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CASE-STUDIES AND APPROACHES LINKING BIODIVERSITY AND CLIMATE CHANGE-RELATED RISKS AND VULNERABILITIES

Note by the Executive Secretary

I. INTRODUCTION

1. The following document was developed in order to facilitate consideration of two of the items in the terms of reference of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change: (i) identifying case-studies and general principles to guide local and regional activities aimed at reducing risks to biodiversity values associated with climate change; and (ii) identifying ways that components of biodiversity can reduce risk and damage associated with climate change impacts.

Defining risk and vulnerability

2. According to the International Strategy for Disaster Reduction (ISDR), risk is defined as:

> "The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions. Conventionally risk is expressed by the notation Risk = Hazards x Vulnerability."1/

3. Risk is also described as a function of exposure to hazards defined by ISDR as:

> "A potentially damaging physical event, phenomenon or human activity, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation."

4. The United Nations Framework Convention on Climate Change, in its glossary of terms, defines vulnerability in the context of climate change as:

> "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity."2/

1/ Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR), 2004. Living with Risk: global review of disaster reduction initiatives 2004 version.

2/ http://unfccc.int/essential_background/glossary/items/3666.php

/…

Definition of associated concepts

5. Resilience is defined as the capacity of an ecosystem to return to the pre-condition state following perturbation, maintaining its essential functions and structures. 3/, 4/ This "resilience" is an emergent property of ecosystems that is conferred at multiple scales by genes, species, functional groups, and processes within the system. 5/, 6/ Resistance, which refers to the capacity of the ecosystem to absorb disturbances and remain unchanged; and stability, which is the capacity of an ecosystem to remain more or less in the same state within bounds, that is, to maintain a dynamic equilibrium.

II. CLIMATE CHANGE RELATED RISKS AND VULNERABILITIES

6. The amount of risk that a given area faces is influenced by both physical and socio-cultural aspects of vulnerability. When considering biodiversity, vulnerability is expressed not only in terms of individual genes or species but also in terms of assemblages of species and their functional roles within a given ecosystem including their cultural and economic uses.

7. A number of vulnerability assessments have been undertaken on biodiversity and climate change, and the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) summarized these findings in identifying the following vulnerable ecosystems:

- Wetlands in prairies;
- Wetlands in arid lands;
- Temperate grasslands and prairies;
- Mediterranean forests, woodlands and scrub;
- Montane grasslands and shrublands;
- Mangroves;
- Tropical forests;
- Boreal forests/taiga;
- Small island developing States;
- Arctic islands;
- Peatlands;
- Mangroves; and
- Coral reefs.

Creating new risk and vulnerability

8. As risk is a function of vulnerability, exposure to hazards and the capacity to respond, climate change is creating new risks for biodiversity by placing additional pressures on species (thus increasing vulnerability), increasing the frequency and intensity of extreme weather events and hazards such as fire (thus increasing exposure to hazards) and pushing some species beyond their natural adaptive capacity (thus exceeding the capacity to respond).

3/ Holling, C.S. 1973. *Resilience and stability of ecological systems.* Ann. Rev. Ecol. Syst. 4: 1-13.

4/ Walker, B. 1995. *Conserving biological diversity through ecosystem resilience*. Conserv. Biol. 9: 747-752.

5/ Gunderson, L.H. 2000. *Ecological resilience – in theory and application*. Ann. Rev. Ecol. Syst. 31: 425-439.

6/ Drever, C.R., G. Peterson, C. Messier, Y. Bergeron, and M. Flannigan. 2006. *Can forest management based on natural disturbances maintain ecological resilience?* Can. Jour, For. Res. 36: 2285-2299.

9. A key climate-change-related risk for biodiversity is dramatic change in state (form and function) within an ecosystem if resilience has been overcome. Risks that emerge from such a process include a reduction in the ability of the ecosystem to deliver goods and services, and the replacement of the original ecosystem with a new ecosystem which is highly resilient to change, making it difficult or impossible to recover the original flow of goods and services valued by local societies.

10. Some of the physical impacts of climate change that are exposing biodiversity to new vulnerabilities were identified by the first meeting of the second AHTEG on biodiversity and climate change which finalized the main points as follows:

(a) Changes in the climate and in atmospheric carbon dioxide levels have already had observed impacts on natural ecosystems and species. Some species and ecosystems are demonstrating some capacity for natural adaptation, but others are already showing negative impacts under current levels of climate change, which is modest compared to most future projected changes;

(b) Climate change is projected to increase species extinction rates, with approximately 10 per cent of the species assessed so far at an increasingly high risk of extinction for every 1^0C rise in global mean surface temperature within the range of future scenarios typically modelled in impact assessments (usually $<5^0$C global temperature rise);

(c) Projections of the future impacts of climate change on biodiversity have identified wetlands, mangroves, coral reefs, Arctic ecosystems and cloud forests as being particularly vulnerable. In the absence of strong mitigation action, there is the possibility that some cloud forests and coral reefs would cease to function in their current forms within a few decades;

(d) Further climate change will have predominantly adverse impacts on many ecosystems and their services essential for human well-being, including the potential sequestration and storage of carbon, with significant adverse economic consequences, including the loss of natural capital;

(e) Enhancing natural adaptation of biodiversity through conservation and management strategies to maintain and enhance biodiversity can reduce some of the negative impacts from climate change and contribute to climate change mitigation by preserving carbon sequestration and other key functions; however there are levels of climate change for which natural adaptation will become increasingly difficult.

Exacerbating existing risks

11. The impacts associated with a changing climate, combined with other stressors such as land use and pollution, challenge the ability of ecosystems to adapt. The alterations in ecosystems as a result of climate change provide opportunities for other negative phenomena to occur. As such, in addition to creating new risk and vulnerability, the above impacts of climate change are also serving to exacerbate existing risks to biodiversity as identified in the Millennium Ecosystem Assessment in table 1 below. 7/ In fact, in the United States, a vulnerability assessment by the National Forest Service revealed that climate change will exacerbate the impacts of wildfires, invasive alien species, extreme weather events, and air pollution within forest ecosystems. 8/

7/ Ecosystems and Human Well Being: Biodiversity Synthesis. Millennium Ecosystem Assessment, 2005.

8/ National Forests. In: *Preliminary review of adaptation options for climate-sensitive ecosystems and resources.* A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Joyce, L.A., G.M. Blate, J.S. Littell, S.G. McNulty, C.I. Millar, S.C. Moser, R.P. Neilson, K. O'Halloran, and D.L. Peterson. U.S. Environmental Protection Agency, Washington, DC, USA, 2008

Table 1: Drivers of Biodiversity Loss (Millennium Ecosystem Assessment Biodiversity Synthesis, 2007)

		Habitat change	Climate change	Invasive species	Over-exploitation	Pollution (nitrogen, phosphorus)
Forest	Boreal	↗ (Low)	↑ (Low)	↗ (Low)	→ (Low)	↑ (Moderate)
	Temperate	↘ (High)	↑ (Low)	↑ (Low)	→ (Moderate)	↑ (Moderate)
	Tropical	↑ (Very high)	↑ (Low)	↑ (Low)	↗ (High)	↑ (Low)
Dryland	Temperate grassland	↗ (Very high)	↑ (Low)	→ (Moderate)	→ (Low)	↑ (Very high)
	Mediterranean	↗ (High)	↑ (Low)	↑ (High)	→ (Moderate)	↑ (Low)
	Tropical grassland and savanna	↗ (High)	↑ (Moderate)	↑ (Low)	→ (Very high)	↑ (Moderate)
	Desert	→ (Low)	↑ (Moderate)	→ (Moderate)	→ (Low)	↑ (Low)
Inland water		↑ (Very high)	↑ (Low)	↑ (High)	→ (Moderate)	↑ (Very high)
Coastal		↗ (Very high)	↑ (Moderate)	↗ (High)	↗ (High)	↑ (Very high)
Marine		↑ (Moderate)	↑ (Low)	→ (Low)	↗ (Very high)	↑ (Low)
Island		→ (High)	↑ (Low)	→ (Very high)	→ (High)	↑ (Low)
Mountain		→ (High)	↑ (Moderate)	→ (Low)	→ (Low)	↑ (Low)
Polar		↗ (Low)	↑ (High)	→ (Low)	↗ (Moderate)	↑ (Moderate)

Driver's impact on biodiversity over the last century	Driver's current trends
Low	↘ Decreasing impact
Moderate	→ Continuing impact
High	↗ Increasing impact
Very high	↑ Very rapid increase of the impact

Source: Millennium Ecosystem Assessment

12. Perhaps the most striking example of the exacerbating function of climate change on existing risks to biodiversity is linked to invasive alien species. In particular, the species that are most likely to survive changes in the climate are those with short life-cycles that can adapt quickly and those that are readily dispersed - common characteristics of most weed species and insects. Changes in temperature, rainfall patterns and extreme events often favour invasive species.

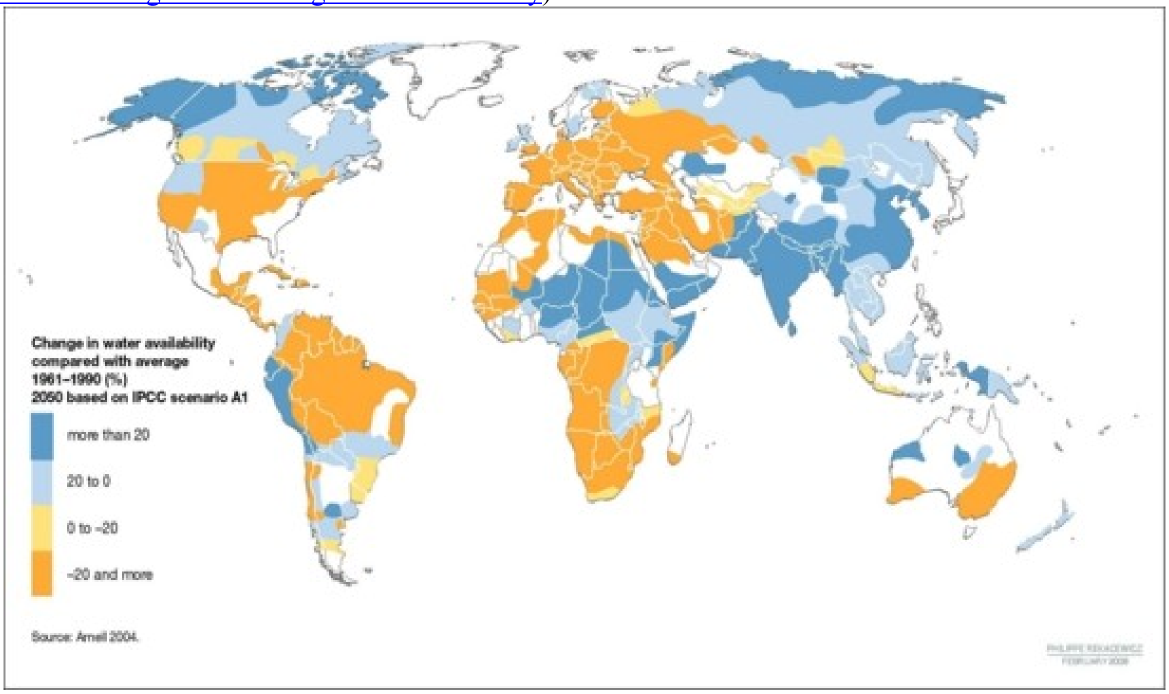
13. Already, in Canada, rising temperatures have allowed the mountain pine beetle to extend its range into the higher elevations where whitebark pine (*Pinus albicaulis*) thrives and east into the boreal forest where jack pine (*Pinus banksiana*) may also be susceptible. It is estimated that, at the current rate of spread, 80 per cent of the mature pine in British Columbia will be dead by 2013. 9/ Elsewhere, on Macquarie Island (south of Australia and New Zealand), rabbits are benefiting from a milder climate. The survival rate of rabbit kittens born in winter has increased, not only because temperatures are higher but also because there is less snow to melt to flood burrows. They are now removing large areas of vegetation, threatening the entire island ecosystem. 10/

9/ British Columbia Mountain Pine Beetle Program http://mpb.cfs.nrcan.gc.ca/index_e.html

10/ Climate Change and Invasive Species. A Review of Interactions. November 2006, Workshop Report. http://www.environment.gov.au/biodiversity/publications/pubs/interactions-cc-invasive.pdf

14. A similar trend can be expected when considering the impacts of climate change on risks to biodiversity associated with over-exploitation. One such example of the exacerbating nature of climate change is related to the significant impacts of climate change on water availability as indicated in figure 1 below. 11/ When considering that 54 per cent of accessible runoff is already appropriated for anthropogenic use, 12/ declining water availability in desert margins and dryland areas, such as North Africa, the Mediterranean and south-eastern Australia, will likely result in the increased exploitation of aquifers, inland waters and oasis. This increased exploitation will have negative impacts on some riparian systems which is particularly worrying considering that 25 per cent of the estimated 10,000 freshwater species are already threatened, endangered or extinct.

Figure 1: Projected Changes in Water Availability (http://maps.grida.no/go/graphic/the-contribution-of-climate-change-to-declining-water-availability)



15. Additional examples of climate change exacerbating other risks to biodiversity include:

- *Polar bears:* the average weight of female polar bears in Northern Canada has been decreasing as a result of climate change impacts on sea ice and food availability. At the same time, increased exposure to toxic substances carried to the region on ocean currents is reducing reproductive success.
- *Corals*: coral reefs are increasingly exposed to bleaching events which are causing die-backs which, in some areas, may become annual events. At the same time, nutrient loading as a result of land-based pollution has been shown to slow reproductive rates in corals. 13/

11/ The contribution of climate change to declining water availability, http://maps.grida.no/go/graphic/the-contribution-of-climate-change-to-declining-water-availability.

12/ Threats to Rivers, Lakes and Wetlands. WWF, http://www.panda.org/about_our_earth/about_freshwater/freshwater_problems/

13/ *'ENCORE: the effect of nutrient enrichment on coral reefs; synthesis of results and conclusions*. 'Koop, K, Booth, D, Broadbent, AD, Brodie, J, Bucher, D, Capone, D, Coll, J, Dennison, W, Erdmann, M, Harrison, P, Hutchings, O, Jones, GB, Larkum, AW, O'Neil, J, Steven, A, Tentori, E, Ward, A, WIlliamson, J & Yellowlees, D 2001, *Marine Pollution Bulletin*, vol. 42, no. 2, pp. 91-120.

- *Protea*: 30 – 40 per cent of the Protea species in the Cape Floristic Region are projected to become extinct as a result of climate change. 14/ At the same time, destruction of protea habitat as a result of the expansion of agriculture in areas throughout the Western Cape Province is accelerating.

III. MANAGING BIODIVERSITY IN THE FACE OF VULNERABILITY AND RISK

Findings of the first AHTEG on biodiversity and climate change

16. The first AHTEG on biodiversity and climate change identified a number of tools that can be employed in order to manage biodiversity in the face of climate change related vulnerability and risk. These are available in CBD Technical Series Nos. 10 and 25 and include: environmental impact assessments, strategic environmental assessments and decision analytic frameworks.

17. The first AHTEG also recognized the importance of applying the ecosystem approach when reducing climate change related risks to biodiversity including the following 12 principles:

(a) The objectives of management of land, water and living resources are a matter of societal choice.

(b) Management should be decentralized to the lowest appropriate level.

(c) Ecosystem managers should consider the effects (actual and potential) of their activities on adjacent and other ecosystems.

(d) Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context.

(e) Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.

(f) Ecosystems must be managed within the limits of their functioning.

(g) The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.

(h) Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.

(i) Management must recognize that change is inevitable.

(j) The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.

(k) The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.

(l) The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

Other relevant guidance

18. In addition to the guidance developed by the first AHTEG, the Conference of the Parties, through decision IX/16, urged Parties to enhance the integration of climate change within implementation of the Convention including through an initial list of ten possible actions.

14/ C.D. Thomas et al., 2004, Extinction risk from climate change, *Nature*, vol. 427, proof pages 145-148.

19. Furthermore, at the regional level, the South Pacific Regional Environment Programme (SPREP) has published a Guide to Community Vulnerability and Adaptation Assessment and Action 15/ comprised of six steps:

(a) *Adaptation context phase*: Define the policy framework that will guide work including linking community and national planning processes;

(b) *Diagnostic phase*: Identify the risks associated with the climate change impacts including through the participatory learning-by-doing (hands-on) approach;

(c) *Assessment and evaluation phase:* Assess the causal relationships between the risks they are facing (now *and possibly in the future)*;

(d) *Development phase*: Develop possible solutions to the challenges/problems identified and their benefits (opportunities) or constraints;

(e) *Implementation phase*: Actual 'action or undertaking' of solutions that have been identified and evaluated during the diagnostic and evaluation process;

(f) *Monitoring phase*: Ongoing monitoring and evaluation on the progress of actions undertaken at community level throughout the project.

20. With regard to the above, some of the main considerations for identifying and managing climate-change related risks to biodiversity include: identifying vulnerability, assessing threats and likely impacts, developing monitoring and modelling programmes, and enhancing the integration of biodiversity considerations such as resilience within climate change responses. The AHTEG may wish to consider the above points within the framework of (i) building knowledge on risks and vulnerabilities; and (ii) ways and means to reduce risks and vulnerabilities.

Building knowledge on climate change related risks and vulnerabilities

21. Some species are more vulnerable than others to the impacts of climate change. Characteristics that have been linked to higher vulnerability include:

(a) Species with restricted ranges, especially alpine species

(b) Species at the limit of their environmental tolerances

(c) Long-lived/slow maturing species

(d) Species congregating in large groups at certain life stages (e.g. breeding or migrating)

(e) Species with limited dispersal capacities

(f) Species with temperature or precipitation determined phenological traits

22. Many Parties have also developed national guidelines for risk and vulnerability assessments.

(a) The United Kingdom Department for Environment, Food and Rural Affairs, for example, has published guidelines for environmental risk assessments 16/ which recommend an analysis of the following:

(i) What impacts to the environment may occur?

(ii) How harmful are these impacts to the environment?

(iii) How likely is it that these impacts will occur?

15/ Guide to Community Vulnerability and Adaptation Assessment and Action. SPREP. http://www.sprep.org/att/publication/000437_cvaguidee.pdf

16/ Guidelines for Environmental Risk Assessment and Management. United Kingdom Department for Environment, Food and Rural Affairs. http://www.defra.gov.uk/ENVIRONMENT/risk/eramguide/05.htm

(iv) How frequently and where will these impacts occur?

(v) How much confidence can be placed in the results of the risk assessment?

(vi) What are the critical data gaps and can these gaps be filled?

(vii) Are further iterations to the risk assessment needed?

(b) The Government of Australia, in its assessment of climate change risk and vulnerability, identified five vulnerability criteria in its framework criteria¨17/

(i) Exposure

(ii) Sensitivity

(iii) Adaptive capacity

(iv) Adverse implications

(v) Potential to benefit from planning

(c) The European Union ALARM 18/ project framework for assessing risk includes:

(i) *Hazard identification*: The aim is to identify impacts and should be considered for risk analysis in relation to the identified risk area;

(ii) *Risk assessment*: This is the characterization of risk based on an evaluation of the evidence to estimate the likelihood and consequences of an adverse event, and the associated uncertainty. Risk assessment is split into three interrelated steps:

- Species categorization
- Assessment of the probability of impacts
- Assessment of potential economic consequences (including environmental impacts)

(iii) *Risk_management* refers to the analytical process used to identify risk mitigation options and evaluate these for efficacy, feasibility and impacts in order to decide or recommend the most appropriate means to mitigate risks that are found to be unacceptable as a result of risk. The uncertainty noted in the assessments of economic consequences and probability of introduction are also considered and included in the selection of a pest management option;

(iv) *Risk communication*: The final step is to communicate findings in terms that are clear to all stakeholders. This final step is a critical one as it ensures that all parties understand the scientific and regulatory bases for the recommendations.

23. Regardless of the model selected, in order to manage climate change related risks and vulnerabilities, it is first important to identify where such risks and vulnerabilities exist. Drawing on the principles of the ecosystem approach, the AHTEG may wish to consider the following guidance:

(a) Vulnerability should be viewed as a function not just of direct impacts on the ecosystem or species being assessed, but also of impacts on adjacent ecosystems or associated species;

(b) Vulnerability assessments should include an analysis of biodiversity-based livelihoods and alternative livelihood options in order to consider the link between biodiversity and economics;

17/ Climate Change Risk and Vulnerability: Promoting an Efficient Adaptation Response in Australia. Australia Department of the Environment and Heritage. http://www.climatechange.gov.au/impacts/publications/pubs/risk-vulnerability.pdf

18/ http://www.alarmproject.net

(c) Vulnerability should be evaluated within the framework of ecosystem resilience and resistance;

(d) Vulnerability within ecosystems may relate to thresholds that once exceeded will result in change in state;

(e) Vulnerability should be viewed as changing over time;

(f) Vulnerability should be assessed using all forms of relevant information, including indigenous and local knowledge, innovations and practices;

(g) Vulnerability should consider not just physical aspects of vulnerability but also social and cultural aspects.

24. Furthermore, with regards to assessing risk, an analysis of impact assessment studies has revealed the following good practices:

(a) Identify risks over short (0-5 years), medium (5-20 years) and long (>20 years) terms;

(b) Use a one meter sea level rise scenario for coastal vulnerability assessments in order to build in a precautionary margin of error (IPCC);

(c) Consider a full range of scenarios in order to assign different levels of certainty and likelihood to impact assessments;

(d) Clearly define what is known and unknown including consideration of the certainty of each impact or occurrence;

(e) Conduct assessments in order to identify ‘no regrets’ strategies;

(f) Plan for periodic reviews and reassessments of risks and vulnerabilities;

(g) Identify interactions which may diminish or exacerbate risk and vulnerability;

(h) Stakeholder involvement can increase the quality of research and responses;

(i) Build assessments from existing regional and global research programmes on biodiversity – climate interactions.

IV. WAYS AND MEANS TO REDUCE CLIMATE CHANGE RELATED RISKS AND VULNERABILITIES

Climate-change mitigation

25. The clearest way to reduce climate change related risks and vulnerabilities is to limit greenhouse-gas emissions. In doing so, temperature increases and other associated impacts will be minimized, thereby reducing exposure to risk.

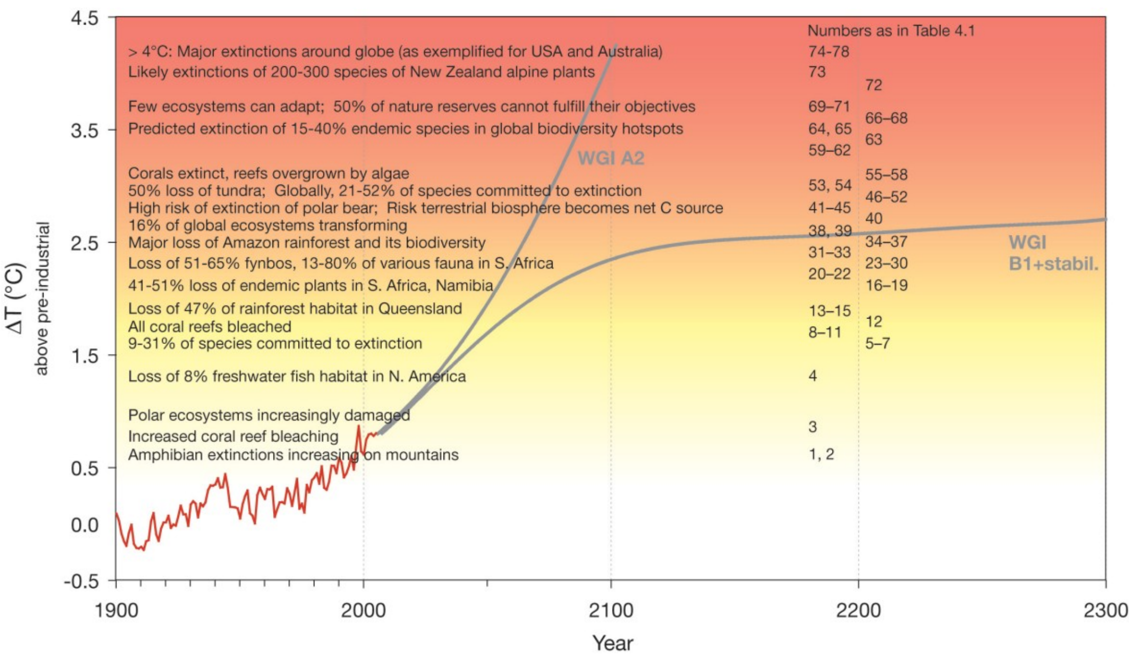
26. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) examined the predicted impacts of different climate change scenarios on biodiversity as presented in figure 2 below. 19/ In the figure below, the A2 scenario refers to a world in which the global economy differentiates into a series of regional economies with uneven economic growth. In the A2 scenario population growth is high and global average GDP per capita is low. The B1 scenario, on the other hand, assumes growth with a high level of environmental consciousness and a strong emphasis on sustainable development. The B1 scenario assumes the development of new technologies, however it does not consider any climate change policies. 20/

19/ Working Group II Report – Impacts, Adaptation and Vulnerability. Intergovernmental Panel on Climate Change. 2008. http://www.ipcc.ch/ipccreports/ar4-wg2.htm

20/ Special Report on Emissions Scenarios. Nakicenovic, N. and R. Swart. Intergovernmental Panel on Climate Change. 2000. http://www.ipcc.ch/ipccreports/sres/emission/index.htm

27. With regards to reducing risks and vulnerability as a result of climate change, it is important that any mitigation measures adopted consider not only the impacts on greenhouse gas emissions, but also potential impacts on biodiversity. Such considerations can be captured through, *inter alia¸* strategic environmental impact assessments and the adoption of the ecosystem approach.

Figure 2: Projected Impacts of Climate Change on Biodiversity under Different Emission Scenarios (IPCC Fourth Assessment Report – Working Group II)



Reduce other threats to biodiversity

28. As indicated in table 1 above, climate change is only one driver of biodiversity loss. Overall risk to biodiversity is, therefore, not only a function of vulnerability and exposure to hazards related to climate change, but also a function of the impacts of other drivers such as habitat change, invasive alien species and over-exploitation and their interactions. One way to reduce climate change related risks and vulnerabilities is, therefore, to reduce other threats to biodiversity so as to maximize ecosystem resilience and natural adaptive capacity.

29. In fact, such an approach has already been adopted by a number of risk management programmes. The vulnerability assessment of the Great Barrier Reef, for example, acknowledges that corals that are exposed to pollutants and sedimentation are more vulnerable to bleaching and are, in fact, less able to survive a bleaching episode. Accordingly, management responses to reduce risk include: reduce stress from water pollution, protect biodiversity, protect key functional groups, and protect refugia. 21/

Expand networks of protected areas and corridors

30. The proper management of existing protected areas and the expansion of networks of protected areas and corridors can help reduce the risk and vulnerability of biodiversity to climate change. Protected areas usually designated primarily for the purpose of biodiversity conservation, but they also serve as important elements of climate change adaptation. By conserving unbroken blocks of intact habitat and restoring degraded ecosystems, protected areas can increase the resilience of ecosystems to climate

21/ *Climate Change and the Great Barrier Reef: A Vulnerability Assessment*. Johnson, J.E. and P.A. Marshall. Great Barrier Reef Marine Park Authority and Australian Greenhouse Office. 2007 change since ecosystems with high biodiversity and intact structural components are believed to recover more easily from climatic disturbances, in part because of the functional redundancy in intact systems. 22/

31. Protected areas, particularly corridors, have an important role to play in providing habitat to facilitate population shifts and migrations, maximizing the natural adaptive capacity of biodiversity. Protected areas also often act as important barriers for land conversion and other threats to biodiversity.

32. The programme of work on protected areas of the Convention on Biological Diversity calls for a complete protected-area-system gap analysis at national and regional levels based on the requirements for representative systems of protected areas that adequately and comprehensively conserve terrestrial, marine and inland water biodiversity. A gap analysis is an assessment of the extent to which a protected area system meets protection goals set by a nation or region to represent its biological diversity. Gap analyses should take into account criteria such as irreplaceability of target biodiversity components, minimum effective size and viability requirements, species migration requirements, integrity, ecological processes and ecosystem services. 23/ Furthermore, in decision IX/20 on marine and coastal biodiversity, the Conference of the Parties to the Convention on Biological Diversity adopted scientific criteria for identifying ecologically or biologically significant marine areas in need of protection, and scientific guidance for designing representative networks of marine protected areas.

33. Through their national gap analyses, countries identify high-priority sites to expand or improve the protected area system and network, often taking into account future effects of climate change to improve adaptation. Protection of these areas can maximize biodiversity conservation, while also securing key ecosystem services and supporting sustainable livelihoods. Protected areas provide a cost-effective opportunity for adaptation, as sites are already established, some infrastructure is in place, some analysis is completed, and the local communities have awareness of the protection.

34. Some countries have included protected areas in their national adaptation plans and strategies. In Samoa, the identification of priority conservation areas is included in their national adaptation plan of ction (NAPA) to ensure there is sufficient habitat which will provide refuges for species threatened by climate change. 24/ The Gambia, Sierra Leone and Burundi, have included the establishment, expansion or strengthened management of terrestrial protected areas as an adaptation activity in their NAPA. 25/

Ex situ conservation

35. In extreme cases, where species are unable to adapt to climate change even with active management, *ex situ* conservation may be necessary. Plant Genetic Resources of Canada, for example, has already expanded its *ex situ* collections to include wild plant species that are threatened by climate change. 26/ With regards to the conservation of forest genetic resources, *ex situ* conservation is appropriate when considering species that are rare, grow only in small patches, face significant other threats or for which regeneration is uncertain. 27/

36. The Gran Canaria Declaration II highlights some specific actions related to *ex situ* conservation as a tool to reduce climate change – related risks including:

(a) Conduct an audit of existing *ex situ* collections;

22/ Mulongoy, K.J. and S.B. Gidda (2008). *The Value of Nature: Ecological, Economic, Cultural and Social Benefits of Protected Areas*. Secretariat of the Convention on Biological Diversity, Montreal, 30 pages. https://www.cbd.int/doc/publications/cbd-value-nature-en.pdf

23/ Ecological Gap Analysis. Secretariat of the Convention on Biological Diversity. https://www.cbd.int/protected/gap.shtml

24/ National Adaptation Programme of Action. Samoa. http://unfccc.int/resource/docs/napa/sam01.pdf

25/ National Adaptation Programmes of Action received by the Secretariat of the UNFCCC. http://unfccc.int/cooperation_support/least_developed_countries_portal/submitted_napas/items/4585.php

26/ Agriculture and Agri-Food Canada. Plant Gene Resources of Canada. http://pgrc3.agr.gc.ca/wildplant.pdf

27/ Climate Change and Forest Genetic Diversity: Implications for sustainable forest management in Europe. Koskela, J., A. Buck and E. Teissier du Cros. 2007

(b) Establish a global network of *ex situ* conservation centres; and

(c) Conduct a gap analysis of *ex situ* conservation actions. 28/

V. USING BIODIVERSITY TO REDUCE RISK AND DAMAGE ASSOCIATED WITH CLIMATE CHANGE

37. In addition to having negative impacts on biodiversity, climate change is also expected to affect issues such as health, livelihoods, food security, development, infrastructure and social and cultural values. The conservation and sustainable use of biodiversity and the equitable sharing of benefits from the use of biodiversity resources can contribute to reducing risks and damages from climate change by reducing exposure to risk, limiting the impact of hazards and enhancing the adaptive capacity of physical, social and economic systems.

38. Furthermore, since many biodiversity-management strategies employ an integrated, multi-sector approach, such management frameworks may be well positioned to incorporate risk reduction strategies into broader climate change adaptation plans. 29/

Limiting the impacts of hazards

39. The conservation and sustainable use of biodiversity can act as a buffer against hazards such as floods and drought. Examples include the following:

(a) The conservation and restoration of wetlands, for example, has already been identified as an important hazard management strategy in the face of climate change. 30/ Not only can such actions be more cost effective than traditional engineering responses but also provide substantial benefits in terms of the provision of goods, increased resilience and an improved aesthetic and cultural environment;

(b) In Samoa, the replanting of mangroves is an integral part of a large restoration project to enhance food security and protect local communities from storm surges which are expected to increase as a result of climate change; 31/

(c) The conservation and sustainable use of biodiversity also feature drought-management strategies including through actions such as maintaining the genetic diversity of indigenous livestock and crops and through the conservation of forests which act as micro-climates. 32/

Enhancing adaptive capacity

40. Intact ecosystems, with natural levels of genetic, species and functional diversity, are, in most cases, more capable of adapting to climate change than impoverished systems. This is because of the redundancy within systems, where some species may become increasingly important because of their tolerance to the new climatic conditions, and because of the genetic capacity within species enabling them to adapt to the changes. Therefore, maintaining intact and connected systems (as opposed to impoverished systems in isolated remnants) will be important for the possibility of continued flows of ecosystem goods and services as the climate changes.

28/ Gran Canaria Declaration II on Climate Change and Plant Conservation. http://www.bgci.org/files/All/Key_Publications/gcdccenglish.pdf

29/ Environmental Degradation and Disaster Risk. ISDR, 2004.

30/ European Water Directive. European Commission, 2000. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:327:0001:0072:EN:PDF

31/ Community Based Adaptation: Samoa. UNDP, 2008. http://sdnhq.undp.org/gef-adaptation/projects/websites/index.php?option=com_content&task=view&id=252&sub=1

32/ Drought Management Considerations for Climate Change Adaptation: Focus on the Mekong Region. Oxfam Cambodia and Graduate School of Global Environmental Studies of Kyoto University, Japan.

41. The conservation and sustainable use of biodiversity can contribute to enhanced ecosystem resilience. This, in turn, increases the adaptive capacity of ecosystems including associated ecosystem services which may be critical for food security and livelihoods. The United Republic of Tanzania, for example, identified eight projects within its National Adaptation Programme of Action (NAPA) that have a direct or indirect link to biodiversity and ecosystem services including: catchment conservation and sustainable use, forest-fire prevention and wildlife extension services. 33/

33/ National Adaptation Programme of Action for Tanzania. Division of Environment, 2006.