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TECHNICAL AND REGULATORY MATTERS ON GEOENGINEERING IN RELATION TO THE CONVENTION ON BIOLOGICAL DIVERSITY

Note by the Executive Secretary

EXECUTIVE SUMMARY

At its tenth meeting, the Conference of the Parties to the Convention on Biological Diversity (CBD) adopted a decision on climate-related geoengineering and its impacts on the achievement of the objectives of the Convention as part of its decision X/33 on biodiversity and climate change. In response to this decision, three studies were prepared and are presented to the Subsidiary Body on Scientific, Technical and Technological Advice as information documents. The studies compile and synthesize information on: (i) the possible impacts of geoengineering techniques on biodiversity and associated social, economic and cultural considerations; (ii) the regulatory framework of geoengineering relevant to the Convention; and (iii) the views and experiences of indigenous and local communities and stakeholders on the impacts of geoengineering on biodiversity.

The technical study indicates that the deployment of some geoengineering techniques, if feasible and effective, could reduce the magnitude of climate change and its impacts on biodiversity. At the same time, most geoengineering techniques are associated with unintended impacts on biodiversity, particularly when deployed at a climatically-significant scale, together with significant risks and uncertainties. The study also recognizes many areas where knowledge is still very limited.

The study on the legal and regulatory framework of geoengineering indicates that the current regulatory mechanisms that could apply to climate-related geoengineering relevant to the Convention do not constitute a framework for geoengineering as a whole that meets the criteria of being science-based, global, transparent and effective. With the possible exceptions of ocean fertilization experiments and carbon dioxide storage in geological formations, the existing legal and regulatory framework is currently not commensurate with the potential scale and scope of the climate-related geoengineering, including transboundary effects. The need for science-based global, transparent and effective control and regulatory mechanisms may be most relevant for those geoengineering concepts that have a potential to cause significant adverse transboundary effects, and for those deployed in areas beyond national jurisdiction and in the atmosphere. The lack of regulatory mechanisms for sunlight-reflection methods is a major gap, especially given the potential for significant deleterious transboundary effects.

* UNEP/CBD/SBSTTA/16/1.

Initial views and experiences of indigenous and local communities and stakeholders indicate that so far, the contribution of indigenous peoples to this debate has been very limited and culturally relevant capacity-building programmes and information on these issues is scant. Understanding geoengineering impacts from indigenous perspectives is an issue that requires further exploration. Various United Nations standards, including the *United Nations Declaration on the Rights of Indigenous Peoples*,* emphasize the need for indigenous peoples to effectively participate in all matters that may impact upon them and yet there has been little participation in discussions around geoengineering.

SUGGESTED RECOMMENDATIONS

The Subsidiary Body on Scientific, Technical and Technological Advice may wish to recommend that the Conference of the Parties, at its eleventh meeting adopts a decision along the following lines:

The Conference of the Parties

1. *Welcomes* the report on the impacts of climate related geoengineering on biological diversity (UNEP/CBD/SBSTTA/16/INF/28), the study on the regulatory framework of climate-related geoengineering relevant to the Convention on Biological Diversity (UNEP/CBD/SBSTTA/16/INF/29) and the overview of the views and experiences of indigenous and local communities and stakeholders (UNEP/CBD/SBSTTA/16/INF/30);

2. *Takes note* of the main messages presented in the current document (UNEP/CBD/SBSTTA/16/10);

3. *Notes* that climate-related geoengineering may be defined as a deliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change and/or its impacts through, *inter alia*, sunlight reflection methods or removing greenhouse gases from the atmosphere;

4. *Further notes* that there remain significant gaps in the understanding of the impacts of climate-related geoengineering on biodiversity, including:

(a) The overall effectiveness of some of the techniques, based on realistic estimates of their scalability;

(b) How the proposed geoengineering techniques can be expected to affect weather and climate regionally and globally;

(c) How biodiversity, ecosystems and their services are likely to respond to geoengineered changes in climate; and

(d) The unintended effects of different proposed geoengineering techniques on biodiversity;

(e) The social and economic implications, particularly with regard to geo-political acceptability, governance and the potential need to address the issue that some may benefit while others may suffer negative impacts.

5. *Recalling* paragraph (8(x)) of its decision X/33, *welcomes* the consideration being given under the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 and its 1996 Protocol to the possible development of the regulatory framework for proposed marine geoengineering techniques beyond ocean fertilization;

6. *Noting* that customary law, including the obligation to avoid transboundary harm and the obligation to conduct environmental impact assessments, could be applied to potential geoengineering activities but would still form an incomplete basis for global regulation;

7. *Further notes* of the potential relevance existing treaties and organizations for the governance of potential geoengineering activities, including the United Nations Convention on the Law of

* General Assembly resolution 61/295, annex.

the Sea, the London Convention and its Protocol, the United Nations Framework Convention on Climate Change and its Kyoto Protocol, the Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol, and regional conventions, as well as the United Nations General Assembly, the United Nations Environment Programme and the World Meteorological Organization;

8. *Recognizes* that, for most proposed climate-related geoengineering techniques, the elements of the current regulatory framework do not constitute a science-based, global, transparent and effective framework;

9. *Recognizes* that the need for science-based global, transparent and effective control and regulatory mechanisms may be most relevant for those geoengineering concepts that have a potential to cause significant adverse transboundary effects, and those deployed in areas beyond national jurisdiction and in the atmosphere;

10. *Requests* the Executive Secretary to transmit this decision, and the reports referred to in paragraph 1 above, to the secretariats of the treaties and organizations referred to in paragraph 7 above, for their possible consideration.

I. INTRODUCTION

1. At its tenth meeting, the Conference of the Parties adopted decision X/33 on climate-related geoengineering and its impacts on the achievement of the objectives of the Convention as part of its decision on biodiversity and climate change.

2. Specifically, in paragraph 8 of that decision, the Conference of the Parties invited Parties and other Governments, according to national circumstances and priorities, as well as relevant organizations and processes, to consider the guidance below on ways to conserve, sustainably use and restore biodiversity and ecosystem services while contributing to climate change mitigation and adaptation to: (….)

> "(w) Ensure, in line and consistent with decision IX/16 C, on ocean fertilization and biodiversity and climate change, in the absence of science based, global, transparent and effective control and regulatory mechanisms for geo-engineering, and in accordance with the precautionary approach and Article 14 of the Convention, that no climate-related geo-engineering activities[1] that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts, with the exception of small scale scientific research studies that would be conducted in a controlled setting in accordance with Article 3 of the Convention, and only if they are justified by the need to gather specific scientific data and are subject to a thorough prior assessment of the potential impacts on the environment;
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> (x) Make sure that ocean fertilization activities are addressed in accordance with decision IX/16 C, acknowledging the work of the London Convention/London Protocol;"

3. Further, in paragraph 9 of that decision, the Conference of the Parties requested the Executive Secretary to: (…)

> "(l) Compile and synthesize available scientific information, and views and experiences of indigenous and local communities and other stakeholders, on the possible impacts of geo engineering techniques on biodiversity and associated social, economic and cultural considerations, and options on definitions and understandings of climate-related geo-engineering relevant to the Convention on Biological Diversity and make it available for consideration at a meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) prior to the eleventh meeting of the Conference of the Parties; and
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> (m) Taking into account the possible need for science based global, transparent and effective control and regulatory mechanisms, subject to the availability of financial resources, undertake a study on gaps in such existing mechanisms for climate-related geo-engineering relevant to the Convention on Biological Diversity, bearing in mind that such mechanisms may not be best placed under the Convention on Biological Diversity, for consideration by SBSTTA prior to a future meeting of the Conference of the Parties and to communicate the results to relevant organizations."

4. Pursuant to paragraph 9 (l) of decision X/33, a study on the impacts of climate-related geoengineering on biological diversity was prepared by a group of experts and the Secretariat of the Convention following discussions of a liaison group convened thanks to financial support from the

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1 Without prejudice to future deliberations on the definition of geo-engineering activities, understanding that any technologies that deliberately reduce solar insolation or increase carbon sequestration from the atmosphere on a large scale that may affect biodiversity (excluding carbon capture and storage from fossil fuels when it captures carbon dioxide before it is released into the atmosphere) should be considered as forms of geo-engineering which are relevant to the Convention on Biological Diversity until a more precise definition can be developed. It is noted that solar insolation is defined as a measure of solar radiation energy received on a given surface area in a given hour and that carbon sequestration is defined as the process of increasing the carbon content of a reservoir/pool other than the atmosphere.

Governments of the United Kingdom and Norway. The report compiles and synthesizes available scientific information on the possible impacts of geoengineering techniques on biodiversity, including information on associated social, economic and cultural considerations and options on definitions. The key messages from the study are presented in section II below. The full report can be found in document UNEP/CBD/SBSTTA/16/INF/28.

5. In response to decision X/33 paragraph 9 (m), a study on the regulatory framework of climate-related geoengineering relevant to the Convention on Biological Diversity has been prepared for the Secretariat by a lead author, with review comments and additional contributions from group of experts as well as the Secretariat of the Convention on Biological Diversity. The key messages from the study are presented in section III below. The full report can be found in document UNEP/CBD/SBSTTA/16/INF/29.

6. The study on the impacts of climate-related geoengineering on biological diversity mentioned in paragraph 4 above acknowledges that there is currently very little information available about the perspectives from indigenous and local communities. The Secretariat organized two sessions—on the margins of the seventh meeting of the Ad Hoc Open-ended Working Group on Article 8(j) and Related Provisions of the Convention on Biological Diversity and of the fifteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice—to initiate dialogue on the subject and to hear preliminary views and experiences of indigenous and local communities and other stakeholders.

7. The Secretariat also launched an electronic discussion to collect views and experiences of indigenous and local communities and other stakeholders, on the possible impacts of geo engineering techniques on biodiversity, using the online global forum for indigenous peoples, small islands and vulnerable communities – “Climate Frontlines” – which is run by the United Nations Educational, Scientific and Cultural Organization (UNESCO), in partnership with the Secretariat of the Convention on Biological Diversity, the Secretariat of the United Nations Permanent Forum on Indigenous Issues (SPFII) and the Office of the High Commissioner on Human Rights (OHCHR). The forum reaches over 46,000 people and operates in English, French and Spanish. A summary of the main messages from the online discussion is presented in section IV below. The full report of the online discussion can be found in document UNEP/CBD/SBSTTA/16/INF/30.

II. IMPACTS OF CLIMATE-RELATED GEOENGINEERING ON BIOLOGICAL DIVERSITY

8. The key messages from the study on the impacts of climate-related geoengineering on biological diversity are presented below. The full report can be found in document UNEP/CBD/SBSTTA/16/INF/28.

9. **Biodiversity, ecosystems and their services are critical to human well-being. Protection of biodiversity and ecosystems requires that drivers of biodiversity loss are reduced.** The current main direct drivers of biodiversity loss are habitat conversion, over-exploitation, introduction of invasive species, pollution and climate change. These in turn are being driven by demographic, economic, technological, socio-political and cultural changes. Human-driven climate change due to greenhouse-gas emissions is becoming increasingly important as a driver of biodiversity loss and the degradation of ecosystem services. A rapid transition to a low-carbon economy is the best strategy to reduce such adverse impacts on biodiversity. However, on the basis of current greenhouse-gas emissions, their long atmospheric residence times and the relatively limited action to date to reduce future emissions, the use of geoengineering techniques has also been suggested as an additional means to limit the magnitude of human-induced climate change and its impacts.

Proposed climate-related geoengineering techniques

10. **In this report, climate-related geoengineering is defined as a deliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change**

and its impacts. Geoengineering techniques include increasing the reflectivity of the Earth's surface or atmosphere, and removing greenhouse gases from the atmosphere; other approaches have also been proposed. This definition of geoengineering encompasses a wide spectrum of possible actions to counteract (or remedy) global warming and its associated consequences. The commonality of those actions is that they could produce global cooling, if applied at sufficient scale. Geoengineering can therefore be differentiated from actions that mitigate (reduce or prevent) anthropogenic greenhouse-gas emissions. Carbon capture and storage (CCS) linked to fossil fuel combustion is not here considered as geoengineering, although some geoengineering techniques may involve the same or similar processes of managed carbon storage. Afforestation/reforestation and large scale land-management changes are, however, included, notwithstanding that such measures are already deployed for climate-change mitigation and other purposes, and that they involve minimal use of new technologies. (*Sections 2.1-2.2*)[2]

11. **Sunlight reflection methods (SRM), also known as solar radiation management, aim to counteract warming and associated climatic changes by reducing the incidence and subsequent absorption of short-wave solar radiation, reflecting a small proportion of it back into space.** They are expected to rapidly have an effect once deployed at the appropriate scale, and thus have the potential to reduce surface global temperatures within a few months or years if that were considered desirable. SRM would not address the root cause of human-driven climate change arising from increased greenhouse-gas concentrations in the atmosphere: instead they would mask the warming effect of accumulating greenhouse gases. They would introduce a new dynamic between the warming effects of greenhouse gases and the cooling effects of SRM with uncertain climatic implications, especially at the regional scale. SRM would not directly address ocean acidification. SRM proposals include:

1. *Space-based approaches:* reducing the amount of solar energy reaching the Earth by positioning sun-shields in space with the aim of reflecting or deflecting solar radiation;
2. *Changes in stratospheric aerosols*: injecting sulphates or other types of particles into the upper atmosphere, with the aim of increasing the scattering of sunlight back to space;
3. *Increases in cloud reflectivity:* increasing the concentration of cloud-condensation nuclei in the lower atmosphere, particularly over ocean areas, thereby whitening clouds with the aim of increasing the reflection of solar radiation;
4. *Increases in surface albedo:* modifying land or ocean surfaces with the aim of reflecting more solar radiation out to space.

SRM could be implemented separately or in combination, at a range of scales. (*Section 2.2.1*)

12. **Carbon dioxide removal (CDR) techniques aim to remove CO_2, a major greenhouse gas, from the atmosphere**, allowing outgoing long-wave (thermal infra-red) radiation to escape more easily. In principle, other greenhouse gases, such as nitrous oxide (N_2O), and methane (CH_4), could also be removed from the atmosphere or reduced at source, but such approaches are currently highly speculative. Proposed CDR techniques include:

1. *Ocean fertilization:* the enrichment of nutrients in marine environments with the intention of stimulating plant production, hence CO_2 uptake from the atmosphere and the deposition of carbon in the deep ocean;
2. *Enhanced weathering:* artificially increasing the rate by which CO_2 is naturally removed from the atmosphere by the weathering (dissolution) of carbonate and silicate rocks;
3. *Increasing carbon sequestration through ecosystem management:* through, for example: afforestation, reforestation, or measures that enhance natural carbon storage in soils and wetlands

[2] Information in parentheses indicates where full details, with references, can be found in the main report (UNEP/CBD/SBSTTA/INF/28).

4. *Biological carbon capture, using harvested biomass and subsequent carbon storage:* for example, through biochar, the long term storage of crop residues or timber, or bio-energy with carbon capture and storage; and

5. *Direct, chemical capture of carbon from the atmosphere and its subsequent storage*, for example, with storage as liquid CO_2 in geological formations or in the deep ocean.

CDR approaches involve two steps: (1) CO_2 capture from the atmosphere; and (2) long-term storage (sequestration) of the captured carbon. In the first three techniques, these two steps are very closely linked, although the permanence of the storage may be variable and technique-specific; in the fourth and fifth, capture and storage may be separated in time and space. Ecosystem-based approaches such as afforestation, reforestation or the enhancement of soil carbon are already employed as climate-change mitigation activities, and are not universally regarded as geoengineering technologies. CDR techniques act relatively slowly: to have a significant impact on the climate, such interventions, individually or collectively, would need to involve the removal from the atmosphere of several Gt C/yr (gigatonnes of carbon per year), maintained over decades. This seems unlikely to be achievable for several proposed CDR approaches. (*Section 2.2.2*)

13. **There is no single geoengineering approach that currently meets all three basic criteria for effectiveness, safety and affordability. Different techniques are at different stages of development, mostly theoretical, and many are of doubtful effectiveness.** Few, if any, of the approaches proposed above can be considered well-researched; for most, the practicalities of their implementation have yet to be investigated, and mechanisms for their governance are potentially problematic. Early indications are that several of the techniques, both SRM and CDR, are unlikely to be effective at the global scale. (*Section 2*)

Climate change and ocean acidification, and their impacts on biodiversity

14. **The continued increase in CO_2 and other atmospheric greenhouse gases not only has profound implications for global and regional average temperatures, but also for precipitation, soil moisture, ice-sheet dynamics, sea-level rise, ocean acidification and the frequency and magnitude of extreme events such as floods, droughts and wildfires.** Future climatic perturbations could be abrupt or irreversible, and potentially extend over millennial time scales; they will inevitably have major consequences for natural and human systems, severely affecting biodiversity and incurring very high socio-economic costs. (*Section 3.1*).

15. **Since 2000, the rate of increase in anthropogenic CO2 emissions has accelerated, averaging ~3.1% per year. Emissions of other greenhouse gases are also increasing. As a result, it will be extremely challenging to limit global warming to the proposed target of 2°C.** In fact, current commitments to limit greenhouse-gas emissions correspond to a 3-5°C warmer world. Avoidance of high risk of dangerous climate change therefore requires an urgent and massive effort to reduce greenhouse-gas emissions, as well as protecting existing natural carbon sinks, including through sustainable land management. If such efforts are not made, geoengineering approaches are likely to be increasingly proposed to offset at least some of the impacts of climate change, despite the risks and uncertainties involved (*Section 3.1.2*).

16. **Even with strong climate mitigation policies, further human-driven climate change is inevitable due to lagged responses in the Earth climate system.** Increases in global mean surface temperature of 0.3 - 2.2°C are projected to occur over several centuries after atmospheric concentrations of greenhouse gases have been stabilized, with associated increases in sea level due to thermally-driven expansion and ice-melt. The seriousness of these changes provides the reason why geoengineering has attracted attention. (*Section 3.1.2*)

17. **Human-driven climate change poses an increasingly severe range of threats to biodiversity and ecosystem services, greatly increasing the risk of species extinctions and local losses.** Temperature, precipitation and other climate attributes strongly influence the distribution and abundance

of species, and their interactions. Because species respond to climate change in different ways, ecosystems (and the services they provide) will be disrupted. Projected climate change is not only more rapid than recent naturally-occurring climate change (e.g., during ice age cycles) but now the scope for such adaptive responses is reduced by other anthropogenic pressures, including over-exploitation, habitat loss, fragmentation and degradation, introduction of non-native species, and pollution. Risk of global extinction and local extirpations is therefore increased, since the abundance and genetic diversity of many species are already reduced, and their adaptive capacity is lessened. (*Section 3.2.1*)

18. **The terrestrial impacts of projected climate change are likely to be greatest for montane and polar habitats, for coastal areas affected by sea-level change, and wherever there are major changes in freshwater availability.** Species with limited adaptive capability will be particularly at risk; while insect pests and disease vectors in temperate regions are expected to benefit. Forest ecosystems, and the goods and services they provide, are likely to be affected as much, or more, by changes in hydrological regimes (affecting fire risk) and pest abundance, than by direct effects of temperature change. *(Section 3.2.2)*

19. **Marine species and ecosystems are increasingly subject to ocean acidification as well as changes in temperature.** Climate driven changes in the reproductive success, abundance and distribution of marine organisms are already occurring, more rapidly than on land. The loss of summer sea-ice in the Arctic will have major biodiversity implications. Biological impacts of ocean acidification (an inevitable chemical consequence of the increase in atmospheric CO_2) are less certain; nevertheless, an atmospheric CO_2 concentration of 450 ppm would decrease surface pH by ~0.2 units, making large-scale and ecologically significant effects likely. Tropical corals seem to be especially at risk, being vulnerable to the combination of ocean acidification, temperature stress (coral bleaching), coastal pollution (eutrophication and increased sediment load), sea-level rise and human exploitation (over-fishing and coral-harvesting). (*Section 3.2.3*)

20. **The biosphere plays a key role in climate processes, especially as part of the carbon and water cycles**. Very large amounts of carbon are naturally circulated and stored by terrestrial and marine ecosystems, through biologically-driven processes. Proportionately small changes in ocean and terrestrial carbon stores, caused by changes in the balance of natural exchange processes, can have climatically-significant implications for atmospheric CO_2 levels. Potential tipping points that may cause the rapid release of long-term carbon stores, e.g., as methane, are poorly understood. (*Section 3.3*)

Potential impacts on biodiversity of SRM geoengineering

21. **SRM, if effective in abating the magnitude of warming, would reduce several of the climate-change related impacts on biodiversity. Such techniques are also likely to have other, unintended impacts on biodiversity.** Assessment of the totality of those impacts is not straightforward: not only are the effects of specific SRM measures uncertain, but the outcome of the risk assessment will depend on the alternative, non-SRM strategy used as the 'control' for comparisons. Because climate change is projected to occur, climate-change scenarios provide relevant controls for assessing the risks and benefits of geoengineering, including the implications for biodiversity (*Chapter 4; Introduction*)

22. **Model-based analyses and evidence from volcanic eruptions indicate that uniform dimming of sunlight by 1-2% through an unspecified atmospheric SRM measure could, for most areas of the planet, reduce future temperature changes projected under unmitigated greenhouse gas emissions.** Overall, this would reduce several of the adverse impacts of projected climate change on biodiversity. These benefits would vary regionally, and might be negligible or absent for some areas. However, only limited research has been done; uniform dimming is a theoretical concept and may not be achievable; and many uncertainties remain concerning the effects of different atmospheric SRM measures and their geo-spatial consequences, for the hydrological cycle as well as for heat distribution. It is therefore not yet possible to predict effects with any confidence. (*Section 4.1.1*)

23. **SRM would introduce a new dynamic between the heating effects of greenhouse gases and the cooling due to sunlight reduction**. There are no known palaeo-precedents for the radiative impacts of high greenhouse-gas concentrations to be balanced by reduced light quantity; thus the stability of that combination is uncertain, and it is not clear what specific environmental challenges an "SRM world" might present to individual species and ecosystems, either on a short-term or a long-term basis. (*Section 4.1.3*)

24. **The amount of anthropogenic CO_2 in the atmosphere is unaffected by SRM. Thus SRM would have little effect on ocean acidification and its associated impacts on marine biodiversity, nor the impacts (positive or negative) of elevated atmospheric CO_2 on terrestrial ecosystems.** Some indirect effects of SRM on atmospheric CO_2 are possible; e.g., if such techniques prevent the temperature-driven release of additional CO_2 from natural systems. Nevertheless, SRM cannot be considered as an alternative to emission mitigation or CDR in terms of avoiding detrimental effects on the (marine) biosphere. (*Section 4.1.4*)

25. **Rapid termination of SRM, that had been deployed for some time and masking a high degree of warming due to continued greenhouse-gas emissions, would almost certainly have large negative impacts on biodiversity and ecosystem services.** Those adverse consequences would be more severe than those resulting from gradual climate change, since the opportunity for adaptation, including through population migration, would be much reduced. (*Section 4.1.5*)

26. **Stratospheric aerosol injection, using sulphate particles, would affect the overall quantity and quality of light reaching the biosphere; have relatively minor effects on atmospheric acidity; and could also contribute to stratospheric ozone depletion.** All these unintended impacts have implications for biodiversity and ecosystem services. Stratospheric aerosols would decrease the amount of photosynthetically active radiation (PAR) reaching the Earth by 1-2%, but would increase the proportion of diffuse (as opposed to direct) radiation. This would be expected to affect community composition and structure. It may lead to an increase of gross primary productivity (GPP) in forest ecosystems whilst decreasing ocean productivity. However, the magnitude and nature of effects on biodiversity are likely to be mixed, and are currently not well understood. Increased ozone depletion, primarily in the polar regions, would cause an increase in the amount of ultra violet (UV) radiation reaching the Earth, although potentially offset by the UV scattering of the aerosol particles themselves. (*Section 4.2.1*)

27. **Cloud brightening is a more localised SRM proposal, with its application likely to be limited to specific ocean areas. The predictability of its climatic impacts is currently uncertain;** nevertheless regional cooling with associated atmospheric and oceanic perturbations are likely, with potentially significant effects on terrestrial and marine biodiversity and ecosystems. Unintended impacts could be positive as well as negative. (*Section 4.2.2*)

28. **Surface albedo changes would need to be deployed over very large land areas (sub-continental scale) or over much of the global ocean to have substantive effects on the global climate, with consequent impacts on ecosystems. Strong localized cooling could have a disruptive effect on regional weather patterns.** For instance, covering deserts with reflective material on a scale large enough to be effective in addressing the impacts of climate change would greatly reduce habitat availability for desert fauna and flora, as well as affecting its customary use. (*Section 4.2.3*)

Potential impacts on biodiversity of CDR geoengineering techniques

29. **Carbon dioxide removal techniques, if effective and feasible, would be expected to reduce the negative impacts on biodiversity of climate change and, in most cases, of ocean acidification.** By removing CO_2 from the atmosphere, CDR techniques reduce the concentration of the main causal agent of anthropogenic climate change, Acidification of the surface ocean would also be reduced, but the effect of CDR on the ocean as a whole will depend on the location of long-term carbon storage. CDR methods are generally slow in affecting the atmospheric CO_2 concentration, with further substantial time-lags in the

climatic benefits. Several of the techniques are of doubtful effectiveness, because of limited scalability. (*Section 5.1*)

30. **Individual CDR techniques may have significant unintended impacts on terrestrial, and/or ocean ecosystems, depending on the nature, scale and location of carbon capture and storage.** In some biologically-driven processes (ocean fertilization; afforestation, reforestation and soil carbon enhancement), carbon removal from the atmosphere and its subsequent storage are very closely linked. In these cases, impacts on biodiversity are likely to be limited to marine and terrestrial systems respectively. In other cases, the steps are discrete, and various combinations of capture and storage options are possible. Thus the carbon that is fixed within land biomass, for example, could be either: dumped in the ocean as crop residues; incorporated into the soil as charcoal; or used as fuel with the resultant CO_2 chemically removed at source and stored either in sub-surface reservoirs or the deep ocean. In these cases, each step will have different and additive potential impacts on biodiversity, and potentially separate impacts on marine and terrestrial environments. (*Section 5.1*)

31. **Ocean fertilization involves increased biological primary production with associated changes in phytoplankton community structure and species diversity, and implications for the wider food web.** Ocean fertilization may be achieved through the external addition of nutrients (Fe, N or P) or, possibly, by modifying ocean upwelling. If carried out on a climatically significant scale, changes may include an increased risk of harmful algal blooms, and increased benthic biomass. Potential effects on fisheries are uncertain. If Fe is used to stimulate primary production, increases in one region may be offset, to some degree, by decreases elsewhere. Ocean fertilization is expected to increase the midwater production of methane and nitrous oxide; if released to the atmosphere, these greenhouse gases would significantly reduce the effectiveness of the technique. Large-scale ocean fertilization would slow near-surface ocean acidification but increase acidification (and potential anoxia) in mid- and deep-water. The small-scale experiments conducted to date indicate that this is a technique of doubtful effectiveness for geoengineering purposes. (*Section 5.2.1*)

32. **Enhanced weathering would involve large-scale mining and transport of carbonate and silicate rocks, and the spreading of solid or liquid materials on land or sea. The scale of impacts (that may be positive as well as negative) on terrestrial and coastal ecosystems will depend on the method and scale of implementation.** CO_2 is naturally removed from the atmosphere by the weathering (dissolution) of carbonate and silicate rocks. This process could be artificially accelerated by techniques that include releasing calcium carbonate or other dissolution products of alkaline minerals into the ocean or spreading abundant silicate minerals such as olivine over agricultural soils. In the ocean, this technique could, in theory, be used to counter ocean acidification; the practicalities have yet to be tested. (*Section 5.2.2*)

33. **The impacts on biodiversity of ecosystem carbon storage through afforestation, reforestation, or the enhancement of soil and wetland carbon depend on the method and scale of implementation.** If managed well, such approaches have the potential to increase or maintain biodiversity. Afforestation, reforestation and land-use change are already being promoted as climate change mitigation options, and are not considered by many to be geoengineering. Much guidance has already been developed, by the Convention on Biological Diversity and others, to maximize the biodiversity benefits of these approaches and minimize the disadvantages (e.g., planting assemblages of native species rather than exotic monocultures). (*Section 5.2.3*)

34. **Production of biomass for carbon sequestration on a scale large enough to be climatically significant is likely to either compete for land with food and other crops or involve large-scale land-use change, with impacts on biodiversity as well as greenhouse-gas emissions that may partially offset (or even exceed) the carbon sequestered as biomass.** The coupling of biomass production with its use as bioenergy in power stations equipped with effective carbon capture at source has the potential to be carbon negative. The net effects on biodiversity and greenhouse-gas emissions would depend on the approaches used. The storage or disposal of biomass may have impacts on biodiversity separate from those involved in its production. Removal of organic matter from agricultural ecosystems is likely to have

negative impacts on agricultural productivity and biodiversity, and may increase the need for fertilizer application to maintain soil fertility. (*Section 5.2.4.1*)

35. **The impacts of long-term storage of biochar (charcoal) in different soil types and under different environmental conditions are not well understood.** Important issues that need to be resolved include the stability of carbon in the biochar, and effects on soil water retention, N_2O release, crop yields, mycorrhizal fungi, soil microbial communities and detritivores. (*Section 5.2.4.2.1*)

36. **Ocean storage of terrestrial biomass (e.g., crop residues) is expected to have a negative impact on biodiversity.** The deposition of ballasted bales would likely have significant local physical impacts on the seabed due to the sheer mass of the material. Wider, long-term indirect effects of oxygen depletion and deep-water acidification could be regionally significant if there were cumulative deposition, and subsequent decomposition, of many gigatonnes of organic carbon. (*Section 5.2.4.2.2*)

37. **Chemical capture of CO_2 from ambient air would require a large amount of energy. Some proposed processes may also have high demand for freshwater, and potential risk of chemical pollution from sorbent manufacture; otherwise they would have relatively small direct impacts on biodiversity.** Removal of CO_2 from the ambient air (where its concentration is 0.04%) is much more difficult and energy intensive than its capture from flue gases of power stations (where levels are about 300 times higher, at ~12%); it is therefore unlikely to be viable without additional carbon-free energy sources. CO_2 extracted from the atmosphere would need to be stored either in the ocean or in sub-surface geological reservoirs with additional potential impacts; alternatively, it could be converted to carbonates and bicarbonates. (*Section 5.2.5.1*)

38. **Ocean CO_2 storage will necessarily alter the local chemical environment, with a high likelihood of biological effects.** Effects on mid-water and seafloor ecosystems are likely through the exposure of marine invertebrates, fish and microbes to pH reductions of 0.1 - 0.3 units. Near-total destruction of deep seafloor organisms can be expected if lakes of liquid CO_2 are created. Chronic effects on ecosystems of direct CO_2 injection into the ocean over large ocean areas and long time scales have not yet been studied, and the capacity of ecosystems to compensate or adjust to such CO_2 induced shifts is unknown. (*Section 5.2.5.2.1*)

39. **Leakage from CO_2 stored in sub-seafloor geological reservoirs, though considered unlikely if sites are well selected, would have biodiversity implications for benthic fauna on a local scale.** CO_2 storage in sub-seafloor geological reservoirs is already being implemented at pilot-scale levels. Its effects on lithospheric microbial communities seem likely to be severe, but have not been studied (*Section 5.2.5.2.2*)

Social, economic, cultural and ethical considerations of climate-related geoengineering

40. **The consideration of geoengineering as a potential option raises many socio-economic, cultural and ethical issues, regardless of the specific geoengineering approach.** Such issues include global justice, the unequal spatial distribution of impacts and benefits, and intergenerational equity. Confidence in technological solutions, or alternatively risk-aversion, may be both highly differentiated across social groups and highly dynamic. (*Section 6.3*)

41. **Humanity is now the major force altering the planetary environment**. This has important repercussions, not only because it forces society to consider multiple and interacting global environmental changes, but also because it requires difficult discussions on whether it is desirable to move from (1) unintentional modifications of the Earth system, with implications that until a few decades ago we were unaware of; to (2) attempts to reach international agreement to reduce the actions causing the damage; and finally to (3) consideration of actions to deliberately modify global cycles and systems, to try to avoid the worst outcomes of climate change. (*Section 6.3.1*)

42. **The 'moral hazard' of geoengineering is that it is perceived as a technological fallback, possibly reducing effort on mitigation.** However, the opposite may also occur: when there is wider

knowledge on geoengineering, and its limitations and uncertainties, increased policy effort might be directed at emission reductions. Other ethical considerations include the question of whether it is acceptable to remediate one pollutant by introducing another. (*Section 6.3.1*)

43. **In addition to limiting the undesirable impacts of climate change, the large-scale application of geoengineering techniques is near-certain to involve unintended side effects and increase socio-political tensions.** While technological innovation has helped to transform societies and improve the quality of life in many ways, it has not always done so in a sustainable manner. Failures to respond to early warnings of unintended consequences of particular technologies have been documented, and it has been questioned whether technological approaches are the best option to address problems created by the application of earlier technologies. (*Section 6.3.2*)

44. **An additional issue is the possibility of technological, political and social "lock in"**, whereby the development of geoengineering technologies might also result in the emergence of vested interests and increasing social momentum. It has been argued that this path of dependency could make deployment more likely, and/or limit the reversibility of geoengineering techniques. To minimise such risks, research to assess the safety, feasibility and cost-effectiveness of geoengineering must be open-minded and objective, without prejudice to the desirability or otherwise of geoengineering implementation. (*Section 6.3.2*)

45. **Geoengineering raises a number of questions regarding the distribution of resources and impacts within and among societies and across time.** Access to natural resources is needed for some geoengineering techniques. Competition for limited resources can be expected to increase if land-based CDR techniques emerge as a competing activity for land, water and energy use. The distribution of impacts (both positive and negative) of SRM geoengineering is unlikely to be uniform – neither are the impacts of climate change itself. (*Section 6.3.4*)

46. **In cases in which geoengineering experimentation or interventions might have transboundary effects or impacts on areas beyond national jurisdiction, geopolitical tensions could arise** regardless of causation of actual negative impacts, especially in the absence of international agreement. As with climate change, geoengineering could also entail intergenerational issues: future generations might be faced with the need to maintain geoengineering measures in order to avoid termination effects that might be mostly caused by emissions from several decades earlier. (*Section 6.3.5*)

Synthesis

47. **The deployment of geoengineering techniques, if feasible and effective, could reduce the magnitude of climate change and its impacts on biodiversity. At the same time, most geoengineering techniques are likely to have unintended impacts on biodiversity, particularly when deployed at a climatically-significant scale, together with significant risks and uncertainties.** The nature of the unintended effects, and their spatial distribution, will vary among techniques; overall outcomes are difficult to predict. For several techniques, there would increases in land use change, and there could also be an increase in other drivers of biodiversity loss. (*Section 7.1*)

48. **There are many areas where knowledge is still very limited**. These include: (1) the overall effectiveness of some of the techniques, based on realistic estimates of their scalability; (2) how the proposed geoengineering techniques can be expected to affect weather and climate regionally and globally; (3) how biodiversity, ecosystems and their services are likely to respond to geoengineered changes in climate; (4) the unintended effects of different proposed geoengineering techniques on biodiversity; and (5) the social and economic implications, particularly with regard to geo-political acceptability, governance and the potential need for international compensation in the event of there being 'winners and losers'. Targeted research could help fill these gaps (*Section 7.3*)

49. **There is very limited understanding among stakeholders of geoengineering concepts, techniques and their potential positive and negative impacts on biodiversity.** Not only is much less information available on geoengineering than for climate change, but there has been little consideration of

the issues by indigenous peoples, local communities and marginalized groups, especially in developing countries. Since these communities play a major role in actively managing ecosystems that deliver key climatic services, the lack of knowledge of their perspective is a major gap that requires further attention (*Section 7.3*)

III. REGULATORY FRAMEWORK OF CLIMATE RELATED GEOENGINEERING RELEVANT TO THE CONVENTION ON BIOLOGICAL DIVERSITY

50. The key messages from the study on the regulatory framework of climate related geoengineering relevant to the Convention on Biological Diversity are presented below. The full report can be found in document UNEP/CBD/SBSTTA/INF/29.

The Conference of the Parties to the Convention on Biological Diversity, taking into account *the possible need for science based global, transparent and effective control and regulatory mechanisms*, requested a study to be undertaken on gaps in such existing mechanisms for climate-related geoengineering relevant to the Convention on Biological Diversity (decision X/33, paragraph 9 (m)). This request was made in the context of the CBD decision on geoengineering which provides guidance for Parties and other Governments to ensure, "*in the absence of science based, global, transparent and effective control and regulatory mechanisms for geoengineering*", that no climate-related geoengineering activities that may affect biodiversity take place, until certain conditions are met, with some exceptions for small scale research (decision X/33, paragraph 8(w)). (*Section 1.1)*[3]

51. **"Climate-related geoengineering" is a general term that encompasses several different geoengineering concepts, techniques or technologies.** The Conference of the Parties to the Convention on Biological Diversity, at its tenth meeting adopted a preliminary definition for climate-related geoengineering in 2010 and will further discuss the matter in 2012. In the study on the potential impacts on biodiversity, climate-related geoengineering is defined as a deliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change and/or its impacts through, *inter alia*, sunlight reflection methods or removing greenhouse gases from the atmosphere. However, there is no universal and uniform use of the term "geoengineering". Thus, the definition will need to be analysed for its suitability for governance in a normative context. (*Section 1.3*)

52. **The need for science-based global, transparent and effective control and regulatory mechanisms may be most relevant for those geoengineering concepts that have a potential to cause significant adverse transboundary effects, and those deployed in areas beyond national jurisdiction and in the atmosphere.** For example, injection of aerosols into the atmosphere would have transboundary effects that may be deleterious, while ocean fertilization would be carried out in areas that extend beyond national jurisdiction. Some activities such as afforestation, reforestation and terrestrial biomass production, when carried out within a single country, might be deemed to be adequately governed through domestic regulations. (*Section 1.3*)

53. **The existing regulatory framework includes general customary rules of international law and specific international treaties.** The rules of customary international law and other general principles of international law apply to all activities and therefore would, in principle, be relevant to geoengineering. In addition, some international treaties have provisions that may be relevant to particular categories of activities. (*Section 1.5*)

General rules of customary international law

54. **State responsibility describes the rules governing the general conditions under which a state is responsible for wrongful actions or omissions, and the resulting legal consequences**. Although the

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3 Information in parentheses indicates where full details, with references, can be found in the main report (UNEP/CBD/SBSTTA/16/INF/29).

rules on state responsibility provide a general framework for addressing breaches of international law, they do not address under which conditions geoengineering activities would be permitted or prohibited. They require a breach on an obligation without defining these obligations. States are not as such responsible for acts for private actors. However, a state might have to address private actors in order to fulfil its own obligation. A state could be in breach of an obligation if it fails to take necessary measures to prevent effects caused by private actors. (*Section 2.1*)

55. **All states are under a general obligation to ensure that activities within their jurisdiction or control respect the environment of other States or of areas beyond national jurisdiction or control**. This duty to respect the environment does not mean, however, that *any* environmental harm, pollution, degradation or impact is generally prohibited. The duty prohibits a state from causing *significant transboundary* harm and obliges a state of origin to take adequate measures to control and regulate in advance sources of such potential harm. States have to exercise “due diligence” before carrying out potentially harmful activities. What constitutes “due diligence” would largely depend on the circumstances of each case. Establishing state responsibility for any harm from a geoengineering activity would require that (i) the geoengineering activity can be attributed to a particular state and (ii) can be associated with a significant and particular harm to the environment of other States or of areas beyond national jurisdiction or control. (*Section 2.2*)

56. **States have the duty to carry out an environmental impact assessment for activities that may have a significant adverse impact in a transboundary context, in particular, on a shared resource**. Among others, the Convention on Biological Diversity includes a provision for environmental assessment in Article 14 that is referred to in its decision on geoengineering (decision X/33 8(w)). An environmental impacts assessment (EIA) is required in many domestic legal orders and the International Court of Justice has recently recognised that the accepted practice among states amounts to “a requirement under general international law”. Thus, where there is a risk that a proposed industrial activity may have a significant adverse impact in a transboundary context, the requirement to carry out an environmental impact assessment applies even in the absence of a treaty obligation to this effect. However, this does not necessarily extend to a requirement to undertake strategic environmental assessments. (*Section 2.3*)

57. **The precautionary principle or approach is relevant but its legal status and content in customary international law has not yet been clearly established, and the implications of its application to geoengineering are unclear.** Under the Convention, the precautionary approach has been introduced recognizing that “where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat”. This has been invoked in its decision on geoengineering which invites Parties and others to ensure (with some exceptions and until certain conditions are met) that no geoengineering activities take place (decision X/33 paragraph 8(w)). Under the London Protocol, Article 3.1 requires the application of the precautionary approach. Under the United Nations Framework Convention on Climate Change (UNFCCC), the precautionary approach is generally considered as intending to prevent states from postponing mitigation measures by referring to scientific uncertainty about climate change. However, an interpretation in support of geoengineering or pursuing further geoengineering research would not be evidently contrary to the wording. (*Section 2.4*)

58. **Other relevant general concepts include sustainable development, common but differentiated responsibilities, and concepts addressing international interest in the protection of areas beyond national jurisdiction and shared resources as well as issues of common concern such as biodiversity**. However the status of these concepts as customary international law is not clearly established. (*Section 2.6*)

Specific treaty regimes and institutions

59. **The Convention on Biological Diversity has adopted a decision on geoengineering that covers all technologies that may affect biodiversity.** The Convention contains many provisions that are

relevant but not specific to geoengineering, including provisions on environmental assessment. Additional relevant guidance has been developed under the Convention. The CBD decision on geoengineering invites Parties and others to ensure (with some exceptions and until certain conditions are met) that no geoengineering activities take place (decision X/33 paragraph 8(w)). The decision refers specifically to "the precautionary approach and Article 14 of the Convention. While not expressed in legally binding language, the decision is important for a global governance framework because of the wide consensus it represents. The Parties to the Convention have also recognized that while science-based global transparent and effective control and regulatory mechanism for geoengineering may be needed, they may not be best placed under the Convention. The Convention on Biological Diversity has referred to and incorporated the work of the London Convention and its Protocol (LC/LP) on ocean fertilization in its own decisions, thus widening the application of this work beyond the smaller number of Parties to the LC/LP. (*Section 3.1*)

60. **The United Nations Convention on the Law of the Sea (UNCLOS) sets out the legal framework within which all activities in the oceans and seas must be carried out, including relevant geoengineering activities**, such as ocean fertilisation, modification of downwelling and/or upwelling, maritime cloud albedo enhancement, and altering ocean chemistry through enhanced weathering. Under the Convention, States have the general obligations to protect and preserve the marine environment and to take all measures necessary to prevent, reduce and control pollution of the marine environment from any source, including pollution by dumping. While states are allowed to pursue a range of activities under the "freedom of the high seas", these activities must be exercised in accordance with the provisions of UNCLOS and with due regard for the interests of other States. Rules and standards established under LC/LP are considered to be relevant for the implementation of UNCLOS. (*Section 3.2*)

61. **The London Convention and its Protocol (LC/LP) have provided detailed guidance on ocean fertilization, as well as carbon storage, and are considering wider application to other marine geoengineering activities within their mandate. Disposal of CO_2 in the water column or on the seabed is not allowed under the London Protocol**. The LC/LP are global instruments that address marine pollution from dumping of wastes and other matter at sea. In 2010 the Parties adopted the "Assessment Framework for Scientific Research Involving Ocean Fertilization". This non-binding Assessment Framework, which has been recognized by the Convention on Biological Diversity, guides Parties as to how proposals they receive for ocean fertilization research should be assessed and provides criteria for an initial assessment of such proposals and detailed steps for completion of an environmental assessment, including risk management and monitoring. The LP has also adopted amendments to regulate CO_2 sequestration in sub-seabed geological formations supported by a risk assessment and management framework and additional guidelines. (*Section 3.3*)

62. **The UNFCCC and Kyoto Protocol have not addressed geoengineering concepts as such or its governance.**[4] The objective of both instruments as stated in Article 2 of UNFCCC is to stabilise greenhouse-gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Under these instruments, guidance has been developed that address afforestation, reforestation and enhancement of soil carbon. Beyond these techniques, the obligations on Parties to take measures to limit emissions and protect carbon sinks do not promote or prohibit geoengineering measures as such. (*Section 3.4*)

63. **The Vienna Convention for the Protection of the Ozone Layer requires Parties, *inter alia*, to take measures to protect human health and the environment against likely adverse effects resulting from human activities that modify or are likely to modify the ozone layer. The Montreal Protocol requires Parties to phase down certain substances that deplete the ozone layer.** Activities such as aerosol injection could raise issues under these agreements, particularly if they involve a substance covered by the Montreal Protocol. The Vienna Convention defines "adverse effects" as changes in the physical environment or biota, including changes in climate, which have significant deleterious effects on

4 However have addressed carbon capture and storage, which may have some relevance for CO_2 storage.

human health or on the composition, resilience and productivity of natural and managed ecosystems, or on materials useful to mankind. (*Section 3.5*)

64. **The Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) would only apply directly to geoengineering if it were used as a means of warfare.** The main substantial obligation is that listed parties “undertake not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party”. However, the Convention could be a possible source of ideas, concepts and procedures useful for addressing geoengineering. (*Section 3.6*)

65. **The deployment of shields or mirrors in outer space to reflect or block solar radiation would fall under Space Law.** The international legal regime regulating environmental aspects of outer space includes the Outer Space treaty, four other main treaties and several resolutions of the United Nations General Assembly. The Outer Space Treaty provides that experiments that “would cause potentially harmful interference with activities of other States” are subject to prior appropriate international consultation. Activities such as aerosol injection in the stratosphere would not be regarded as falling under the purview of space Law because they would be below 80 km. (*Section 3.7*)

66. **The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) prohibits CO_2 storage in the water column or on the seabed and has developed rules and guidance for the storage of CO_2 in geological formations under the seabed.** The amendments allowing sub-surface CO_2 storage were adopted in 2007 but have not yet entered into force. (*Section 3.9*)

67. **The Convention on Long Range Transboundary Air Pollution (LRTAP) may be relevant for geoengineering concepts such as aerosol injection, which introduce sulphur or other substances into the atmosphere.** It is a regional convention covering most states in Europe and North America. Although the LRTAP Convention requires parties to make efforts at limiting, gradually reducing and preventing air pollution including long-range transboundary air pollution”, the wording of these obligations and the definition of air pollution soften its content considerably. The same goes for the obligation on parties to develop policies and strategies for combating the discharge of air pollutants. These general obligations do not require specific legal measures to prevent air pollution or to restrict aerosol injection. Apart from this obligation, LRTAP requires the sharing of data on pollutants and stipulates procedural obligations that may apply to certain geoengineering activities. Several protocols under the LRTAP impose specific obligations to reduce sulphur emissions or transboundary fluxes, but at most only up to 2010. (*Section 3.10*)

68. The Antarctic treaty system would apply to geoengineering activities carried out in the Antarctic. (*Section 3.8*)

69. **Human rights law would be relevant if a particular geoengineering activity violates specific human rights.** Which human right could be impacted would depend on how a particular geoengineering activity would be carried out and which effects it might actually have. In addition, impacts on human rights might be justified in a particular case. Most human rights are not absolute and are subject to restrictions under certain conditions, e.g. that the restrictions are provided by law, address specific aims and are necessary to achieve a legitimate purpose. (*Section 3.11*)

70. **International institutions such as the United Nations General Assembly, United Nations Environment Programme (UNEP), World Meteorological Organization (WMO) and Intergovernmental Oceanographic Commission (IOC) of UNESCO are relevant to the governance of geoengineering**. The United Nations General Assembly has addressed ocean fertilization and could address additional issues related to geoengineering. It has also encouraged the further development of EIA processes. In 1980, UNEP developed guidelines on weather modification. The mandate of WMO covers meteorology, the atmosphere and hydrology and could, in principle, address sunlight reflection

methods. It has issued non-binding guidance on weather modification. UNESCO's IOC has assessed the potential impact of ocean fertilization. In addition, depending on the impacts and activity in question, states might argue that geoengineering activities constitute a threat to or breach of the peace or aggression under Article 39 of the Charter of the United Nations. However, the current state of knowledge concerning geoengineering reveals a great deal of uncertainty. In any event, the Security Council has wide discretion in determining whether the requirements of Article 39 of the Charter of the United Nations are met and deciding on its response. (*Section 4.2; Section 4.4; Section 4.5; Section 4.6; Section 2.5*)

71. **Research is generally not specifically addressed under international law as distinct from the deployment of technology with known impacts or risks, apart from special rules in certain areas**. In a few cases, certain types of research might be prohibited, for instance if it would encourage nuclear weapons test explosions prohibited by the Partial Test Ban Treaty or the Comprehensive Nuclear-Test-Ban Treaty. While the CBD decision on geoengineering invites Parties and others to ensure (until certain conditions are met) that no geoengineering activities take place, it excludes from this limitation small scale scientific research studies that are conducted in a controlled setting, scientifically justified and subject to prior environmental impact assessments (decision X/33 paragraph 8(w)). UNCLOS has provisions that address marine scientific research. The LC/LP assessment framework on ocean fertilization provides guidance that is applicable to research studies. A major gap concerns sunlight reflection methods. (*Section 5.1; Section 5.2*)

Gaps in the current regulatory framework

72. **The current regulatory mechanisms that could apply to climate-related geoengineering relevant to the Convention on Biological Diversity do not constitute a framework for geoengineering as a whole that meets the criteria of being science-based, global, transparent and effective.** While the CBD decision on geoengineering provides a comprehensive non-binding normative framework, there is no legally-binding framework for geoengineering as a whole. With the possible exceptions of ocean fertilisation experiments and CO_2 storage in geological formations, the existing legal and regulatory framework is currently not commensurate with the potential scale and scope of the climate related geoengineering, including transboundary effects. (*Section 6*)

73. **Some general principles of international law such as the duty to avoid transboundary harm, and the need to conduct an environmental impact assessment (EIA), together with the rules of state responsibility provide some guidance relevant to geoengineering.** However, they are an incomplete basis for international governance, because of the uncertainties of their application in the absence of decision-making institutions or specific guidance and because the scope and risks associated with geoengineering are so large-scale. As an overarching concept including several distinct concepts and technologies, geoengineering is currently not as such prohibited by international law. Specific potential impacts of specific geoengineering concepts might violate particular rules, but this cannot be determined unless there is greater confidence in estimates of such potential impacts. (*Section 6*)

74. **Some geoengineering techniques are regulated under existing treaty regimes, while others are prohibited**:

(a) **Disposal of CO_2 in the water column or on the seabed is not allowed under the LP**. It is also prohibited under OSPAR;

(b) **Ocean fertilization experiments are regulated under the LC/LP's provision on dumping and additional non-binding guidance including a risk assessment framework**; and

(c) **CO_2 storage in sub-surface geological formations is regulated under the LC/LP and the OSPAR Convention**. Further guidance has been developed under the UNFCCC based on IPCC assessments. (*Section 6.1*)

75. **Some other geoengineering techniques would be subject to general procedural obligations within existing treaty regimes, but, to date, no specific rules governing these particular techniques have been developed**:

(a) Storage of biomass in the ocean would be subject to the LC/LP and UNCLOS;

(b) Altering ocean chemistry through enhanced weathering would be subject to the LC/LP and UNCLOS;

(c) LRTAP might impose procedural obligations on the use of aerosols in the atmosphere; and

(d) Deployment of mirrors in space would be subject to space law (Outer Space Treaty). (*Section 6.1*)

76. **Most, but not all treaties, potentially provide for mechanisms, procedures or institutions that could determine whether the treaty in question applies to a specific geoengineering activity and address such activities**. In legal terms, the mandate of several major treaties or institutions is sufficiently broad to address some or all geoengineering concepts. However, this could lead to potentially overlapping or inconsistent rules or guidance. From a global perspective, the different regimes and institutions have different legal and political weight, depending, for instance, on their legal status, particular mandate or their respective levels of participation. (*Section 1.3; Section 6*)

77. **The lack of regulatory mechanisms for sunlight reflection methods is a major gap, especially given the potential for significant deleterious transboundary effects** of techniques such as stratospheric aerosols and maritime cloud albedo enhancement. In principle, existing institutions, such as the World Meteorological Organization have a mandate that could address such issues. (*Section 4.5; Section 6*)

78. **Most regulatory mechanisms discussed in the report were developed before geoengineering was a significant issue and, as such, do not currently contain explicit references to geoengineering approaches**. However, many of the treaties examined impose procedural obligations on geoengineering activities falling within their scope of application. Moreover, the international regulatory framework comprises a multitude of treaties, actual and potential customary rules and general principles of law, as well as other regulatory instruments and mechanisms that could apply to all or some geoengineering concepts. As a minimum, it is suggested that states engaged in geoengineering field activities have a duty to inform other states prior to conducting them e.g., as required in the London Convention/Protocol Ocean Fertilization Assessment Framework. Few rules provide for public participation beyond the representation of the public by delegates, except for the usual rules on observer participation in treaty regimes and institutions. The treaties examined provide few *specific* rules on responsibility and liability, but the International Law Commission's articles on state responsibility provide general rules in cases where geoengineering would be in breach of an international obligation. (*Section 1.3; Section 6*)

IV. IMPACTS OF CLIMATE RELATED GEOENGINEERING ON BIODIVERSITY: SOME VIEWS AND EXPERIENCES OF INDIGENOUS AND LOCAL COMMUNITIES AND STAKEHOLDERS

79. The key messages from the online forum on the views and experiences of indigenous and local communities and other stakeholders and the possible impacts of geoengineering techniques on biodiversity are presented below. The full report of the online discussion can be found in document UNEP/CBD/SBSTTA/16/INF/30.

80. **The lack of attention to and serious consideration of the contributions of indigenous peoples and local communities to addressing the issues related to anthropogenic climate change is an important gap.** In highlighting their contributions to reducing the impact of global climate change, indigenous peoples and local communities draw on their local experiences, and their traditional knowledge which is based on a detailed and holistic understanding of the interrelatedness of the physical,

biological, social and spiritual worlds. This holistic understanding of the environment is crucial to understanding the responses of indigenous peoples to issues such as geoengineering. For many indigenous peoples, these values and the possibility of added impacts brought about by new technologies are of immense concern as has been expressed through various statements by indigenous representatives at the international level.

81. **Various United Nations standards, including the United Nations Declaration of Indigenous peoples, emphasize the need for indigenous peoples to effectively participate in all matters that may impact upon them and yet there has been little participation in discussions around geoengineering.** Indigenous peoples approached individually have responded by saying they have not looked into the issue or that they are not experts in the area. More capacity-building is needed; culturally relevant capacity-building and information on these issues remains at best scant. The reliance on reports by the NGO community highlights the lack of expertise and availability of reports generated on new technologies by indigenous peoples themselves.

82. **However, the consistency with which indigenous peoples highlight the importance of their values relative to understanding specific technologies deserves specific examination.** It is necessary for decision makers and scientists to understand the wider multidisciplinary concerns expressed by indigenous peoples, to root their geoengineering proposals within this broader framework and to set aside part of their investigation to understanding how to incorporate a holistic approach into their work.

83. **Guidance relevant to geoengineering already exists albeit in the form of voluntary CBD agreements.** These include the Voluntary Guidelines for the Conduct of Cultural, Environmental and Social Impact Assessment regarding Developments Proposed to take place on, or which are Likely to Impact on, Sacred Sites and on Lands and Waters Traditionally Occupied or Used by Indigenous and Local Communities, as well as the recently adopted Tkarihwaié:ri Code of Ethical Conduct on Respect for the Cultural and Intellectual Heritage of Indigenous and Local Communities Relevant for the Conservation and Sustainable Use of Biological Diversity. Also, principles including the precautionary approach contained in principle 15 of the Rio Declaration on Environment and Development and in the preamble to the Convention on Biological Diversity are of utmost importance in approaching geoengineering proposals. The precautionary principle would require that the prediction and assessment of potential harms to biological diversity by geoengineering proposals should include local criteria and indicators, and should fully involve the relevant indigenous and local communities. Discussions continue about the need for more stringent and enforceable guidelines.

84. **Geoengineering has received little support from indigenous and local communities who are acknowledged as being among the world's most vulnerable populations to climate change.** Indigenous participants have called for greater involvement of indigenous and local communities in the development of proposals for geoengineering. Not all indigenous and local communities have called for a total ban or for modeling work or controlled in-laboratory experimentation to cease. In fact, some see it as useful in further understanding the complexities of the Earth's ecosystems and in better understanding the potential benefits and harms of geoengineering proposals. On the other hand, there is certainly a strong reluctance to see geoengineering experiments being carried out on a significant scale in the natural world.

85. **Understanding geoengineering impacts from indigenous perspectives is an issue that requires further exploration.** Further efforts are needed to broaden outreach through short and accessible information on geoengineering and relevant international frameworks and for the collection of views through in-depth interviews with indigenous climate change experts.
