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REVIEW OF NEW SCIENTIFIC AND TECHNICAL INFORMATION ON BIODIVERSITY AND CLIMATE CHANGE AND POTENTIAL IMPLICATIONS FOR THE WORK OF THE CONVENTION ON BIOLOGICAL DIVERSITY

Note by the Executive Secretary

1. In paragraph 13 of decision 14/5, the Conference of the Parties requested the Executive Secretary, in consultation with the Intergovernmental Panel on Climate Change (IPCC), and subject to the availability of resources:

(a) To review new scientific and technical information, including by taking into account traditional knowledge and the findings of Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, with respect to:

(i) The impacts of climate change on biodiversity and on communities that depend on ecosystem services and functions, particularly indigenous peoples and local communities;

(ii) The role of ecosystems and their integrity, for climate change adaptation, mitigation and disaster risk reduction, and ecosystem restoration and sustainable land management;

(b) To prepare a report on potential implications of the above for the work of the Convention for consideration by the Subsidiary Body on Scientific, Technical and Technological Advice at a meeting to be held prior to the fifteenth meeting of the Conference of the Parties; and

(c) To develop targeted messaging on how biodiversity and ecosystem integrity, functions and services contribute to tackle the challenges of climate change.

2. Pursuant to this request, the Secretariat prepared document CBD/SBSTTA/23/3, which contains a summary of the main findings from the review of new scientific and technical information on biodiversity and climate change and of its implications for the work of the Convention.

3. The present information document provides a more detailed review and analysis, as well as complementary information to support the findings presented in CBD/SBSTTA/23/3.

4. Section I of the present note provides additional details to support the key messages from the review of new scientific and technical information, including references to the assessments and other literature. Section II provides complementary information on the potential implications of the new scientific and technical information for the work of the Convention.

* CBD/SBSTTA/23/1.

I. COMPLIMENTARY INFORMATION SUPPORTING THE KEY MESSAGES FROM THE REVIEW OF NEW SCIENTIFIC AND TECHNICAL INFORMATION ON BIODIVERSITY AND CLIMATE CHANGE

5. Section A provides additional details to support the key messages regarding the impacts of climate change on biodiversity and on communities that depend on ecosystem services and functions, particularly indigenous peoples and local communities. Section B provides additional details to support the key messages regarding the role of ecosystems and their integrity, for climate change adaptation, mitigation and disaster risk reduction, and ecosystem restoration and sustainable land management.

A. The impacts of climate change on biodiversity and on communities that depend on ecosystem services and functions, particularly indigenous peoples and local communities

6. Climate change and biodiversity loss are inseparable crises yet new scientific and technical knowledge and solutions to these issues are often deliberated within their respective disciplinary silos. The two main intergovernmental processes to assess new scientific and technical information on climate change and biodiversity, Intergovernmental Panel on Climate Change (IPCC) and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), do so in response to their respective mandates.

7. Biodiversity and climate are interconnected in many ways and must be addressed together. On the one hand, biodiversity is strongly affected by climate change, with negative consequences for human well-being and the long-term stability of critical ecosystems. On the other hand, the conservation of biodiversity, through the ecosystem services it supports, makes an indispensable contribution to addressing climate change.

8. Better protection, management and restoration of natural and managed ecosystems can make significant contributions to the mitigation of human-induced climate change, while ecosystem-based approaches can also contribute significantly to climate change adaptation and disaster risk reduction thereby reducing the vulnerability of people, and the ecosystems upon which they depend, in the face of climate change.

9. Many direct (e.g. changes in land and sea use) and indirect drivers (e.g. consumption of food, materials and energy) are mutual to both climate change and biodiversity loss and so their solutions should be addressed together.

10. The next 10 years are critical. Deep changes would be required in all aspects of society (e.g. energy, land, buildings, transport, food and diets, cities) to reach near-net-zero emissions reduction by 2050 or earlier. It is imperative that new technologies, cleaner energy sources, less deforestation, better land management and sustainable agriculture all be implemented in order to achieve a successful sustainable transition. The sooner emissions fall, the more options will be kept on the table.

11. For further information on the projected risks to natural and human systems at 1.5°C and 2°C of global warming, see IPCC SR1.5, Chapter 3, Table 3.5.

1. The impacts of climate change on biodiversity and ecosystem services and functions

12. Limiting the global average temperature increase to 1.5°C above pre-industrial levels, as compared to a 2°C rise or higher, would reduce risks to biodiversity, ecosystems, food systems, water resources and human livelihoods.

13. Although many terrestrial and ocean ecosystems and their functions and services have already been affected by the impacts of climate change, new impacts and observed impacts will be enhanced as global warming persists. The extent of future climate-related risks depends on the rate, peak and duration of warming. Impacts on ecosystem functions and services are predicted to be greater if warming peaks above 1.5°C and decreases compared to limiting warming to 1.5°C without overshoot. The rate, peak and duration of global warming throughout the twenty-first century will be directly and indirectly affected by the speed of decarbonization and its level of impact on land systems.

14. Impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5°C of global warming compared to 2°C. Limiting global warming to 1.5°C would impede changes in biome transformations, the loss of species range, changes in phenology and the frequency of extreme weather events, all of which contribute to the disruption of ecosystem functioning and loss of cultural, provisioning and regulating services. For example, climate change can lead to ecosystem disruption by catalysing evolutionary or behavioural processes such as seasonally earlier reproduction in organisms.

15. Changes in biodiversity and ecosystem integrity as a result of climate change can lead to range shifts and greater populations of invasive species, especially as glaciers recede and snow-free seasons become longer. Feedback within regional climate systems can have further detrimental impacts on biodiversity and ecosystem integrity as a result of the interactions between drivers of climate change, such as the reduction in evapotranspiration from deforestation that feeds back on surface humidity and cloud formation, potentially increasing the vulnerability of forests to fire and drought.[1]

16. Feedback loops are important when considering the trade-offs and co-benefits affecting biodiversity and ecosystem functions and services, such that the "decrease in regulating services will also negatively affect provision of material services that depend on the regulating ones".[2] According to IPBES, many trade-offs and co-benefits of nature's contribution to people such as cultural services, material and non-material, are not considered in the development of future scenario modelling, and thus is an area that needs more research.[3]

17. Biodiversity is declining at rates unprecedented in human history and it is clear that every degree of global warming matters. The impacts of climate change can already be seen on biodiversity and ecosystems and felt by people and communities. According to the 2019 update of the International Union for Conservation of Nature's Red List of Threatened Species, an assessment of the health of the world's biodiversity, there has been no species whose conservation status has improved enough to lower its threat category.[4]

18. Projection scenarios show that limiting global warming to 1.5°C can lower biodiversity loss by 50% when compared to 2°C warming scenarios. Recent findings show that global warming of 2°C would lead to projected bioclimatic range losses of greater than 50% in 18% (6–35%) of 19,848 insect species, 8% (4–16%) of 12,429 vertebrate species and 16% (9–28%) of 73,224 plant species by 2100. At 1.5°C of warming, these values fall to 6% (1–18%) for insects, 4% (2–9%) for vertebrates and 8% (4–15%) for plant species.

19. While the loss of global terrestrial biodiversity based on species richness due to land-use change has been estimated to be around 8-14%,[5] a doubling of the areal extent of biome shifts is also projected at 2°C of global warming compared to 1.5°C.[6] Overall, more species will experience a contraction of their habitat ranges and less suitable climatic conditions. It is expected that limiting global warming to 1.5°C compared with 2°C would reduce both range losses and associated extinction risks in terrestrial species. The aggregated amount of terrestrial species that are projected to lose over 90% of their range will be much smaller at 1.5°C of global warming compared with 2°C.

20. Protected areas and area-based conservation measures are an effective policy measure to safeguard the integrity of ecosystems and have been shown to help species adjust to rapidly changing climatic

[1] IPBES GA 4.5.2
[2] IPBES GA 4.5.3
[3] Ibid.
[4] 2019 IUCN Red List of Threatened Species
[5] IPCC SRCCL SPM A2.2
[6] IPCC SR1.5

conditions, contributing to the mitigation of impending biodiversity loss.[7] New research suggests that protected areas are often "too small or spatially isolated to provide a refuge from larger-scale factors," such as wide-spread changes in forest understory and climate change, especially for migratory bird species.[8] One study of 746 marine protected areas found that only 11% considered connectivity as an ecological criterion.[9] According to IPBES, "there are currently few protected areas whose objectives and management take climate change into account" and there needs to be a re-evaluation of conservation objectives to include the impacts of climate change on the effectiveness of protected areas. Significant changes in the range of terrestrial protected areas are expected to adversely affect the capacity of these ecosystems to conserve species.

1.1. Pollinators

21. Risks to ecosystem functionality, phenological mismatches and geographic ranges of key insect crop pollinator families are lower under global warming of 1.5°C compared to 2°C or higher. A greater occurrence of mismatches is projected between plants and their insect pollinators, which will ultimately reduce pollination productivity. Despite having higher thermal tolerance to warmer temperatures, climate change is expected to impact pollinators in temperate zones due to their vulnerability to projected increases in the frequency of extreme heat events.[10] In some cases, climate change can also affect the growth and size of some insect pollinator species, where warmer temperatures have been associated with a decrease in the average size of tree wasps in the Iberian Peninsula, due to changes in early life development.[11]

22. A decline in pollination productivity would have significant effects on regulating ecosystem functions and services and on human livelihoods. This decline would adversely affect global food crop productivity such as fruits and vegetables and some of the most important cash crops (e.g. coffee, cocoa and almonds); where more than 75% of global food crop types rely on animal pollination.[12]

23. These impacts are particularly concerning when future ecosystem changes are coupled with increasing range contraction, since climate change adaptation measures are rarely considered in protected area management.

1.2. Invasive species

24. The migration of climatic conditions and species that inhabit them can invite greater opportunities for invasive species to migrate. In terrestrial and ocean ecosystems, changes in ecosystem corridors that were previously disconnected, can allow for the migration of pests and disease agents. This may have devastating impacts for these ecosystems and their functions and services. Opportunities for the spread of invasive species and the associated risks would generally be lower at 1.5°C compared to 2°C of global warming.

25. Many studies on the impacts of range shifts and expansion of invasive alien species under different climate change scenarios have been performed to help prioritize management strategies. Studies have found that climate change is contributing to the spread of invasive species in two ways: directly by increasing hospitable conditions and also by opening up more isolated regions to people that were once inaccessible, such as in the Arctic.[13]

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[7] Lehikoinen et al. (2018)
[8] Brown et al. (2019)
[9] Balbar & Metaxas (2019)
[10] Sutton et al. (2018)
[11] Polidori et al. (2019)
[12] IPBES GA 2.3
[13] Chan et al. (2018)

1.3. Forest ecosystems

26. Under global warming of 2°C, forest ecosystems and their biodiversity, functions and services are expected to experience greater risks such as forest fires, extreme weather events, and the spread of invasive species, pests and diseases, compared to 1.5°C.

27. While forest ecosystems are important for biodiversity, water provisioning and other ecosystem functions and services, forest ecosystem restoration is of particular importance to climate change mitigation measures because of its potential for carbon sequestration and storage. The conversion of forests from carbon sinks to carbon sources will be exacerbated with 2°C of global warming compared to 1.5°C. It is estimated that the potential of woodland and forest restoration could amount to an additional 0.9 billion hectares of global canopy cover, which could sequester 205 gigatonnes of carbon;[14] however the need to incorporate appropriate safeguards which consider potential impacts on biodiversity, among other factors, should be highlighted.

28. High-latitude forests, namely the Northern Hemisphere's circumpolar Boreal forest, are expected to experience warmer temperatures than the global average and can lead to a poleward shift, where its latitudinal limits will expand in the north and diminish in the south.[15] Plant productivity in tundra and forest biomes in high-mountain and polar regions are expected to increase, however changes in the cryosphere can both positively and negatively affect ecosystem functions and services in these regions.[16] In contrast, tropical rainforests are expected to lose biomass. For example, the tropical rainforests of Central America are projected to lose 20% of their biomass by 2050 at 1.5°C of warming.[17] Both high-latitude and tropical forest ecosystems are estimated to surpass tipping points for significant diebacks between 3°C and 4°C of global warming.[18]

1.4. Marine ecosystems

29. Ocean ecosystems and marine species have experienced geographical shifts, reductions in the abundance and productivity of species and changes in food-web interactions due to ocean warming and acidification, loss of oxygen and sea ice reduction; all of which are exacerbated by human activities.

30. The warming of ocean basins and the weakening of ocean circulation patterns have resulted in marine organisms to shift their biogeographical ranges to higher latitudes, which have consequently affected the structure and function of oceans, along with its biodiversity and food webs. The range expansion of species due to warming ocean temperatures have changed the structure and functioning of some ecosystems, particularly in the North Atlantic, Northeast Pacific and Arctic oceans.[19] Ocean stratification in the Arctic is expected to increase and can substantially decrease upwelling of nutrient and impact the rate of primary production of marine ecosystems.[20] There has been a greater emergence of 'dead zones' for oxygen-dependent species, due to low oxygen levels from changes in ocean mixing and metabolic rates, increased temperatures and a greater supply of organic carbon to deep areas.[21,22] Cold-water coral reefs are among the most devastated marine ecosystems suffering from these changes, where the combined effects of "ocean warming, oxygen loss, ocean acidification and decrease in flux of organic

[14] Bastin et al. (2019)
[15] IPCC SROCC SPM B4.2
[16] IPCC SROCC SPM A4.3
[17] IPCC SR1.5 3.5.5.6 & 3.5.5.7
[18] Ibid.
[19] IPCC SROCC SPM A5.3
[20] IPCC SROCC SPM B5.3
[21] IPCC SR1.5 3.3.10
[22] Diaz & Rosenberg (2008)

carbon from the surface to the deep ocean will decrease calcification and exacerbate bioerosion and dissolution of non-living components of cold-water coral communities which support high biodiversity."[23]

31. Evidence strongly suggests that ocean pH has decreased by 0.1 pH units due to human-induced climate change. The projected level of ocean acidification under both 1.5°C and 2°C of global warming is expected to amplify adverse effects such as the growth, development, calcification, survival and abundance of a broad range of species and cause cascading impacts on ecosystems.[24]

32. Recent research shows that the average number of days classified as 'marine heatwave days' are expected to increase by a factor of 16 for global warming of 1.5°C and a factor of 23 for global warming of 2°C.[25] These extreme ocean temperatures can cause irreversible destruction to marine organisms and ecosystems and decrease their resiliency to climate change.[26]

1.5. Coastal ecosystems

33. Climate change directly and indirectly affects coastal ecosystems and marine organisms through the effects of sea level rise, changing temperatures and ocean chemistry (e.g. acidification and eutrophication), increased rates of erosion and extreme weather events such as storms. Some of the most biodiverse marine ecosystems involve organisms that form the habitat for a large number of species such as seagrass meadows, kelp forests, oyster reefs, salt marshes, mangrove forests and coral reefs. These ecosystems provide food, livelihoods, cultural significance, and ecosystem functions and services to human communities.

34. Increasing ocean temperatures cause a myriad of impacts including sea level rise, salt water intrusions in freshwater coastal areas and other issues which have cascading ecological and economic impacts.[27]

35. Coastal ecosystems will experience high to very high levels of risk under high emissions scenarios. While seagrass meadows and kelp forests are expected to undergo high levels of risk at global warming of 2°C, coral reefs will experience the very high risk even under low emissions scenarios that limit global warming to 1.5°C above pre-industrial temperatures.[28]

36. Nearly 50 per cent of coastal wetlands have been lost over the 20th century as a result of human pressures and the impacts of climate change.[29] The ability of ecosystems to adapt and respond to these impacts will be further impaired if human and natural pressures increase (as projected in higher emissions scenarios.

37. "The decline in coral reefs will greatly compromise the services they provide to society, such as food provision, coastal protection and tourism."[30] The IPCC states with very high confidence that coral reefs are projected to decline by 70–90% at 1.5°C of global warming compared to greater than 99% at 2°C. There is high confidence that warm-water (tropical) coral reefs will reach very high risk of impact at 1.2°C, while "most coral-dominated ecosystems will be non-existent at this temperature or higher."[31]

38. Seagrass and mangrove forests are under pressure due to an increase in magnitude and frequency of storms, sea-level rise and extreme temperatures. In recent years, new research shows that climate change risks to mangroves have been underestimated. Large-scale die-offs of mangroves have identified climate

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[23] IPCC SROCC SPM B5.4
[24] IPCC SR1.5
[25] Frölicher et al. (2018)
[26] Ibid.
[27] Verges & Wernberg (2019)
[28] IPCC SROCC SPM B6.1
[29] IPCC SROCC SPM A6.1
[30] IPCC SROCC SPM B6.4
[31] IPCC SR1.5 3.4.4.10

change to be a greater risk to these ecosystems than previously thought. In addition to the risks from deforestation and unsustainable coastal development, there is medium confidence that climate change now poses moderate risk to mangroves at 1.3°C of global warming, as opposed to 1.8°C. Seagrasses are projected to reach moderate to high levels of risk at 1.8°C of global warming.

39. Mangroves in particular are important for reducing peak surge water levels and to protect communities and coastal economic regions during tropical cyclone and storm exposures.[32] As maximum temperature, frequency and duration of heat waves increase due to a changing climate, the structure and function of coastal marine ecosystems are expected to change.[33]

40. It is well documented that warming waters are also increasing the frequency and size of harmful algal blooms which impact coastal communities. Studies show that species of phytoplankton and cyanobacteria adapted to warmer waters and changing conditions will dominate over species that are less well adapted, resulting in even greater blooms.[34] Studies encourage the consideration of these harmful algal blooms as a climate co-stressor. As these events get worse, the impacts of these blooms in addition to and as a result of climate change should be included in management plans which protect fisheries, aquaculture, and human health in order to fully safeguard against their impacts.[35]

2. The impacts of climate change on communities that depend on ecosystem services and functions

2.1. Land degradation

41. Much like the complex interdependencies and interconnectivity between climate change and biodiversity, land degradation contributes to climate change and biodiversity loss, while climate change and biodiversity loss can perpetuate and exacerbate the impacts of land degradation.[36]

42. Land degradation and its associated loss of biodiversity and ecosystem services has far-reaching negative consequences for human wellbeing. Increasing genetic and species diversity in managed forests and in agricultural systems are examples of ways in which biodiversity can contribute to enhancing the capacity of ecosystems to adapt to climate change.

43. Some land management measures can have unintended negative impacts on biodiversity and ecosystem services.[37] For example, the use of herbicides and pesticides, afforestation through monoculture plantation, expansion of land used for bioenergy crops (including net displacement of croplands as a result of increasing competition for land between food and bioenergy crops) and excessive overprotection of wildfire.[38]

44. IPCC identified that the shared socio-economic pathways that encourage cropland expansion result in larger declines in biodiversity through reductions in mean species abundance and species richness.[39]

2.2. Agriculture and food systems

45. Agricultural production is one of the leading causes of biodiversity loss.[40] Agriculture and food production can affect biodiversity by competing for land-use which can exacerbate climate change-induced changes in crop yield. An example of this competition for land can be seen in the trade-off between land used for reforestation mitigation activities and for crop growth for bioenergy purposes. Competition

[32] Hochard & Barbier (2019)
[33] Pansch et al. (2018)
[34] Pesce et al. (2018)
[35] Griffith & Gobler (2019)
[36] IPBES LDR SPM B5
[37] IPBES LDR SPM 13 (p.27)
[38] IPBES LDR SPM A14 (p.27-28)
[39] Newbold et al. (2015); from IPCC SRCCL 6.1.4
[40] IPBES LDR Figure SPM6

between biodiversity and food production can depend on land use governance, agricultural intensification, demand for food, feed and timber, and supply chain contexts.

46. Integrated assessment models produce varying results when projecting different biodiversity conservation measures and impacts on agricultural production and food. One study found that a trade-off would exist between implementing more ambitious protected area measures and the amount of productive land available for agriculture.[41] Another study found that an increase in agricultural productivity per hectare can contribute to the 50% to 70% increase in food demand that is expected until 2050, while halting the conversion of natural habitats.[42]

47. It is projected that there will be a greater reduction in global crop yields and global nutrition under global warming of 2°C compared to 1.5°C. By 2050, land degradation and climate change together are predicted to reduce crop yields by an average of 11 per cent in regions that already experience food insecurity.[43] Decreasing land productivity, among other factors, make societies vulnerable to socioeconomic instability, particularly on drylands. This decline in food availability is expected to disproportionately affect the Sahel, southern Africa, the Mediterranean, central Europe, and the Amazon.

48. The loss of global biodiversity, including the loss of genetic diversity and crop wild relatives, undermines agricultural system resilience to pests, pathogens and climate change and poses a severe risk to long-term food security.

49. In the Arctic, changes in the availability of freshwater due to changes in snow, lake and river ice and permafrost have caused a decline in agricultural productivity in high-mountain areas. These changes have impacted food security and water quantity and quality, particularly affecting the livelihoods of indigenous peoples and local communities.[44]

50. Sustainable agricultural production practices, such as integrated pest and nutrient management, organic agriculture, agro-ecological practices, soil and water conservation practices, agroforestry, silvo-pastoral systems, irrigation management and practices to improve animal welfare, can help safeguard the adaptive capacity of food production through the conservation of genetic diversity while also contributing to healthy and culturally-relevant nutrition.[45]

51. Climate change impacts on food security can be reduced substantially at 1.5°C of global warming compared to 2°C with appropriate investment, awareness campaigns for crop yield-maintaining technologies and adaptation strategies and polices such as integrated agriculture-aquaculture practices, greater investment in crop diversification, and integrated water resource management.

2.3. Livestock

52. Greenhouse gas emissions, primarily methane and nitrous oxide, from the agricultural industry, including livestock, pastures and rangelands, have continued to grow. The potential impacts of climate change on livestock, such as the impacts from higher temperatures and greater levels of heat stress, have been less well studied than impacts on crop yield. Climate change is expected to impact livestock indirectly through changes in feed quality, the spread of pests and diseases and changes in water resource availability.

53. One study projected that a 7 to 10 per cent global decline in livestock is expected at 2°C global warming.[46]

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[41] Visconti et al. (2015); from IPBES GA 4.6.1
[42] van Vuuren et al. (2015); from IPBES GA 4.6.1
[43] IPBES LDR 5.3.2.6
[44] SROCC SPM A7.1
[45] IPBES GA SPM Background D36
[46] Boone et al. (2018); from SR1.5 3.4.6

54. Several options that promote diversification within food systems present significant opportunities to reduce the associated risks from climate change. Options such as integrated production systems, broad-based genetic resources, and more balanced and plant-based diets can contribute to climate change mitigation and adaptation while achieving co-benefits for other Sustainable Development Goals.

55. The mitigation potential of dietary changes can vary greatly. While estimates show a mitigation potential of 0.7 to 8.0 $GtCO_2$ equivalent per year, dietary changes could also potentially free several million square kilometres of land that would otherwise be land used to grow feed for livestock.[47]

56. With 25-30% of total food produced being lost or wasted, improving the efficiency of food systems can be an important and cost-effective method to combat climate change. Reducing food loss and waste can contribute to mitigation efforts by lowering greenhouse gas emissions and adaptation efforts by decreasing the land area needed for food production.[48]

57. The land area freed from these options that promote diversification within food systems can have multiple benefits for sustainable development, including for biodiversity conservation and ecosystem restoration, reversing desertification and land degradation, climate change mitigation from the land sector and improved water and food security.[49]

2.4. Fisheries

58. Climatic drivers have caused an increase in the frequency and an expansion of the range of algal blooms that take over fisheries and coastal ecosystems. Climatic drivers and stressors have cascading effects throughout these ecosystems which can have negative impacts on biodiversity, the economy and human health.

59. Although the impact on fisheries is highly determined by poor management practices, climate change is growing as a major factor contributing to biodiversity loss in these ecosystems. IPBES indicated that "climate change is projected to decrease ocean net primary production by between 3% and 10%,"[50] while IPCC stated that "the global-scale biomass of marine animals across the food web is projected to decrease by 15.0 ± 5.9% (very likely range) and the maximum catch potential of fisheries by 20.5–24.1% by the end of the 21st century relative to 1986–2005 under RCP8.5 (medium confidence)."[51] While one global fishery model "projected a decrease in global annual catch for marine fisheries of about 1.5 million tonnes for 1.5°C of global warming compared to a loss of more than 3 million tonnes for 2°C of global warming,"[52] more recent estimates show that these losses would (very likely) be three to four times larger under RCP8.5 than RCP2.6.[53]

60. Reduced ocean mixing and a greater frequency of 'dead zone' areas will affect the process of deep ocean circulation and thus halt ocean upwelling that is necessary to support life in open and coastal waters. A reduction in ocean upwelling can have significant consequences for industries and people who depend on fisheries for food and livelihoods, including indigenous peoples and local communities.

61. Global warming of 1.5°C is projected to impact coastal resources and the productivity of fisheries and aquaculture disproportionately at different latitudes. The range of many marine species will shift to higher latitudes due to increased ocean temperatures at lower latitudes. However, limiting global warming to 1.5°C is expected to yield lower risks to marine biodiversity, ecosystems and their functions and services to humans than at 2°C.

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[47] SRCCL SPM B6.2
[48] SRCCL SPM B6.3
[49] IPBES GA 4.5.4
[50] IPBES GA 4.2.2.2.1
[51] IPCC SROCC SPM B5.1
[52] IPCC SR1.5 SPM B4.4; SR1.5 3.4.4, Box 3.4
[53] IPCC SROCC SPM B5.1; SROCC 3.2.3, 3.3.3, 5.2.2, 5.2.3, 5.4.1, Figure SPM.3

62. Since the destruction of coastal ecosystems is predominantly caused by overfishing and other unsustainable fishing and aquaculture practices, the solutions to coastal ecosystem restoration are mainly through adapting fisheries management. It is important that the impacts of climate change are considered when adapting fishery and aquaculture management plans.

2.5. Water demand and scarcity

63. Climate change directly affects the availability of water through its influence on extreme weather. It was well established in earlier IPCC reports that there will be more frequent floods and droughts with each increasing degree of climate change and this projection remains true in the most recent reports. What is now clearer is its impact on livelihoods, particularly on small island developing states and indigenous peoples and local communities.

64. Virtually all future socio-economic pathways explored by IPCC result in an increase in water demand as well as water scarcity.[54] According to IPCC, “limiting global warming to 1.5°C compared to 2°C may reduce the proportion of the world population exposed to a climate change-induced increase in water stress, such as small island developing states, by up to 50%, although there is considerable variability between regions.”[55]

65. Although there is a lack of literature comparing the impacts of climate change on water quality under global warming of 1.5°C and 2°C, studies have detected impacts on several indices of water quality in lakes and watersheds such as the chloride standard for drinking water, oxygen and nutrient concentrations, impacts posed by land-use change, and annual nitrogen and phosphorus yields; in which the negative impact of each index is enhanced at 2°C.[56]

66. In Arctic regions, climate-induced changes in snow, lake and river ice and permafrost have negatively impacted food security and water quantity and quality.[57]

2.6. Groundwater and runoff

67. The hydrological cycle is generally well understood in relation to the impacts of climate change, however opportunities exist in global, regional and integrated climate models regarding the projection of precipitation and streamflow trends. A number of factors can influence regional trends in streamflow and runoff such as multi-decadal and multi-year climate cycles, anthropogenic greenhouse gases and aerosols and human activities that modify landscapes (e.g. land-use change, modifications in river morphology and water table depth, construction and operation of hydropower plants, dikes and weirs, wetland drainage and irrigation practices).[58]

68. Climate change exacerbates groundwater depletion and compounds the pressure put on water resources. A study indicated that “2% of the global land area is projected to suffer from an extreme decrease in renewable groundwater resources of more than 70% at 2°C” of global warming.[59]

69. Global warming of 2°C, compared to 1.5°C, is expected to further amplify the exposure of vulnerable communities and ecosystems, small islands and low-lying coastal areas to the risks associated with sea level rise such as increased salt water intrusion, flooding and damage to infrastructure. Each increasing degree of global warming can lead to an expansion of the global land area with significant increases in runoff and flood hazards. At 2°C, there may also be fewer opportunities for climate change adaptation, including coastal ecosystem restoration and the reinforcement of natural infrastructure.[60]

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[54] IPCC SRCCL 6.1.4
[55] IPCC SR1.5 SPM B5.4
[56] IPCC SR1.5 3.4.2.4
[57] IPCC SROCC SPM A7.1
[58] IPCC SR1.5 3.3.5
[59] Portmann et al. (2013); from IPCC SR1.5 3.4.2.3
[60] IPCC SR1.5 3.3.5

70. In contrast, significant reductions of runoff can occur in high-mountain and Arctic ecosystems and is expected to reduce the productivity of irrigated agriculture and diminish food and water security for communities and livelihoods that depend on these ecosystems.[61]

2.7. Health and human livelihoods

71. Climate change, biodiversity loss and ecosystem degradation directly and indirectly impact human health. As nature underpins all dimensions of human health and wellbeing, "the diversity of nature maintains humanity's ability to choose alternatives in the face of an uncertain future."[62]

72. Ecosystems and biodiversity have both intrinsic value and support non-material ecosystem services, such as spiritual enrichment and aesthetic value, in addition to providing ecosystem functions and services all of which mediate human physical and psychological health.

73. Global warming of 2°C compared to 1.5°C would result in a greater risk to peoples' health and wellbeing as there would be an increase in temperature-related morbidity and mortality, poorer air quality and a shift in the geographic range, seasonality and transmission of certain vector-borne diseases, such as malaria, dengue fever, chikungunya, yellow fever and Zika virus.[63]

2.8. Society

74. The negative impacts of climate change are often disproportionately distributed, including over large populations of indigenous peoples and the world's poorest communities who depend on ecosystem functions and services for subsistence, livelihoods and health. Climate change and land degradation exacerbate threats to the already vulnerable livelihoods of people and communities and further increasing their vulnerabilities to poverty and food insecurity.

75. Activities that put pressure on indigenous peoples and local communities such as resource extraction, commodity production, mining and transport and energy infrastructure in addition to some climate change mitigation programmes can negatively impact local livelihoods and health and challenge traditional management and the intergenerational transmission of indigenous and local knowledge.[64] For example, climate change impacts on marine ecosystems can threaten the livelihoods that depend on them and erode the local and indigenous cultures, knowledge and traditional diets, while reducing food security and opportunities for aesthetic and spiritual appreciation and marine recreational activities.[65]

76. Contrarily, "education, information, and community approaches, including those that are informed by indigenous knowledge and local knowledge, can accelerate the wide-scale behaviour changes and systems transitions consistent with adapting to and limiting global warming to 1.5°C."[66]

2.9. Economy

77. The degradation of ecosystems and the functions and services they provide can significantly impact the gross domestic product of the world and many countries. For example, the resilience of terrestrial ecosystems can be threatened by the impacts of climate change-induced land degradation, such as permafrost thaw, coastal erosion and soil erosion. These impacts can impede productivity and economic growth, as the annual value of the world's total terrestrial ecosystem services has been estimated to be about USD 75–85 trillion.[67]

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[61] IPCC SROCC 2.3.1
[62] IPBES GA SPM A1
[63] IPCC SR1.5 3.4.7
[64] IPBES GA SPM B6
[65] IPCC SROCC Ch. 5 Executive Summary
[66] IPCC SR1.5 SPM D5.6
[67] Costanza et al. (2014); from IPCC SRCCL 1.1.1

78. Risks to global economic growth are projected to be lower at 1.5°C of global warming compared to 2°C, with the possibility that tropical countries and those in the Southern Hemisphere subtropics will disproportionately experience the largest impacts to economic growth.

79. Although there have been significant increases in funding aid to biodiversity, mainly provided by the Global Environment Facility, IPBES identified that the current status of resource mobilization is not sufficient to achieve the Aichi Biodiversity Targets.[68] However, a mixture of policy- and market-based options and other finance-policy-based instruments exist that allow for 1.5°C pathways to be achieved, such as "flexible carbon credits, disaster risk and health insurance, social protection and adaptive safety nets, contingent finance and reserve funds, and universal access to early warning systems."[69]

80. The literature suggests that in order to obtain transformational change toward a more sustainable future, an evolutionary paradigm shift needs to occur in which more economic indicators are needed (in addition to gross domestic product) to capture more holistic and long-term views of economics and quality of life.

2.10. Social and environmental justice and the SDGs

81. IPCC's fifth assessment report concluded, with very high confidence, that "climate change and climate variability worsen existing poverty and exacerbate inequalities, especially for those disadvantaged by gender, age, race, class, caste, indigeneity and (dis)ability."[70] Climate change continues to affect the world disproportionately and unjustly.

82. The adaptive capacity of disadvantaged and vulnerable populations, some indigenous peoples, local communities dependent on agricultural or coastal ecosystems and countries and populations considered to be small island developing states and least developed countries will face greater risks in a world of global warming of 2°C compared to 1.5°C. Limiting global warming to 1.5°C would also avoid climate change impacts on overall sustainable development and maximize efforts to eradicate poverty and reduce inequalities through the inclusion of ethics and equity in climate change and biodiversity action plans and national strategies.

83. Climate change "disproportionally affects children and the elderly and can increase gender inequality,"[71] while its impacts on ecosystem services, particularly those resulting in land degradation, can "exacerbate income inequality since the negative impacts fall disproportionately on people in vulnerable situations, including women, indigenous peoples and local communities, and lower-income groups."[72]

84. Increasing investment in physical and social infrastructure is vital to enhancing resiliency and adaptability of societies. If well managed, the integration of sustainable development and ecosystem-based adaptation to climate change has many lasting advantages such as safeguarding food and water security, reducing disaster risk, improving human health conditions, maintaining ecosystem functions and services and reducing poverty and gender and social inequality.

85. The most sustainable pathways outlined by IPCC that limit global warming to 1.5°C involve social justice and equity to address the challenges and trade-offs arising from the mitigation measures needed to reduce atmospheric greenhouse gas concentrations. Nature-based or ecosystem-based mitigation measures can aid in reducing trade-offs and synergizing climate change actions, conservation and the sustainable use of biodiversity and the Sustainable Development Goals. Doing so can contribute to eradicating poverty (SDG 1), reducing hunger (SDG2), health and well-being (SDG 3), clean water (SDG 6), sustainable cities

[68] IPBES GA SPM C1

[69] IPCC SRCCL Executive Summary

[70] Olsson et al. (2014); from IPCC SR1.5 5.2

[71] Kaijser & Kronsell (2014); Vinyeta et al. (2015); Carter et al. (2016); Hanna & Oliva (2016); Li et al. (2016); from IPCC SR1.5 5.2.1

[72] IPBES-LDR SPM A8 (p. 25)

(SDG 11), climate action (SDG 13) and the protection of ecosystems on land (SDG 14) and in water (SDG 15).

86. In contrast, current trends of biodiversity loss and ecosystem degradation are expected to undermine progress towards 80% of the targets under the above SDGs.[73] Current trajectories show a failure to meet goals for conservation and sustainable use of nature unless transformative changes in economic, social, political and technological factors are made.[74]

B. The role of ecosystems and their integrity, for climate change adaptation, mitigation and disaster risk reduction, and ecosystem restoration and sustainable land management

87. While climate change is a main driver of biodiversity loss and ecosystem degradation, the integrity and resilience of biodiversity, ecosystems and their functions and services are essential solutions to mitigating and adapting to the climate change crisis.

88. Nature-based solutions[75] offer immediate and cost-effective benefits to both mitigate climate change and to adapt to its unavoidable effects. These solutions include reducing deforestation and other land-use change and degradation, restoring degraded lands and ecosystems and enhancing soil management in agricultural and range lands.

89. Ecosystem-based approaches to climate change mitigation and adaptation, including biodiversity conservation, the reduction of ecosystem degradation, and restoration of ecosystems, are examples of nature-based solutions that provide significant contributions to stabilizing warming to below 2°C, and closer to 1.5°C above pre-industrial levels, while delivering multiple co-benefits for biodiversity and sustainable development.

1. Biodiversity and climate change mitigation

90. Under the United Nations 2030 Agenda for Sustainable Development and the Paris Agreement under the process of the United Nations Framework Convention on Climate Change, the world has pledged to pursue efforts to limit the global average temperature to well below 2°C above pre-industrial levels and to make efforts to keep the increase below 1.5°C. Dealing with climate change remains an urgent priority and deep cuts in greenhouse gas emissions are necessary to avoid catastrophic impacts of climate change on economies, societies and life on earth.

91. In order to keep the increase in global mean temperature below 2°C, with a likely chance (>66% probability), atmospheric greenhouse gas concentrations need to remain at around 450 ppm CO_2eq or less. This roughly corresponds to a remaining overall emission budget of 1000 GtCO_2 (assuming emission reductions of non-CO_2 gases).[76]

92. At their current standing, national ambitions accumulated from Nationally Determined Contributions fall short of achieving the goals of the Paris Agreement. Ambitions need to be raised significantly if the global goal of 1.5°C global warming is to be achieved.

93. In order to mitigate climate change, carbon dioxide removal (CDR) is expected to play a significant role in the dynamics of how global warming can be limited to 1.5°C. Some CDR measures, such as the large-scale deployment of intensive bioenergy plantations, including monocultures, replacing natural forests and subsistence farmlands, may have potential negative impacts on biodiversity and threaten food and water security as well as local livelihoods.

94. All IPCC scenarios that limit temperature increase to 1.5°C with limited or no overshoot, include some combination of CDR methods. According to IPCC, "pathways that overshoot 1.5°C of global

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[73] IPBES GA SPM C2

[74] IPBES GA SPM C

[75] IUCN defines nature-based solutions as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".

[76] van Vuuren et al. (2015b); from IPCC AR5

warming rely on CDR exceeding residual CO_2 emissions later in the century to return to below 1.5°C by 2100, with larger overshoots requiring greater amounts of CDR. Limitations on the speed, scale, and societal acceptability of CDR deployment hence determine the ability to return global warming to below 1.5°C following an overshoot."[77]

95. Examples of carbon dioxide removal measures include bioenergy with carbon capture and storage (BECCS), afforestation and reforestation, soil carbon sequestration, direct air capture, biochar and enhanced weathering. For further information on the comparison of land-based CDR options, see IPCC SR1.5, Chapter 3, Cross-Chapter Box 7, Table 1 and Chapter 4, Figure 4.2.

96. In scenarios where emissions reductions were limited and additional CDR measures were implemented, enormous losses of both cropland and natural ecosystems occurred, indicating potential severe loss of biodiversity. In fact, most CDR measures could have significant impacts on land, energy, water or nutrients if deployed at large scale, depending on their maturity, sequestration potentials, costs, risks, co-benefits and trade-offs. The impacts and implications of CDR methods vary according to the type and scale of execution, and must consider "people's needs, biodiversity, and other dimensions of sustainable development."[78]

1.1. Carbon sources and sinks

97. Land is both a source of and a sink for atmospheric greenhouse gases and presents important opportunities and solutions for the duel crises of climate change and biodiversity loss. While agriculture, forestry and other land-use accounted for approximately 22% of total anthropogenic greenhouse gas emissions between 2007 and 2016, the net land-atmosphere flux of emissions (carbon dioxide equivalent) on both managed and unmanaged lands very likely resulted in a global net removal of approximately $-6.2 \pm 3.7\ GtCO_2\ yr^{-1}$ from 2008 to 2017.[79]

98. However many uncertainties and conflicting feedback loops occur when projecting the interactions between terrestrial ecosystems and climate change. The global terrestrial land area at risk of undergoing ecosystem transformation is projected to be approximately 50% lower at 1.5°C compared to 2°C.[80] While biomass and soil carbon stocks in terrestrial ecosystems act as carbon sinks and are currently increasing, it is expected that the increase in the intensity of storms, wildfires, land degradation and pest outbreaks will contribute to a decrease in the overall terrestrial carbon sink.

99. Some mitigation measures such as afforestation and bioenergy with carbon capture and storage can have significant adverse impacts on agricultural and food systems, biodiversity and ecosystem services. However most of the assessed pathways that limit warming to 1.5°C with requirements for extensive land-based mitigation include different combinations of reforestation, afforestation, reduced deforestation and large-scale bioenergy.[81]

100. Significant changes in land-use governance and actions are crucial, in addition to reducing greenhouse gas emissions from fossil fuel use and other industrial and agricultural activities, in limiting global warming to well below 2°C. Some mitigation options can have negative impacts on biodiversity such as the large-scale deployment of intensive bioenergy plantations, including monocultures and replacing existing forests and subsistence farmlands. These measures can ultimately threaten food and water security and local livelihoods. The most sustainable pathways that meet the goal of 2°C of global warming also limit the negative impacts on biodiversity, food and water security and other vital factors.

[77] IPCC SR1.5 SPM C3.3
[78] IPCC SR1.5 SPM D4.3
[79] IPCC SRCCL 2.3; 2.3.1
[80] IPCC SRCCL SPM B3.1
[81] IPCC SRCCL SPM B7

101. The net result of land restoration and reduced and avoided land degradation that either increases carbon storage or avoids emissions is predicted to provide more than one third of the cost-effective mitigation required by 2030 to keep global warming to below 2°C.[82]

102. The management of carbon stocks can play a significant role in efforts not only to mitigate and adapt to climate change, but in reversing biodiversity loss and ecosystem and land degradation. Investing simultaneously in ecosystem restoration, the rehabilitation of degraded agricultural and pasture lands, and ways to sustainably enhance agricultural productivity can contribute to combating climate change and biodiversity loss and enhance food security at the same time.

1.2. Afforestation and reforestation

103. Deployment of afforestation measures can create competition for land with other land uses and may have significant impacts on agricultural and food systems, biodiversity, and other ecosystem functions and services.

104. Some concerns about afforestation and reforestation[83] exist, where trade-offs can occur between biodiversity, climate mitigation and water use. In addition, these methods can have a higher land footprint per tonne of CO_2 removed. "For example, changing forest management to strategies favouring faster growing species, greater residue extraction and shorter rotations may have a negative impact on biodiversity (de Jong et al., 2014). In contrast, reforestation of degraded land with native trees can have substantial benefits for biodiversity."

105. The biodiversity and environmental impact of large-scale afforestation and reforestation measures depend on the size and type of land-use to be converted and the type of species to be introduced/planted. For example, the "afforestation of native grassland ecosystems or diverse agricultural landscapes with monocultures or invasive alien species can have significant negative impacts on biodiversity," water resources and energy and nutrient cycles,[84,85] "while forest ecosystem restoration with native species can have positive social and environmental impacts."[86]

106. The ability of a reforested area to deliver benefits to biodiversity "strongly depends on the precise nature of the reforestation."[87] Reforestation as ecosystem restoration can have the greatest potential to achieve co-benefits for "carbon sequestration and the conservation of biodiversity and ecosystem functions and services and can contribute to the achievement of the Aichi Biodiversity Targets."[88]

107. While deforestation due to natural processes, such as storms and wildfires, are integrated in the IPCC projected scenarios, the benefits of avoiding human-caused deforestation are self-evident. According to IPBES, "the benefits of avoiding and reducing deforestation and promoting restoration can be significant for biodiversity and are expected to have co-benefits for local communities."[89]

1.3. Bioenergy with carbon capture and storage (BECCS)

108. The carbon sequestering potential for bioenergy with carbon capture and storage (BECCS) varies greatly in the literature, while many studies have been concerned with the "range of potential consequences

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[82] IPBES LDR SPM A3

[83] The IPCC defines afforestation as the establishment of forest on land that has been without forest for a period of time (e.g., 20-50 years or more) and was previously under a different land use, while reforestation is the planting of forests on lands that have previously contained forests but that have been converted to some other use.

[84] Smith et al. (2014)

[85] IPBES LDR SPM A23; 3.5

[86] Cunningham et al. (2015); Locatelli et al. (2015); Paul et al. (2016)

[87] Pistorious & Kiff (2017)

[88] Leadley et al. (2016)

[89] IPBES GA SPM 4.2.4.3 (p. 25)

including greatly increased demand for freshwater use, increased competition for land, loss of biodiversity and/or impacts on food security."[90]

109. Although BECCS has been included in scenario pathways assessed in previous IPCC reports, new 1.5°C pathways have emerged without the need for BECCS. Within these pathways, the mitigation potential for BECCS is limited due to its constraints on the sustainability of its bioenergy potentials as well as the availability to safely store the sequestered carbon. Estimates in the literature show a mitigation potential range of 1-85 $GtCO_2$ by the year 2050, while one study estimated a more narrow range of 0.5-5 $GtCO_2$ yr^{-1}.[91] These estimates indicate that "BECCS mitigation potentials are not necessarily sufficient for 1.5°C-consistent pathways" due to their sustainability concerns.[92]

110. Generally, there is a low level of agreement on the availability of land across the literature, as land area estimates differ in scale and are not necessarily a good indicator of competition between land-uses. Thus the properties of BECCS seem to be case-specific and "productivity, food production and competition with other ecosystem services and land uses by local communities are important factors that must be assessed in designing regulation."[93]

111. Although most of the pathways include substantial deployment of bioenergy-based measures, the 1.5°C consistent pathways that exist without the need for BECCS require a greater reliance on "rapid and far-reaching transitions in energy, land, urban systems and infrastructure and on behavioural and lifestyle changes."[94]

112. When considering bioenergy and biomass-based measures, attention should be given to the direct and indirect effects of related land-use changes, including net greenhouse gas emissions, water and nutrient constraints and changes in albedo. This will be necessary to ensure that these measures contribute to climate change mitigation without unduly compromising biodiversity, food security, ecosystem resilience and adaptation to climate change. The deployment of bioenergy, including bioenergy with carbon capture and storage, on a very large scale as envisaged in some mitigation scenarios, could have significant negative impacts on biodiversity and food security through land-use change.

1.4. Soil carbon sequestration

113. Climate change has intensified land degradation and soil erosion through the increase in the frequency and intensity of heavy precipitation events, "flooding, drought frequency and severity, heat stress, dry spells, wind, sea-level rise and wave action, with outcomes being modulated by land management."[95] Soil carbon sequestration is a CDR option with minimal risk and can have positive impacts for mitigating and adapting to climate change, reducing biodiversity loss and reversing land degradation. Soil carbon sequestration can be deployed without significant changes in land-use, water or energy and can improve soil nutrient levels, soil fertility and food security.

1.5. Mitigation priorities

114. Biodiversity loss could be greater in scenarios that limit global warming more than land-use change throughout the century.[96] This may indicate that trade-offs exist between biodiversity and land-use change, where they are inversely related when considering different climate change scenarios. Land area requirements that are necessary for climate change mitigation measures are lower in projected scenarios that assume greater sustainability in consumption patterns and would lead to less regional competition for

[90] Heck et al. (2018)
[91] Fuss et al. (2018); from IPCC SR1.5 4.3.7.1
[92] Boysen et al. (2017); Heck et al. (2018); Henry et al. (2018); from IPCC SR1.5 4.3.7.1
[93] IPCC SR1.5 4.3.7.1
[94] IPCC SRCCL SPM B7.4
[95] IPCC SRCCL SPM A2.7
[96] Newbold et al. (2015)

land.[97] More effective governance will be important if business-as-usual scenarios persist, where land area for carbon dioxide removal, such as for bioenergy production, may compete with protected areas and restoration of natural ecosystems.

115. Despite these trade-offs, opportunities exist to prioritize methods of carbon dioxide removal that minimize indicators of climate change and biodiversity loss. Ecosystem-based approaches and other nature-based solutions to climate change, if implemented as priority actions, have immediate and cost-effective benefits across the Sustainable Development Goals.

116. Nature-based carbon dioxide removal measures that encourage co-benefits between ecosystem and land restoration, biodiversity and climate change mitigation and adaptation such as ecosystem-based approaches should be prioritized. These nature-based solutions and other ‘natural climate solutions’ that encourage conservation, ecosystem restoration and improved land management are estimated to “provide 37% of the cost-effective CO_2 mitigation by 2030 in order to have a >66% chance of holding warming to below 2°C.”[98]

117. For further information on the mitigation potential of different ecosystem types, see CBD Technical Series No. 86, Table 2 and Figure 3.[99]

2. Biodiversity and climate change adaptation and disaster risk reduction

118. Protecting and conserving biodiversity and ecosystems is critical in order to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change. Diverse, well-functioning and resilient ecosystems are better able to provide society with ecosystem services and benefits that support climate change adaptation and disaster risk reduction.

119. Ecosystems and food and health systems will face fewer challenges when adapting to climate change at 1.5°C of global warming compared to 2°C. Generally, adaptation needs will be lower in a 1.5°C world compared to 2°C, while in many cases the “effectiveness of some ecosystem-based adaptation approaches will be compromised under high emission scenarios.”[100]

2.1. Ecosystem-based adaptation

120. Ecosystem-based approaches to adaptation, or ecosystem-based adaptation (EbA), incorporates biodiversity and ecosystem services into an overall adaptation strategy to help people to adapt to the adverse effects of climate change.[101] For example, ecosystem-based agricultural practices can contribute to climate change adaptation measures by increasing the diversity of mixed crop-livestock production. Increasing the genetic diversity of livestock can increase the resilience to the impacts of climate change and also “improve fodder and feed management and disease prevention and control.”[102,103,104] One study found that “shifting towards mixed crop–livestock systems is estimated to reduce agricultural adaptation costs to 0.3% of total production costs while abating deforestation by 76 Mha globally, making it a highly cost effective adaptation option with mitigation co-benefits.”[105] However, the literature also highlights some unintended negative impacts, “including increased burdens on women, higher requirements of capital, competing uses of crop residues (e.g., feed vs. mulching vs. carbon sequestration) and higher requirements of management skills, which can be a challenge across several low income countries.”[106]

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[97] Popp et al. (2017)
[98] Griscom et al. (2017)
[99] Epple et al. (2016)
[100] SROCC SPM C2
[101] Secretariat of the Convention on Biological Diversity (2009)
[102] Bell et al. (2014); Havet et al. (2014)
[103] Skuce et al. (2013); Nguyen et al. (2016)
[104] IPCC SR1.5 4.3.2.1
[105] IPCC SR1.5 4.3.2.1; Weindl et al. (2015)
[106] IPCC SR1.5 4.3.2.1; Thornton & Herrero (2015); Thornton et al. (2018)

121. The literature indicates that costly scalability is often the limiting factor when implementing ecosystem-based adaptation to fisheries and coastal ecosystems such as mangroves, coral reefs and seagrass. Terrestrial ecosystem restoration is generally less expensive than coastal marine ecosystems.

122. In addition to the benefits for climate change, biodiversity loss and land degradation goals, the incorporation of ecosystem- and community-based adaptation and indigenous and local knowledge can also deliver multiple benefits for several sustainable development goals, such as SDGs 5 (gender equality), 10 (reducing inequalities) and 16 (inclusive societies).[107] For example, indigenous and local practices often contribute to enhancing the resiliency of ecosystems against the impacts of climate change and desertification, through agro-ecological practices such as forest, water, soil, and fertility management, local seed use, improved grazing, and ecological restoration. These practices are often based on locally appropriate indigenous knowledge and should be appropriately considered when choosing response options and policies.[108]

2.2. Disaster risk reduction

123. Ecosystem-based disaster risk reduction is defined as the sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development.[109]. For example, increased vegetation in coastal ecosystems can create a physical buffer from hazards such as storm, flooding and erosion events and secure soils and sediments.

124. Not only do these nature-based solutions to disaster risk reduction promote healthy ecosystems and their functions and services, they can also be more cost-effective than ‘hard’ climate solutions such as grey infrastructure. One study found that “intact salt marshes and mangroves can be two to five times cheaper than submerged breakwaters.”[110]

125. The resilience of indigenous peoples and local communities to the impacts of climate change relies on the long-term and inter-generational transfer of knowledge, experiences and practices. The integration of indigenous and local knowledge into risk assessment and management programs is vital for communities to anticipate, manage and adapt to natural hazards.

2.3. Green infrastructure

126. Increasing the use of green infrastructure[111] and other ecosystem-based approaches can help to advance sustainable urban development while contributing to both climate change mitigation and adaptation. In contrast with grey infrastructure, green infrastructure in urban settings can offer many of the same benefits to biodiversity and ecosystem services as protected area networks. Grey and green infrastructure can complement each other and provide benefits such as flood protection, temperature regulation, cleaning of air and water, treating wastewater and the provision of energy, locally sourced food and the health benefits of interaction with nature.[112]

127. While green infrastructure can aid in efforts to mitigate climate change by sequestering carbon from the atmosphere, it can also support adaptation efforts by building resilience in ecosystems and communities that rely on them. If implemented properly, green infrastructure can contribute to better “storm water management and flood protection, temperature regulation, cleaner air and water, urban food production, recreation, and health benefits, as well as contributing to habitat creation and restoration, connectivity of ecological networks, and increasing urban biodiversity.”[113]

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[107] IPCC SR1.5 Ch. 5 Executive Summary

[108] IPCC SRCCL Ch. 7 Cross-Chapter Box 13: Indigenous and Local Knowledge

[109] Lo (2016)

[110] Narayan et al. (2016); from IPBES GA 3.3.2.2 SDG 11

[111] Defined by the European Commission as “a strategically planned network of natural and semi-natural areas with other environmental features designed and managed so as to deliver a wide range of ecosystem services.”

[112] IPBES GA SPM D9

[113] Andersson et al. (2014); Garmendia et al. (2016); from IPBES GA 6.3.5.2

2.4. Adaptation priorities

128. The appeal of adaptation measures is enhanced when there are also synergies and co-benefits for climate change mitigation. Combining adaptation and mitigation options often increases cost-effectiveness, however "trade-offs can limit the speed of and potential for scaling up."[114]

129. The literature on the progress of Aichi Biodiversity Target 11 indicates that few protected areas currently take climate change into consideration within their management plans.[115] Generally, protected areas successfully conserve biodiversity and ecosystem services within their borders; however more attention must be put on areas where climate change will impact in the future. Better management of protected areas that help buffer climate change impacts and reduce disaster risks are an effective way for biodiversity and ecosystems to adapt to climate change while offering co-benefits for climate change mitigation.

130. Not only must protected area management evolve to integrate climate change adaptation measures, but better management of these areas can be used to adapt to climate change through ecosystem restoration. Protected areas can be more effective when they are large enough to minimize human impacts from outside their boundaries and retain natural processes (fire regimes, long-distance migration), provide connectivity and support genetic diversity, and have decreased vulnerabilities to climate change.[116]

3. Ecosystem restoration and sustainable land management

131. Certain land-based adaptation and mitigation measures can be prioritized, such as to avoid deforestation, promote land and ecosystem restoration, improve agricultural management (including soil carbon), and prevent degradation of wetlands and peatlands. Nature-based solutions that prioritize ecosystem restoration and sustainable land management can help prevent trophic cascading that may lead to ecological collapse.

132. Reducing and reversing land degradation through ecosystem restoration and sustainable land management practices can help maintain land productivity, build ecosystem resilience to adapt to climate change and contribute to mitigation targets.[117]

133. Many of these nature-based solutions are low-risk options that improve and secure the integrity of ecosystems and their functions and services. Strong ambitions to reduce global emissions make it easier for ecosystems to further enhance climate change mitigation and adaptation. Nature-based solutions should be prioritized as cost-effective and immediately beneficial actions to avoid unfavourable trade-offs and enhance synergies between biodiversity goals, climate action and the Sustainable Development Goals.

134. Ecosystem restoration and sustainable land management, as adaptation strategies, can reduce the vulnerability of people and livelihoods to climate change by safeguarding ecosystem functions and services. "Recognizing the knowledge, innovations and practices, institutions and values of indigenous peoples and local communities and their inclusion and participation in environmental governance often enhances their quality of life, as well as nature conservation, restoration and sustainable use which is relevant to broader society. Governance, including customary institutions and management systems, and co-management regimes involving indigenous peoples and local communities, can be an effective way to safeguard nature and its contributions to people, incorporating locally attuned management systems and indigenous and local knowledge."[118]

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[114] IPCC SR1.5 Ch. 4 Executive Summary

[115] Poiani et al. (2010); from IPBES GA 3.2.1 Aichi Target 11 (p. 41)

[116] Coristine et al. (2018)

[117] IPCC SRCCL SPM B5

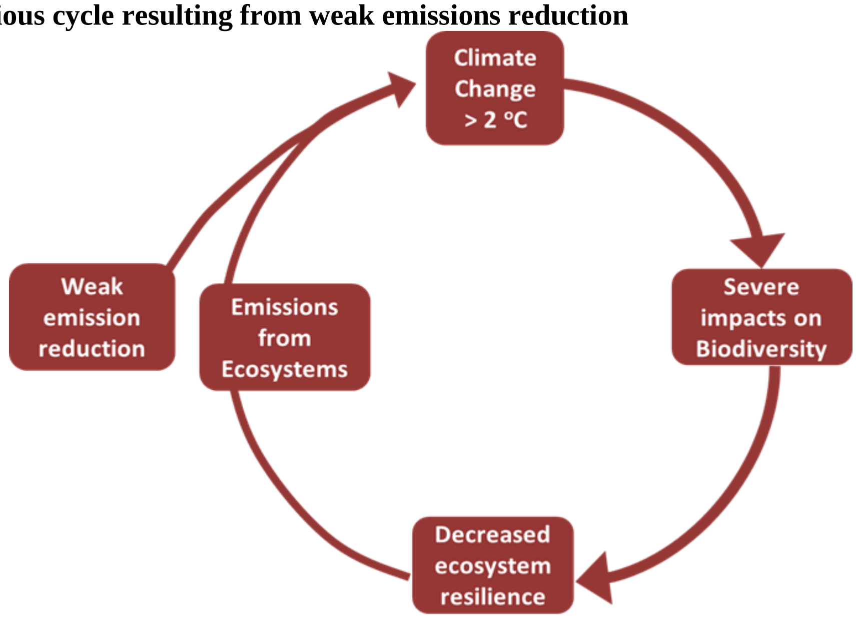
[118] IPBES GA SPM D5

4. Win-win solutions for climate change and biodiversity

135. Synergies exist among measures for climate change adaptation that prioritize ecosystem restoration, the transformation of agriculture systems and the strengthening of indigenous and community land rights. For example, community-based conservation and local governance can sometimes be more effective than formally established protected areas, with "several studies highlighting contributions by indigenous peoples and local communities in limiting deforestation."[119]

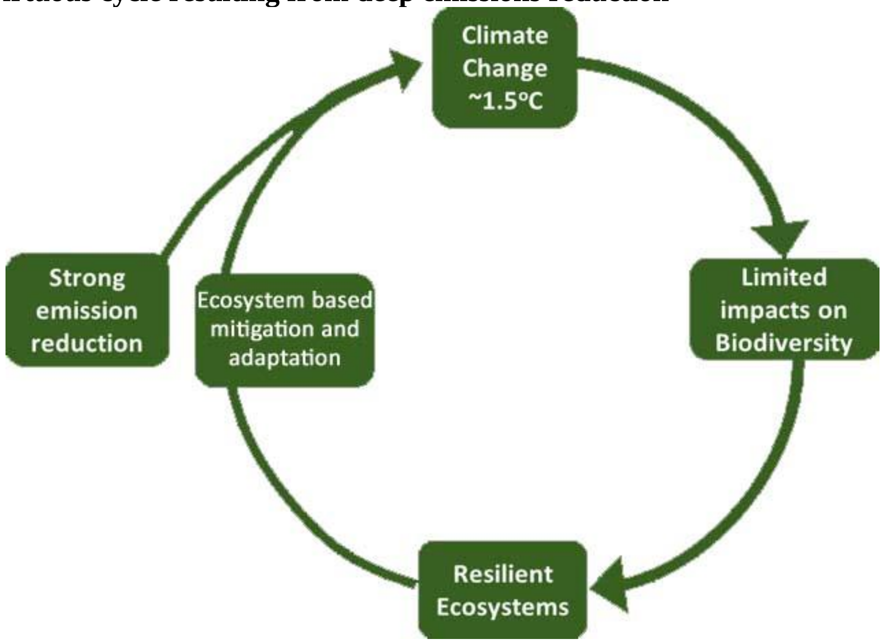
136. The ability of biodiversity and ecosystems to adapt to the effects of climate change greatly depends on the world's level of commitment to reduce emissions. Figures 1 and 2[120] below shows positive feedback loops for both future scenarios that amplify the effects on ecosystem integrity and resilience of a 2°C or greater world or a 1.5°C world, according to weak or strong ambitions to reduce emissions. Figure 1 shows how weak emissions reduction can exacerbate the impacts of climate change on biodiversity and decrease ecosystem resilience; further contributing to emissions from ecosystems. Figure 2 illustrates how strong ambitions to reduce global emissions limit the impacts on biodiversity and build ecosystem resilience; further contributing to ecosystem-based mitigation and adaptation. Nature-based approaches that promote healthy ecosystems and perpetuate the virtuous cycle shown in figure 2 help to further enhance climate change mitigation and adaptation.

Figure 1. The vicious cycle resulting from weak emissions reduction



[119] IPBES GA SPM B20
[120] CBD (2018)

Figure 2. The virtuous cycle resulting from deep emissions reduction



II. COMPLEMENTARY INFORMATION ON THE IMPLICATIONS OF NEW SCIENTIFIC AND TECHNICAL INFORMATION ON BIODIVERSITY AND CLIMATE CHANGE FOR THE WORK OF THE CONVENTION

137. To complement the information on potential implications of new scientific and technical information on biodiversity and climate change for the work of the Convention discussed in section II of document CBD/SBSTTA/23/3, section A below provides supplementary information on existing guidance on biodiversity and climate change under the CBD. Section B provides an overview of new developments on nature-based solutions such as recent findings, information and tools to support their design and implementation. Section C provides complementary information on pathways to achieve the 2050 Vision of "Living in Harmony with Nature".

A. Supplementary information on existing guidance on biodiversity and climate change under the Convention on Biological Diversity

1. Overview of CBD decision X/33

138. Decision X/33 of the Conference of the Parties is a comprehensive decision on biodiversity and climate change providing guidance to Parties on ways to conserve, sustainably use and restore biodiversity and ecosystem services while contributing to climate change mitigation and adaptation. This guidance was derived from the work of the Second Ad Hoc Technical Expert Group (AHTEG) on Biodiversity and Climate Change.[121]

139. Paragraph 8 of decision X/33 provides guidance on essential considerations related to assessing the impacts of climate change on biodiversity, on reducing the impacts of climate change on biodiversity and biodiversity-based livelihoods, on ecosystem-based approaches for adaptation and mitigation, on reducing the impacts of climate change mitigation and adaptation measures and on valuation and incentive measures.

140. The guidance also recognizes that ecosystems can be managed to limit climate change impacts on biodiversity and to help people adapt to the adverse effects of climate change, through implementing

[121] Secretariat of the Convention on Biological Diversity (2009)

ecosystem-based approaches for adaptation, such as sustainable management, conservation and restoration of ecosystems, as part of an overall adaptation strategy that takes into account the multiple social, economic and cultural co-benefits for local communities.

141. Parties and other Governments are invited to integrate ecosystem-based approaches for adaptation into relevant strategies, including adaptation strategies and plans, national action plans to combat desertification, national biodiversity strategies and action plans, poverty reduction strategies, disaster-risk reduction strategies and sustainable land management strategies.

142. Guidance is also provided on ecosystem-based approaches for mitigation through ecosystem-management activities, including the protection of natural forests, natural grasslands and peatlands, the sustainable management of forests considering the use of native communities of forest species in reforestation activities, sustainable wetland management, restoration of degraded wetlands and natural grasslands, conservation of mangroves, salt marshes and seagrass beds, sustainable agricultural practices and soil management.

143. A number of biodiversity safeguards for afforestation, reforestation and forest restoration activities for climate change mitigation are presented, including:

(a) Prioritizing the use of native communities of species;

(b) Converting only land of low biodiversity value or ecosystems largely composed of non-native species, and preferably degraded ones;

(c) Prioritizing, whenever feasible, local and acclimated native tree species when selecting species for planting;

(d) Avoiding invasive alien species;

(e) Preventing net reduction of carbon stocks in all organic carbon pools;

(f) Strategically locating afforestation activities within the landscape to enhance connectivity and increase the provision of ecosystem services within forest areas;

(g) Ensuring the full and effective participation of indigenous and local communities in relevant policy-making and implementation processes, where appropriate; and considering land ownership and land tenure, in accordance with national legislation.

2. Climate change elements in the programmes of work, cross-cutting issues and other programmes and initiatives of the Convention on Biological Diversity

144. The in-depth review of the cross-cutting issue on biodiversity and climate change[122] undertaken in 2010 identified the climate change elements and guidance in the programmes of work under the Convention. An update of this review, looking at additional programmes and initiatives under the CBD, is presented in table 1 below. The analysis reveals that the majority of the programmes contain some references to climate change, mostly acknowledging the impacts of climate change on biodiversity and the role of biodiversity for climate change adaptation and mitigation. Only a few of them, such as the programmes of work on island biodiversity and marine and coastal biodiversity, provide information on specific activities to integrate climate change.

[122] CBD (2010)

Table 1. Climate change elements in the programmes of work, cross-cutting issues and other programmes and initiatives of the CBD

Programme of work, cross-cutting issue, other programme or initiative under the CBD / relevant decisions	Climate change elements and considerations
Agricultural Biodiversity (programme of work, decision V/5)	Activity 2.1. Calls for Parties to take into account the multiple goods and services provided by the different levels and functions of agricultural biodiversity including the role of genetic diversity in providing resilience, reducing vulnerability, and enhancing adaptability of production systems to changing environments and needs. In the scope of the agricultural biodiversity section, climate regulation and carbon sequestration are recognized as ecosystem services provided by agricultural biodiversity.
Dry and Sub-humid Lands Biodiversity (programme of work, decision V/23)	Activity 7(f) Calls for Parties to take due account of better understanding of climate variability in developing effective in situ biological conservation strategies.
Forest Biodiversity (programme of work, VI/22)	Goal 2: Objective 3: Mitigate the negative impacts of climate change on forest biodiversity.
Inland Waters Biodiversity (programme of work, VII/4)	1.1.2 Develop effective management strategies to maintain or improve the sustainability of inland water ecosystems (…) while giving due consideration to the likely impacts of climate change. 1.1.7 Provide to the Executive Secretary advice on (…) implementing adaptive management and mitigation strategies for combating the impacts of climate change. 1.1.9 Assess the linkages between inland water ecosystems and climate change and the management options for mitigation of and adaptation to climate change.
Island Biodiversity (programme of work, VIII/1)	1.2.1.5. Integrate climate change adaptation measures when establishing networks of island protected areas. Goal 7: Address challenges to island biodiversity from climate change, and pollution 8.1.2.1. Identify and implement effective early-warning systems (forecasting) and strategies that address natural (…), such as (…) tropical storms and longer-term trends such as climate change, sea level rise, (…).
Marine and Coastal Biodiversity (programme of work, VII/5)	Operational objective 3.3: (b) To address, through appropriate integrated marine and coastal management approaches, all threats, (…) taking into account possible effects of climate change such as rising sea levels. Appendix 1: Specific Work Plan on Coral Bleaching Appendix 4: Priority 2.3(c) develop methods for adapting marine and coastal protected areas management in response to possible changing species and habitat distribution patterns, which may result from climate change.
Mountain Biodiversity (programme of work, IV/16)	1.1.5. Monitor and exchange information on the impacts of global climate change on mountain biological diversity, and identify and implement ways and means to reduce the negative impacts. 1.2.1. Develop and implement programmes (…) to enhance the capacity of mountain ecosystems to resist and adapt to climate change, or recover from its negative impacts including, inter alia, by establishing corridors (…).

Programme of work, cross-cutting issue, other programme or initiative under the CBD / relevant decisions	Climate change elements and considerations
	2.3.4. Strengthen collaboration and synergies between the work programmes of the Convention on Biological Diversity and other global conventions and agreements on climate change, (…). 3.1.1. Promote the monitoring of susceptible areas subject to climate change. 3.1.6. Promote collaboration among the secretariats and national focal points of United Nations Framework Convention on Climate Change, United Nations Convention to Combat Desertification (…) to develop adaptive strategies for mountain ecosystems and for the monitoring of changes due to the impact of global processes, where appropriate. 3.2.4. Assess and address the changing status of both local and long-range pollution and global climate change issues with special relevance to mountain ecosystems.
Global Taxonomy Initiative (GTI) (programme of work, VI/8)	No mention
Protected Areas (programme of work, VII/28)	Target 1.4.5. Integrate climate change adaptation measures in protected area planning, management strategies, and in the design of protected area systems.
Article 8(j) and related provisions (programme of work, V/16)	No mention
Ecosystem Approach (description of the ecosystem approach and operational guidance, V/6)	Principle 9: Management must recognize that change is inevitable. Rationale: Ecosystems change, including species composition and population abundance. Hence, management should adapt to the changes. Apart from their inherent dynamics of change, ecosystems are beset by a complex of uncertainties and potential "surprises" in the human, biological and environmental realms. Traditional disturbance regimes may be important for ecosystem structure and functioning, and may need to be maintained or restored. The ecosystem approach must utilize adaptive management in order to anticipate and cater for such changes and events and should be cautious in making any decision that may foreclose options, but, at the same time, consider mitigating actions to cope with long-term changes such as climate change.
Invasive Alien Species (Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that Threaten Ecosystems, Habitats or Species, VI/23)	15(a). Urges Parties, Governments, multilateral organizations and other relevant bodies to consider the potential effects of global change on the risk of invasive alien species to biodiversity, and related ecosystem goods and services and invites the United Nations Framework Convention on Climate Change to consider this matter when it considers measures for adaptation to and mitigation of climate change in particular with respect to the lifestyles of indigenous and local communities. 24(a). Urges parties, governments and relevant organizations to promote and carry out, as appropriate, research and assessments on the characteristics of invasive species and the vulnerability of ecosystems and habitats to invasion by alien species, and the impact of climate change on these parameters.
Global Strategy for Plant Conservation (GSPC) (Global Strategy for Plant Conservation 2002-2010, VI/9	B. Rationale, scope and general principles: Plants are universally recognized as a vital part of the world's biological diversity and an essential resource for the planet. (…) Plants play a key role in maintaining the planet's basic environmental balance and ecosystem stability and provide an important component of the habitats for the world's animal life. (…) Of particular concern is the fact that many are in danger of extinction,

Programme of work, cross-cutting issue, other programme or initiative under the CBD / relevant decisions	Climate change elements and considerations
and Updated Global Strategy for Plant Conservation 2011-2020, X/17)	threatened by habitat transformation, over-exploitation, alien invasive species, pollution and climate change. (…) The Global Strategy for Plant Conservation is proposed to address this challenge.
Ecosystem Restoration (short term action plan, XIII/5)	*Objective and purpose:* 1. The overall objective of this action plan is to promote restoration of degraded natural and seminatural ecosystems, including in urban environments, as a contribution to reversing the loss of biodiversity, recovering connectivity, improving ecosystem resilience, enhancing the provision of ecosystem services, mitigating and adapting to the effects of climate change, combating desertification and land degradation, and improving human well-being while reducing environmental risks and scarcities. 2. The purpose of the action plan is to help Parties, as well as any relevant organizations and initiatives, to accelerate and upscale activities on ecosystem restoration. It aims to support timely achievement of the Strategic Plan for Biodiversity 2011-2020, in particular Aichi Biodiversity Targets 14 and 15. (…). The action plan can also contribute to the achievement of objectives and commitments under other conventions, including the United Nations Framework Convention on Climate Change, the United Nations Convention to Combat Desertification, (…), as well as the 2030 Agenda for Sustainable Development and the Sendai Framework for Disaster Risk Reduction 2015-2030. *Key activities of the action plan:* 6. Review, improve or establish targets, policies and strategies for ecosystem restoration. These activities would normally be reflected in national biodiversity strategies and action plans, and/or national plans for sustainable development, climate change mitigation and adaptation and land management. (…). 2. Consider how ecosystem restoration activities can support the ecological and economic sustainability of agriculture and other production activities, as well as climate change mitigation and adaptation, and disaster risk reduction (…). Potential future environmental changes, such as those resulting from climate change, should be taken into account. *Appendix I: Guidance for integrating biodiversity considerations into ecosystem restoration* Address the drivers of biodiversity loss, including land-use change, fragmentation, degradation and loss, over-exploitation, pollution, climate change, and invasive alien species (…).
Cultural diversity (Joint work programme with UNESCO, X/20, UNEP/CBD/COP/10/INF/3)	No mention
Capacity-building (Short-term Action Plan (2017-2020) to Enhance and Support Capacity-Building for the Implementation of the Convention and its Protocols, XIII/23)	B. Substantive capacity-building activities for the effective implementation of the Convention on Biological Diversity, including those relating to different Aichi Biodiversity Targets Aichi Biodiversity Targets 15, 14, 7 Activity 60: Facilitate capacity-building activities for Parties to promote ecosystem-based solutions/ approaches to climate change adaptation and disaster risk reduction (DRR).

Programme of work, cross-cutting issue, other programme or initiative under the CBD / relevant decisions	Climate change elements and considerations
	Activity 61: Continue to collaborate with the Least Developed Countries Expert Group of the United Nations Framework Convention on Climate Change on organizing training workshops for the integration of biodiversity conservation and sustainable use into national adaptation plans (NAPs).
Incentive measures (Programme of work, V/15)	6. Urges Parties and other Governments to explore possible ways and means by which incentive measures promoted through the Kyoto Protocol under the United Nations Framework Convention on Climate Change can support the objectives of the Convention on Biological Diversity.
Gender and biodiversity (Gender plan of action 2015-2020, XII/7)	No mention
Sustainable use (Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity, VII/12)	Practical principle 10: International, national policies should take into account current and potential values derived from the use of biological diversity; intrinsic and other non-economic values of biological diversity and market forces affecting the values and use. *Rationale*: Recent work in calculating the potential costs of replacing natural systems with man-made alternatives has shown that such natural systems should be valued very highly. (…) For instance, mangroves have the function of fish-spawning and nursery sites, erosion and storm-surge alleviation and carbon sequestration.
Sustainable wildlife management (Revised recommendations of the Liaison Group on Bushmeat, XI/25)	I. National level: 11. *Climate change:* Adaptation and mitigation policies and measures should take into account the importance of wildlife for maintaining healthy ecosystems and ecosystem services.
(Plan of Action on Customary Sustainable Use of Biological Diversity, XII/12)	III. Considerations of special relevance *6. (a)* (…) Indigenous and local communities, through customary sustainable use of biological diversity, constantly shape and reshape social and ecological systems, landscapes, seascapes, plants and animal populations, genetic resources and related management practices, and are therefore well placed to adapt to changing conditions such as climate change, and to contribute to the maintenance of biodiversity and ecosystem services, and the strengthening of the resilience of the social and ecological systems. IV. Rationale: *8.* Many indigenous and local communities are engaged in community-based initiatives to enhance implementation of Article 10(c) at the national and local levels. Such initiatives include (…) biodiversity and climate change monitoring and research.
(Voluntary guidance for a sustainable wild meat sector, 14/7)	6. (…) More attention should be given to the positive contributions that relate to livelihood benefits, local economic growth and connections to climate change adaptation, which can provide incentives for the improved management of wildlife resources. 9. Mitigating the effects of overhunting is a complex issue. The reasons for wild meat overexploitation (…) may include employment availability, property rights issues, the role of institutions, lack of incentives for managing the resource sustainably, migration, failures of crop harvests and availability of food from livestock, weather patterns and climate change, logging and resource extraction, overgrazing, urban sprawl, natural disasters, displacement, poaching, illegal trade war and strife. (…). III. Technical guidance for achieving a sustainable wild meat sector

Programme of work, cross-cutting issue, other programme or initiative under the CBD / relevant decisions	**Climate change elements and considerations**
	A. Managing and improving the sustainability of wild meat supply at the source 22. Forms of co-management between communities and the State and/or private companies, according to national legislation, inter alia, may include: (…)(d) (…) Communities may be paid to maintain “food stocks” at sustainable levels or even to maintain “carbon stocks” through sustainable hunting or strict conservation of key tree seed dispersers, respecting the cultural relation of indigenous peoples and local communities with wildlife.
Tourism and biodiversity (Assessment of the interlinkages between biological diversity and tourism, V/25)	No mention
(Guidelines on biodiversity and tourism development, VII/14)	B. The policy-making, development planning and management process 6. Impact management and mitigation 49. Impact management for tourism development and activities can include the adoption and effective implementation of policies, good practices and lessons learned that cover, inter alia: (…) (e) Promoting the design of facilities that are more eco-efficient, which adopt the cleaner production approach, and use environmentally sound technologies, in particular to reduce emissions of carbon dioxide and other greenhouse gases and ozone-depleting substances, as set out in international agreements.
Cities and subnational governments (Plan of Action on Subnational Governments, Cities and Other Local Authorities for Biodiversity, X/22)	D. Indicative list of activities Parties may wish to consider the activities below, (…) in order to enable and support their subnational governments and local authorities to contribute to the objectives of the Convention on Biological Diversity: 5. (h) Promote and support the representation of subnational governments, cities and other local authorities in delegations for official events and activities under the Convention on Biological Diversity (…). Local authorities can contribute specifically to thematic programmes of work and cross-cutting issues such as inland waters, protected areas, invasive alien species, climate change, development and poverty alleviation, tourism, health and biodiversity, agriculture, food and nutrition, among others. *G. Funding* *Parties may identify funding avenues oriented specifically towards biodiversity at the subnational and local levels for the implementation of this plan of action. Initiatives may include, inter alia:* 13. (b) Engaging and linking subnational governments and local authorities and their networks with new and innovative financial mechanisms being discussed and formulated in other areas such as climate change, payments for ecosystem services, and enhanced efforts to reduce emissions from deforestation and forest degradation (REDD +).
Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefit Arising from their Utilization (Text and Annex)	Preamble *Recognizing* the importance of genetic resources to food security, public health, biodiversity conservation, and the mitigation of and adaptation to climate change. *Recognizing* the interdependence of all countries with regard to genetic resources for food and agriculture as well as their special nature and importance for achieving food security worldwide and for sustainable development of agriculture in the context of poverty alleviation and climate change and acknowledging the fundamental role of the International Treaty on Plant Genetic Resources for Food and Agriculture and the FAO Commission on Genetic Resources for Food and Agriculture in this regard.

Programme of work, cross-cutting issue, other programme or initiative under the CBD / relevant decisions	Climate change elements and considerations
Cartagena Protocol on Biosafety (Text)	No mention

3. Climate change elements in the Aichi Biodiversity Targets

145. Climate change is also addressed through the Aichi Biodiversity Targets. Aichi Targets 10 and 15 explicitly make reference to climate change. However, as biodiversity is inextricably linked to climate change, a connection between the majority of the Targets and climate change can be easily drawn. Target 5, for example, sets a goal for significantly reducing the rate of loss, degradation and fragmentation of natural habitats. Slowing the loss of natural habitats also plays an important role in climate change mitigation and adaptation through avoidance of greenhouse gas emissions and increased resiliency, further strengthening the case for prioritization of these actions both for their climate and biodiversity benefits. Another example is Target 9 which focuses on the control, management and eradication of invasive alien species. The increased level of threat from invasive alien species due to climate change should be considered when developing future targets.

146. An analysis of all 20 Aichi Biodiversity Targets was conducted to identify the links with climate change and assess whether the Targets reflect the level of threat and impacts identified in the recent scientific assessments reviewed. The analysis also assesses whether the Targets sufficiently reflect the role of ecosystems and their integrity in climate change adaptation, mitigation and disaster reduction. This analysis could help inform the development of future targets. The findings are summarized in table 2 below.

Table 2. Aichi Biodiversity Targets: links with climate change and implications of new scientific and technical information on biodiversity and climate change

Aichi Biodiversity Targets	Links with climate change and implications of new scientific and technical information
Target 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.	Biodiversity contributes significantly to climate change adaptation, mitigation and disaster risk reduction. Awareness of its values and steps to conserve and use it sustainably will have a positive impact on efforts to address climate change.
Target 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.	Development and poverty reduction strategies should consider the role of biodiversity in reducing people's vulnerability to the impacts of climate change. The potential income generating potential of ecosystem-based approaches for climate change adaptation, mitigation and disaster risk reduction, should be recognized. Such approaches should be integrated into relevant plans and strategies.
Target 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	Unsustainable food and land use systems lead to land degradation, biodiversity loss and climate change. The elimination of harmful subsidies, and the development of positive incentives for ecosystem-based approaches to

Aichi Biodiversity Targets	Links with climate change and implications of new scientific and technical information
sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socioeconomic conditions.	climate change adaptation and mitigation will have benefits for both the fight against biodiversity loss and climate change.
Target 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.	Globally, biodiversity loss is driven in large part by land use and food consumption, while consumption of non-food goods and services is one of the main drivers of biodiversity loss in high income per capita countries. Implementation of more sustainable consumption and production initiatives that simultaneously provide ecosystem services to communities, such as agroforestry, can have a large impact on curbing this effect and should also be recognized for their potential climate benefits from avoided greenhouse gas emissions and increased resilience.
Target 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.	Slowing loss of natural habitats, such as forests, and habitat conversion will mitigate climate change through avoidance of greenhouse gas emissions. While deforestation rates are inconsistent, there is overall indication of poor or mixed progress and lack of emphasis on re-establishing natural habitats which are optimal for biodiversity. At the same time, there has been an increase in studies showing the key contribution of forests to climate change mitigation. These actions should be incorporated into climate mitigation strategies while taking into consideration the optimal conditions for biodiversity conservation. Slowing the loss of natural habitats also plays an important role in climate change adaptation through increased resiliency and should be prioritized for both its climate and biodiversity benefits.
Target 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.	Climate change will impact the abundance and distribution of fish, making it more difficult to sustainably manage fisheries. At the same time, sustainable harvesting and ecosystem-based approaches can help to increase climate change adaptation as they increase stability and promote more robust and climate resilient ecosystems able to deliver ecosystem services.
Target 7 By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.	In addition to being a main driver of biodiversity loss, the agriculture sector has recently surpassed deforestation in its greenhouse gas emissions. More sustainable agriculture practices have many benefits such as promoting rich biodiversity and stable ecosystems through soil conservation which also promotes soil carbon sequestration—an important source of terrestrial carbon sequestration, reducing methane emissions from rice paddies and livestock through improved management, and reduced erosion from conservation

Aichi Biodiversity Targets	**Links with climate change and implications of new scientific and technical information**
	tillage. Sustainable management of agriculture and forests through practices such as conservation agriculture have great potential for both biodiversity conservation and climate change mitigation and adaptation.
Target 8 By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.	The negative effects of pollution are continuing to drive species to extinction. Specific pollutants, such as nitrogen, cause widespread plant biodiversity loss which has cascading effects and has negative impacts on climate. Nitrogen deposition increases greenhouse gas emissions in the tropics, causing a positive feedback loop and further threatening biodiversity. Both the direct and indirect impacts of pollution on biodiversity should be acknowledged and incorporated into pollution reduction initiatives.
Target 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.	The threat of invasive alien species will be exacerbated by climate change**.** As climate change may cause a range shift or increase in habitat disturbances due to such things as weather events, invasive species, which often capitalize on these disturbances and shifting conditions, may become an even larger issue and should be given special attention. The combination of a significant rise in the number of invasive alien species introductions and lack of a significant increase in the number of countries with invasive alien species legislation shows the continued need for action or incentives to spur action in this area.
Target 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.	Climate change will continue to impact the most vulnerable ecosystems as habitats shift and climatic conditions change. Live corals, especially tropical corals, have experienced a decrease indicating that their “integrity and functioning” are not being maintained but slightly worsened and are experiencing continued threat due to climate change. Other identified vulnerable ecosystems, such as glacial landscapes, deep-sea corals, mountain ecosystems, tropical forests and mangrove forests, should also receive future attention.
Target 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.	Climate change impacts species as it forces them to move to find more suitable habitats. Species composition may shift at differing rates, compromising ecosystem services. High emissions scenarios predict high rates of species turnover and species migration. Protected areas and other area-based conservation measures, in addition to reducing the risk of local species extinction and allowing for species migration, contributes to both climate mitigation and adaptation though avoidance of greenhouse gas emissions and through protection of ecosystem services which are important for adaptation and disaster risk reduction.

Aichi Biodiversity Targets	**Links with climate change and implications of new scientific and technical information**
Target 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.	Climate change poses a high risk for species extinction, with the highest levels of warming predicted to lead to mass extinctions, and may cause large scale changes in species distributions which can have negative effects on ecosystem services. Limiting global warming to 2°C or less could significantly reduce pressure on species to move and increase their likelihood to locally adapt to changes. Efforts which focus on species conservation and extinction prevention must take into consideration the various impacts of climate change on species in order to effectively achieve their goals.
Target 13 By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.	A lack of information on global genetic diversity and a decline in cultivation and conservation of many varieties have impinged upon achieving Target 13. Climate change compounds these uncertainties as it causes species range shifts, which can introduce invasive species that contaminate gene flow, or fragmentation of species populations which reduces genetic diversity especially in vulnerable ecosystems. Conversely, higher genetic diversity increases resilience and reduces the risk of climate change affecting food security and livelihoods. The compounding effects of climate change on genetic diversity must be considered in species cultivation and conservation strategies. Emphasis should be placed on the importance of higher genetic diversity as a safeguard against the negative effects of climate change while acknowledging the threat posed by climate change to gene flow.
Target 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.	Loss and degradation of forests and native vegetation reduce the availability of the essential services they provide, including climate change adaptation and mitigation through carbon sequestration. Loss of these services renders both the ecosystems and the people that depend on them for their wellbeing and livelihoods more vulnerable to the impacts of climate change and heightened disaster risk.
Target 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.	Ecosystem conservation avoids greenhouse gas emissions and increases carbon sequestration and storage, further contributing to climate change mitigation. Ecosystem restoration and conservation should be prioritized for their climate benefits, in addition to biodiversity benefits.
Target 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.	Climate change, as one of the key drivers of biodiversity loss, poses risks to genetic resources (plants, animals, forests, aquatic resources, invertebrates and micro-organisms). This may have significant impacts on food and agriculture. However, genetic resources, in particular for the food and agriculture sectors, are also expected to play a significant role in mitigation of and adaptation to

Aichi Biodiversity Targets	**Links with climate change and implications of new scientific and technical information**
	climate change, through their contribution to food security and nutrition.[123] Greater genetic diversity contributes to the resilience of ecosystems in the face of climate variability (availability of landraces adapted to certain climate conditions). This creates an incentive for conserving the diversity of plant and animal genetic resources. The Nagoya Protocol provides a mechanism for ensuring benefit-sharing for the custodians of these genetic resources. In implementing the Nagoya Protocol on Access and Benefit-sharing and the Fair and Equitable Sharing of Benefits Arising from their Utilization, Parties should consider the importance of access to genetic resources for use in sustainable agriculture and the significant role of these resources for food security and adaptation to climate change.
Target 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.	The national biodiversity strategy and action plan can be an important tool for integrating climate change considerations into biodiversity panning. Where appropriate, ecosystem-based approaches to climate change should be identified for their potential to achieve multiple benefits for biodiversity conservation and climate change adaptation and mitigation.
Target 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.	People who depend on ecosystem services for livelihoods are particularly at risk from the impacts of climate change. Indigenous peoples and local communities, through their traditional knowledge, innovations and practices, contribute to identifying impacts of climate change and to the implementation of nature-based solutions. Hence the full integration of the traditional knowledge, innovations and practices of indigenous and local communities in the implementation of the Convention can support the achievement of the biodiversity, climate change and sustainable development objectives.
Target 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.	Climate change adds a level of uncertainty to science-based knowledge relating to biodiversity. Climate change as a confounding variable should be acknowledged in the creation, transfer and application of knowledge of science and technologies relating to biodiversity. Improving the science base relating to biodiversity will contribute to enhancing knowledge on ecosystem-based approaches to climate change mitigation and adaptation.
Target 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 co-benefits between biodiversity conservation, ecosystem restoration and climate change mitigation and adaptation should be acknowledged by financing mechanisms and emphasized in projects so that they can

[123] FAO (2015)

Aichi Biodiversity Targets	**Links with climate change and implications of new scientific and technical information**
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.	tap into several cross-disciplinary sources of funding and increase investments and incentives and mobilize finance mechanisms.

4. Guidance on ways and means to address climate change and its impacts on biodiversity and on communities

147. A number of past decisions of the Conference of the Parties address the impacts of climate change on biodiversity and provide guidance on ways and means to reduce those impacts. Table 3 presents a summary of such guidance in recent decisions.

Table 3. Guidance on ways and means to address climate change and its impacts on biodiversity and on communities in decisions of the Conference of the Parties

Decision number	**Summary of guidance to address climate change and its impacts on biodiversity and on communities**
IX/16	*The Conference of the Parties* 4. *Urges* Parties to enhance the integration of climate-change considerations related to biodiversity in their implementation of the Convention with the full and effective involvement of relevant stakeholders and considering changing consumption and production models, including: (a) Identifying, within their own countries, vulnerable regions, subregions and, where possible, ecosystem types, including vulnerable components of biodiversity within these areas, including with regard to the impacts on indigenous and local communities, in order to enhance national, regional and international cooperation; (b) Integrating concerns relating to the impacts of climate change * and both the positive and negative impacts of climate change mitigation and adaptation activities on biodiversity within national biodiversity strategy and action plans; (c) Assessing the threats and likely impacts of climate change * and both the positive and negative impacts of climate change mitigation and adaptation activities on biodiversity; (d) Identifying and adopting, within their own countries, monitoring and modelling programmes for regions, subregions and ecosystems affected by climate change and promote international cooperation in this area; (e) Enhancing scientific tools, methodologies, knowledge and approaches to respond to the impacts of climate change, * and both the positive and negative impacts of climate change mitigation and adaptation activities on biodiversity, including socio-economic and cultural impacts; (f) Enhancing the methodology and the knowledge needed to integrate biodiversity considerations within climate change response activities, such as baseline information, scenarios, potential impacts on and risks to biodiversity, and resilience and resistance of ecosystems and selected species populations and communities/assemblages and encouraging the exchange of such knowledge at the national, regional and international level; (g) Increasing stakeholder involvement in the decision-making process relating to the impacts of climate change, * and both the positive and negative impacts of climate-change mitigation and adaptation activities on biodiversity, as appropriate; (h) Applying the principles and guidance of the ecosystem approach such as adaptive management, the use of traditional knowledge, and the use of science and monitoring;

* Including increasing climate variability and increasing frequency and intensity of extreme weather events.

Decision number	**Summary of guidance to address climate change and its impacts on biodiversity and on communities**
	(i) Taking appropriate actions to address and monitor the impacts of climate change of climate-change and both the positive and negative impacts of climate change mitigation and adaptation activities on biodiversity; (j) Enhancing cooperation with relevant organizations and among national focal points;
X/33	*The Conference of the Parties* 8. *Invites* Parties and other Governments, according to national circumstances and priorities, as well as relevant organizations and processes, to consider the guidance below on ways to conserve, sustainably use and restore biodiversity and ecosystem services while contributing to climate-change mitigation and adaptation: **Assessing the impacts of climate change on biodiversity** (a) Identify, monitor and address the impacts of climate change and ocean acidification on biodiversity and ecosystem services, and assess the future risks for biodiversity and the provision of ecosystem services using the latest available vulnerability and impact assessment frameworks and guidelines; (b) Assess the impacts of climate change on biodiversity and biodiversity-based livelihoods, particularly with regard to livelihoods within those ecosystems that have been identified as being particularly vulnerable to the negative impacts of climate change with a view to identifying adaptation priorities; **Reducing the impacts of climate change on biodiversity and biodiversity-based livelihoods** (c) Reduce the negative impacts from climate change as far as ecologically feasible, through conservation and sustainable management strategies that maintain and restore biodiversity; (d) Implement activities to increase the adaptive capacity of species and the resilience of ecosystems in the face of climate change, including, *inter alia*: (i) Reducing non-climatic stresses, such as pollution, over-exploitation, habitat loss and fragmentation and invasive alien species; (ii) Reducing climate-related stresses, where possible, such as through enhanced adaptive and integrated water resource and marine and coastal management; (iii) Strengthening protected area networks including through the use of connectivity measures such as the development of ecological networks and ecological corridors and the restoration of degraded habitats and landscapes in accordance with decision IX/18 on protected areas and the programme of work on protected areas (goal 1.2, activity 1.2.3); (iv) Integrating biodiversity into wider seascape and landscape management; (v) Restoring degraded ecosystems and ecosystem functions; and (vi) Facilitating adaptive management by strengthening monitoring and evaluation systems; (e) Bearing in mind that under climate change, natural adaptation will be difficult and recognizing that *in situ* conservation actions are more effective, also consider *ex situ* measures, such as relocation, assisted migration and captive breeding, among others, that could contribute to maintaining the adaptive capacity and securing the survival of species at risk, taking into account the precautionary approach in order to avoid unintended ecological consequences including, for example, the spread of invasive alien species; (f) Develop a strategy for biodiversity conservation and sustainable use, including landscape and seascape management in those areas that are becoming accessible to new uses as a

Decision number	**Summary of guidance to address climate change and its impacts on biodiversity and on communities**
	consequence of climate change; (g) Take specific measures: (i) For species that are vulnerable to climate change, including migratory species; and (ii) To maintain genetic diversity in the face of climate change taking into account paragraph 2 of Annex I to the Convention; (h) Undertake awareness-raising and capacity-building strategies on the key role of biodiversity conservation and sustainable use as a mechanism for climate-change mitigation and adaptation; (i) Recognize the role of indigenous and local community conserved areas in strengthening ecosystem connectivity and resilience across the sea and landscape thereby maintaining essential ecosystem services and supporting biodiversity–based livelihoods in the face of climate change;
XI/21	*The Conference of the Parties,* 6. *Encourages* Parties and other Governments to: (a) Take into account the importance of traditional knowledge, innovations and practices related to biodiversity when addressing the impacts of climate change in sectoral plans and strategies, especially when considering vulnerable communities; (b) Strengthen knowledge and information, including comparable data sets, and related research and monitoring activities on the linkages between biodiversity, climate change and human well-being in educational programmes at all levels; (c) Promote synergies between biodiversity and climate-change policies and measures; (d) Recognize the significant role that protected areas, restored ecosystems and other conservation measures can play in climate-change-related activities; (e) Support the strengthening of inventorying and monitoring of biodiversity and ecosystem services at appropriate scales in order to evaluate the threats and likely impacts of climate change and both positive and negative impacts of climate-change mitigation and adaptation on biodiversity and ecosystem services; (f) Consider reviewing land-use planning with a view to enhancing ecosystem-based adaptation to climate change, such as the role of mangroves in adapting to changes in sea level;
XIII/4	*The Conference of the Parties,* 8. *Encourages* Parties, other Governments and relevant organizations: (a) To address the degradation of, loss of, and impacts on biodiversity and, where appropriate, related social, environmental and economic impacts associated with climate change and disasters, considering the costs of inaction, and the value of investing in actions in a timely manner in order to reduce biodiversity loss and other negative impacts; (b) To take into consideration the status of biodiversity and its vulnerability to current and future climate change impacts when planning and implementing ecosystem-based approaches to climate change adaptation, mitigation and disaster risk reduction activities, and to minimize and, where possible, avoid activities that may increase the vulnerability and reduce the resilience of biodiversity and ecosystems; (…)
14/5	*The Conference of the Parties,*

Decision number	Summary of guidance to address climate change and its impacts on biodiversity and on communities
	4. *Encourages* Parties, pursuant to decisions IX/16, X/33, XII/20, XIII/4 and XIII/5, to further strengthen their efforts: (a) To identify regions, ecosystems and components of biodiversity that are or will become vulnerable to climate change at a geographic scale and assess the current and future risks and impacts on biodiversity and biodiversity-based livelihoods, considering the use of biodiversity models and scenarios, as appropriate, while taking into account their important contribution to climate change adaptation and disaster risk reduction; (b) To integrate climate change issues and related national priorities into national biodiversity strategies and action plans and to integrate biodiversity and ecosystem integrity considerations into national policies, strategies and plans on climate change, such as nationally determined contributions, as appropriate, and national climate change adaptation planning, in their capacity as national instruments for the prioritization of actions for mitigation and adaptation; (c) To promote ecosystem restoration and sustainable management post-restoration; (d) To take appropriate actions to address and reduce the negative impacts of climate change; (e) To enhance the positive and minimize the negative impacts of climate change mitigation and adaptation activities on ecosystem functions and services, biodiversity and biodiversity-based livelihoods; (f) To put in place systems and/or tools to monitor and assess the impacts of climate change on biodiversity and biodiversity-based livelihoods, in particular livelihoods of indigenous peoples and local communities, as well as to assess the effectiveness of ecosystem-based approaches for adaptation, and mitigation and disaster risk reduction; (g) To include information on the above in their reports to the Convention;

B. Information and tools to support the design and implementation of ecosystem-based approaches to climate change adaptation, mitigation and disaster risk reduction

148. The links between biodiversity and climate change are not only being considered under CBD but are increasingly being addressed by other fora. The present section provides an overview of new developments, more particularly on nature-based solutions, including recent findings, information, guidance and tools (table 4) to complement the information provided in section II of document CBD/SBSTTA/23/3.

Table 4. Overview of recent information, guidance and tools on nature-based solutions

Information, guidance and tools on nature-based solutions	Description
Exploring evidence and assessing effectiveness	
Is ecosystem-based adaptation effective? Perceptions and lessons learned from 13 project sites, June 2019, by IIED, IUCN and UNEP WCMC	This report shares results from research assessing effectiveness of ecosystem-based approaches to climate change adaptation (EbA) at 13 case study sites in 12 countries. It also describes political, institutional and governance-related conditions that facilitate or inhibit effective EbA at each site.
Nature-based solutions evidence tool, by University of Oxford	An interactive map linking nature-based solutions to climate change adaptation outcomes based on a systematic review of the peer-reviewed literature. The

	tool can help: (1) Explore evidence on how effective different nature-based interventions are for addressing climate change impacts; (2) Compare social, economic, and environmental effects of different nature-based interventions; (3) Filter by region, country, habitat, intervention type, or type of outcome; (4) Generate maps, graphs and download data; (5) Directly link from science to national climate policy.
Tools	
EbA Tools Navigator, by IIED, UNEP-WCMC, IUCN and GIZ	The navigator is a searchable database of tools and methods relevant to EbA, providing practical information about more than 240 tools, methodologies and guidance documents. The tools featured cover an array of topics, including planning and assessments, implementation and valuation, monitoring and mainstreaming.
UN Biodiversity Lab, by UNDP, UNEP, and CBD (with GEF funding and data from a range of organizations and research institutions)	The *UN Biodiversity Lab* provides a free, customized, online spatial analysis platform to support conservation and development decision-making. The platform, powered by MapX, allows policymakers and other partners to access global data layers, upload and manipulate their own datasets, and query multiple datasets to provide key information on the Aichi Biodiversity Targets and nature-based Sustainable Development Goals. For example, the map can provide data relating to climate change, carbon storage and sequestration.
Mangrove restoration map, by University of Cambridge, The Nature Conservancy and IUCN	This mapping tool can assist decision-makers in identifying where restoration should be attempted by providing information on locations where mangroves once thrived and where they may once again thrive, while calculating what ecosystem services (such as carbon sequestration) might be gained from their restoration.
Ecosystems opportunities to reduce hazard exposure, by UNEP and UNEP-GRID at the Global Platform for Disaster Risk Reduction 2019 and powered by MapX	The geospatial tool overlays global data sets on ecosystem distribution and hazard exposure, with the aim of highlighting ecosystem restoration and protection opportunities areas for disaster risk reduction.
Natural Climate Solutions Carbon Mapper, by Nature4Climate Partnership	The Carbon Mapper provides information for Parties to understand better the mitigation potential from land use in relation to Nationally Determined Contributions. The estimates provide a starting point for initial engagement and for further in-depth accounting by countries.
Guidance	

Emerging lessons for mainstreaming Ecosystem-based Adaptation: Strategic entry points and processes, by GIZ	The report identifies potential entry points for mainstreaming ecosystem-based adaptation into policies and planning, based on 16 case studies from Mexico, Peru, South Africa, Philippines and Vietnam.
Monitoring and evaluation	
Guidebook for Monitoring and Evaluating Ecosystem-Based Adaptation Interventions (to be published October/November 2019), by UNEP WCMC, GIZ and the Friends of Ecosystem-based Adaptation (FEBA).	The guidebook will provide an overview of the process needed for designing and implementing effective monitoring and evaluation for EbA interventions.
Nature-based solutions in Nationally Determined Contributions	
Nature-based solutions in nationally determined contributions: synthesis and recommendations for enhancing climate ambition and action by 2020, September 2019, by IUCN and the University of Oxford.	The report presents an overview of the current level of ambition for nature within NDCs, and highlights what can be done further to fully harness the potential of nature-based solutions in global climate action going forward.
NDC Partnership's Knowledge Portal, by the NDC Partnership	The Knowledge Portal provides free online access to data, tools, guidance, case studies, and funding opportunities for climate action. The Portal also provides information on potential alignment between the targets, actions, policy measures and needs in countries' NDCs and the targets of the Sustainable Development Goals, as well as a Good Practice Database.
Sourcebooks	
Disaster and Ecosystem: resilience in a changing climate sourcebook, 2019, by UNEP	The sourcebook aims to explain the importance of ecosystems and their management for disaster risk reduction and climate change adaptation, and provide guidance and tools to plan and implement ecosystem-based approaches to climate change adaptation and disaster risk reduction.
Financing nature-based solutions	
Investing in nature: financing conservation and nature-based solutions: A practical guide for Europe, by the European Investment Bank and the European Commission	The guide presents a seven-step guide to financing conservation and nature-based solutions projects in Europe, as well as examples of projects and how to assess finance from the European Investment Bank's Natural Capital Financing Facility and elsewhere.

C. Complementary information on pathways to achieve the 2050 Vision of "Living in Harmony with Nature"

149. Pathways to achieve the 2050 Vision of "Living in Harmony with Nature" will need to include ambitious climate change mitigation measures. Conversely, pathways to achieve the climate objectives will need to elevate biodiversity considerations and acknowledge the mutual benefits gained from the conservation and sustainable use of biodiversity. Many scenarios that limit global warming to below 2°C or 1.5°C rely on large-scale bioenergy with carbon capture and storage, with potential risks for

biodiversity. Pathways designed to achieve multiple benefits should favour approaches that protect, restore and sustainably manage ecosystems.

150. A recent study[124] provided an assessment of land-based activities (agriculture, bioenergy, land use, land-use change, and forestry), and their potential contributions to the Paris Agreement temperature target of 1.5°C. The authors of the study also conducted four complementary analyses, including a roadmap of priority mitigation actions to fulfil the 1.5 °C land-sector transformation pathway by 2050. The roadmap was designed to not only meet the targets of the Paris Agreement, but also deliver on other international commitments including the Sustainable Development Goals, the New York Declaration on Forests, and the Aichi Biodiversity Targets.

151. The roadmap acknowledges that land interventions have interlinked implications for climate mitigation, adaptation, food security, biodiversity and other ecosystem services, and seeks to avoid undesirable impacts from larger-scale deployment of bioenergy with carbon capture and storage (BECCS). The roadmap relies on deeper emissions reductions from lifestyle changes such as reducing food waste and shifting diets, and on higher removals from ecosystem-based sequestration including forest, peatland and coastal mangrove restoration, forest management and agricultural soils, which enhance essential ecosystem services, while delivering economic, environmental and health co-benefits.

152. The study calls for better incorporation of environmental and social safeguards in integrated assessment models and scenario setting, taking into account potential impacts associated with largescale deployment of BECCS on natural ecosystems and agricultural land. It also suggests that increased dialogue between scientists and policymakers is important for bridging the knowledge gap and to catalyse political action. It also recognizes the limitations and barriers to the implementation of these activities, such as political inertia, governance issues and lack of finance.

153. The IPBES global assessment on biodiversity and ecosystem services, in its Chapter 5 on pathways towards a sustainable future, also provides information on potential pathways towards successfully achieving the Paris Agreement, the Aichi Biodiversity Targets, and the Sustainable Development Goals.

154. The report identifies the common factors of sustainable pathways that contribute to the achievement of the seven nature-based Sustainable Development Goals (SDGs 2, 3, 6, 11, 13, 14 and 15). These key elements include: (a) safeguarding remaining natural habitats on land and sea by strengthening, consolidating and expanding protected areas and their integration with surrounding land uses, (b) undertaking large-scale restoration of degraded habitats, and (c) integrating these activities with development through sustainable planning and management of landscapes and seascapes so that they contribute to meet human needs including food, fibre, water and energy security, while continually reducing pressure on natural habitats[125].

[124] Roe et al. (2019)
[125] IPBES GA 5.3.3

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