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IN-DEPTH REVIEW OF THE WORK ON BIODIVERSITY AND CLIMATE CHANGE

Addendum

INTEGRATION OF CLIMATE CHANGE IMPACTS AND RESPONSE ACTIVITIES WITHIN THE PROGRAMME OF WORK ON THE BIODIVERSITY OF DRY AND SUB-HUMID LANDS

Note by the Executive Secretary

EXECUTIVE SUMMARY

In paragraph 10 of decision IX/17, the Conference of the Parties requested the Executive Secretary, in collaboration with the Secretariat of the United Nations Convention to Combat Desertification, to develop proposals for the integration of climate change considerations within the programme of work on the biodiversity of dry and sub-humid lands, for consideration by the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) prior to the tenth meeting of the Conference of the Parties, building on the elements of the guidance contained in decision IX/16 on climate change and biodiversity.

The programme of work on the biodiversity of dry and sub-humid lands adopted in decision V/23 does not contain any specific activities addressing climate change, except target 7.1 of the framework for monitoring implementation of the achievement of the 2010 target in dry and sub-humid lands (in decision VIII/2 and annex IV of decision VIII/15) that states that resilience of the components of biodiversity to adapt to climate change in dry and sub-humid lands should be maintained and enhanced by 2010. Implementation of this target has thus far been limited within dry and sub-humid lands as a result of a lack of knowledge on the observed and projected impacts of climate change on biodiversity, lack of public awareness on the importance of the links between biodiversity and climate change and the lack of cross-sector coordination in the management of dry and sub-humid lands. However, there are many local examples of successful adaptation activities, particularly in response to increased frequency and intensity of extreme events such as drought from which lessons learned can be drawn.

Furthermore, an assessment of the adaptation and mitigation activities implemented in dry and sub-humid lands reveals that there are a number of opportunities for win-win scenarios that address climate change while furthering the objectives of the Convention on Biological Diversity. This is particularly the case with regard to the restoration of degraded land, the conservation of plants important

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for health and agriculture and disaster management. In order to fully realize synergies, however, additional information is needed on the mitigation potential of dry and sub-humid lands, especially when considering soil carbon.

SUGGESTED RECOMMENDATIONS

Suggested recommendations can be found in the in-depth review of work on biodiversity and climate change (UNEP/CBD/SBSTTA/14/6).

I. INTRODUCTION

1. Decision IX/16 of the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) on biodiversity and climate change requests the Executive Secretary, when conducting the in-depth review of the programmes of work to integrate climate change considerations where relevant and appropriate considering the following:

(a) The assessment of potential impacts of climate change [*] and both the positive and negative impacts of climate change mitigation and adaptation activities on relevant ecosystems;

(b) The most vulnerable components of biodiversity;

(c) The risks and consequences for ecosystem services and human well-being;

(d) The threats and likely impacts of climate change * and both the positive and negative impacts of climate change mitigation and adaptation activities on biodiversity and the opportunities they provide for the conservation and sustainable use of biodiversity;

(e) Monitoring of the threats and likely impacts of climate change * and both the positive and negative impacts of climate change mitigation and adaptation activities on biodiversity;

(f) Appropriate monitoring and evaluation techniques, related technology transfer and capacity-building support within the programmes of work;

(g) Critical knowledge needed to support implementation, including, *inter alia*, scientific research, availability of data, appropriate measurement and monitoring techniques technology and traditional knowledge;

(h) The ecosystem-approach principles and guidance and the precautionary approach;

(i) The contribution of biodiversity to climate-change adaptation, and measures that enhance the adaptive potential of components of biodiversity.

2. Since the in-depth review of the programme of work on the biodiversity of dry and sub-humid lands was completed before this decision was taken, decision IX/17 requests the Executive Secretary, in collaboration with the Secretariat of the United Nations Convention to Combat Desertification (UNCCD), to develop proposals for the integration of climate change considerations within the programme of work on the biodiversity of dry and sub-humid lands, considering the importance of sustainable forest management and sustainable land management in dry and sub-humid lands and the need to enhance the understanding of the role of dryland forests with relation to climate change.

3. Main sources of information for this study include the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), CBD Technical Series Nos. 10, 25, 41 and 42 and a review of the fourth national reports under the Convention and relevant second, third and fourth national communications under the United Nations Framework Convention on Climate Change.

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

4. Section II highlights the gaps in the integration of climate change impact and response activities in the programme of work on the biodiversity of dry and sub-humid lands. Section III briefly reviews the impacts of climate change and climate change mitigation and adaptation activities on the biodiversity of dry and sub-humid. Section IV contains proposals on the enhanced integration of climate change within the programme of work under the Convention. A draft of this note was posted for comments from 30 November 2009 to 20 December 2009 under notification 2009-156, and comments were incorporated as appropriate.

II. CLIMATE-CHANGE IMPACT AND RESPONSE ACTIVITIES IN THE PROGRAMME OF WORK ON THE BIODIVERISTY OF DRY AND SUB-HUMID LANDS

5. The programme of work on the biodiversity of dry and sub-humid lands is set out in decision V/23. In this decision, climate change is not explicitly mentioned although activity 7 (f) calls for Parties to take due account of better understanding of climate variability in developing effective *in situ* biological conservation strategies.

6. In decisions VIII/2 and VIII/15, the Conference of the Parties adopted a set of goals and targets for the programme of work on the biodiversity of dry and sub-humid lands including target 7.1 to maintain and enhance resilience of the components of biodiversity to adapt to climate change.

A. Assessment of implementation

7. The extent to which Parties have implemented the climate change elements of the programme of work on the biodiversity of dry and sub-humid lands has been assessed based on an analysis of fourth national reports to the Convention on Biological Diversity and second, third and fourth national communications to UNFCCC.

8. Based on an analysis of the 61 Parties who submitted their fourth national reports as of 15 September, 2009, only 12 Parties[2] have reported on climate change activities specifically targeted at the biodiversity of dry and sub-humid lands. This is in spite of the fact that 28 Parties recognized that increased drought associated with climate change may pose a threat to biodiversity including through converting non dry areas to dry or sub-humid lands and through increasing stresses on dry and sub-humid ecosystems.

9. Of the fourth national reports examined, no Party reported on activities specifically within dry forests. Six Parties[3] reported on activities related to climate-change and the biodiversity of dry and sub-humid lands through their National Communications to UNFCCC. Examples of activities reported by Parties include:

(a) Drought monitoring and management programmes;

(b) Climate change adaptation plans in partnerships with herders and rangeland managers;

(c) Development of drought tolerant crops and trees;

(d) Addressing land degradation and desertification to reduce vulnerability to climate change impacts;

(e) Conservation of vulnerable habitats (including through dune fixation, water management in oases and the restoration of degraded lands);

(f) Research on the links between biodiversity, climate change and desertification;

[2] Algeria, Australia, Burundi, Djibouti, Mongolia, Morocco, South Africa, Sudan, the Syrian Arab Republic, Tunisia, Turkmenistan, and Uganda.

[3] The former Yugoslav Republic of Macedonia, Italy, Kazakhstan, Tajikistan, Turkey and Uzbekistan.

(g) Monitoring programmes on the impacts of climate change on the biodiversity of dry and sub-humid lands;

(h) Integration of the impacts of climate change on dryland ecosystems within National Action Programmes under UNCCD; and

(i) Enhanced synergies between the three Rio conventions.

B. Gaps in the integration of climate change impact and response activities in the programme of work on the biodiversity of dry and sub-humid lands

10. In reporting on activities, Parties also identified a number of barriers that are preventing the further implementation of target 7.1 within the programme of work on the biodiversity of dry and sub-humid lands. These include:

(a) Lack of vulnerability and impact assessments covering dry and sub-humid lands (especially savannahs and other tropical grasslands);

(b) Lack of information on the links between climate change, drought and biodiversity in dry and sub-humid lands;

(c) Limited public awareness of the impacts of climate change on the biodiversity of dry and sub-humid lands;

(d) Lack of cross-sector coordination on issues linking climate change and biodiversity (especially with regards to the agriculture sector);

(e) Uncertainty with regards to precipitation modelling.

III. THE IMPACTS OF CLIMATE CHANGE AND CLIMATE CHANGE MITIGATION AND ADAPTATION ACTIVITIES ON THE BIODIVERSITY OF DRY AND SUB-HUMID LANDS

A. Assessment of potential impacts of climate change on biodiversity and dry and sub-humid lands ecosystems

11. Projected impacts of climate change on dry and sub-humid lands include declining species richness in grasslands (especially protected areas) and among mammals in the Mediterranean.[4] In fact, in grasslands, the proportion of threatened mammals may increase by 10 – 40 per cent between 2050 and 2080.[5] Climate change is also expected to restrict the ranges of many species such as endemic species in the Cape Floristic Kingdom. In southern Africa, savannah species are projected to experience restrictions in extent as a result of expanding shrublands.[6]

12. Some components of the biodiversity of dry and sub-humid lands are, however, projected to benefit from climate change. There is some evidence of the expansion of desert ecosystems in the Sahel into the Sudan zone.[7] Models are also predicting a northward expansion of savannah ecosystems into the Amazon forest as a result of changing precipitation patterns.[8]

13. Additional details on impacts are presented below.

1. Increased air temperature

14. The impacts of increased temperatures on the biodiversity of dry and sub-humid lands may be positive or negative depending on the degree of increase, the location and the interactions between

[4] Levinsky et al. 2007
[5] IPCC WG II FAR
[6] Biggs et al. 2008
[7] Wittig et al. 2007
[8] Cook & Vizy 2008;Salazar *et al*. 2007

warming and precipitation. For example, desert reptiles may benefit from warming air temperatures however, this will depend on precipitation. As another example, there is experimental evidence that warming may lead to earlier grass flowering in temperate grasslands, but the actual impacts of increased air temperature are likely to be heavily impacted by rainfall.[9]

15. With extreme temperature increases of between 3.2°C and 4.4°C above pre-industrial levels, some positive impacts are expected for biodiversity in Africa and Southern Hemisphere arid regions. Similar temperature increases are projected to lead to an increase of savannah area by 50 per cent at the expense of forests. In the Californian desert and grassland, expansion is expected at the expense of shrublands if temperatures increase by more that 2°C.

16. However other studies cited in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change show negative impacts on biodiversity at lower temperatures. For example, in the Succulent Karoo region of South Africa, 2,800 plant species face potential extinction if temperatures increase 1.5°C to 2.7°C. The Cape Fynbos biome is projected to lose 65 per cent of its area if temperatures increase by more than 1.8°C with a long-term extinction rate of 23per cent. At the same temperature increase, Southern Europe is expected to lose between 60 and 80 per cent of current species.

2. Increased carbon-dioxide concentrations

17. In dry and sub-humid lands, the impacts of increased carbon-dioxide concentrations are tied closely to temperature and precipitation. Taken alone, carbon-dioxide fertilization may cause increased dominance of tree species over grasses in some areas causing a decrease in grassland areas while a doubling of carbon-dioxide concentration is projected to lead to an increase in wildfire events in California by up to 50 per cent. On the other hand, carbon-dioxide fertilization could increase the resilience of the Sahel.

18. However, when taken in combination with other impacts of climate change, the links between carbon-dioxide fertilization and biodiversity are less clear. For example, C3 grasses will benefit from carbon-dioxide fertilization but suffer because of warming. On the other hand C4 grasses will benefit from warming but will be negatively impacted by carbon-dioxide fertilization. With regards to the relationship between carbon dioxide fertilization and precipitation, carbon-dioxide increases have already increased net primary productivity in Mediterranean landscapes however this increase is expected to be constrained by increased drying.

19. In some cases, there are positive links between increased carbon-dioxide concentrations and increased temperatures. In short grass prairies, carbon-dioxide fertilization combined with temperature increased of 2.6°C increased production by 26 to 47 per cent.

3. Increased instances of extreme weather

20. Dry and sub-humid lands are subject to a number of extreme weather events, with biodiversity being particularly impacted by drought and flood. As a result of climate change extreme drought affected terrestrial areas are projected to increase from the current level of 1 to 30 per cent by 2090. In fact, more intense and longer droughts have already been recorded over wider areas since the 1970s, particularly in the tropics and subtropics. Drought will be exacerbated in some Mediterranean landscapes with projected negative impacts not only directly but also in-directly through increased risks from wildfires.

21. Some species are projected to be able to adapt to increased drought, such as non-succulent shrubs in deserts whereas others, such as leaf succulent species will be highly vulnerable.[10]

4. Changes in precipitation

22. About a third of the Sahel is expected to become drier if temperatures increase by 1.5°C to 2°C by 2050 however some areas are expected to become wetter for the same temperature increases. Since dry and sub-humid lands species are often so well adapted to specific precipitation regimes any change can

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[9] Cleland *et al.* 2006

[10] Musil *et al*. 2005.

have a negative impact. For example, episodic wet periods may increase vulnerability to invasive alien species and plant disease while reduced precipitation is expected to cause a reduction in Sahelian woody plants.[11]

23. Even if total precipitation remains the same, increased variability in terms of the timing will likely result in reduced net primary productivity over the medium to long term. Migratory ungulates and their predators are also vulnerable to reduced summer rainfall even if winter rainfall increases by a comparable amount,

24. With regards to feedbacks between reduced production and precipitation, the removal of all savannahs has a greater impact on global precipitation than any other biome.[12]

5. Secondary impacts

25. Climate change and its impacts on both precipitation and wind patterns is projected to result in an increased risk of erosion within the Kalahari dune systems with warming of between 2.5°C and 3.5°C causing the reactivation of most dune fields by 2100.

26. The impacts of climate change on the biodiversity of dry and sub-humid lands will result in a number of changes that will, themselves, increase threats to biodiversity. For example, a projected invasion by woody plants as a result of changes to temperature and carbon dioxide concentrations will alter the hydrological function, reducing water yield in many cases.

27. Finally, climate change, in combination with other pressures, is expected to result in greater fire frequencies for many dry and sub-humid lands, including most of the Mediterranean Basin.

B. The most vulnerable components of biodiversity[13]

28. Dry and sub-humid ecosystems that have been identified as being particularly vulnerable to the negative impacts of climate change include prairies, remnant grasslands, deserts and desert margins, Mediterranean systems, wetlands in drylands and fynbos. Although few local models are available to assess vulnerability, in China open shrub and desert steppe are among the ecosystems likely to be most severely affected by climate change.[14]

29. In terms of species, as with other ecosystems, species that have limited ranges or that are at the limit of their heat or drought tolerance are expected to be most vulnerable. However, it is difficult to generalize across all dry and sub-humid ecosystems given the varied landscapes and projected impacts. For example, in California and the Cape Floristic Kingdom, lowland plains species are at higher risk than montane species, however in the Mediterranean Basin, montane species are facing higher risks as a result of climate change. With regards to desert ecosystems, species that rely on rainfall events to initiate breeding or migration are expected to face the highest risks from climate change although this may not hold true in those desert areas in which precipitation is expected to increase as a result of climate change.

C. The risks and consequences for ecosystem services and human well-being

30. Climate change is projected to have a number of impacts on the ecosystem services provided by dry and sub-humid lands. For examples, carbon stocks are likely to be reduced in grasslands because of increased disturbances and enhanced soil respiratory losses. Water stress is also projected to cause grasslands to shift from sinks to sources while modelling has suggested that Mediterranean systems will switch from sinks to sources of carbon by 2100, mainly as a result of deteriorating water balance.[15]

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[11] Hobbs *et al.* 2007.

[12] Li *et al.* 2007.

[13] The UNFCCC, 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."

[14] Wu et al. 2007.

[15] Morales *et al.* 2007

31. With regards to provisioning services, climate change is expected to reduce the productivity of many dry and sub-humid lands both annually and seasonally. For example, an accelerated decline in annual groundnut production in West Africa has been associated with climate change, while crop and forage models project large increases in the frequency of rainy season failure. This reduced productivity is expected to result in increasingly scarce, scattered and unpredictable pastures with negative consequences for human well-being among pastoral communities[16] including food insecurity.

32. Declines in populations and diversity of savannah mammals associated with climate change may have further implications for human well-being due to reduced revenues from nature-based tourism. Scarcer resources may lead to stronger competition between communities within dry and sub-humid lands including from changing migration patterns, possibly resulting in conflict and even violent clashes [17] as well as the further marginalization of vulnerable groups.

D. Assessment of the positive and negative impacts of climate change mitigation and adaptation activities on the biodiversity of dry and sub-humid lands

33. Climate change mitigation and adaptation can have a positive, neutral or negative impact on the biodiversity of dry and sub-humid lands depending on the manner in which such activities are implemented and the extent to which the impacts on biodiversity are considered during planning and implementation.

34. In general, the negative impacts can be minimized and the positive impacts enhanced if the ecosystem approach is applied to climate change adaptation and if tools such as biodiversity-inclusive strategic environmental assessments or environmental impact assessments are applied. With regards to mitigation, reducing emissions from deforestation and forest degradation (REDD) may be an emerging mechanism through which the positive impacts of climate change mitigation for biodiversity can be enhanced in dry forests. Additional examples of potential impacts are presented below.

Agricultural sector

35. Investments in irrigation infrastructure which increase withdraw rates from already stressed wetlands in drylands will have a negative impact on the biodiversity of dry and sub-humid lands. However, many adaptation programmes for the agricultural sector are focusing on increasing water efficiency and improved land management to reduce erosion, which would likely have a neutral or positive impact. Furthermore, adaptation actions that include the conservation of wild races and land races of crops in order to preserve genetic diversity that could lead to increased heat and drought tolerance, can be expected to have a positive impact.

Forest sector

36. There is very little information available on planned adaptation activities within dry forests however, some energy based adaptation activities, such as those which promote a shift from wood fuel, which may become less accessible under changing climatic conditions, to small scale solar and wind energy, which are not reliant upon ecosystem production, may have positive impacts on the biodiversity of dry and sub-humid lands by reducing the demand for wood-based forestry products.

Health sector

37. There is still a relatively high reliance upon traditional medicines in dry and sub-humid lands. As such, adaptation programmes that consider the conservation and sustainable use of medicinal plants can be expected to have positive impacts on biodiversity.

[16] http://www.ccdcommission.org/Filer/pdf/pb_climate_change_drylands.pdf
[17] Dietz *et al*. 2004

38. On the other hand, changes in precipitation in some dry and sub-humid areas are expected to contribute to the spread of water-borne diseases. In Africa, for example, the number of person-months exposure to malaria is expected to increase by as much as 28 per cent by 2100 as a result of climate change.[18] Where such increased risks are countered by improved environmental management, adaptation can be expected to have a neutral or positive impact on biodiversity. Where new infrastructure construction changes water flows, however, the impact can be expected to be neutral to negative.

Disaster management

39. One of the most commonly addressed fields of adaptation in dry and sub-humid lands is disaster management, largely because of projected impacts of climate change on the frequency and intensity of floods and drought. Adaptation activities include early warning systems, education and awareness raising, improved land and water management and the development of reservoirs.

40. All of the above-mentioned activities have the potential to deliver positive benefits for biodiversity if such considerations are integrated into planning. For example, an early warning system that considers climate data in addition to data on ecosystem carrying capacity would have more positive benefits than a system based on climate data alone.

E. The contribution of the biodiversity of dry and sub-humid lands to climate-change adaptation

Agricultural sector

41. The conservation of agrobiodiversity can provide specific gene pools for crop and livestock adaptation to climatic variability while also diversifying food products, conserving local and traditional knowledge and practices and maintaining key ecosystem services such as bees for pollination of cultivated crops.

42. As one example, the International Centre for Agricultural Research in Dry Areas (ICARDA) has developed a programme on climate change and drought management in Central Asia and China which seeks to enhance food security and livelihood options through sustainable agricultural management and the development and dissemination of new genetic varieties.

Health sector

43. The conservation of medicinal plants used by local and indigenous communities can ensure the provision of local medicines for health problems resulting from climate change while also providing a potential source of income for local people

Other

44. The sustainable management of dry and sub-humid lands can protect against floods and droughts, store nutrients and maintain soil structure while providing income opportunities from grazing, agriculture, recreation and tourism.

F. Measures that enhance the adaptive potential of components of the biodiversity of dry and sub-humid lands

45. Climate change is one of many drivers causing the loss of the biodiversity of dry and sub-humid lands. As such, the best strategy to enhance the adaptive potential of the biodiversity of dry and sub-humid lands is to reduce other threats while considering both current threats and those threats that are, themselves, expected to be exacerbated by climate change.

46. Additional measures to enhance the adaptive capacity of the biodiversity of dry and sub-humid lands include:

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[18] Tanser et al, 2003.

(a) Identifying those species and ecosystems that are particularly vulnerable to the negative impacts of climate change;

(b) Where appropriate, enhancing connectivity;

(c) Protect biodiversity habitat in the full range of environments types in the dry and sub-humid lands;

(d) Consider, in the case of extreme circumstances and under appropriate risk analysis, assisted migration;

(e) Restoring degraded ecosystems;

(f) On-farm and *ex-situ* conservation of agricultural biodiversity; and

(g) Expanding the network of protected areas incorporating dry and sub-humid lands.

47. Further approaches and guidelines for enhancing the adaptive capacity of biodiversity are included in the draft report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change.

G. Opportunities from climate change mitigation and adaptation activities for the conservation and sustainable use of biodiversity

Adaptation

48. Very few countries have already integrated components for the conservation and sustainable use of biodiversity within dry and sub-humid lands as a part of national adaptation programmes or have recognized the vulnerability of dry and sub-humid land species.[19] However, within the UNFCCC national communications the following priority activities have been identified:

(a) The development of ecosystem specific vulnerability assessments;

(b) Improved agricultural management in dry and sub-humid lands;

(c) Addressing desertification to enhance ecosystem resilience; and

(d) Protection of biodiversity in vulnerable areas (e.g. wetlands in drylands).

49. It should also be noted that some Parties have recognized that climate change is likely to cause an expansion in the area of dry and sub-humid lands.[20]

Mitigation

50. The links between greenhouse gas emissions and the destruction and degradation of dry and sub-humid land ecosystems have been established and are continuing to be better elaborated. For example, it is estimated that annually, drylands emit 0.23 to 0.29 gigatonnes of carbon as a result of land-use change and degradation.[21] On the other hand, drylands account for 36 per cent of the total carbon stock of terrestrial ecosystems and despite low plant biomass per unit area, there is an estimated sequestration potential of 0.4 to 0.6 gigatonnes of carbon per year for soil within dry and sub-humid lands.

51. The link between climate change mitigation and dry and sub-humid lands is however, not well recognized in National Communications under the UNFCCC. In fact, a review of second, third and fourth National Communications reveals that no Parties have identified ways and means to enhance the role of dry and sub-humid lands in storing and sequestering carbon.

[19] Italy, Kazakhstan, Tajikistan, Turkey and Uzbekistan.

[20] The former Yugoslav Republic of Macedonia.

[21] http://www.unccd.int/knowledge/docs/UNCCDPolicyBrief-Mitigation-02.pdf

IV. ENHANCING THE INTEGRATION OF CLIMATE CHANGE WITHIN THE PROGRAMME OF WORK ON THE BIODIVERSITY OF DRY AND SUB-HUMID LANDS

A. Appropriate monitoring and evaluation techniques, related technology transfer and capacity-building support within the programmes of work

1. Monitoring and evaluation techniques

52. Guidance on cost effective tools and methods to assess the threats and likely impacts of climate change faced by biodiversity in the identified vulnerable areas was compiled from a literature review conducted by the Secretariat, as well as from the Technical Series No. 10 and No. 25; and the Intergovernmental Panel on Climate Change Technical Guidelines for Assessing Climate Change Impacts and Adaptations,[22] which identify six steps for analysing vulnerability:

(a) Definition of the problem;

(b) Selection of the methods;

(c) Testing the methods;

(d) Selection of scenarios;

(e) Assessment of biophysical and socio-economic impacts; and

(f) Assessment of autonomous adjustments.

53. Tools identified in the technical guidelines include: experimentation, impact projections, empirical analogue studies, and expert judgement. To evaluate current impacts, observations and literature reviews are also useful tools.

54. In addition, given the particular vulnerability of dry and sub-humid lands to small changes in precipitation brought on by climate change, there is also a need for micro-level vulnerability assessments focusing on precipitation, floods and droughts. Such assessments can benefit from technologies such as geographic information systems and remote sensing.[23] However it is also important to integrate biological information such as ecosystem carrying capacity and productivity data. Furthermore, it should be noted that the accuracy of remote sensing technology is currently limited and would require further development. When considering the vulnerability of an individual species or group of species it is also useful to include genetic modelling in order to more fully capture vulnerability,[24] but such data is often not available.

55. Additional tools and networks listed in the table below provide examples of some of the more commonly implemented tools and methods to assess the impacts of climate change on the biodiversity of dry and sub-humid lands. A key limiting factor is ecological theory about changing ecosystems, and syntheses of evidence about the many different types of responses of species and ecosystem to climate change.

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[22] Carter et al 1994.

[23] http://vasat.icrisat.ac.in/?q=node/70

[24] http://www.fort.usgs.gov/Research/research_tasks.asp?TaskID=2336

Table: Examples of tools and methods to assess vulnerability

Tools	Elements Monitored or Evaluated
International Satellite Land Surface Climatology Project [25]	Precipitation levels
Food Assessment by Satellite Technology[26]	Precipitation, evapotranspiration and yield
USGS Drought Monitoring[27]	Drought
DESMED – Monitoring Desertification in the Mediterranean Region[28]	Land degradation and desertification
African Monitoring of the Environment for Sustainable Development (AMESD)[29]	
Networks	**Elements Monitored or Evaluated**
African Monitoring of the Environment for Sustainable Development (AMESD)[30]	Water, degradation, productivity
Hungarian National Association of Radio Distress Signalling and Infocommunications Emergency and Disaster Information Service (EDIS)[31]	Climate change
African Drought Risk and Development Network[32]	Drought
Drought Monitoring Centre for the Greater Horn of Africa[33]	Drought
North America Drought Monitor[34]	Drought

2. *Technology transfer*

56. Under the cross-cutting issue on technology transfer, Parties to the Convention on Biological Diversity undertake to provide and/or facilitate access for and transfer to other Contracting Parties of technologies that are relevant to the conservation and sustainable use of biological diversity or make use of genetic resources and do not cause significant damage to the environment. With regards to enhancing the integration of climate change considerations within the programme of work on the biodiversity of dry and sub-humid lands, such technologies could apply to adaptation and mitigation.

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[25] http://www.gewex.org/islscp.html
[26] http://www.ears.nl/faoyield.php
[27] http://gisdata.usgs.gov/website/drought_monitoring/
[28] http://www-roc.inria.fr/clime/desmed/index.html
[29] http://www.amesd.org/
[30] http://www.amesd.org/
[31] http://cc.rsoe.hu/
[32] http://www.frameweb.org/CommunityBrowser.aspx?id=3003
[33] http://www.dmcn.org/
[34] http://www.ncdc.noaa.gov/oa/climate/monitoring/drought/nadm/

57. With regard to adaptation based on the needs stated by Parties, relevant technologies may include improved early warning systems for drought and floods, heat and drought tolerant crops and trees, and improved climate change impact monitoring systems.

58. With regards to mitigation, technologies may include tools for monitoring carbon sinks and emission rates, especially within soils which currently have uncertainty rates on estimated carbon content of up to 90 per cent. With regards to carbon sequestration assessment technologies, it is important for technologies to be transferred to developing countries and for monitoring to be conducted on an aggregated scale in order to reduce overall monitoring costs.

59. Creation of a knowledge base and sharing of data and information on ecosystems and social and economic benefits of carbon sequestration within dry and sub-humid lands has also been identified by the UNCCD COP as being necessary for enhancing soil improvement practices and reducing vulnerability to climate change.

60. Finally, building a better understanding of the contribution of different land management techniques to carbon sequestration is important for the design and implementation of climate change mitigation projects which consider biodiversity. Currently models suggest that the most effective practices for increasing soil carbon include the input of organic matter (up to 0.09 tonnes C per hectare per year), maintaining tree cover (up to 0.15 tonnes C per hectare per year) and adopting zero tillage (up to 0.04 tonnes C per hectare per year.[35]

3. Capacity-building

61. With regards to capacity-building, Parties to the Convention on Biological Diversity identified two main needs (i) improved knowledge; and (ii) institutional capacity building for enhanced international cooperation.

62. The need for capacity-building to enhance knowledge has also been expressed under the UNFCCC Nairobi work programme on impacts, vulnerability and adaptation to climate change, which has called for capacity-building to improve bioclimatic modelling. Such models consider not only the physical impacts of climate change but also the effects of such impacts on biological processes and the functioning of ecosystems. Additional capacity-building has been requested to improve the down-scaling of climate models and the accuracy of precipitation modelling.

63. The UNCCD further identified two key requirements in order to enhance climate change mitigation in dry and sub-humid lands: further research to demonstrate the feasibility of large area measurement schemes and further research on the cost-benefit ratio of soil improvement and carbon sequestration practices for small landholders and subsistence farmers in dryland ecosystems.[36]

B. Critical knowledge needed to support implementation

64. The fourth assessment report of the IPCC and the IPCC Technical Report on Water and Climate Change identify several uncertainties concerning the links between climate change and the biodiversity of dry and sub-humid lands including:

Gaps in observational data

- Precipitation data;
- Soil moisture and actual evapotranspiration;
- Ground water;
- Wind patterns.

[35] Farage et al 2007.

[36] http://www.unccd.int/knowledge/docs/CSD17.pdf

Gaps in knowledge concerning impacts and vulnerability

- Understanding of the relationship (and difference) between changes in species and ecosystems and loss in societal values associated with biodiversity;
- Isolation of the causal relationship between observed impacts and anthropogenic climate change;
- Relationships between CO_2 fertilization, precipitation and temperature;
- Catchment scale projections;
- Feedbacks between land use change and climate change;
- Links between climate change impacts and species migration patterns; and
- The extent of vulnerability and adaptive capacity of marginalized populations inhabiting dry and sub-humid lands including the poor.

65. Parties to the Convention on Biological Diversity, through their fourth national reports also identified knowledge gaps preventing implementation of the existing climate change elements of the programme of work on the biodiversity of dry and sub-humid lands including:

(a) Projected impacts of climate change on savannah and other tropical grassland ecosystems;

(b) Impacts on livelihoods; and

(c) The role of the biodiversity of dry and sub-humid lands in climate change adaptation.

66. Technical Series No. 10 and No. 25 also identify key research needs although these are not specific to the biodiversity of dry and sub-humid lands. Knowledge needs identified by the Technical Series include additional research on:

(a) The relationship between biodiversity and ecosystem structure and the delivery of ecosystem services;

(b) Which ecosystem functions are most vulnerable to species loss;

(c) Projected climate change impacts on soil biodiversity;

(d) The effects of energy activities on biodiversity; and

(e) Indicators.

C. The ecosystem-approach principles and guidance and the precautionary approach

67. Since the ecosystem approach takes a broad perspective to management, it has been identified as a potential methodology through which the multiple impacts from climate change, including on biodiversity, can be reflected in comprehensive and responsive adaptation planning.

68. With regards to biodiversity and climate change within dry and sub-humid lands of particular interest is the link between land and water resources, which can often only be captured through activities at the basin level.

69. Furthermore, ensuring the participation of stakeholders representing different land uses has been identified as being key in dry and sub-humid lands in order to avoid conflict between, *inter alia*, sedentary agriculture, pastoralism, and conservation and tourism. However, one of the principal challenges in applying the ecosystem approach in dry and sub-humid lands as identified by Parties is ensuring stakeholder participation. Reasons for this include: the diversity of stakeholders (including a diversity of languages), the lack of participation of many dry and sub-humid lands groups in national political processes and the lack of communication infrastructure in many dry and sub-humid lands.

70. In addition to the ecosystem approach, the risk management approach to the management of biodiversity in dry and sub-humid lands in the face of climate change is being recognized, including the

need to adopt the precautionary approach. The Word Bank Group, for example, published a guide for applying the risk management approach for incorporating climate change within World Bank Operations.[37] The guide suggests that all projects should be screened for climate risks, with those that are identified as posing possible risks subjected to a more detailed and complete risk analysis. The guide also suggests that a precautionary approach should be adopted to better manage risk where possible threats and vulnerabilities have been identified.

71. In fact given uncertainties with regards to the impacts of climate change and associated response activities on the biodiversity of dry and sub-humid lands, the precautionary approach could help prevent the biodiversity of dry and sub-humid lands from reaching the tipping point, or threshold, beyond which damage would be inevitable and could be irreversible. It should be noted, with regards to thresholds, that there is still a great deal of uncertainty with regards to when these will be reached. Furthermore, even if thresholds are reached some changes, such as the drying of wetlands in drylands, may be very rapid while others, such as the collapse of large ice sheets, will take place over a long time period.

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37 http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2004/10/06/000160016_20041006165241/Rendered/PDF/300650PAPER0Look0Before0You0Leap.pdf

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