestock health and associated social and economic investments (Elston *et al.,* 2017; Morens *et al*., 2004; Ordaz-Németh *et al.,* 2017). Failure to address the underlying vulnerabilities of communities that rely on nature and NCP for survival and a good quality of life can result in these communities being 'trapped' in poverty should the frequency, duration and intensity of the environmental change overwhelm coping, adaptation or transformation capabilities (Barrett & Carter, 2013). Slower, incremental changes in biophysical variables associated with climate patterns and the distributions of species, notably agricultural (Hatfield *et al.,* 2011) and marine species (Gattuso *et al.,* 2015) can also result in increased inequality between people, communities and nations, as well as between individuals at local levels e.g., with gender-differentiated impacts (Béné & Merten, 2008; Harper *et al.,* 2013).

Inequality also affects nature and NCP indirectly through how it influences human activities and actions, which then positively or negatively affect or impact the quality and state of nature and flow of NCP. There is evidence of the links between inequality and decreasing levels of biodiversity (Holland *et al*., 2009; Mikkelson *et al*., 2007; Pandit & Laband, 2009), with varying evidence on how income inequality impacts environmental quality indicators such as CO_2 emissions, air and water quality (Berthe & Elie, 2015; Cushing *et al*., 2015; Grunewald *et al*., 2017; Hamann *et al*., 2018). A study by Hamann *et al.* (2018) outline how inequality affects nature and NCP through four pathways: perceptions and sense of fairness e.g., in the success or failure of marine protected areas (Chaigneau & Brown, 2016; Edgar *et al.,* 2014) or climate negotiations (Dubash, 2009), aspirations e.g., linked to changes in consumption patterns such as increases in meat consumption which has knock-on effects on local and global biodiversity (Ranganathan *et al*., 2016; Tilman & Clark, 2014), market concentration where asymmetries in resource control can impact the management of the resource such as in fisheries at national and global scales, and cooperation in sustaining the local commons which sees varying levels of inequality having different impacts on nature and NCP conservation depending on the local context (Hamann *et al.,* 2018).

Addressing issues related to equality and the SDGs through attention to distributional, procedural and recognitional aspects of inequality can enable marginalized groups and people to have a stronger voice and more positive outcomes in the decisions that affect nature and NCP (Leach *et al*., 2018).

SDG 16: Peace, justice and strong institutions

There are clear links between the condition and availability of nature and NCP to people and violent conflict (Rustad & Binningsbo, 2012; Schleussner *et al*., 2016; von Uexkull *et al*l., 2016). A review by Hanson *et al*. (2009) highlighted that over 90% of the armed conflicts that took place between 1950 and 2000 were within countries containing biodiversity hotspots, and over 80% of these conflicts occurred directly within hotspot areas. There remains a large gap in terms of our knowledge of the impacts of war on nature and NCP, especially from post-conflict zones in Africa (IPBES, 2018). However, evidence exists regarding the negative relationships between many activities associated with military forces, warfare and defense activities and nature and NCP such as those linked to: production and testing on nuclear weapons, aerial and naval bombardment, land mines, despoliation, defoliation and toxic pollution (Leaning, 2000). Wars and civil unrest generate feedbacks that reinforce and amplify interactions between and among resource availability, ecosystem vulnerability and violent conflict (Dudley *et al*., 2002). Thus, resolving natural resource conflicts has been identified as a precursor to sustainable development especially in unstable states (United Nations, 2002).

Scarcity of NCP e.g., drought has been linked to increases in violence in previously stable states (Bell & Keys, 2016). A report by UNEP on the role of natural resources and the environment in relation to conflict and peacekeeping, highlighted that around 40% of all conflicts within states in the last 60 years can be linked directly to natural resources, and that the exploitation of natural resources has powered and contributed financially to approximately 18 conflicts since 1990 (UNEP, 2009). However, not all of these conflicts have been linked to nature or NCP and have centered on conflicts related to mineral resources. Material NCP have been shown to be the most common cause of conflicts (see **Table 3.6**; Ross, 2003; UNEP, 2009), and often it is nature and NCP that is affected following conflict as people and communities attempt to rebuild local livelihoods and satisfy basic human needs. For example, conflicts in the Middle

Table 3 6 **Recent civil wars and internal unrest fuelled by natural resources.**

Source: UNEP (2009).

Country	Duration	Resources
Afghanistan	1978-2001	Gems, timber, opium
Angola	1975-2002	Oil, diamonds
Burma	1949-	Timber, tin, gems, opium
Cambodia	1978-1997	Timber, gems
Colombia	1984	Oil, gold, coca, timber, emeralds
Congo, Dem Rep. of	1996-1998, 1998-2003, 2003-2008	Copper, coltan, diamonds, gold, cobalt, timber, tin
Congo, Rep. of	1997-	Oil
Côte d'Ivoire	2002-2007	Diamonds, cocoa, cotton
Indonesia – Aceh	1975-2006	Timber, natural gas
Indonesia – West Papua	1969-	Copper, gold, timber
Liberia	1989-2003	Timber, diamonds, iron, palm oil, cocoa, coffee, rubber, gold
Nepal	1996-2007	Yarsagumba (fungus)
PNG - Boungainville	1989-1998	Copper, gold
Peru	1980-1995	Coca
Senegal – Casamance	1982-	Timber, cashew nuts
Sierra Leone	1991-2000	Diamonds, cocoa, coffee
Somalia	1991-	Fish, charcoal
Sudan	1983-2005	Oil

East in Syria, Lebanon, Palestine and Israel and Yemen have all shown a reduction in nature and NCP following or during ongoing conflicts, with most of these conflicts having devastating effects on human well-being and food and water security because of their long-lasting disruption of the productive base, and its impacts on overall well-being (UNEP, 2016; Weisman, 2006). Consequently, those countries involved in conflict, and those with higher levels of inequity experience higher levels of food emergencies (Teodosijević, 2003).

The development of effective, accountable and transparent institutions (target 16.6) and broadening and strengthening the participation of developing countries in the institutions of global governance (target 16.8) can help reduce the impacts of unrest on nature and NCP. Enhancing governance mechanisms through this goal and associated targets can also reduce the negative social and ecological impacts of unregulated transnational land acquisitions (land grabbing) which are occurring at increasing rates in all continents except Antarctica (Rulli *et al*., 2013; **Figure 3.11**). The global increase in the demand for agricultural land often results in large scale land acquisitions directly and indirectly contributing to land degradation and deforestation which is occurring at increasing rates in the affected countries as much of the land was not used for agriculture but was savanna or forest ecosystems (Koh *et al*., 2008). Thus, these large scale land acquisitions have significant impacts on nature and NCP, and further undermining the ability to achieve many of the SDGs linked to food and water security, reducing inequality and promoting a good quality of life (Borras *et al*., 2011; Tscharntke *et al*., 2012).

Achieving SDG16 also means significantly reducing all forms of violence and related death rates everywhere (16.1). Those resisting the appropriation of tracts of land and water, notably indigenous and local community members and activists, have increasingly been targeted and killed over the last decade with most years reporting higher statistics than the previous year, signalling a worrying increase in attacks on environmental activists and nature defenders (Global Witness, 2018; Rowell, 1996; **Figure 3.12**).

The global trade in illegal wildlife has been valued between US$5 billion and US$20 billion a year and threatens biodiversity, nature and NCP and acts as a potential avenue for invasive species and disease spread (Rosen & Smith, 2010; Wyler & Sheik, 2008). Without strengthening and developing effective, accountable and transparent institutions at all levels to target organized crime syndicates

Figure 3 11 **A global map of the land-grabbing network: land-grabbed countries (green disks) are connected to their grabbers (red triangles) by a network link.**

Relations between grabbing (red triangles) and grabbed (green circles) are shown (green lines) only when they are associated with a land grabbing exceeding 100,00 ha. Source: Rulli *et al.* (2013).

WHERE ENVIRONMENTAL ACTIVISTS WERE KILLED 2010 TO 2015

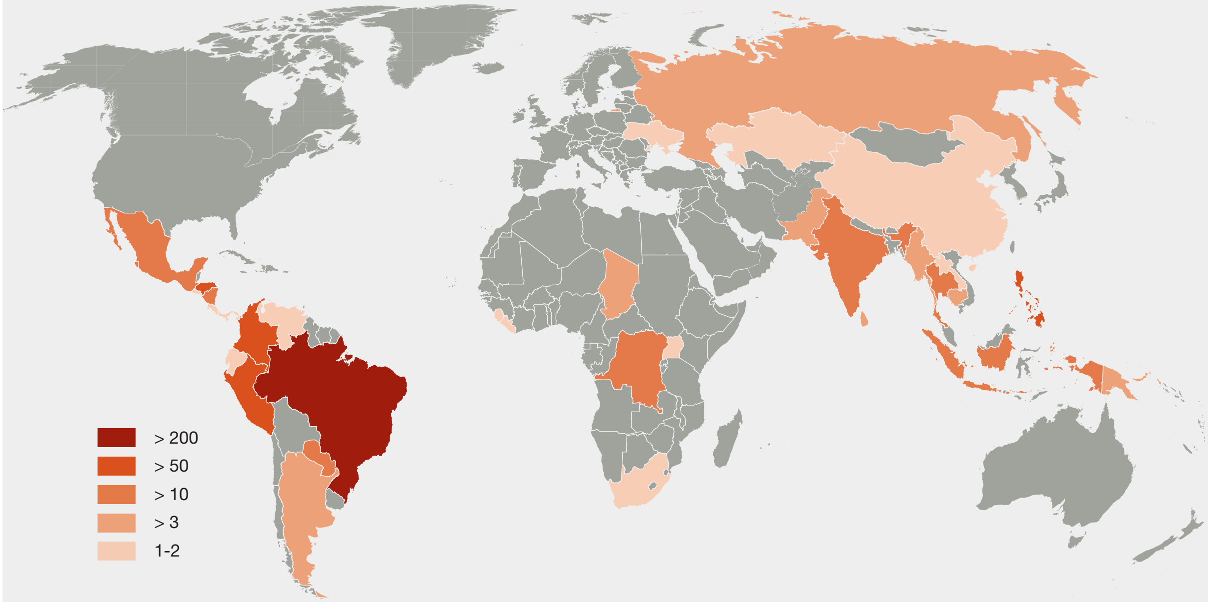


Figure 3 12 **Number of reported deaths of environmental activists during 2010-2015.**

Source: https://www.globalwitness.org/en/.

and tighten national and international cooperation to combat illegal wildlife trade (target 16.6) many populations of endangered species will continue to decline in the wild. Illegal trade in wildlife products has also been linked to financing the activities of militant groups and catalyzing social conflict (Douglas & Alie, 2014) and as the scarcity of rare and endangered species becomes more apparent, their rarity is likely to fuel more demand, increasing the potential for overexploitation and intensifying conflict dynamics.

In terms of enhancing the role of justice in the governance of nature and NCP, this has mainly been looked at in relation to addressing issues linked with inequality with a particular focus on more inclusive and fair protected area management by focusing on issues related to recognition (Martin *et al*., 2016), social justice (Vucetich *et al*., 2018), understanding and managing conservation conflicts (Redpath *et al*., 2012) and better understanding the role of social equity (Friedman *et al*., 2018). Notions of justice and nature have also been increasingly integrated in urban planning processes (see SDG 11.7), especially in relation to urban nature and NCP and their role in building resilience and addressing inequities (Dearing *et al*., 2014; Graham & Ernstson, 2012; Ziervogel *et al*., 2017).

3.3.2.4 Cluster 4: Drivers (Goals 7, 8, 9, 12)

Several SDGs have the potential to be negative or positive drivers of change in nature and NCP, depending on the pathways that are chosen to achieve them. Impacts from particular activities and economic sectors on nature and NCP, as well as trends in all of these, are detailed in chapter 2. Here, we briefly summarize how nature and NCP may be positively or negatively impacted by these SDGs.

SDG 7: Affordable and clean energy

Achievement of targets under SDG 7 can have both positive and negative impacts on nature and NCP. Clean energy should help to mitigate the impacts of climate change, which would have positive impacts on several SDGs including SDGs 1, 2, 3, 6, 13, 14, and 15. Key pathways to achieving clean energy will include developing wind, wave, and water-based (hydropower) energy projects. These developments can have positive or negative impacts on nature and NCP and related SDGs depending on how they are constructed. Dams can radically alter river flow regimes, affecting the function and productivity of downstream waters, which can negatively impact achieving targets within SDGs 6 and 15 related to aquatic ecosystems. However, recent research has found that careful monitoring of flows can be managed to ensure healthy fish stocks, a key concern for food security in some regions (Sabo *et al*., 2017). If not designed and constructed properly, wind and wave energy projects could affect the achievement of targets under SDGs 14 and 15. Clean energy may also include petroleum development projects, which may still negatively impact reduction of greenhouse gases associated with climate change.

SDG 8: Decent work and economic growth

Nature and NCP can provide pathways to achievement of SDG 8 but can also be positively or negatively impact by policies and measures implemented to achieve them (See SDG 1 for a discussion of economic growth, poverty alleviation and nature). Achievement of Target 8.4 on improvements in global resource efficiency would have strong positive impacts on nature and NCP by decoupling economic growth from environmental degradation. At the same time, nature and NCP provide pathways for achieving economic growth. Effective management of nature and NCP may provide greater employment opportunities and revenue generation. The forestry and fisheries sectors alone are worth at least $583 billion (FAO, 2014b) and $148 billion per year (FAO, 2016), respectively. Employment in sectors that depend on sustainable production in these ecosystems and others can also be critically important to national economies (FAO, 2014b; Jaunky, 2011).

There are recognized needs to initiate reforms in some ecosystem-based sectors to meet Target 8.7 (on ending slavery and child labour) and 8.8 (on labour rights and safe working environments). For example, the need to initiate reforms in the fisheries sector has received increased focus (Kittinger *et al*., 2017) as has the role of companies in improving practices along their supply chain (Österblom *et al*., 2015). Similarly, achievement of Target 8.9 could also have potential positive impacts on nature and NCP through the development of sustainable tourism. Implementation of activities to achieve many other targets under SDG 8 will need to consider how they may have impacts on nature and NCP and whether these can be mitigated or minimized. Future work should also consider the role of nature and NCP in creating decent work in new areas, as well as rights-based approaches to employment and job creation.

SDG 9: Industry, innovation and infrastructure

Achievement of SDG 9 targets can have either positive or negative impacts depending on approach, although the potential for large negative impacts appears high. Efforts to develop quality reliable infrastructure in Target 9.1 could include developing public transportation systems and enhancing rail networks, both of which would have positive impacts in the achievement of SDG 13 by mitigating climate change, with consequent indirect positive impacts on SDGs 6, 14, and 15. However, indicators for Target 9.1 suggest that road-building would also be a major aspect of achieving Target 9.1. Roads can be a major source of habitat fragmentation with negative impacts for ecosystems (Pfeifer *et al*., 2017) and species like birds and mammals (Benitez-Lopez *et al*., 2010). Roads are also associated with increased deforestation in the Amazon (Barber *et al*., 2014). Similar potential positive and negative impacts could be associated with the development pathways that may be chosen for Targets 9.2 (promote sustainable industrialization) and 9.3 (increase access of small-scale industries to financial services). Target 9.4 (upgrade infrastructure and retrofit industries to make them more sustainable) is likely to have positive impacts on nature and NCP by making industries more sustainable and cleaner, with lower CO_2 footprints. Achievement of Target 9.5 (Enhance scientific research and upgrade technological capabilities of industrial sectors) may also have positive impacts through the development of technology that reduces industrial footprints, identifies opportunities for circular economies, or improvement to supply chains.

SDG 12: Responsible consumption and production

Meeting the targets under Goal 12 has the significant potential to have positive impacts on nature and NCP by changing production and consumption patterns. Target 12.2 on resource use, target 12.4 on waste management, target 12.7 on procurement practices, and target 12.8 on information and awareness of sustainable development are particularly relevant to efforts to conserve and sustainably manage nature and NCP.

Target 12.2 is fundamental to the notion of sustainable development and development's reliance on renewable and non-renewable land, ocean, water and nature resources. Their exploitation is linked to positive impacts on well-being on average, but negative implications for nature and NCP, as well as unequal and negative impacts on certain groups, places and generations (WSSD, 2002). The scale of human impacts now implies that the effects of not achieving this target will be globally realized e.g., through climate change, shifts in biogeochemical pollutant loads and the loss of biosphere resilience (Steffen *et al*., 2015). This target has overlaps with several targets in SDG 15 on conservation, sustainable management and resource use. The concept of efficient use has some potential but requires clarification and standards emerging from fields such as Life Cycle Analysis and others in order to make it measurable and the challenges of incommensurability of inputs and outputs may prove an obstacle. This would be challenging especially in the light of IPBES's embrace of multiple values implying that an economic analysis to efficiency would be insufficient.

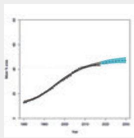
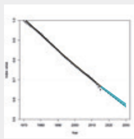
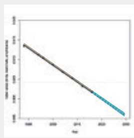
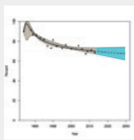
Target 12.4 on waste management is an area likely to have many positive implications on nature and NCP as well as GQL of all people. Currently waste, through its impacts on air and water quality, has negative impacts on well-being, especially in poor and vulnerable communities. This target relates closely to SDGs 6, 14, and 15, as well as aspects of SDG 3 and 11, in terms of trends in pollution and its impacts on health and the environment. Recent work on chemical pollution has highlighted what are referred to as "novel entities" – created entirely by humans e.g., synthetic organic pollutants, radioactive materials, genetically modified organisms, nanomaterials, and microplastics. These have important implications for nature and people, they can exist for a very long time, and their effects are potentially irreversible (Steffen *et al*., 2015).

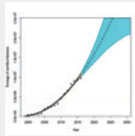
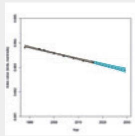
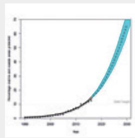
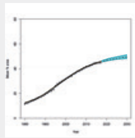
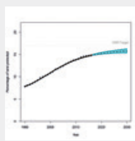
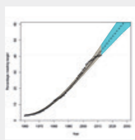
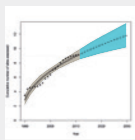
Target 12.7 focuses on public procurement which is widely recognized as a way to achieve GQL outcomes, including those linked to sustainability (McCrudden, 2004). There have been documented successes in terms of addressing equality and human rights (McCrudden, 2004). Achievement of this target could benefit nature and NCP by only sourcing materials that were harvested sustainability or produced with minimal impact in the supply chains used by public entities. The considerable buying power and scope of these purchases have the potential to transform supply chains even for non-public entities. Previous estimates of the scale of public procurement suggest that 8–25% of the gross domestic product of Organisation for Economic Cooperation and Development (OECD) countries and 16% of European Union (EU) GDP are attributable to government purchases of goods or services (Brammer & Walker, 2011). Green public procurement is a "demand side" policy that functions by creating the demand for sustainable produced products (Cheng *et al*., 2018). Achievement of this target could have direct positive impacts on nature and NCP and therefore on SDGs 6, 14, and 15. Leadership and senior manager support for sustainable green procurement and its inclusion in planning, strategies and goal setting is a major factor in its implementation. Similarly, if government policy and legislation support sustainable procurement, public sector organizations are more likely to implement it. Challenges for sustainable public procurement include the voluntary nature of most policies and practices and competing budgetary constraints (Brammer & Walker, 2011). Sustainable public procurement is still relatively nascent, and research has focused more on implementation than effectiveness, so the scope of potential impacts remains unknown (Cheng *et al*., 2018).

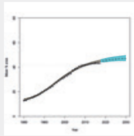
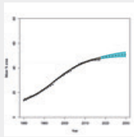
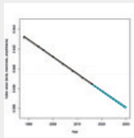
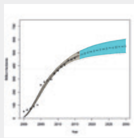
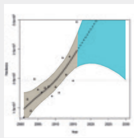
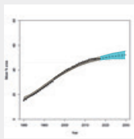
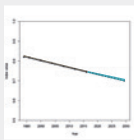
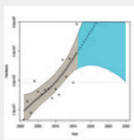
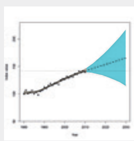
Target 12.8 is similar in aims to Aichi Target 1, on raising awareness of biodiversity and the steps needed to conserve and use it sustainably. As discussed in section 3.2, progress on this issue has so far been insufficient, but is increasing, although these findings largely related to awareness of biodiversity values **(Table 3.3)**. There is currently little evidence as to progress on public awareness and information on sustainable development, suggesting it has not yet had large-scale general uptake. SDG 4 is also relevant and is discussed above under the GQL cluster.

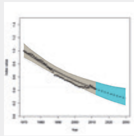
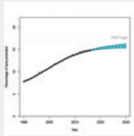
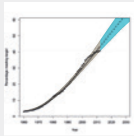
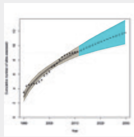
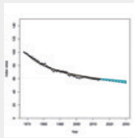
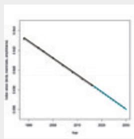
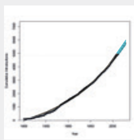
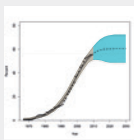
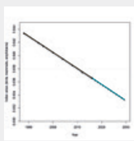
Table 3 7 **Trends of indicators extrapolated to 2030 to assess progress towards Sustainable Development Goals 6, 14 and 15 and their targets that are most closely related to nature and its contributions to people.**

Targets listed in red had no indicators suitable for extrapolation. Larger format versions of the thumbnail graphs, which include y-axis labels and background information on each indicator, are provided in Table S3.6.

SDG	Target	Indicator name	Alignment	Projected trend (2010-2030)	Graph
CLEAN WATER & SANITATION	**6.3** By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally				
	6.4 By 2030, substantially increase water-use across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity				
	6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate				
	6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	Percentage of freshwater Key Biodiversity Areas covered by protected areas*	High	Significant increase	
		Wetland Extent Trends Index	Medium	Significant decrease	
LIFE BELOW WATER	**14.1** By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	Red List Index (impacts of pollution)	Low	Significant decrease	
	14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans				
	14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels				
	14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	Proportion of fish stocks in safe biological limits*	High	Non-significant decrease	

SDG	Target	Indicator name	Alignment	Projected trend (2010-2030)	Graph
		Marine Stewardship Council engaged fisheries (tonnes)	High	Significant increase	
		Red List Index (impacts of fisheries)	Medium	Significant decrease	
	14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	Percentage of marine and coastal areas covered by protected areas*	High	Significant increase	
		Percentage of marine Key Biodiversity Areas covered by protected areas	High	Significant increase	
	14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation.				
	14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism				
15 LIFE ON LAND **LIFE ON LAND**	**15.1** By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	Percentage of terrestrial areas covered by protected areas	High	Significant increase	
		Percentage of terrestrial ecoregions covered by protected areas	Medium	Significant increase	
		Number of protected area management effectiveness assessments	Low	Significant increase	

SDG	Target	Indicator name	Alignment	Projected trend (2010-2030)	Graph
		Percentage of freshwater Key Biodiversity Areas covered by protected areas*	High	Significant increase	
		Percentage of terrestrial Key Biodiversity Areas covered by protected areas*	High	Significant increase	
		Red List Index (impacts of utilization)	High	Significant decrease	
	15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	Area of forest under sustainable management: total FSC and PEFC forest management certification (million ha)	High	Significant increase	
		Area of tree cover loss (ha)	High	Significant increase	
	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world				
	15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	Percentage of mountain Key Biodiversity Areas covered by protected areas*	High	Significant increase	
	15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	Red List Index*	High	Significant decrease	
		Area of tree cover loss (ha)	Medium	Significant increase	
		Climatic Impact Index for Birds	Medium	Significant increase	

SDG	Target	Indicator name	Alignment	Projected trend (2010-2030)	Graph
		Living Planet Index	High	Significant decrease	
		Percentage of terrestrial areas covered by protected areas	High	Significant increase	
		Percentage of terrestrial ecoregions covered by protected areas	Medium	Significant increase	
		Number of protected area management effectiveness assessments	Low	Significant increase	
		Wild Bird Index (habitat specialists)	High	Significant decrease	
	15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed				
	15.7 Take urgent action to end poaching and trafficking	Red List Index (impacts of utilization)	Medium	Significant decrease	
	15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	Number of invasive alien species introductions	High	Significant increase	
		Percentage of countries with invasive alien species legislation	High	No significant change	
		Red List Index (impacts of invasive alien species)	High	Significant decrease	

SDG	Target	Indicator name	Alignment	Projected trend (2010-2030)	Graph
	15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts				
	15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems				
	15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation				

Selected Sustainable Development Goals	Selected targets (abbreviated)	Recent status and trends in aspects of nature and nature's contributions to people that support progress towards target *		Uncertain relationship
		Poor/Declining support	Partial support	
No poverty	1.1 Eradicate extreme poverty			U
	1.2 Halve the proportion of people in poverty			U
	1.4 Ensure that all have equal rights to economic resources			
	1.5 Build the resilience of the poor			
Zero hunger	2.1 End hunger and ensure access to food all year round			
	2.3 Double productivity and incomes of small-scale food producers			
	2.4 Ensure sustainable food production systems			
	2.5 Maintain genetic diversity of cultivated plants and farmed animals			
Good health and well-being	3.2 End preventable deaths of newborns and children			U
	3.3 End AIDS, tuberculosis, malaria and neglected tropical diseases			U
	3.4 Reduce premature mortality from non-communicable diseases	Unknown		
	3.9 Reduce deaths and illnesses from pollution	Unknown		
Clean water and sanitation	6.3 Improve water quality			
	6.4 Increase water use and ensure sustainable withdrawals			
	6.5 Implement integrated water resource management			
	6.6 Protect and restore water-related ecosystems			
Sustainable cities and communities	11.3 Enhance inclusive and sustainable urbanization			
	11.4 Protect and safeguard cultural and natural heritage			
	11.5 Reduce deaths and the number of people affected by disasters			
	11.6 Reduce the adverse environmental impact of cities			
	11.7 Provide universal access to green and public spaces			
Climate action	13.1 Strengthen resilience to climate-related hazards			
	13.2 Integrate climate change into policies, strategies and planning			
	13.3 Improve education and capacity on mitigation and adaptation	Unknown		
	13a Mobilize US$100 billion/year for mitigation by developing countries	Unknown		
	13b Raise capacity for climate change planning and management	Unknown		
Life below water	14.1 Prevent and reduce marine pollution			
	14.2 Sustainably manage and protect marine and coastal ecosystems			
	14.3 Minimize and address ocean acidification			
	14.4 Regulate harvesting and end overfishing			
	14.5 Conserve at least 10 per cent of coastal and marine areas			
	14.6 Prohibit subsidies contributing to overfishing			
	14.7 Increase economic benefits from sustainable use of marine resources			

Life on land	15.1 Ensure conservation of terrestrial and freshwater ecosystems			
	15.2 Sustainably manage and restore degraded forests and halt deforestation			
	15.3 Combat desertification and restore degraded land			
	15.4 Conserve mountain ecosystems			
	15.5 Reduce degradation of natural habitats and prevent extinctions			
	15.6 Promote fair sharing of benefits from use of genetic resources			
	15.7 End poaching and trafficking			
	15.8 Prevent introduction and reduce impact of invasive alien species			
	15.9 Integrate biodiversity values into planning and poverty reduction			
	15a Increase financial resources to conserve and sustainably use biodiversity			
	15b Mobilize resources for sustainable forest management			

* There were no targets that were scored as good/positive status and trends

Figure 3 13 **Summary of recent status of, and trends in, aspects of nature and nature's contributions to people that support progress towards achieving selected targets of the Sustainable Development Goals.**

Selected targets are those where current evidence and target wording enable assessment of the consequences for target achievement of trends in nature and nature's contribution to people. Chapter 3 section 3.3 provides a goal-level assessment of the evidence of links between nature and all Sustainable Development Goals. Scores for targets are based on systematic assessments of the literature and quantitative analysis of indicators where possible. None of the targets scored 'Full support' (that is, good status or substantial positive trends at a global scale); consequently, it was not included in the table. 'Partial support': the overall global status and trends are good or positive but insubstantial or insufficient, or there may be substantial positive trends for some relevant aspects but negative trends for others, or the trends are positive in some geographic regions but negative in others; 'Poor/Declining support': poor status or substantial negative trends at a global scale; "Uncertain relationship": the relationship between nature and/or nature's contributions to people and achieving the target is uncertain; "Unknown": insufficient information to score the status and trends.

3.3.3 The Sustainable Development Goals and Indigenous Peoples and Local Communities

In this section, we review the role of IPLCs in efforts to achieve the SDGs, their contributions to progress to date, and the implications of achieving the SDGs to IPLCs. We focus primarily on the positive contributions that IPLCs make to achieve SDGs and their targets, but recognize that there are exceptions, some related to differing worldviews, and note some of these in the text. IPLCs have participated in meetings held under CBD and other international initiatives such as UNPFII, EMRIPS and the special rapporteur on Indigenous Peoples' rights. However, overall, Indigenous Peoples' participation at the UN level has been smaller than desirable. National dialogue on the Sustainable Development Goals (SDGs) between Indigenous Peoples and governments has also very limited in most countries (AIPP *et al*., 2015). Indigenous Peoples are mentioned only six times in the SDGs, and only in two targets (2.3, 4.5), which has been seen as a major disappointment for IPLCs (AIPP *et al*., 2015), UN Environment, 2015), although the lack of mentions elsewhere does not limit application of the broader goals and targets to their specific contexts. While a lot of the themes promoted and advocated by Indigenous Peoples in recent years have been included in the 2030 Agenda, the SDGs lack attention to issues such as the importance of free, prior and informed consent, and potential conflicts between the economic growth goals of the agenda and the environmental and social goals. an opportunity to use the SDGs to continue advances (AIPP *et al*., 2015). Weak participation in setting the goals hampers IPLCs ability to monitor and assess progress.

SDG 1: End poverty in all its forms everywhere

Indigenous Peoples are accounted as the poorest of the world's poor (Hall & Patrinos, 2012; Macdonald, 2012). Moreover, poverty is higher in rural remote areas (Ahmed *et al*., 2007; Sunderlin *et al*., 2005) and areas of importance for biodiversity conservation (Fisher & Christopher, 2007), where most IPLCs live. Nevertheless, IPLCs have a threefold contribution to poverty eradication. First, IPLCs are the main actors in the so-called win-win initiatives (or triple benefit; Brockington & Duffy, 2011) aimed at biodiversity conservation and climate mitigation while improving income level (e.g., Adhikari *et al*., 2004; Ahenkan & Boon, 2010; Brown *et al*., 2011; Campos-Silva & Peres, 2016; Chirenje, 2017; Dulal *et al*., 2012; El Bagouri, 2007; Roe, 2008). Second, IPLCs traditional institutions (e.g., taboos; Cinner *et al*., 2009), ILK and management practices (e.g., diversification) help mitigate the effects of poverty and vulnerabilities (Aryal *et al*., 2014) and to adapt to natural disasters and global changes (Ingty, 2017; Parraguez-Vergara *et al*., 2016). Third, interventions among IPLCs have contributed to the debate on whether poverty definitions based on monetary indicators are adequate (Fukuda-Parr, 2016). IPLCs often have different understandings of what poverty or wealth are (Chambers, 2005), rely on non-monetary sources of wild natural resources (Angelsen *et al*., 2014; Ehara *et al*., 2016; Robinson, 2016), and face multiple stressors (Gratzer & Keeton, 2017), or multidimensional poverty. Given that conservation and development interventions occasionally coincide with the loss of access to land and resources (e.g., Asquith *et al*., 2002), income (e.g., L'Roe & Naughton-Treves, 2014), and traditional livelihoods and culture (Mbaiwa *et al*., 2008) alternative approaches to monetary assessments of poverty have been devised for understanding and guiding policymaking (Bridgewater *et al*., 2015) and environmental policy frameworks (e.g., in REDD+ safeguards; Arhin, 2014) addressed to IPLCs. As remote rural inhabitants rely substantially on natural resources, increased access to monetary income may affect IPLC livelihoods, while also impacting biodiversity in multiple ways (Godoy *et al*., 2005), not necessarily taking pressure off natural resources (Angelsen *et al*., 2014). Moreover, the evidence regarding integrated conservation and poverty alleviation initiatives has been mixed and sometimes poorly quantified (Charnley & Poe, 2007; Romero-Brito *et al*., 2016). Restricting IPLCs' rights on forest products harvest and trade has precluded opportunities for income generation (e.g., Mbaiwa *et al*., 2008; Scheba & Mustalahti, 2015), or lowered cash income (e.g., Katikiro, 2016). Government and non-government development projects have frequently neglected IPLCs' rights and knowledge and have not adequately addressed asymmetric relations and inequities in their access to economic and political opportunities (Reyes-Garcia *et al*., 2010). Government-led poverty-alleviation programs are not necessarily adapted to IPLCs, sometimes being culturally inaccessible to indigenous families (Zavaleta *et al*., 2017).

SDG2: Zero Hunger

IPLCs have developed a variety of systems to achieve local food security through sustainable use of the environment. For example, research shows that traditional farming systems that exploit biodiversification, soil and water management have helped IPLCs to achieve food security through sustainable agricultural production (Altieri & Nicholls, 2017; Bjornlund & Bjornlund, 2010). Similarly, sustainable forest management, agroforestry, wild edible plant collection (Appiah & Pappinen, 2010; Boscolo *et al*., 2010; Ciftcioglu, 2015; Takahashi & Liang, 2016) and small-scale fisheries (Ali *et al*., 2017) have also played a vital role in IPLCs' food security. However, malnutrition and under nourishment among children under five years old is major problem among some IPLCs, particularly after they lose access to their lands and traditional livelihoods (Anticona & Sebastian, 2014; Babatunde, 2011; Dutta & Pant, 2003; Ferreira *et al*., 2012; Gracey, 2007). Moreover, dietary transitions affecting IPLCs are leading to increasing rates of overweight, obesity and associated chronic diseases, known as "hidden hunger" (Crittenden & Schnorr, 2017; Ganry *et al*., 2011; Kuhnlein *et al*., 2006, 2009; Popkin, 2004). Scientists now recognize that many food production systems developed by IPLCs could contribute to sustainable food production (Altieri & Nicholls, 2017; Barrios *et al*., 2015; Campos-Silva & Peres, 2016; Kahane *et al*., 2013; Pauli et. al 2016; Winowiecki et. al. 2014). However, it is also acknowledged that the success of programs integrating insights from those systems remains dependent on rights and access allocation, corruption, lack of local financial, intellectual and innovative capacity and centralized governance (Ferrol-Schulte *et al*., 2013), for which policies to fight hunger need addressing not only technical measures, but also tackling power asymmetries that reduce access to land and other resources for IPLCs (Francescon, 2006; Beckh *et al*., 2015) or raising investment in capital and organizational infrastructure (Godfray *et al*., 2010).

SDG 3: Ensure healthy lives and promote well-being for all at all ages

While most contemporary peoples have plural medical systems, traditional medicine continues to play an important role among IPLCs (Cartaxo *et al*., 2010; Chekole, 2017; Cox, 2004; Moura-Costa *et al*., 2012; Padalia *et al*., 2015; Paniagua-Zambrana *et al*., 2015; Tolossa *et al*., 2013). Limited access to other healthcare systems makes traditional medicine the only treatment option in certain communities (Paniagua-Zambrana *et al*., 2015; Tolossa *et al*., 2013); however, traditional medicine can be the preferred treatment option even when other healthcare systems are accessible (Padalia *et al*., 2015). Medicinal ILK has contributed to the discovery of active principles for drug development to treat non-communicable and infectious diseases, including AIDS, neglected tropical diseases, hepatitis, and water-borne diseases (Cartaxo *et al*., 2010; Johnson *et al*., 2008; Moura-Costa *et al*., 2012; Padalia *et al*., 2015; Tolossa *et al*., 2013; Rullas *et al*., 2004). This use, however, has often neglected IPLCs' contributions, giving raise to conflicts over unfair appropriation of ILK (Nelliyat, 2017). Research has shown higher rates of mortality and morbidity among Indigenous Peoples than among their non-indigenous counterparts (Anderson *et al*., 2016; Coimbra *et al*., 2013; Hernandez *et al*., 2017; Hurtado *et al*., 2005). Nutritional transitions have also resulted in a high prevalence and incidence of obesity, diabetes, and poor nutrition among many IPLCs (e.g., Corsi *et al*., 2008; McDermott *et al*., 2009; Port Lourenco *et al*., 2008; Rosinger *et al*., 2013) as well as high rates of alcohol use and tobacco smoking (Kirmayer *et al*., 2000; Natera *et al*., 2002; Wolsko *et al*., 2007). Given IPLCs' direct dependence on the environment to cover their material (e.g., water, food, shelter and medicines) and cultural needs (e.g., spiritual beliefs and worldviews), environmental changes (e.g., climate change, chemical contamination, land use changes) threaten to jeopardize the achievement of SDG3 for IPLCs (Anderson *et al*., 2015; Aparicio-Effen *et al*., 2016; Bradford *et al*., 2016; Dudley *et al*., 2015; Genthe *et al*., 2013). ILK can aid in the development of local strategies to cope with environmental factors that might put at risk IPLCs' health (Negi *et al*., 2017; Rahman & Alam, 2016), and there exists a handful of community-based interventions aimed at controlling infectious diseases in a sustainable, environmentally friendly way (Andersson *et al*., 2015; Arunachalam *et al*., 2012; Ledogar *et al*., 2017). Some researchers argue for the need to create new indicators of indigenous health that are socially and culturally sensitive and that adopt a more holistic and integrated approach, capturing IPLC definitions of health and well-being (Malkina-Pykh & Pykh, 2008; McMhom, 2002; Zorondo-Rodriguez *et al*., 2014) and addressing the causes of inequalities (Hernandez *et al*., 2017; WHO, 2013).

SDG 6: Clean Water and Sanitation

There is well established evidence that IPLCs have developed complex customary institutions for governing and managing freshwater resources in sustainable ways (e.g., Boelens, 2014; Strauch *et al*., 2016; Tharakan, 2015; Weir *et al*., 2013). Many studies have shown the strong cultural and spiritual ties between IPLCs and freshwater bodies (e.g., lakes, rivers and lagoons), which are deeply rooted in cultural beliefs and social practices and are thus at the basis of IPLC customary institutions for water management (e.g., Anderson *et al*., 2013; Dallmann *et al*., 2013; Jaravani *et al*., 2017; McGregor 2012). ILK-based water management systems are diverse, and include time-honored practices such as rainwater harvesting (Oweis, 2014; Widiyanti & Dittmann, 2014), small-scale sand dams (Lasage *et al*., 2008, 2015), water tanks (Ariza-Montobbio *et al*., 2007; Reyes-García *et al*., 2011), traditional water purification methods (Mwabi *et al*., 2013; Opare, 2017), forestry-based groundwater recharge (Camacho *et al*., 2016; Everard *et al*., 2018; Strauch *et al*., 2016), and complex systems of river zonation (e.g., Tagal System in Malaysia; AIPP, 2015; Halim *et al*., 2013). Additionally, several water-smart agricultural practices have been deemed effective at simultaneously ensuring water availability and conservation of biodiversity (Hughey & Booth, 2012; Lasing, 2006; Reyes-García *et al*., 2011). The strong cultural connections that IPLCs maintain with their freshwater bodies have allowed them to closely monitor water availability and quality (Alessa *et al*., 2008; Bradford *et al*., 2017; Sardarli, 2013). There is well established evidence that water insecurity disproportionately impacts IPLCs (Medeiros *et al*., 2017; Lam *et al*., 2017), resulting in multiple adverse health, economic and sociocultural burdens (e.g., Daley *et al*., 2015; Henessy & Bressler, 2016; Sarkar *et al*., 2015). Research shows that IPLCs have systematically lower access to clean water supplies than other segments of the population (Baillie *et al*., 2004; McGinnis & Davis, 2001; Ring & Brown, 2002), leading to high prevalence of several infectious diseases (Anuar *et al*., 2016; Han *et al*., 2016; Stigler-Granados *et al*., 2014). Moreover, environmental pollution (Bradford *et al*., 2017; Dudarev *et al*., 2013) and climate change (Dussias, 2009; Ford *et al*., 2014; Nakashima *et al*., 2012) exacerbate ongoing threats to the water supplies of IPLCs. IPLCs are also some of the most vulnerable groups to the impact of large-scale water resource development projects (Finn & Jackson, 2011; King & Brown, 2010), including dams and irrigations plans (Dell'Angelo *et al*., 2017; Winemiller *et al*., 2016). IPLCs have often been excluded from water decision-making bodies (Finn & Jackson, 2011; Hanrahan, 2017; Weir, 2010), as narrow conceptualizations of IPLCs water rights limit their ability to sustainably manage water resources according to traditional responsibilities (Durette, 2010; Tan & Jackson, 2013). Low participation of IPLCs in water management bodies has often fueled water conflicts and disagreement over the most culturally-appropriate policy options to ensure availability and sustainable management of water (Jiménez *et al*., 2015; Trawick, 2003). If interventions aimed at improving the role of indigenous water management systems are to be effective, water resource planners need to consider not only technical but also sociocultural factors (Dobbs *et al*., 2016; Jaravani *et al*., 2016; Pahl-Wostl *et al*., 2007; Reyes-García *et al*., 2011), including greater respect towards ILK and IPLC cultural values (Henwood *et al*., 2016; Maclean & The Bana Yarralji Bubu Inc. 2015; Tipa, 2009).

SDG 11: Sustainable cities and communities

It is increasingly acknowledged that IPLCs can contribute to enhance urban sustainability in aspects such as efficient water and energy consumption, reducing waste production and improving its disposal, reducing urban carbon footprints, and making urban agriculture more sustainable (e.g., Cosmi *et al*., 2016; Barthel *et al*., 2010; Langemeyer *et al*., 2017; Mihelcic *et al*., 2007; Schoor *et al*., 2015). IPLCs can also contribute to social-ecological resilience and to a sustained flow of ecosystem services in urban contexts under change (Andersson & Barthel, 2016; Hurlimann *et al*., 2014), as shown in examples from European cities during World Wars I and II (Barthel *et al*., 2015) and Havana, Cuba, after the end of the Soviet Union (Altieri *et al*., 1999). IPLCs can make cities safer by improving disaster risk detection and management, for which scholars have defended the importance of integrating ILK into risk assessment and management programs (Arriagada-Sickinger *et al*., 2016; Zweig, 2017). IPLCs and ILK are increasingly being valued in sustainable urban planning and design (Bunting *et al*., 2010; Young *et al*., 2017), but there is a further need to continue to do so, for which efficient methods are emerging (Kyttä *et al*., 2013, 2016; Samuelsson *et al*., 2018). Yet, researchers have also argued that IPLCs alone are not sufficient to create critical urban resilience, underscoring the need for functioning institutions to support IPLCs (Walters, 2015).

SDG 12: Responsible consumption and production

The existing body of academic research on IPLCs and responsible production and consumption is illuminating on three issues that not only affect IPLCs but are also obstacles for sustainable development. First, there is much heterogeneity between people with regards to drivers and consequences of resource use expansion linked to unsustainable production and consumption (Pichler *et al*., 2017). Through their low degree of involvement with mass production and consumption, IPLCs are not a driving force of the global environmental change from which they nevertheless disproportionally suffer (Chance and Andreeva, 1995; Martinez-Alier, 2014; Smith and Rhiney, 2016; Tsosie, 2007). Second, power disparities play a critical role in the appropriation of natural resources, including via the appropriation of ILK. As the resource frontier is continuously expanded for economic growth and increased production and consumption, encroachment on IPLCs' land has become widespread (e.g., Finer *et al*., 2008; Pichler, 2013), commonly threatening livelihoods (Bunker, 1984; Gerber, 2011; Larsen *et al*., 2014; Mingorría *et al*., 2014). In this economic model, the power of IPLCs to determine resource use is severely restricted (Benda-Beckmann & Benda-Beckmann, 2010, Devine & Ojeda, 2017; Li, 2001, 2010; Watts and Vidal, 2017). Notwithstanding this, the appropriation of ILK is considered pivotal in attaining more sustainable management of resources (e.g., Fearnside, 1999; Gadgil *et al*., 1993; Johannes *et al*., 2000; Véron, 2001). Published research has focused very strongly on integrating ILK into the existing capitalist system of production and consumption (Donovan and Puri, 2004; Ilori *et al*., 1997; Kahane *et al*., 2013; Sarkar, 2013; Usher, 2000) with its reliance on growth through the appropriation of resources and labour (Moore, 2015). Integrating ILK into production and consumption may endanger any sustainability benefits (Nadasdy, 1999b). Third, despite the inherent unsustainability of the current resource use trajectory, existing tools for sustainable resource management typically propose the integration of IPLC claims (Fernandez-Gimenez *et al*., 2006; O'Faircheallaigh, 2007), rather than interpreting the (often non-monetary) preferences of IPLCs (Avcı *et al*., 2010; Dongoske *et al*., 2015; Martinez-Alier, 2009) in terms of possible alternative resource use futures (White, 2006). To achieve sustainable production and consumption, greater consideration is needed of alternative visions of what it means to prosper and to live well, rather than in material abundance (Kothari *et al*., 2014; Radcliffe, 2012; Zimmerer, 2015).

SDG 13: Climate Action. Combat climate change and its impacts

It is well established that IPLCs have contributed to mitigation of climate change effects (Campbell, 2011; Gabay *et al*., 2017; Lunga & Musarurwa, 2016), partly because of their low contribution to GHG emissions (Heckbert *et al*., 2012; Russell-Smith *et al*., 2013). Agreement is also growing that ILK can be an alternative source of knowledge in efforts to mitigate and adapt to climate change (Altieri & Nicholls, 2017; Chanza & De Wit, 2016; Eicken, 2010; Magni, 2017; Pearce *et al*., 2015). It is also well acknowledged that IPLCs are among the groups most affected by the impacts of climate change**,** including effects of unexpected extreme rainfall events (Baird *et al*., 2014; Joshi *et al*., 2013), floods (Cai *et al*., 2017), droughts (Kalanda-Joshua *et al*., 2011; Swe *et al*., 2015), pasture disappearance (He & Richards, 2015; Wu *et al*., 2015), extinction of medicinal plants (Klein *et al*., 2014; Mapfumo *et al*., 2016), changes in animal behaviour patterns (Pringle & Conway, 2012), and the spread of pests and invasive alien species (Shijin & Dahe, 2015; Shukla *et al*., 2016). While in the past, ILK had allowed IPLCs to understand weather variability and change, ILK might now be less accurate as weather becomes increasingly unpredictable (Cai *et al*., 2017; Konchar *et al*., 2015). The failure of ILK to detect, interpret and respond to change generates a feeling of insecurity and defenselessness that undermines IPLC resilience and exacerbates their vulnerability (Mercer & Perales, 2010; Simelton *et al*., 2013). The potential of combining ILK and scientific knowledge to design successful climate adaptation policies is increasingly acknowledged (Alessa *et al*., 2016; Altieri and Nicholls, 2017; Austin *et al*., 2017; Boillat & Berkes, 2013; Hiwasaki *et al*., 2014; Ingty, 2017; Kasali, 2011; Mantyka-Pringle *et al*., 2017), although there are few efforts to make IPLCs aware of the scientific approaches being promoted to combat climate change impacts (Fernández-Llamazares *et al*., 2015; Inamara & Thomas, 2017; Shukla *et al*., 2016), and examples of initiatives aiming to integrate ILK into climate policies are still rare (Seijo *et al*., 2105). Increasing the adoption of climate-smart technologies among IPLCs might contribute to strengthen their adaptive capacity (Scherr *et al*., 2012).

SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

IPLCs have long history of interacting with the oceans and sustainably managing coastal and marine resources (Cordell, 1989; Johannes, 1978; Lepofsky & Caldwell, 2013; Lotze & Milewski, 2004; Spanier *et al*., 2015; Thornton & Mamontova, 2017). IPLCs also have a deep knowledge of marine ecology (McGreer & Frid, 2017; Salomon *et al*., 2007; Savo *et al*., 2017) that can help sustainably manage marine ecosystems, including coral reefs and mangroves (Cinner *et al*., 2006; Datta *et al*., 2012; Thaman *et al*., 2017). However, traditional marine management regimes can also result in intense resources exploitation (e.g., Andreu-Cazenave *et al*., 2017; Islam & Haque, 2004; Ratner, 2006), for which researchers have warned against the uncritical use of ILK (Turner *et al*., 2013; Turvey *et al*., 2010). The continued degradation of marine ecosystems affects the many IPLCs who are dependent on them, affecting food security (de Lara & Corral, 2017; McGreer & Frid, 2017; Robards & Greenberg, 2007; Watts *et al*., 2017) and social and spiritual integrity (McCarthy *et al*., 2014). Moreover, IPLCs also face important social restrictions regarding marine resources use, including fishing and tenure right restrictions (Joyce & Satterfield, 2010; Thornton &

Mamontova, 2017) and coastal lands dispossession by outside interests (e.g., governments, tourist operators) (Bavinck *et al*., 2017; Hill, 2017). While including IPLCs in managing marine resources can help sustainably managing marine ecosystems (Jupiter *et al*., 2014b), this potential is not always recognized (Johnson *et al*., 2016; Jones *et al*., 2017). Moreover, in many areas traditional fishing techniques have been made illegal (Deur *et al*., 2015; Jones *et al*., 2017; Langdon, 2007; von der Porten *et al*., 2016).

SDG 15: Life on land

With an estimated 28% of the world's land surface held by IPLCs (Garnett *et al*., 2018) and 80% of biodiversity found there (FAO, 2017), IPLCs play a substantial role in governing and managing forests, land, and biodiversity. The often long-lasting relationship between IPLCs and terrestrial ecosystems has led to a co-evolution of social and ecological components that has enhanced adaptive capacity, resilience and sustainability (Berkes *et al*., 2000; Folke, 2006; MacLean *et al*., 2013; Pascua *et al*., 2017). IPLCs contribute to the maintenance and enhancement of land-based ecosystems through management practices that focus on ecological processes (Herrmann & Torri, 2009; see also 2.2.4), multiple use (Toledo *et al*., 2003), agroforestry (Suyanto *et al*., 2005), sustainable logging and hunting (Roopsind *et al*., 2017), fire management (Mistry *et al*., 2016), protection and management of culturally significant trees (Genin & Simenel, 2011; Stara *et al*., 2015), and long-term monitoring (Long & Zhou, 2001; Olivero *et al*., 2016). Giving land titles to IPLCs tends to protect forests from large-scale conversion into other land uses (Blackman *et al*., 2017; Chhatre *et al*., 2012; Nepstad *et al*., 2006) and forests that have cultural and religious significance for IPLCs are usually more diverse, denser and harbour larger and older trees than non-sacred forests (Aerts *et al*., 2016; Borona, 2014; Frascaroli *et al*., 2016; Ormsby, 2013; Rao *et al*., 2011). IPLCs directly benefit from biodiversity, for example through the use of wild plants in diet and medicinal purposes (Singh *et al*., 2014). Biodiversity can have a spiritual importance to IPLCs (Torri & Herrmann, 2011). Biodiversity also makes cultural landscapes and agroecosystems more resilient to climate change (Altieri & Nicholls, 2017; Ingty, 2017). Furthermore, non-extractive uses of biodiversity can provide additional income to IPLCs through carbon offsetting (Renwick *et al*., 2014), ecotourism (Gonzalez *et al*., 2008; Sakata & Prideaux, 2013) and intellectual property rights on biodiversity use (Efferth *et al*., 2016). Yet the equitable sharing of these benefits remains a challenge in practice (De Jonge, 2011; Suiseeya, 2014). IPLCs benefit from ecosystem services provided by resilient lands (Sigwela *et al*., 2017) and are particularity vulnerable to land degradation (Ellis-Jones, 1999). The largest body of literature addresses the participation of IPLCs in combating land degradation in relation with externally supported projects and the need to establish effective participation and knowledge co-production schemes (Oba *et al*., 2008; Raymond *et al*., 2010b; Reed *et al*., 2013; Sedzimir, 2011). While there is relatively little literature on how IPLCs can contribute to combat desertification, the existing one shows that IPLCs have also contributed to fight desertification and soil erosion through indigenous initiatives, some of them rooted in a long-term relation with their environment. This includes plant selection for resistance to drought (Gaur & Gaur, 2004), keeping spiritually relevant patches of forest to halt soil erosion (Yuan & Liu, 2009), the construction and maintenance of traditional irrigation systems (Ashraf *et al*., 2016; Ostrom, 1990), traditional knowledge on soil types and conditions (Barrera-Bassols *et al*., 2006) and terrace construction (Boillat *et al*., 2004). IPLCs can play a key role in monitoring land degradation and soil conditions (Forsyth, 1996; Roba & Oba, 2009) and in land rehabilitation (Yirdaw *et al*., 2017).

3.4 PROGRESS TOWARDS GOALS AND TARGETS OF OTHER GLOBAL AGREEMENTS RELATED TO NATURE AND NATURE'S CONTRIBUTIONS TO PEOPLE

There are more than 150 multilateral environmental agreements related to biodiversity, but six are global in scope and pursue biodiversity conservation as a core objective (Gomar *et al*., 2014). These comprise one framework convention—the 1992 Convention on Biological Diversity (CBD)—and five focused agreements: (1) the 1971 Convention on Wetlands of International Importance Especially as Waterfowl Habitat (the Ramsar Convention on Wetlands); (2) the 1972 Convention Concerning the Protection of the World Cultural and Natural Heritage (WHC); (3) the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); (4) the 1979 Convention on the Conservation of Migratory Species of Wild Animals (CMS); and (5) the 2001 International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA; S3.10). In this section, we review progress towards the goals of the first four of these Conventions, plus the International Plant Protection Convention (IPPC) and the United Nations Convention to Combat Desertification (UNCCD), as the implementation of both of these has a significant impact on biodiversity and livelihoods. Given that the ITPGRFA has not yet adopted a strategic plan with specified objectives, we do not assess progress, but address this Convention in section S3.10. We also address the United Nations Convention on the Law of the Sea (UNCLOS; Articles 61-66; **Box 3.1**), given that all of the others focus solely on the terrestrial realm **(Table 3.8)**, and two polar conventions, given the global consequences of conservation of these two regions: the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF, **Box 3.2**). The means by which the CBD coordinates efforts with these MEAs is covered in section S3.9.

Table 3.8 summarizes a high-level assessment of the literature on progress towards the goals and strategic objectives of CMS, CITES, Ramsar Convention, UNCCD, WHC, and IPPC. A more rigorous quantitative analysis of indicators for each of the detailed underlying targets, like that employed for the Aichi Biodiversity Targets in section 3.2, is needed to validate these assessments, but is beyond the scope of this chapter.

Table 3 8 **Progress towards achieving the goals of other global agreements related to nature and nature's contributions to people, based on a synthesis of the literature and available information.**

Progress towards goals is scored as Good ◎ (substantial positive trends at a global scale relating to most aspects of the element), Moderate ◎ (the overall global trend is positive, but insubstantial or insufficient, or there may be substantial positive trends for some aspects of the goal, but little or no progress for others, or the trends are positive in some geographic regions but not in others), Poor ◎ (little or no progress towards goal, or movement away from goal; while there may be local/national or case-specific successes and positive trends for some aspects, the overall global trend shows little or negative progress), or Unknown '?' (insufficient information to score progress).

Convention	Goals	Progress
CMS	**Goal 1:** Address the underlying causes of decline of migratory species by mainstreaming relevant conservation and sustainable use priorities across government and society	Moderate
	Goal 2: Reduce the direct pressures on migratory species and their habitats	Poor
	Goal 3: Improve the conservation status of migratory species and the ecological connectivity and resilience of their habitats	Poor
	Goal 4: Enhance the benefits to all from the favourable conservation status of migratory species	?
	Goal 5: Enhance implementation through participatory planning, knowledge management and capacity-building	Moderate

Convention	Goals	Progress
CITES	**Goal 1:** Ensure compliance with and implementation and enforcement of the Convention.	
	Goal 2: Secure the necessary financial resources and means for the operation and implementation of the Convention.	
	Goal 3: Contribute to significantly reducing the rate of biodiversity loss by ensuring that CITES and other multilateral instruments and processes are coherent and mutually supportive.	
RAMSAR	**Goal 1:** Addressing the drivers of wetland loss and degradation	
	Goal 2: Effectively conserving and managing the Ramsar site network	
	Goal 3: Wisely using all wetlands	
	Goal 4: Enhancing implementation	
UNCCD	**Goal 1:** To improve the living conditions of affected populations	
	Goal 2: To improve the condition of affected ecosystems	
	Goal 3: To generate global benefits through effective implementation of the UNCCD	
	Goal 4: To mobilize resources to support implementation of the Convention through building effective partnerships between national and international actors	
WHC	**Objective 1:** Strengthen the Credibility of the World Heritage List, as a representative and geographically balanced testimony of cultural and natural properties of outstanding universal value	
	Objective 2: Ensure the effective Conservation of World Heritage properties	
	Objective 3: Promote the development of effective capacity-building measures, including assistance for preparing the nomination of properties to the World Heritage List, for the understanding and implementation of the World Heritage Convention and related instruments	
	Objective 4: Increase public awareness, involvement and support for World Heritage through Communication	
	Objective 5: Enhance the role of Communities in the implementation of the World Heritage Convention	
IPPC	**Strategic objective A:** To protect sustainable agriculture and enhance global food security through the prevention of pest spread;	
	Strategic objective B: To protect the environment, forests and biodiversity from plant pests	
	Strategic objective C: To facilitate economic and trade development through the promotion of harmonized scientifically based phytosanitary measures	
	Strategic objective D: To develop phytosanitary capacity for members to accomplish objectives A, B and C	

3.4.1 The Convention on the Conservation of Migratory Species of Wild Animals

The CMS (or 'Bonn Convention') is an intergovernmental treaty aimed at conserving terrestrial, marine and avian migratory species throughout their range (CMS, 2017). Signed in 1979 and entering into force in 1983, the Convention is currently ratified by 124 Parties. CMS Parties strive towards strictly protecting threatened migratory species (Appendix I species) and conserving or restoring the places where they live, mitigating obstacles to migration and controlling other factors that threaten them (CMS, 2017). Non-endangered species with unfavorable conservation status (Appendix II species) that would benefit from international cooperation, are also addressed by the Convention. As well as establishing obligations for CMS Parties, the Convention, promotes concerted action among the range states of migratory species (CMS, 2017). CMS's 11th Conference of the Parties adopted the Strategic Plan for Migratory Species 2015–2023 which has five Goals consisting of 16 Targets (CMS, 2014). Indicators for measuring progress towards these are still in development.

Mainstreaming relevant conservation and sustainable use priorities across government and society to address the underlying causes of decline of migratory species (Goal 1) is underway, but progress has been slow. World Migratory Bird Day has been celebrated annually since 2006, with events now held in over 130 countries worldwide stimulating conservation of migratory birds and raising awareness about the need for their conservation (Target 1; Caddell 2013a, CMS, 2016). Other efforts to raise awareness of migratory species and the steps needed to conserve them have included the 'Year of the Bat' (2017) and similar initiatives for gorillas (2007) and dolphins (2009), but the impact of these initiatives on awareness has not been systematically assessed. Little information is available on the degree to which the values of migratory species and their habitats have been integrated into development and poverty reduction strategies and planning processes and incorporated into national accounting (Target 2).

CMS coordinates the development and implementation of multilateral agreements among countries that share migratory species (Caddell 2013b). Migratory waterbirds, seabirds, cetaceans and bats are among the species groups covered by formal protocols concluded under the Convention. In the case of migratory birds, intergovernmental efforts to identify flyways and coordinate action have been highly successful. For most parts of the world, the policies and processes to secure the well-being of flyways is in place, but the challenge lies in implementing them (Boere & Piersma, 2012). Hence, progress has been made towards improving national, regional and international governance arrangements and agreements affecting migratory species, and to make relevant policy, legislative and implementation processes more coherent, accountable, transparent, participatory, equitable and inclusive (Target 3). Insufficient information is available to assess progress towards ending or reforming incentives, including subsidies that are harmful to migratory species, and to developing and applying positive incentives to their conservation (Target 4).

The direct pressures on migratory species and their habitats have not decreased, and may be worsening, meaning we are not progressing towards achievement of Goal 2. Land-use change owing to agriculture is the most significant threat to terrestrial migratory species, affecting nearly 80% of all threatened and near-threatened migratory bird species (Flockhart *et al*., 2015; Kirby *et al*., 2008), while overexploitation and its indirect impacts is the biggest threat to migratory species in the marine environment (e.g., Croxall *et al*., 2012). Habitat conversion and degradation limit the degree to which many species can modify their migratory routes and may increase the threat from climate change (Robinson *et al*., 2009; Studds *et al*., 2017). Forest fragmentation and deforestation in breeding areas has contributed to the declines of Nearctic–Neotropical bird migrants (Bregman *et al*., 2014; Flockhart *et al*., 2015) and Afro-Palaearctic migrants (Vickery *et al*., 2014). In non-breeding areas, the interaction between habitat degradation and climatic conditions (in particular, drought) are also possible factors (Taylor & Stutchbury, 2016; Vickery *et al*., 2014). Infrastructure development including wind turbines, cables, towers and masts can also be a threat, particularly to migratory soaring bird species (Angelov *et al*., 2013; Bellebaum *et al*., 2013; Kirby *et al*., 2008) and migratory bats. Overharvesting and persecution, often illegal, remain serious threats, particularly at key migration locations (Brochet *et al*., 2016, 2017; Harris *et al*., 2011; Ogada *et al*., 2012). Climate change is negatively affecting many bird species already and is expected to exacerbate these pressures (Howard *et al*., 2018) as well as increasing competition between migratory and non-migratory species (Robinson *et al*., 2009). Climate change may have significant negative effects on the population size of 84% of migratory bird species, which is comparable to the proportion affected by all other anthropogenic threats (80%) (Kuletz *et al*., 2014; Robinson *et al*., 2009). Protected areas can help to mitigate some threats, but just 9% of migratory bird species are adequately covered by protected areas across all stages of their annual cycle, compared with 45% of non-migratory species, a pattern driven by protected area placement that does not cover the full annual cycle of migratory species (Martin *et al*., 2007; Runge *et al*., 2015).

The conservation status of migratory species and the ecological connectivity and resilience of their habitats is worsening, meaning that we are moving away from achievement of Goal 3. More than 11% of migratory land- and waterbirds are threatened or Near Threatened on the IUCN Red List (Kirby *et al*., 2008). Since 1988, the Red List Index shows that migratory birds have become more threatened, with 33 species deteriorating sufficiently to move to higher categories of threat on the IUCN Red List, and only six improving in status to qualify for downlisting (Kirby *et al*., 2008). More than half of migratory bird species across all major flyways have undergone population declines over the past 30 years (Kirby *et al*., 2008). There is increasing evidence of regional-scale declines in migrant birds: more Nearctic–Neotropical migrants have declined than increased in North America since the 1980s, and more Palearctic–Afrotropical migrants breeding in Europe declined than increased during 1970–2000. Regional assessments show that 51% of migratory raptors species in the African–Eurasian region and 33% of species in Central, South and East Asia have unfavorable conservation status. Some species appear to be particularly affected by declines in habitat extent and condition in non-breeding areas, notably in arid areas of tropical Africa (Kirby *et al*., 2008).

The prospect for large-bodied ungulates is no better. Mass migrations for six large-bodied ungulate species are extinct or unknown (Harris *et al*., 2009). With the exception of a few ungulates (such as Common Wildebeest *Connochaetes taurinus* and other migrants in the Serengeti Mara Ecosystem, White-eared Kob *Kobus kob* and Tiang *Damaliscus lunatus* in Sudan, and some Caribou *Rangifer tarandus* populations), the abundance of all other large-bodied migrant ungulates has declined (Harris *et al*., 2009). In the case of migratory species occurring in the marine environment, 21% are classified as threatened (i.e. categorized as Critically Endangered, Endangered or Vulnerable) with an additional 27% classified as Near Threatened or Data Deficient (Lascelles *et al*., 2014). Sea turtles are the most threatened group (85%), followed by seabirds (27%), cartilaginous fish (26%), marine mammals (15%) and bony fish (11%). Migratory species in marine ecosystems may be even more affected by climate change impacts than terrestrial species (Robinson *et al*., 2009). Highly migratory and straddling marine fishes (i.e., fish species that move through or exist in more than one exclusive economic zone) are further governed by the United Nations Fish Stocks Agreement (UNFSA), which has been in force since 2001. The objective of UNFSA is to "ensure the long-term conservation and sustainable use of straddling fish stocks and highly migratory fish stocks" (UNFSA, 2018). A recent assessment of global progress towards implementing this agreement concluded that the overall status of migratory fish stocks and straddling fish stocks had not improved since the 2006 Review Conference (Baez *et al*., 2016). Moreover, since 2010, there has been a decline in the overall status of highly migratory fish stocks and straddling stocks, and 60% of shark species are considered to be potentially overexploited or depleted (Baez *et al*., 2016).

There is little information to assess progress towards enhancing the benefits to all from the favourable conservation status of migratory species (Goal 4). Some progress has been made towards enhancing implementation through participatory planning, knowledge management and capacity-building (Goal 5). CMS Strategic Plan 2006–2011 and the Bali Strategic Plan for Technology Support and Capacity-Building provide the framework for capacity-building (CMS, 2018)**.** The Convention promotes a bottom-up and participatory approach in identifying specific objectives, strategies and activities for implementation by governments, NGOs and other stakeholders. Collaboration with NGOs to facilitate implementation and capacity-building has increased over the years, enabling cost-sharing, especially in developing and emerging economies (Prideaux, 2015), despite some NGO relationships with CMS instruments tending to be *ad hoc*, with some key discussions closed to them (Prideaux, 2014). National Biodiversity Strategy and Action Plans (NBSAPs) often fail to consider adequately the needs of migratory species which are typically not endemic or may not comprise a significant component of the local biodiversity (CMS, 2017).

3.4.2 The Convention on International Trade in Endangered Species of Wild Fauna and Flora

In force since 1975, CITES aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival (CITES, 2017). The primary policy tool of CITES is the regulation of trade to avoid utilization incompatible with species' survival (Appendix II listed species) and the prohibition of trade for commercial purposes on all species listed in Appendix I (e.g., leopard *Panthera pardus*, sea turtles, bowhead whale *Balaena mysticetus*, and the monkey-puzzle tree *Araucaria araucana*). The Convention contains a number of exceptions to this general prohibition, however (CITES, 2017). It controls international trade of selected species through a licensing system that requires authorization of all import, export or re-export of all species covered. CITES presently exercises responsibility over almost 35,600 species of flora and fauna (CITES, 2017). Only 3% of these are under Appendix I. CITES has 183 Parties, which have adopted three goals outlined in the Convention's Strategic Vision (2008–2020) (CITES, 2017). The goals address compliance with, and implementation and enforcement of, the Convention (Goal 1), securing financial resources for Convention implementation and operationalization (Goal 2), and ensuring coherence and support between CITES and other multilateral agreements such as the CBD, CMS and relevant SDGs (Goal 3).

Trade in wildlife is increasing: on average, over 100 million individuals were traded annually during 2005–2014 compared with a mean of 9 million per year during 1975–1985 (Harfoot *et al*., 2018). Overall, trade seems to have shifted towards captive-bred rather than wild-sourced individuals for many (but not all) taxa (Harfoot *et al*., 2018).

Implementation compliance and enforcement of CITES is improving, but slowly, (Nowell, 2012) and trade bans are possibly worsening the situation for some species (Conrad, 2012; Santos *et al*., 2011), so progress towards Goal 1 has been moderate. Controls and bans on trade have been successful in helping to stabilize populations of certain species (Conrad, 2012; Gehring & Ruffing, 2008) such as the endangered Giant Otter *Pteronura brasiliensis* (Uscamaita & Bodmer, 2009), and spotted cats and crocodilians (Ginsberg, 2002), with some taxa showing modest population recoveries (e.g., Citron-crested Cockatoo *Cacatua sulphurea citrinocristata*; Cahill *et al*., 2006). However, unsustainable levels of wildlife trade, some of which is legal and international, continue to pose major threats to global biodiversity (Joppa *et al*., 2016; Santos *et al*., 2011). The conservation status of some species, such as Lear's Macaw *Anodorhynchus leari* and Imperial *Amazona imperialis* has improved (toward less threatened categories of the IUCN Red List) as a consequence of control of trapping and trade, including through CITES regulations, but many more species have deteriorated in status toward more threatened categories owing to unsustainable harvests driven in part by international trade (Butchart, 2008; Di Marco *et al*., 2014; Hoffmann *et al*., 2010). In some cases, bans on legal trade drive increases in illegal trade, further threatening species already at risk (Di Minin *et al*., 2016; Fischer, 2010; Rivalan *et al*., 2007). Globalization and the interlinks between organized crime, terror organizations, social conflict and illegal wildlife trade also play a key role, particularly in the recent precipitous decline of elephant and rhino species in Africa and Asia (Brashares *et al*., 2014; Sollund, 2016; Wasser *et al*., 2009; but see UNODC, 2016).

Violations of the agreement are widespread (e.g., Dongol *et al*., 2012), while trade quotas typically do not consider population dynamics and are not based on population modelling (Smith *et al.,* 2011) despite evidence that such approaches are critical for many of the species impacted by international trade (e.g., Balme *et al*., 2012; Valle *et al*., 2018). The introduction of stricter legislation, wildlife trade controls and penalties in a number of countries led to improvements in compliance during 2010–2012 (Nowell, 2012). Nevertheless, major prosecutions for wildlife crime are still rare, and overall, enforcement has lagged behind compliance, despite examples of national scale bans combined with CITES restrictions decreasing unsustainable wildlife trade (Santos *et al*., 2011). Biennial reporting was virtually moribund (Reeve, 2006) and has subsequently been replaced with the requirement for an Implementation Report covering the three-year cycles between CITES Conferences of the Parties (CITES 2018a). CITES also requires Parties to submit annual trade reports and annual illegal trade reports (CITES 2018b). Non-compliance on annual reporting of trade and illegal trade is common, however, limiting the reliability of conclusions drawn from trade statistics generated from such reports (Challender *et al*., 2015b; Foster *et al*., 2016; Phelps, 2010; Underwood *et al*., 2013).

Financial and other resources for the operation and implementation of CITES have been insufficient and are declining, meaning that we are moving away from achieving Goal 2**.** Funding remains a principal limitation to the effectiveness of CITES, especially for on-the-ground execution of mandates and for proposed enhancements (Phelps *et al*., 2010). The core administrative costs of the Secretariat, the Conference of the Parties and various committees are financed from the CITES Trust Fund which is replenished from contributions from the Parties to the Convention (CITES, 2017). Its annual budget of US$6 million is shrinking in real terms, even though Parties agreed to an increase of 0.24% in 2016. As of 31 July 2017, contributing Parties have failed to pay a total of nearly USD 850,000 for 2016 and prior years that they owe to the Trust Fund (CITES, 2017). As a 'pre-Rio' Convention, CITES cannot directly access the Global Environment Facility (Reeve, 2006). Nevertheless, during the period 1 January 2016 to 31 July 2017, CITES received USD 14.3 million in voluntary contributions to its Trust Fund. Lack of funding is one of the reasons that Parties are reluctant to establish a dedicated compliance or implementation committee (Nowell, 2012).

CITES and other multilateral instruments and processes are generally coherent and mutually supportive, meaning that there is good progress towards Goal 3**.** CITES actively engages with allied biodiversity MEAs, most significantly with the Ramsar Convention, WHC, CMS, CBD, and ITPGRFA (with which it cooperates under a body called the 'Liaison Group of Biodiversity-related Conventions' to explore opportunities for synergistic activities and increased coordination, and to exchange information; CITES, 2018c; Couzens, 2013; Yeater, 2013). Given its focus on international trade, MEA counterparts tend to refer to CITES on issues of trade and transportation permits, while the CMS has advocated close engagement with CITES and encouraged application of the lessons learned through CITES implementation (Caddell, 2013a). Although there is high level of inter-treaty cooperation (Caddell, 2012, 2013b), opportunities for enhancing synergies remain untapped (Ministry of the Environment of Finland 2010), e.g., in relation to taxonomy and reporting (Phelps *et al*., 2010). One multilateral process in which alignment with

CITES has been challenging is the International Whaling Convention, with which there has been disagreement on the hierarchical arrangement between the two regimes (Caddell, 2012, 2013b).

3.4.3 The Ramsar Convention on Wetlands

The Ramsar Convention addresses the conservation and wise use of wetlands and has 170 Parties. The four Goals of the Convention's 4th Strategic Plan (2016–2024) relate to addressing the drivers of wetlands loss and degradation (Goal 1), the effective conservation and management of the Ramsar Site network (Goal 2), wise use of all wetlands (Goal 3), and enhanced implementation of the Convention (Goal 4). Wetland loss is continuing because of poor progress in addressing the drivers of wetland loss, meaning we are moving away from achieving Goal 1. The long-term loss of natural wetlands was 54–57% since 18th century, while during the 20th and early 21st centuries the rate of loss significantly increased with a loss of 64–71% of wetlands since 1900 AD, based on a subset of sites with available data (Davidson, 2014). Although the rate of wetland lost slowed down in North America and Europe since 1980s (Davidson, 2014), 4.8% of marshes and bogs have been lost in Europe during 1990–2006 (EEA, 2015, p 18), and 80,000 acres of wetlands were lost annually during 2004–2009 in coastal watersheds in the conterminous United States (Dahl & Stedman, 2013). The rates of wetland loss remain high in Asia (Russi *et al*., 2012, p. 19–20) with, for example, an average annual loss of 1.6% of the area of wetlands in Northeast and South-East Asia (Gopal, 2013; UNEP, 2016b, p.65), 65% loss of intertidal wetlands in the Yellow Sea over the past 50 years (Murray *et al*., 2014), and loss of 51% of coastal wetlands in China, 40% in the Republic of Korea and >70% in Singapore during 1955–2005 (MacKinnon *et al*., 2012, p.1). There is limited information on wetland loss in Africa, Latin America and the Caribbean and Oceania (Davidson, 2014). The Red List Index for wetland birds, mammals and amphibians, plus corals, is continuing to decline, indicating that overall, these species are moving towards extinction (Ramsar Convention, 2018).

Wetland benefits feature in some national/local policy strategies and plans in key sectors, for example the US Agricultural Act of 2014 has funding schemes for wetland conservation (USDA, 2017) while the EU Water Framework Directive (2000) features wetlands in integrated river basin management plans to improve water quality. However, there are large gaps; for example, many wetlands in India are under anthropogenic pressures because wetlands barely figure in water resource management and development plans (Bassi, 2014), while the absence of wetland considerations in local land-use planning is the main driver for wetland degradation in the Mediterranean (Mediterranean Wetlands Observatory, 2012, p.44). Finlayson (2012) found that national-level implementation of the Ramsar Convention is, overall, inadequate. Wetlands in almost all regions continue to be degraded due to anthropogenic factors such as land claim for agriculture (e.g., in 1990–2006, 35% of wetlands loss in the EU was to agriculture; EEA, 2015, p.18; Murray *et al*., 2014; Russi *et al*., 2012), urbanization (Hettiarachchi *et al*., 2015) and pollution (Gopal, 2013; Junk *et al*., 2013; Ramsar Convention, 2018), although there are exceptions: the EU made significant progress in reducing nutrient levels in lakes and rivers between 1992 and 2007 by improving wastewater treatment and reducing agricultural inputs (EEA, 2015, p.70). Ramsar COP 12 National Reports show that in many countries some parts of public and private sectors are applying guidelines for the wise use of water and wetlands; however, there is no evidence to access the scale and effectiveness of this.

Invasive alien species threaten native biodiversity (Lodge *et al*., 2006), with wetlands being particularly susceptible to invasions (Zedler & Kercher, 2004). In Europe, the cumulative number of alien species in freshwater, marine and estuarine ecosystems has been constantly increasing since the 1900s. The trend is slowing down for freshwater species, but not for alien marine and estuarine species (EEA, 2010). In 2018, 40% of Ramsar Parties had developed a comprehensive national inventory of invasive alien species impacting wetlands, but only 26% had established national policies or guidance on control or management of invasive alien species impacting wetlands (Ramsar Convention, 2018). Information about wetland invasive alien species is increasingly accessible through the Global Invasive Species Database (http://www.iucngisd.org/gisd/).

Parties do not appear to be on track to achieve effective conservation and management of the Ramsar site network (Goal 2). Only c. 11% of inland wetlands are designated as national protected areas and/or Ramsar Sites, ranging from 20% in Central and 18% in South America to only 8% in Asia (Reis *et al*., 2017). While 2,314 Wetlands of International Importance covering 245.6 million ha had been designated Ramsar Sites as of August 2018, ecological representation remains low. Only 24% of 3,359 wetland Important Bird and Biodiversity Areas (IBAs) that qualify as Ramsar Sites had been designated under the convention by March 2015, representing 14% of the area of all qualifying sites. Coverage is highest in Europe and Africa (with at least 30% of qualifying IBAs completely or partially covered) and lowest in Asia (just 12% completely or partially covered); results for the Americas and the Pacific are currently unavailable. The percentage of qualifying IBAs completely or partially covered by Ramsar Sites has increased from 16% in 2000 to 24% in 2015 (BirdLife International, 2015). The rate of designation of Ramsar Sites has slowed considerably in the 2010s, and only

41% of Parties have established a strategy and priorities for future Ramsar Site designation (Ramsar Convention, 2018). Only slightly more than half of all Ramsar Sites have management plans that are being actively implemented (Ramsar Convention, 2018).

Progress towards wise use of all wetlands (Goal 3) has been poor. Wetland inventories are missing, incomplete or out of date in many countries (Junk *et al*., 2013), although the recent publication of a global wetland layer based on remote sensing (Pekel *et al*., 2016) may help to address this issue. Based on 140 National Reports (2018), 44% of Contracting Parties have completed National Wetlands Inventories and 29% are in progress. The proportion of Parties having completed inventories is highest in North America (67%) and Europe (62%) and lowest in Asia (30%). In 2015, 37% of Parties to the Ramsar Convention reported that they have removed perverse incentives that discourage the conservation and wise use of wetlands, while 51% reported that actions had been taken to implement positive incentives that encourage the conservation and wise use of wetlands (Ramsar Convention, 2018). By 2018, 73 Parties had established a National Wetland Policy or equivalent, and 18 additional countries have elements of such a policy in place (Ramsar Convention, 2018). Integrated resource management at the scale of river basins and coastal zones is often insufficient.

While traditional knowledge, innovations and practices of IPLCs are sometimes integrated into implementation of the Convention, this does not happen universally, despite the fact that engaging local actors in rule development typically leads to greater consensus and more effective multilateral implementation (Mauerhofer *et al*., 2015). Wetland functions, services and benefits are widely demonstrated, documented and disseminated (Ghermandi *et al*., 2010; Ramsar Convention, 2018). While some efforts are underway to restore degraded wetlands (e.g., Cui *et al*., 2009; Zhao *et al*., 2016b,), climate change is likely to exacerbate the pressures on wetlands (Finlayson *et al*., 2017; Gopal, 2013; Junk *et al*., 2013).

Implementation of the Ramsar Convention is being strengthened, but slowly (Goal 4). Scientific and technical guidance on relevant topics are increasingly available and used by policy makers and practitioners (e.g., Ramsar guidance shaped the governance of urban wetlands in Colombo, Sri Lanka; Hettiarachchi *et al*., 2015). The Ramsar Convention's Programme on communication, capacity-building, education, participation and awareness promotes World Wetland Day to mainstream wise use of wetlands. To assist in implementing the Convention, 19 Ramsar Regional Initiatives, including networks of regional cooperation such as the Niger River Basin Network and the West African Coastal Zone Wetlands Network, have been developed.

3.4.4 United Nations Convention to Combat Desertification (UNCCD)

The UNCCD has a strategic plan for 2008–2018 which sets four long-term strategic goals and five short- and medium-term operational objectives (UNCCD, 2007). The goals aim to: improve living conditions of the communities (Goal 1) and the ecosystems (Goal 2) affected by land degradation and desertification; generate global benefits for biodiversity conservation and climate change mitigation (Goal 3); and mobilize resources and build partnerships for implementation of the Convention (Goal 4).

There has been poor progress towards improving the living conditions of affected populations (Goal 1). Desertification and land degradation are roughly estimated to affect over 1.5 billion people whose livelihoods and well-being are dependent on dryland areas and agriculture (Amiraslani & Dragovich, 2011; Bai *et al*., 2008; Sanz *et al*., 2017 p.29,). Adverse effects of land degradation have most impact on the poor and vulnerable social groups (IPBES, 2018). Globally, 74% of the poor (42% of the very poor and 32% of the moderately poor) are directly affected by land degradation (Sanz *et al*., 2017). About 20% of irrigated land (45 million hectares) is moderately or severely salinized (Rengasamy, 2006), including the Indo-Gangetic Basin in India (Gupta & Abrol, 2000), Aral Sea Basin of Central Asia (Cai *et al*., 2003), and the Murray-Darling Basin in Australia (Rengasamy, 2006). Desertification undermines affected people's livelihoods and contributes to increased levels of poverty and rural-urban migration (Amiraslani, 2011; Bates, 2002; Verstraete, 2009). Although migration is often caused by a mix of social, economic, political and environmental drivers (Warner *et al*., 2010), 'environmental migrants' outnumber traditional socio-political refugees in sub-Saharan Africa (Myers, 2002). Desertification may displace globally 50 million people in the next 10 years (Sanz *et al*., 2017). Since the mid-20th century, there has been increasing aridification of Africa, East and Southern Asia, Eastern Australia, and Southern Europe (Dai, 2011; Sheffield *et al*., 2009). Under a 'business-as-usual' scenario, up to 50% of the earth's surface may be in drought at the end of the 21st (Burke *et al*., 2006). Increasing droughts may further jeopardize the livelihoods and well-being of communities dependent on agriculture (Morton, 2007).

There seems to be a moderate progress towards improving the condition of affected ecosystems (Goal 2). There has been 'some progress' towards UNCCD targets related to deforestation, but 'little or no progress' towards those related to desertification and drought (UNEP, 2012). While some subtropical deserts (e.g., the Sahara, Arabian, Kalahari, Gobi and Great Sandy Desert) are expanding (Zeng & Yoon, 2009), some arid territories such as the Sahel, the Mediterranean basin, Southern Africa are currently 'greening up' and are not expanding (Hellden & Tottrup, 2008). Estimates of the global area of degraded land range between 1 and 6 billion ha (Gibbs and Salmon, 2015). Of the c. 24% of global land area that is degrading, 23% is broadleaved forest, 19% is needle-leaved forest, and 20–25% is rangeland (Bai *et al*., 2008). One of the drivers is land conversion for agricultural expansion (Lambin & Meyfroidt, 2011), especially in the tropical forest regions (Gibbs *et al*., 2010; Keenan *et al*., 2015). Desertification also contributes to the emission and long-range transport of fine mineral dust (D'Odorico *et al*., 2013), which may adversely affect ecosystems ranging from lowlands to mountain glaciers (Indoitu *et al*., 2015).

We appear to be making moderate progress in generating global benefits for the conservation and sustainable use of biodiversity and the mitigation of climate change through implementation of the convention (Goal 3). Land degradation, affecting about 25% of global land area (Bai *et al*., 2008), influences in a complex way the magnitude and direction of climate impacts on agricultural land and biodiversity (Webb *et al*., 2017). Practices and technologies that mitigate land degradation, climate change adaptation and mitigation often positively affect biodiversity (Sanz *et al*., 2017, p. 81). Climate change is likely to affect agricultural yields and threaten future global food security (World Bank, 2008, p. 100) and reduce communities' adaptability and resilience towards climate change (Neely *et al*., 2009). Net greenhouse gas emissions from land-use changes amounted to approximately 10–12% of total emissions around the year 2005 (Sanz *et al*., 2017, p. 35). Although CO2 emissions from net forest conversion in 2011–2015 decreased significantly since 2001–2010 period, the share of CO2 emissions from forest degradation increased (Federici *et al*., 2015). Global emissions from land use, land use change and forestry decreased from 1.54±1.06 $GtCO_2e\ yr^{-1}$ in 1990 to 0.01±0.86 $GtCO_2e\ yr^{-1}$ in 2010, and future net emissions by 2030 range from an increase of 1.94 ± 1.53 $GtCO_2e$ yr−1 to a decrease of −1.14±0.48 $GtCO_2e\ yr^{-1}$ under different policy scenarios (Grassi *et al*., 2017). Reducing agriculture-driven deforestation and forest-sparing interventions could reduce 1-1.3 $GtCO_2e\ yr^{-1}$ from the agriculture sector (Carter *et al*., 2015). Most countries (89%) have included agriculture and/or land use, land-use change and forestry (LULUCF) in emission reduction targets in their Intended Nationally Determined Contributions (Sanz *et al*., 2017, p.37).

Good progress has been made in mobilizing resources to support implementation of the Convention through building effective partnerships between national and international actors (Goal 4). UNCCD has committed to harmonize its strategies with the SDGs and direct its activities to meet SDG 15.3 (to combat desertification and restore degraded land and soil… and strive to achieve a land degradation-neutral world). With support from the convention, 102 countries agreed in 2016 to set voluntary Land Degradation Neutrality targets. The formal agreement of the definition of Land Degradation Neutrality in 2015 (UNCCD, 2015) was followed by the development of a Scientific Conceptual Framework for Land Degradation Neutrality, which takes into account quantitative and qualitative data and emphasizes stakeholder participation (Akhtar-Schuster *et al*. 2017; Cowie *et al*., 2018; Orr *et al*., 2017).

UNCCD has developed a monitoring and assessment framework, which takes into account quantitative and qualitative data and emphasizes stakeholder participation (Akhtar-Schuster *et al*., 2017). There are some challenges in operationalizing indicators against these targets (Chasek *et al*., 2015; Dooley & Wunder, 2015; Sietz *et al*., 2017), a lack of baseline data for assessing progress (Grainger, 2015) and no uniform criteria and standard methodology to assess land degradation and the effectiveness of restoration measures; nevertheless, progress towards setting Land Degradation Neutrality targets appears to be significant.

3.4.5 The Convention concerning the Protection of the World Cultural and Natural Heritage

The WHC was adopted by the General Conference of the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1972, and came into force in December 1975. The Convention seeks to encourage the identification and conservation of natural and cultural heritage of 'Outstanding Universal Value', which is defined as 'cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity' (UNESCO WHC, 2016). The Convention requires its 193 Parties to identify and protect relevant sites (UNESCO WHC, 2017). The WHC is the most universal international legal instrument for global protection of cultural and natural heritage.

World Heritage Sites are landmarks or areas of outstanding universal value that have been officially recognized by UNESCO, following decisions from the intergovernmental World Heritage Committee. Signatories have to conserve both world heritage and national heritage in their countries. As of April 2018, there are 1,092 sites on the World Heritage List, of which 209 sites are classified as 'natural' heritage, 845 as 'cultural' heritage and 38 as 'mixed' heritage (i.e., natural and cultural) (UNESCO, 2018). Natural heritage sites include natural features, geological and physiographical formations, and natural areas with aesthetical, scientific and conservation value. Parties are encouraged to integrate cultural and natural heritage protection into regional planning programmes, undertake relevant conservation research, and enhance the function of heritage in people's lives. The World

Heritage Committee may inscribe a property on the 'List of World Heritage in Danger'. At present, 16 of the 54 sites on this list are natural sites (UNESCO, 2018). Annual reviews are required of the state of conservation of properties on the List.

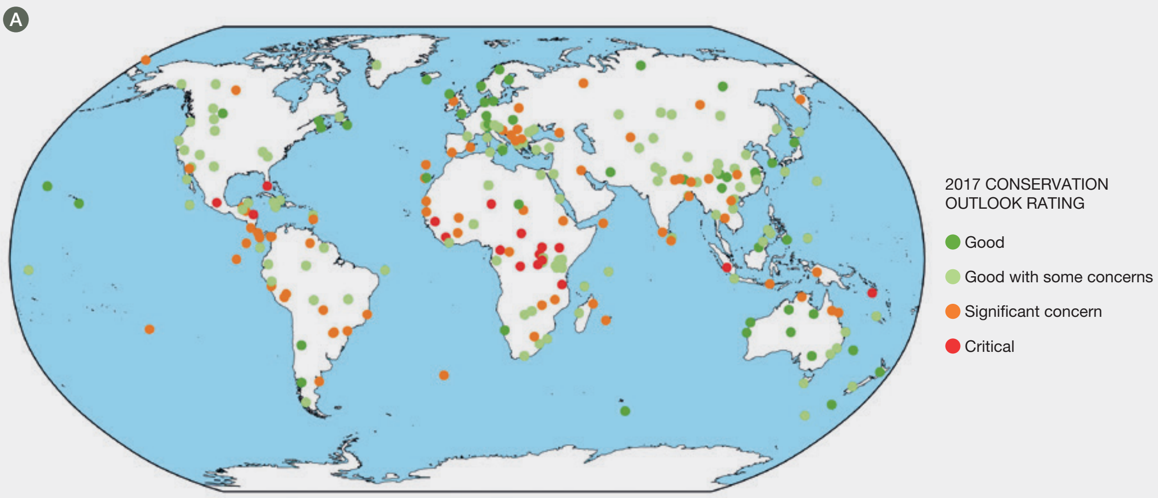
In 1994, the World Heritage Committee launched a Global Strategy for a Representative, Balanced and Credible World Heritage List to ensure that it reflects the world's cultural and natural diversity of outstanding universal value. In 2002, at its 26th Session of the Committee, the Budapest Declaration on World Heritage was adopted, setting out four main objectives of the Convention; a fifth was added in 2007. In November 2017, UNESCO published the World Heritage Outlook 2, which assessed the conservation status of 241 natural and mixed sites.

Good progress has been made to strengthen the credibility of the World Heritage List as a representative and geographically balanced testimony of cultural and natural properties of outstanding universal value (Objective 1). The number of States (i.e. Parties) to the WHC has risen from 139 to 167 in the last 20 years, with the number of sites listed growing from 33 to 1,092 (UNESCO, 2018). The list of sites is often accused of being highly biased, with Europe and North America having 47% of all sites (23% of all natural sites) while sub-Saharan Africa and the Arabian countries, for example, have 9% and 8% of all sites, respectively (Frey *et al*., 2013; Bertacchini and Saccone, 2012). In an effort to improve geographic representativeness, the WHS Secretariat has encouraged more countries to submit Tentative Lists for consideration (183 States have done this so far; UNESCO, 2018). Evaluations of the representativeness of World Heritage Sites indicate that they provide highly uneven biodiversity coverage, and underrepresent tropical and subtropical coniferous forests, temperate grasslands, Mediterranean forests, and tropical and subtropical dry forests (Anthamatten & Hazen, 2007; Bertzky, *et al*., 2013; Brooks *et al*., 2009). These biomes, however, are also poorly represented by protected areas more generally (Anthamatten & Hazen, 2007). Moreover, some Parties do not have any inscribed sites, even though they may possess sites likely to fulfil the selection criterion of 'outstanding universal value' (Frey *et al*., 2013). The dominance of the national over the international interest in World Heritage Site selection has also been noted (Frey *et al*., 2013).

Poor progress has been made in ensuring the effective conservation of World Heritage properties, particularly natural sites (Objective 2). Natural World Heritage sites are facing a wide range of threats, particularly invasive species, tourism, commercial hunting, fishing, dams and logging (Osipova *et al*., 2014, 2017). The two most significant current threats to natural World Heritage are invasive species and climate change **(Figure 3.14)**. Tourism impacts, legal and illegal fishing and hunting, fires, water pollution and dams are among the top threats. Between 2014 and 2017, the number of sites for which climate change was assessed as high or very high threat almost doubled, while the threat of fires increased by 33% (from 27 to 36 sites) (Osipova *et al*., 2017). Regional differences in current threat assessments exist. The highest number of sites where climate change was assessed as a high or very high current threat were in Oceania and Mesoamerica and the Caribbean. Oceania and North America have the most sites where invasive species are a high or very high threat. Europe and Asia have the most sites where tourism is a high or very high threat.

Only about half of the natural sites on the World Heritage List are regularly monitored through the main monitoring mechanisms of the Convention (Osipova *et al*., 2014). For those regions where Key Biodiversity Areas have been comprehensively assessed, all natural and mixed World Heritage sites have been found to qualify as Key Biodiversity Areas (Foster *et al*., 2010). For almost two thirds of all sites (64%) the conservation outlook is either good or good with some concerns, for 29% of sites the outlook is of significant concern, and for 7% it is critical (Osipova *et al*., 2017). Some World Heritage sites are additionally recognized as fulfilling the criteria for Outstanding Universal Value, defined as having "cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity" (UNESCO, 2016). For 70% of World Heritage sites, the values for which they were listed are either in a good state or of low concern, whereas for 27% and in 5% of sites the current state is of high concern or critical, respectively **(Figure 3.14)**. In 2014, the values associated with geoheritage (criterion viii) were in the best condition, with 94% of cases assessed as either good or of low concern. The values associated with biodiversity have tended to be of higher concern (Osipova *et al*., 2014, 2017).

Osipova *et al*. (2017) assessed 14 criteria for site protection and management and concluded that "only 48% of sites have overall effective or highly effective protection and management and in 12% of sites protection and management are of serious concern". Protection and management effectiveness decreased between 2014 and 2017, with the most effective criterion being research while sustainable finance was the criterion of highest concern. Good progress is being made in promoting the development of effective capacity-building measures, including for preparing site nominations and implementing the Convention (Objective 3). World Heritage programmes addressing this objective include resource manuals to help Parties nominate sites, to manage natural and cultural values within them, and to manage of disaster risks, and capacity-building. However, there is no independent



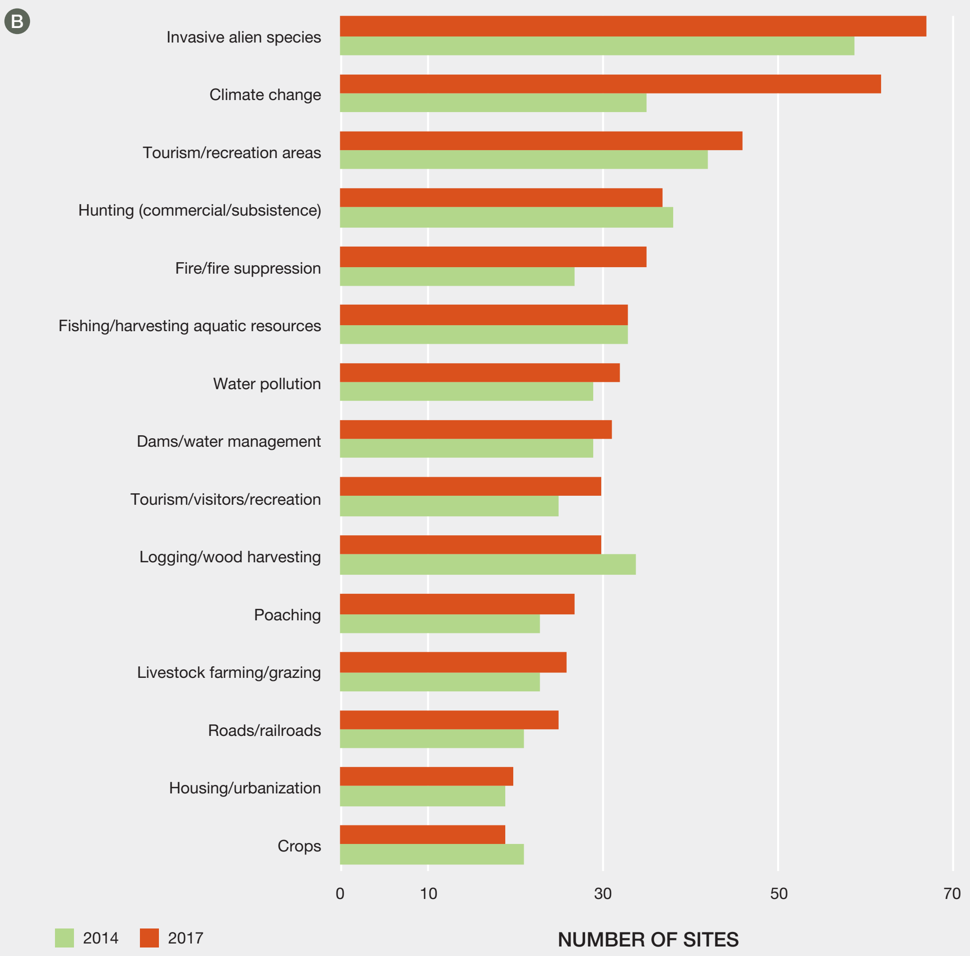


Figure 3 14 **A Conservation Outlook rating of 241 natural World Heritage sites, and B threats to natural World Heritage sites assessed as high or very high in 2014 and 2017.**

Source: Osipova *et al.*,(2017).

information on the effectiveness of these measures in building capacity.

Recent improved communication efforts have increased public awareness, involvement and support for World Heritage, indicating progress towards Objective 4, but information to assess this robustly is lacking. Awareness is likely to have been raised through the publication of the World Heritage Paper Series (launched in 2002), the dissemination of the quarterly World Heritage Review and World Heritage Newsletter, through the World Heritage Volunteers Initiative, the World Heritage Education Programme and the recent publication of the World Heritage Outlook 2.

The role of communities in the implementation of the World Heritage Convention is likely to have been enhanced, but at an insufficient rate (Objective 5). Programmes such as the World Heritage Volunteers Initiative and World Heritage Education Programme are likely to have increased community involvement, and there are a number of examples of sustainable development at World Heritage Sites being achieved through the involvement of local communities and the integration of multiple values and traditional and local ecological knowledge (Galla, 2012). In terms of relationships with local people, a criterion that was assessed in Outlook 2, it was considered highly effective in 35 sites and of serious concern for 22 sites of the 241 natural WHS (**Figure 3.14**; Osipova *et al*., 2017).

3.4.6 The International Plant Protection Convention

The IPPC has set four Strategic Goals for the period 2012–2019: A) to protect sustainable agriculture and enhance global food security through the prevention of pest spread; B) to protect the environment, forests and biodiversity from plant pests; C) to facilitate economic and trade development through the promotion of harmonized scientifically based phytosanitary measures; and D) to develop phytosanitary capacity for members to accomplish a), b) and c). IPPC's Strategic Goals contribute to the Strategic Objectives of the Food and Agriculture Organization of the United Nations, as well as to Sustainable Development Goals 8, 13, 15 and 17 and Aichi Target 9. Strategic Goal B is the one most closely related to conservation of biodiversity, while Goals A, C and D are more focused on agriculture and food security.

There is poor progress towards protecting sustainable agriculture and enhancing global food security through the prevention of pest spread (Goal A). Crop losses to pests have not significantly decreased during the last 40 years (Oerke, 2006). Analysis of the distribution of pests (arthropods, gastropods and nematodes), pathogens (fungi, oomycetes, protozoa, bacteria and viruses) and crops shows that more than one tenth of all pests have reached more than half the countries in which the crops they affect are grown. By the middle of the 21st century, these crop producing areas are likely to be fully saturated with pests (Bebber *et al*., 2014). Fungi and oomycetes are the most widespread and most rapidly spreading crop pests and make up the largest fraction of the 50 most rapidly spreading pests. Although some pests have global distributions, the majority of pest assemblages remain strongly regionalized, with their distributions determined by the distributions of their hosts (Bebber *et al*., 2014). Human activities remain the main factor facilitating spread of pests, although climate change may play a growing role in future. An average poleward shift of 2.7 ± 0.8 km yr−1 since 1960 has been observed for hundreds of pests and pathogens, with significant variation in trends among taxonomic groups (Bebber *et al*., 2013).

Global agricultural intensification is continuing in order to meet the increasing demand for food (Phalan *et al*., 2011; Tilman *et al*., 2011), but the associated landscape simplification negatively affects natural pest control. Growing agricultural expansion has a negative effect on biodiversity (Kehoe *et al*., 2017). Homogeneous landscapes dominated by cultivated land have 46% lower pest control levels than more complex landscapes. Conserving and restoring semi-natural habitats helps to maintain and enhance pest control services provided by predatory arthropods to agriculture (Rusch *et al*., 2016), and this also benefits biodiversity more broadly.

There is poor progress towards protecting the environment, forests and biodiversity from plant pests (Goal B). Biosecurity measures are critical for future food security (Cook *et al*., 2011), but pesticides remain the predominant measure for pest control in agriculture, with a >750% increase in pesticide production between 1955 and 2000 (Tilman *et al*., 2001). Broadscale and prophylactic use of some pest control measures such as insecticides may harm other organisms that are beneficial to agriculture, and in turn their ecological function, such as pollination (van der Sluijs *et al*., 2014; Whitehorn *et al*., 2012). Meta-analysis of 838 peer-reviewed studies (covering >2,500 sites in 73 countries) suggests that 52.4% (5,915 cases; 68.5% of the sites) of the 11,300 measured insecticide concentrations exceeded the accepted regulatory threshold levels for either surface water or sediments (Stehle & Schultz, 2015). High pesticide levels negatively affect freshwater invertebrate biodiversity (Beketov *et al*., 2013). Alternatives to intensive insecticide application include using more diverse crop rotations, altering the timing of planting, tillage and irrigation, using alternative crops in infested areas, applying biological control agents, and using lower-risk insecticides (Furlan & Kreutzweiser, 2015). Non-crop habitats at landscape scale tend to increase the diversity and/or the abundance of pests' natural enemies in fields (Attwood *et al*., 2008; Langelotto & Denno, 2004), which provides more effective control of herbivorous arthropods (Letourneau *et al*., 2009).

Good progress is being made to facilitate economic and trade development through the promotion of harmonized scientifically based phytosanitary measures (Goal C). The Agreement on the Application of Sanitary and Phytosanitary Measures is an important part of the World Trade Organization's Law of Domestic Regulation of Goods. Articles 2.2. and 5.6 require that sanitary and phytosanitary measures must not be trade-restrictive, and they must be based on scientific principles and applied only to the extent necessary to protect human, animal or plant life or health (Marceau & Trachtman, 2014). Sanitary and phytosanitary measures tend to restrict trade by increasing the costs for exporters of entering the market (Crivelli & Gröschl, 2015), especially for middle- and low-income exporting countries (Swinnen & Vandermoortele, 2011; Yue *et al*., 2010). Increasing stringency of such measures in developed countries has a substantial negative effect on exported volumes from developing countries (Melo *et al*., 2014). At the same time, these measures increase consumer confidence in product safety and positively affect trade of those exporters that comply with the requirements (Crivelli & Gröschl. 2015; Henson & Humphrey, 2010; Sheldon, 2012). Overall, such measures and their stringency do not tend to evolve uniformly across countries and regions (Woods *et al*., 2006) and the exporters capable of compliance tend to outcompete those which are not (Murina *et al*., 2015). Analysis of 47 fresh fruit and vegetable product imports into the USA from 89 exporting countries during 1996–2008 showed that sanitary and phytosanitary measures generally reduce trade in the early stages, but then their restrictiveness diminishes as exporters accumulate experience and reach a certain threshold (Peterson *et al*., 2013).

There has been moderate progress towards developing phytosanitary capacity for IPPC Parties to accomplish these goals (Goal D). Human-mediated pathways remain the main source of agricultural pest spread at global and regional scales (Bebber *et al*., 2013; Lopes-da-Silva *et al*., 2014). IPPC has developed the National Phytosanitary Capacity Development Strategy in 2012 as well as the Phytosanitary Capacity Evaluation tool. The latter provides a summary of a country's phytosanitary capacity at a particular time, which can be used for further strategic planning, priority setting and fundraising (IPPC, 2017).

Box 3 1 Progress towards achieving the objectives of the United Nations Convention on the Law of the Sea (UNCLOS).

Background on UNCLOS is given in section S3.11. Here we describe progress towards the objectives of UNCLOS Articles 61-68.

Progress in conserving fisheries stocks

Based on stock size and exploitation rates as indicators of a population's maximum sustainable yield, stocks overfished beyond biologically sustainable levels increased from 10% in 1974 to 31.4% in 2013. Of the stocks assessed in 2013, 58.1% were fully fished and only 10.5% were underfished (FAO, 2016). These assessments do not consider broader impacts such as those from by-catch, habitat and food web alteration. Since the 1950s, marine captures increased continuously until reaching a maximum of 86.4 million tonnes (mt) in 1996, but since then, captures have slowly declined, becoming relatively stable between 2003 and 2009, with slight growth to reach a new maximum in 2014 (81.5 mt), the last year fisheries catches were analyzed and reported globally (FAO, 2016). While global captures have been relatively stable, regional patterns have changed in response to local and regional changing conditions, deployment of new fishing technologies and increased fishing capacity (FAO, 2014a, 2016; Hazin *et al*., 2016; Rosenberg, 2016).

The largest marine fisheries landings are for Peruvian anchoveta, Alaska pollock, skipjack tuna, several sardine species, Atlantic herring, chub mackerel, scads, yellowfin tuna, Japanese anchovy and largehead hairtail. The trends for each of these groups or populations has been highly variable (FAO, 2016). In addition, climate change has already produced shifts in the distribution and productivity of some fisheries resources, especially those that are highly sensitive to changing oceanographic conditions (e.g., Peruvian anchoveta) (FAO, 2016; Rosenberg, 2016). Highlighting the most iconic fisheries, tuna captures reached a maximum in 2012 of 7 mt. For tuna and billfish, about half of the 41 assessed populations are under variable fishing pressures including being overfished or experiencing overfishing, or both (Restrepo *et al*., 2016; Inter-American Tropical Tuna Commission (IATTC) reports: https://www.iattc.org/StockAssessmentReports/StockAssessmentReportsENG.htm). For sharks (and other chondrichthyans), many populations are overexploited, with more than 2 mt of sharks captured per year, and some species are threatened. The shark fin market alone comprises more than 17,000 tonnes (Dulvy *et al*., 2017; Ward-Paige, 2017). Maximum global landings of sharks occurred in 2000 and have declined since then. These declines may be attributed to conservation management measures adopted by several RFMOs (e.g., prohibitions of catch for certain shark species; introduction of by-catch mitigation measures) (http://www.fao.

org/ipoa-sharks/regional-sharks-measures/en/), or to a change (and reduction) of consumption patterns in major markets including China (Vallianos *et al*., 2018). However, declines in landing have also been attributed to populations declines (Davidson *et al*., 2016).

Among invertebrates, the most valuable groups, lobster, shrimps and cephalopods (mostly squid), reached maximum levels of captures in 2014 (shrimp catches are stable around 3.5 mt and cephalopod catches exceeded 4.5 mt) (FAO, 2016). The areas where most global fisheries occur are the Northwest Pacific (27%), the Western Central Pacific (15%), the Southeast Pacific (11%) and the Northeast Atlantic (10%). About 18 countries are responsible for 76% of global captures (FAO, 2016).

In addition to the effects of captures on target species, there are also significant effects on by-catch species, ecosystems, food webs and benthic and demersal habitats (Hazin *et al*., 2016). While there has been increased awareness of these problems and efforts made to reduce by-catch and other broader ecosystem impacts of fishing, implementation of by-catch mitigation measures is variable, and there is insufficient monitoring of their success (Rosenberg, 2016).

Finally, catches in illegal, unreported and unregulated (IUU) fisheries, which have major negative effects on biodiversity, have been estimated to total 11-26 mt per year, concentrated in developing countries in particular. IUU fisheries have undermined the effectiveness of stock management measures (Gjerde *et al*., 2013). Success in reducing IUU fisheries varies across counties and regions and is highly related to governance (Agnew *et al*., 2009) and the effectiveness of law enforcement (Gjerde *et al*., 2013).

Progress in conserving other marine biodiversity

Best estimates of the proportion (with lower and upper estimates) of threatened species varies between taxonomic groups. In decreasing order these are: marine mammals 41% (28-60%); reef-building corals 33% (27-44%); sharks and rays 31% (18-59%); marine birds 20% (20-21%); marine reptiles (marine turtles, crocodiles and seasnakes) 20% (14-44%); hagfishes 20% (12-51%); mangroves 17% (16-21%); seagrasses 16% (14-26%); cone snails 8% (6-20%); selected marine bony fishes (sturgeons, tunas, billfishes, blennies, pufferfishes, angelfishes, butterflyfishes, surgeonfishes, tarpons, ladyfishes, groupers, wrasses, seabreams, picarels and porgies) 7% (6-18%); lobsters <1% (0-35%) (**Figure 3.15**; IUCN, 2017). The most threatened group, marine mammals, has seen the reduction of almost all populations since pre-exploitation times, with some species becoming extinct, such as Steller's Sea Cow *Hydrodamalis gigas* and Caribbean Monk Seal *Neomonachus tropicalis* (IUCN, 2017). Banning hunting has allowed for population recovery of the humpback whale *Megaptera novaeangliae* and blue whale *Balaenoptera musculus* following controls on commercial whaling. Protecting the feeding and breeding areas has also proved to be effective in the recovery of some marine mammal populations (Rodrigues *et al*., 2014). However, marine mammals still face many anthropogenic threats mostly due to habitat alterations (e.g., pollution, coastal development, noise) and climate change (Smith *et al*., 2016). The fact that there is a significant bias towards the study of less endangered species may also hinder the ability of policymakers to develop and apply the most appropriate conservation and management practices (Jaric *et al*., 2014).

The second most threatened group, corals, are impacted by a variety of stressors including pollution, sedimentation, physical destruction, overfishing, diseases, ocean acidification, and climate change. These stressors act synergistically with natural stresses and result in significant damage (Wilkinson *et al*., 2016), in particular the loss of live coral cover. In the Caribbean, average coral cover was reduced from 34.8% in the 1970s-1980s to 16.3% in ~2000-2010 (Jackson *et al*., 2014). At present, one of the major concerns is large-scale coral bleaching, which is associated with increasingly warming waters. Bleaching events have become more frequent, severe, and extensive, hindering the capacity of corals to recover (Hughes *et al*., 2017a, 2018). For example, the Great Barrier Reef suffered a bleaching event in 2015-2016 that affected 75% of surveyed locations.

Seabirds are threatened by pressures both at sea (e.g., fishing by-catch, pollution) and on land (e.g., disturbance, hunting, and predation by invasive species), and their status has deteriorated significantly in recent decades (Croxall *et al*., 2012; Lascelles *et al*., 2016). Almost 30% of 346 seabird species are globally threatened, and nearly half are known or suspected to have population declines (Croxall *et al*., 2012). Targeted conservation actions, including eradication of invasive species such as feral cats and rats from islands with seabird breeding colonies, and other actions focused on the most important marine and terrestrial locations for seabirds (identified as Important Bird and Biodiversity Areas) have improved the status of some populations and species (Croxall *et al*., 2012). FAO plans to reduce incidental by-catch of seabirds (http://www.fao.org/fishery/ipoa-seabirds/npoa/er/en) have not yet reduced this threat to seabirds (Croxall *et al*., 2012).

Trends in other groups of marine species (e.g., plankton, benthos, fish and pelagic macro-invertebrates, marine reptiles) and habitats are mostly negative (see the World Ocean Assessment (http://www.un.org/depts/los/global_reporting/WOA_RegProcess.htm; Rice, 2016). In general, no ocean biodiversity nor ecosystem has escaped the impact of human pressures. These pressures act either directly or indirectly and vary in intensity and spread. The most stressing impacts that act on marine biodiversity and ecosystems which also have societal and economic consequences are climate change (e.g., temperature increase and acidification), overfishing and human disturbance (e.g., catches, by-catches, collisions, net entanglement, habitat destruction), input of pollutants and solid waste to the ocean (e.g., nutrients, plastics, pathogens), increase in use of ocean space and physical alteration (e.g., shipping routes, wind farms, causeways, major channels), underwater noise, and introduction of invasive alien species (Bernal *et al.*, 2016). Despite some progress in developing ecosystem-based approaches to manage human activities in the ocean, there is still a major need for assessments that integrate all environmental components across social and economic sectors for all parts of the world. To accomplish this, significant capacity development will be required (Bernal *et al.*, 2016).

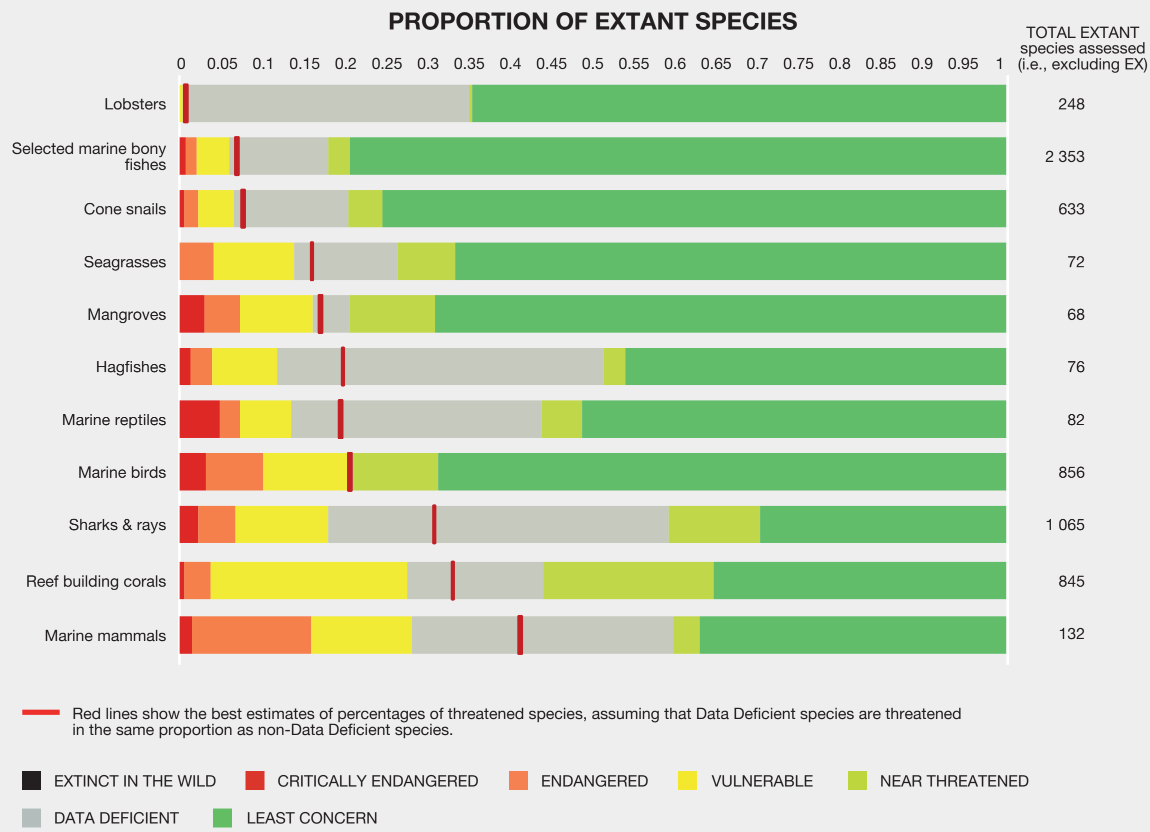


Figure 3 15 **The proportion of marine species in each category of extinction risk on the IUCN Red List.**

Groups are ordered according to the vertical red lines, which indicate the best estimate for proportion of extant species considered threatened (Critically Endangered or Vulnerable). The numbers to the right of each bar represent the total number of extant species assessed for each group. Extinct species are excluded. Source: IUCN (2017).

Protecting marine areas

For progress towards establishing marine protected areas, including description of Ecologically and Biologically Significant Areas (a process coordinated by the CBD), and the establishment of protected areas for biodiversity beyond national jurisdictions (a process managed through the United Nations General Assembly) see section 3.2. on Aichi Target 11.

Box 3 2 Progress towards achieving the objectives of polar agreements and cooperative arrangements.

The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)

Background on CCAMLR is given in section S3.12. Here we describe progress towards its objectives. CCAMLR has achieved considerable progress to meeting its goal of "conservation of Antarctic living resources". It is regarded as a leader in High Seas conservation (Brook, 2013) and in developing ecosystem-based fisheries management (Constable, 2011). Progress made towards achieving the goals of the Convention include: 1) the establishment and enforcement of fisheries controls, 2) the establishment Marine Protected Areas (MPAs) within the Convention area in accordance with international law (including UNCLOS), 3) the reduction of seabird mortality, 4) the establishment of the CCAMLR Ecosystem Monitoring Program (CEMP), and 5) the identification and management of vulnerable marine ecosystems (e.g., seamounts, hydrothermal vents, cold water corals and sponge fields).

With regard to fisheries, CCAMLR has implemented a series of measurements to address the impact of bottom fisheries (trawling or demersal long-lines) as well as to control illegal, unreported and unregulated (IUU) fishing. Such measures include the appointment of scientific observers under the CCAMLR Scheme of International Scientific Observation within every ship engaged in fisheries (Reid, 2011). This internationally recognized program has successfully improved the conservation of the seafloor and seabirds (Croxall, 2013) and the identification of vulnerable marine ecosystems (Reid, 2011). Such methods and encounter protocols developed for fishing vessels to identify and protect vulnerable marine ecosystems have led to calls for regulation of bottom fishing on the high seas (Reid, 2011). Bottom trawling has been banned around the Antarctic Peninsula since the early 1990s. Since then, some stocks have recovered in this area; however, neither the mackerel icefish *Champsocephalus gunnari*, one of the most abundant species before exploitation, nor the yellow notothenia *Gobionotethen gibberifrons* have yet recovered (Gutt *et al*., 2010).

With regard to the establishment of marine protected areas, CCAMLR has negotiated the establishment of important protected areas in the Southern Ocean, e.g., in the South Orkney Islands in 2010, and in the Ross Sea in 2016 (Brook, 2013; CCAMLR, 2016; UNEP-WCMC & IUCN, 2018). The marine protected area in the Ross Sea is the largest in the world, covering more than 2 million km^2 (CCAMLR, 2016). Another potential major protected area in the Weddell Sea is currently under consideration (Teschke *et al*., 2013, 2014).

Overexploitation of fisheries resources, mainly Antarctic toothfish *Dissostichus mawsoni*, Patagonian toothfish *D. eleginoides*, and mackerel icefish, along with bycatch, habitat loss, human disturbance, pollution and climate change are the major threats to marine biodiversity and ecosystems in the Southern Ocean (Alder *et al*., 2016; Griffiths, 2010). For seabirds, significant decreases in populations of species known to be caught on longline fisheries (e.g., albatrosses, Southern Giant Petrel *Macronectes giganteus* and large petrels *Procellaria* spp.) had been reported in the early 2000s (Tuck *et al*., 2003; Woehler *et al*., 2001). While populations in the north of the CCAMLR area are still at risk, the reduction of seabird mortality has been significant in fisheries regulated by CCAMLR (Ramm, 2013).

Scientific research and monitoring have been intensive in the Southern Ocean for more than a century. One of the most noteworthy of these research programs was the Census of Antarctic Marine Life (CAML), a project framed in the Census of Marine Life program. Within the CAML framework and the International Polar Year 2007-2009, 19 research voyages were coordinated with researchers from over 30 nations (Miloslavich *et al*., 2016). These expeditions significantly advanced our understanding of Southern Ocean ecosystems and biodiversity (Brandt *et al*., 2007; Broyer and Koubbi, 2014) and also helped to identify and declare new areas as vulnerable marine ecosystems (Gutt *et al*., 2010). To manage the effects of fishing in both target and associated species, the CAMLR convention also established in 1989 the Ecosystem Monitoring Program (CEMP) to allow for the detection of changes in the ecosystem components and their attribution. CAMLR goals and CEMP are supported by a very strong community of practice (e.g., the Southern Ocean Observing System; SOOS). SOOS has proposed and is currently developing a set of ecosystem Essential Ocean Variables to be measured in a sustained and coordinated manner to assess changes in Southern Ocean diversity and ecosystems and its causes (Constable *et al*., 2016).

The Conservation for the Arctic Flora and Fauna (CAFF)

Background on CAFF is given in section S3.12. Here we assess progress towards its objectives. Research and monitoring have been carried out in the Arctic for more than a century, but given the size, remoteness, habitat complexity and technical challenges, baseline inventories of species in many areas are still lacking or incomplete, especially for the marine realm (Gradinger *et al*., 2010). This knowledge gap makes it very difficult to assess Arctic biodiversity patterns and trends over time (Archambault *et al*., 2010; CAFF, 2013; Lindal Jorgensen *et al*., 2016). However, with the Circumpolar Biodiversity Monitoring Program and the State of the Arctic Biodiversity reports, gaps and available data are being identified for the Arctic Focal Ecosystem Components (CAFF, 2017). The Arctic has undergone dramatic changes since the Holocene, driven mostly by climate fluctuations which have impoverished its biodiversity. At present, climate change is the most important driver of environmental change in terrestrial, freshwater and marine ecosystems, including the thinning of the ice pack (CAFF, 2017; Ims and Ehrich, 2013; Michel, 2013; Wrona and Reist, 2013). Other drivers causing changes and degradation of the Arctic ecosystems are ocean acidification, pollution, landscape disturbance, changes in currents, invasive species and exploitation of resources (CAFF, 2017). How these changes will affect biodiversity is poorly understood, but under future scenarios of climate change, Arctic habitats may be irrevocably lost (Michel, 2013). Food resources are being lost for many Arctic marine species; increasing numbers and diversity of southern species are moving into Arctic waters, and current trends indicate that the high Arctic marine species are under huge pressure. Species that depend on sea ice for reproduction, resting or foraging will experience range reductions. Arctic marine species and ecosystems are also undergoing pressure from changes in their physical, chemical and biological environment (CAFF, 2017). While there are few time series available that date back to the 1950s and 1960s, an analysis of the Arctic Species Trend Index data by decade indicated that the proportion of locations with decreasing populations has grown from 35% in 1950-1960 to 54% in 2000-2010 (Bohm *et al*., 2012; McRae *et al*., 2012). Awareness of the profound changes in the Arctic has also been improving thanks to the establishment of several Arctic Long-Term Ecological Research sites, especially since the late 1990s when more detailed and across ecosystem analyses was implemented (Soltwedel *et al*., 2016).

Several marine mammal species were historically hunted in the Arctic, with some overharvested such that populations were depleted (e.g., bowhead whale *Balaena mysticetus*) or driven extinct (e.g., Steller's sea cow *Hydrodamalis gigas*). Regulation of these activities has led to stabilization or recovery of some populations of some species (Jorgensen *et al*., 2016). The Circumpolar Biodiversity Monitoring Program has identified 32 Focal Ecosystem Components to use as indicators of ecosystem state. For marine mammals for example, an assessment of 84 stocks of 11 species indicated that eight are increasing, 14 are stable, four are decreasing, but for the remaining 53, trends are unknown. The most dramatic cases are for polar bear *Ursus maritimus*, for which seven out of 19 populations are declining, four are stable, and only one is increasing (Reid *et al*., 2013). Another example is the Cook Inlet beluga whale *Delphinapterus leucas* population, which declined in the 1990s and still remains Critically Endangered (Jorgensen *et al*., 2016). For terrestrial carnivores, trends vary among species, populations and regions, ranging from increases to local extirpation, while for herbivores, populations fluctuate through time, independently of human stressors (Reid *et al*., 2013). With regards to birds, most of the Arctic species are migratory and therefore their population trends are affected by drivers (e.g., food availability, habitat loss) across their migratory routes. Some migratory populations are known to have increased (e.g., many Nearctic and Western Palearctic waterfowl populations, especially geese), while others have decreased (e.g., in the Eastern Palearctic). For resident bird species, trends are poorly known (Ganter & Gaston, 2013). For most seabird populations, trends have been negative (Jorgensen *et al*., 2016) or are difficult to assess due to lack of information. Particularly for geese populations, it is suspected that those species with the poorest information are those with the greatest declines (CAFF, 2018). For amphibians and reptiles, there are no reports of declines, but data are very scarce (Kuzmin & Tessler, 2013). For freshwater fish species, about 28% are under threat (e.g., the five sturgeon species), while for marine species, population trends cannot be inferred due to the lack of data except for a few commercial species (Christiansen & Reist, 2013). Fisheries and bycatch are the main threats to marine fishes and occur mostly in the shelf areas connecting the Arctic to boreal regions of the Atlantic and Pacific Oceans (e.g., the Barents Sea and Bering Sea). It is expected that as the waters continue to warm, fishing activities will spread to previously unfished Arctic regions. For phytoplankton, zooplankton and benthic invertebrates, there is insufficient information to infer trends, but there are a few documented cases of the negative effects of anthropogenic activities on population size, abundance, growth and species distribution (Gradinger *et al*., 2010; Jorgensen *et al*., 2016). Overall, current monitoring is not sufficient to determine status and trends for most Focal Ecosystem Components (CAFF, 2017).

Protected areas within the CAFF boundary cover 20.2% of the Arctic's terrestrial area and 4.7% of the marine area, which is almost two and four times the terrestrial and marine areas protected in 1980 respectively. Combined, these areas and cover 3.7 million km^2 and 11.4% of the Arctic. The effectiveness of the management of these areas, and their levels of governance vary across countries. While this represents progress towards policy goals, these protected areas still do not represent all ecologically relevant ecosystems, cover all important sites for biodiversity, or meet other aspects of Aichi Target 11 within the Arctic region (Barry *et al*., 2017; CAFF & PAME, 2017).

3.5 CROSS-CUTTING SYNTHESIS OF TARGET ACHIEVEMENT

To identify broad patterns of progress towards the Aichi Biodiversity Targets and SDGs, we first identified thematic groups of Aichi Biodiversity Targets and SDG targets based on an assessment of the relationships between each target and the different components (nature and NCP) of the IPBES conceptual framework (see chapter 1). We then synthesized the patterns of progress presented in sections 3.2 (on Aichi Biodiversity Targets), 3.3 (on SDGs) and 3.4 (on other biodiversity agreements) for each of these themes. As most other agreements endorse the Aichi Biodiversity Targets (see sections 3.4 and S3.9), we assumed alignment of individual targets of these agreements with the Aichi Biodiversity Targets.

To identify themes that are cross-cutting across the Aichi Biodiversity Targets and SDGs, we carried out an expert-based classification exercise to assess the relationships between the targets/goals and two main elements of the IPBES conceptual framework (nature and NCP). For the SDGs, we scored both the goals and the most relevant targets within them. Scores rating the direction and the strength of the relationships were assigned in a Delphi process involving 31 authors of the IPBES global assessment and refined by a smaller core team of four experts. Based on these scores, nine broad thematic groups of targets and goals were identified **(Figure 3.16)**. These thematic groups (themes) identify cross-cutting commonalities that emerge across various multinational environmental agreements in terms of the IPBES conceptual framework. Each theme contains only the most dominant targets that are considered cross-cutting across the SDGs and Aichi Biodiversity Targets (derived from the scoring exercise). Other related targets are considered to complement the discussion relating to the theme. Progress in achieving targets within the themes is summarized in the following paragraphs. It is to be noted that we synthesize results of assessments on progress towards the Aichi Biodiversity Targets and other biodiversity agreements and on trends in nature and NCP relating to achieving

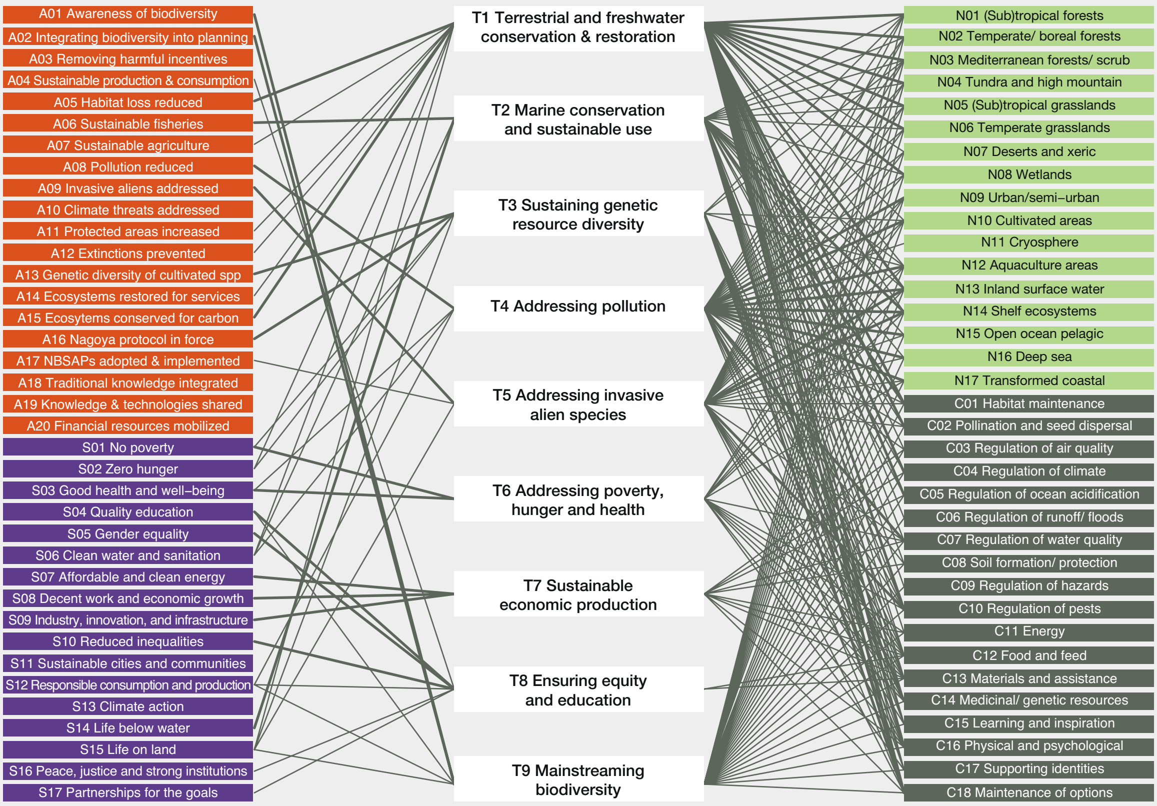


Figure 3 16 **Nine themes cutting across the Aichi Biodiversity Targets, SDGs and other related multilateral environmental agreements.**

These themes were defined through their relationships to targets of major environmental agreements (Aichi Biodiversity Targets, Sustainable Development Goals), and elements of the IPBES conceptual framework (nature and nature's contributions to people) in a cluster analysis exercise (see section S3.13). The thickness of the lines indicates a degree of association. Only targets significantly associated with each theme are shown.

the SDG targets. The term 'progress' is therefore used in a broad sense, encompassing trends related to the individual agreement goals/targets. Details of the expert-based scoring and the statistical analysis of the results are documented in S3.13, Figure S3.1, Table S3.9, Table S3.10, and Table S3.11 in the Supplementary Materials.

1. Terrestrial and freshwater conservation and restoration

This theme brings together goals and targets related to the conservation and restoration of terrestrial and freshwater ecosystems. It includes measures to conserve threatened species and actions to ensure the integrity of ecosystems. Apart from cross-cutting targets of Aichi Biodiversity Targets 5 (habitat loss, degradation & fragmentation reduced) and 15 (conservation and restoration of ecosystems for carbon) and SDG target 15.1 (freshwater ecosystem conservation), other targets associated with this theme include Aichi Biodiversity Targets 11 (protected areas etc.), 12 (extinctions prevented & threatened species conserved), 14 (ecosystems providing services restored and safeguarded), SDG target 6.6 (protect and restore water-related ecosystems), and several other targets from SDG 15 (e.g., 15.2, 15.3 and 15.5). Relevant targets and goals from other conventions such as the UNCCD, Ramsar Convention, CMS and the ITPGRFA also reinforce achieving conservation of terrestrial resources and ecosystems.

This group of targets receives considerable attention from policymakers, as most human activities happen on land, from agriculture to urbanization, among others. Several NCP, material goods and cultural contexts of nature are linked to ecosystems and resources on land including species, water and green spaces. Progress across relevant targets is varied. For instance, for some elements of some targets (such as protected area coverage) there has been good progress, while progress has been poor to moderate in others such as those relating to effective management and coverage of areas of importance for biodiversity, ensuring sustainable production and management systems in sectors such as agriculture and forestry, ensuring health, food and water security, reducing species declines, and building resilience of vulnerable populations (see sections 3.2,2, 3.2.3, 3.4.2, 3.4.3). This is reinforced by results from other relevant biodiversity related agreements such as the UNCCD, CITES, CMS, Ramsar Convention on Wetlands, and the IPPC (section 3.4). That said, better standards for phytosanitary measures in trade in biological resources and efforts to improve compliance with CITES measures are showing moderate progress. Some of the major drivers of land use change have been the impacts of urbanization and increasing consumption, which has resulted in high ecological footprints with increasing pressures on all resources.

Several of the targets do not have sufficient data to assess trends (e.g., reduction in disasters, access to green spaces). Moderate progress is reported in the achievement of targets towards conservation of natural and cultural heritage, which is also reflected in the progress towards the achievement of the goals of the Convention concerning the protection of the World Cultural and Natural Heritage (section 3.4).

Overall, more concerted and synchronized efforts are required to ensure that local actions can be implemented considering both policy goals and local priorities. This links also to raising awareness, building capacities of different actors in an inclusive and reflexive manner, and providing relevant incentives and disincentives to trigger appropriate action towards sustainable use and management of terrestrial ecosystems.

2. Marine conservation and sustainable use

This theme emphasizes the need for specific attention and actions relating to the oceans and marine ecosystems to ensure conservation and sustainable use of marine resources through actions including regulation of fisheries and appropriate incentives to ensure the health of marine ecosystems. The theme reaffirms the close linkages between human well-being and the health of the oceans. It is captured across the Aichi Biodiversity Targets (6 on sustainable fisheries) and SDGs (14 on life below land) and other conventions related to the oceans.

Progress and trends towards goals related to marine conservation and restoration vary from poor to moderate. Some significant steps have been made in the implementation of umbrella conventions such as the UN Convention on the Law of the Sea (UNCLOS), the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) and the United Nations Fish Stocks Agreement (UNFSA), but marine biodiversity and ecosystems continue to face multiple threats from human activities, including habitat loss, pollution, human disturbance, unsustainable and unregulated fisheries and climate change. Measures such as managing trade, expanding marine protected areas, and developing guidelines for no-fishing zones (through conventions such as CITES or reporting guidelines of FAO, the Convention on Biological Diversity (CBD) and the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) have had some positive effects. However, it has also been noted that focus is often paid to the conservation of certain marine species, which impedes conservation efforts of other species (see sections 3.2.2; 3.4.2 and **Boxes 3.1, 3.2**). The consequences of coastal and deep-sea fishery stock depletion and ecosystem degradation has had negative consequences for the well-being of IPLCs in terms of food security, spiritual and social integrity and livelihoods. Furthermore, despite the long associations and interactions between IPLCs and oceans, the knowledge and experience of IPLCs has largely remained untapped in designing conservation and management strategies (see sections 3.2.4; 3.3.3).

3. Sustaining genetic resource diversity

This theme focuses on the basic units of life that provide diversity to life forms and options for the future (whether as food, medicine, materials, etc) and on incentives to ensure this diversity is maintained. It is the specific focus of Aichi Biodiversity Targets 13 (genetic diversity of cultivated species and wild relatives) and 16 (Nagoya Protocol), and SDG targets 2.5 and 15.6 (on prioritising genetic diversity of crops and promoting fair and equitable benefit-sharing respectively), suggesting that human well-being is connected to ensuring existence and access to diverse germplasm. It also emphasises the importance of ensuring that accessing these resources and generating benefits are achieved with the full, informed participation of all stakeholders in a manner that can be considered equitable. Implementing the Nagoya Protocol requires acknowledging the merits of traditional knowledge and practices for management of biodiversity and ecosystems.

Insufficient progress is being made in safeguarding the genetic diversity of plants, animals and their wild relatives, which require, greater effort to document the patterns of this diversity, and greater participation of local actors such as IPLCs to actively conserve germplasm in the form of landraces or native cultivars (see 3.2.4 3.3.2; 3.3.3). Little progress is also reported in related targets to end illegal trade of protected species, although institutional efforts are being strengthened (section 3.3 and section 3.4.2). It is noteworthy that the trends towards achieving genetic diversity targets are mixed, with positive trends noted in some crops and negative for others and livestock diversity. Targets such as SDG 2.3 (double productivity and incomes of small-scale producers) will need to be carefully implemented in the light of potential negative impacts if the pathways chosen increase intensive agriculture and mono-cropping practices. Local experiences illustrate that given adequate support; it is possible to achieve these various targets (see section 3.2.3; 3.3.2).

There has been moderate progress in the achievement of targets related to access to genetic resources and equity in sharing benefits arising from their use (Aichi Target 13 and SDG target 15.6), which are directly linked to equity and fairness. It is pertinent that the major indicator used to track equity is the number of countries that have ratified the Nagoya Protocol. Although much progress has been reported on the Access and Benefit-Sharing Clearing-House Mechanism (ABSCH) on national implementation, including legislative measures and monetary and non-monetary benefit-sharing, specific indicators capturing such information are still to be developed and included in the assessment of progress towards the targets. The ITPGRFA also deals with accessing genetic resources and benefit-sharing for selected food and agricultural crops through a well-functioning system of exchange of plant genetic resources for food and agriculture (PGFRA) from *ex situ* collections to different users. Furthermore, benefit transfers to providers of resources is developing through a mix of donations and payments for access to germplasm collections (see S3.10).

4. Addressing pollution

This theme focuses on pollution, its relationship with nature, good quality of life and the regulatory functions of NCP. It focuses also on the need to reduce pollution for healthy lives through appropriate clean production. It is seen as an area to be addressed in other conventions such as the Ramsar Convention, IPPC and the UNCCD in order to address their specific objectives too.

Pollution is one of the most important drivers that affects ecosystem integrity, species populations and human well-being. Aichi Target 8 (reduce pollution) and SDGs 3.9 (reduce deaths and illnesses from pollution) 6.3 (improve water quality by reducing pollution) and 14.1 (reduce marine pollution of all kinds) specifically aim to tackle this issue. While the adverse effects of pollution are well understood, actions towards addressing various types of pollution (air, water, soil, ocean etc) through different interventions have resulted in poor to moderate progress and trends to achieving the targets. Assessment of trends are also impaired due to inadequate data (either globally or regionally) on the links between pollution and quality of life, (e.g., SDG 3). Overall, despite the availability of appropriate technologies and high levels of awareness of the problems of pollution to nature, NCP and human well-being, there has been insufficient progress towards these targets globally (see sections 3.2, 3.3 and **Figure 3.13**)

5. Addressing invasive alien species

This theme brings together targets (Aichi Target 9 on invasive alien species identified and addressed and SDG 15.8 on reducing the impacts of invasive alien species) that focus on restricting the spread and impacts of invasive alien species, which cause significant ecological, economic and social impacts in most regions (see also chapter 2.1 and 2.2). This theme is linked to other indirect drivers such as the movement of resources due to trade (legal and illegal) or migration, and hence progress to achieving associated goals and targets is reliant on progress in implementing measures related to these drivers. Specific targets to tackle invasive alien species are also included in other conventions such as the Ramsar Convention on Wetlands.

While encouraging progress has been made in implementing eradications of invasive alien species (at least on islands), with substantial benefits to native species, poor progress has been reported in the achievement of targets related to containing and reducing the spread and impact of invasive alien species, with countries reporting this to be one of the least achieved targets (section 3.3; 3.4). Little progress has also been reported on the integration of ILK into implementation, despite evidence from the ground of the benefits of such an approach (sections 3.2.3, 3.3.2. Overall, while there are local examples of good practices to ensure the integrity of ecosystems, determined efforts are needed to address various dimensions that impact ecosystem integrity.

6. Addressing poverty, hunger and health

This thematic group brings together three of the most critical well-being needs of people: sustained and sufficient income, food and nourishment and the ability to lead healthy lives. These emerge as a set of cross-cutting topics that are sought to be achieved explicitly in the SDGs (Goals 1, 2, 3) and also given importance within the Aichi Biodiversity Targets (Target 14), and further impacted by policies implemented through other MEAs including the Ramsar Convention, ITPGRFA and CITES. Achieving these different goals hinges on the availability and access to various material, regulating and non-material contributions from nature, and anthropogenic assets including technology, knowledge and institutions.

Most targets and goals in this theme are from the SDGs, and trends towards achieving them vary from negative to insufficient. Poverty, malnourishment and health security continue to be major challenges encountered especially by socially vulnerable populations, and this may relate to lack of rights to access and utilize resources and benefits from them (see also section 3.2.3). It has been observed that even while some quality of life parameters show improvement in the short term, indicators relating to the supporting elements from nature and NCP show declining trends, indicating unsustainable development pathways (see sections 3.3; 3.4).

7. Sustainable economic production

This theme captures good quality of life elements including targets to ensure decent work and economic growth, access to affordable and clean energy for these purposes and innovation for sustainable production activities, including infrastructure (SDGs 8, 7 and 9 respectively). These activities also act as drivers to the utilization of ecosystems, resources and how nature's contributions to people can be sustained.

For many SDGs, the pathways chosen to achieve the targets will have impacts (positive and negative) on nature and the sustainable provision of its contributions to people, with far-reaching impacts on other SDGs, particularly the case for Goals 7, 8, 9, 12. New approaches to achieve these goals are available that can have positive impacts (such as growing demand for 'green' products). Assessing progress towards this theme is also limited by availability of relevant information and appropriate indicators. While the targets are of high relevance to IPLCs, unsustainable resource extraction for various production uses has resulted in many conflicts, including over the production of biofuels, other energy and mining. Overall trends are negative in achieving the various targets related to this theme (see section 3.2.3).

8. Ensuring equity and education

This theme focuses attention on several of the less tangible good quality of life elements such as education on sustainable development, ensuring inclusive development, ensuring peace and justice, ensuring equitable access to basic necessities such as food and resources, measures such as reducing waste of resources, and building operational and supportive partnerships between different actors. Achieving various targets under these goals also has consequences for desirable actions needed to achieve goals related to sustainable economic production. These have been identified as necessary to address targets pertaining to various dimensions related to nature, nature's contributions to people and good quality of life.

Measuring progress towards this theme is generally constrained by availability of sufficiently developed indicators. Still, a general inadequacy in having participatory and inclusive approaches in planning and design for both conservation and development policies appears to have stymied efforts to address various issues related to their effective implementation. Overall, despite advances in technologies and the presence of multiple policies to address human well-being and sustainability, trends still appear negative towards achieving relevant targets on this theme, requiring more focused and inclusive actions are required if we are to reach these goals.

9. Mainstreaming biodiversity

This theme focuses on targets and goals on including biodiversity and ecosystems in planning processes and thereby integrating the values of biodiversity across sectors and decision-making. Goals and targets included are those relating to awareness of biodiversity, integration of biodiversity in planning and sustainable development actions. This is a recurrent theme in most other Conventions including Ramsar, CMS, UNCCD and others.

Progress in mainstreaming actions vary from medium to low. Certainly, efforts to generate more awareness about biodiversity and ecosystems to sustain life and human well-being are being strengthened (sections 3.2, 3.3). However, adoption into planning processes is still lagging, indicated by a general inadequacy in ensuring coherence between sectoral policies such as for instance ensuring that urban planning is aligned with availability of green spaces, human health, food security and diversity in a changing climate. Progress in other associated targets and goals that pertain to actions across various sectors of production, consumption, conservation of biological and cultural diversity, innovation, equitable partnerships, and financial support further accentuate that more efforts are required to achieve good progress in this theme.

3.6 REASONS FOR VARIATION IN PROGRESS TOWARDS POLICY GOALS AND TARGETS

As shown in the preceding sections, there is a high degree of variation in progress towards meeting the goals and targets of Aichi, SDGs and other Conventions. This variation occurs between targets (i.e. some targets have greater progress than others), as well as between regions (i.e. some regions show greater progress than others towards particular targets, although information on this was available only for a subset of indicators and Aichi Biodiversity Targets). A review of the literature shows that multiple factors contribute to variation in the achievement of goals and targets. These factors can be broadly categorized as follows:

Biophysical and socioeconomic conditions: The distribution of biodiversity, socioeconomic status and development trajectories vary substantially between countries. This variation has implications for the ability of countries to meet specific policy targets (Robinson *et al*., 2009). However, the relationships between biodiversity, development and conservation or sustainable use are not simple or linear, and are often impacted by historic development, legacy effects and cross-scale dynamics and feedbacks from other countries and regions (Raudsepp-Hearne *et al*., 2010).

Human, institutional and financial capacity: These capacities are critical to the overall ability of nations to develop and implement plans and actions to achieve any given goal or target (Nowell, 2012; Reeve, 2006). For example, an analysis of a global database of hundreds of marine protected areas (MPAs) showed that the ability of MPAs to protect biodiversity was not only a function of environmental factors (e.g., ocean conditions) or of aspects of the MPA itself (e.g., size or regulations), but also dependent on the MPA's human and financial capacity (Gill *et al*., 2017).

Norms and values: Rands *et al*. (2010) suggest that, in addition to resources, the will to achieve a goal is critical for its actual achievement. Unfortunately, this is often overlooked; policy responses to biodiversity loss often fail to establish the institutions, governance, and behaviours necessary for achieving the specific targets and objectives of Conventions (Geldmann *et al*., 2018; Rands *et al*., 2010). The concept and value of biodiversity is often articulated or measured differently between different groups of people or across different regions (Gotelli & Colwell, 2001). Consequently, goals or targets that can incorporate multiple perspectives on biodiversity and its benefits, or which take into account local values, are more likely to resonate with key local stakeholders and to receive greater attention and, as a result, they are more likely to be achieved (Anthamatten & Hazen, 2007; IPBES, 2015; Pascual *et al*., 2017).

Governance and institutions: Building on previous results showing that governance is an important predictor of biodiversity loss (Smith *et al*., 2003), deforestation rates (Umemiya *et al*., 2010), protected area effectiveness (Barnes *et al*., 2016) and poaching (Burn *et al*., 2011), a recent analysis found that the governance quality explained substantially more variation in investment in biodiversity conservation than did direct measures of wealth (Baynham-Herd *et al*., 2018).

The focus and formulation of the target: The goals and targets assessed link to nature in different and complex ways, and, due to the complex interrelationships in socio-ecological systems, are themselves also interconnected and interdependent (Nilsson *et al*., 2016). Certain types of goals and targets may, therefore, be easier (or harder) to achieve than others. Some, such as Aichi Target 12 (preventing extinctions), are highly dependent on achievement of other targets (such as Target 5 addressing habitat conversion, Targets 6 and 7 on sustainable production, Targets 8 and 9 on particular drivers such as invasive alien species and pollution, and Target 11 on protected areas; see section 3.2). A review of efforts in Canada to meet the Aichi Biodiversity Targets found that implemented responses tend to be associated with targets that have specified levels of ambition or that are more straightforward to achieve (e.g., knowledge capacity and awareness) (Hagerman & Pelai, 2016). By contrast, targets addressing equity, rights or policy reform were associated with fewer actions, presumably because of less effective target design combined with a lack of fit within existing institutional commitments (Hagerman & Pelai, 2016). Furthermore, it may be harder to meet goals and targets that require global collaboration than it is to meet those achieved primarily through local action (Mazor *et al*., 2018). A recent review of the Aichi Biodiversity Targets strongly suggested that the articulation and framing of the targets may influence their achievements (CBD 2018c). The study found that significantly greater progress has been made towards targets that are considered more measurable, realistic, unambiguous and scalable, and targets that best adhered to the principals of 'SMART' objectives (i.e., Specific, Measurable, Ambitious, Realistic and Time-bound) were those that contained explicitly defined deliverables (CBD, 2018c). This is consistent with previous assessments that suggested that the degree to which progress can be measured may impact progress (Butchart *et al*., 2016; Campagne, 2017; CBD 2018c; Kenny, 2015; Moldan *et al*., 2012; Tittensor *et al*., 2014). Lack of robust data (Wood *et al*., 2008), incomplete datasets, dependency on self-reporting and shortfalls in the human and financial capacity to generate, analyse and report on progress (Nowell, 2012) also hinder the ability to measure progress and may in turn therefore impede achievement of goals and targets.

We found no consistent regional patterns of variation in progress towards the Aichi Biodiversity Targets, with some regions achieving greater progress than others towards particular targets (section 3.2.3. For example, there appeared to be greater progress towards Aichi Target 19 (on improving and sharing biodiversity knowledge and technologies) in the Americas, but slower progress for Targets 5 (on loss of natural habitats) and 11 (on protected areas). However, data constraints meant that this assessment was based on a limited set of indicators and only a subset of Aichi Biodiversity Targets. Due to the size of IPBES regions, the mixed patterns of progress and the limited scale of the regional assessment conducted, no clear factors emerged as important in determining regional differences in progress. It is likely that multiple factors are relevant in national and regional contexts with implications for target achievement. Regional variation in progress towards other conventions, as well as in the impacts of trends in nature and NCP on progress to the SDGs, was not assessed owing to insufficient regionally disaggregated information and indicators.

Consistent differences in progress were more apparent between different goals and targets. There has been greater progress towards goals and targets related to policy responses and actions to conserve nature and use it more sustainably than towards goals and targets addressing the drivers of loss of nature and NCP. Consequently, there was generally poor progress towards Targets aiming to improve the state of nature and aspects of NCP (**Tables 3.8** and **3.9**; **Figures 3.7, 3.8, 3.19**). For example, there has been good progress on responses such as eradicating invasive alien species (at least on islands; Aichi Target 9), expanding protected areas (albeit with caveats about their location and effectiveness; Aichi Target 11), implementing the Nagoya Protocol (Aichi Target 16), developing NBSAPs (Aichi Target 17), implementing plans for sustainable urbanization and climate action (SDGs 11 and 13), and efforts to conserve and sustainably use ecosystems (SDGs 14 and 15), and sharing information and coordinating between MEAs (see sections 3.2, 3.3, 3.4). Despite this, indicators show that the drivers of biodiversity loss are increasing, and hence progress towards goals and targets to reduce these pressures has been generally poor. For example, freshwater, marine and urban pollution is increasing (Aichi Target 8, SDGs 6, 14 and 11), invasive alien species are increasingly having negative impacts (Aichi Target 9, SDGs 14 and 15), and drivers associated with unsustainable agriculture, aquaculture, forestry and fisheries are increasing pressures on nature and its ability to deliver NCP (Aichi Target 5, 6, 7, SDGs 12, 14, 15; sections 3.2 and 3.3).

As a result of the progress towards targets addressing drivers being insufficient, despite positive progress to targets addressing responses to biodiversity loss, progress to targets aiming to improve the state of biodiversity has been poor. For example, natural habitats continue to be lost, species' abundance is declining, and extinction risk trends are deteriorating (Aichi Biodiversity Targets 5 and 12, SDGs 14 and 15; sections 3.2 and 3.3). Trends in the magnitude of NCP are less well known, but four of five indicators used to assess progress towards Aichi Biodiversity Targets show significantly worsening trends (section 3.2). The NCP-dependent cluster of SDGs (1, 2, 3 and 11, addressing poverty, hunger, health and well-being, and sustainable cities) showed similarly negative impacts of declines in NCP (section 3.3).

This disconnect between progress in responses and increases in drivers of change in nature and NCP requires consideration. There is not a simple linear relationship, owing to several reasons. First, from a small set of counterfactual studies and other assessments (e.g., Geldmann *et al*., 2013; Hoffmann *et al*., 2010, 2015; Jones *et al*., 2016; Waldron *et al*., 2017), trends in drivers and the state of nature would be worse without the conservation responses that have been implemented (section 3.2). Second, the responses assessed are only a small set of sectorally limited responses out of many possible and necessary responses required to stem the drivers of loss in nature and NCP. For example, approaches to achieve several of the SDGs on climate, energy, economic growth, industry, and consumption and production (7, 8, 9, 12, 13) are likely to have a substantial impact on trends in drivers including pollution, habitat loss and degradation, invasive alien species, and on the state of nature and NCP, requiring more than just protected areas to prevent impacts (Maron *et al*., 2018). Third, many of the targets track responses at the planning or policy level, rather than the actual enforcement and implementation level, implying that the responses may be less effective than assessed at stemming drivers and loss of nature. For example, the extent of protected areas has grown considerably, but their effectiveness is often insufficient (e.g., Clark *et al*., 2013; Gill *et al*., 2017; Marine Conservation Institute, 2017; Schulze *et al*., 2018; section 3.2). Finally, there is the potential for mismatches (spatially, temporally and sectorally) between responses and drivers, made more complex by telecoupling—interactions between distant places—which are increasingly widespread and influential, and can lead to unexpected outcomes with profound implications for our ability to meet global goals for sustainability (Liu *et al*., 2013). Policy coherence across sectors and scales, at the heart of Agenda 2030 and the SDGs, will better account for different trade-offs between these interdependent goals and targets.

While there is a considerable body of literature on the potential explanations for variation in achieving goals in particular locations or achieving a particular goal in multiple regions, the existing literature is notably lacking in synthetic understanding of the reasons for variation. Improving understanding and evidence of these reasons for variation in progress towards goals would help achieve greater success in future.

3.7 IMPLICATIONS FOR DEVELOPMENT OF A NEW STRATEGIC PLAN ON BIODIVERSITY AND REVISED TARGETS

The Strategic Plan on Biodiversity 2011–2020, adopted under the CBD, proposed ambitious biodiversity-related targets to be achieved by 2020 (CBD, 2010a). Here we discuss implications for any follow up to the plan (proposed by CBD, 2016a) such as a revised version with new or revised targets. We based this on considerations from the challenge of assessing progress towards the existing Aichi Biodiversity Targets (section 3.2 above), as well as towards SDGs (section 3.3) and the goals of other Conventions related to nature and nature's contributions to people (section 3.4), and secondly based on the considerations of the progress achieved or lack thereof (drawing on these three sections plus the cross-cutting synthesis in section 3.5 and discussion of reasons for variation in progress in section 3.6). Additional considerations when setting revised targets include the need for suitable language and wording to engage stakeholders and inspire action, socio-economic transformations for sustainable consumption, transformative changes and governance (see below and chapter 6), and to illustrate the importance of tackling a particular issue in order to address biodiversity loss. However, these aspects have been rarely addressed in the literature to date. Finally, it may not be possible for a particular future target to take full account of all of the points below, but their consideration across the whole suite of targets will hopefully strengthen any future version of the strategic plan.

Future targets with clear, unambiguous, simple language, and quantitative elements are likely to be more effective. Some of the existing Aichi Biodiversity Targets are difficult to interpret because they have ambiguous wording, undefined terms that are open to alternative interpretations, unquantified elements with unclear definitions of the desired end point, unnecessary complexities, and redundant clauses (Butchart *et al*., 2016; CBD 2018c). Of the 20 Aichi Biodiversity Targets, 70% lack quantifiable elements (i.e., there is no clear threshold to be met for the target to be achieved) and 30% are overly complex or contain redundancies (Butchart *et al*., 2016). For example, Target 7 calls for areas under agriculture, aquaculture and forestry to be 'managed sustainably', without providing any quantification in relation to sustainability. This makes it more challenging to determine the necessary actions to achieve them, to coordinate these across Parties, and to assess progress towards achieving them (Butchart *et al*., 2016; CBD, 2018c; Maxwell *et al*., 2015; Stafford-Smith, 2014), although vague wording may make it easier to achieve consensus in some contexts (Maxwell *et al*., 2015). Using simple succinct language in targets, and providing explanations, definitions and caveats in background documents, guidance, and preambular text, would be beneficial (Butchart *et al*., 2016; CBD, 2018c). Quantification, however, will be only helpful if it focuses on the most appropriate metrics (see below in relation to protected area coverage).

Future targets that more explicitly account for aspects of nature or NCP relevant to good quality of life will be more effective at tracking the consequences of declines in nature and NCP for well-being, as well as better able to support future assessments of implications for SDG achievement. The assessment of SDG targets concluded that while nature and NCP were known to be important for goals related to education, equity, gender equality, and peace; a current lack of targets capturing these aspects of nature made an assessment of implications for these SDGs not currently possible. Clearer formulation of targets which capture the contributions of nature to these important development goals, will not only support improved assessments, but also foster new knowledge and evidence of these complex linkages. Similarly, the assessment of SDGs 1, 2, 3 on poverty, hunger and health respectively was limited to a few targets capturing the contributions of nature to these goals, however a wider set of contributions is known to exist but not currently assessed due to this gap.

Future targets may be more effective if they take greater account of socioeconomic and cultural contexts. Targets focused on equity, rights, or policy reform for better governance and sustainable economies (see chapter 6 section 6.4) appear to have resulted in fewer actions than other targets, mainly because of a lack of fit within existing institutional commitments (Hangerman & Pelai (2016), and perhaps because they are more difficult to achieve. Increasing consideration of values, drivers, and methods of valuation in the context of policies and decision-making when setting targets may also help to reduce lack of political cooperation, inadequate economic incentives, haphazard application of policies and measures, and inadequate involvement of civil society (Ehara *et al*., 2018; Hangerman & Pelai, 2016; Meine, 2013). For example, it has been argued that there is a need for frameworks and tools for understanding and acting upon the linkages between human rights, good governance and biodiversity (Ituarte-Lima *et al*., 2018). Targets may be easier to interpret if they are more explicit about the socioeconomic and cultural contexts that determine the pathways through which the outcome should be achieved, to avoid undesirable socioeconomic consequences (e.g., protected area expansion or establishment taking into account the impacts on IPLCs; Agrawal & Redford, 2009) or negative impacts on different cultures.

Future target setting will be more inclusive if it integrates insights from the conservation science community, social scientists, IPLCs, indigenous and local knowledge, and other stakeholders. For example, conservation scientists can help to establish ecologically sensible protected area targets and to identify clear and comparable performance metrics of ecological effectiveness (Watson *et al*., 2016a). However, to take into account governance issues and trade-offs between ecological, economic, and social goals, inputs and perspectives from social scientists, indigenous and local knowledge, and non-academic stakeholders from all regions are also needed (Balvanera *et al*., 2016; Bennett *et al*., 2015; Larigauderie *et al*., 2012; Martin-Lopez and Montes, 2015). Socioeconomic and cultural contexts are often not considered when targets or indicators are proposed. In particular, Hangerman & Pelai (2016) suggested that targets focused on equity, rights, or policy reform were associated with fewer actions mainly because of lack of fit within existing institutional commitments rather than because of a lack of effective target design. It is important to consider epistemological and ethical pluralism (instead of the predominant ethical monism of Western cultures) when discussing values, consumption patterns, and alternative economic models in the context of policies, decision-making and target setting (see section 6.4 of chapter 6).

Finally, it has been suggested that a future version of the strategic plan could consider highlighting fewer and more focused headline targets (including those focused explicitly on retention of biodiversity; Maron *et al*., 2018), alongside specific subsidiary targets capturing other elements. Such headline targets might highlight a set of specific actions for conservation of nature and NCP, e.g., ambitious, specific, quantified targets to reduce deforestation and wetland degradation, increase the sustainability of fisheries, minimize agricultural expansion, manage invasive alien species, increase the extent and effectiveness of protected areas (and their coverage of important sites for biodiversity), address ocean acidification, promote the recovery of threatened species, and increase financing, underpinned by more specific subsidiary targets covering other aspects of the existing Aichi Biodiversity Targets (Butchart *et al*., 2016; Maron *et al*., 2018). An alternative approach would be to retain and update all Aichi Biodiversity Targets, but focus on a subset such as those listed above for communications and publicity.

The failure to achieve some targets or particular elements of targets, alongside success in achieving other elements, also has implications for a new version of the strategic plan. Thus, targets that have not been achieved may require increased effort and/or new tactics, while the elements of targets that have been successfully achieved may require increased ambition and/or monitoring to detect and avoid potential regression. In this sense, time-bound targets could be considered as milestones in a process, rather than as final objectives. CBD (2018c) suggested that future targets should be ambitious but realistic, recognizing that ambition without realism can undermine confidence in the ability to deliver on targets, but equally that ambition also promotes and drives progress.

Future protected area targets that focus on enhancing coverage of important locations for biodiversity and strengthening management effectiveness may be more effective than simply setting a specific percentage of the terrestrial and marine environments to be conserved. In implementing Aichi Target 11, most focus has been on achieving the target percentages of terrestrial and marine area to be covered by protected areas (Barnes, 2015; Barnes *et al*., 2018; McOwen *et al*., 2016; Spalding *et al*., 2016; Thomas *et al*., 2014; Tittensor *et al*., 2014), at least partly owing to lack of explicit guidance on other aspects specified in target, for example on how to measure ecological representation, how to conserve through effective and equitable management, or how to define 'other effective area-based conservation measures' (OECMs). In particular, a focus on the area percentage may have distracted from the need to locate protected areas to cover effectively 'areas of particular importance for biodiversity' such as Key Biodiversity Areas (Butchart *et al*., 2012, 2014; Edgar *et al*., 2008; Juffe-Bignoli *et al*., 2014, 2016; Spalding *et al*., 2016; Tittensor *et al*., 2014), and to ensure that they are effectively managed (Barnes *et al*., 2015, 2018; Clark *et al*., 2013; Coad *et al*., 2015; Juffe-Bignoli *et al*., 2014, 2016b; Spalding *et al*., 2016; Watson *et al*., 2016b). While there have been calls for substantially higher area-based targets, tripling the current protected area network to cover 50% of the terrestrial surface (Baillie & Zhang, 2018; Dinerstein *et al*., 2017;Noss *et al*., 2012; Wilson, 2016; Wuerthner *et al*., 2015), these have also been criticized as being unfeasible and counter-effective in particular because they fail to consider the social impacts and the need to sustain protected areas socially and politically (Büscher *et al*., 2017). They may also deliver perverse outcomes (Barnes *et al*., 2018; Jones & De Santo, 2016), and if protected area expansion is concentrated in areas with low human influence, it is unlikely to conserve species diversity sufficiently (Pimm *et al*., 2018) or contribute to effective conservation outcomes (Magris & Pressey, 2018). While some efforts have been taken to operationalize other aspects of Target 11 (e.g., Faith *et al*., 2001; MacKinnon *et al*., 2015), any future protected area target may be more effective if it is structured to reduce the risk that areas with limited conservation value are protected at the expense of areas of biodiversity importance. In consequence, more effective nature conservation may be delivered by shifting the focus from efforts to achieve a pre-determined areal extent to efforts that achieve a specified biodiversity outcome (Barnes *et al*., 2018). This would require monitoring biodiversity outcomes and realistic targets and indicators taking account of financial and data constraints (Barnes *et al*., 2018). Alongside this, the terrestrial network of protected areas and OECMs will need to be substantially strengthened in order to conserve the most important sites for biodiversity while achieving ecological representation, improved effectiveness, better integration into the wider landscape and seascape, etc. (Butchart *et al*., 2015).

Future targets for marine protected areas may deliver better biodiversity benefits if they focus on management effectiveness in particular. Protection of marine areas is generally weak, even in wealthier nations (Boonzaier & Pauly, 2016; Shugart-Schmidt *et al*., 2015), with many marine protected areas being poorly enforced and ineffectively managed (Shugart-Schmidt *et al*., 2015). Management effectiveness may be enhanced through greater involvement of local stakeholders such as IPLCs (e.g., through the Locally Managed Marine Areas network; http://lmmanetwork.org/) and greater focus on key drivers such as pollution and unsustainable fisheries (see chapter 6). Increased consideration of the connectivity of marine protected areas is also needed (Lagabrielle *et al*., 2014; Toonen *et al*., 2013). In areas beyond national jurisdiction, future targets would focus on creating internationally recognized marine protected areas (Rochette *et al*., 2014). As in the terrestrial realm, a substantial scaling up of efforts, will be necessary to protect biodiversity, preserve ecosystem services, and achieve socioeconomic aims (O'Leary *et al*., 2016).

Future protected area targets may be more effective if they also explicitly address freshwater ecosystems and their processes, integrating nature and people, considering also the threats impacting them, and the actions needed to sustain them, including management strategies that consider connectivity, contextual vulnerability, and human and technical capacity (Juffe-Bignoli *et al*., 2016b).

A greater focus on protected area governance is important, including the implementation of participatory policies, improving institutional and community organization capacity, and consideration of self-regulatory management practices based on indigenous and local knowledge (Ramirez, 2016). Potential actions in this direction include: knowledge and capacity-building, valuation, improving policy frameworks, strengthening partnerships across sectors and engaging IPLCs (Dudley *et al*., 2015). Progress to date also suggests that understanding the expectations of all stakeholders can facilitate progress towards targets, and that equity issues between stakeholders can be explicitly considered (Hill *et al*., 2016). For example, for protected areas, participatory area management and spatial and temporal zoning can help to distribute benefits and costs equitably between stakeholders (Hill *et al*., 2016).

The implementation of future targets on conservation of species and sites could be more efficient through effective prioritization. Formal prioritization methods (which involve setting explicit objectives and incorporating the costs of actions, their probability of success, and the size of budget) allow cost-efficient implementation of actions to achieve targets (Visconti *et al*., 2015). For example, in the EU, focusing restoration efforts on habitats with unfavorable conservation status (as reported under the Habitats Directive) may provide the largest benefit for species and the delivery of NCP (Egoh *et al*., 2014). Many countries face the challenge of prioritizing with little capacity for biodiversity conservation and poor baseline data on most biological groups, requiring the development of better strategies for prioritizing based on changes in ecological, social and economic criteria (McGeoch *et al*., 2016) at the global, regional and local levels.

A new framework for biodiversity will be less effective if it does not explicitly address the implications of climate change for nature conservation. For example, many species, key biodiversity areas and protected areas will require adaptation plans to be developed and implemented, with actions coordinated across species' distributions and coherent strategies implemented across protected area and site networks (Hole *et al*., 2009). Potential unintended consequences of climate change mitigation efforts that may have negative impacts on biodiversity (e.g., displacement of food crop cultivation into natural areas as a consequence of biofuel expansion, or mortality of birds and bats from inappropriately sited wind-energy developments; Küppel *et al*., 2017; Oorschot *et al*., 2010; Schuster *et al*., 2015), need to be minimized. At the same time, the role of healthy ecosystems in helping people (particularly IPLCs) adapt to climate change ('ecosystem-based adaptation'; Munang *et al*., 2013), can be integrated into planning and policies.

Future targets may be more effective if they consider the availability of existing indicators and the feasibility of developing new ones. Close to the end of the period for achieving the Aichi Biodiversity Targets, some of them (Targets 15 and 18) still lack functional quantitative indicators entirely, while others lack indicators covering particular elements of the targets (**Table 3.3**; McOwen *et al*., 2016; Tittensor *et al*., 2014). In some cases, the paucity of indicators is because the targets are not particularly 'SMART' (specific, measurable, ambitious, realistic, and time-bound; CBD 2018c; Perrings *et al*., 2010). In a recent review, targets that scored higher on these characteristics were associated with greater progress (CBD 2018c). In some cases, although indicators may exist, their sufficiency and suitability for tracking progress are considered inadequate (Butchart *et al*., 2016; McOwen *et al*., 2016; Tittensor *et al*., 2014), e.g., owing to limited spatial, temporal or taxonomic coverage (Tittensor *et al*., 2014) and/or their alignment with the text of the target (McOwen *et al*., 2016; Tittensor *et al*., 2014). While existing or potential indicator availability is only one consideration when setting targets, without appropriate indicators, it is much more challenging to determine if progress has been made or if targets have been met (Butchart *et al*., 2016; CBD 2018c; McOwen *et al*., 2016; Tittensor *et al*., 2014).

Given the importance of adequate information and indicators for biodiversity based on robust datasets (Geijzendorffer *et al*., 2016), **sustained and augmented investment is needed to maintain, expand and improve knowledge products that underpin multiple indicators**, such as the *World Database on Protected Areas* (IUCN & UNEP-WCMC, 2017), the *World Database of Key Biodiversity Areas* (BirdLife International 2016b), IUCN Red Lists of threatened species and ecosystems (Brooks *et al*., 2015; Juffe-Bignoli *et al*., 2016a, Thomas *et al*., 2014) and the *Global Biodiversity Information Facility* (Jetz *et al*., 2012), alongside strengthened regional and global coordination and cooperation for data sharing and reporting (Knowles *et al*., 2015) and the development of new indicators to address key gaps.

A new version of the strategic plan is likely to be more effective if it gives greater emphasis to the trade-offs and synergies between targets. Efforts to achieve one particular target can contribute to achieving others (synergies) but may reduce the extent to which a different target may be achieved (trade-offs). For example, under Aichi Target 11, expansion of terrestrial protected area coverage could also contribute to reducing the loss of natural habitats (Target 5), reducing extinctions (Target 12), and maintaining carbon stocks (Target 15) (Di Marco *et al*., 2016b), but might have unintended consequences on good quality of life if people are displaced from new protected areas (Targets 14 and 18), especially if attention is not paid to the elements of the target relating to equitable management and integration into wider landscapes and seascapes. Similarly, different SDGs may have synergistic interactions or competing demands and critical trade-offs. Identifying these is an essential precursor to developing pathways for integrated and socially just governance processes (Mueller *et al*., 2017). For example, progressive changes in human consumption may improve biodiversity outcomes even in the absence of additional protection (Visconti *et al*., 2015). It will also be important to consider trade-offs related to the distribution of limited resources between multiple targets (i.e., expanding the use of natural resources to achieve economic development goals (Brunnschweiler, 2008). Identifying and securing synergies between targets, and minimizing trade-offs, would maintain options for co-benefits before they are reduced by increasing human impacts (Di Marco *et al*., 2016b). Evaluation of trade-offs is likely to vary depending on the criteria used, including in relation to social equity, models of economic growth, justice and fairness as well as biodiversity conservation (see chapter 6).

Trade-offs related to the distribution of limited resources between multiple targets is also an important point to be considered. Currently, most nations around the world are expanding the use of natural resources to achieve liberal economic development goals (Brunnschweiler, 2008; but see section 6.4, chapter 6). Consequently, rates of anthropogenic habitat conversion are rising in conjunction with biodiversity loss (Bianchi & Haig, 2013; Dirzo *et al*., 2014; Hansen *et al*., 2013; Watson *et al*., 2016a), while financial resources for conservation are limited, requiring effective prioritization of resources for actions addressing different and multiple targets (e.g., Polak *et al*., 2016; Venter *et al*., 2014). Finally, trade-offs may occur between different goals across spatial scales (i.e., the effects of the trade-off are felt locally or at a distant location) and temporal scales (i.e., the effects take place relatively rapidly or slowly) and these could also be considered and made explicit (Green *et al*., 2018; McShane *et al*., 2011; Rodríguez *et al*., 2006; see chapter 6).

Given that IPLCs manage or have tenure rights over a quarter of the world's land surface, an area that intersects with c.40% of all terrestrial protected areas and ecologically intact landscapes (Garnett *et al*., 2018), a revised strategic plan on biodiversity may be strengthened by taking account explicitly of the contribution of IPLCs to achieving and monitoring biodiversity goals and targets at local, national and international levels, integrating the importance of formal recognition of customary rights under national law (e.g., appropriate recognition of Indigenous and Community Conserved Areas and sacred sites, respect of free, prior and informed consent etc.), and recognizing the need to disaggregate indicators to quantify the contributions and impacts on IPLCs (Bennett *et al*., 2015; Hagerman & Pelai, 2016). Related to this, 'other effective area-based conservation measures' (as referred to in Aichi Target 12) have been argued to be essential for meeting more ambitious targets for conserving biodiversity in future (Dudley *et al*., 2018).

Maron *et al*. (2018) argue that future targets need to be explicit about the state of nature that meeting them is intended to achieve, noting that unquantified or rate-based targets can lead to unanticipated and undesirable outcomes. They propose the development of a series of area-based, quality-specific 'retention' targets to ensure adequate provision of key ecosystem services as well as biodiversity conservation.

Finally, Mace *et al*. (2018) suggested that tracking progress towards future biodiversity targets should focus on three aspects: near-future losses of species (i.e. extinctions, e.g., using the Red List Index), trends in the abundance of wild species (e.g., using population-level indicators such as the Living Planet Index) and changes in terrestrial biotic integrity (e.g., using the Biodiversity Intactness Index), although improved representativeness, integration and data coverage are needed for indicators for all three aspects.

3.8 KNOWLEDGE GAPS AND NEEDS FOR RESEARCH AND CAPACITY-BUILDING

There are clear gaps in available knowledge that have limited our ability to assess progress towards the Aichi Biodiversity Targets, Sustainable Development Goals, and the targets of other biodiversity-related conventions. Despite these limitations, we have enough information to recognize that biodiversity is declining due to complex, integrated social, economic and political factors (see chapter 6), and that actions are needed at the global, regional and local level to meet agreed policy objectives for sustainable development.

For our quantitative analysis of indicators to assess progress against the Aichi Biodiversity Targets, many potential indicators could not be included because they are available only for particular regions or have time series that are too short. The indicators that were included vary in their geographical and/or taxonomic coverage, as well as the degree to which they are aligned with targets, leading to variable levels of coverage (**Tables 3.3,** S3.1; Tittensor, *et al*., 2014). Existing indicators based on species' data are biased to better known groups, and underrepresent invertebrates, plants, fungi and micro-organisms. Among drivers of biodiversity loss, information is particularly poor for unsustainable exploitation e.g., spatial patterns in the intensity of hunting, trapping, and harvesting of terrestrial wild plants (Joppa *et al*., 2016). For 19 elements of 13 Aichi Biodiversity Targets, representing 35% of the elements and 65% of the targets, indicator datasets suitable for extrapolation were unavailable (e.g., relating to harmful subsidies for Target 3, and sustainability of management of areas under aquaculture for Target 7). Targets 15 (ecosystem resilience and contribution of biodiversity to carbon stocks) and 18 (integration of traditional knowledge and effective participation of indigenous and local communities) lack any suitable indicators that could be extrapolated, and hence progress on these Targets could not be assessed on the basis of indicator extrapolations. For Target 15, and elements of Targets 6 (on sustainable fisheries) and 14 (on ecosystem services), the lack of both quantitative indicators and qualitative information means that no assessment of progress was possible **(Figure 3.6)**. For Target 11 (site-based conservation and delivery of ecosystem services and equitable benefits from protected areas) there is insufficient information on trends in management effectiveness of protected areas, and inadequate quantitative information on the contribution of 'other effective area-based conservation measures' to meeting the target. For Target 12 (preventing extinctions), there is a lack of information (particularly on trends) for extinction risk of invertebrates and plants, and for trends in population abundance for species in tropical regions as well. There are gaps in our understanding of the relationship between indicators and the underlying system functions/properties that they measure. There are also particularly few indicators relating to nature's contributions to people (**Table 3.3**; **Figure 3.5**; Tittensor *et al*., 2014). The sufficiency of indicators for the Aichi Biodiversity Targets (judged in relation to their alignment, temporal relevance and spatial scale) is lowest for Strategic Goal E (on enhancing implementation through participatory planning, knowledge management and capacity-building) (McCowen *et al*., 2016).

New indicators for such aspects will need to be developed for assessing progress under a post-2020 global biodiversity framework (CBD 2018d), and this will require resourcing (McOwen *et al*., 2016 Tittensor *et al*., 2014), along with continued updating of the existing indicators, most of which lack any sustained core funding (Juffe-Bignoli *et al*., 2016a, McOwen *et al*., 2016). Many of the existing indicators cannot be disaggregated to show trends in relation to indigenous and local people (leading to calls for including an 'indigenous qualifier' in data collection and SDG indicator development, in order to highlight the inequalities that Indigenous Peoples face across all SDGs (AIPP *et al*., 2015).

A new synthesis of the high-level messages and key findings from different biodiversity-related assessments may be helpful in developing and implementing new targets and indicators for a post-2020 global biodiversity framework (CBD 2018d). New data collection and sharing platforms, and support and capacity-building for data mobilization analysis is needed, particularly for developing nations (Tittensor *et al*., 2014) and non-western data sources (Meyer *et al*., 2015). Scaled-up *in situ* monitoring of biodiversity state, drivers and conservation responses is urgently needed to address the various gaps, particularly in tropical regions (Stephenson *et al*., 2017), and encompassing community and citizen science initiatives (Latombe *et al*., 2017). Appropriate national systems and data platforms for coordinating the collection and dissemination of monitoring data (e.g., 'clearing house mechanisms') would help to address this need, while capacity-building is needed in relation to data collection and analysis. While indicators are probably the most useful and best tool to assess progress, it is unlikely that all of the indicators needed will ever be available. Gaps can also be filled with other sources of information such as published studies and case studies (see sections 3.2, 3.3), or national reports from countries (e.g., CBD National reports) that may help measure progress towards achieving targets.

Other knowledge gaps limit the effectiveness of attempts to formulate and/or implement appropriate policies and responses. In particular, it would useful to review the effectiveness of further policy options, interventions, resource mobilization and the successful use of funding when implementing targets or developing new indicators (CBD 2018d). There is a lack of information on the effectiveness of different area-based conservation mechanisms (protected areas, community reserves, sacred sites etc.), restoration methodologies and indicators to assess progress, and a number of key threats (e.g., from unsustainable exploitation) lack adequate global spatial datasets (Joppa *et al*., 2016). Inadequate monitoring has limited the ability to adapt and adjust policies and their implementation to enhance their effectiveness and to share lessons.

For some of the SDGs, (e.g., Goals 1 and 3), the relationships between nature and achievement of these goals are not well understood, as they are complex, nonlinear, dynamic, context-specific and heavily affected by other anthropogenic mediating factors such as access, policies, governance contexts (see section 6.2), the dominant economic model (see section 6.4 of chapter 6), and demographic factors. Generally, the provision of ecosystem services is widely assumed to contribute to poverty alleviation, particularly in rural areas of developing countries. However, the means by which these contributions are achieved remains unclear (Suich *et al*., 2015; see section 6.3 of chapter 6). There is good evidence on the role that nature plays in supporting the well-being of people, but far less evidence on how (and whether) nature can help people move out of poverty and what changes in nature mean for pathways out of poverty.

Marine biodiversity and ecosystem knowledge vary considerably in quality and extent across geographic regions, habitats, depth and taxonomic groups. It is estimated that 98.7% of the ocean is still largely under sampled, meaning that we lack even the most basic knowledge needed for effective management (Appeltans *et al*., 2016; Figure 3.24). While coastal shelves and slopes in developed nations (e.g., the North Atlantic) are better known (Rice *et al*., 2016), even for these, knowledge is patchy both at temporal and spatial scales. Sampling efforts have been relatively high along coastal ecosystems but are still quite low in the open ocean (>2,000 km from land) even if they have intensified in the last decades (Appeltans *et al*., 2016). Some regions have received considerable attention, but habitat complexity and logistical challenges mean that knowledge is fragmented, and some areas are very poorly known (Alder *et al*., 2016; Appeltans *et al*., 2016; Lindal Jorgensen *et al*., 2016; Miloslavich *et al*., 2016; Ruwa & Rice, 2016). Knowledge of the sea below 1,000 m depth (i.e. almost 99% of the ocean volume), is very limited as this environment is significantly under sampled. A global strategy to assess deep sea ecosystems in a coordinated manner has been recently initiated in anticipation of potentially intensive exploitation of deep-sea resources (Johnson *et al*., 2016).

The best assessed marine species groups are commercial and top predator fish stocks (Campana *et al*., 2016; FAO, 2016; Hazin *et al*., 2016; Pauly & Lam, 2016; Restrepo *et al*., 2016), marine mammals (mainly focused on iconic or threatened species) (Rodrigues *et al*., 2014; Smith *et al*., 2016), seabirds (Croxall *et al*., 2012; Lascelles *et al*., 2016), turtles (Wallace *et al*., 2016), and plankton (Batten *et al*., 2016; Edwards *et al*., 2012), and coastal ecosystems such as coral reefs (Wilkinson *et al*., 2016). However, even within these, few have long-term time series data as, for example, the Continuous Plankton Recorder (80+ years) or the Great Barrier Reef Monitoring Program (20+ years). Only 4% of the 230,000 described marine species have been assessed for the IUCN Red List (IUCN, 2017). Of these, 29% are classified as Data Deficient, and 17% are threatened or extinct, many of which occur in regions of high biodiversity but that are poorly known (Webb & Mindel, 2015). As many of these high-biodiversity regions are also highly threatened by overfishing, habitat loss, pollution, invasive species and the impacts of climate change (Costello *et al*., 2010), it is likely that the number of threatened species will increase as assessments and knowledge of these areas improves (Appeltans *et al*., 2016). Species distributional information is particularly scarce at greater depths **(Figure S3.5)**. All of these knowledge gaps hinder development of effective ecosystem-based management and governance in the marine environment.

Most existing studies on the links between nature and development have focused at an aggregate scale, often only on quantifiable aspects; e.g., income or provisioning services rather than capturing the multidimensional nature of development and nature. More focus has been put on the observation of correlations or relationships, and less on the mechanisms of the links (Roe *et al*., 2014; Suich *et al*., 2015). Thus, most studies are not able to clarify which groups of people benefit (or not) from nature, whether the poor are among these beneficiaries, and which aspects of quality of life are affected by which aspects of nature. Achieving the SDGs will have significant implications for nature (e.g., Goals 7, 8, 9, 11, 12). Choices about how these goals are achieved will have very different consequences for nature, but significant knowledge gaps remain in understanding the positive and negative relationships that nature and its contributions to people may have in achieving targets and vice versa.

Finally, improved information is needed on the role of IPLCs in achieving the Aichi Biodiversity Targets and SDGs, because they hold significant knowledge on the links between nature, sustainable development and quality of life (e.g., Circumpolar Inuit Declaration; Gadamus *et al*., 2015; Ituarte-Lima *et al*., 2018; Singh *et al*., 2018). In addition, capacity-building can help to increase the participation and engagement of IPLCs in sustainable development planning and decision-making at all levels because biodiversity conservation in many locations is under their customary practices or land tenure. Customary institutions, such as local councils, can take the initiative in the recognition, implementation and enforcement of customary laws. However, failure to do so may end up in undermining these laws and result in failure in harnessing all the benefits that may ensue from their implementation.

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