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TOOLS AND METHODOLOGIES FOR ASSESSING THE IMPACTS ON AND VULNERABILITIES OF BIODIVERSITY AS A RESULT OF CLIMATE CHANGE

*Note by the Executive Secretary***

INTRODUCTION

1. Annex III of decision IX/16 outlines the terms of reference for the Ad Hoc Technical Expert Group (AHTEG) on Biodiversity and Climate Change including: identify relevant tools, methodologies and best practice examples for assessing the impacts on and vulnerabilities of biodiversity as a result of climate change. In order to provide background material for the above, the World Conservation Monitoring Centre of the United Nations Environment Programme (UNEP-WCMC) prepared a review of the tools and methodologies employed in the studies on impacts and vulnerability outlined in the summary of available scientific information on the vulnerability of biodiversity to the impacts of climate change and mitigation and adaptation activities (UNEP/CBD/AHTEG/BD-CC-2/1/3). Accordingly this document was prepared by UNEP-WCMC and the Executive Secretary. This document highlights three methodologies: experimental studies, modelled predictions and observations of climate change impacts. The document also discusses the contribution of traditional knowledge to climate change impact assessments.

2. When considering tools and methodologies, it should be recalled that the first Ad Hoc Technical Expert Group on Biodiversity and Climate Change identified a number of research needs and gaps with regards to assessing the impacts of climate change on biodiversity. These were presented in CBD Technical Series No. 10 as:

> "Further research of present and projected climate change impacts on soils and on coastal and marine ecosystems is warranted. There are also some information gaps that affect the ability of making reliable projections of impacts. The main ones relate to development of data and models for:

* UNEP/CBD/ AHTEG/BD-CC-2/1/1.

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/…

(a) The geographical distribution of terrestrial, freshwater, coastal and marine species, especially those based on quantitative information and at high resolution Special attention should be given to invertebrates, lower plants and key species in ecosystems;

(b) The inclusion of human land and water use patterns, as they will greatly affect the ability of organisms to respond to climate change via migration, to provide a realistic projection of the future state of the Earth's ecosystems;

(c) Enabling the elucidation of the impacts of climate change compared with pressures from other human activities;

(d) Projections on changes in biodiversity in response to climate change especially at the regional and local level;

(e) Assessing impacts and adaptations to climate change at genetic, population and ecosystem level."

3. A review of literature on the impacts of climate change on biodiversity conducted in 2006 (Parmesan, 2006) revealed a continuing terrestrial bias and identified additional gaps with regards to geographic distribution. In particular the review revealed that, of the 866 peer-reviewed papers considered, most impact studies were based in North America, northern Europe and Russia. On the other hand, there were very few studies on impacts in South America, and even fewer from Africa (mostly South Africa) and Asia (mostly Japan).

I. EXPERIMENTAL STUDIES

4. Experimental studies control or artificially create certain conditions in order to identify the impacts of a number of variables on outcomes. Such studies can establish causality and define both the nature and the magnitude of cause and effect relationships.

5. Experimental studies are, however, limited by the number of factors that can be manipulated simultaneously. Single-factor experiments (e.g. increasing CO2 concentrations) represent least realistic simulations of future climate change, whereas multi-factorial experiments may capture interactions more realistically (e.g. manipulating CO2 concentrations, temperature and nutrients simultaneously).

6. Examples of experimental studies include: identifying the impacts of warmer winters with increased summer rainfall, and warmer winters with summer drought on the distribution of snails and slugs in grasslands (Sternberg, 2001), the impacts of reduced cloud water on epiphytes in tropical cloud forests (Nadkarni & Solano), and the impacts of soil warming on nutrient cycling in forests (Farnsworth *et al*, 1995).

7. Experimental studies can take place over the short term in laboratories or longer seasonal or annual time frames. In fact the study of soil warming, undertaken at the Harvard Forest, has been ongoing since 1991.

8. It is suggested that experimental studies on the impacts of climate change on biodiversity should be measured against three criteria (Parmesan, 2006):

(a) Detection: ability to isolate long-term trends as opposed to yearly variability and to differentiate between real changes and changes that are brought about by changes in methodology;

(b) Attribution: isolating climate change as the causal driver of an observed biological change;

(c) Globally coherent: identifying a causal link that would have a similar effect across multiple ecosystems spread across different regions.

II. MODELLING STUDIES

9. The limitations of modelling studies have been reviewed previously (IPCC AR4). Most modelling studies reviewed here are correlative, i.e. they derive functions or algorithms that relate the probability of species and ecosystems to current climatic or other factors. These functions or algorithms are then used to project distributions under future climates, assuming that the observed correlations will hold in the future. The current distribution may not reflect the full fundamental climatic niche of a species, which may not be fully expressed. Where range limits are underestimates (likely for most field based studies) then the extinction risk will be over-estimated. Bioclimatic envelope studies generally assume no adaptation will occur due to the speed of climate change.

10. Outputs from correlative studies are dependent on the choice of explanatory variables considered, with most studies only considering climatic variables (Dormann 2007), but see Jetz et al. (2007) for land use and climate change impacts on birds. Further, the climatic variables included represent the mean over many years or decade, ignoring extreme events that are likely be more important in limiting distributions than average values. Downscaling of climate data is particularly poor for precipitation and extreme events. Similarly, most models only consider global climate drivers, ignoring local drivers, such as land use change, urban effects or fire, as well as ignoring interactions among different impacts (Betts 2007;Midgley et al. 2007). Feedbacks from impacts to climate change, which often involve land ecosystem- atmosphere interactions, are often neglected. This can result in representations of global changes that are at best inconsistent and at worst completely misleading (Betts 2007).

11. Few modelling studies deal explicitly with interactions and dynamics among species, such as migration, dispersal and competition (Thuiller et al. 2008) (Jeschke & Strayer 2008) (Levinsky et al. 2007). Inclusion of interspecific interactions and dispersal ability in models can highlight the subtle balances of processes, non-linear dynamics and abrupt changes from species coexistence under climate change (Brooker *et al.* 2007). Further, feedbacks between several factors, such as climate change and land use change impacts should be considered, to predict climate change impacts more accurately (Malhi *et al.* 2008).

12. Various studies have compared the available statistical modelling techniques, as well as the different ways of assessing the goodness of fit of such models (Jeschke & Strayer 2008).

13. Recently, the bioclimatic envelope approach has been questioned and Beale et al. (2008) argue that the species-climate associations from bioclimatic envelope methods are no better than chance for most European bird species investigated, suggesting that bird species are not sensitive to climate variables currently available. However, other studies have validated climate envelope models by showing that historic population trends are driven by climate variables (Green *et al.* 2008). To achieve better predictions of a species impacts, possibly more complex models are needed such as those combining both habitat (climate envelope) and individual-based approaches (Chamaille-Jammes *et al.* 2006). However, most importantly, the hypotheses generated by models need to be tested and validated, using retrodiction (Grosbois et al. 2008;Hijmans & Graham 2006). Currently validation of models is lacking and would require long term strategic observations (Midgley *et al.* 2007), especially in areas where data are sparse, e.g. tropics (IPCC 2007). Lastly, research is needed to find direct evidence of how species respond to environmental variables (Gordo 2007).

III. OBSERVATIONS FROM INDIGENOUS AND LOCAL COMMUNITIES

14. In addition to peer-reviewed studies in scientific journals, observational data gathered by indigenous and local communities, who often observe species and ecosystems on a daily basis, can form

an important tool for assessing the impacts of climate change on biodiversity. In fact, such observations have already been integrated into a number of impact assessments including the Arctic Climate Impact Assessment 1/ and the Many Strong Voices project for the dynamic assessment of vulnerability and adaptation to climate change in small island developing States. 2/

15. Some of the impacts of climate change on biodiversity that have been identified by indigenous and local communities include: coral bleaching events in the Great Barrier Reef, 3/ the impacts of climate change on the migration patterns of mountain birds, 4/ and the impacts of changing ice conditions on walrus and whales. 5/

16. Combining observations from indigenous and local communities with other evaluation methods does, however, require some special consideration. From 25 to 28 March 2008 an international expert meeting was held thanks to the contribution of the Government of Finland on responses to climate change for indigenous and local communities and the impact on their traditional knowledge related to biodiversity in the Arctic region.

17. Experts participating in this meeting developed guidelines and good practices to improve tools and methods for monitoring the impacts of climate change on biodiversity in partnership with indigenous and local communities. These include:

(a) Establish data sharing on indigenous and local community terms;

(b) Systemize community-based monitoring as a component for management;

(c) Governments and academic institutions need to address political implications of intellectual property rights;

(d) Recognize that there are different types of knowledge in the Arctic (including scientific knowledge and various types of traditional knowledge) and give equal political value to each;

(e) Explore uses/opportunities for community-based monitoring: use of tools such as identification tables distributed in indigenous and local communities (including schools);

(f) Ensure that communities have access to the compiled and analysed data;

(g) Facilitate data gathering and analysis in local languages since these languages are better able to convey details on threats, impacts, and trends (also same species have different names);

(h) Recognize that monitoring is inextricably linked to decision-making;

(i) Ensure that scientific monitoring is validated by indigenous peoples; and

(j) Recognize that indigenous communities are able to provide data and monitoring on a whole system rather than small sections / sectors.

1/ http://www.acia.uaf.edu/

2/ http://www.manystrongvoices.org/_res/site/file/2007%20Deliverables/SIDS%20Assessment%20Project%20Outline.pdf

3/ http://www.gbrmpa.gov.au/corp_site/key_issues/climate_change/management_responses/bleach_watch2.html

4/ http://www.vtecostudies.org/MBW/

5/ Observation by Mr. Merlin Koonooka from the Native Village of Gambell, Alaska.

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