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Options and Proposals for the International Governance of Geoengineering

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Options and Proposals for the International Governance of Geoengineering

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Abstract

The debate about geoengineering as a potential option for climate policy is gaining attention at the policy interface. In this research project for the German Federal Environment Agency, Ecologic Institute develops specific proposals for the governance of the main currently discussed geoengineering concepts at the international level. Based on a comprehensive analysis of the existing regulatory framework and its gaps, the study identifies general options and specific recommended actions for the effective governance of geoengineering. A key consideration is that the recommendations can be implemented in practice. First, the study explores whether and to what extent it is useful and feasible to have a single definition of geoengineering for governance purposes. It then analyses the existing governance of geoengineering in international law, with a brief overview of EU and German law. On this basis, it develops specific regulatory options and proposals. We analyse why governance of geoengineering should be pursued and develop specific proposals how such governance should be designed. We first make explicit the objectives and functions that governance of geoenginering is to fulfil. The geoengineering debate for the most part has not addressed this issue. Second, we derive core elements of appropriate governance design from these objectives and criteria. Third, we assess which geoengineering techniques require international governance on the basis of the objectives and criteria. Fourth, we identify governance gaps where the existing international framework does not correspond to our proposed core governance elements. Fifth, we make proposals to fill the governance gaps.

Kurzbeschreibung

Die Diskussion um Geoengineering als mögliche Option der Klimapolitik gewinnt zunehmend Aufmerksamkeit an der Schnittstelle zwischen Wissenschaft und Politik. In diesem Forschungsprojekt für das Umweltbundesamt entwickelt das Ecologic Institut konkrete Vorschläge für die Governance der gegenwärtig diskutierten Geoengineering-Konzepte auf internationaler Ebene. Auf Grundlage einer umfassenden Analyse des bestehenden Regelungsrahmens und seiner Lücken entwickelt diese Studie allgemeine Optionen und konkrete Handlungsempfehlungen für die wirksame Governance von Geoengineering. Ein zentrales Anliegen ist, dass die Empfehlungen praktisch umsetzbar sind. Die Studie erörtert zunächst, ob und inwieweit es sinnvoll und durchführbar ist, eine einzige Definition von Geoengineering als Grundlage von Governance zu nehmen. Sie untersucht die bestehende Governance von Geoengineering im internationalen Umweltrecht, und gibt einen kurzen Überblick des EU und deutschen Rechts. Auf dieser Grundlage entwickelt sie konkrete Regulierungsoptionen und -vorschläge. Wir analysieren, warum Governance von Geoengineering angestrebt werden sollte, und entwickeln konkrete Vorschläge, wie solche Governance gestaltet werden sollte. Wir legen zuerst ausdrücklich die Ziele und Kriterien dar, die die Governance von Geoengineering erfüllen soll. Die bisherige Diskussion zu Geoengineering hat sich meist nicht damit befasst. Zweitens leiten wir aus diesen Zielen und Kriterien Kernelemente einer angemessenen Governancestruktur ab. Drittens bewerten wir auf Grundlage der Ziele und Kriterien, für welche Geoengineering-Konzepte internationale Governance erforderlich ist. Viertens identifizieren wir Regelungslücken, wo der bestehende internationale Regelungsrahmen nicht den von uns vorgeschlagenen Kernelementen der Governance entspricht. Fünftens machen wir Vorschläge, wie diese Governancelücken auszufüllen sind.

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List of Abbreviations

ABS	Access and Benefit-Sharing from genetic resources
ATS	Antarctic Treaty System
CBD	Convention on Biological Diversity
CCD	Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CDR	carbon dioxide removal
CEOS	Committee on the Earth Observation Satellites
CFREU	Charter of fundamental rights of the European Union
CMP	Conference of Parties serving as the Meeting of Parties
CMS	Convention on Migratory Species
COP	Conference of Parties
COPUOS	Committee on the Peaceful Uses of Outer Space
COSPAR	Committee on Space Research
DNA	
ECI	European Court of First Instance
ECJ	European Court of Justice
EEZ	exclusive economic zone
EEZ	exclusive economic zone
ENMOD Convention	Convention on the Prohibition of Military Use of Environmental Modification Techniques
ETC Group	Action group on Erosion, Technology and Concentration
EU	European Union
FAO	Food and Agriculture Organisation
GG	Grundgesetz
IADC	Inter-Agency Space Debris Coordination Committee
ICAO	International Civil Aviation Organization
ICJ	International Court of Justice
IISL	International Institute of Space Law
ILA	International Law Association
ILC	United Nations International Law Commission
IMO	International Maritime Organisation
IPCC	Intergovernmental Panel on Climate Change

ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
ITU	International Telecommunication Union
KP	Kyoto Protocol to the United Nations Framework Convention on Climate Change
LC	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter
LP	Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter
LULUCF	Land use, land-use change and forestry
MARPOL	International Convention for the Prevention of Pollution from Ships
MEA	Multilateral Environmental Agreement
NGO	Non-governmental organisation
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PSSA	Particularly Sensitive Sea Area
Ramsar Convention	Convention Convention on Wetlands of International Importance
REDD+	Reducing Emissions from Deforestation and Forest Degradation "plus" conservation
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice
SEA	Strategic Environmental Assessment
SEA Protocol	Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context
SRM	solar radiation management
TFEU	Treaty on the functioning of the European Union
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCLOS	United Nations Convention on the Law of the Sea
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	United Nations General Assembly
US GAO	United States Government Accountability Office
WHO	World Health Organisation
WIPO	World Intellectual Property Organization
WMO	World Meteorological Organization
WTO	World Trade Organization

1 Summary

The debate about geoengineering as a potential option for climate policy is gaining attention at the policy interface. For several years the feasibility, risks and desirability of geoengineering (also referred to as climate engineering) have been discussed mainly within the science community. Today, while many geoengineering techniques are at the conceptual or modelling stage, there have also been field experiments followed by an emerging public debate. These developments raise the question of whether a governance framework for geoengineering is needed over and above the current framework, and what it should look like. In this research project for the German Federal Environment Agency, Ecologic Institute develops specific proposals for the governance of the main currently discussed geoengineering concepts at the international level. Based on a comprehensive analysis of the existing regulatory framework and its gaps, the study identifies general options and specific recommended actions for the effective governance of geoengineering. A key consideration is that the recommendations can be implemented in practice.

The question of governance encompasses more than binding legal rules. In this sense, our understanding of “governance” is broader than “regulation”. We also include formal and informal, implicit and explicit processes, procedures and institutions. Governance, meant in this broader sense, is not necessarily restrictive. It can also provide legal certainty and political legitimacy, or fulfil pragmatic functions such as coordination.

The study has three main parts: After the introduction, section 4 explores whether and to what extent it is useful and feasible to have a single definition of geoengineering for governance purposes. section 5 analyses the existing governance of geoengineering in international law, with a brief overview of EU and German law. On this basis, section 6 develops specific regulatory options and proposals. We analyse why governance of geoengineering should be pursued and develop specific proposals how such governance should be designed. The key results of these three parts are summarised in this section.

1.1 Definition of geoengineering

Affixing a precise definition to geoengineering presents a challenge, as common usage of the term encompasses a wide range of dissimilar techniques with varying methodologies, levels of risk, and feasibility. A definition of geoengineering can be sought for different purposes and carries political and social implications. Without a clear notion of the political objectives and regulatory purpose, proposing a regulatory definition could in essence put the cart before the horse.

Typically, geoengineering techniques are subdivided into overarching categories of either carbon dioxide removal (CDR) or solar radiation management (SRM). The CDR category includes techniques that are intended to remove CO_2 from the atmosphere and therefore one of the main contributors to climate change. CDR techniques involve two steps: removal of CO_2 from the atmosphere and subsequent long-term storage of the captured CO_2 in order to take it out of circulation for a climatically relevant period. Several techniques are being discussed for each step. SRM techniques aim at changing the earth’s energy balance by reducing the incidence and subsequent absorption of short-wave solar radiation. There is no consensus as to the full scope of activities that ought to be included under these categories and as geoengineering, and a number remain subject to debate, e.g. afforestation and carbon capture and storage.

Contemporary definitions have evolved over time and share commonalities, although there is no standard or uniform use. However, the majority of existing geoengineering definitions share the same primary elements of activity, purpose, intent, and scale. The purpose of including "intent" and "purpose" as a requirement is to be exclusive, eliminating activities where the resulting climate impacts are e.g. cumulative or perceived to be collateral, or have climate-warming impacts. However, from a normative perspective it is questionable why the same activity would be or would not be considered geoengineering, merely because it serves a certain subjective purpose or not - the impacts are the same. In addition, it is not clear why some definitions use *both* intent and purpose. Conventional definitions identify geoengineering as "large" in scale, relating to more to the magnitude of impacts, but also to the size of the efforts, although altering the climate would more than likely necessarily entail a sizeable level of activity. However current definitions mostly fail to specify a standard of measurement for what is "large."

While all existing definitions have strengths and weaknesses, the definition developed by an expert group in the impact study for the CBD appears to the most convincing to date: *"A deliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change and/or its impacts."* However, the definition has weaknesses that would make it insufficient for a regulatory purpose if applied by itself.

Alternatively, geoengineering could be preliminarily defined as: "Activities designed and undertaken with the purpose of producing environmental change on a regional or global scale, primarily for counteracting anthropogenic climate change or reducing its warming impacts, through, inter alia, removal of greenhouse gases from the atmosphere or reducing solar insolation."

We suggest that *any* definition, including the CBD's, that is used as a basis for a regulatory purpose would have to be complemented by further details on determining and measuring broad terms such as scale. This can be achieved in several ways. One approach, also addressing the difficulty of crafting a sufficiently broad definition to cover a wide range of methods, would be to complement the definition with a positive list that expressly mentions specific techniques -or activities- which are considered geoengineering. Such a list could be comprehensive and absolute, or left open, allowing for adaptation and interpretation as new methods and scenarios develop. Another, supplementary option is to envisage a process or institution providing further guidance in advance or on a case by case basis.

1.2 The existing legal framework

1.2.1 International Law

Besides the established traditional sources of international law, this study also looks at instruments and governance tools that may be not binding in the strict sense, but that provide politically or legally relevant guidance to states. In particular, it includes relevant institutions and quasi-legislative treaty bodies such as regular meetings of the Parties, depending on their mandate.

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. However, it might be difficult to show which precise effects resulted from the particular geoengineering activity and which harm it caused. In addition, although the obligation to respect the environment requires a due diligence standard on a case by case

basis, it is not clear which degree of environmental harm would constitute a breach, and which measures states are required to take in order to prevent environmental harm. It would also be legally difficult to demand provisional measures on the basis of a potential future breach of this obligation before the geoengineering activity has already taken place.

There is no uniform formulation or usage for the precautionary principle and its legal status in customary international law has not yet been clearly established. Conceptual legal uncertainties as well as its openness regarding content make it difficult to draw conclusions without imputing desired outcomes. From one point of view, scientific uncertainty is a reason to refrain from or slow down potentially harmful activities such as geoengineering. From another perspective, scientific uncertainty regarding geoengineering should not be used as a reason to restrict geoengineering as a potential tool for helping to address global warming. Recourse to the precautionary principle as a legal rule does not resolve the conflict between the objectives of avoiding the effects of global climate change *vis-à-vis* avoiding the risks of geoengineering. All the common ground it can currently provide is to establish interpretative guidance and procedural safeguards for dealing with scientific uncertainty. At least in the current state of international law, the precautionary principle does not provide a sufficient legal tool for making essentially political decisions about conflicting objectives and managing risks.

Several treaties and international documents relevant to geoengineering contain an obligation or a reference to carrying out environmental assessments. The LC/LP's rules on ocean fertilisation are complemented by additional non-binding guidance including a risk assessment framework, which provides detailed steps for completion of an environmental assessment. The ICJ has recently recognised that the accepted practice amongst states amounted to a general "requirement under general international law to undertake an environmental impact assessment where there is a risk that the proposed industrial activity may have a significant adverse impact in a transboundary context, in particular, on a shared resource". While the ICJ left it to the states to determine the specific content of the impact assessment required, it specified some details, most notably including that the obligation involves continuous monitoring of the activity's effect on the environment.

Unless there are specific rules taking precedence, the rules on state responsibility apply to all existing or new obligations regarding geoengineering and provide a general framework for determining the legal consequences of breaches. It is unclear whether a state could avoid responsibility by relying on circumstances precluding wrongfulness, in particular necessity. The ILC Articles on State Responsibility do not include institutions or procedures to enforce these obligations. In addition to the rules on state responsibility, the ILC has also pursued concepts addressing harmful effects of hazardous acts that do *not* contravene international law. However, at this stage these proposals do not amount to customary law and it remains to be seen to what extent they could influence legal aspects of geoengineering.

Although under the general rules on state responsibility states are generally not responsible for the conduct of private actors, a state may be responsible for its own conduct in relation to the conduct of private actors if it failed to take necessary measures to prevent the conduct or its effects. Whether and to what extent a state has an obligation to take such measures depends on the obligation in question and the particular case.

Other concepts mentioned in the environmental debate are e.g. sustainable development and inter-generational equity. Although these and other concepts are frequently mentioned in key instruments and documents, there is no consensus about their legal status and precise content.

The ENMOD Convention is a special case, as it addresses large scale modifications of the environment, albeit in the context of international humanitarian law. Although the ENMOD Convention is not directly applicable in peacetime and was not designed to govern contemporary geoengineering technologies, it is argued that some of its concepts could be considered and useful in addressing geoengineering governance.

Besides decisions on ocean fertilisation, the CBD has also addressed reengineering *in general* in two COP decisions 2010 and 2012. Decision X/33 of 2010, para 8(w) appears to be the only all-encompassing governance measure at this level to date: Although the CBD geoengineering decision is not binding, it represents the consensus of 193 parties - albeit not including the US. As a result of political compromise, the language of the decision text is not entirely clear. The core of the operative part of paragraph 8(w) is the guidance that no climate-related geo-engineering activities that may affect biodiversity take place. It is difficult to imagine geoengineering activities that reach a scale sufficiently large to fulfil the definition, but do not have any effect on biodiversity. The decision thus covers all geoengineering techniques currently discussed.

The CBD decision's intended restriction of geoengineering appears to be subject to three provisos: First, the operative part as a whole is worded as a transitional measure intended to apply "in the absence of science based, global, transparent and effective control and regulatory mechanisms for geoengineering". Second, the restriction is to apply "until there is an adequate scientific basis on which to justify" geoengineering activities, which includes a comprehensive risk assessment. Third, it exempts small-scale scientific research studies, provided that they fulfil certain conditions. With regards to implementation, it appears to be subject to the determination of each Party whether the conditions for the second and third proviso are met.

The subsequent CBD COP decision XI/20 of 2012 does not add normative content over and above decision X/33. It might be regarded as a step backwards in terms of clarity, but it makes small steps towards providing elements of a governance framework. Besides the on-going debate on semi-legal and *de facto* implications of COP decisions within treaty regimes, the decisions also send a political signal that would be difficult to ignore in practice, solely on the grounds that they are not binding.

In accordance with the terms of reference, ocean fertilisation is not addressed in the legal analysis of specific geoengineering techniques, but we include it in our analysis of governance options, because the existing regulatory efforts on this area provide an important precedent and potential governance model.

Stratospheric aerosol injection: It can reasonably be argued that stratospheric aerosol injection by introducing H_2S and SO_2 into the stratosphere is at present not as such prohibited or significantly restricted by the main international treaties governing the emission of those substances. Although the impacts of this geoengineering technique could also be addressed under international law in the area of biodiversity protection, the obligations of the relevant treaties do not establish clear and precise obligations that would allow for determining potential infringements in abstract at this stage.

Cloud brightening from ships: The Ozone Convention, even though potentially applicable, does not impose practically significant restrictions on cloud brightening from ships. UNCLOS provides the most pertinent rules, but for activities in the EEZ refers to the resolution of conflicts in each individual case. As for the high seas, it is arguable but not clear that cloud brightening would fall under the UNCLOS provisions against marine pollution. The LP does not prohibit cloud brightening as long as sea water vapour is used and does not constitute dumping.

Desert reflectors: The mostly local and regional impacts of desert reflectors could contravene international law for the protection of biodiversity, habitats etc. As these potentially applicable rules quite unspecific, an assessment would have to be made in each individual case considering the scale of the desert reflectors, causation and the actual specific legal content of e.g. the Cod's obligations.

Installations in outer space: International space law was developed without consideration of geoengineering, and does not prohibit it as such. However, certain general obligations and restrictions would generally apply to space-based geoengineering as to other space activities. These are mostly procedural in nature, such as duties to co-operate and give due regard to the interests of other states in the use of the outer space. In respect of environmental obligations and liability, not all potential side-effects and consequences associated with space-based geoengineering techniques, to the extent that they can be anticipated at this stage, are covered by space law.

Carbon capture and storage: Although it is controversial whether CCS should qualify as geoengineering, a number of risks associated with CCS are similar to other geoengineering concepts and on this basis it is conceivable to assess it in the same context. As to CCS *on land*, there is no international legal regime that specifically addresses CCS. However, CCS plays a role in the UNFCCC process and has recently been included into the Clean Development Mechanism (CDM) under Kyoto Protocol's flexible mechanisms. This development is controversial because the general acceptance and incentive for CCS through the CDM does not promote reducing the *production* of CO_2 . CCS *in the oceans* is not explicitly prohibited by UNCLOS, but could fall under rules established for "dumping" activities under sectoral treaties such as LC and LP. Since 2007 sub-seabed storage has been generally allowed under certain conditions under the LP. The same goes for an amendment to the OPSAR Convention of 2007. An LP amendment of 2009, that has not entered into force yet, allows parties under certain conditions o share sub-seabed geological formations for CCS projects. By conclusion *e contrario*, CO_2 storage *on* the seabed and in the water column is not allowed under the LC and the OSPAR Convention. The same goes for the LC, unless the parties provide interpretative guidance to the contrary.

Ocean liming is not directly addressed under current international law regimes. However, the technique may be subject to provisions governing protection of the marine environment and ocean dumping under UNCLOS, the LC and LP, and the OSPAR Convention. The former would depend largely upon whether the activity is, on the whole, considered either detrimental or beneficial to the marine environment according to the treaty provisions. However, it is not clear whether the activity would qualify as "dumping" and thus fall under the corresponding rules. Other treaties may apply where transboundary impacts or harm to biodiversity incur, or in specially protected areas.

Ocean sequestration of biomass is not directly addressed under current international law. Generally the same considerations as for ocean liming apply. Apart from cross-cutting general rules, international law does not prohibit the production of biomass materials.

Biomass and biochar: Apart from cross-cutting general rules, international law does not prohibit the production of biomass, of biochar, or the application of biochar on soil as such. The same goes for the considerable large-scale land use changes that might occur in order to produce and apply the necessary amount of biomass and biochar. Although such land use or land use changes do not seem to be as such prohibited or restricted by international law, they could indirectly conflict with rules requiring to the protection of biodiversity, ecosystems and habitats, rules protecting previous land use, and human rights relating to land-use change. Whether and to what extent such rules could apply would depend on which biomass and

biochar are produced, to what extent this actually involves land use change, as well as where and how.

Enhanced weathering: Similar to geoengineering by biomass and biochar production and storage, enhanced weathering in the form of spreading base minerals mainly has land-use change impacts. And similar to ocean liming, this technique would require a considerable amount of mining in order to procure the minerals, plus transporting the minerals to the soil. The legal framework is similar to that applying to biomass and biochar: General rules apply, but the use or land use change relevant for enhanced weathering is not prohibited as such. However, there could be conflicts with previous or actual land use, and with rules e.g. on the protection of biodiversity, depending on impacts in each case.

Carbon capture from air (‚artificial trees‘): Given the expected local implementation and low impacts, there appear to be no requirements in international law of specific interest for geoengineering by artificial trees. However, international law could become relevant when a carbon capture, e.g. in cumulative deployment, has potential transboundary impacts. The applicable rules would presumably be the general and cross-cutting rules on discussed in other sections. Air capture installations could generally be regarded as carbon sinks and potentially be addressed by the UNFCCC regime.

1.2.2 Conclusions on existing international governance

Geoengineering is currently not as such prohibited by international law. The main legal studies so far show an emerging consensus that -details aside- existing international law hardly addresses the potential impacts of geoengineering or related key questions. Most of international law was developed before geoengineering was a significant issue and, as such, does not currently contain explicit references to geoengineering approaches. There is minimal common legal ground regarding *general* cross-cutting legal rules and principles that apply to all states and all geoengineering concepts. Their content is not specific enough to provide clear guidance as to specific geoengineering techniques. Potential application of *specific* rules and provisions to geoengineering would inter alia depend on specific actual or potential impacts of the activity, depending on the rule in question. Whether such impacts would actually occur is difficult to assess or predict at this stage. Virtually all treaties examined impose *procedural obligations* on geoengineering activities falling within their scope of application.

In legal terms, the mandate of many international regimes and institutions would allow them to address geoengineering, or some aspects of it, even if they have not done so to date. This raises questions regarding different treaties or institutions potentially competing for addressing geoengineering with overlapping or inconsistent rules or guidance. Recent developments under the LC/LP and the CBD have produced pertinent rules specifically on geoengineering in general or particular techniques. Most of these rules have been adopted in the form of decisions by treaty bodies and are not binding in the strict legal sense, although there are proposals for binding amendments under the LP. These developments do not mean that the question of whether and how to consider international geoengineering governance is resolved.

1.2.3 European Law and German Law

Except for CCS, so far there is no explicit regulation of geoengineering in EU law or in German law. However, existing environmental rules and standards of EU and German law do already apply to geoengineering techniques to some extent. General provisions of EU and German law applicable to each of these techniques include the precautionary principle, the principle of the

protection of the environment, basic individual rights including the right to freedom of research.

The injection of large amounts of sulphate aerosols into the stratosphere above Member States´ territory is permissible as long as it does not substantially contribute to exceeding the national emission ceiling according to Directive 2001/81/EC and the 39th Federal Immission Control Ordinance transposing the Directive into German law. This depends on the amount of SO_2 injected into the stratosphere. However, the discharge of substances as sulphate aerosols out of or from aircraft is generally forbidden by section 7 (1) of the Federal Air Traffic Ordinance, but may be allowed for if any danger for human safety or property is excluded.

The rules on CCS are more developed, both technically and legally, than other CDR techniques. CCS is regulated by the CCS Directive including amendments to other Directives, which as of yet have been transposed to German law only to a small extent.

Air capture installations are not included in the annexes of EU and German legislation governing installations subject to licensing, but are regulated by the rules of the Federal Immission Control Act concerning installations not subject to licensing, especially the obligation to be able to dispose of the produced waste in a proper way. However, this may not be sufficient to adequately cover the pollution risks of the chemicals involved in the process.

Biomass and biochar techniques are regulated to some extent by EU and German legislation on installations as well as legislation concerning the deposition of biomass into or on soils. With the exception of charcoal made of wood which has not been treated chemically, there is no sound legal basis for the use of biochar as fertiliser. Biomass disposal without fertilising effect is generally not permissible according to EU and German Waste laws.

The increase of the pH value of waters as a result of enhanced weathering might interfere with EU and German legislation on waters requiring the preservation or attainment of a good ecological and chemical status of surface waters. Further analysis is also required to assess the conformity of this technique with Federal soil legislation.

1.3 Regulatory options and proposals

Academic and political discussion on geoengineering governance should be based on <u>explicit</u> objectives and criteria that any proposed governance arrangements are meant to pursue, balance and fulfil. While there is no shortage of proposals concerning international governance arrangements, the assumptions, rationales and goals to be pursued by them have hardly been made explicit. There is no obvious panacea for the international governance of geoengineering and no obviously superior set of objectives and criteria. We suggest, however, that making the criteria and objectives explicit is necessary in order to facilitate a debate about such goals and rationales, which present an important guideline for designing feasible, effective and appropriate governance arrangements. It is also important to disaggregate the debate into objectives and means of governance that are available for achieving these objectives.

In this study, we first make explicit the objectives and functions that governance of geoengineering is to fulfil. The geoengineering debate for the most part has not addressed this issue. Second, we derive core elements of appropriate governance design from these objectives and criteria. Third, we assess which geoengineering techniques require international governance on the basis of the objectives and criteria. Fourth, we identify governance gaps where the existing international framework does not correspond to our proposed core governance elements. Fifth, we make proposals to fill the governance gaps.

We therefore suggest a set of explicit objectives and criteria of international governance arrangements. In this respect, three overarching objectives can guide us:

a) to avoid negative transboundary environmental and health risks and impacts;

b) to avoid political tension and conflicts, in particular resulting from unilateral action, as well as legal disputes; and

c) as a more technical matter, to coordinate scientific research.

In addition, and on this basis, we suggest that the international governance of geo-engineering should be guided by the following more concrete criteria:

a) It should implement a precautionary approach in respect of the risks of geoengineering;

b) It should facilitate broad international participation and acceptance;

c) It should avoid or at least minimize any direct or indirect undermining of climate mitigation efforts;

d) It should aim at a high level of legitimacy, including through (public) participation and transparency, in particular with respect to (i) general rule-making, (ii) case-specific decision-making on any proposed concrete geoengineering activity in the field, and (iii) any actual permitted geoengineering activity, e.g. through monitoring and reporting; and

e) It should allow for a sufficient level of flexibility in order to be able to respond to new scientific knowledge as well as the evolving public debate on geoengineering.

We base our thinking about appropriate arrangements for the international governance of geoengineering on these criteria and objectives, bearing in mind the potential for trade-offs between them, especially as regards international participation and acceptance.

In view of these objectives and criteria, in particular two types of geoengineering techniques pose significant direct risks of transboundary effects (i.e. effects on other countries or areas beyond national jurisdiction) and, consequently, political tension, and thus are in need of international governance: marine techniques such as ocean fertilisation or ocean liming, and atmospheric solar radiation management such as injection of sulphate aerosols into the atmosphere. Other techniques, in particular those encapsulating or removing carbon from the atmosphere, such as "artificial tress" or enhanced weathering, would not appear to have similar transboundary effects. The international governance of marine geoengineering techniques and solar radiation management techniques thus deserves, according to current knowledge, priority attention.

As regards the normative approach, we recommend a general prohibition of geoengineering activities that entail significant transboundary risks, combined with the possibility of exemptions. The prohibition would in principle also apply to research activities such as field experiments, but not to e.g. modelling (on research see also below). In general, there is a broad range of binding and non-binding tools, instruments and legal techniques to choose from, with the general approach ranging from a general prohibition (with exemptions) to a general permission (with specific restrictions). A general prohibition with exemptions on the basis of clear criteria would best reflect a precautionary approach in (i) minimizing environmental and health risks, including minimising the risk of undermining climate mitigation efforts, as well as (ii) defusing the potential for international conflicts and disputes. This overall approach could be specified as follows:

a) Clarity on which activities are prohibited could best be achieved by a positive list of the geoengineering techniques covered by the prohibition. Although an overall definition covering *all* geoengineering techniques might be useful as a political and normative reference point, it would inevitably be vague and would, on its own, not provide sufficient normative certainty. In order to build in flexibility and as guidance to states, the governance regime could provide a non-exhaustive list of the criteria used in establishing the prohibition and determining its scope in combination with a regular review of the positive list.

b) The clear framing of the exemptions should enable legitimate research to proceed (see below) and thus facilitate international acceptance of the governance approach. Exemptions should be granted based on a transparent decision-making process applying strict and clear criteria.

c) Decision-making on both the positive list of prohibited geoengineering activities (including its review) and exemptions (including applicable criteria) should facilitate broad participation in decision-making. Depending on the circumstances, a non-binding approach could be considered with a view to its evolving into binding law over time.

This approach does not necessarily mean that the actual decision-making needs to be centralised at the *international* level. For instance, the general prohibition and the criteria for exemptions could be stated at the international level, while leaving implementation of the corresponding rules, standards and procedures, including case-specific decisions to the national level. Such a vertical division of labour could facilitate acceptance and address concerns about international micro-management. At the same time, it would require appropriate structures at the international level for reporting and monitoring of national-level decisions and activities.

We suggest that the governance of geoengineering research best be integrated into the general governance arrangements. Research in the form of field experiments or other activities in the real world should *not* be addressed separately from, and earlier than, any "deployment" of geoengineering techniques. Such a separation of governance structures (and implied sequencing of their elaboration) seems problematic and non-advisable because (1) there is no clear-cut separation of the application of geoengineering techniques “for research” from the application “for other purposes” and (2) any such separate governance structures for research would be likely to provide an important precedent and blueprint for the governance of deployment (for other purposes). In our design, research would fall within the scope of and be integrated into the general governance and the prohibition, but it could proceed on the basis of case-specific exemptions, based on an environmental impact assessment, independent expert advice, and provided it implies a small-scale intervention only. This approach would not restrict or stifle research beyond what is necessary to minimise the risks that are posed by research activities in the same way as by any geoengineering activities for other purposes. At the same time, our approach could enhance transparency and legitimacy of research activities.

Existing international institutions only partially cover the issue area of geoengineering and fall short of providing a comprehensive governance framework that fulfils the objectives and criteria mentioned above and our normative approach. The LC/LP has developed a soft-law approach for the governance of geoengineering regarding marine techniques and is in the process of further developing this system and providing a more stable framework under international law. The normative approach pursued seems to be largely in line with the "general prohibition with exemptions" approach advocated here. However, the current proposals have yet to be adopted and enter into force. There might also be concern about

whether the procedures and assessments are over-burdensome and the conditions difficult to satisfy in practice. Generally, the LC/LP is a comparatively small regime and the framework is limited to marine geoengineering techniques. The same is true for the limited activities under OSPAR, which are also limited in their regional scope. In part building on the approach of the London Convention/London Protocol, the CBD has developed some broader guidance and has served as a forum for more general discussions on geoengineering and its governance. The CBD framework does, however, not yet provide a stable basis and is not yet generally recognised as a or the central institution for discussing international governance of geoengineering. At the same time, other international institutions have hardly addressed geoengineering to a significant extent yet. This is a significant gap in particular regarding SRM techniques, especially atmospheric SRM such as aerosol injection.

Therefore, current international governance of geoengineering is characterised by the involvement of several institutions - mainly CBD, LC/LP and OSPAR. They form the beginning of an institutional complex with significant gaps/shortcomings and with an emerging inter-institutional division of labour in need of further clarification. First, the institutional landscape does not yet provide for a central institution that is clearly recognised as the central point of contact, providing the opportunity for actors to discuss crosscutting issues, develop overarching guidance (across other relevant institutions) and raise emerging issues; developing general principles and perspectives, and facilitating the exchange of information. Second, the existing institutional complex lacks regulation of SRM techniques. Increased regulatory capacity in international geoengineering governance also raises the question of how appropriate scientific input into decision-making can be provided. In addition, if geoengineering field experiments were to increase in number and scale, there would be scope for better international coordination of research and related exchange of information.

Our discussion of options for filling these governance gaps and for progressing towards a coherent and encompassing structure for international geoengineering governance is further premised on the following considerations: First, we focus on the use of existing institutions, rather than the creation of new ones, for reasons of “institutional economy” and because, in our assessment, international discussions on geoengineering have not yet reached a level that would likely support the creation of major new institutions in this field. Working with existing institutions may also yield results more quickly. We are also guided by an evolutionary approach that further develops and elaborates (and possibly expands) the existing institutional complex of international geoengineering governance, rather than a revolutionary centralisation in one institution.

We consider the CBD the prime candidate for becoming the central institution recognised as a first point of contact. By “central” we mean overarching but not supervisory. The CBD already fulfils this function to some extent, although not on a stable and prominent basis. Although its mandate is not unlimited, in particular the mandate to protect biological diversity allows pursuing a sufficiently broad precautionary approach, which could be further broadened if considered warranted by parties. Making the CBD the central institution in the field would appear to first of all suggest a conscious decision of its parties to establish appropriate stable structures (possibly including a work programme) to pursue targeted discussion of geoengineering on a regular basis. The establishment of such structures may help address concerns about a lack of priority and expertise in the CBD framework.

In our assessment, the UN Framework Convention on Climate Change (UNFCCC) does not provide a suitable or promising governance framework for fulfilling the governance tasks identified above. However, the trade-off underlying the assessment of the UNFCCC, in particular vis-à-vis the CBD, is a difficult one. The advantages of the UNFCCC are not easily

outweighed, including its role as a central forum for international climate diplomacy, the participation of the US, and the climate regime's experience in setting up institutions for specific tasks. Against this backdrop, institutional economy on its own might not be reason enough to choose the CBD, unless there is also confidence that the governance provided by the CBD is implemented and effective. However, the UNFCCC has important drawbacks. The main reasons are, first, that negotiations under the UNFCCC are already characterised by a very high level of complexity and being politicised. Adding geoengineering as another item on the UNFCCC negotiating agenda is likely to suffer a similar fate as others before, namely being deadlocked, being used as a negotiating chip, or not receiving appropriate attention. Second, and perhaps more importantly, the institutional logic of the UNFCCC is directed at combating climate change. Avoiding other negative impacts on e.g. biodiversity or other environmental objectives is addressed only to a marginal extent, e.g. in respect of the economic consequences of addressing climate change. As a result, it might be intrinsically difficult for the current climate regime to pursue a precautionary approach that is *restrictive* to geoengineering. In addition, geoengineering does not fit easily with the overall approach of the UNFCCC aimed at mitigating greenhouse gas emissions and adapting to the impacts of climate change. The UNFCCC may thus best be considered a complementary forum that may be suitable for incentivising any "encapsulated" geoengineering activities, i.e. those that have significant climate benefits while having insignificant environmental and health risks. In any event, irrespective of the institutional governance structure, *politically* geoengineering is not separable from climate policy and the climate regime.

There is no obvious other candidate for becoming the central institution in the international governance of geoengineering. Other institutions have neither been active so far nor would their more limited mandates or political setup make them promising candidates. However, UNEP might be a second-best solution for overarching governance, as it is the only relevant overarching international environmental institution and might assume a strengthened role in the course of its current reform. Although it does not usually engage directly in international regulation, it might launch a related initiative if no further action can be taken through the CBD, and contribute to scientific and technological assessment (see below).

The CBD may also be the most appropriate forum for pursuing more concrete governance arrangements for SRM activities. Again, it could build on the existing work already undertaken in elaborating a more concrete "prohibition with exemptions" framework. Such a framework could be established by means of a decision of the Conference of the Parties to the CBD. If a binding framework was considered warranted, a related Protocol to the CBD could in principle be elaborated. The 1985 Vienna Convention for the Protection of the Ozone Layer and its 1987 Montreal Protocol do not constitute a very promising alternative since their mandate is limited to the protection of the ozone layer, whereas not all relevant SRM techniques clearly affect the ozone layer. In addition, previous attempts to broaden the interpretation of the mandate of the Montreal Protocol in respect of a different issue politicised that issue, which is an important risk if tried for geoengineering. The World Meteorological Organization (WMO) does not have a clear regulatory mandate or significant experience and may thus only be able to contribute to related scientific and technological assessments (see below). If action on SRM activities proved impossible under the CBD, launching a related process under UNEP may be a second-best alternative at the international level. Complementing global efforts, regional action could be explored in a European context under the UNECE's LRTAP regime, which might serve to advance global action.

As international (and national) governance of geoengineering advances, demand for international scientific and technological assessments is likely to grow. At the international

governance level, a mandate to regularly compile and perhaps assess the current knowledge could be useful. Where there is specific scientific input to underpin other governance functions, e.g. in order to update or amend general guidance or rules, scientific input should be separate from political decision-making. In respect of individual decisions, e.g. on permits, it does not currently seem necessary that the *international* level provides more than general guidance as to the conditions under which the national level should allow for exemptions from the general prohibition.

2 Zusammenfassung

Die Diskussion um Geoengineering als mögliche Option der Klimapolitik gewinnt zunehmend Aufmerksamkeit an der Schnittstelle zwischen Wissenschaft und Politik. Mehrere Jahre wurden Möglichkeiten, Risiken von Geoengineering (auch als "Climate engineering" bezeichnet) und mögliche Gründe dafür vor allem in Wissenschaftskreisen diskutiert. Obwohl viele Geoengineering-Konzepte noch Gedankenspiele oder Modellierungen sind, hat es mittlerweile erste Feldversuche gegeben und eine öffentliche Diskussion entsteht. Diese Entwicklungen werfen die Frage auf, ob Geoengineering mittlerweile einen Governancerahmen erfordert, der über den bestehenden Regelungsrahmen hinausgeht, und wie solche Governance gestaltet sein sollte. In diesem Forschungsprojekt für das Umweltbundesamt entwickelt das Ecologic Institut konkrete Vorschläge für die Governance der gegenwärtig diskutierten Geoengineering-Konzepte auf internationaler Ebene. Auf Grundlage einer umfassenden Analyse des bestehenden Regelungsrahmens und seiner Lücken entwickelt diese Studie allgemeine Optionen und konkrete Handlungsempfehlungen für die wirksame Governance von Geoengineering. Ein zentrales Anliegen ist, dass die Empfehlungen praktisch umsetzbar sind.

Die Frage nach Governance umfasst mehr als nur rechtliche verbindliche Regeln. In diesem Sinn verstehen die Autoren den Begriff "Governance" in einem weiteren Sinn als "Regulierung": Wir schließen formelle und informelle, implizite und explizite Prozesse, Verfahren und Institutionen mit ein. Governance in diesem weiten Verständnis ist nicht unbedingt restriktiv. Sie kann auch Rechtssicherheit und politische Legitimation herstellen, oder pragmatische Funktionen wie Koordination erfüllen.

Die Studie hat drei Hauptteile: Nach der Einleitung untersucht Kapitel 4, ob und inwieweit es sinnvoll und durchführbar ist, eine einzige Definition von Geoengineering als Grundlage von Governance zu nehmen. Kapitel 5 untersucht die bestehende Governance von Geoengineering im internationalen Umweltrecht, und gibt einen kurzen Überblick des EU und deutschen Rechts. Auf dieser Grundlage entwickelt Kapitel 6 konkrete Regulierungsoptionen und -vorschläge. Wir analysieren, warum Governance von Geoengineering angestrebt werden sollte, und entwickeln konkrete Vorschläge, wie solche Governance gestaltet werden sollte. Die Kernergebnisse werden in dieser Zusammenfassung vorgestellt.

2.1 Definition von Geoengineering

Eine präzise Definition von Geoengineering festzulegen, ist eine Herausforderung, denn im allgemeinen Gebrauch umfasst der Begriff eine ganze Bandbreite von unterschiedlichen Konzepten und Methoden, Risikograden und Realisierbarkeit. Eine Definition kann verschiedenen Zwecken dienen und hat außerdem politische und gesellschaftliche Folgen. Ohne klare Vorstellung über die politischen Ziele und den Regelungszweck würde der Vorschlag für eine normative Definition den Karren vor das Pferd spannen.

Geoengineering-Konzepte werden typischerweise in zwei übergreifende Kategorien eingeteilt: Konzepte, die darauf abzielen, dem atmosphärischen Kohlenstoffkreislauf Kohlendioxid zu entziehen und dauerhaft zu speichern (so genanntes carbon dioxide removal - CDR) und Maßnahmen, die den Strahlungshaushalt beeinflussen (solar radiation management - SRM). CDR umfasst Konzepte, die CO_2, einen wesentlichen Mitverursacher des Klimawandels, aus der Atmosphäre entfernen wollen. CDR Konzepte beinhalten zwei Schritte: das Entfernen des CO_2 aus der Atmosphäre und danach die langfristige Speicherung des CO_2 für einen klimatisch relevanten Zeitraum aus den klimarelevanten Kreisläufen. Für jeden der beiden Schritte werden mehrere Konzepte diskutiert. SRM Konzepte zielen darauf ab, die Energiebilanz der

Erde zu verändern, indem die Einstrahlung und die Aufnahme von kurzwelliger Sonneneinstrahlung verringert werden. Es gibt keinen vollständigen Konsens darüber, welche Konzepte und Handlungen von diesen Kategorien erfasst werden sollen, und einige Ideen sind kontrovers, z.B. Aufforstung und die Abscheidung und Speicherung von CO_2 (CCS).

Die heutigen Definitionen sind mit der Zeit entstanden und haben Gemeinsamkeiten, auch wenn es keine Standarddefinition oder einheitlichen Gebrauch gibt. Jedoch zeigen die Mehrheit der Definitionen gemeinsame grundlegende Elemente in Bezug auf Handlung, Zweck, Vorsatz und Größenordnung. Die Merkmale "Zweck" und "Vorsatz" als Voraussetzung für Geoengineering können Handlungen von der Definition ausschließen, deren Auswirkungen auf das Klima zum Beispiel erst kumulativ mit anderen Handlungen entstehen, oder die als Nebenfolgen angesehen werden. Allgemein ist aus normativer Sicht jedoch durchaus fragwürdig, warum ein und dieselbe Handlung die Definition von Geoengineering erfüllt oder nicht, nur weil sie subjektiv einem bestimmten Zweck dient oder nicht - denn die Auswirkungen sind die gleichen. Darüber hinaus ist nicht klar, warum manche Definitionen sowohl auf den Vorsatz *als auch* auf den Zweck abstellen. Nach den üblichen Definitionen ist für Geoengineering zudem eine "große" Größenordnung erforderlich. Dabei ist manchmal die Größe der Auswirkungen gemeint, manchmal aber (auch) der Umfang der Handlung - obwohl die beabsichtigten Auswirkungen auf das Klima aller Wahrscheinlichkeit nach ohnehin eine bestimmte Größenordnung der entsprechenden Aktivität erfordern dürften. Allerdings geben die meisten Definitionen keine Anhaltspunkte dafür, nach welchem Maßstäben das Element "groß" zu bemessen ist.

Während alle Definitionen Stärken und Schwächen haben, erscheint die Definition derzeit am meisten überzeugend, die eine Expertengruppe im Rahmen einer Studie für die CBD zu möglichen Auswirkungen von Geoengineering formuliert hat: "Eine absichtliche Intervention in die planetarische Umwelt, die nach Art und Größenordnung beabsichtigt, dem anthropogenen Klimawandel und/oder seinen Auswirkungen entgegenzuwirken" (*"A deliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change and/or its impacts.")*.

Als Alternative könnte Geoengineering definiert werden als "Handlungen, die mit dem Zweck gestaltet und unternommen werden, Umweltveränderungen in regionaler oder globaler Größenordnung herbeizuführen, hauptsächlich um anthropogenem Klimawandel entgegenzuwirken oder dessen wärmende Auswirkung zu mindern, indem beispielsweise Treibhausgase aus der Atmosphäre entfernt oder die Sonneneinstrahlung vermindert werden."

Wir meinen, dass *jede* Definition, auch die der CBD, die als Grundlage für oder Bestandteil von Regelungen dient, um weitere Details ergänzt werden müsste, um weit gefasste Begriffe wie "Größenordnung" bestimmbar und messbar zu machen. Dies kann auf verschiedene Weise erreicht werden. Ein Ansatz wäre, die allgemeine Definition um eine Positivliste zu ergänzen, die ausdrücklich konkrete Konzepte oder Handlungen nennt, die als Geoengineering gelten. Damit würde man auch die Schwierigkeit angehen, dass die Definition zunächst weit genug sein muss, um die große Bandbreite von Geoengineering-Konzepten grundsätzlich zu erfassen. Eine solche Liste kann umfassend und abschließend sein, oder offen mit der Möglichkeit, sie anzupassen und zu interpretieren, wenn neue Konzepte und Szenarien entwickelt werden. Eine weitere, auch zusätzlich zur Positivliste umsetzbare Option wäre, einen Prozess oder eine Institution vorzusehen, der oder die weitere Richtlinien ausarbeitet - abstrakt im Voraus oder im jeweiligen Einzelfall.

2.2 Der bestehende Regelungsrahmen

2.2.1 Völkerrecht

Neben den etablierten traditionellen Quellen des Völkerrechts bezieht diese Studie auch Governanceinstrumente mit ein, die streng genommen nicht rechtlich bindend sind, aber politisch oder rechtlich relevante Lenkungswirkung haben. Insbesondere berücksichtigt sie relevante Institutionen und quasi-rechtsetzende Vertragsregime wie die regelmäßigen Vertragsstaatenkonferenzen, je nach ihrem Mandat.

Alle Staaten haben die allgemeine Pflicht, sicherzustellen, dass Handlungen in ihrem Hoheitsbereich oder unter ihrer Kontrolle die Umwelt anderer Staaten oder der Gebiete jenseits nationaler Hoheitsbereiche und Kontrolle respektiert. Es könnte jedoch schwierig sein, zu zeigen, genau welche Wirkungen eine bestimmte Geoengineering-Handlung hatte und welchen Schaden sie verursachte. Obwohl die Pflicht, die Umwelt zu respektieren, im Einzelfall am Maßstab der gebotenen Sorgfalt zu messen ist, ist außerdem unklar, welche Art von Umweltschaden einen Verstoß bedeuten würde, und welche Maßnahmen ein Staat ergreifen muss, um Umweltschäden zu vermeiden. Es dürfte zudem rechtlich schwierig sein, eine Forderung nach vorläufigen Maßnahmen im Hinblick auf eine mögliche zukünftige Verletzung dieser Pflicht rechtlich zu begründen, bevor die Geoengineering-Handlung stattgefunden hat.

Es gibt keine einheitliche Formulierung oder Anwendung des Vorsorgeprinzips, und sein rechtlicher Status als Gewohnheitsrecht ist noch nicht eindeutig anerkannt. Konzeptionelle rechtliche Unsicherheiten und seine inhaltliche Offenheit machen es schwierig, Schlüsse aus dem Vorsorgeprinzip zu ziehen, ohne bereits das gewünschte Ergebnis hineinzulesen. Aus einer Sicht ist wissenschaftliche Unsicherheit ein Grund, möglicherweise schädliche Handlungen wie Geoengineering zu unterlassen oder abzuschwächen. Aus anderer Perspektive sollte die wissenschaftliche Unsicherheit über Geoengineering nicht als Grund dafür herhalten, Geoengineering als mögliches Instrument gegen die Auswirkungen der Klimaerwärmung zu beschränken. Der Rückgriff auf das Vorsorgeprinzip als Rechtsregel löst nicht den Konflikt zwischen dem Ziel, Auswirkungen des Klimawandels zu vermeiden, und dem Ziel, Risiken von Geoengineering zu vermeiden. Als gemeinsamen Nenner bietet es derzeit lediglich eine Auslegungshilfe und Verfahrensregeln, um mit wissenschaftlicher Unsicherheit umzugehen. Jedenfalls beim gegenwärtigen Stand des Völkerrechts ist das Vorsorgeprinzip kein ausreichendes Instrument, um letztlich politische Entscheidungen über miteinander in Konflikt stehende Ziele zu treffen und mit Risiken umzugehen.

Mehrere völkerrechtliche Verträge und Dokumente, die für Geoengineering relevant sind, enthalten eine Pflicht zur oder einen Verweis auf die Durchführung einer Umweltprüfung. Unter dem LC/LP werden die Regelungen zur Ozeandüngung ergänzt durch zusätzliche, rechtlich nicht verbindliche Leitlinien einschließlich eines Rahmens zur Risikoabschätzung, der detaillierte Schritte für die Umweltprüfung vorgibt. Der IGH hat kürzlich anerkannt, dass die Praxis der Staaten sich zu einer “völkerrechtlichen Anforderung” verdichtet hat, eine Umweltprüfung durchzuführen, sofern ein Risiko besteht, dass die geplante gewerbliche Handlung erhebliche Auswirkungen haben könnte in grenzüberschreitendem Zusammenhang, insbesondere auf eine gemeinsame Ressource. Der IGH überlässt es zwar den Staaten, den konkreten Inhalt der erforderlichen Umweltprüfung festzulegen. Er nennt aber einige Details, insbesondere dass zur Pflicht auch die kontinuierliche Überprüfung der Auswirkungen der Handlung auf die Umwelt gehört.

Sofern keine speziellen Regeln greifen, sind die Regeln zur Staatenverantwortlichkeit anwendbar auf alle bestehenden oder neuen Pflichten in Bezug auf Geoengineering und bilden

einen allgemeinen Rahmen, um die rechtlichen Folgen von Verstößen zu bestimmen. Ungeklärt ist, ob ein Staat die rechtliche Verantwortlichkeit vermeiden kann, indem er sich auf rechtfertigende Umstände beruft, insbesondere Notstand. Die ILC Artikel zur Staatenverantwortlichkeit enthalten allerdings keine Institutionen oder Verfahren, um die Pflichten durchzusetzen. Neben den Regeln zur Staatenverantwortlichkeit hat die ILC auch Konzepte verfolgt, die sich mit schädigenden Auswirkungen von gefährlichen, aber nicht verbotenen Handlungen befassen. Diese Vorschläge sind jedoch bislang kein Gewohnheitsrecht und es bleibt abzuwarten, inwieweit sie rechtliche Aspekte von Geoengineering beeinflussen könnten.

Staaten sind nach den allgemeinen Regeln der Staatenverantwortlichkeit zwar grundsätzlich nicht verantwortlich für das Verhalten privater Akteure. Ein Staat kann jedoch für eigenes Verhalten im Zusammenhang mit dem Verhalten Privater verantwortlich sein, falls er es unterlassen hat, die erforderlichen Maßnahmen zu ergreifen, um dieses Verhalten oder seine Auswirkungen zu verhindern. Ob und in welchem Umfang ein Staat verpflichtet ist, auch solche Maßnahmen zu ergreifen, hängt von der jeweiligen Pflicht und dem Einzelfall ab.

Es gibt weitere Konzepte in der umweltrechtlichen Diskussion, z.B. nachhaltige Entwicklung und inter-generationelle Gerechtigkeit. Obwohl diese und andere Konzepte häufig in wichtigen Instrumenten und Dokumenten genannt sind, gibt es keinen Konsens über ihren Rechtsstatus und konkreten Gehalt.

Die ENMOD-Konvention ist ein Spezialfall, da sie die großskalige Veränderung der Umwelt zum Gegenstand hat, allerdings auf dem Gebiet des humanitären Völkerrechts. Obwohl die ENMOD-Konvention nur im bewaffneten Konflikt Anwendung findet und nicht im Hinblick auf die Governance heutiger Geoengineering-Konzepte erarbeitet wurde, könnten manche ihrer Regelungen dafür nützliche Grundlagen bieten und Ideen liefern.

Neben Entscheidungen zur Ozeandüngung hat sich die CBD in zwei COP-Entscheidungen von 2010 und 2012 auch mit Geoengineering *im Allgemeinen* befasst. Entscheidung X/33 von 2010, Ziffer 8(w) ist bislang offenbar die einzige umfassende Governance-Regelung auf dieser Ebene: Die Entscheidung ist rechtlich nicht bindend, drückt aber den Konsens der 193 Vertragsstaaten aus - zu denen jedoch nicht die USA gehören. Als Ergebnis eines politischen Kompromisses ist der Wortlaut der Entscheidung teilweise unklar. Der Kern des operativen Teils von Ziffer 8(w) enthält die Leitlinie, dass keine Geoengineering-Aktivitäten stattfinden sollen, die die Biodiversität beeinträchtigen könnten. Es ist schwer vorstellbar, dass Geoengineering-Aktivitäten in einer Größenordnung, die die Definition von Geoengineering erfüllt, keine Auswirkungen auf Biodiversität haben. Die Entscheidung erfasst insofern alle gegenwärtig diskutierten Geoengineering-Konzepte.

Die in der CBD-Entscheidung beabsichtigte Einschränkung von Geoengineering enthält drei Ausnahmen: Erstens ist der operative Teil insgesamt als Übergangsmaßnahme formuliert, die anwendbar sein soll “in Abwesenheit von wissenschaftsbasierten, globalen, transparenten und wirksamen Kontroll- und Regelungsmechanismen für Geoengineering”. Zweitens soll die Einschränkung anwendbar sein “bis es eine ausreichende wissenschaftliche Grundlage gibt, auf der Geoengineering-Aktivitäten gerechtfertigt werden können”, einschließlich einer umfassenden Risikobewertung. Drittens sind kleinskalige wissenschaftliche Forschungsstudien ausgenommen, sofern sie bestimmte Bedingungen erfüllen. In Bezug auf die Umsetzung überlässt es die Entscheidung anscheinend den Vertragsparteien, zu bestimmen, ob die Voraussetzungen der zweiten und dritten Ausnahme erfüllt sind.

Die nachfolgende CBD COP-Entscheidung XI/20 von 2012 fügt Entscheidung X/33 keine weiteren normativen Gehalt hinzu und könnte wegen mangelnder Klarheit sogar als

Rückschritt angesehen werden. Allerdings macht sie kleine Schritte vorwärts dabei, Elemente eines Rahmens für Governance bereitzustellen. Unabhängig von der Diskussion um quasi-rechtliche und faktische Wirkungen von COP-Entscheidungen in Vertragsregimen geben die Entscheidungen auch ein politisches Signal, das man in der Praxis nur schwer ignorieren kann, nur weil sie rechtlich nicht verbindlich sind.

Gemäß der Leistungsbeschreibung werden die bestehenden Regelungen zu Ozeandüngung bei der Untersuchung des geltenden Rechtsrahmens nicht behandelt. Wir schließen sie jedoch in der Analyse der Regelungsoptionen mit ein, da die bestehende Governance in diesem Bereich ein wichtiges Beispiel und mögliches Governancemodell darstellt.

Einbringen von Aerosolen in die Stratosphäre: Es lässt sich gut vertreten, dass die wesentlichen völkerrechtlichen Verträge, die Emissionen der einschlägigen Stoffe regeln, das Einbringen von Aerosolen in die Stratosphäre derzeit nicht als solche verbieten oder erheblich beschränken. Die Auswirkungen dieses Geoengineering-Konzepts könnte zwar auch durch völkerrechtliche Regelungen zur Biodiversität geregelt werden, jedoch sind die Pflichten in den in Betracht kommenden Verträgen nicht klar und präzise genug, um im Voraus abstrakt mögliche Verstöße festzustellen.

Aufhellen von Wolken von Schiffen aus: Die Ozonkonvention könnte zwar einschlägig sein, enthält aber keine praktisch relevanten Beschränkungen für das Aufhellen von Wolken von Schiffen aus. UNCLOS enthält die am meisten sachbezogenen Regelungen in dieser Hinsicht, sieht für Handlungen in der ausschließlichen Wirtschaftszone aber die Lösung von Konflikten im Einzelfall vor. Für die Hohe See ist es vertretbar, wenn auch nicht eindeutig, dass das Aufhellen von Wolken den UNCLOS-Regelungen über marine Umweltverschmutzung unterfällt. Das LP verbietet das Aufhellen von Wolken nicht, sofern Meerwasserdampf dafür eingesetzt wird und dies kein Einbringen (“dumping”) in das Meer darstellt.

Wüstenreflektoren: Die wohl hauptsächlich lokalen und regionalen Auswirkungen von Wüstenreflektoren könnten gegen völkerrechtliche Regeln zum Schutz der Biodiversität, Habitats etc. verstoßen. Die möglicherweise einschlägigen Regelungen sind jedoch wenig konkret und ein möglicher Verstoß müsste in jedem Einzelfall geprüft werden, unter Berücksichtigung der Größenordnung der Reflektoren, Kausalität und des konkreten rechtlichen Gehalts der jeweiligen Regelung z.B. der CBD.

Weltrauminstallationen: Das Weltraumrecht entstand im Wesentlichen vor der Diskussion um Geoengineering und verbietet Geoengineering im Weltraum nicht ausdrücklich. Einige Pflichten und Beschränkungen könnten jedoch allgemein auf Geoengineering anwendbar sein wie auf jede Weltraumaktivität. Die in Betracht kommenden Regeln laufen vor allem auf Verfahrenspflichten hinaus, z.B. die Kooperationspflicht und die Pflicht, bei der Nutzung des Weltraums die Interessen anderer Staaten angemessen zu berücksichtigen. Die wenigen Regeln zu Umwelt und Haftung erfassen nicht die möglichen Auswirkungen und Nebenfolgen von Geoengineering im Weltraum, soweit diese sich derzeit überhaupt schätzen lassen.

CO_2 Abscheidung und Speicherung: Obwohl es umstritten ist, ob CCS als Geoengineering gelten soll, sind einige dabei auftretende Risiken ähnlich wie bei anderen Geoengineering-Konzepten, so dass man CCS im gleichen Zusammenhang behandeln kann. Für CCS an *Land* gibt es kein völkerrechtliches Regime, das spezifisch CCS regelt. CCS spielt allerdings eine Rolle im UNFCCC Regime und wurde in den Clean Development Mechanism (CDM) des KP aufgenommen. Diese Entwicklung ist allerdings kontrovers, weil die allgemeine Akzeptanz und der Anreiz für CCS, den der CDM bietet, nicht dazu beiträgt, die *Herstellung* von CO_2 zu verringern. CCS im *Meer* ist von UNCLOS nicht verboten, könnte aber unter die Regeln gegen das Einbringen fallen, die es unter sektoralen Verträgen wie LC und LP gibt. Seit 2007 erlaubt das LP die Speicherung

unter dem Meeresboden, sofern bestimmte Bedingungen erfüllt sind. Das Gleiche gilt für eine Änderung der OSPAR-Konvention von 2007. Eine weitere, nicht in Kraft getretene Änderung des LP erlaubt den Vertragsstaaten unter bestimmten Bedingungen, geologische Formationen unter dem Meeresboden für CCS Projekte gemeinsam zu nutzen. Im Umkehrschluss erlauben das LP und die OSPAR Konvention nicht die CO_2 Speicherung *auf* dem Meeresboden und in der Wassersäule. Das Gleiche gilt für die LC, sofern sich die Vertragsstaaten nicht auf eine erlaubende Auslegung einigen.

Ozeankalkung ist völkerrechtlich nicht direkt geregelt. Dieses Konzept kann jedoch unter die Regelungen zum Schutz der Meeresumwelt und gegen "Dumping" fallen unter UNCLOS, LC, LP und der OSPAR Konvention. Ob die Regeln zum Schutz der Meeresumwelt anwendbar sind hängt davon ab, ob die Aktivität nach den jeweiligen Regelungen insgesamt für die Meeresumwelt schädlich oder dienlich ist. Es ist allerdings nicht geklärt, ob die Aktivität "Einbringen" wäre und den entsprechenden Regelungen unterfallen würde. Andere Verträge könnten anwendbar sein wenn grenzüberschreitende Auswirkungen oder Schäden an der Biodiversität auftreten, oder in Meeresschutzgebieten.

Speicherung von Biomasse im Ozean ist völkerrechtlich nicht direkt geregelt. Grundsätzlich gelten die gleichen Erwägungen wie bei der Ozeankalkung. Abgesehen von übergreifenden Regeln verbietet das Völkerrecht die Herstellung von Biomasse nicht.

Biomasse und Biokohle: Abgesehen von übergreifenden Regeln verbietet das Völkerrecht weder die Herstellung von Biomasse oder Biokohle noch an sich das Ausbringen von Biokohle auf Böden. Das Gleiche gilt für die erheblichen und großskaligen Änderungen der Landnutzung, die bei Herstellung und Anwendung der erforderlichen Mengen an Biomasse und Biokohle entstehen können. Jedoch könnten rechtliche Konflikte mit früheren oder anderen Landnutzungen entstehen, mit Regeln zum Schutz der Biodiversität, Ökosysteme und Lebensräume, und mit Menschenrechten. Ob und inwieweit solche Regeln tatsächlich anwendbar sind, hängt davon ab, um welche Biomasse und Biokohle es sich handelt, sowie wo und in welchem Umfang Landnutzungsänderungen auftreten.

Nutzung von Verwitterungsprozessen: Ähnlich wie die Geoengineering-Konzepte Biomasse und Biokohle hat die Nutzung von Verwitterungsprozessen durch das Ausbringen von Mineralien vor allem Auswirkungen auf die Landnutzung. Wie die Ozeankalkung erfordert es Bergbau in großem Umfang, um die erforderlichen Mengen an Mineralien zu fördern, und deren Transport zu den jeweiligen Ausbringungsorten. Der rechtliche Rahmen entspricht in etwa dem für Biomasse und Biokohle: Die übergreifenden Regeln sind anwendbar, aber die Landnutzung oder Landnutzungsänderung ist nicht als solche verboten eingeschränkt. Jedoch könnten rechtliche Konflikte mit früheren oder anderen Landnutzungen entstehen, sowie je nach tatsächlicher Auswirkung auch mit Regeln zum Schutz der Biodiversität usw.

Kohlenstofffilterung aus der Umgebungsluft ("künstliche Bäume"): Aufgrund der örtlichen Anwendung und geringen Auswirkungen gibt es grundsätzlichen keine völkerrechtlichen Vorgaben spezifisch für Geoengineering mit künstlichen Bäumen. Völkerrechtliche Regeln könnten vor allem dann relevant werden, sofern die Kohlenstofffilterung aus der Luft grenzüberschreitende Auswirkungen hat, etwa bei Großanlagen. In diesem Fall dürften hauptsächlich die übergreifenden Regeln anwendbar sein. Darüber hinaus könnten solche Anlagen als Senken in Betracht kommen und insofern vom UNFCCC Klimaregime einbezogen werden.

2.2.2 Bewertung bestehender internationale Governance

Geoengineering ist völkerrechtlich derzeit nicht als solches verboten. Die bisherigen rechtlichen Studien zeigen weitgehende Übereinstimmung, dass -von Details abgesehen- das bestehende Völkerrecht die möglichen Auswirkungen von Geoengineering und damit zusammenhängende Fragen kaum behandelt. Die meisten völkerrechtlichen Regeln entstanden, bevor Geoengineering ein relevantes Thema war, und enthalten keine ausdrücklichen Regelungen für Geoengineering-Konzepte. Es gibt minimale gemeinsame Grundlagen in Form von *allgemeinen* übergreifenden Regeln und Prinzipien, die für alle Staaten und alle Geoengineering-Konzepte gelten. Ihr Regelungsgehalt ist jedoch nicht hinreichend konkret, um klare Vorgaben für spezifische Geoengineering-Konzepte zu bieten. Die mögliche Anwendung *spezifischer* Regeln auf Geoengineering hängt je nach Regelung unter anderem von den konkreten möglichen oder tatsächlichen Auswirkungen der Handlung ab. Ob die Auswirkungen tatsächlich eintreten würden, ist derzeit nur sehr schwierig abzuschätzen. So gut wie alle der untersuchten Verträge enthalten *Verfahrenspflichten*, die für Geoengineering-Aktivitäten in ihrem jeweiligen Anwendungsbereich anwendbar wären.

Aus rechtlicher Sicht erlauben die Mandate vieler internationaler Regime und Institutionen es ihnen, Geoengineering oder Teilaspekte davon zu behandeln, auch wenn sie das bisher nicht getan haben. Dies wirft Fragen auf in Bezug auf mögliche Regelungskonflikte zwischen verschiedenen Verträgen und Institutionen, die möglicherweise sich überschneidende oder widersprechende Regelungen oder Leitlinien zur Governance erlassen könnten. In jüngerer Zeit haben die LC/LP und die CBD Regelungen für Geoengineering allgemein oder für bestimmte Konzepte entwickelt und beschlossen. Die meisten dieser Regeln wurden in Form von Entscheidungen der jeweiligen Institutionen unter diesen Verträgen angenommen und sind nicht im strengen Sinn bindend, auch wenn es nun formale Vorschläge für bindende Änderungen des LP gibt. Diese Entwicklung bedeutet allerdings nicht, dass die Frage gelöst ist, ob und wie internationale Governance von Geoengineering gestaltet werden sollte.

2.2.3 Europäisches und deutsches Recht

Mit Ausnahme von CCS gibt es bisher keine ausdrückliche Regelung von Geoengineering im EU oder deutschen Recht. Allerdings sind bestehende umweltrechtliche Regelungen in gewissem Umfang auf Geoengineering-Konzepte anwendbar. Dazu gehören allgemeine Regeln wie das Vorsorgeprinzip, der Umweltschutz und Grundrechte wie die Forschungsfreiheit.

Das Einbringen von Schwefelaerosolen in die Stratosphäre ist erlaubt, solange dies nicht erheblich dazu beiträgt, die nationalen Emissionsobergrenzen unter Richtlinie 2001/81/EC und der 39. BImSchV zu überschreiten. Dies hängt von der Menge der eingebrachten Schwefelaerosole ab. Allgemein ist das Abwerfen von solchen Gegenständen aus Flugzeugen unter Paragraph 7(1) der Luftverkehrsverordnung verboten, kann aber erlaubt werden, sofern keine Gefahr für Personen oder Sachen besteht.

Der Rahmen für CCS ist technisch und rechtlich weiter entwickelt als bei anderen CDR-Konzepten. CCS ist reguliert unter der EU CCS-Richtlinie einschließlich Änderungen anderer Rechtsakte, die bisher erst zu einem kleinen Teil in deutsches Recht umgesetzt wurden.

Anlagen zur Kohlenstofffilterung aus der Luft sind bisher nicht in den Regelungen enthalten, die Genehmigungspflichten für Anlagen vorschreiben. Sie unterfallen jedoch den Regelungen des deutschen Bundes-Immissionsschutzgesetzes für Anlagen, die nicht genehmigungsbedürftig sind, insbesondere der Pflicht, entstehenden Abfall ordnungsgemäß zu entsorgen. Dies könnte

allerdings unzureichend sein, um die bei diesem Konzept beteiligten Chemikalien angemessen zu erfassen.

Konzepte mit Biomasse und Biokohle sind teilweise von EU- und deutschem Recht erfasst, das genehmigungsbedürftige Anlagen betrifft oder Ausbringen auf dem oder in den Boden. Mit Ausnahme von nicht chemisch behandelter Biokohle aus Holz gibt es keine tragfähige Rechtsgrundlage für die Nutzung von Biokohle als Dünger. Die Beseitigung von Biomasse ohne Düngung ist grundsätzlich nicht erlaubt unter EU und deutschem Abfallrecht.

Sofern die Nutzung von Verwitterungsprozessen den pH-Wert von Gewässern erhöht, könnte dies EU und deutsches Wasserrecht verletzen, das verlangt, einen guten ökologischen und chemischen Zustand des Gewässers zu erhalten oder zu erreichen. Die Einhaltung deutschen Bodenschutzrechts wäre eingehend zu prüfen.

2.3 Regelungsoptionen und -vorschläge

Grundlage der wissenschaftlichen und politischen Diskussion über die Governance von Geoengineering sollten ausdrücklich genannte Ziele und Kriterien sein, die die vorgeschlagenen Governancestrukturen verfolgen, erfüllen und miteinander in Ausgleich bringen sollen. Es gibt zwar viele Vorschläge zur internationalen Governance von Geoengineering, aber die sie stützenden Annahmen, Gründe und Ziele werden nur selten offengelegt. Es gibt kein offensichtliches Patentrezept für die internationale Governance von Geoengineering, und keine offensichtlich überlegenen Ziele und Kriterien. Wir schlagen vor, dass die Ziele und Kriterien für die Governance von Geoengineering offengelegt werden müssen, damit eine Diskussion über solche grundlegenden Überlegungen geführt werden kann. Diese Diskussion wird eine wichtige Richtschnur für die Gestaltung durchführbarer, wirksamer und angemessener Governancestrukturen darstellen. Es ist überdies wichtig, die Diskussion über Ziele der Governance zu trennen von der Diskussion über die Mittel, die zur Verfügung stehen, um diese Ziele zu erreichen.

In dieser Studie legen wir zuerst ausdrücklich die Ziele und Kriterien dar, die die Governance von Geoengineering erfüllen soll. Die bisherige Diskussion zu Geoengineering hat sich meist nicht damit befasst. Zweitens leiten wir aus diesen Zielen und Kriterien Kernelemente einer angemessenen Governancestruktur ab. Drittens bewerten wir auf Grundlage der Ziele und Kriterien, für welche Geoengineering-Konzepte internationale Governance erforderlich ist. Viertens identifizieren wir Regelungslücken, wo der bestehende internationale Regelungsrahmen nicht den von uns vorgeschlagenen Kernelementen der Governance entspricht. Fünftens machen wir Vorschläge, wie diese Governancelücken auszufüllen sind.

Wir schlagen daher ein Bündel von ausdrücklichen Zielen und Kriterien für internationale Governancestrukturen vor. Drei übergreifende Ziele leiten die Überlegungen:

a) negative grenzüberschreitende Risiken und Auswirkungen auf Umwelt und Gesundheit vermeiden;

b) politische Spannungen und Konflikte vermeiden, die sich insbesondere aus einseitig vorgenommenen Handlungen ergeben könnten, sowie Rechtsstreitigkeiten vermeiden;

c) als eher technische Frage, die Koordinierung der wissenschaftlichen Forschung.

Auf dieser Grundlage und darüber hinaus schlagen wir vor. dass die internationale Governance von Geoengineering von folgenden konkreteren Kriterien bestimmt werden sollte:

a) die Governancestruktur sollte den Vorsorgeansatz umsetzen in Bezug auf die Risiken des Geoengineering;

b) sie sollte breite internationale Teilnahme und Akzeptanz erleichtern;

c) sie sollte so weit wie möglich vermeiden, dass Minderungsanstrengungen unmittelbar oder mittelbar untergraben werden;

d) sie sollte ein hohes Maß an Legitimität anstreben, unter anderem durch (öffentliche) Beteiligung und Transparenz, insbesondere in Bezug auf (i) das Setzen allgemeiner Regeln, (ii) Entscheidungen im Einzelfall über geplante Geoengineering-Aktivitäten außerhalb des Labors sowie (iii) jeweilige tatsächlich erlaubte Geoengineering-Handlungen, z.B. durch Überwachung und Berichterstattung;

e) sie sollte ein ausreichendes Maß an Flexibilität gewährleisten, damit man auf neue wissenschaftliche Erkenntnisse ebenso reagieren kann wie auf die sich weiter entwickelnde öffentliche Diskussion über Geoengineering.

Unsere Überlegungen zu den angemessenen Strukturen für die internationale Governance von Geoengineering beruhen auf diesen Zielen und Kriterien, wobei wir berücksichtigen, dass möglicherweise zwischen diesen Zielen und Kriterien abgewogen und Kompromisse gefunden werden müssen, insbesondere in Bezug auf die internationale Teilnahme und Akzeptanz.

Vor dem Hintergrund dieser Ziele und Kriterien sind es insbesondere zwei Geoengineering-Konzepte, die internationale Governance erfordern, weil sie verbunden sind mit erheblichen Risiken unmittelbarer grenzüberschreitender Auswirkungen (im Sinne von Auswirkungen auf andere Staaten oder auf hoheitsfreie Räume) und damit politischer Spannungen: Marine Konzepte wie Ozeandüngung und Ozeankalkung sowie “solar radiation management” in der Atmosphäre, z.B. das Einbringen von Schwefelaerosolen. Andere Konzepte dürften keine ähnlichen grenzüberschreitenden Auswirkungen haben. Das gilt insbesondere für Konzepte, die Kohlenstoff einschließen oder aus der Atmosphäre filtern, z.B. künstliche Bäume oder Verwitterungsprozesse. Nach gegenwärtigem Wissenstand sollte daher die internationale Governance von Konzepten für marines Geoengineering und SRM mit vorrangiger Aufmerksamkeit behandelt werden.

Als normativen Ansatz empfehlen wir ein allgemeines (präventives) Verbot von Geoengineering-Handlungen, die erhebliche grenzüberschreitende Risiken nach sich ziehen, verbunden mit der Möglichkeit, Ausnahmen zuzulassen. Das Verbot würde grundsätzlich auch Forschungsaktivitäten wie Feldversuche umfassen, nicht jedoch z.B. Modellierungen (zur Forschung siehe unten). Allgemein steht dafür eine breite Auswahl von rechtlich verbindlichen und nicht verbindlichen Instrumenten und Rechtstechniken zur Verfügung, von einem allgemeinen Verbot (mit Ausnahmen) bis zur allgemeinen Erlaubnis (mit bestimmten Einschränkungen).Ein allgemeines Verbot mit Ausnahmen auf Grundlage klarer Kriterien würde am besten einen Vorsorgeansatz widerspiegeln, indem (a) Umwelt- und Gesundheitsrisiken minimiert werden, einschließlich dem Risiko, Minderungsanstrengungen zu untergraben, und (b) das Potential für internationale Konflikte und Streitigkeiten entschärft werden. Dieser allgemeine Ansatz lässt sich wie folgt konkretisieren:

a) Klarheit über die verbotenen Aktivitäten wird am besten mit einer Positivliste der vom Verbot erfassten Geoengineering-Konzepte erreicht. Obwohl eine übergreifende Definition, die *alle* Geoengineering-Konzepte erfasst, nützlich wäre als politischer und normativer Bezugspunkt, wäre sie zwangsläufig unbestimmt und würde für sich allein nicht die erforderliche Rechtssicherheit bieten. Um Flexibilität und Leitlinien für Staaten einzubauen, könnte die Governancestruktur eine nicht ausschließliche

Liste der Kriterien bereitstellen, nach denen das Verbot und sein Anwendungsbereich definiert wurden, kombiniert mit einer regelmäßigen Überprüfung der Positivliste.

b) Die klare Festlegung der Ausnahmen sollte legitime Forschung ermöglichen (siehe unten), und damit die internationale Akzeptanz des Governanceansatzes fördern. Ausnahmen sollten gewährt werden auf Grundlage eines transparenten Entscheidungsprozesses mit strengen und klaren Kriterien.

c) Die Entscheidungsfindung sowohl über die Positivliste der verbotenen Geoengineering-Konzepte (einschließlich ihrer Überprüfung) als auch über die Ausnahmen (einschließlich der anzuwendenden Kriterien) sollte eine breite Teilnahme an den Entscheidungen fördern. Je nach den Umständen könnte ein rechtlich nicht verbindlicher Ansatz in Betracht kommen, in der Absicht, dass dieser sich mit der Zeit zu verbindlichem Recht entwickelt.

Dieser Ansatz bedeutet nicht unbedingt, dass alle Entscheidungen zentralisiert auf der internationalen Ebene getroffen werden müssen. Zum Beispiel könnten das allgemeine Verbot und die Kriterien für Ausnahmen auf internationaler Ebene verankert sein, während die Umsetzung in Form von entsprechenden Vorschriften, Standards und Verfahren einschließlich der Einzelfallentscheidungen der nationalen Ebene überlassen bleiben. Diese vertikale Arbeitsteilung könnte die Akzeptanz fördern und Bedenken ausräumen, es werde internationales Mikromanagement betrieben. Gleichzeitig würde dies angemessene internationale Strukturen zur Überwachung und Berichterstattung über Entscheidungen und Aktivitäten auf nationaler Ebene erfordern.

Wir empfehlen, dass die Governance von Geoengineering-Forschung am besten in die allgemeinen Governancestrukturen für Geoengineering integriert wird. Forschung in Form von Feldversuchen oder andern Aktivitäten außerhalb des Labors sollten *nicht* separat von oder früher geregelt werden als die "Anwendung" von Geoengineering-Konzepten. Eine solche Trennung der Governancestrukturen (und die damit implizierte Abfolge ihrer Ausgestaltung) erscheint problematisch und nicht ratsam, weil (1) es keine klare Trennung gibt zwischen der Durchführung von Geoengineering zu Forschungszwecken und der Durchführung zu anderen Zwecken und (2) solche getrennten Governancestrukturen für die Forschung wahrscheinlich einen wichtigen Präzedenzfall für die Zukunft schaffen würde und eine Blaupause für die Governance der tatsächlichen "Anwendung" (zu anderen Zwecken). In unserem Entwurf würde Forschung in die allgemeine Governancestruktur integriert und in den Anwendungsbereich des allgemeinen Verbots fallen, könnte aber durchgeführt werden über fallspezifische Ausnahmen auf Grundlage von Umweltprüfungen, Stellungnahmen unabhängiger Experten und sofern es sich nur um kleinskalige Eingriffe handelt. Dieser Ansatz würde die Forschung nicht über das Maß hinaus unterdrücken oder beschränken, dass erforderlich ist, um die Risiken zu minimieren, die von Forschungsaktivitäten in gleicher Weise ausgehen wie von Geoengineering-Aktivitäten zu anderen Zwecken. Gleichzeitig würde unser Ansatz auch die Transparenz und Legitimität der Forschung erhöhen.

Die bestehenden internationalen Institutionen decken das Themengebiet Geoengineering nur teilweise ab und stellen keinen umfassenden Governancerahmen bereit, der die oben genannten Ziele und Kriterien erfüllt und unserem normativen Regelungsansatz entspricht. Die LC/LP hat einen „Soft-law"-Ansatz für die Governance von marinen Geoengineering-Konzepten entwickelt und ist dabei, diese Struktur weiterzuentwickeln und einen festeren völkerrechtlichen Rahmen zu schaffen. Der dabei verfolgte normative Ansatz entspricht anscheinend weitgehend dem Ansatz eines "allgemeinen Verbots mit Ausnahmen", den wir

hier vertreten. Die derzeitigen Vorschläge müssen jedoch noch angenommen werden und in Kraft treten. Auch könnten Bedenken bestehen, ob die Verfahren und Prüfungen übermäßig beschwerlich und die Bedingungen in der Praxis schwierig zu erfüllen sind. Die LC/LP ist zudem ein vergleichsweise kleines Regime und ihr Rahmen ist beschränkt auf marine Geoengineering-Konzepte. Das Gleiche gilt für die begrenzten Aktivitäten unter OSPAR, die zudem in ihrem regionalen Anwendungsbereich beschränkt sind. Die CBD hat den Ansatz der LC/LP teilweise aufgegriffen und daraus breitere Leitlinien entwickelt, und diente bereits als Forum für allgemeine Diskussionen über Geoengineering und dessen Governance. Der Regelungsrahmen unter der CBD bildet jedoch noch keine stabile Grundlage und die CBD ist noch nicht allgemein anerkannt als eine oder die zentrale Institution, in der internationale Governance von Geoengineering diskutiert wird. Dabei haben andere internationale Institutionen Geoengineering bisher kaum in relevantem Maß behandelt. Dies ist eine bedeutende Lücke insbesondere in Bezug auf SRM-Konzepte und damit atmosphärisches SRM wie das Einbringen von Schwefelaerosolen.

In die gegenwärtige internationale Governance von Geoengineering sind mehrere Institutionen involviert - hauptsächlich die CBD, LC/LP und die OSPAR Konvention. Sie bilden das Anfangsstadium eines institutionellen Komplexes, der noch erhebliche Lücken und Defizite aufweist und eine inter-institutionelle Arbeitsteilung herausbildet, die noch weiterer Klärung bedarf. Erstens gibt es noch keine zentrale Institution, die klar als zentraler Kontaktpunkt anerkannt ist und den Akteuren Gelegenheit bietet, Querschnittsthemen zu behandeln, institutionenübergreifende Leitlinien zu entwickeln und aufkommende Themen anzusprechen; und die allgemeine Prinzipien und Perspektiven entwickelt und den Austausch von Informationen fördert. Zweitens fehlt im bestehenden institutionellen Komplex die Regelung von SRM-Konzepten. Wenn die Möglichkeiten zur Regelung internationaler Governance von Geoengineering erweitert werden, wirft dies zudem die Frage auf, wie den Entscheidungsprozessen geeigneter wissenschaftlicher Input zugeführt werden kann. Sofern sich außerdem Anzahl und Größe der Feldversuche zu Geoengineering erhöhen sollte, gäbe es Raum für bessere internationale Koordination der Forschung und diesbezüglichen Informationsaustausch.

Unsere Untersuchung der Optionen, um diese Lücken zu füllen und Fortschritte zu machen bei einer kohärenten und umfassenden Struktur für die internationale Governance von Geoengineering, beruht außerdem auf folgenden Überlegungen: Zunächst konzentrieren wir uns darauf, bestehende Institutionen zu nutzen statt neue zu schaffen, aus Effizienzerwägungen ("institutional economy") und weil nach unserer Einschätzung die internationale Diskussion zu Geoengineering bisher noch nicht eine Qualität erreicht hat, die die Schaffung neuer großer Institutionen in diesem Bereich unterstützen würde. Die Arbeit mit bestehenden Institutionen könnte auch schneller zu Ergebnissen führen. Wir folgen zudem einem evolutionären Ansatz, der den bestehenden institutionellen Komplex internationaler Geoengineering-Governance weiter entwickelt, ausgestaltet und möglicherweise ausweitet, anstatt einer revolutionären Zentralisierung in einer einzigen Institution.

Wir halten die CBD für die beste Kandidatin, die zentrale Institution zu werden, die als erste Kontaktstelle anerkannt ist. Mit "zentral" meinen wir übergreifend, aber nicht übergeordnet. Die CBD füllt diese Funktion bereits in gewissem Umfang aus, allerdings ist dies nicht dauerhaft angelegt oder mit besonderer Bedeutung versehen. Obwohl das Mandat der CBD nicht unbegrenzt ist, erlaubt insbesondere das Mandat zur Erhaltung der Biodiversität einen hinreichend breiten vorsorgeorientierten Ansatz, der ausgeweitet werden könnte, sofern die Vertragsstaaten dies für gerechtfertigt halten. Die CBD zur zentralen Institution in diesem Bereich zu machen, dürfte zunächst eine bewusste Entscheidung der Vertragsparteien

voraussetzen, angemessene dauerhafte Strukturen zu schaffen (die möglicherweise ein Arbeitsprogramm enthalten), um eine regelmäßige zielgerichtete Diskussion über Geoengineering zu führen. Die Einrichtung solcher Strukturen könnte auch Bedenken begegnen, dass dieses Thema im Rahmen der CBD keine Bedeutung hat und es an Fachkenntnis mangelt.

Nach unserer Bewertung bietet die Klimarahmenkonvention (UNFCCC) keinen geeigneten oder vielversprechenden Rahmen, um die oben beschriebenen Funktionen und Aufgaben der Governance zu erfüllen. Allerdings ist die Abwägung, auf der sich die Bewertung der UNFCCC gründet, schwierig zu treffen, insbesondere gegenüber der CBD. Die Vorteile der UNFCCC sind nicht einfach zu übertreffen, einschließlich ihrer Rolle als zentrales Forum für internationale Klimadiplomatie, der Beteiligung der USA und der Erfahrung des Klimaregimes darin, Institutionen für spezifische Aufgaben einzurichten. Vor diesem Hintergrund könnten Effizienzerwägungen ("institutional economy") für sich allein nicht hinreichend sein, um sich für die CBD zu entscheiden - es sei denn, es besteht Vertrauen, dass Governance durch die CBD auch umgesetzt wird und wirksam ist. Die UNFCCC hat jedoch auch bedeutende Nachteile. Die Hauptgründe dafür sind erstens, dass die Verhandlungen unter der UNFCCC bereits durch ein hohes Maß an Komplexität und Politisierung gekennzeichnet sind. Wenn man Geoengineering als weiteres Thema auf die Tagesordnung der UNFCCC-Verhandlungen bringen würde, würde dies für Geoengineering wahrscheinlich ein ähnliches Los bedeuten wie für andere Themen zuvor, nämlich blockiert zu werden, als Verhandlungsmasse benutzt zu werden, oder nicht die gebotene Aufmerksamkeit zu erhalten. Ein vielleicht noch wichtigerer Grund ist zweitens, dass die institutionelle Logik der UNFCCC auf die Bekämpfung des Klimawandels gerichtet ist. Sie befasst sich nur am Rande damit, sonstige negative Auswirkungen zum Beispiel auf die Biodiversität oder andere Umweltziele zu vermeiden, etwa in Bezug auf die wirtschaftlichen Folgen der Maßnahmen gegen den Klimawandel. Infolgedessen könnte es für das derzeitige Klimaregime immanent schwierig sein, einen Vorsorgeansatz zu verfolgen, der in Bezug auf Geoengineering *einschränkend* ist. Außerdem passt Geoengineering nicht leicht zu dem allgemeinen Ansatz der UNFCCC, der auf die Minderung von Treibhausgasen und die Anpassung an die Auswirkungen des Klimawandels ausgerichtet ist. Die UNFCCC könnte daher am ehesten als ein ergänzendes Forum in Betracht kommen, das geeignet sein könnte, Anreize für "abgeschottete" Geoengineering-Aktivitäten zu schaffen, d.h. solche, die erhebliche Klimavorteile haben, aber nur wenige negative Auswirkungen auf Umwelt und Gesundheit. Unabhängig von der institutionellen Governancestruktur ist Geoengineering jedenfalls *politisch* nicht von Klimapolitik und dem Klimaregie zu trennen.

Es gibt keinen anderen offensichtlichen Kandidaten für eine zentrale Institution für die internationale Governance von Geoengineering. Andere Institutionen waren bisher weder aktiv noch machen ihre beschränkteren Mandate und politische Aufstellung sie zu vielversprechenden Kandidaten. UNEP könnte aber eine zweitbeste Lösung für übergreifende Governance sein, da es die einzige relevante übergreifende Umweltinstitution ist und im Zuge ihrer gegenwärtigen Reform eine stärkere Rolle einnehmen könnte. Obwohl UNEP sich normalerweise nicht direkt mit internationaler Regulierung befasst, könnte es eine diesbezügliche Initiative starten, sofern die Handlungsmöglichkeiten im Rahmen der CBD ausgeschöpft sind, und zu wissenschaftlichen und technischen Bewertungen beitragen (s.u.).

Die CBD könnte auch das am besten geeignete Forum sein, um konkrete Governancestrukturen für SRM-Aktivitäten anzugehen. Auch hier könnte sie auf der bereits geleisteten Arbeit aufbauen, um einen konkreteren Rahmen eines "Verbots mit Ausnahmen" zu erarbeiten. Ein solcher Rahmen könnte durch eine Entscheidung der CBD-Vertragsstaatenkonferenz geschaffen werden. Sofern ein rechtlich verbindlicher Rahmen angebracht erscheint, könnte grundsätzlich

ein Protokoll zur CBD erarbeitet werden. Die Wiener Ozonkonvention von 1985 und das Montrealer Protokoll von 1987 sind keine aussichtsreichen Alternativen, da ihr Mandat beschränkt ist auf den Schutz der Ozonschicht, wohingegen nicht alle relevanten SRM-Konzepte eindeutig auf die Ozonschicht einwirken. Außerdem führten frühere Versuche, das Mandat des Montrealer Protokolls in Bezug auf ein anderes Problem weit auszulegen, zur Politisierung dieses Themas. Dies wäre ein bedeutendes Risiko, sofern man Gleiches für Geoengineering versuchte. Die Weltorganisation für Meteorologie (WMO) hat kein klares Mandat für Regulierung oder bedeutende Erfahrung darin, und könnte daher allenfalls in der Lage sein, zu wissenschaftlichen und technischen Bewertungen beizutragen (s.u.). Falls Maßnahmen zu SRM-Aktivitäten unter der CBD nicht möglich sein sollten, könnte ein entsprechender Prozess unter UNEP eine zweitbeste Alternative auf internationaler Ebene sein. In Ergänzung globaler Bemühungen könnte man regionales Handeln im europäischen Kontext des UNECE LRTAP Übereinkommens in Erwägung ziehen, was globales Handeln weiter vorantreiben könnte.

Mit fortschreitender internationaler (und nationaler) Governance von Geoengineering dürfte der Bedarf an internationalen wissenschaftlichen und technischen Bewertungen steigen. Auf der Ebene internationaler Governance könnte ein Mandat nützlich sein, den jeweiligen Wissensstand regelmäßig zusammenzutragen und vielleicht auch zu bewerten. Sofern spezifischer wissenschaftlicher Input vorgesehen ist, um andere Governancefunktionen zu unterstützen, z.B. um allgemeine Regeln oder Leitlinien zu aktualisieren oder zu ändern, sollte der wissenschaftliche Input von politischer Entscheidungsfindung getrennt sein. Für Einzelfallentscheidungen, z.B. über Genehmigungen, erscheint es derzeit nicht erforderlich, dass die *internationale* Ebene mehr als allgemeine Leitlinien bereitstellt in Bezug auf die Bedingungen, unter denen die nationale Ebene Ausnahmen vom allgemeinen Verbot zulassen sollte.

3 Introduction

In this research project for the German Federal Environment Agency, Ecologic Institute develops specific proposals for governance of geoengineering at the international level. Based on a comprehensive analysis of the existing regulatory framework and its gaps, the study identifies general options and specific recommended actions for the effective governance of geoengineering. A key consideration is that the recommendations can be implemented in practice.

Although the debate about geoengineering is still largely driven by scientists, it is gaining attention at the policy interface.[1] The emerging governance debate has gained considerable pace in recent years, but appears to be strangely out of proportion to the actual state of play of geoengineering research and activities: Many geoengineering techniques are at the conceptual or modelling stage, and geoengineering might turn out to be a storm in a teacup and not be politically viable. On the other hand, there have been field experiments followed by an emerging public debate and a rapid growth of academic and policy literature. Geoengineering is also inextricably linked to international climate policy. These aspects raise the question of whether an international governance framework is needed over and above the current framework, and what it should look like.

Geoengineering is a generic and general term comprising several different concepts. The project focuses on the following geoengineering techniques.

- SRM techniques:
    - Sulphate aerosols in the atmosphere
    - Cloud brightening from ships
    - Desert reflectors
    - Installations in outer space
- CDR techniques
    - Carbon capture and storage (CCS)
    - Ocean liming
    - Ocean biomass storage
    - Biomass and biochar on land
    - Enhanced weathering

Air capture of CO_2

- ("artificial trees")

In accordance with the terms of reference, ocean fertilisation is not addressed in this study. However, to date ocean fertilisation is the geoengineering technique subject to the most detailed regulatory efforts in particular by the London Convention (LC) and London Protocol

[1] Bodle (2013) 469.

(LP).[2] It therefore provides an important precedent and potential governance model[3] that we include in our analysis of governance options (section 6, ocean fertilisation) .

In accordance with the terms of reference, the study has three main parts: The definition of geoengineering, the existing international law, and developing specific regulatory options.

Section 4 provides an assessment of definitions and categories of geoengineering and explores problems and options for a single definition *for governance purposes*. Section 5 analyses the existing international law on geoengineering. Just as international law does not operate in a political vacuum, policy assessments and options regarding geoengineering are not disconnected from international rules. Existing international law and frameworks for international cooperation reflect previous policy choices and create legitimate expectations by other states and the international community. They have to be taken into account when designing a governance framework and exercising policy choices regarding geoengineering. Section 5 includes a subsection on EU and German law, areas that have not drawn much attention so far.[4]

Section 6 analyses *why* governance of geoengineering should be pursued and develops specific proposals *how* such governance should be designed. First, we make explicit the objectives and functions that such governance is to fulfil, as well as the choices made regarding a particular governance design. Governance, meant in a sense broader than legal rules, is not necessarily restrictive and can also provide legal certainty and political legitimacy. Second, we derive core elements of appropriate governance design from these objectives and criteria. Third, we assess geoengineering techniques require international governance in view of the objectives and criteria? Fourth, we identify governance gaps where the existing international framework does not correspond to our proposed core governance elements. Fifth, we make proposals to fil the governance gaps.

During the course of the project, preliminary results and proposals were discussed at an international workshop at Ecologic Institute, Berlin, in November 2012. We thank the participants for their comments and open discussion, under Chatham House rules, which fed back into the analysis, arguments and proposals of this study. The discussion paper and summary is attached in the annex.

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[2] The later London Protocol entered into force in 2006 and eventually replaces for its Parties the earlier London Convention. The two instruments will continue to apply in parallel for the time being.

[3] Cf. Bodle et al (2012) 125-126; for a detailed overview and analysis see Ginzky/Markus (2011).

[4] Except for a recent study for the German Parliament (2012, on file with the authors, not published as yet).

4 Definition of geoengineering

This section (project work package 1) analyses concepts and definitions of geoengineering with a view to developing a workable definition for a regulatory purpose.

4.1 Definitional context

Affixing a precise definition to geoengineering presents a challenge, as common usage of the term encompasses a wide range of dissimilar techniques with varying methodologies, levels of risk, and feasibility. They are considered together mainly because of their actual, potential or perceived high risk to the environment, combined with their common underlying motivation and objective and their relation to climate change policy. The risks of geoengineering are characterized by potential adverse impacts that are currently neither fully known nor understood, may be irreversible, and are not easily controlled. Reasons for attempting to pin a comprehensive and all-inclusive definition may be related to governance, regulatory, political, or conceptual purposes, each of relevance and involving distinct considerations.

From a legal perspective, definitions often determine the scope of application of a legal rule. A definition includes the activities, actors, impacts etc that should fall within the scope of application, which at the same time excludes that which does not meet the definition. A definition of geoengineering for legal and regulatory purposes would seek to include those techniques that pose a high risk while excluding activities that do not raise similar concerns. In a similar manner, the way in which geoengineering is defined helps evaluate and influence how and whether the existing regulatory framework is to be applied.

A definition of geoengineering carries political and social implications. Identifying an activity as geoengineering associates it with these concerns and may consequently label it as negative or controversial. This could be a desired or unwelcome effect. For instance, addressing the “moral hazard” of stifling efforts to address emissions reductions[5] could also be part of the definition’s objective.

Without a clear notion of the political objectives and regulatory purpose, proposing a regulatory definition could in essence put the cart before the horse. This study therefore aims at defining geoengineering for specific regulatory purposes while considering the potential interests in doing so.

4.2 Existing definitions

Contemporary definitions share commonalities, although there is no standard or uniform use.[6]

Geoengineering terminology has evolved over time along with the concept. Proposals for deliberate climate engineering emerged as early as 1877, although the term geoengineering as commonly used today first arose in the 1970s in reference to carbon dioxide capture from fossil

[5] *See e.g.* Lin (2009) 14; Keith (2000) 276.

[6] See e.g. overview of selected definitions on Williamson et al (2012) 82-84.

7 Williamson et al (2012) 21, *citing* N. Shaler (1877).

fuel-based power plants and injection into deep ocean waters[8], entering the mainstream in the 1990s.[9] Geoengineering is the most common term of reference, but others such as "climate remediation" or "climate engineering" are alternatively applied to the same concept.[10] One explanation has been that the use of "engineering" suggests the intentional application of techniques.[11] These alternative terms may perhaps be viewed as "softer" and avoid the association with high risk technological hubris that may accompany geoengineering.

Typically, geoengineering techniques are subdivided into overarching categories of either carbon dioxide removal (CDR) or solar radiation management (SRM).[12] The CDR category includes techniques that are intended to remove CO_2 from the atmosphere and therefore one of the main contributors to climate change. CDR techniques involve two steps: removal of CO_2 from the atmosphere and subsequent long-term storage of the captured CO_2 in order to take it out of circulation for a climatically relevant period.[13] Several techniques are being discussed for each step.[14] SRM techniques aim at changing the earth's energy balance by reducing the incidence and subsequent absorption of short-wave solar radiation.[15]

Even so, there is no consensus as to the full scope of activities that ought to be included under these categories and as geoengineering, and a number remain subject to debate. In one example of debated geoengineering techniques, afforestation and reforestation to use forests as carbon sinks, is considered a form of CDR by some, but not others.[16] One explanation is that forestry methods should instead be categorized as mitigation or sinks, perhaps for use in mechanisms such as REDD+.[17] Likewise, carbon capture and storage (CCS) has been labeled geoengineering,[18] but other interpretations exclude emissions captured from point sources, making a distinction between capture of carbon dioxide pre- and post-release into the atmosphere and where the latter qualifies as CDR.[19] This distinction for CCS attempts to draw a line between mitigation, reducing the *generation* of greenhouse gas emissions, and

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8 Marchetti (1976). For further detail on the history of climate geoengineering and weather modification see Keith (2000); Czarnecki (2008).

9 Keith (2000) 248.

10 *See e.g.* Bipartisan Policy Center (2011); Gordon (2010).

11 Rickels et al (2011) 1.

12 For overviews and details on the concept and science of the various geoengineering techniques see Royal Society (2009); Rickels et al (2011); UBA (2011); US GAO (2011); Williamson et al (2012).

13 Williamson et al (2012) 54.

14 Cf. UBA (2011) 18).

15 UBA (2011) 9; Williamson et al (2012) 8.

16 *See e.g.* NAS (1992); Rickels et al (2011); as opposed to Royal Society (2009); also UBA (2011) 18 (footnote) and 23; Williamson et al (2012) 23-24, 84.

17 *See e.g.* NAS (1992); Keith and Dowlatabadi (1992); as opposed to Royal Society (2009).

18 UBA (2011).

19 *See e.g.* CBD Decision X/33 (2010); Royal Society (2009); Keith (2000).

geoengineering, reducing pre-existing atmospheric *concentrations*.[20] Another reason for CCS's possible exclusion is due to greater acceptance of the technology, which is on the verge becoming an established and commercially viable alternative application for industrial enhanced oil recovery, and has been introduced in the KP's CDM (see section on CCS below section 5.1.7). These examples illustrate that there are geoengineering techniques that in principle may fit the common definitional elements of geoengineering, as discussed in section 4, but which are sought by some to be excluded from categorisation as geoengineering.

Despite divergences and a lack of standardized form, the majority of existing geoengineering definitions exhibit key characteristics and share the same primary elements of activity, purpose, intent, and scale.

4.3 Activity

The subject of the definition is the activity or activities that qualify geoengineering. This subject can be framed broadly or narrowly. Existing definitions frame the activity through terminology that includes, inter alia, "interventions," "options," "efforts," and "manipulations."[21] Further narrowing attributes and modifying prepositional phrases are commonly provided to link the subject to its purpose, such as with "manipulation *of climate forcings*," "modification *of the Earth's climate systems*," or "steps *to alter the climate*."[22]

Dissecting this element may appear to be an academic or linguistic exercise, yet a strict interpretation has the potential to significantly restrict or expand the definitional scope, whether intentionally or otherwise. For example, a "branch of science"[23] could suggest activities restricted to research rather than other purposes, e.g. commercial, or restricted to research rather than deployment. "Proposals"[24] could similarly imply a more preliminary stage of progress. Defining geoengineering as "technologies"[25] could denote a highly engineered and technical approach that might exclude less technical methods such as forestation or enhanced weathering.

In the same way, this framing of the activity can have political or societal subtexts. By framing geoengineering as research or as proposals, one connotation is that the activity is not widely deployed, and thus seemingly under a greater degree of control. Likewise, by framing as science, a resulting implication is that activities are outside of the realm of commercial interests and private initiatives which may be viewed as less controllable and constituting higher risk. The question of whether and how to address research activities through a definition is also relevant for the "intent" element of the definition.

Using the broad categories of CDR or SRM as the identified activities could potentially limit application as well. While the "C" in CDR focuses on removal of carbon dioxide from the atmosphere, it may theoretically be possible to remove other greenhouse gases, e.g. methane

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[20] *See* Keith (2000).

[21] *See e.g.* Williamson et al (2012); NAS (1992); Royal Society (2009); IPCC glossary for AR3, entry „geoengnieering“ at http://www.grida.no/publications/other/ipcc_tar/

[22] Keith and Dowlatabadi (1992); Gordon (2010); Asilomar Conference Report (2010).

[23] Australian Academy of Sciences (2010).

[24] SRMGI (2011).

[25] IPCC (2007); Bipartisan Policy Center (2011).

or NOx. On a similar note, specifying removal of gases from the "atmosphere" can distinguish capture of emissions pre- and post-release, a point of dispute, as noted.

4.4 Intent

The element of intent serves to distinguish geoengineering techniques from activities that may have a sizeable, yet inadvertent, effect on the global climate. The majority of geoengineering definitions indicate a level of intent, often using the terms "deliberate" or "intentional."[26] The purpose of including intent as a requirement is to be exclusive, eliminating activities where the resulting climate impacts are cumulative and indirect.

Intent is also closely linked to the element of purpose (see section 4.5) and could in theory be applied to exclude climate-warming activities. However, it is not clear why *both* intent and purpose are used in some geoengineering definitions. It is difficult to imagine many scenarios where a wide-scale, global cooling effect is performed unintentionally.

A regulatory definition has to consider (a) whether climate impacts that are incidental or secondary are of a similar nature and concern as where impacts are the principle objectives; and (b) if so, whether it is desirable to govern these activities within the same framework as methods applied with the sole purpose of combating anthropogenic climate change or its effects. In this respect, "intent" is also relevant for addressing research activities. Presumably the main intention of research is to find out about the workings and impacts of potential geoengineering techniques, rather than to actually implement them and cause such impacts. On the other hand, research would lay the necessary groundwork for potential subsequent geoengineering activities. In addition, while modelling and small-scale field experiments are unlikely to fulfil the "scale" element of a definition, large field trials could reach such scale and have impacts similar to deployment. Against this background, does the "intent" element merely refer to the activity as such, or would it also cover the intention to lay the groundwork for future activities that could be performed to counteract the effects of climate change? This problem is also closely connected to the "purpose" element.

From a legal perspective, indicating involvement of intent does not fully address a requisite state of mind. As outlined, actions that are undertaken deliberately can have a side effect of impacting the climate, but be performed for unrelated reasons. However, would knowledge or awareness of climatic impacts qualify as sufficient intent to be deemed geoengineering? For example, the cumulative aerosol emissions from fossil fuel-based power plants result in significant radiative effects and changes to carbon dioxide uptake.[27] Could these be qualified as geoengineering because the radiative effects are known and similar to SRM techniques? It could be argued that with current knowledge about climate change, a state allowing the cumulative emissions from fossil fuels at this scale must be deemed to know about their radiative effects, and continuing to allow them in the knowledge of their radiative effects amounts to intention. However, the primary purpose would be energy production, not climate cooling. The language in existing definitions and the evidently close link between intention and purpose of an activity, would indicate that the level of intent required by geoengineering

[26] *See e.g.* Royal Society (2009); Gordon (2010); Bipartisan Policy Center (2011); MacCracken (2009); Keith (2000).

[27] *See* Mahowald, Natalie. *Aerosol Indirect Effect on Biogeochemical Cycles and Climate*. Science 334, 794 (2011); "Schwefel gegen Treibhausgas", Sueddeutsche Zeitung v. 06.07.2011, <http://www.sueddeutsche.de/wissen/klimawandel-schwefel-gegen-treibhausgas-1.1116608>.

is specific. In other words, the actor responsible for execution of geoengineering activities does so with the specific *purpose* of causing a particular outcome.

In addition, where the international level addressed states, as it for the very most part does, it is highly unusual and also difficult in practice to refer to the intention of states for normative purposes. The definition of “environmental modification techniques" in the ENMOD Convention refers to the “deliberate” manipulation of natural processes, but it has never been applied and thus tested in practice (see section 5.1.2). States are abstractions that do not have a state of mind like human beings, and attributing a “will” to a state might not only be difficult, but also not useful in for a specific governance purpose.

4.5 Purpose

Existing definitions typically identify the purpose of geoengineering as seeking to counteract anthropogenic climate change, to counteract climate change’s effects, or both. The purpose element in a definition differentiates application of methods for geoengineering from other functions.

Definitions of geoengineering do not generally require precise temperatures or levels of atmospheric carbon as objectives - although it might be considered implicit that the desired state of the climate and the aim of geoengineering is a state of pre-industrial carbon levels. Practically speaking, there is little rationale to prescribe such a specific target climate level to achieve or maintain, especially given the inability of current techniques to target such an exact mark. CDR techniques, through removal of greenhouse gases from the atmosphere, address both the physical cause of anthropogenic climate change (but not emissions as their cause) and, in doing so, its impacts. SRM, on the other hand, mitigates the symptoms of climate change by altering radiation levels and producing cooling, but does not address the root cause and leaves atmospheric greenhouse gas levels unchanged. An effective definition, particularly for regulatory purposes, should be broad enough to include both CDR and SRM and measures combating both the problem of climate change and resulting warming. It could be a separate and subsequent consideration whether the same legal consequences apply to both categories.

A further aspect is how geoengineering relates to mitigation and adaptation as established categories of climate efforts. How geoengineering is differentiated from mitigation is not always expressly stated or acknowledged, as shown by CCS between emission capture pre-and post-release.[28] Another arguable distinction is the imagined scale of activity. For adaptation, general understanding suggests that adaptation measures make modifications and preparations to manage the consequences of warming. Geoengineering could be distinguished from adaptation as it seeks to counteract planetary warming, whether through emissions removal or cooling, rather than treating it as a given. Distinguishing between these categories of climate efforts may be of practical import for application under climate-related legal frameworks and funding schemes. However, this question is a matter for the interpretation of those rules that draw a distinction between adaptation and mitigation. It does not have to be addressed or resolved in the definition of geoengineering.

In addition to the distinction from mitigation and adaptation, geoengineering might also have to be distinguished from weather modification. One differentiating factor may be the scale of time, whereas “weather” refers to short-cycle conditions and “climate” indicates longer-term

[28] *See* Keith (2000).

patterns.[29] Other distinctions could relate to the geographical impact: local or regional weather vs. global climate, or to purpose, whereby geoengineering seeks to modify the climate as a response to anthropogenic climate change.[30]

The objective of geoengineering is widely understood as combating climate change, however a critical question for answer is whether using the same techniques for alternative purposes would still be considered geoengineering. First, would using a technique that is otherwise considered geoengineering for a purpose other than climate cooling still fall under the definition? For instance, biochar can serve the purpose of carbon sequestration and potentially also of soil enhancement. The purpose of an ocean fertilisation technique or activity might be enhancing fishery yields. Secondly, can large-scale and deliberate climate *warming* be geoengineering? In the former Soviet Union in the 1950s and 1960s, for instance there were recurring proposals for warming to create a more temperate climate in the north and for removal of polar ice cover.[31]

Theoretically, geoengineering methods could be applied for a variety of economic, commercial, social, or military objectives that are not related to anthropogenic climate change impacts or regulation. Requiring a narrow purpose and determining whether this element is fulfilled might be pose problems. As with intent, purpose may be difficult to prove in practice when turning on the subjective aim of the actor, rather than the objective design of the technology. On the other hand, unfeasible attempts at cooling the earth may also nevertheless have deleterious impacts.

Purpose might be of lesser significance as a standalone element. Unless the activity is performed at a scale of sufficient magnitude to either impact the climate or to create adverse effects, the same perceived risks are not present and concern and interest in control dissipates.

4.6 Scale

Conventional definitions identify geoengineering as “large” in scale.[32] This element relates more to the magnitude of impacts, but also to the size of the efforts, although altering the climate would more than likely necessarily entail a sizeable level of activity. “Large” scale may be of a planetary, but also regional, degree. Recently, proposals have been issued for specific application of geoengineering techniques in the Arctic region in order to slow polar ice melt.[33]

The scale element helps distinguish geoengineering efforts from more minor activities affecting the climate, such as painting rooftops white to increase albedo or localized tree planting. Such activities could potentially be classified as geoengineering but are unlikely to carry the high risks and potential far-reaching impacts of larger-scale activities. For these reasons, and given that impacts would likely be more localized, small-scale are activities are also less likely to be desirable within the same scope of regulation as large-scale activities.[34]

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[29] *See e.g.* www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html.

[30] See Keith (2000) 250: “Weather and climate modification therefore had two of the three defining attributes (Section 2.1) of geoengineering— scale and intent–but not the third, as it was not a countervailing measure.”

[31] Keith (2000); Williamson et al (2012) 30.

[32] *See e.g.* Keith (2000)247; NAS (1992) 433; Royal Society (2010) 1.

[33] *See* Aldous (2012).

[34] Cf. Ginzky (2011) 475.

However current definitions mostly fail to specify a standard of measurement for what is "large." In particular for regulatory purposes, stating "large-scale" demands a further definition, line, or threshold past which an activity would qualify as geoengineering. The primary constraints to offering this descriptor lies in the dissimilar natures of various geoengineering technologies, as well as the lack of knowledge of about which impacts would occur at which scale. The standard by which one technique may be large enough to have a sizeable impact on the climate, environment, or health is unlikely to be equal to the standard for another technique, nor even quantifiable by the same standard of measurement. Using the approach of listing individual geoengineering technologies as part of a definition could correspondingly apply individual standards of measurement. *Parson and Keith* propose two technical thresholds for SRM, based on the strength of the solar radiation perturbation. Interventions above the first threshold should be subject to a moratorium, while those below the second threshold should be generally permitted. However, they explicitly avoid the "hard governance issue that lie in the wide middle".[35]

An activity might have deleterious impacts of concern even before it is performed at a sufficient scale to counteract climate change or its effects. Most techniques can theoretically be performed at a small scale, e.g. placement of a single desert reflector or space panel, injection of one batch of aerosols, dumping one batch of iron or alkaline minerals into the ocean. Whether there is an interest in regulating at a smaller scale where impacts may be of a lesser degree, and whether small-scale activities might be better dealt with via other mechanisms, has to be addressed in governance considerations.

Another issue of concern could be the relation between drawing the line between small and large scale and the distinction between research and deployment. Prior to wide-scale deployment, small-scale trials are likely to be performed. Drawing a concrete line of scale may have the effect of either permitting or obstructing field experiments, whereas an ill-defined notion leaves room for interpretation. Small-scale may not necessarily be correlated with research, but are more likely to. Where rules or principles are designed for research activities, might lines be drawn based upon subjective purpose and intent, objective size, or other factors? Lastly, where the scale of impacts is of concern, regulatory jurisdiction should not be based on the scale of activity.

4.7 Conclusions

While all existing definitions have strengths and weaknesses, the definition developed by an expert group in the impact study for the CBD appears to the most convincing to date:[36]

> *A deliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change and/or its impacts.*

The definition is concise while including all the essential elements discussed above. It is workable in the sense that guides the necessary further refinements regarding thresholds, measuring etc. However, the definition has weaknesses that would make it insufficient for a regulatory purpose if applied by itself (see further below in this section).

Alternatively, applying a highly broad, inclusive, and multi-purposed definition, one that attempts to cover all techniques that have been considered geoengineering and most of the

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[35] Parson and Keith (2013) 1279.

[36] Williamson et al (2012) 8. On the wording of the CBD's 2010 geoengineering decision see Bodle (2010) 315-316.

discussed intentions, but that is not appropriate for narrower regulatory or governance purposes, geoengineering could be preliminarily defined as:

> *Activities designed and undertaken with the purpose of producing environmental change on a regional or global scale, primarily for counteracting anthropogenic climate change or reducing its warming impacts, through, inter alia, removal of greenhouse gases from the atmosphere or reducing solar insolation.*

The selection of the activity, activity and intervention respectively, are both relatively neutral subjects without significant subtexts or connotations. Activity carries somewhat greater impartiality, as intervention may begin to implicate purpose and intent, and perhaps greater definitional clarity can be achieved by separating out these elements.

On the other hand, the elements are intimately connected. The CBD impact study's definition captures and uses this connection advantageously, linking the description of the activity with intent, purpose, and scale. As discussed, purpose and intent, while serving to identify the deliberate and man-made nature of the environmental change, fail to stand alone in the absence of scale. On the other hand, scale without purpose or specific intent leaves open the possibility of unintended climate impacts, primarily from anthropogenic warming.

As noted, it is not entirely clear why, applying a strict interpretation, both purpose and intent are needed in a definition. One conceivable rationale is that deliberation signifies the intent of the *actor* executing the geoengineering method, whereas purpose denotes the primary application of the *technique* in use. Including both could eliminate a degree of concern over discerning both feasibility of methods and subjective intent. Thus, where applied methods are unsuccessful but used in a manner intended for geoengineering change, or where a technology designed for geoengineering is deployed for an alternative purpose or unintentionally, both scenarios with potential risks and adverse impacts, this two-fold angle captures both cases. Along this line of thought, specifying activities "designed and undertaken with the purpose of producing environmental change" in the above definition seeks to capture both the intent of the actor and the methodological design. Use of "designed" may also help capture research or trial activities that with the ultimate goal of large-scale environmental change, but that are not deployed applied at that level yet.

The purpose of the activity under CBD impact study's definition is "to counteract anthropogenic climate change and/or its impacts." Generally, geoengineering is understood as seeking to reduce climate warming. Nevertheless, as other purposes are imaginable, a broader purpose of "producing environmental change on a regional or global scale" is used here, providing greater flexibility while also noting that this is "*primarily* for counteracting anthropogenic climate change or reducing its warming impacts." Referring to climate "warming" rather than the impacts of climate change, provides further differentiation from adaptation measures. "Environmental change," as opposed to climatic, is also intended to broaden the scope of potential purposes. It is open for discussion whether this broadens the scope too much.

The CBD impact study's choice of definition links the level of scale to the intent and purpose of the activity. However, it is not clear whether small-scale application of techniques, such as for research, may be covered. Further, the exact level of scale appears to turn upon the subjective intent of the actor, where it could be said that if the activity is not intended to effect climate alteration, even where feasible, the activity is not of scale *intended* to counteract anthropogenic climate change and/or its impacts. The above alternative definition uses "activities designed or undertaken with the purpose of producing environmental change on *a regional or global scale.*" While still linked to intent and purpose, the separation of these two

elements, via "or" reaches further beyond the actor's intent. It also clarifies the trademark large-scale quality of geoengineering as occurring on a regional or global scale, not local.

Both definitions identify general categories of CDR and SRM, but do so, inter alia, by allowing room for other potential approaches and advances. Whereas the CBD impact study refers to "sunlight reflection methods," the above definition substitutes "reducing solar insolation." While both are appropriate, however, "solar" provides a slightly broader connotation, referring to heat or light relating to the sun and more closely to radiation, as opposed to only light.[37]

The CBD impact study's definition is a useful and plausible starting point, as it captures the essence of the current debate in clear terms. However, its openness its also its weakness when it comes to determining whether or not a specific activity falls under the definition. We suggest that *any* definition, including the CBD impact study's, that is used as a basis for a regulatory purpose would have to be complemented by further details on determining and measuring broad terms such as scale. This can be achieved in several ways. One approach, also addressing the difficulty of crafting a sufficiently broad definition to cover a wide range of methods, would be to complement the definition with a positive list that expressly mentions specific techniques -or activities- which are considered geoengineering. Such a list could be comprehensive and absolute, or left open, allowing for adaptation and interpretation as new methods and scenarios develop. Another option is to envisage a process or institution providing further guidance in advance or on a case by case basis.

[37] Cf. the definitions in the online Oxford dictionary of "solar" and "insolation" to that of sunlight".

5 The existing legal framework

While still small compared to the large amount of scientific literature, there have been a number of detailed legal analyses on how existing international law would apply to geoengineering techniques.[38] This section (project work package 2) builds on this previous work.

5.1 International Law

5.1.1 Introduction

Similar to previous studies, this section (work package 2) addresses only those rules and institutions that apply to geoengineering or which could reasonably be expected to apply.[39] A useful, albeit not always exact distinction can be drawn between considering (i) rules governing the *activity* in question, e.g. releasing aerosols into the atmosphere and (ii) rules regarding the *effects* of an activity.

Questions regarding the potential status of obligations as *ius cogens* or obligations *erga omnes* do not have practical relevance for geoengineering at this stage. There are very few rules that are likely to be universally recognised as *ius cogens*, such as the prohibition of genocide or slavery, or *erga omnes* obligations. In addition, the details on the legal implications of these concepts have been under debate for a long time.[40]

In addition to binding international law within the meaning of Article 38 ICJ Statute, this study also looks at instruments that may be not binding in this strict sense, but that provide politically or legally relevant guidance to states. In particular, it includes relevant institutions and quasi-legislative treaty bodies such as regular meetings of the Parties, depending on their mandate. On the basis of the traditional sources of international law, most of the decisions of such institutions are not as such binding (unless the treaty so provides). However, following the development and importance of treaty regimes with permanent institutions such as COPs, there are suggestions that COP decisions could be binding as such.[41] Yet there is hardly any state practice that could confirm that states are willing to accept this. One important implication and argument against this notion would be that a government could incur a legal obligation for the state it represents by not objecting to a COP decision although there was no clear prior or subsequent Parliamentary approval to such an obligation. In any event, the distinction between binding and non-binding is sometimes difficult to draw in international practice and particularly in treaty implementation. COP decisions, for instance, can express parties' views on

[38] For instance, after initial overviews by Bodansky (1996), Zedalis (2010) and Bodle (2010), see Rickels et al (2011); Bodle et al (2012). For other, more cursory overviews see for instance US GAO (2010); Umweltbundesamt (2011); Bodle (2013).

[39] Cf. Bodle et al (2012) 111.

[40] Bodle et al (2012) 113 fn. 22.

[41] Cf. Churchill and Ulfstein (2000); Brunnee (2002); Gehring (2007); see also Frenzel (2011).

how to implement and develop the regime, and their relevance in practice may come close to binding rules.

For ease of reference, references to "states" in this study also include the EU unless otherwise stated.[42]

5.1.2 Cross-cutting general rules

There are cross-cutting international laws and other rules which, by virtue of their universal nature, are relevant to all geoengineering concepts.

5.1.2.1 Duty to respect the environment

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. The ICJ has held that this rule has become customary international law.[43] The finding of the ICJ builds on previous findings in the *Trail Smelter* arbitration[44] and several references in key international documents and treaties such as principle 2 of the Rio Declaration,[45] and article 3 CBD. The obligation has evolved in more recent formulations, in particular by the ICJ, to encompass the environment in general, as well as areas beyond national jurisdiction.

While it would in many cases not be a problem to detect geoengineering activities and to determine whether they can be attributed to a state,[46] it might be difficult to show which precise effects resulted from the particular geoengineering activity and which harm it caused.[47] For instance, a potential claimant state would have to establish a causal link between the particular geoengineering activity and changes in precipitation, as well as between those changes in precipitation patterns and specific environmental harm.[48] In view of the extent of the potential damage, reversing the burden of proof is being discussed on the basis of the precautionary principle.[49]

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[42] Following the entry into force of the Treaty of Lisbon, cf. Articles 1, 3(2) and 47 Treaty of European Union (TEU), 216 Treaty on the Functioning of the Union (TFEU). According to Article 1 TEU, the EU replaced and succeeded the European Community (EC), which had entered into treaties prior to the Treaty of Lisbon.

[43] ICJ, Legality of the Threat or Use of Nuclear Weapons (Advisory Opinion - General Assembly), ICJ Rep. 1996, 22, para 29; ICJ, Case concerning the Gabcikovo-Nagymaros Project (Hungary v. *Slovakia)*, ICJ Rep. 1997, 7, para 53; ICJ, *Case concerning pulp mills on the river Uruguay (Argentia v. Uruguay)*, judgment of 20 April 2010, para 193 <www.icj-cij.org>. Note that the ICJ's formulation is "activities within their jurisdiction *and* control".

[44] RIAA, Bd. III, 1905 ff., 1963-1965.

[45] 31 ILM 876 (1992); cf. principle 21 of the preceding 1972 Declaration of the UN Conference on the Human Environment (Stockholm Declaration), 11 ILM 1416 (1972).

[46] See below on state responsibility.

[47] Bodle et al (2012) 115-115.

[48] Bodle (2010) 306-307.

[49] See the section on the precautionary principle.

These factual difficulties are further complicated by legal uncertainties. This obligation has so far very rarely been subject of disputes which could have clarified its precise content. Although the ICJ has recently been more forthcoming in elaborating on its implications, the scope of the obligation it is not quite clear. In particular, it is not clear which degree of environmental harm would constitute a breach, and which measures states are required to take in order to prevent environmental harm.[50]

The ICJ has also contributed to the lack of clarity. The wording "respect the environment" which the ICJ used in several cases, avoids the issue of whether a breach requires a certain degree of risk or harm. Moreover, it could indicate that the obligation also comprises a duty to actively prevent damage. The rationale behind it could be to provide an incentive for states to avoid conflicts with other states over environmental impacts. In its most recent judgment on this issue, the ICJ not only reiterates the obligation to respect the environment, but in another part of the decision refers to the "principle of prevention". According to the ICJ, this principle means that a state "is thus obliged to use all the means at its disposal in order to avoid activities which take place in its territory, or in any area under its jurisdiction, causing significant damage to the environment of another State.[51] The ICJ does not mention this principle anywhere else in this judgment and it is unclear how it relates to the general obligation to respect the environment. In the passage introducing the "principle of prevention", the ICJ first reiterates the general obligation established in the *Corfu Channel* case, which was not related to the environment, before pronouncing its specific meaning regarding the environment.

This explicit recourse could mean that the ICJ distinguishes two obligations: the (more recent) obligation to respect the environment and the (older) principle of prevention, as applied to the environment. Alternatively, it could also mean that the principle of prevention is part of the obligation to respect the environment. Given the significant overlap in the formulations and their objectives, the latter seems reasonable.[52]

It is common ground that the obligation to respect the environment requires a due diligence standard and that the problem of which diligence is "due" depends on the particular case.[53] Apart from academic writing, the actual case law and state practice on this obligation is scarce and the ICJ's statements are not entirely clear.[54] Against this background, it is suggested that drawing a distinction is between obligations of conduct and obligations of result should be used with caution in ascertaining when a breach has occurred. The distinction can be useful conceptually, but is not exclusive.[55]

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[50] Cf. Rickel et al (2011) 99; ILC commentary on Art. 2 of the *Draft Articles on Prevention of Transboundary Harm from Hazardous Activities*, UN Doc A/56/10, para 6; *Epiney*, AVR 1995, 334; *Beyerlin*, Umweltvölkerrecht, para 119; *Heintschel v. Heinegg,* in: Ipsen (ed.), Völkerrecht, 1049 para 17.

[51] ICJ, Case concerning pulp mills on the river Uruguay (Argentina v. Uruguay), judgment of 20 April 2010, para 101.

[52] Cf. Bodle et al (2012) 116.

[53] Birnie et al (2009) 147; Bodle (2010) 307; Rickels et al (2011) 99; Bodle et al (2012) 116.

[54] In the recent *Pulp Mills* case, the ICJ held that conducting an EIA was part of exercising due diligence in this particular case, ICJ, Pulp mills on the river Uruguay, para 204-206.

[55] Cf. ILC, Draft Articles on Responsibility of States for Internationally Wrongful Acts, UN Doc. A/56/10, commentary to Article 12, para 11 with references.

However, the distinction sheds light on the main problem with the obligation to respect the environment, namely that it is retrospective. Generally, the duty to respect the environment of other states or of areas beyond national jurisdiction or control does not mean that any environmental impact is for that reason generally prohibited.[56] It would be difficult to argue that a state is in breach of this obligation before the geoengineering activity has already taken place. International law provides only very limited means to obtain advance provisional measures in order to stop activities that could be in breach of international obligations.[57]

5.1.2.2 Precautionary principle

The precautionary principle or approach is frequently underlying arguments in favour of and against geoengineering. However, there is no uniform formulation or usage for the precautionary principle and its legal status in customary international law has not yet been clearly established, although it has been invoked several times in international cases.[58] The fact that some reject the term precautionary "*principle*" and prefer the term "*approach*"[59] highlights that even the legal meaning of "principles" is not clear or agreed in international law.[60] On the other hand, the concept of "principles" is relevant in practice and has a legal basis in some treaties, e.g. in article 3 UNFCCC, which is under the heading "principles". This study uses the term "precautionary principle" for ease of reference and without prejudice to these concerns.

These conceptual legal uncertainties regarding the precautionary principle, as well as its openness regarding content, make it difficult to draw conclusions without imputing desired outcomes. However, there are explicit and implicit references to the precautionary principle in several documents and treaties, some of which are highly relevant for geoengineering governance, such as the CBD, the LC/LP and article 3(3) UNFCCC. The CBD decision X/33 on geoengineering is based on and stresses the importance of the precautionary approach.[61] In the geoengineering context, article 3(3) UNFCCC is of particular relevance because it incorporates the precautionary principle in the operative part of a treaty text with near universal participation, including the US. However, its precise legal consequences remain unclear.

A potential general legal implication of the precautionary principle relates to the burden of proof. For instance, it has been argued that when a proposed geoengineering activity has the potential for irreversible and catastrophic harm, the burden should be placed on those proposing the action[62] - although the implications of this burden in practical terms are not

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[56] Cf. Rickels et al (2011) 99; Bodle et al (2012) 115.

[57] Bodle (2010) 308, with references to ICJ case law.

[58] See generally Erben (2005); Birnie et al (2009) 157; Bodle et al (2012) 119 with further references; Recent cases include ICJ, *Pulp Mills on the river Uruguay (Argentina v. Uruguay),* judgment of 20 April 2010, <www.icj-cij.org>; ITLOS case No.17, "Responsibilities and obligations of States sponsoring persons and entities with respect to activities in the Area (Request for Advisory Opinion submitted to the Seabed Disputes Chamber)", para 125-135, <http://www.itlos.org>.

[59] See the overview in Birnie et al (2009) 154-155.

[60] On the theoretical underpinning of the legal concept of "principles" see Rickels et al (2011)102.

[61] See the section on this decision below.

[62] Bodansky (2011) 15.

further elaborated. Another implication of the precautionary principle could be to ease or even shift the burden of proof after environmental impacts have occurred. For instance, a state to which a geoengineering activity is attributable would have to rebut the assumption that it changed the earth's albedo and that this caused the alleged environmental harm.[63] Sectoral applications of the precautionary principle under specific regimes may adopt such or similar legal implications.[64] However, international state practice and precedents do not suggest that international law generally requires a state to prove that activities within its jurisdiction or control are environmentally safe.[65] In the recent *Pulp mills on the river Uruguay* case, the ICJ accepted that a precautionary approach "may be relevant" in the interpretation and application of the treaty in question. However, the court also stated that "it does not follow that it operates as a reversal of the burden of proof".[66] The wording of the court is not clear as to whether this applies to the specific case or generally excludes a reversal.

The precautionary principle can cut both ways: From one point of view, scientific uncertainty is a reason to refrain from or slow down potentially harmful activities such as geoengineering. From another perspective, scientific uncertainty regarding geoengineering should not be used as a reason to restrict geoengineering as a potential tool for helping to address global warming. Specific instances of the precautionary principle such as article 3(3) UNFCCC provide arguments in support of this second view - or at least against the notion that geoengineering would be against the precautionary principle.[67] Reading Article 3(3) UNFCCC at face value in this way, in support of geoengineering, would be unusual, but not evidently contrary to the wording.[68] This interpretation could also be supported to some extent by Article 4(1)(f) UNFCCC,[69] although this provision is not very specific and would only apply to geoengineering techniques that are regarded as mitigation or adaptation measures.[70]

Against this background, recourse to the precautionary principle as a legal rule does not resolve the conflict between the objectives of avoiding the effects of global climate change *vis a vis* avoiding the risks of geoengineering - in particular as there are shades of grey between these two objectives. In contrast, *Rickels* et al argue that the precautionary principle can serve to balance conflicting objectives: In this view, because the precautionary principle(s) in different instruments can be satisfied to different degrees, they therefore allow for determining which degree of environmental damage can be accepted in order to advance the comprehensive goal of climate protection.[71] This view appears to boil down to an overall cost-

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[63] Bodle (2010) 307.

[64] See for instance ITLOS case No.17, "Responsibilities and obligations of States sponsoring persons and entities with respect to activities in the Area (Request for Advisory Opinion submitted to the Seabed Disputes Chamber)", para 125-135, <http://www.itlos.org>; Jessen (2012) 77.

[65] Birnie et al (2009) 158.

[66] ICJ, Pulp mills on the river Uruguay, para 164.

[67] Bodle (2010) 310-311; Rickels et al (2011) 102.

[68] Bodle (2010) 310.

[69] Requiring all Parties to employ appropriate methods "with a view to" minimising adverse effects of their mitigation and adaptation measures on the economy, public health and the quality of the environment

[70] Bodle et al (212) para 62.

[71] Rickels et al (2011) 101-103.

benefit analysis of geoengineering across the board, but it is not clear why the legal effect of the precautionary principle should be to endorse this particular method. In addition, this view appears to contradict the findings that many environmental legal rules that could potentially apply to geoengineering are not open to "net" approaches.

While the precautionary principle still means many things in different contexts,[72] it can provide guidance on dealing with scientific uncertainty - so far mainly by procedural safeguards. On the other hand, it has been argued that if the precautionary principle is applied in isolation, there is a risk of perpetuating the scientific uncertainty that gives rise to its application in the first place.[73] As long as the precautionary principle embodies the core arguments both for and against geoengineering, all the common ground it can provide is to establish interpretative guidance and procedural safeguards for dealing with scientific uncertainty. At least in the current state of international law, the precautionary principle does not provide a sufficient legal tool for making essentially political decisions about conflicting objectives and managing risks.[74]

5.1.2.3 Duty to undertake an environmental impact assessment

Several treaties and international documents relevant to geoengineering contain an obligation or a reference to carrying out environmental assessments. The duty to conduct an environmental assessment is included in several treaties such as Article 14 CBD, Article 206 UNCLOS, Article 4(1)(f) UNFCCC (to some extent) and regional instruments such as the UNECE Espoo Convention, which also has a Protocol on strategic environmental assessment (SEA). Notably, Article 14(1)(b) of the CBD provides a near-global obligation in this regard, to which CBD COP decision X/33 on geoengineering refers, and the CBD COP has developed guidelines for its implementation.[75] The LC/LP's rules on ocean fertilisation are complemented by additional non-binding guidance including a risk assessment framework, which provides detailed steps for completion of an environmental assessment, including risk management and monitoring.[76]

The LC/LP Assessment Framework is not legally binding in form or in wording. In addition, participation in the London Convention and London Protocol is not comparable to, for instance, the CBD or the UNFCCC in terms of number of Parties. However, the LC/LP Assessment Framework was incorporated by reference in the CBD COP10 decision on ocean fertilisation.

In addition, the ICJ has recently recognised that the accepted practice amongst states amounted to "a requirement under general international law to undertake an environmental impact assessment where there is a risk that the proposed industrial activity may have a significant adverse impact in a transboundary context, in particular, on a shared resource".[77]

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[72] Birnie et al (2009 155.

[73] Rickels et al (2011) 102.

[74] See also Birnie et al (2009) 161.

[75] CBD DecisionVI/7, U.N. Doc. UNEP/CBD/COP/6/20 at 93.

[76] Resolution LC-LP.2(2010) on the assessment framework for scientific research involving ocean fertilization, adopted on 14 October 2010. For the Assessment framework see the draft elaborated by the Scientific Group of the London Protocol and the Scientific Group of the London Protocol, LC/SG/32/15, Annex 2.

[77] ICJ, *Pulp mills on the river Uruguay*, para 204-206.

While the ICJ left it to the states to determine the specific content of the impact assessment required, it specified some details, most notably including that the obligation involves continuous monitoring of the activity's effect on the environment. As a legal rule in customary international law, this is an important development that might require clarification as to its precise implications.

In respect of SEA, there is numerous guidance in non-binding documents and treaty regimes such as the CBD,[78] but there is not sufficient evidence to assume a customary obligation to carry out SEA. The SEA Protocol to the Espoo Convention provides binding rules and entered into force in 2010, but its 23 European parties so far provide relatively small impetus to a global obligation. The ICJ judgment in the *Pulp Mills* case refers to particular industrial activities and does not necessarily establish a general requirement for a SEA. There is therefore no globally applicable obligation to integrate SEA of proposed geoengineering policies, plans or programmes into potential geoengineering policy development.

5.1.2.4 State responsibility

The rules on state responsibility comprise the general conditions under which a state is responsible for wrongful actions or omissions, and the resulting legal consequences. The International Law Commission's Articles on Responsibility of States for Internationally Wrongful Acts of 2001 ("Articles on State Responsibility")[79] for the most part reflect customary law, although some concepts may not be universally accepted. These rules apply to geoengineering activities, but they do *not* determine which geoengineering activities are permitted or prohibited. Instead, they apply only if geoengineering activities breach an international obligation.[80] Unless there are specific rules taking precedence, the rules on state responsibility apply to all existing or new obligations regarding geoengineering and provide a general framework for determining the legal consequences of such breach.

Establishing responsibility of a state for geoengineering would require that

- the geoengineering activity is attributable to that state under international law,
- the geoengineering activity constitutes a breach of an international obligation of that state, and
- there are no circumstances precluding the wrongfulness.[81]

In respect of attributing a geoengineering activity to a state, the scale required for global impacts would probably make it possible to detect and attribute such activities, using global information systems and technology such as satellite observation.[82] However, attributing a certain activity to a state is not the same as establishing that the particular requirements for a breach of an obligation are met. For instance, a breach of an international obligation might require that certain impacts are caused by the activity in question. An activity might be

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[78] Cf. the CBD's draft guidance on biodiversity-inclusive strategic environmental assessment, decision VIII/28 and document UNEP/CBD/COP/8/27/Add.2.

[79] Annex to UNGA Res. A/RES/56/83 of 12.12.2001.

[80] In this sense, the International Law Commission (ILC) uses the term "secondary rules".

[81] Articles 2 and 20-27.

[82] Bodle (2010) 306.

attributable to a state while it can remain difficult or impossible to prove that it caused such impacts.

States are generally not responsible for the conduct of private actors. However, a state may be responsible for itw own conduct in relation to the conduct of private actors if it failed to take necessary measures to prevent the conduct or its effects.[83] Whether and to what extent a state has an obligation to take such measures depends on the obligation in question and the particular case. For instance, in June 2012 a large-scale ocean fertilisation experiment was conducted by a American private company off the Canadian coast, which sparked media headlines alleging a "violation" of "UN rules", meaning decisions by the COPs of the CBD and the LC/LP.[84] Even if the these decisions imposed binding restrictions under international law, they would apply to the parties to the respective regime to which these rules belong, but they would not bind a private the company. However, Canada or the US could potentially have been in breach of obligations by not restricting or preventing the experiment in some way. This not only presupposes that the "rules" on question were binding obligations on these states, but also that these obligations required these states to take specific measures to prevent the experiment and that the failed to meet these requirements. This is difficult to determine in the abstract.

State responsibility does not as such require fault or negligence of the state. Again, the conduct required or prohibited and the standards to be observed depend on the obligation in question and the particular case (cf. above on the duty to prevent transboundary harm).[85]

Assuming a case in which a particular geoengineering activity would be attributable to a state and would constitute a breach of an international obligation, it is unclear whether a state could avoid responsibility by relying on circumstances precluding wrongfulness, in particular necessity.[86] For instance, a state causing transboundary environmental harm by geoengineering might argue that it is particularly affected by climate change and claim distress or necessity as a legal defense.[87]

The consequences of state responsibility include legal obligations to cease the activity, to offer appropriate assurances and guarantees of non-repetition, if circumstances so require, and to make full reparation for the injury caused.[88] However, the Articles on State Responsibility do not include institutions or procedures to enforce these obligations.

In addition to the rules on state responsibility, the ILC has also pursued concepts addressing harmful effects of hazardous acts that do not contravene international law.[89] However, at this stage these proposals do not amount to customary law and it remains to be seen to what extent they could influence legal aspects of geoengineering.

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[83] ILC, Draft Articles on Responsibility of States for Internationally Wrongful Acts, with commentaries 2001, 39.

[84] "World's biggest geoengineering experiment 'violates' UN rules, *The Guardian*, 15. October 2012, http://www.guardian.co.uk/environment/2012/oct/15/.

[85] Bodle et al (2011) para 34.

[86] Articles on State Responsibility, Article 25.

[87] Bodle (2010) 308.

[88] Articles 30 and 31 of the Articles on State Responsibility.

[89] ILC, Draft articles on prevention of transboundary harm from hazardous activities, UN Doc. A/56/10 and Corr.1; ILC, Draft principles on the allocation of loss in the case of transboundary harm arising out of hazardous activities, UN Doc. A/RES/61/36.

5.1.2.5 Other principles

Other key concepts mentioned in the environmental debate that could be of relvance to geoengineering governance are in particular sustainable development and inter-generational equity. Although these concepts are frequently mentioned in key instruments and documents, there is no consensus that these concepts are legal principles or have acquired status as customary law.

5.1.2.6 ENMOD Treaty

The ENMOD Convention is a treaty that appears to apply to geoengineering as it addresses environmental modification techniques having widespread, long-lasting or severe effects. Originally intended to restrict deliberate attempts at weather modification as a means of warfare,[90] it provides rules and procedures that could apply to geoengineering when used for hostile or military purposes as well as definitions which may be useful to consider as precedents for other processes.

However, the ENMOD Convention's applicability to geoengineering is limited by its material scope, its limited number of parties[91] and the lack of practice to draw from.[92] It expressly applies without prejudice to the use for peaceful purposes, according to the preamble, article III and the Understanding relating to Article III ENMOD. In other words, it only applies in armed conflict. Although it may be tempting for a state to unilaterally regard a particular geoengineering activity as "hostile" and therefore prohibited, this should be determined in accordance with the laws of armed conflict. The distinction between the law applying in peacetime and the law of armed conflict is crucial and should not easily be eroded.[93]

The main substantial obligation under ENMOD is that the Parties in Article I ENMOD are prohibited from engaging 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". Article II ENMOD provides a broad definition of environmental modification techniques comprising "any technique for changing - through the deliberate manipulation of natural processes - the dynamics, composition or structure of the Earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space". An interpretative understanding[94] provides further definitions and clarifies that its scope covers

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[90] ENMOD preamble, first sentence: "Guided by the interest of [...] saving mankind from the danger of using new means of warfare".

[91] It has 74 Parties, of which only few have acceded in recent years, <http://treaties.un.org> accessed on 31.10.2010. However, key states that are parties to it include Brazil, China, India, Japan, USA, United Kingdom and Russia, cf. Bodle (2010) 312-313.

[92] For instance, the ENMOD Convention was not applicable to actions in the 1991 Gulf war such as the burning of oil fields by Iraq, because Iraq had not ratified it, United States Department of Defense report to Congress on the conduct of the Persian Gulf conflict. Appendix O: The Role of the law of war, 31 ILM 612 (1992): 616.

[93] Bodle (2010) 312.

[94] The understanding is not part of the treaty but is part of the negotiating record and was included in the report of the negotiating Committee to the United Nations General Assembly. It can guide interpretation in accordance with Art. 31 (2) and (4) of the Vienna Convention on the Law of Treaties.

inducing changes in climate patterns, which would arguably apply to at least some geoengineering concepts.[95]

Although the ENMOD Convention is not directly applicable in peacetime and was not designed to govern contemporary geoengineering technologies, it is argued that some of its concepts could be considered in addressing geoengineering governance.[96] For instance, Article V ENMOD provides for a rudimentary implementation procedure through a Consultative Committee of Experts and also envisages dispute resolution through a complaint procedure to the UN Security Council.

5.1.2.7 CBD Decisions

At CBD COP10 in 2010, the parties went beyond previous decisions addressing ocean fertilisation and adopted a decision addressing geoengineering *in general* ("the CBD geoengineering decision").[97] Decision X/33, para 8(w) appears to be the only all-encompassing governance measure at this level to date: The chapeau "invites Parties and other Governments, according to national circumstances and priorities," to consider the guidance given by this decision, which includes the following subparagraph (w) on geoengineering:

> *"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 geoengineering, and in accordance with the precautionary approach and Article 14 of the Convention, that no climate-related geoengineering activities 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;"*

Although the CBD geoengineering decision is not binding, it represents the consensus of 193 parties. The US is not a party, although as a signatory it is under an obligation not to defeat its object and purpose (Article 18 VCLT) - which, however, is unlikely to include any COP decisions or specific paragraphs thereof. Besides the on-going debate on semi-legal and *de facto* implications of COP decisions within treaty regimes, the decisions also send a political signal that would be difficult to ignore in practice, solely on the grounds that they are not binding.

As a result of political compromise, the language of the decision text is not entirely clear. On the basis of detailed analyses of the decision elsewhere,[98] the main implications of the decision can be summarised as follows:

Although the wording of the operative part includes terms such as "ensure" and "shall", which usually signify clear legal obligations, the chapeau of the relevant paragraph merely "invites"

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[95] The understanding is not part of the treaty but is part of the negotiating record and was included in the report of the negotiating Committee to the United Nations General Assembly.

[96] Bodle et al (2012) 130.

[97] UNEP/CBD/COP/DEC/X/33, <www.cbd.int/cop10/doc/>.

[98] Bodle (2010); Sugiyama (2010).

parties to “consider” its “guidance”. These are weak formulations using the usual codes used for decision language.[99]

The decision provides a tentative definition by way of a footnote, with key elements being “deliberate” and “large-scale”.[100] The definition explicitly excludes CCS. The wording is quite lengthy compared to the revised definition by the subsequent expert study for CBD SBSTTA on the impacts of geoengineering[101] (see above section 4).

The core of the operative part of paragraph 8(w) is the guidance that no climate-related geoengineering activities that may affect biodiversity take place. It is difficult to imagine geoengineering activities that reach a scale sufficiently large to fulfil the definition, but do not have any effect on biodiversity. The decision thus covers all geoengineering techniques currently discussed.

Although the language and grammar are not entirely clear, the intended restriction of geoengineering appears to be subject to three provisos:[102]

- First, the operative part as a whole is worded as a transitional measure intended to apply “in the absence of science based, global, transparent and effective control and regulatory mechanisms for geoengineering”;
- Second, the restriction is to apply “until there is an adequate scientific basis on which to justify” geoengineering activities, which includes a comprehensive risk assessment;
- Third, it exempts small-scale scientific research studies, provided that they are
    - conducted in a controlled setting,
    - justified by the need to gather specific scientific data and
    - subject to a thorough prior assessment of the potential impacts on the environment.

With regards to implementation, it appears to be subject to the determination of each Party whether the conditions for the second and third proviso are met.[103] The CBD geoengineering decision does not establish an international procedure or institution for this. In terms of substance, the decision elsewhere refers to the LC/LP’s Assessment Framework for ocean fertilisation, but it does not extend this reference to geoengineering in general.

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[99] Bodle (2010) 314.

[100] “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 geoengineering 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.”

[101] Williamson et al (2012) 8. On the wording of the Geoengineering decision see Bodle (2010) 315-316.

[102] Bodle (2013) 463.

[103] Bodle et al (2012) 124.

In accordance with the mandate in decision X/33, the CBD Secretariat commissioned two reports, one on the impacts of geoengineering and one on gaps in the international regulatory framework.[104] The subsequent COP decision XI/20 of 2012 takes note of these studies but does not add normative content over and above decision X/33. It might be regarded as a step backwards in terms of clarity, as it mentions several definitions.[105] However, it makes small steps towards providing elements of a governance framework (see assessment in section 6 below).

5.1.3 Stratospheric aerosol injection

The geoengineering technique of injecting of aerosols into the stratosphere aims at increasing the planetary albedo and thereby reduce the incoming solar radiation. A wide range of types of particles, which are considered as suitable for this purpose, is being discussed in scientific literature.[106] The focus of discussions has, however, been on the use of sulphate aerosols.[107] In this case, hydrogen sulphide (H_2S) or sulphur dioxide (SO_2) would be introduced into the stratosphere as gases, where they are expected to oxidize into sulphate particles.[108] To deliver the chemicals to the stratosphere, a fleet of aircraft was suggested as most effective.[109]

5.1.3.1 LRTAP Convention

The LRTAP Convention aims at the protection of humans and the human environment against air pollution. It obliges its parties to make an effort to limit, reduce and prevent air pollution, including long-range transboundary air pollution.[110] The injection of aerosols into the stratosphere, especially of H_2S and SO_2, would fall under the scope of this convention to the extent that it satisfies the LRTAP Convention's definition of air pollution and long-range transboundary air pollution.

The LRTAP Convention is a regional convention; its geographical scope is limited to the UNECE region. As of March 2011, the LRTAP Convention had 51 contracting parties,[111] covering virtually the entire area of the UNECE region in North America and Europe.[112] In the remaining three countries in the Central Asian part of the UNECE region, Tajikistan, Turkmenistan, and Uzbekistan, efforts which could lead to accession to the Convention are

[104] Williamson et al (2012); Bodle et al (2012).

[105] CBD Decision XI/20, para 5.

[106] Williamson et al (2012) 26 and 49 with further references.

[107] See for example GAO (2011) 33.

[108] Royal Society (2009) 29.

[109] Royal Society (2009) 32; See also Rasch et al (2008) 4015 and GAO (2011) 33-34.

[110] LRTAP Convention, Article 2.

[111] See UNECE web site, Status of Ratification, http://www.unece.org/env/lrtap/status/Status%20of%20the%20Convention.pdf (30 March 2012).

[112] For a map of the UNECE region see UNECE web site, http://www.unece.org/oes/nutshell/ecemap.html (30 March 2012).

reported, but so far they have not become parties.[113] The LRTAP Convention functions mainly as a framework for cooperation and development of further, more specific obligations for the implementation of the Convention.[114] The Executive Body, established by Article 10 of the LRTAP Convention, comprises all contracting parties as members and serves as the highest decision-making body of the LRTAP Convention. In its annual sessions, the Executive Body adopted 8 protocols, which govern specific pollutants or issues.[115] All of these Protocols entered into force, even though their number of parties varies significantly. Only those three Protocols, which address SO_2 emissions and are therefore directly relevant to the injection of SO_2 into the stratosphere, will be discussed below.

Some of the provisions of the LRTAP Convention refer to "air pollution" generally, others to "air pollution including long-range transboundary air pollution", or to "long-range transboundary air pollution". The latter is defined by Article 1 (b) of the LRTAP Convention as air pollution, the physical origin of which "is situated wholly or in part within the area under the national jurisdiction of one State and which has adverse effects in the area under the jurisdiction of another State". Notably, such effects are defined as occurring "at such a distance that it is not generally possible to distinguish the contribution of individual emission sources or groups of sources."[116] The LRTAP Convention therefore covers emissions with negative effects occurring on the territory of states other than the emitting state, the cause of which cannot be explicitly determined. Thereby, the definition in Article 1 (b) of the LRTAP Convention addresses the problem that it is in many cases difficult to establish a causal link between emissions in one country and effects of these emissions in another, which could also likely be the case for the injection of aerosols into the stratosphere.

"Air pollution" is defined by the LRTAP Convention as "the introduction by man, directly or indirectly, of substances or energy into the air resulting in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems and material property and impair or interfere with amenities and other legitimate uses of the environment."[117] This definition contains three elements, all of which have to be fulfilled to constitute air pollution:

- a pollutant (substances or energy introduced in the air)
- a specific actor (by man) and
- to prove causality (resulting in deleterious effects).[118]

The introduction of H_2S and SO_2 into the stratosphere as a geoengineering measure would meet the first two requirements.[119] The third, causality, which is also required for the LRTAP

[113] UNECE (2007) 13. As of 15 November 2011, they still had not become parties to the LRTAP Convention, see UNECE Website, Status of ratification of the 1979 Geneva Convention on Long-range Transboundary Air Pollution, <www.unece.org/env/lrtap/status/lrtap_st.html>.

[114] Beyerlin/Marauhn (2011) 150.

[115] Despite the fact that the LRTAP Convention does not provide the Executive Body with an *explicit* mandate to adopt new protocols, cf. Beyerlin (2000) 156.

[116] LRTAP Convention, Article 1 (b).

[117] LRTAP Convention, Article 1(a).

[118] See also Larsson (1999) 139, for a broader overview and discussion of definitions of "pollution".

[119] For the same assessment see Zedalis (2010) 21.

Convention to apply,[120] is more difficult to determine. In the case at hand, the introduction of H_2S and SO_2 into the stratosphere would have to actually have resulted in deleterious effects.[121] Situations in which the introduction of H_2S and SO_2 may have or are likely to have deleterious impacts on the environment are therefore not sufficient;[122] "harmless" substances are explicitly excuded.[123] Article 4 of the LRTAP Convention is an exception proving this rule.[124] It establishes the specific obligation to "exchange information on and review their policies, scientific activities and technical measures" regarding the discharge of air pollutants which *may* have adverse effects. It is notable that "air pollution" according to Article 1 (a) has to result in "deleterious effects" while long-range transboundary air pollution requires "adverse effects". It is not clear whether this choice of terms implies a difference in the intensity of negative effects required.

Article 1 (a) of the LRTAP Convention defines "deleterious effects" with a broad scope. It includes a range of negative effects, including harm of living resources and ecosystems and material property and interference with other legitimate uses of the environment.[125] The mere possibility of such effects does not appear sufficient to fulfil the definition; their existence hast to be actually proven.[126] The introduction of H_2S and SO_2 into the stratosphere at a scale, which could theoretically counteract either all or most of the radiative forcing from greenhouse gases at the global scale,[127] could harm living resources and ecosystems to some degree, as it would lead to an increase in acidity of precipitation ('acid rain').[128] Scientific studies suggest, however, that the size of this effect is considered to be small.[129] The decrease in photosynthetically active radiation and increase in the amount of diffuse (as opposed to direct) short-wave solar irradiation, caused by an increase of stratospheric aerosols, will have opposing ecological effects. The net impact is likely to differ between species and between ecosystems.[130] So far, such effects are not well enough understood to allow for a combined analysis of all effects. Marine photosynthesis, for example, may decrease[131] and negatively impact marine biodiversity. Effects on crops could interfere with food production and constitute an "interference with other legitimate uses of the environment". Some studies, however, predict, depending on the crop species, positive impacts on crops.[132]

In determining "deleterious effects", it could be asked whether in the case of geoengineering the negative effects of an introduction of H_2S and SO_2 into the stratosphere need to be weighed

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[120] Described by Larsson (1999) 139 as "the most difficult issue in air pollution": "the possibility of demonstrating the source and proving causality".

[121] Zedalis (2010) 23, also emphasizes that the LRTAP Convention will not be applicable in case this requirement is not fulfilled – completely independent from a political judgment about the desirability of geoengineering techniques.

[122] See for a similar argument Rickels et al. (2011) 90.

[123] Zedalis (2010) 21.

[124] Zedalis (2010) 22.

[125] Rickels et al. (2011) 90, also state that the enumeration of possible effects is not exhaustive but merely exemplary.

[126] This is assessment is shared by Rickels et al. (2011) 90 and Zedalis (2010) 22.

[127] Williamson et al (2012) 45.

[128] Williamson et al (2012) 46.

[129] Williamson et al (2012) 47.

[130] Williamson et al (2012) 47.

[131] Williamson et al (2012) 47.

[132] Williamson et al (2012) 47.

against future negative impacts of climate change, which this measure avoids.[133] If interpreted in this way, "deleterious effects" would be determined as "net" effects. The LC/LP Resolution on the Assessment Framework for Scientific Research Involving Ocean Fertilization, for example, provides to a certain degree for such weighting.[134] This line of argument, however, is not reflected in the text of the LRTAP Convention. Rickels et al. discuss the same issue through a related argument: They ask how, for the case of a geoengineering measure, the potentially arising conflict between the objectives of two Conventions could be resolved.[135] In case of the LRTAP Convention, it could be argued along those lines that the objectives of the LRTAP Convention, including avoiding negative effects of an introduction of H_2S and SO_2 into the stratosphere, clashes with those of the UNFCCC, which include avoiding future negative impacts of climate change. While suggest to employ the precautionary principle to balance the conflicting objectives, the LRTAP Convention,[136] in its Article 1 (a), only refers to specific effects resulting from the introduction of substances or energy into the air and contains no explicit reference to the precautionary principle.[137] Therefore, regardless of the whether this approach is generally suitable, it does not appear to be justified in the case of the LRTAP Convention. Also, the definition in Article 1 (a) of the LRTAP Convention does not require a minimum scale of deleterious effects.

It can be concluded that the introduction of H_2S and SO_2 into the stratosphere could, depending on the actual effects of such measures, potentially harm living resources and ecosystems, human health or interfere with other uses of the environment. As the elements describing "deleterious effects" are not cumulative, one of these elements would be sufficient to constitute "air pollution". Other studies, also suggest that it is not possible to rule out that the injection of sulphate aerosols into the stratosphere will result in "deleterious effects".[138] As the existence of deleterious effects is a precondition for the applicability of most of the LRTAP Convention's obligations to the injection of sulphate aerosols into the stratosphere, this needs to be assessed on an on-going basis, as new scientific results about negative effects of this geoengineering measure become available.

Even if the introduction of H_2S and SO_2 into the stratosphere constitutes "air pollution" or "transboundary air pollution" within the meaning of the LRTAP Convention, this does not imply that such activities would be forbidden or restricted under its provisions. In fact, the LRTAP Convention does not prohibit any "air pollution", article 2 merely requires parties to "*endeavour* to limit and, *as far as possible*, gradually reduce and prevent air pollution including long-range transboundary air pollution" (emphasis added). While this is a legally binding obligation,[139] its content is much softened by the terms "as far as possible" and

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[133] Zedalis (2010) 23 emphasizes that "the palpable objective driving geoengineering is far from one planned to have or likely to have an adverse effect".See also Reichwein and Wiertz (2010) 22.

[134] See Resolution LC-LP.2 (2010). On the development of the assessment framework see Ginzky (2010) 73-74; for a discussion of the assessment framework in the context of the CBD see Bodle (2011) 320.

[135] Rickels et al. (2011) 91.

[136] See Rickels et al. (2011) 101.

[137] In their discussion of the LRTAP Convention, Rickels et al. do note that the Convention does not contain an explicit reference to the precautionary principle, see Rickels et al. (2011) 90.

[138] Rickels et al. (2011) 26.

[139] In contrast, Beyerlin (2000) 155 states that this obligation only has a weak legal binding effect. However, a distinction needs to be made between the legal status of an obligation (part of a treaty) and the specificity of its content. As Klabbers (1996) 181, states: " [...] law can be more or less specific, more or less exact, more or

"gradually". Drafted in a similar fashion, Article 3 requires parties to develop, "by means of exchanges of information, consultation, research and monitoring, [...] without undue delay policies and strategies which shall serve as a means of combating the discharge of air pollutants".[140] It would be difficult to argue that this general provision entails an obligation to develop *specific* legal measures prohibiting the injection of aerosols in the stratosphere. Referring to these obligations as a "prohibition" seems misconstrued in this respect.[141] Similarly vague, Article 6 of the LRTAP Convention requires parties "to develop the best policies and strategies including air quality management systems and, as part of them, control measures compatible with balanced development, in particular by using the best available technology which is economically feasible [...]".[142]

The LRTAP Convention also contains provisions on information exchange and consultation, which are relevant to the introduction of H_2S and SO_2 into the stratosphere. In Article 8(a), the LRTAP Convention requires its parties to exchange information on "[d]ata on emissions [...] of agreed air pollutants, starting with sulphur dioxide, [...] or on the fluxes of agreed air pollutants, starting with sulphur dioxide, across national borders, [...]". Under this article, a party may have to provide a certain degree of transparency regarding the geoengineering measures it conducts, which involve SO_2. In the context of transboundary pollution, Article 5 of the LRTAP Convention requires that parties, which are "actually affected by or exposed to a significant risk of long-range air pollution" conduct consultations with (potentially) polluting states.

Depending on its actual impacts, the introduction of H_2S and SO_2 into the stratosphere would, as explained above, likely fulfill all the elements of the definition in Article 1 (a) of the LRTAP Convention and constitute air pollution or even transboundary air pollution as defined by Article 1 (b). However, the obligations of the LRTAP Convention regarding air pollution are weak,[143] and are unlikely to restrict such geoengineering activities in a significant way.[144] In addition, as mentioned above, the LRTAP Convention is not explicitly based on the precautionary approach, which could narrow the potential for a more flexible interpretation. However, some of its protocols explicitly include this approach,[145] and also explicitly regulate SO_2 emissions:

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less determinate, more or less wide in scope, more or less pressing, more or less serious, more or less farreaching; the only thing it cannot be is more or less binding."

[140] LRTAP Convention, Article 3.

[141] Rickels et al. (2011) 90: " In the absence of reference to aspects of precaution, it is necessary that the negative environmental impacts caused by the introduction of aerosols or particles into the stratosphere are verified before the prohibition contained in CLRTAP can become applicable."

[142] See Beyerlin (2000) 155 and (Birnie et al (2009) 345.

[143] Similar assessment by Beyerlin/Marauhn (2011) 150; see also Lin (2011) 18.

[144] The Congressional Research Service (2010) concluded regarding the LRTAP Convention "It is uncertain which geoengineering activities CLRTAP would regulate, or how such regulation would be implemented." As showed in the sections above, it appears possible to discuss the applicability and obligations under the LRTAP Convention for the injection of aerosols in the atmosphere.

[145] Cf. the preambles of the 1994 Oslo Protocol on Further Reduction of Sulphur Emissions; 1998 Aarhus Protocol on Heavy Metals; 1998 Aarhus Protocol on Persistent Organic Pollutants (POPs); 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone.

The Helsinki Protocol, the first protocol to the LRTAP Convention, adopted in 1985, aimed at the reduction of sulphur emissions or their transboundary fluxes by at least 30% by 1993, using 1980 as base year.[146] In contrast to the LRTAP Convention, the Helsinki Protocol established a specific target to reduce sulphur emissions or their transboundary fluxes.[147] The protocol was negotiated as a response to damage caused by acid rain – which may also be caused by the introduction of H_2S and SO_2 into the stratosphere, and, as discussed above, potentially harm, at least in specific cases, ecosystems. However, the reduction target in the Helsinki Protocol is outdated. The – at this time – 21 parties to the protocol all achieved their reduction targets for 1993, with all parties achieving more than 50% and 11 parties more than 60%.[148] In addition, the Helsinki Protocol also established reporting obligations,[149] which would include emissions resulting from the introduction of H_2S and SO_2 into the stratosphere. These obligations continue apply after 1993. For those parties that became parties to the Oslo Protocol (e.g. Belarus, Estonia, Russian Federation, and Ukraine), the reporting obligations of the Oslo Protocol factually superseded the Helsinki protocol.[150]

The Oslo Protocol, adopted in 1994, obliges its 29 parties to reduce their sulphur emissions further – compared to the obligations of parties under the Helsinki Protocol. Article 2 (1) of the Oslo Protocol requires that "depositions of oxidized sulphur compounds in the long term do not exceed critical loads for sulphur" as listed in Annex I to the Protocol as "critical sulphur depositions in accordance with present scientific knowledge".[151] This obligation serves as a long-term goal; its content is, however, softened by qualifications referring to „critical sulphur depositions", and „as far as possible, without entailing excessive costs". While the Helsinki Protocol set a target for all its parties to reduce their sulphur emissions by 30% by 1993, the Oslo Protocol contains in its Annex II individual, mandatory targets for each of its 29 parties.[152] This approach was chosen to achieve the highest possible reduction of sulphur emissions. The individual targets were developed based on the "regional acidification information and simulation model" of the International Institute for Applied Systems Analysis, which was used to estimate the vulnerability of ecosystems across Europe to pollution.[153] As a first step to implement the objective expressed in Article 2 (1) of the Oslo Protocol, emission ceilings are listed in Annex II, which become gradually more stringent, for most parties from the years

[146] The Helsinki Protocol has 25 Parties, see http://www.unece.org/env/lrtap/status/85s_st.htm (31 March 2012).

[147] Helsinki Protocol, Article 2.

[148] UNECE (2007) 24.

[149] Helsinki Protokoll, Article 4 "Each Party shall provide annually to the Executive Body its levels of national annual sulphur emissions, and the basis upon which they have been calculated" and Article 5 "EMEP shall in good time before the annual meetings of the Executive Body provide to the Executive Body calculations of sulphur budgets and also of transboundary fluxes and depositions of sulphur compounds for each previous year within the geographical scope of EMEP, utilizing appropriate models. In areas outside the geographical scope of EMEP, models appropriate to the particular circumstances of Parties therein shall be used".

[150] UNECE (2007) 24. The reporting obligations are contained in Article 5 of the Oslo Protocol.

[151] However, the obligation is softened by qualifications referring to „critical sulphur depositions", and „as far as possible, without entailing excessive costs" .

[152] Oslo Protocol, Article 2 (2). See also the definitions on Article 1 (11) and 1 (12). Parties to the Oslo Protocol are besides EU member states also Canada, Norway and Macedonia, see "Status of Ratification" http://www.unece.org/env/lrtap/status/94s_st.htm (31 March 2012).

[153] Rowlands (2007) 318.

2000, 2005 and 2010. Parties also appear to have implemented these obligations overall successfully.[154]

With regard to reporting requirements, Article 5 of the Oslo Protocol contains the obligation to report periodically on the levels of sulphur emissions with temporal and spatial resolution. For the first time under the LRTAP regime,[155] the Oslo Protocol established an Implementation Committee with the mandate to address implementation of the Protocol and cases of potential non-compliance.

The latest protocol adopted under the LRTAP Convention, the Gothenburg Protocol,[156] also sets emission ceilings, including for sulphur, but follows a different approach than the Helsinki and Oslo Protocols. It addresses four specific effects, still including acidification; the emission ceilings for the control of the pollutions causing them are means to this end.[157] Article 2 of the Gothenburg Protocol requires its parties to ensure "as far as possible" that "in the long term and in a stepwise approach", the depositions and concentrations by 2010 do not exceed specified critical levels. The Gothenburg Protocol, like the Oslo Protocol, sets specific targets for each party, ensuring that those parties, whose emissions have especially negative impacts on the environment or human health and whose emissions can be reduced in an economical fashion, have higher targets than others.[158] Revisions of the Gothenburg Protocol were intended to conclude at the thirtieth session of the LRTAP Executive Board between 30 April and 4 May 2012.[159]

In sum, the Helsinki, Oslo and Gothenburg Protocols contain gradually strengthened emission ceilings for SO_2. These targets apply economy-wide to parties and do not directly regulate the introduction of SO_2 into the stratosphere. A party conducting geoengineering measures on its territory involving SO2 aerosols would have to account for these emissions, against its overall SO_2 emissions ceiling. The geoengineering activity could therefore contribute to a breach of obligations under these protocols only insofar as the amount of SO_2 emitted for the geoengineering measure could lead to a party exceeding its emissions threshold. This depends on the amount of SO_2 injected into the stratosphere.[160]

In conclusion, the LRTAP Convention on its own does not contain provisions that are specific enough to prohibit or significantly restrict introduction of SO2 into the stratosphere. The views expressed by some that such geoengineering activities would be „contrary to the spirit of LRTAP"[161]are legally beside the point. The LRTAP Convention establishes a framework of procedural obligations on information exchange and consultation among parties, which could generally apply to the introduction of SO2 into the stratosphere. As the introduction of SO_2 into the stratosphere is likely to fall within the scope of the LRTAP Convention, this convention provides a platform for further regulation of the introduction of SO_2 into the stratosphere. The three protocols relating to sulphur establish reporting obligations for parties. The introduction

[154] For an overview of the status of implementation in 2006 see UNECE (2007) 29.

[155] Beyerlin/Marauhn (2011) 152.

[156] See UNECE Website, available at http://www.unece.org/env/lrtap/status/99multi_st.html (28 March 2012).

[157] See UNECE (2007) 36.

[158] Beyerlin/Marauhn (2012) 153.

[159] See decision 2011/1 (contained in document ECE/EB.AIR/109/Add.1) paragraph 3.

[160] Lin (2011) 18 and Rickels et al. (2011) 90.

[161] Bodansky (1996) 313. This view is also expressed in Umweltbundesamt (2011) 32.

of SO_2 into the stratosphere would be restricted to the extent that it would lead to exceeding a party's emission ceiling under the protocols. Generally, the LRTAP regime is successful with high levels of implementation, but its limited geographical scope has to be taken into account.

5.1.3.2 Ozone Convention and Montreal Protocol

According to science, the injection of H_2S and SO_2 into the stratosphere could result, at least seasonally and regionally, in increased ozone depletion.[162] Therefore, the Vienna Ozone Convention and its Montreal Protocol could potentially apply to this form of geoengineering. Both treaties have been ratified by almost all states.[163]

Article 2 (1) of the Ozone Convention requires its parties to take "appropriate measures" to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer. To this end, parties to the Ozone Convention are further obliged, among others, to develop, in accordance with their means and capabilities, appropriate laws and policies "to control, limit, reduce or prevent human activities" if they are at least likely to have adverse effects resulting from modification or likely modification of the ozone layer.[164]

The Ozone Convention does not define which substances are considered as modifying or likely to modify the ozone layer, for the purpose of its provisions. However, Paragraph 4 of Annex I to the Ozone Convention contains a list of substances which "are thought to" have the potential to modify the chemical and physical properties of the ozone layer;[165] the Ozone Convention is therefore more specific than the LRTAP Convention.[166] Neither H_2S nor SO_2 are included in this list. As the list is non-exhaustive, this does not mean that activities involving these substances are not covered by the Ozone Convention.

At the same time, the fact that an activity modifies or is likely to modify the ozone layer alone does not trigger the obligation in Article 2 (1) of the Ozone Convention.[167] This is not made entirely clear in existing studies on the regulatory framework for geoengineering measures.[168] The activity would, in addition, have to result or be likely to result in "adverse effects". Such effects are defined in Article 1 (2) as "changes in the physical environment or biota, including changes in climate, which have significant deleterious effects on human health or on the composition, resilience and productivity of natural and managed ecosystems, or on materials useful to mankind". Thereby, the Ozone Convention requires a certain intensity of effects – they have to be "significant", which appears to differ at least from just any deleterious effects.[169] The

[162] See with further references: Williamson et al (2012) 11 and 49.

[163] The Vienna Convention and the original 1987 Montreal Protocol have 197 parties. Subsequent amendments to the Montreal Protocol have slightly fewer parties; cf. http://ozone.unep.org/new_site/en/treaty_ratification_status.php.

[164] Article 2 (2)(b) Ozone Convention. Article 2 (1) and 2 (2) are also discussed by Zedalis (2010) 22, as relevant to the injection of aerosols into the stratosphere.

[165] For a more detailed discussion of this list see Rickels et al. (2011) 91.

[166] Heintschel van Heinegg (2004) 1013.

[167] In support of this argument see Zedalis (2010) 23.

[168] For example, ETC (2010) 41.

[169] Larsson (1999) 139.

injection of H_2S and SO_2 into the stratosphere could, by modifying the ozone layer, lead to an increase in ultra violet radiation to reach the Earth's surface. The additional radiation, in turn, could potentially cause negative effects, especially on the productivity of ecosystems.[170]

As with obligations in other treaties, it could be asked whether "adverse effects" could be interpreted as meaning "net" effects. In this case, adverse impacts of this geoengineering activity would be an "adverse effect" in the sense of the Ozone Convention only if they outweigh the negative impacts of climate change avoided by geoengineering. Some argue that although scientific models suggest that "adverse effects" will be possible, the Ozone Convention as such should not apply in light of the overall purpose of geoengineering.[171] Zedalis emphasizes that "[b]arring some untoward and unintended twist of fate, however, the palpable objective driving geoengineering is far from one planned to have or likely to have an adverse effect".[172] However, it has been argued that the wording and ordinary meaning of the Ozone Convention, as the primary reference for interpretation under Article 31 VCLT, leave no room for a "net" approach to "adverse effects".[173]

Whether the effects are expected to be "significant" has to be established by science. It should be noted, however, that Article 2 (1) as well as Article 2 (2) (b) both refer to effects that are "likely to" occur. Therefore, it is not necessary that these effects are proven.[174] In sum, the injection of H_2S and SO_2 into the stratosphere could constitute a human activity, which modifies or is likely to modify the ozone layer and cause or is likely to cause adverse effects, according to Article 2 (1) of the Ozone Convention[175].

This result, however, does not trigger strict obligations for parties under the Ozone Convention.[176] Article 2 (1) of the Ozone Convention does not require its parties to take concrete measures to reduce ozone-depleting substances like H_2S and SO_2 could be considered to be. Article 2 (2) of the Ozone Convention, which obliges parties, among others, to use "systematic observations, research and information exchange" to achieve a better understanding and assessment of the effects on human activities on the ozone layer, and to adopt appropriate legislative or administrative measures, contains a chapeau paragraph which softens these requirements considerably. They only have to adhere to these obligations "in accordance with the means at their disposal and their capabilities".[177] Article 2 (2) (b) also allows parties a wide discretion in determining which measures are considered to be "appropriate". Therefore, it can be argued that the Ozone Convention does neither prohibit or significantly restrict the introduction of H_2S and SO_2 into the stratosphere, nor does it contain a

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170 Williamson et al (2012) 11 and 49.

171 Reichwein and Wiertz (2010) 22.

172 Zedalis (2010) 23.

173 Rickels et al. (2011) 91.

174 Rickels et al. (2011) 91.

175 For a restrictive evaluation of the potential effects of this geoengineering measure see Barrett (2008) 45.

176 Beyerlin/Marauhn (2011) 155. Umweltbundesamt (2011) 34, uses the term „contradict" and might therefore be misleading in this regard („Die Ausbringung von Schwefelaerosolen würde daher den Vorgaben des Wiener Übereinkommens *widersprechen*, wenn anzunehmen ist, dass dadurch z. B. wegen der ausgebrachten Mengen die Ozonschicht geschädigt wird und dadurch Gesundheitsbeeinträchtigungen verursacht werden" (emphasis added).

177 See also Beyerlin (2000) 168; Heintschel van Heinegg (2004) 1013.

sufficiently specific obligation for its parties to adopt measures which impose a ban or significant restrictions.[178]

Rather, the Ozone Convention constitutes a first step, a framework, under which the development of specific obligations was envisaged. To this end, the Ozone Convention allows for the adoption of Protocols by its Conference of the Parties in Article 6 (4) (h).[179] Parties already started to negotiate a protocol at the diplomatic conference, where the Ozone Convention was adopted.[180] Its own obligations are characterized by "abstractness and broad language".[181]

The Montreal Protocol, in contrast, contains very specific measures. In its original form, its core provision was Article 2, the obligation of parties to limit and reduce the consumption and production of the ozone-depleting substances listed in its Annex A.[182] A distinct characteristic of the Montreal Protocol consists in its innovative provisions allowing for flexible amendments (Article 2 (10)) and adjustments (Article 2 (9)).[183] Parties used these provisions to widen the scope of the Montreal Protocol considerably over the years, mainly by subjecting more substances to the regulations of the Montreal Protocol. However, H_2S and SO_2 are both not covered by the Montreal Protocol, but it would be generally possible to include these substances through amendments to the protocol.[184] It needs to be stressed that even if the Montreal Protocol would include H_2S and SO_2, it would regulate their import, export, production and consumption; not their use or emission. This point is rarely mentioned in previous studies on the legal framework for geoengineering.[185]It means that including H_2S and SO_2, under the current structure of the Montreal Protocol would restrict this geoengineering activity only to the extent that the restrictions imposed on production or import of these substances would affect the actual carrying out of the activity.

5.1.3.3 Chicago Convention

One way of injecting aerosols into the atmosphere is by emitting them from airplanes. This section therefore briefly analyses international law applying to airplane traffic that could be relevant for geoengineering.[186]

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[178] For a similar assessment see Virgoe (2009) 111,

[179] Heintschel van Heinegg (2004) 1013.

[180] Beyerlin (2000) 169.

[181] Beyerlin/Marauhn (2011) 154.

[182] See Beyerlin (2000) 170; Beyerlin/Marauhn (2011) 156 and Heintschel van Heinegg (2004) 1013.

[183] For a comprehensive discussion of these flexible provisions see Bankobeza (2005) 114 and 117; see also Gehring (2007) 489.

[184] This assessment is not disputed in the literature. See for example Reichwein and Wiertz (2010) 22.

[185] For example, Virgoe (2009) 111, merely states that "the Montreal Protocol might pose a serious obstacle to stratospheric sulfur injections, given the known impact of sulfate aerosol on stratospheric ozone". Lin (2011) however, explicitly mentions that the Montreal Protocol "restricts the *consumption and production* of ozone-depleting substances" (emphasis added).

[186] With the exception of Proelß et al (2011) and -very briefly- UBA (2011), previous studies have not addressed this aspect. Proelß et al. (2011) 31. The study by Proelß et al. (2011) served as input for Rickels et al. (2011). As the discussion of the Chicago Convention was not included in the latter, the former is quoted here.

State sovereignty extends to the air column above a state's territory, and ends where outer space begins.[187] This principle is affirmed in Article 1 of the Chicago Convention. Although the exact delimitation between airspace and outer space has been debated for decades,[188] it is common ground that geoengineering by stratospheric aerosols would be carried out in airspace. A state would therefore generally be allowed to introduce H_2S and SO_2 into the stratosphere *over its own territory*. According to Article 17 of the Chicago Convention, aircraft have the nationality of the state in which they are registered.

The introduction of H_2S and SO_2 into the stratosphere over the *territory of a different state* (in this case, different from the nationality of the aircraft) is generally subject to the rules of international law protecting the sovereignty of states. The overflight of a state's territory[189] as well as the release of H_2S and SO_2 into the stratosphere over a state's territory would therefore generally require the agreement of this state. However, states have entered into a number of multilateral and bilateral conventions which permit, under certain conditions, overflight and landing of aircraft in the territories of contracting parties.[190] For example, Article 5 of the Chicago Convention allows aircraft on non-scheduled flights "to make flights into or in transit non-stop across [other contracting parties'] territory".[191] In contrast, scheduled international flights over or into the territory of another state require, according to the Chicago Convention, the authorisation of that state.[192] However, there is a special rule for scheduled international flights under the International Air Services Transit Agreement, which supplements the Chicago Convention, contracting states grant each other the privilege to fly across their territory without landing.

As to the introduction of H_2S and SO_2 into the stratosphere over *areas beyond national jurisdiction*, i.e., the high seas, Article 87.1 (b) UNCLOS provides that the freedom of the high seas includes freedom of overflight both for coastal and land-locked states. For the parties to the Chicago Convention, the freedom of overflight is subject to regulation adopted based on its Article 12.[193]

In contrast to the rights to overflight, the disposal of substances from aircraft over the territory of another state is apparently not addressed by the Chicago Convention or any other multilateral convention. It would therefore be subject to the regulation of the subjacent state and generally require the authorisation of that state. There is no specific regulation concerning

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187 Fischer (2004) 903. Proelß et al. (2011) 31 and Umweltbundesamt (2011) 34, also note this principle in the context of geoengineering measures.

188 See section on space installations.

189 "The principle of respect for territorial sovereignty is also directly infringed by the unauthorised overflight of a state's territory by aircraft belonging to or under the control of the government of another state.", ICJ, *Military and Paramilitary Activities in and against Nicaragua (Nicaragua v. United States of America)*, judgment of 27 June 1986, para. 251.

190 Shaw (2008) 542.

191 According to Article 6 of the Convention on International Civil Aviation, scheduled international flights over or into the territory of another state require the authorization of that state.

192 Article 6 Chicago Convention.

193 Fischer (2004) 906.

the disposal of substances over the high seas.[194] This does, however, not necessarily imply that such disposal completely unrestricted. It could be argued, for example, that the freedom over the high seas do not give the right to exclude for a significant period of time other states from exercising their right to use the high seas and the air space above.[195] This has been argued regarding military maneuvers on the high seas A similar restriction could apply to the introduction of aerosols into the stratosphere. However, whether and to what extent this geoengineering technique would exclude others from exercising their rights, and thus be restricted, would probably need to be established in each specific case.

5.1.3.4 London Convention / London Protocol; UNCLOS

LC and LP were adopted in 1972 and 1996 respectively. They both govern pollution from dumping of wastes and other material in the marine environment. The LP supersedes the LC for its parties (Article 23 LP). However, to date, not all parties of the LC have signed and ratified the LP. Thus, the LC maintains to be relevant to ocean dumping activities.

The LC and LP apply to all marine areas outside internal waters.[196] Broadly, the LC and LP require Parties to individually and collectively promote the effective control of all sources of marine pollution. Under the LC, dumping is defined as the “any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea.” (LC Article 3(1)(a)). Article 4(1) LP contains almost the same definition, referring to dumping as “any deliberate disposal *into* the sea”.[197] Article 4 of the LC prohibits the dumping of wastes listed in Annex I and requires a special or general permit for all other dumped wastes of significant amounts and concern (Article 4). The LP prohibits dumping as a rule, making exemptions only for wastes listed in Annex I.

Dumping explicitly includes the disposal of matter from aircraft and therefore covers the injection of aerosols into the atmosphere by emitting them from airplanes. "Wastes or other matter" under both LC and LP is defined as “material and substance of any kind, form or description”,[198] and accordingly includes H_2S and SO_2. The disposal of aerosols would clearly be deliberate.

To constitute dumping, the disposal would have to take place “at sea” (LC) or “into the sea” (LP). The sea includes all marine waters other than the internal waters of states.[199] On the face of the wording of the LP, the introduction of aerosols into the stratosphere does not directly dispose of them *into* the sea. Even when the aerosols introduced into the stratosphere might potentially be washed down into the sea, they are likely to be transformed by chemical reaction into other substances. As far as the substances released into the atmosphere are different from those

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[194] For a similar assessment see Proelß et al. (2011) 31, Additionally, Czarnecki (2008) 136-137 notes that the international law governing air traffic does not contain any specific regulation regarding weather modification activities.

[195] Fischer (2004) 909-910.

[196] As of 5 April 2012, there are 87 parties to the London Convention and 40 parties to the London Protocol, *see* <www.londonprotocol.imo.org>.

[197] Emphasis added.

[198] according to Article 3 (4) LC and Article 1 (8) LP

[199] The LC or LP have not been addressed by previous studies in respect of aerosol injection. Cf. Rickels et al. (2011), Umweltbundesamt (2011) and Zedalis (2010) 23.

reaching the sea, the release into the atmosphere arguably does not qualify as disposal *into* the sea.[200] This reading of the LP's wording could be expanded by referring to the LC's "at sea" for consistency. Yet, to the contrary, the fact that the LP uses a different wording than the older LC could be regarded as a clarification of the LC's less clear wording in this respect. Some support for this latter understanding is provided by the German official translations of the LC and LP, which state "into" the sea for *both* instruments.[201] There is no indication that the purpose of the LC includes addressing emissions into the atmosphere as well as the marine environment. On this basis, the introduction of aerosols into the stratosphere would apparently not constitute dumping un*der* the LC and LP. However, the parties to the LP could clarify their interpretation of this requirement in accordance with Article 31(2)(a) VCLT.

If the release of aerosols into the stratosphere would, contrary to the arguments above, be considered as disposal "into" the sea and therefore fulfill the definition of dumping, the exception in LC Article 3(1)(b)(2) and LP Article 1(4.2.2) could apply. According to these provisions, the "placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of [the Convention / Protocol]" is expressly exempted and no to be considered dumping. The purpose of injecting H_2S and SO_2 *into* the sea would be to reduce solar radiation transmittance, not the disposal of these substances. In order to be exempt, the placement would also have to be not contrary to the aims of the LC or LP. The overall aim of the LC and the LP includes protecting and preserving the marine environment from all sources of pollution.[202] This could be understood as excluding activities having adverse environmental impacts, even if they are carried out for purposes other than mere disposal.[203] However, the fact that both instruments explicitly provide for the possibility of an exemption for placement means that this possibility must not be rendered meaningless by categorically ruling it out on the basis of potential negative effects on the marine environment. Unless the parties clearly agree otherwise, it would depend on each case to what extent the aims of the LC and the LP can exclude the exemption for a placement activity.

If, on the basis of the arguments above, the introduction of H_2S and SO_2 into the stratosphere does not constitute dumping, then this geoengineering technique is not prohibited under the

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[200] Further debate could arise on whether the purpose of geoengineering would exempt it from the definition, cf. the section on CCS.

[201] See BGBl. 1977 II S. 180 and BGBl 1998 II S. 1346.

[202] Article 1 LC: „Contracting Parties shall individually and collectively promote the effective control of all sources of pollution of the marine environment, and pledge themselves especially to take all practicable steps to prevent the pollution of the sea by the dumping of waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea." Article 2 LP: "Contracting Parties shall individually and collectively protect and preserve the marine environment from all sources of pollution and take effective measures, according to their scientific, technical and economic capabilities, to prevent, reduce and where practicable eliminate pollution caused by dumping or incineration at sea of wastes or other matter. Where appropriate, they shall harmonize their policies in this regard. Contracting Parties shall individually and collectively promote the effective control of all source of pollution of the marine environment, and pledge themselves especially to take all practicable steps to prevent the pollution of the sea by the dumping of waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea."

[203] Ginzky (2010) 64.

LP or LC and does not require a permit under the LC. In case the introduction of H_2S and SO_2 into the stratosphere at sea is generally considered dumping, the assessment whether this activity could qualify as placement and thus be exempt from the definition of dumping depends on whether the activity is considered contrary to the aims of the LC or the LP.

Similar questions arise under UNCLOS. The definition of "pollution of marine environment" in Article 1 (4) UNCLOS includes the introduction of substances into the marine environment, and the definition of dumping in Article 1 (1)(5)(a) explicitly includes disposal from aircraft.

5.1.3.5 Nature and ecosystem protection

The impacts from introducing of aerosols such as H_2S and SO_2 into the stratosphere, and the intended albedo increases could have potentially significant negative effects on ecosystems, areas and species protected under international law, for instance the CBD and :

- the obligation to protect the habitat of migratory species listed in Annex I to the CMS (Article 3 (4) CMS),
- the obligation to promote the protection of wetlands according to Article 4 (1) of the Ramsar Convention and,
- the obligation to take measures to protect and conserve world heritage sites according to Article 5 of the World Heritage Convention.

The CBD is a framework convention for promoting conservation and sustainable use of biodiversity. The treaty's provisions are largely expressed as goals and principles to be followed and implemented by Parties through national measures and policies, rather than as binding obligations.[204] Many provisions use conditional language, requiring Parties to meet obligations only "as far as possible and as appropriate" or "in accordance with its particular conditions and capacity."[205] These include obligations for situ conservation (Article 8), ex situ conservation (Article 9), sustainable use (Article 10), and to put in place environmental impacts assessment procedures for projects that may have significant adverse effects on biological diversity (Article 14). Article 14 of the CBD includes provisions on environmental impact assessment of proposed projects, as well as strategic environmental assessment of programs and policies that are likely to have significant adverse impacts on biodiversity. Article 3 CBD also incorporates the duty to prevent transboundary harm (see section on cross-cutting rules).

The effectiveness of some of these treaties is limited due to its narrow scope of parties. In addition, their specific content is considerably softened by their wording and various qualifying clauses. Therefore, there are no specific obligations relevant for aerosol injection, and is difficult to assess in abstract whether this activity would be in breach of one of these obligations.

5.1.3.6 Conclusion

It can reasonably be argued that the introduction of H_2S and SO_2 into the stratosphere is at present not as such prohibited or significantly restricted by the main international treaties governing the emission of those substances. Although the impacts of this geoengineering technique could also be addressed under international law in the area of biodiversity

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[204] Birnie et al (2009) 616; Lin (2012).

[205] Hunter (2007) 1027

protection, the obligations of the relevant treaties do not establish clear and precise obligations that would allow for determining potential infringements in abstract at this stage.

5.1.4 Cloud brightening from ships

Cloud brightening, also referred to as cloud-albedo enhancement or cloud seeding, describes a geoengineering technique by which clouds are increased and whitened over parts of the ocean and therefore reflect more short-wave solar radiation back to space.[206] The idea is to increase cloud-condensation nuclei per unit volume in low-level marine clouds, which scatter and reflect more of the incident light.[207] In practice, a "suitable hydrophilic powder"[208] would be released from a conventional ocean-going vessel into the troposphere, particularly over ocean areas. Generating fine particles of sea-salt derived from ocean water is the most prominently discussed technique,[209] although other proposals for cloud brightening could be developed.[210]

5.1.4.1 Ozone Convention and Montreal Protocol

The ozone regime, including its general obligation under Article 2(1) of the Ozone Convention, could apply to cloud brightening, provided that sea-salt particles are considered as ozone modifying or likely to modify the ozone layer in accordance with the provisions of the Ozone Convention.

As discussed in the section on aerosol injection into the stratosphere, paragraph 4 of Annex I to the Ozone Convention contains a list of substances which "are thought to" have the potential to modify the ozone layer. Paragraph 4 (e) of Annex I lists, among others, "hydrogen substances", including water, which "plays a vital role in both tropospheric and stratospheric photochemistry.[211] Cloud brightening would release sea-water vapor, which would increase the concentration in the lower atmosphere of very small sea-salt particles as cloud condensation nuclei[212] (also referred to as cloud seeds). While such cloud nuclei do not appear to be potentially ozone-depleting substances, water vapor, which is used as a "vehicle" for this technique, potentially could be ozone depleting.[213]

Additionally, Article 2 (1) of the Ozone Convention requires that the introduction of cloud nuclei results in "deleterious effects" (see above on aerosol induction).[214] Cloud brightening is

[206] Williamson et al (2012) 8; See also Royal Society (2009) 26 and GAO (2011) 35.

[207] Williamson et al (2012) 26 and 51. See also Royal Society (2009) 27.

[208] Royal Society (2009) 27.

[209] Royal Society (2009) 27. See also BPC (2011) 10.

[210] See House of Commons (2010) Ev 33.

[211] Proelß et al. (2011) 32, also address water vapor in their consideration of the Ozone Convention, while the version of the study by Rickels et al. (2011) does not address this issue in this context.

[212] Rickels et al. (2011) 42.

[213] Zedalis (2010) 22, concludes that "geoengineering strategies designed to generate previously non-existent, or stimulate the futher development of naturally present cloud nuclei through pumping water vapor or other hydrogen sources into the troposphere would fall within what the Convention considers an activity modifying or likely to modify the ozone layer".

[214] Zedalis (2010) 22 emphasizes this requirement.

expected to result in strong regional or local atmospheric and oceanic perturbations.[215] While the overall effects are difficult to assess, there could be strong local effects such as local cooling, which may potentially cause negative effects on biodiversity and ecosystems.[216] Therefore, it is possible that the impacts of cloud brightening could cause deleterious effects within the scope of the Ozone Convention. If such deleterious effects occur, the obligations of the Ozone Convention apply to the use of water vapor in cloud brightening techniques. However, the actual content of the obligations under the Ozone Convention are weak and, as in the case of aerosol injection, would not prohibit cloud brightening as such (see section on aerosols). As for the Montreal Protocol, water vapor is not among the substances regulated by it.

5.1.4.2 UNCLOS

The release of particles from ocean-going vessels[217] is generally governed by the provisions of UNCLOS. UNCLOS contains provisions regulating for each “maritime zone” the navigation of the releasing vessel and activities to be undertaken in this zone. In addition, UNCLOS contains provisions regarding the protection of the marine environment, which apply to the marine environment as a whole, including the high seas.

Cloud brightening activities in the territorial sea of a state are subject to the laws and regulations of that state in accordance with Article 2 (1) UNCLOS. A ship, which is intended to release particles for cloud seeding in the territorial sea of a state other than its flag state, could be allowed to navigate in this maritime zone by the “right of innocent passage” in accordance with Article 17 UNCLOS. The right of innocent passage only covers “continuous and expeditious” passage in accordance with Article 18 (2) UNCLOS, with stops and anchoring generally only taking place as required by “ordinary navigation”. Navigation of ships for cloud brightening activities may not fulfill this condition if it includes stops for the release of sea-water vapor.[218] In addition, a passage is not “innocent” according to UNCLOS if it constitutes an “act of willful and serious pollution” contrary to the provisions of UNCLOS, or “research or survey activities”, or an “activity not having a direct bearing on passage”.[219] While the release of water vapor is unlikely to cause serious pollution, cloud seeding research would be excluded. The deployment of cloud brightening activities would constitute an activity not having a direct bearing on passage, and therefore also exempt the vessel from the right of innocent passage.[220]

Cloud seeding in the EEZ is subject to the provisions of Part V of UNCLOS. The provisions of this part define which activities in this zone are subject to the jurisdiction of coastal states, which freedom other states enjoy, and which procedure applies for activities not covered by the former or the latter set of rules.

Under Article 56 (1) (b) (ii), “marine scientific research” is one of the activities in the exclusive economic zone which is to the jurisdiction of the coastal state. While UNCLOS does not define

[215] See with further references: Williamson et al (2012) 51. See also GAO (2011) 36.

[216] Williamson et al (2012) 51.

[217] Assuming that such vessels are considered “ships” for the purposes of UNCLOS. See Proelß et al. (2011), p. 33, for a detailed explanation, why vessels are to be considered ships in this case. Rickels et al. (2011), do not include the same detailed discussion.

[218] Rickels et al. (2011), p. 92.

[219] Article 19 (1)-(2)(h),(j) and (l).

[220] With the same result, but focusing on cloud seeding as research, see Rickels et al. (2011), p. 92.

marine scientific research, it has been argued that cloud brightening activities would not qualify, because the main activity, the release of particles into the stratosphere, takes place in the air, not the sea.[221] As the particles released will eventually be washed down into the marine environment, a similar argument could be made as in the case of aerosols under the LC/LP (see section 5.1.3). In addition, the subject of cloud brightening research is not the marine environment, even though the activities might have implications for it. For this reason research regarding cloud brightening does not constitute marine scientific research and is therefore not subject to the jurisdiction of the coastal state according to Article 56 (1) (b) (ii).[222]

Furthermore, cloud brightening activities could be subject to sovereign rights of the coastal state with regard to activities for the economic exploitation and exploration of the EEZ in Article 56 (1) (a) UNCLOS. Cloud brightening activities, however, are arguably not intended for economic exploitation or exploration of the EEZ.

Furthermore, cloud brightening does not appear to be covered by the freedom of navigation which states enjoy in the EEZ of another state in accordance with Article 58 (1) and Article 87 (1)(a) UNCLOS. Cloud brightening activities arguably are not a “passage”, and also not “navigation” or “uses of the sea related to” navigation.[223] Therefore, only the navigation of a ship for cloud brightening into the EEZ of another state could be covered by the freedom of navigation, not the cloud brightening activity as such.

On this basis, cloud brightening activities in the EEZ are neither subject to the jurisdiction of the coastal state, nor covered by the rights of other states under Arcticle 58 UNCLOS. Accordingly, cloud brightening activities would be covered by Article 59 UNCLOS which requires that conflicts have to be resolved on the basis of equity and in the light of all the relevant circumstances, taking into account the respective importance of the interests involved to the parties as well as to the international community as a whole. Strictly speaking, cloud brightening would have to be assessed on a case by case basis. Cloud brightening could be permitted based on, for instance, an argument could be made that geoengineering activities would be conducted in the interest of the international community.[224]

Cloud brightening activities taking place at the high seas would generally be covered by the freedoms of the high seas, which are not limited to those expressly listed in Article 87 (1) UNCLOS. However, these freedoms are subject to “the conditions laid down by [UNCLOS] and by other rules of international law”.

For example, cloud seeding activities in any marine area (except internal waters) would arguably have to be in conformity with the provisions of UNCLOS, in particular those in Part VII on the protection of the marine environment.[225] According to Article 192 UNCLOS states have a general duty to protect and preserve the marine environment and to take all measures necessary in order to prevent, reduce and control marine pollution from any source, including by dumping (Articles 1, 194, 210 UNCLOS).

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[221] Rickels et al. (2011), p. 92.

[222] Same assessment by Rickels et al. (2011), p. 92.

[223] For a similar assessment see Rickels et al. (2011) 93.

[224] See Proelß et al. (2011), p. 37. Rickels et al. (2011), discuss the issue in less detail, Rickels et al. (2011), p. 93.

[225] Zedalis (2010), p. 28, and Rickels et al. (2011), p. 93, also point out the relevance of these rules for cloud brightening.

"Pollution of the marine environment" is defined in Article 1(4) UNCLOS as the introduction by man, directly or indirectly, of substances into the marine environment that are likely to cause deleterious effects to living resources, human health or marine activities and uses. For cloud brightening activities to constitute such an introduction, either the air above a marine area would have to be part of the marine environment or washing down of cloud nuclei into the sea at some point would still have to qualify as introduction. Above it was argued that the introduction of substances into the stratosphere would not qualify as disposal into the sea, even if they are washed down eventually. Whether the same line of arguments can be applied to the introduction of substances into the marine environment under UNCLOS needs to be further assessed for each individual case. The further requirement for "pollution", that this introduction would likely result in deleterious effects, cannot generally be ruled out.[226] To the extent that cloud brightening would constitute marine pollution according to Article 192 UNCLOS, the relevant provisions of the Conventions Part VII apply (see the section on ocean liming for further analysis).

5.1.4.3 London Convention and London Protocol

The assessment of the provisions of the LC and LP in the context of the injection of H_2S and SO_2 into the stratosphere applies to cloud brightening. Dumping explicitly includes the disposal of matter from ships, water vapor as "material and substance of any kind, form or description"[227] constitutes "wastes or other matter", and the release of particles for cloud brightening would be deliberate. As with the injection of H_2S and SO_2 into the stratosphere, it is questionable whether the particles are disposed *into* the sea. As argued above, such particles may only be washed down into the sea at some later point, transformed by chemical reaction into other substances. An interpretation that would consider all activities which release substances and are eventually washed into the sea as dumping, would widen the scope of the LC and LP far beyond its textual scope.

If a different argumentation is followed and cloud brightening is considered dumping under the LC and LP, the exception in LC Article 3(1)(b)(2) and LP Article 1(4.2.2) could apply. As discussed above regarding the injection of H_2S and SO_2 into the stratosphere, whether cloud brightening activities would be exempt from the definition of dumping depends on whether they are considered contrary to the aims of the LC or the LP.

Furthermore, even if cloud brightening activities were to constitute dumping, the exception in Article 4 (1.1) LP and paragraph 1.6 of its Annex would exempt this activity from the general prohibition of dumping and subject it to the requirement of a permit only (Article 4 (1.2)). Thus, sea-water vapor, "may be considered for dumping" under Annex I, paragraph 1 (6) LP as it constitutes "organic material of natural origin".

5.1.4.4 Nature and ecosystem protection

The introduction of sea-water particles into the troposphere for cloud brightening raises similar question as the introduction of H_2S and SO_2 into the stratosphere. As for aerosol injection, examples for relevant provisions are:

- the obligation to protect the habitat of migratory species listed in Annex I to the CMS (Article 3 (4) CMS);

[226] Convention on Biological Diversity (2012), p. 48.

[227] According to Article 3 (4) LC and Article 1 (8) LP.

- the obligation to promote the protection of wetlands according to Article 4 (1) of the Ramsar Convention
- the obligation to take measures to protect and conserve world heritage sites according to Article 5 of the World Heritage Convention.

In addition, the rules and guidance established by the CBD COP could be relevant. Although they are not binding, they are likely to influence and potentially de facto restrict the actions of parties (see section on CBD Decision X/33). Relevant guidance include the Jakarta Mandate on costal and marine biodiversity (Decision II/10), the protection of genetic resources in areas beyond national jurisdiction (decision VIII/21) and the establishment of marine protected areas (decision VIII/24).

The effectiveness of some of these instruments is limited due to small number of parties, or by qualifying clauses softening their specific content. Therefore there appear to be no specific obligations which would be breached by cloud brightening, although this could depend on the scale of deployment.

5.1.4.5 Conclusion

Against this background, it is difficult to assess in abstract whether and to what extent cloud brightening would be permitted. The Ozone Convention, even though potentially applicable, does not impose practically significant restrictions. UNCLOS provides the most pertinent rules, but for activities in the EEZ refers to the resolution of conflicts in each individual case. As for the high seas, it is arguable but not clear that cloud brightening would fall under the UNCLOS provisions against marine pollution. The LP does not prohibit cloud brightening as long as sea water vapor is used and does not constitute dumping.

5.1.5 Desert reflectors

Proposals to use desert reflectors advocate covering of desert surfaces with highly reflective materials so as to increase solar radiation reflection. While reflective materials could be applied in any region, deserts are singled out for characteristics as largely uninhabited, flat surfaces, having limited vegetation, and as having a high levels incident solar radiation.[228] The potential of desert reflectors for increasing surface albedo would be limited by the size of available land and by potential land-use conflicts.[229]

The localized and irregular nature of radiative forcings from desert reflector albedo modification could result in alterations to atmospheric circulation patterns and reductions in cloud cover and rainfall.[230] Transport of desert sand to oceans, which plays an important function in supplying iron as a nutrient, could be disrupted.[231] More evident impacts would consist of disruptions to desert ecosystems, diverse and unique environments that are often overlooked in proposals as empty wastelands.[232] Covering large areas with reflective materials

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[228] Lenton and Vaughan (2009) 5549; Royal Society (2009) 26.

[229] Rickels et al (2011) 44.

[230] Royal Society (2009) 25-26.

[231] Umweltbundesamt (2011) 13.

[232] Gordon (2010) 43.

could severely harm desert biodiversity by destroying habitats and blocking migratory corridors for species. Further, exclusion of sunlight and regional cooling would alter the ecosystem and conditions for local flora and fauna.

As the scope of activity and impacts would largely be related to localized land use modification, regulation of desert reflectors or similar installations would primarily fall under national, rather than international, law (cf. section on biomass and biochar). Cross-cutting rules of international law would nonetheless apply depending on their particular scope (see section 4.1.2).

Adverse impacts to biodiversity resulting from desert reflectors, as well as other geoengineering measures, could be contrary to the CBD's overarching objective of conserving biodiversity and to these general conservation responsibilities. However, given the broadness of the objectives, it is not clear which adverse impacts on biodiversity would actually constitute non-conformity with the CBD. The same goes for the few more substantive obligations under the CBD. An assessment would have to be made in each individual case considering the scale of the desert reflectors, causation and the actual specific legal content of the CBD's obligations.

Impacts to biodiversity may also interfere with the CMS, which aims at protecting migratory species, species' habitats and migration routes. The treaty's 116 Parties cover applicable areas for desert reflector siting including most of Saharan Africa.[233] For species listed as endangered under Appendix I, Parties have an obligation to conserve species' habitats and to prevent or minimize factors contributing to endangerment (art. 3(4)). Parties are also required to prevent, remove, or minimize obstacles to migration (art. 3(4)). Installation of desert reflectors that serves to reduce or modify habitat, or where siting obstructs migratory pathways of endangered species, could contravene these provisions. As in the case of the CBD and other treaties for nature and ecosystems protection, the obligations of the CMS Convention are broad and general in nature[234], and it is difficult to determine in advance and abstract which particular activity involving desert reflector would not be in conformity with the CMS. For desert reflectors sited in areas of special cultural or natural heritage, the World Heritage Convention, could also apply. The World Heritage Convention seeks to protect both natural and cultural sites by obligating Parties to protect and conserve specially listed sites (art. 5), and more broadly, to do everything possible to identify, conserve, protect, and transfer to future generations natural heritage located within jurisdictions, regardless of whether the site is formally listed (art. 4). Examples of listed desert sites that require protection by Parties, both those whose territory the site is situated and to other State Parties, include Aïr and Ténéré Natural Reserves in Niger, and Tassili n'Ajjer in Algeria, both in the Sahara. Still, application would be limited as relatively few desert sites have been listed under the Convention.[235]

The United Nations Convention to Combat Desertification (UNCCD) creates a framework for action to combat desertification and mitigate the effects of drought, taking a "bottom up" approach that focuses on national action plans and implementing local remedial measures such as drought contingency plans and resources conservation.[236] While geographically relevant, desert reflectors are unlikely to breach a specific and binding commitment.

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[233] See http://www.cms.int/about/Partylist_eng.pdf, As of 18 April 2012.

[234] Birnie et al (2009) 684.

[235] IUCN (2010).

[236] Hunter et al (2007) 1222.

5.1.6 Installations in outer space

Another SRM concept that has been discussed involves outer space: placing installations in outer space in order to reduce the incoming solar radiation on earth. There are different proposals which can be clustered in two groups: First, some proposals include installations positioned in the near-earth orbits, such as free-orbiting or satellite-supported mirrors, scatterers, de- or reflectors or other reflective material/substances. The installation could also be space dust or parasol spacecraft rings or swarms that would be placed in the equatorial plane.[237] Second, installations could be positioned in further away in an area between earth and sun which is known as inner Lagrange point (L1). At this position, gravitational attraction of sun and earth are equal. Less material loss due to weaker light-pressure forces would allow for less material-intensive and lighter weight scattering structures. Proposals include a superfine mesh of aluminum or swarms of reflecting discs.[238]

Space-based technologies aim at blocking solar radiation before reaching the earth in order to reduce the atmospheric temperatures. Their actual impact and effectiveness would depend much on their design, material, location and quantity.[239] There is no experience to draw from, as none of these technologies have been implemented so far. Their realisation would require enormous technological and logistical demands including costs for research, launch and maintenance. Against this background, it is unlikely that geoengineering in outer space will be carried out in the near future.[240] Moreover, there are a number of uncertainties on their intended and unintended impacts on the climate system. The effects of the reduction of sunlight reaching the earth have not been fully assessed yet. The impacts on biodiversity of SRM techniques that aim to achieve uniform dimming (such as space-based geoeongineering technologies) are not fully understood and could have a broad range of predictable and unknown side effects. These include interference of the atmospheric cycling of nutrients, their deposition and recycling processes, in soil and in the ocean. It is also assumed that these techniques do not have the potential to restore temperatures at the regional level evenly, which would lead to a significant geographical redistribution of climatic effects.[241] This would also affect the global hydrology. Reduced sunlight could, for example, disturb the Asian and African monsoons which are crucial to food supplies in those regions.[242] Another risk is the rapidness inherent to this concept: atmospheric temperatures would respond very quickly, if solar radiation was changed on a large scale. If the application was interrupted, e.g. by a political decision to phase out its deployment, there could be a very quick fall-back to much warmer temperatures with unknown consequences.[243]

Potentially, all space-based geoeongineering concepts fall within the scope of international space law. This would be the case if they were carried out in outer space, i.e. beyond airspace.

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[237] See for instance Mautner (1991).

[238] Overview of all proposals in Royal Society (2009) 32 et seqq., United States Government Accountability Office (2011) 36 et seqq., McInnes (2010).

[239] Bracmort et. al. (2011) 20.

[240] Rocal Society (2009) 32, Bracmort (2011) 19.

[241] Williamson et al (2012) 45.

[242] Lin (2009) 6. On aerosols see Robock (2008) 13; Robock (2010).

[243] Royal Society (2009) 32, Williamson et al (2012) 48 call this a ‘termination effect.’

The main difference between these areas is that under international law, states generally enjoy sovereignty in the airspace above their territories, whereas outer space is not subject to the jurisdiction of any state. However, there is no clear physical line between outer space and airspace. Furthermore, neither space law nor air law defines at which height outer space begins. This issue of definition and delimitation has been discussed for decades without a clear agreed outcome. It has been on the agenda of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), the main international institution in this field, since 1960s.[244] There are a number of conceptual approaches to define the boundaries of outer space; including the view that many years of practice had shown that there is no need for a clear definition. However, the area at 110 km above sea level is generally regarded as being part of outer space.[245] Moreover, this lack of clarity on the boundary is not decisive for geoengineering. Solar radiation measures would be carried out either below 80 km, i.e. in the mesosphere or lower, or clearly above 110 km. All discussed space-based technologies would be deployed beyond that height and therefore fall within the scope of space law.[246]

International space law essentially consists of any applicable international customary rule,[247] any international customary space law[248] as well as international treaties focusing on outer space. The latter have been designed and adopted since the 1960s – at a time where exploration and use of the outer space was at its beginning and not all activities and their impacts were foreseen.[249]

The treaties which are potentially relevant are the Outer Space Treaty, the Liability Convention, the Registration Convention, the Moon Treaty, the Liability Convention and the Rescue Agreement. The Outer Space Treaty lays down basic and fundamental principles. Its rules on many matters rather broad and non-specific. Therefore it has been complemented by additional agreements that include more detailed provisions on certain subjects.[250] Additionally, there are a number of UN General Assembly Resolutions on space law. These are not per se legally binding, but they can have legal relevance for interpreting binding rules, and they can reflect or evolve into binding customary law.[251]

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[244] Committee on the Peaceful Uses of Outer Space, 'Historical summary on the consideration of the question on the definition and delimitation of outer space', Report of the Secretariat of 18 January 2002, A/AC.105/769.

[245] Proelß (2010) 443, Hobe (2009) 32 suggest the following definition: '*Outer space encompasses the terrestrial and the interplanetary space of the universe, whereby the delimitation of the Earth space around the Earth to outer space starts at least 110 km above sea level.*' Some authors argue that this line has become accepted as customary international law, cf. Vitt, E (1991) 46.

[246] See also Proelß/Güssow (2011) 14.

[247] cf. Article III Outer Space Treaty, Hobe (2009) 67.

[248] Graf Vitzthum in: Graf Vitzthum (2010) 62.

[249] Lafferranderie (2005) 6.

[250] Zedalis (2010) 23, Malanczuk (1991) 781.

[251] Hobe (2009) 27, the most important are: Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space (UNGA Res. 1962 (VIII) of 13 December 1963); Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting (UNGA Res. 37/92 of 10 December 1982), Principles Relating to Remote Sensing of the Earth from Outer Space (UNGA Res. 41/65 of December 1986); Principles Relevant to the Use of Nuclear Power Sources in Outer Space (UNGA Res. 47/68 of

In addition, there are other institutions dealing with space activities under their particular mandate, e.g. the International Telecommunication Union (ITU), the Committee on Space Research (COSPAR), the Inter-Agency Space Debris Coordination Committee (IADC) or the Committee on the Earth Observation Satellites (CEOS). Important international forums that contribute to the further development of international space law include the International Institute of Space Law (IISL) and the Space Law Committee of the International Law Commission (ILA). So far, geo-engineering does not seem to be of the agenda of the relevant institutions addressing international space law. Climate change is one of the topics addressed by COPUOS. However, the focus has been on using space applications in order to observe climate change consequences.[252]

The main basis for international space law is the Outer Space Treaty. It governs activities of states in the '*exploration and use*' of outer space. Its 101 Parties include the main space nations.[253] In the literature, the legal status of outer space and the celestial bodies, as provided for in the treaty, is generally considered to be customary international law.[254] The basic principles of the Outer Space Treaty are not comprehensive. Moreover, important terms such as 'exploration and use', 'outer space', 'space objects', 'damage' and 'harmful contamination' are not defined.[255]

Article I of the Outer Space Treaty generally deals with the main space activities, i.e. exploration, use and scientific investigation of outer space. It provides that '*exploration and use*' of outer space is '*free*' for all states. Thus, outer space is a common space in which states do not enjoy sovereign rights – similar to the deep seabed and the high seas. It is not subject to claims of sovereignty of individual states. As the broad terms in this article generally cover all space activities, the freedom of outer space does also apply to space-based geoengineering technologies.[256] This freedom is subject to limitations, as space activities have to be '*carried out for the benefit and in the interests of all countries irrespective of their degree of economic and scientific development*' and shall be '*province of all mankind*'.[257] These notions limit the freedom of outer space in the sense that neither exploration nor use of outer space shall be undertaken for the sole advantage of one country, but done only for the benefit of the international community.[258] However, the precise contours of this concept and of its restricting effect are not fully fleshed.[259] As the provision requires that all countries shall be involved in

14 December 1992); Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries (UNGA Res. 51/122 of 13 December 1996).

[252] cf. http://www.oosa.unvienna.org/oosa/en/climatechange/index.html

[253] As of March 2012, there were 101 ratifications and 26 signatories of the Liability Convention, see http://www.oosa.unvienna.org/oosa/en/SpaceLaw/treatystatus/index.html

[254] Durner (2000) 146.

[255] Lafferranderie (2005) 10.

[256] Zedalis (2010) 23, Proelß/Güssow (2011) 15.

[257] Moreover, only peaceful use of outer space is allowed, Article IV Outer Space Treaty.

[258] Hobe (2009) 32.

[259] Hobe (2009) 40.

space explorations irrespective of their development level, it stays unclear whether this amounts to an obligation of the sharing of the benefits of space activities, i.e. if a sort of material balance is necessary.[260] It is also unresolved who would determine, from which perspective and on what basis, whether an activity was for the benefit of all countries. We did not find state practice to draw from in this regard.

Notably, the question of whether such geo-engineering would be in the interest of all countries goes to the heart of the debate around geo-engineering. Opponents would point to the potential and uncertain side effects and the need to address the cause of global warming; proponents would argue that global cooling effects are in the global interest and they would outweigh the side effects at least in the short term.[261] However, the exact wording of Article I seems to second the arguments of the proponents. The provision states that any activity has to be carried out 'for' the benefit of all countries. It is unclear whether the word 'for' means that the geoengineering activity actually would have to result in impacts deemed to be beneficial, or whether it would be sufficient that the intention and design of the geoengineering technique qualify as beneficial - regardless of their actual impacts.[262] It has been suggested that this requirement could only be met by a benefit sharing mechanism and that in absence of it any unilateral geoengineering in outer space would be incompatible with this provision. However, given the general nature of the provision and the absence of state practice, this appears overly specific and to overstretch interpretation.[263] At least it can be concluded that the restrictions in Article I do not prohibit geoengineering in general.

Article IX Outer Space Treaty is potentially relevant as well, as it directly deals with environmental consequences (including on the earth) of space activities (non-contamination), next to principles regarding co-operation, mutual assistance, non-harmful interference and consultation.

The first sentence limits the freedom of states to deploy space activities, as those have to be guided by the '*principle of co-operation and mutual assistance*' and have to be conducted '*with due regard to the corresponding interest*' of all other parties.[264] However, the limitations themselves have their limitations, as they merely refer to the space activities of other parties to the Outer Space Treaty ('*corresponding interests*'). Whether geoengineering techniques in space would interfere with other states' space activities - e.g. communication channels- would depend on the specific case. However, this does not govern other, more severe consequences of these technologies, i.e. unintended side-effects that could occur on earth. Moreover, as the provision concerns the permissibility of certain space activities in general, it does not seem to prohibit space-based geoengineering activities as such. All peaceful uses of space including geoengineering are permitted, as long as the 'due regard' - requirement and the other conditions are met. *Marchisio* argues that states carrying out space activities have to prove beyond reasonable doubt that everything possible was undertaken to prevent a harmful act from occurring.[265] This resembles legal questions raised regarding the due diligence standard

[260] Hobe (2009) 38.

[261] Proponant: Zedalis (2010) 24.

[262] As Zedalis seems to suggest, Zedalis (2010) 24.

[263] Proelß/Güssow (2011) 17; Rickels et al (2011) 88.

[264] Marchisio (2009) 175.

[265] Marchisio (2009) 176, Rickels et all (2011) 88.

under the obligation to respect the environment and the implications of the precautionary principle (cf. section 5.1.2).

The space and earth environment is addressed by the second sentence of Article IX. It provides that parties have to '*pursue studies [...] and conduct exploration [...] so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose*'. According to a strict reading of the wording of Article IX, this obligation to avoid contamination only applies to the '*exploration*' of outer space, but not to the general '*use*'. However, others argue that this sentence also intends to cover '*use*', because the term was left out due to an editorial error.[266] Moreover, it could be argued *a fortiori* that if this limitation applies to exploration, it should even more apply to use-activities, which have likely a stronger impact.

The second sentence of Article IX is complex. Regarding the space environment, any harmful contamination shall be avoided (see wording of Article IX sentence 2 alternative 1). The earth's environment is to be protected only against adverse changes caused by the introduction of extraterrestrial matter (Article IX sentence 2 alternative 2). Again, there is not much state practice or case law to carve out more details of this sentence. There is no definition of '*harmful contamination*', which could mean any alteration of the *status quo* (i.e. the placement of installations in space as such) or only a *harmful* alteration of it[267]. Considering the explicitly added word '*harmful*', the latter interpretation seems preferable. This means that as long as the installation functions and serves its purpose, and does not turn into space debris or poses a risk to other space objects, it cannot be considered to be '*contamination*'. Moreover, it is unclear whether geoengineering installations can be considered '*extraterrestrial matter*'. Again, no definition is provided. In this sense '*Article IX opens more questions than it gives clear answers*'.[268] So far there have been no cases on the basis of Article IX that could provide guidance.[269] Generally, it can be concluded that this provision is too general prohibit space-based geoengineering as such. [270]

The last two sentences of Article IX are potentially relevant as well, as they deal with '*potential harmful interference*' caused by space activities in general, including geoengineering installations. However, these sentences merely require consultation between states in the event of interference. This would apply to geoengineering technologies, but does not concern their permissibility in general. Moreover, consultation is only required if the harmful interference concerns space activities of other parties to the Outer Space Treaty ('*activities of other State Parties in the peaceful exploration and use of outer space*'), but not interference on earth.

Article VI and VII of the Outer Space Treaty address state responsibility and liability for damage caused by space activities. They are potentially relevant for space-based geoengineering techniques, especially considering the harmful side-effects that they could cause. These provisions contain important basic principles, but they were not drafted with a view to address

[266] Frantzen (1991) 612, Proelß/Güssow (2011) 19.

[267] cf. Rickels et al (2011) 88.

[268] Marchisio (2009) 170.

[269] Kerrest/Smith (2009) 144.

[270] Zedalis (2010) 25.

exhaustively all issues on liability.[271] The Liability Convention was drafted in parallel and provides more detailed and specific rules (see below in this section).

Article VI and VII of the Outer Space Treaty do not deal with the permissibility of activities as such. They are retrospective rules that determine responsibility for those space activities that result in some sort of harm.[272] Article VI clarifies that states are responsible for their national activities in outer space, both deployed by governmental and non-governmental actors. This includes, inter alia, an obligation to authorize and supervise such activities. Article VII imposes international liability on those parties which qualify as launching states for damage caused by space objects. As for geoengineering, the latter obligation has certain limitations. According to the wording in Article VII, launching states are only liable for damage caused '*by*' space objects to another party. This approach matches typical environmental problems in outer space: direct damage caused by orbital space debris or objects falling from space or hitting other space objects.[273] However, the key concern with regard to geo-engineering technologies is indirect damage that could occur on the earth's environment, such as whether modification, hydrological interference, impacts on biodiversity etc. – without a physical impact of the space object itself.[274] It is not entirely clear whether such impacts could be qualified as damage '*by'* the geoengineering installations in space. Nevertheless, the provision would cover instances like geoengineering installations falling out of the orbit and causing damage to the earth.

Moreover, neither the Outer Space Treaty nor the Liability Convention contain any definition of space objects. Thus, it is unclear whether the provisions on responsibility/liability apply to every possible geoengineering technology in space (such as dust).[275] It is a pending issue whether the size, material or use of an object determines the qualification of a '*space object*'.[276]

As to the damage covered, Articles VI and VII of the Outer Space Treaty do not appear to exclude any particular kind of damage - material or immaterial, loss suffered as well as gain or loss of profit.[277] Specific conditions to receive damages are not defined. Moreover, the burden of proof lies with the claimant – which would be considerably difficult to show in the case of geoengineering.[278] The damage may be indirect and may not occur locally or immediately. The chain of events may be very long.[279] In addition, Article VII is silent on whether any fault or negligence is required.

The Liability Convention provides more elaborate and specific rules on damage resulting from a space object. The Liability Convention is *lex specialis* to the general rules in the Outer Space

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[271] Kerrest/Smith (2009) 134

[272] Zedalis (2010) 24.

[273] Sands (2003) 382.

[274] Malanczuk (1991) 790

[275] Article I does not include a definition, but only a clarification that individual party or components are covered by the term space object as well ("include").

[276] Kerrest/Smith (2009) 140.

[277] Kerrest/Smith (2009) 141.

[278] Malanczuk (1991) 794.

[279] Kerrest/Smith (2009) 142.

Treaty.[280] However, not all parties to the Outer Space Treaty are party to the Liability Convention.[281] Moreover, also the latter certain limitations that are relevant to geoengineering technologies.

The Liability Convention provides for two bases for legal claims.[282] Article II Liability Convention provides for 'absolute' liability for damage caused '*by*' space objects '*on the surface of the Earth*', irrespective of any fault or negligence. Article III provides for fault-based liability for damage caused elsewhere than on the surface of the Earth. The Liability Convention also contains a definition of damage. Damage means, according to Article I (a), '*loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international organizations'*. However, from the wording, it remains unclear whether damage to the earth's environment in general is covered if they are not considered to be individual or state "property".[283] Moreover, there is no statement whether direct as well as indirect damage is covered. It has been discussed within the COPUOS whether a clarification in that regard was needed. However, it was decided against further clarification as the extent of the damage covered was considered to be a question of adequate causation.[284] Therefore, the problem of proving causation remains and there is virtually no practice to draw from.[285] Due to all these considerations, *Malanczuk* concludes that liability for damage to the earth environment caused by space objects which does not clearly constitute a damage as defined in Article I (a) of the Liability Convention does either not exist or is practically impossible to proof.[286]

Even the Cosmos 954 incident, in which a Soviet satellite went out of control and crashed on Canadian territory, is inconclusive as state practice. Canada's claim for damages was based on the Liability Convention and general principles of international law, but it is subject to debate whether the final settlement and payment was an acknowledgment of an international obligation.[287]

The Moon Treaty could be of potential relevance for space-based geoengineering technologies as well, although its title might be misleading. Regarding the obligation to prevent environmentally harmful activities in Article 7, its scope is broad as it also includes the earth's environment. States are obliged to '*take measures to avoid harmfully affection the environment of the Earth through the introduction of extraterrestrial matter or otherwise*.' However, the obligation only applies to activities that are carried out '*on'* the moon or on celestial bodies within our solar system (other than earth), and orbits around or trajectories to or around the

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[280] Kerrest/Smith (2009) 129.

[281] As of April 2012, there were 88 ratifications and 23 signatories of the Liability Convention, see http://www.oosa.unvienna.org/oosa/en/SpaceLaw/treatystatus/index.html.

[282] Malanczuk (1991) speaks of a dual system of liability (784).

[283] cf. Proelß/Güssow (2011) 23.

[284] Kerrest/Smith (2009) 141; Malanczuk (1991).

[285] Kerrest /Smith (2009) 143.

[286] Malanczuk (1991) 794.

[287] Cf. references in Malanczuk (1991) 775.

moon or those celestial bodies.[288] However, the geoengineering technologies that are discussed so far only involve orbits and trajectories around the earth. Therefore, for the time being, arguably the Moon Treaty does not apply to geoengineering technologies. Moreover, it is of less relevance compared to other space law agreements, as the number of parties is considerably low and does not include main space nations such as the USA, Russia and China.[289]

A number of other rules of international space law are generally relevant for geoengineering. However, none of them seem to be in conflict with space-based geoengineering as such. They are mostly of procedural nature.[290] For instance, there is the obligation to inform about space activities, '*to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities'* in Article XI Outer Space Treaty. Space objects subject to the Registration Convention need to be registered. According to Article XXI of the Liability Convention, states shall assist other states that suffered a '*damage caused by a space object* [if it] *presents a large scale danger to human life or seriously interferes with the living conditions of the population of the functioning of the vital centers*.'

In conclusion, there is no international space law that explicitly prohibits space-based geoengineering as such. These techniques are no usual space activities and have not been in the focus of international space law so far. Still, certain obligations and restrictions imposed by international space law are generally applicable to space-based geoengineering as to any other space activity. For instance, geoengineering activities have to be carried out in due regard to other states interest in use of the outer space as well as in a cooperative and mutual manner. Moreover, space-based geoengineering installations have to be launched and operated in a way that avoids risks and contamination of outer space. Geoengineering experiments that '*would cause potentially harmful interference with activities of other States'* are subject to prior appropriate international consultation. However, as to environmental obligations and liability, not all potential side-effects and consequences associated with space-based geoengineering techniques are covered by space law – in addition to the fact that not all potential side-effects are fully understood yet. More clarification would be needed. For example, one of the points to clarify would be whether geoengineering installations placed in space constitute '*extraterrestrial matter'* which must be introduced in a manner not causing adverse changes in the environment of the earth in accordance with Article IX sentence 2 alternative 2 Outer Space Treaty. Another point is whether indirect side effects of space-based geoengineering –

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[288] According to Article 7, States are obliged "to prevent the disruption of the existing balance of its environment, whether by introducing adverse changes in that environment, by its harmful contamination through the introduction of extra-environmental matter or otherwise". They are also obliged to "take measures to avoid harmfully affection the environment of the Earth through the introduction of extraterrestrial matter or otherwise."

[289] As of April 2012, there were 14 parties and 4 signatories of the Liability Convention, see http://treaties.un.org/pages/ShowMTDSGDetails.aspx?src=UNTSONLINE&tabid=2&mtdsg_no=XXIV-2&chapter=24&lang=en#Participants

[290] This includes amongst others the information obligation of all space activities in Article XI of the Outer Space Treaty. Moreover, according to the Registration Treaty, space objects that are launched in outer space have to be registered with the UN. Of interest is also the obligation to assist in Article XXI of the Liability Convention. It rules that "If the damage caused by a object presents a large-scale danger to human life or seriously interferes with the living conditions of the population or the functioning of vital centres, the States Parties, and in particular the launching State, shall examine the possibility of rendering appropriate and rapid assistance to the State which has suffered the damage, when it requests.

such as harmful changes to the global hydrology – would qualify as *'adverse changes in the environment'* or '*damage*' (see again Article IX sentence 2 alternative 2 Outer Space Treaty and Article VII Outer Space Treaty).

5.1.7 Carbon capture and storage

Carbon Capture and Storage (CCS) is a technology that involves the capturing of CO_2 from human processes before it is released into the atmosphere. Secondly, the CO_2 is transferred and stored in suitable facilities in order to keep it away from atmosphere. Different storage options for the CO_2 are available, including geological storage and ocean storage. In applying the latter, captured CO_2 can directly be injected either into the water column, deep sea sediments in 3 km depth or on the sea floor.[291] Subsurface storage in geological formations is generally possible on land or under the seabed, either in oil or gas fields, un-minable coal beds, or deep saline formations.

The impacts and risks of CCS on the terrestrial and marine environment vary and depend on the technical process that has been chosen in the individual case. CCS generally involves different steps and processes for the capture, transport, injection of the CO_2 and maintenance of its storage. For example, CO_2 which has been stored underground could leak and cause ground or sea water pollution and acidification.[292] CO_2 injected and stored in the water column could destruct deep seafloor organisms if lakes of liquid CO_2 are created.[293] Moreover, there are potential risks and other adverse effects associated with the infrastructure and transport needs of CCS, such as drillings, pipelines or shipping of CO_2.[294] The life cycle and climate footprint of the CCS technology as such is another issue. Capture of CO_2 from emissions requires a substantial amount of energy, which accounts for additional CO_2 emissions if generated in conventional power plants.[295] Moreover, conflicts arising from competitive usages of the underground and its reservoirs (such as for energy storage, geothermal energy) generally need to be taken into consideration.

It is controversial whether CCS should qualify as geoengineering, or rather as mitigation measure (cf. WP1 on definition). Opponents argue that it does not resemble the other geoengineering concepts, as it is an end-of-the-pipe technology, which removes CO_2 before released into the atmosphere. Notably, CCS is not included in the CBD's working definition of geo-engineering.[296] On the other hand, while CCS avoids the actual emission of CO_2 into the atmosphere, it does not reduce the production of CO_2 in the first place. This is what makes it difficult to classify CCS as mitigation. Since a number of risks – similar to other geoengineering concepts – are associated with CCS, it is conceivable to assess it in the same context. Moreover, the guidance concerning the risk assessment framework for storage in sub-surface geological formations developed under the auspice of the London

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[291] In a depth lower 3 km, CO_2 has a higher dense than water and is expected to form stable "Lakes" Compare for the scientific background to the issue the extensive IPCC Special Report on Carbon Capture and Storage.

[292] Friedrich (2007) 212.

[293] Williamson et al (2012) 13.

[294] UBA (2008) 77.

[295] UBA (2011) 20.

[296] Cf. section on WP1: Definition.

Protocol (see below in this section) may be relevant to CDR geoengineering technologies that require the storage of CO_2

5.1.7.1 CCS on land

As to CCS conducted on land, there is no international legal regime that specifically addresses CCS. However, states generally have to comply with existing international obligations relevant in this context, such as the precautionary principle as laid down in the CBD.[297] In some countries and the EU, CCS installations are addressed by and subject to specific domestic legislation, such as planning, construction, water and nature conservation law.[298]

CCS also plays a role in the UNFCCC process. The 2006 IPCC Guidelines for National GHG Inventories set out a methodology on how to consider CCS in national inventories, stating that '*Carbon dioxide (*CO_2*) capture and storage (CCS) is an option in the portfolio of actions that could be used to reduce greenhouse gas emissions from the continued use of fossil fuels*'[299]. Moreover, CCS has recently been included into the Clean Development Mechanism (CDM) under Kyoto Protocol's flexible mechanisms. At CMP7 in 2012 the KP parties adopted the modalities and procedures for carbon dioxide capture and storage in geological formations under the clean development mechanism.[300] However, the incorporation of CCS into the UNFCCC framework is controversial because the general acceptance and incentive for CCS through the CDM does not promote reducing the production of CO_2. Promoting CCS could sit uneasy with the objectives of the UNFCCC and KP, as it could result in an increase or prolonged use of fossil fuels while at the same time prolonging the development of low-carbon long-term solutions.[301]

5.1.7.2 CCS in the oceans

Ocean CO_2 storage and CO_2 storage in sub-surface geological formations in the seabed potentially fall within the scope of UNCLOS, LC/LP as well as OSPAR.

UNCLOS generally applies to all activities in the seas and oceans and is therefore known to be the 'constitution of the oceans'. Therefore, it is relevant to ocean-based CCS as well. It includes a comprehensive set of rules, aiming at "*promoting the peaceful uses of the seas and oceans, the equitable and efficient utilization of their resources, the conservation of their living resources, and the study, protection and preservation of the marine environment.*"

UNCLOS distinguishes different territories, i.e. the territorial shelf (12 nautical miles behind the baseline of the costal state), the contiguous zone, the exclusive economic zone, the continental shelf (area between the territorial sea and the outer edge of the continental margin) and the so called Area (seabed and ocean floor and subsoil thereof). Each area follows a different regulatory approach. The territorial seas are subject to sovereign rights of the coastal states. In the other areas, coastal states are entitled to exercise certain sovereign rights. An exception is the Area, which is not subject to any national jurisdiction. Thus, the applicable provisions of UNCLOS depend much on the location of the CCS storage facility.

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[297] Cooney (2005) 12.

[298] See below section 5.2.

[299] 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 6, 5.5.

[300] Decision 10/CMP.7, UN Doc FCCC/KP/CMP/2011/10/Add.2. See also decision 2/CMP.5, paragraph 29 identifying specific issues.

[301] Friedrich (2007) 214.

Generally, CCS is not explicitly prohibited by UNCLOS.[302] In the areas subject to national jurisdiction, national laws determine its permissibility. Besides, the rules on protection and preservation of the marine environment in UNCLOS (Part XI) are relevant to CCS. Articles 192 and 194 UNCLOS include general obligations to parties concerning all sea-based activities (including CCS). Parties are required to "*prevent, reduce and control pollution of the marine environment from any source*". This obligation is further specified in Articles 207 et seqq. UNCLOS. According to these provisions, parties are required to adopt global rules and standards to regulate potentially harmful activities.

Those rules were established for dumping under sectoral treaties, such as LC and LP. As to the scope and coverage, both LC and LP focus on the "*disposal at sea of wastes or other matter*", but only from "*vessels, aircraft, platforms or other man-made structures at sea".* They do not cover disposal from land-based sources such as pipes and outfalls, wastes generated incidentally, disposal or storage of waste generated from seabed mineral resource exploitation, or placement of materials for purposes other than mere disposal. However, LC and LP have a slightly different scope. For example, according to Article 1 the LP's scope is wider, as it explicitly governs the seabed -not just the sea- as well as the storage of waste -not just the disposal.[303] Therefore, the LP is generally applicable to sub-seabed CO_2 storage. Although the LC does not explicitly include the seabed and the subsoil in its definition of what constitutes dumping at sea, it is widely accepted in literature that – taking the LC's objective to protect the marine environment into account - the LC is applicable as well.[304]

LP and LC follow different regulatory approaches. Under the LC, any activity under its scope is *allowed unless* it is listed in its Annex I. In contrast, the LP dumping *generally prohibited unless* the LP specifically permits it. Only those activities are exempted from the prohibition which are listed in its Annex 1; provided that a permit procedure has been applied in accordance with Annex 2. The LP's regulatory concept is stricter than the provisions of the LC, as it implements the obligation of Article 2 LP to apply the precautionary principle.[305]

Initially, CCS was considered to be not permissible under the LC/LP. Under the LC, CO_2 is regarded as '*industrial waste*' as listed in the Annex I and its disposal in the sea or seabed would therefore not be allowed.[306] Under the LP, CO_2 was not listed in Annex 1 of the LP and its dumping was therefore forbidden under this instrument as well. However, the parties of the LP adopted important changes to promote the deployment of CCS over the last couple of years.

As to sub-seabed storage, the parties to the LP adopted amendments to Annex 1 LP. These amendments entered into force on 10 February 2007 for all LP-Parties. On this basis, storage of CO_2 under the seabed is generally allowed, as the term "*CO_2 streams from* CO_2

302 UBA (2008) 109.

303 *'"Sea" means all marine waters other than the internal waters of States, as well as the seabed and the subsoil thereof; it does not include sub-seabed repositories accessed only from land.'*

304 Friedrich (2007) 220; Stoll/Lehmann (2008) 283; Schlacke (2007) 92.

305 Ginsky (2010) 63.

306 IMO, Report of the Twenty-Second Meeting of the Scientific Group to the London Convention (1999).

capture processes for sequestration" has been added to this list.[307] CO_2 streams may only be permitted for dumping if certain additional conditions are met (Article 4 of LP Annex 1):

- disposal is into sub-seabed geological formations;
- such streams consist overwhelmingly of carbon dioxide (although they may contain incidental associated substances derived from the source material and the capture and sequestration processes used); and
- no waste is added for the purpose of its disposal.

In turn, the explicit reference to sub-seabed geological formations clarifies that other ocean CO_2 storage – i.e. the disposal of CO_2 in the water column or *on* the seabed - is not allowed under the LP. Moreover, the use of the CO_2 stream for enhanced oil recovery is excluded.[308]

Annex 2 of LP contains further rules on the permit procedure on the disposal of CO_2 in the extent it is allowed. Parties are required to adopt further measures (Article 4 LP) to facilitate the procedure. The framework of guidelines adopted so far aims at providing in detail on how to deploy CCS in a manner that meets the requirements of the LP and consist of

- General 'Guidelines for the Assessment of Wastes or Other Matter That May be Considered for Dumping',
- 'Specific Guidelines on Assessment of Carbon Dioxide Streams for Disposal into a Sub-Seabed Geological Formations'[309] (CO_2 Sequestration Guidelines), and

'Risk Assessment and Management Framework for CO_2

- Sequestration in Sub-Seabed Geological Structures'.

There has been a second amendment of the LP with regard to CCS. In 2009, the parties amended Article 6 of the LP on the export of wastes for dumping purposes.[310] This amendment aims at enabling parties to share sub-seabed geological formations for CCS projects by allowing transboundary CO_2 transfer under certain conditions.

Entry into force requires ratification of two-third*s* of the parties.[311] According to the IEA, the achievement of the required number of signatures will be a challenge.[312] As of 31 March 2013, only two parties, Norway and the UK, had ratified this amendment.[313]

In 2010, LP-parties adopted a work plan with timelines to review the 2007 CO_2 Sequestration Guidelines by the LP Scientific Group. This review is supposed to be finalized in 2012. The LP

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[307] Annex 1 Article 1 LP: '*The following wastes or other matter are those that may be considered for dumping being mindful of the Objectives and General Obligations of this Protocol set out in articles 2 and 3*: [...]'.

[308] UBA (2008) 134.

[309] LC 29/17, annex 4.

[310] Resolution LP.3(4) on the amendment to Article 6 of the London Protocol, (adopted on 30 October 2009), available at http://www.imo.org/OurWork/Environment/SpecialProgrammesAndInitiatives/Pages/London-Convention-and-Protocol.aspx.

[311] Art. 21.3 LP.

[312] International Energy Agency (2011) 15.

[313] Status of multilateral Conventions and instruments in respect of which the International Maritime Organization or its Secretary-General performs depositary or other functions. As at 31 March 2013, www.imo.org.

Scientific Group decided to establish an intersessional Correspondence Group for this task, led by the United Kingdom. At the meeting of the contracting parties to the LP in 2011, the intersessional Group presented a progress report on this review and draft revised guidelines.[314] The group reported that a number of policy and legal issues have emerged from that work so far, which led to the establishment of a LP-Legal and Policy Correspondence Group.[315] Further outcomes of these two groups will be presented at the next meeting of the parties in 2012.

In contrast to the LP, the LC was not amended. CO_2 is still blacklisted, as it is categorized as industrial waste. Until there is a different interpretation of industrial waste or an amendment of Annex I, CCS is not permitted under the LC.[316] This especially relevant for those countries that are party to the LC, but not to the LP.

Another relevant treaty in the context of CCS is the regional OSPAR Convention. It focuses on the prevention and elimination of prevent and eliminate pollution in three fields, i.e. '*from land-based sources*' (Article 3 and Annex I), by '*dumping or incineration of wastes or other matter'* (Article 4 and Annex II) and '*from offshore sources'* (Article 5 and Annex III). It is said to be one of the most comprehensive and strictest legal frameworks for the marine environment.[317] Whereas Annex I contains specific conditions and a system of authorisation for pollution from land-based sources, Annex II and II contains a general prohibition of dumping from vessels and from offshore installation.

Although OSPAR does not explicitly refer to CCS, it is generally considered to be applicable to CCS as well. The definition in Article 1 covers the entire "maritime area" including the water column, the surface of the seabed and the seabed. Moreover, placement of CO_2

in the water column, on or under the seabed can be considered "dumping" in the meaning of the convention, as it is generally considered "deliberate disposal of waste or other matter".[318] Whereas Annex I includes an authorisation requirement for pollution from land-based sources, Annex II and III establish a general prohibition of dumping from vessels and from offshore installations. Thus, CCS conducted from land through pipelines would generally be allowed subject to certain conditions. All other types of storage -ocean CO_2 storage as well as storage of CO_2 on and in the seabed if dumped from offshore installations or vessels- were originally not allowed.

However, the OSPAR Convention was amended in 2007 to allow for certain types of CCS. Annexes II and III of were amended to make CO_2 storage in sub-seabed formations generally permissible under certain conditions.[319] The parties adopted a further decision to guide the

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[314] International Maritime Organisation, Waste Assessment Guidance: Review of the 2007 CO2 Sequestration Guidelines in the light of the Amendment to Article 6 of the London Protocol, First Revised Draft of the 2007, First revised draft of the 2007 CO2 Sequestration Guidelines, Submitted by the United Kingdom, LC/SG 34/2.

[315] International Maritime Organisation, Report of the Thirty-Third Consultative meeting and the Sixth Meeting of the Contracting Parties, LC 33/15, 21.

[316] Wilson (2003) 3479.

[317] Friedrich (2007) 223.

[318] Friedrich (2007) 224.

[319] See also Amendments of Annex II and Annex III to the Convention in relation to the Storage of Carbon Dioxide Streams in Geological Formations, ANNEX 4 (Ref. §2.10a), OSTEND: 25-29 JUNE 2007. Exceptions to the general dumping prohibition were included in Annex II and III (Article 3), reading as follows:

authorisation procedures.[320] Moreover, the '*OSPAR Guidelines for Risk Assessment and Management of Storage of CO_2 Streams in Geological Formations'* were adopted to assist the management of CCS. The amendments entered into force and in July 2011 and are in force for eight parties. [321]

On the other hand, Ocean CO_2 storage in the water column and storage of CO_2

on the seabed (not: *under* the seabed) continue to be prohibited. This has been clarified by another decision of the OSPAR-parties adopted in 2007.[322]

In conclusion, ocean CO_2 storage (in the water column and on the seabed) is not allowed under the treaties discussed. Sub-seabed CO_2 storage is permissible under the LP, but only for LP parties. To date, the LP could be regarded as the most advanced international body in addressing a specific geoengineering technique, through its work and rules on sub-seabed CO_2 storage. It is permissible under OSPAR for those parties to which the relevant amendments have entered into force.

5.1.8 Ocean liming

Proposals for enhancing ocean alkalinity, commonly referred to as ocean liming or ocean-based enhanced weathering, suggest adding alkaline minerals or their dissolution products in order to chemically enhance fixing and marine storage of atmospheric carbon dioxide.[323] Current proposals cover a range of alkaline minerals and dissolution products that could be added through direct ocean releases, pipelines to the sea, or indirectly through discharges into river systems draining to the ocean.[324] While liming all of the world's oceans would appear impractical, and the technique's effectiveness is estimated as low in large part due to the infeasibility of covering immense ocean volumes,[325] it could nonetheless be of particular

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„f. carbon dioxide streams from carbon dioxide capture processes for storage, provided:

i. disposal is into a sub-soil geological formation;

ii. the streams consist overwhelmingly of carbon dioxide. They may contain incidental associated substances derived from the source material and the capture, transport and storage processes used;

iii. no wastes or other matter are added for the purpose of disposing of those wastes or other matter;

iv. they are intended to be retained in these formations permanently and will not lead to significant adverse consequences for the marine environment, human health and other legitimate uses of the maritime area."

[320] OSPAR Decision 2007/2 on the Storage of Carbon Dioxide Streams in Geological Formations, ANNEX 6 (Ref. §2.10c).

[321] Norway, Germany, United Kingdom, Spain, European Union, Luxembourg, Denmark and the Netherlands; http://www.ospar.org/content/news_detail.asp?menu=00600725000000_000018_000000.

[322] OSPAR Decision 2007/1 to Prohibit the Storage of Carbon Dioxide Streams in the Water Column or on the Sea-bed, available at http://www.ospar.org/

[323] Williamson et al (2012) 28.

[324] Williamson et al (2012) 61.

[325] Williamson et al (2012) 61-62.

benefit in protecting targeted marine areas of high value, such as coral reefs.[326] Ocean liming would have the added positive benefit of decreasing ocean pH and thus offsetting acidification caused by climate change.

Negative impacts to the marine environment and biodiversity may result from local spatial and temporal pH spikes and from extreme alkalinity levels. These impacts are not well understood and may depend on particular technique and application, where rapid dissolution can minimize effects.[327] Discharges through rivers could impact freshwater biodiversity. Liming of acidified lakes and rivers in Norway has resulted in what is considered to be generally ecologically-beneficial impacts; however, this was carried out to restore the pH of rivers to their historic baselines, rather than a new state.[328] Other unknown side-effects in either marine or freshwater environments could stem from the optical, chemical, or potentially toxic effects of the minerals used and from mineral impurities.[329]

Deployment of ocean liming would require vast volumes of minerals and mining and processing on a tremendous scale in order to extract these quantities.[330] Mining impacts include degradation of river or groundwater quality, sedimentation, fugitive dust emissions, and terrestrial habitat destruction. Scaled operations could also necessitate high volumes of energy, water, and infrastructure.[331] Another consideration, where using calcium hydroxide produced from limestone, is the release of carbon dioxide emissions from this process.[332]

Ocean liming is not directly addressed under current international law regimes. However, the technique may be subject to provisions governing protection of the marine environment and ocean dumping under the LC and LP, UNCLOS, and the OSPAR Convention. Other treaties may apply where transboundary impacts or harm to biodiversity incur, or in specially protected areas.

The LC and LP address marine pollution from dumping of wastes and other matter at sea, covering parties' jurisdictional waters and activities.[333] Broadly, the LC and LP require Parties to individually and collectively promote the effective control of all sources of marine pollution. The LC prohibits or requires special permits for dumping of listed wastes, while the LP conversely allows dumping only for listed wastes (on the LC/LP see above on CCS).

Under the LC and LP, dumping is defined as the "disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea." (LC Article 3(1)(a), LP Article 4(1)). Article 4 of the LC prohibits the dumping of wastes listed in Annex I and requires

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[326] Victor (2008) 327.

[327] Williamson et al (2012) 61-62; Umweltbundesamt (2011) 28.

[328] Williamson et al (2012) 63, citing Fiellheim A. & Raddum G. (2001). Acidification and liming of River Vikedal, western Norway. A 20 year study of responses in the benthic invertebrate fauna. Water, Air, Soil Pollution, 130, 1379-1384; doi: 10.1023/A:1013971821823.

[329] Rickels et al (2011) 47.

[330] Williamson et al (2012) 61; Rickels et al (2011) 46-47.

[331] UBA (2011) 28; Williamson et al (2012) 61; Royal Society (2009) 14.

[332] Rickels et al (2011) 46.

[333] As of 5 April 2012, there are 87 parties to the London Convention and 40 parties to the London Protocol, *see* <www.londonprotocol.imo.org>.

a special or general permit for all other dumped wastes of significant amounts and concern (Article 4). As none of the proposed alkaline substances appear to fall under the list of prohibited wastes in Annex 1, nor meet the criteria for a special permit under Annex II, which generally includes materials with trace amounts of toxic substances, ocean liming would only require a general permit in advance.[334]

The LP prohibits dumping as a rule, making exemptions only for wastes listed in Annex I. Proposed liming substances are not covered by the Annex 1 exemptions.[335] The exemption for "inert, inorganic geological material" (Annex 1, para. 5) would not apply because substances would be added for the purpose of interacting with the marine environment. Neither would the exemption for "organic material of natural origin" (Annex 1, para. 1.6), as carbonates are chemically classified as inorganic and the materials would have presumably been processed prior to addition.[336] Annex 2 sets forth criteria for assessing waste characteristics, and impacts to the environment and human health and where assessments are favourable, a permit for dumping must granted, as would be required for ocean liming. Annex 2 of the LP also requires parties to take measures for waste[337] prevention and reduction, perhaps antithetical in nature to the concept of ocean liming, where alkaline substances would be produced for the sole purpose of dumping.

At the same time, ocean liming is arguably not "dumping" under the LC and LP. It could qualify as "placement" and be exempt from the definition of dumping in accordance with Article 3(1)(b)(2) LC and Article 1 (4.2.2) LP.[338] According to these provisions, the "placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of [the Convention / Protocol]", is expressly exempted and no to be considered dumping (see section 5.1.3). The purpose of ocean liming would be to increase ocean uptake of carbon dioxide and to reduce pH, but not to dispose of materials.

However, the placement could be contrary to the aims of the Convention or the Protocol and therefore not be exempt. The overall aim of the LC and the LP includes protecting and preserving the marine environment from all sources of pollution.[339] On this basis it might be argued that activities that have adverse environmental impacts should not qualify as "placement" and should therefore not be exempt from the LC/LP's prohibition, even if they are carried out for purposes other than mere disposal. However, we argue that the fact that both instruments explicitly provide for the possibility of an exemption for placement means that this

[334] An official determination for treaty applicability to ocean liming has not been made. In the case of ocean fertilisation, a questionnaire of Contracting Parties was inconclusive in determining whether substances would fall under Annex 1 as "industrial waste," or whether materials fell instead under Annex 2 or 3; "Report of the Legal and Intersessional Correspondence Group on Ocean Fertilization (LICG)." LC 30/4. 25 July 2008. Available at: http://www.imo.org/blast/blastDataHelper.asp?data_id=30733&filename=4.pdf.*See also* Ginzky (2010) 64.

[335] Rickels et al (2011) 97.

[336] *See* Ginzky (2010) 64, discussing similar application for ocean fertilisation materials. *See also* "Report of the Legal and Intersessional Correspondence Group on Ocean Fertilization (LICG)" *supra note* 3, noting guidance from the LC/LP Scientific Groups that iron is not an "inert, inorganic geological material."

[337] Wastes are defined as material or substances of any kind, form, or description under LP Article 1(8).

[338] *See* Ginzky (2010) 64, regarding ocean fertilisation under the LC/LP.

[339] Article 1 LC; Article 2 LP.

possibility should not be rendered meaningless by categorically ruling out any exemption on the basis of potential negative effects on the marine environment. In the case of ocean liming, it could be argued that it counteracts ocean acidification and has actual benefits for the marine environment.[340] Unless the parties clearly agree otherwise, it would depend on each case to what extent the aims of the LC and the LP can exclude the exemption for a placement activity.

In addition, research into his particular geoengineering technique can also be considered to be carried out for a purpose other than the mere disposal, and thus be exempted as “placement”. This happened in the case of ocean fertilisation, a more widely referenced geoengineering technique, which similarly requires deposits of inorganic materials into the marine environment. Unlike liming, ocean fertilisation has been directly addressed under the LC/LP, which regulate ocean fertilisation through non-binding guidance and a risk assessment framework. In 2008, LC and LP Parties adopted non-binding resolution LC-LP.1, finding that “legitimate scientific research” on ocean fertilisation, as determined according to the assessment framework, is regarded as “placement” rather than as “dumping.”[341] All other ocean fertilisation activities are considered contrary to the objectives of the LC/LP and do not qualify for exemption. Given the outward similarities between the two techniques, this determination for ocean fertilisation could potentially lend support to an analogous interpretation whereby legitimate research into ocean liming would not be considered “dumping” and contrary to the LC/LP’s objectives. In 2009, Parties to the LC and LP considered whether to address other marine-based geoengineering techniques, deciding to focus on ocean fertilisation while perhaps expanding this focus in the future.[342]

UNCLOS is both widely ratified and recognized as customary international law. Obligations under UNCLOS apply to areas both within and beyond state jurisdiction. Ocean liming, and geoengineering in general, have not been addressed by UNCLOS, but could be subject to general provisions regarding, inter alia, protection and preservation of the marine environment, the rights, jurisdiction, and duties of States and marine scientific research.

UNCLOS Part XII contains specific obligations relating to the protection of the marine environment. States have a general duty to protect and preserve the marine environment (Article 192) and to take all measures necessary in order to prevent, reduce and control marine pollution from any source, including by dumping (Article 1, 194, 210). “Pollution of the marine environment” is defined as the introduction by man, directly or indirectly, of substances into the marine environment that are likely to cause deleterious effects to living resources, human health or marine activities and uses. (Article 1(4)). The addition of alkaline minerals or their dissolution products would clearly be anthropogenic and under current proposals would be either directly deposited into the ocean via ships or pipelines, or indirectly through river discharges.

Still, it can be argued whether the impacts of liming qualify as having a “deleterious effect” and thus be considered “pollution” under this definition. The potential effects of ocean liming are not yet fully understood as no field experiments have been carried out, although changes

[340] Rickels et al (2011) 97.

[341] Resolution LC-LP.1, Article 3. *See also* IMO note to UNFCCC COP16, Nov. 2010, available at http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Documents/COP%2016%20Submissions/IMO%20note%20on%20LC-LP%20matters.pdf.

[342] Bodle et al (2012) 126.

are inevitable and negative impacts to the marine environment possible.[343] Although deleterious impacts cannot be ruled out at this stage, it could also be argued, that ocean liming constitutes a remedial measure offsetting the harmful effects of ocean acidification,[344] and therefore also prevents or mitigates deleterious effects. This line of argument would interpret the definition of "deleterious effects" as allowing for weighing the potential negative effects caused directly by ocean liming against the positive effects achieved by remedying ocean acidification. The text of Article 1(4) UNCLOS does not explicitly provide for this and the plain wording suggests that deleterious effects on the marine environment could constitute pollution without taking into account a "net" effect. All provisions under UNCLOS relating to preventing, reducing and controlling pollution of the marine environment are premised upon this definition of "pollution" to ocean liming.

Under UNCLOS, States must not only protect the marine environment under their own jurisdiction, but are required to take all measures necessary to ensure that activities under their jurisdiction or control do not cause damage by pollution to other states and their environment (Article 194 (2)). States must take, solely or jointly, all necessary measures to prevent, reduce, or control all sources of pollution to the marine environment, Article 194 (1). Where states have reasonable grounds for believing that planned activities under their jurisdiction or control may cause substantial pollution of or significant and harmful changes to the marine environment, they are required to, as far as practicable, assess the potential effects of such activities on the marine environment and share assessment results (Article 206). States are also required to take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies within their jurisdiction or under their control. (Article 196). [345]

Other obligations under UNCLOS include the duty of cooperation between States (Article 197), prior notification of harm (Article 198), monitoring of pollution (Articles 204 and 205), and the development of contingency plans (Article 199).[346]

As a rule, "any" and "all sources" of pollution to the marine environment are subject to UNCLOS (Article 194). For land-based sources of pollution, specifically including rivers and pipelines, Article 207 of UNCLOS requires states to take measures as are necessary to prevent, reduce, and control pollution. (Article 207(1),(2)). Alkaline minerals or their dissolution products added by pipelines or rivers leading to the sea may fall under this article.

Article 210 requires States to adopt laws and regulations and take such measures as necessary to prevent, reduce, and control pollution by marine dumping. Under this article, dumping within a State's territorial sea, exclusive economic zone (EEZ), or onto the continental shelf requires prior permission of the coastal state (Article 210). UNCLOS also provides that national laws, regulations and measures governing marine dumping are to be no less effective than global rules and standards. (Article 210(6)). This is generally understood to include the LC, which therefore serves as baseline standards for ocean dumping under UNCLOS.[347]

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[343] Williamson et al (2012) 62.

[344] Williamson et al (2012) 62.

[345] Whether ocean liming could be considered a "technology" is unclear as "technologies" is not defined for the purposes of this Article.

[346] Scott (2010).

[347] Bodle et al (2012) 125.

Article 1(5)(a) UNCLOS defines "dumping" in the same way as the LC/LP. The analysis regarding the LC/LP (see sections 5.1.3, 5.1.4) can therefore inform the interpretation of UNCLOS regarding the exemption from UNCLOS' dumping provisions for the "placement of matter for a purpose other than the mere disposal thereof" in Article 1(5)(b)(2) UNCLOS. As there are currently no LC/LP's resolutions addressing ocean liming in the way the LC/LP addressed ocean fertilisation, it is argued that ocean liming does not constitute dumping in accordance with the provisions of UNCLOS.[348] Similar to the arguments under the LC/LP, ocean liming would qualify as an activity carried out for purposes other than mere disposal, even with potential environmental benefits,[349] and thus be exempt. As discussed above, the argument in effect introduces the "net" approach to the definition of "pollution", while the definition of negative effects does not allow for such a weighing. Any deleterious effects that are otherwise in accordance with the definition qualify as pollution. This view also holds against the argument that ocean liming should not qualify as dumping under UNCLOS because it does not qualify as dumping under the LP.[350] The respective obligations under the UNCLOS and the LC/LP as well as their parties differ considerably: UNCLOS merely provides general obligations to adopt laws and take measures against pollution, while the LP specifically prohibits dumping altogether.

Arguments have been made that an activity is permitted in principle by the freedom of the high seas unless it specifically excluded by a rule of international law, as would include geoengineering.[351] However, this does not imply that ocean liming has to be generally permitted. The freedom of the High Seas must be exercised in accordance with duties for environmental protection under Part XII and with due regard for the interests of other states. Where conducted on the seabed beyond the jurisdiction of states, activities must be undertaken for the benefit of mankind (Article 140).

Freedom of scientific research is one of these freedoms of the high seas. UNCLOS sets out numerous obligations and rights relating to marine scientific research. It is subject to limitations stemming from other duties under UNCLOS (Article 87(1) (f)). As UNCLOS does not define this term, it is difficult to assess under which conditions ocean liming would qualify as marine scientific research. Some argue that projects of a purely commercial nature do not constitute scientific research.[352] As with other geoengineering techniques, and depending on the scale of the activity, it can be difficult in practice to draw the legal line between research and deployment.

In case ocean liming activities are considered as scientific research, it must not unjustifiably interfere with other legitimate uses of the sea, such as fishing or navigation and must be conducted exclusively for peaceful purposes (Article 240). Research activities taking place within the jurisdiction of coastal states require the consent of the coastal state and may be

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[348] Rickels et al (2011) 97.

[349] Rickels et al (2011) 97.

[350] Rickels et al (2011) 97.

[351] Bodle et al (2012) 125, *citing* Scott (2010).

[352] See „Marine and coastal biodiversity: review, further elaboration and refinement of the programme of work", Study of the relationship between the Convention on Biological Diversity and the United Nations Convention on the Law of the Sea with regard to the conservation and sustainable use of genetic resources on the deep seabed (decision II/10 of the Conference of the Parties to the Convention on Biological Diversity), UN Doc.UNEP/CBD/SBSTTA/8/INF/3/Rev.1, 22 February 2003.

subject to national regulations (Article 245, 246). Information regarding proposed major projects must be published and disseminated (Article 245). States and international organisations are subject to liability for damage caused by pollution of the marine environment arising out of marine scientific research undertaken by them or on their behalf (Articles 235 and 236).

The 1992 OSPAR Convention is a regional convention for protecting the marine environment of the North-East Atlantic that addresses both land-based marine pollution and dumping. Dumping, defined as deliberate disposal in the maritime area from vessels, aircraft, or offshore installations, is generally not permitted by Convention Parties (Article 1(f), 4). Based on the analysis of LC/LP and UNCLOS above, ocean liming would fall under this definition, and not be exempt under one of the exceptions for certain materials (Annex II).[353] However, there is another exemption, similar to the LC/LP and UNCLOS, for "placement of matter for a purpose other than the mere disposal thereof, provided that, if the placement is for a purpose other than that for which the matter was originally designed or constructed, it is in accordance with the relevant provisions of the Convention" (Article 1(g)(ii)). The arguments in favour of or against ocean liming falling under this exception would likely be along the lines of LC/LP and UNCLOS. Additional provisions regulating point source discharges to the maritime area and releases to water that may reach and affect the maritime area, are relevant for liming via pipelines or rivers and are subject to strict authorisation, regulation, and monitoring by authorities. (Annex 1, Article 2).

The regional 1992 UNECE Convention on the Use of Transboundary Watercourses and International Lakes sets forth rules and principles for protection of transboundary water systems. Where Parties performed ocean liming by adding alkaline materials to rivers in a transboundary system, this would have to be in accordance with the obligation to take all appropriate measures to prevent, control and reduce any transboundary impact (Article 2(1)). In addition to procedural obligations on Rivarian parties, other river-specific conventions may also apply depending upon geographic location of application.

The MARPOL Convention allows designation of specially protected Particularly Sensitive Sea Areas (PSSAs) that may be especially vulnerable to oil pollution. (Annex I, Regulation 1(10)). MARPOL permits navigational restrictions on ships passing through these areas. While intended to reduce oil pollution, the restriction in these areas on "discharge into the sea contain[ing] chemicals or other substances in quantities or concentrations which are hazardous to the marine environment," (Annex 1, Regulation 10(3)(b)) could be interpreted to apply to vessel-based dumping of liming materials and would apply to the Great Barrier Reef[354], as well as the Mediterranean, Baltic, Black, and Red Seas. (Annex 1, Regulation 10(1)). Other restrictions on vessels in these areas (e.g. equipment requirements, vessel tracking, monitoring) might apply as well.[355] The Great Barrier Reef is also protected internationally under World Heritage Convention.

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[353] As discussed for the LP liming materials would not qualify as "inert materials of natural origin, that is solid, chemically unprocessed geological material the chemical constituents of which are unlikely to be released into the marine environment." (Annex II, Article 3(2) (b)).

[354] Coral reefs could be a target area for protection through liming.

[355] *See* http://www.imo.org/OurWork/Environment/PollutionPrevention/PSSAs/Pages/Default.aspx.

Should ocean liming activities be performed in Antarctic waters, provisions of the Antarctic Treaty System would correspondingly apply.[356]

In sum, ocean liming could fall under provisions restricting "dumping" under several instruments, but it is not clear under either of these whether it could qualify as "placement" and thus be exempt from the definition of dumping.

5.1.9 Ocean biomass storage

Ocean biomass storage involves deposition of crop residues or other terrestrial vegetative material into deep ocean waters. Biomass would be dumped from ships and sunk with heavy materials at depths from 1000 to 1500m, on or in the seabed.[357] Deep ocean conditions (e.g. cold, oxygen deficiency, lack of enzymes required for cellulosic degradation) would severely slow decomposition of the organic materials, thus fixing carbon dioxide for possibly thousands of years.[358] It has been estimated that this technique could offer 92% efficiency in sequestration and capture 15% of the global CO_2 annual increase.[359] This technique is viewed as particularly beneficial due to its capacity to capture large quantities of carbon, efficient sequestration, repeatability, relative permanence, limited known side effects, and use of available technologies.[360]

Potential adverse environmental effects from ocean biomass storage could include physical impacts to the ocean seabed and sediments from the landing of materials with high mass.[361] Oxygen depletion, acidification, and possible increases in H2S, CH4, N2O and nutrients arising from decomposition of the organic matter could result in biological and chemical impacts to marine ecosystems.[362] Certain impacts might be minimized through deliberate placement of materials near river deltas, areas of high sedimentation which are better adapted to biomass input, and where rivers naturally assist in deep ocean deposition of organic matter.[363] Impacts could depend upon the type and permeability of biomass packaging used.[364] Where performed in shallower waters of about 1000-1500m, impacts on fisheries could be greater.[365] Further, examination of impacts should include consideration of energy consumption required for transport, burying, and processing.[366] As a whole, potential impacts of ocean biomass storage are poorly understood due to limited understanding of deep sea ecosystems.[367]

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[356] Cf. Bodle et al (2012) 105, 133.

[357] Williamson et al (2012) 67-68.

[358] Umweltbundesamt (2011) 29.

[359] Strand (2009).

[360] Strand (2009).

[361] Strand (2009) 1004; Williamson et al (2012) 67.

[362] Williamson et al (2012) 67; Royal Society (2009) 11.

[363] Strand (2009) 1005.

[364] Williamson et al (2012) 67.

[365] Williamson et al (2012) 68.

[366] Royal Society (2009) 11.

[367] Williamson et al (2012) 68.

Ocean sequestration of biomass is not directly addressed under current international law and does not appear to be explicitly prohibited under the LC, LP, or OSPAR Convention. The same goes for UNCLOS, although would be subject to provisions concerning protection of the marine environment. Application of provisions under these treaties, like ocean liming, would depend first, largely upon whether the activity is, on the whole, considered either detrimental or beneficial to the marine environment, and thus in line with treaty objectives. Second, application hinges upon whether the activity qualifies as "dumping" or whether the activity can be sufficiently differentiated. Other treaties may be implicated where transboundary impacts or harm to biodiversity, or in specially protected areas.

The LC and LP do not specifically address crop wastes and biomass, but ocean dumping of these materials would constitute "disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea." (LC Article 3(1), LP Article 4(1)). However, while considered dumping, biomass materials would not likely be subject to restriction under the LC or LP. Biomass would be permitted for dumping under LP Annex 1 as "organic material of natural origin."[368] Even where processed, biomass materials would presumably be exempted as prohibited industrial waste under LC Annex I as "uncontaminated organic material of natural origin."[369] Thus only a general permit would be required under the LC, and ocean dumping would be permissible under the LP following procedural assessment. However, under the "placement exemption" ocean biomass dumping might not even qualify as "dumping" under the LC/LP because the purpose – that is, to sequester carbon dioxide - could be regarded as being for "other than the mere disposal" and thus subject to exemption. (LC Article 3(1)(b)(2), LP Article1(4.2)).

Ocean biomass storage would be subject to States' duties under UNCLOS, covering protection of the marine of environment (Article 192); prevention, reduction, and control of marine environment pollution, including dumping (Article1, 194, 210); States' rights, jurisdiction and duties; and marine scientific research (see also section on ocean liming). UNCLOS requires that, in taking measures to prevent, reduce and control marine pollution, States shall not transfer, indirectly or directly, damage or hazards from one area to another or transform one type of pollution into another (Article 195). It has been suggested that certain geoengineering methods may involve a transfer of one form of pollution into another – here, arguably, atmospheric greenhouse gas concentrations into the form of sequestered biomass materials.[370] As with ocean liming, whether ocean storage of biomass meets the definition of pollution under UNCLOS is open to interpretation as to whether the activity would have a "deleterious effect." Accordingly, provisions restricting dumping would hinge on this definition as well as on UNCLOS' "placement exemption."

Depending on the interpretation of "dumping", ocean biomass storage could be impermissible under the OSPAR Convention's general prohibitions on marine dumping, although dumping of crop wastes or other biomass materials is not expressly covered.

Although most dumping would likely take place in deeper waters on the high seas, biomass storage in near-coastal waters where transboundary impacts would be of greater likelihood, would require assessment of impacts under the Espoo Convention. As discussed for ocean

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[368] Williamson et al (2012) 68.

[369] Williamson et al (2012) 68.

[370] Verlaan (2009).

liming, certain locations for ocean biomass storage could fall under the Antarctic Treaty System, MARPOL, or the Heritage Convention.

In theory, production of biomass materials to be used specifically for geoengineering purposes could fall within the scope of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), where the production activities threatened the conservation and sustainable use of plant genetic resources (Article 5.2, 6.1, 7). Alternatively, if produced crops were genetically engineered, perhaps so as to absorb greater amounts of carbon dioxide, transboundary transport of materials could fall under the scope of the CBD's Cartagena Protocol on Biosafety. Generally, however, international law does not prohibit the production of biomass materials (see also section 4.1.11).

5.1.10 Biomass and biochar

There are several CDR geoengineering techniques involving biomass. One of them involves the biological capture of CO_2 in vegetation and the subsequent deliberate sequestration of the biomass containing the captured CO_2 . The storage is intended to prevent the release of CO_2 into the atmosphere during natural processes of decomposition of dead vegetation.[371] In contrast to CDR techniques involving biological capture through ecosystem management, capture and storage may be separated in time and space.[372] One method for storing the CO_2 captured in biomass is converting the biomass to so-called biochar, which is then applied to soil, where it would gradually decompose over a long period of time.[373]

From a legal perspective, apart from the cross-cutting general rules analysed above, international law does not prohibit the production of biomass, of biochar, or the application of biochar on soil as such. However, biomass and biochar techniques would need to be applied on a very large scale in order to be effective.[374] In order to produce and apply the necessary amount of biomass and biochar, these techniques could entail considerable large-scale land use changes which might be subject to rules of international law. In addition, there is a lack of knowledge and research on the environmental impacts of applying biochar on soil.[375]

There does not seem to be pertinent international law on land use or land use change relevant for biomass and biochar. For instance, the obligations of the CCD are too general in nature to provide relevant guidance regarding biomass and biochar. On the non-binding side, the FAO draft voluntary guidelines on land tenure of March 2012, scheduled for approval by the Committee on World Food Security in May 2012,[376] do not provide guidance for the questions raised here.

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[371] UBA (2011) 22.

[372] Williamson (2012) 9.

[373] On the process see UBA (2011) 22; Williamson et al (2012) 66.

[374] Williamson et al (2012) 65.

[375] UBA (2011) 22; Williamson et al (2012) 13, 66-67.

[376] See http://www.fao.org/news/story/en/item/128907/icode/. The final draft text of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests, is available at http://www.fao.org/fileadmin/user_upload/nr/land_tenure/pdf/VG_en_Final_March_2012.pdf

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However, there is international law requiring the protection of biodiversity, ecosystems and habitats, which indirectly provide rules regarding areas that could be affected by large-scale land use changes that would be part of certain geoengineering techniques. The CBD has provided guidance on geoengineering in general in decision X/33 (see above section 5.1.2), which would apply to biomass and biochar techniques where they qualify as geoengineering. There are other biodiversity-related conventions such as the Ramsar Convention, the Convention on Migratory Species (CMS) regarding the habitat of migratory species and the World Heritage Convention regarding specific areas defined as cultural or natural heritage. Whether and to what extent such area or ecosystem-related rules could apply would depend on which biomass and biochar are produced, to what extent this actually involves land use change, as well as where and how.

Under the climate regime, land use and land use change are important issues in the calculation of and accounting for sinks. Parties to the UNFCCC and KP have to periodically prepare and report annual greenhouse gas (GHG) inventories including the land use, land use change and forestry (LULUCF) sector in accordance with Article 4(1)(a) UNFCCC and Articles 3(3,) 3(4), 3(7) and 4 KP.[377] Decisions by the KP parties define certain forms specifically for this purpose. These rules provide an incentive for states to generate sinks, even for parties to the UNFCCC without quantified reduction obligations under the KP. While this does not amount to permitting or actively promoting geoengineering through biomass and biochar, it is conceivable to imagine moves towards crediting certain types of LULUCF under the KP's flexible mechanisms or in future new market-based mechanisms.[378] However, so far only carbon capture and storage in geological formations has been considered for inclusion in the KP's Clean Development Mechanism.[379]

In addition, the REDD+ mechanism, although not an obligation, provides an incentive to capture more carbon in vegetation. It could in the future develop into a mechanism involving financial incentives (so-called phase 3) and drive a switch to "land-based" accounting, where all emissions from land will have to be accounted for.

Land use changes could also create conflicts with other forms of land-use, such as food production. Large-scale land-use change could also potentially be in conflict with human rights. In particular, the right to food under Article 11 ICSECR could be affected if land previously used for food production was converted to produce biomass that is not edible. Again, this would depend on the specific way in which the land use change would be carried out as well as the content of the right in question. Forced or inadvertent displacement or migration are also imaginable. Any violation of social, economic and cultural rights related to food, housing and water would have to be assessed considering specific cases and circumstances.

The rules identified above that geoengineering by biomass and biochar could conflict with the following categories:

- Rules requiring to the protection of biodiversity, ecosystems and habitats
- Rules protecting previous land use against land use change

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[377] For an introductory overview of LULUCF rules in the climate regime summary see <http://unfccc.int/methods_and_science/lulucf>.

[378] Virgoe (2009); Bertram (2009).

[379] See above section 5.1.7 on CCS.

- Human rights relating to land-use change, in particular food production.

5.1.11 Enhanced weathering

Enhanced weathering is a technique that accelerates the slow natural reaction of silicate rocks with CO_2 (to form solid carbonate and silicate minerals) by spreading finely-ground silicate minerals such as olivine over agricultural soils.[380]

Similar to geoengineering by biomass and biochar production and storage, enhanced weathering in the form of spreading base minerals mainly has land-use change impacts. And similar to ocean liming, this technique would require a considerable amount of mining in order to procure the minerals, plus transporting the minerals to the soil. The potential direct impacts on land include effects on soil structure and fertility and increased soil albedo, while potential indirect impacts include those resulting from the required mining and transport and the associated energy use and water implications. In addition, the scale required in order to be effective could potentially also result in impacts on rivers, coastal seas and the open ocean.[381]

The legal framework is similar to that applying to biomass and biochar (see section 5.1.10): General rules apply, but in absence of specific international law on land use or land use change relevant for enhanced weathering, the rules on the protection of biodiversity, ecosystems and habitats indirectly provide rules regarding areas that could be affected by large-scale land use that would be part of this geoengineering technique.

5.1.12 Carbon capture from air (‚artificial trees')

Geoengineering by air capture comprises a range of industrial processes aimed at extracting CO_2 directly from ambient air. Techniques discussed include the absorption of CO_2 onto solids or absorption into liquids such as highly alkaline solutions or moderately alkaline solutions with a catalyst.[382] The term "artificial trees" reflects the technical rather than biological nature of this technique. Artificial trees always require CO_2 storage as a second step. The analysis of the rules for CCS therefore have to be taken into consideration as well (see section on CCS).

The air capture concept is relatively far advanced and well understood. According to the US GAO, it is the CDR technology with the highest so-called 'technology readiness level.'[383] There have been demonstration projects using prototypes, patents have been issued and small projects are operating.[384] However, the GOA also concluded that the deployment of direct air capture is "decades away from large-scale commercialization".[385] Its implementation is not thermodynamically efficient and would require enormous amounts of energy, which means

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[380] Williamson et al (2012) 62.

[381] Williamson et al (2012) 63.

[382] Williamson et al (2012) 68; Royal Society (2009) 16.

[383] GOA (2011) vi.

[384] For example to the US company Climate Engineering (http://www.carbonengineering.com/), cf. NRP (2011).

[385] GOA (2011) vi.

high costs and - if produced from fossil fuels - will significantly increase the climate footprint of the measure and undermine its actual objectives.[386]

The impact and undesirable consequences on the environment in general and on the environment of other states is arguably very low, given that no hazardous techniques are involved.[387] It has also been argued that the land-use footprint of putting up the air capture installations would be considerably lower compared to other geoengineering techniques. However, there could be some risks of pollution from producing and handling the required chemicals. [388]

Given the expected local implementation and low impacts, there appear to be no requirements in international law of specific interest for geoengineering by artificial trees. However, national and EU law provide rules such as planning, construction, water and nature conservation law which would govern an installation for carbon capture and, for instance, determine whether it would need a permit. However, international law could become relevant when a carbon capture, e.g. in cumulative deployment, has potential transboundary impacts. The applicable rules would presumably be the general rules on discussed in other sections, such as the duty to prevent environmental harm and the duty to carry out an environmental impact assessment.

Air capture installations could generally be regarded as carbon sinks, as they remove CO_2 from the atmosphere. Therefore, they could potentially be addressed by the UNFCCC regime and process. However, the Kyoto Protocol limits the acceptance of sinks to land-use and forestry projects (Article 3 paragraph 3 Kyoto Protocol). Although CCS has recently been included in the CDM, there is currently no indication of similar development regarding artificial trees.

5.2 European Law and German Law

5.2.1 Introduction

While some geoengineering techniques are conceived to be applied outside the jurisdiction of individual states (space, high seas), other ones have potentially far-reaching effects that can hardly be limited to the territory of the state enacting them. Thus, it is not surprising that regulation of geoengineering is been primarily discussed as a matter of public international law.

However, geoengineering techniques, in particular if they are intended to be applied on the territory of a state[389], may also require regulation at the national level. In the case of Member States of the European Union regulation at EU level might be required, for instance under the EU competence for the environment (Article 192 TFEU). Such regulation may be enacted in order to implement international treaties on geoengineering, or in addition to or in absence of international obligations. The rules could also be made to apply to geoengineering activities of nationals outside the territory.

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[386] Royal Society (2009) 15.

[387] GOA (2011) 23, Royal Society (2009) 16.

[388] Williamson et al (2012) 68.

[389] However, national legislation may also concern areas outside the State territory, such as legislation relating to the Exclusive Economic Zone of the State or to nationals operating on the High Seas. See e.g. Article 2 of the Federal High Seas Dumping Act.

At present there is no explicit regulation of geoengineering in EU law or in German law. The only exception is CCS, depending whether or not it is included in the definition of geoengineering.[390]

Nevertheless, existing environmental rules and standards of EU and German law could apply to geoengineering techniques at least to some extent. This section provides a legal analysis of the geoengineering techniques most likely to be governed by existing or forthcoming EU and German law: CCS, sulfate aerosols, air capture, biomass/biochar and weathering. Space installations are not covered, as well as marine techniques (ocean liming, dumping of crops or weathering material into the seas), as the latter are more likely to performed at the high seas rather than within the coastal waters or the Exclusive Economic Zone of states. For the same reason, cloud brightening will also not be analysed in this section, as it is relevant primarily to marine areas.[391] Finally, desert installations are primarily a matter concerning the state using these techniques on its territory and are therefore of less interest to the EU and its Member States, which do not have deserts.

5.2.2 Cross-cutting general rules

Before starting with the analysis of the different geoengineering techniques, some general provisions of EU and German law shall be mentioned which apply equally to each of these techniques and are important for the general approach towards them.

The first of these general provisions is the precautionary principle. It should be noted that the precautionary principle is part of EU law and as such does not necessarily have the same legal content and implications as the precautionary approach in international law.

According to the second sentence of Article 191 (2) TFEU, Union policy on the environment shall be based on the precautionary principle and on inter alia the principle that preventive action should be taken. It is disputed whether both principles are synonymous or whether the principle of preventive action is the more general and the precautionary principle the more specific principle.[392] In any case, both principles are legally binding and not just political maxims.[393]

As the precautionary principle is not defined in Article 191 (2) TFEU, it is ultimately for the courts to flesh out the principle.[394] The ECJ and the ECI have developed case law not only for the environmental sector, but also in the area of health protection. In the latter area, a detailed elaboration of the precautionary principle has been established by the ECI in the *Pfizer* judgment of 11.9.2002[395], which some consider to be the leading case on this principle.[396]

[390] Furthermore, the EU is promoting some geoengineering projects within the 7th Research Framework Programme.

[391] See Umweltbundesamt (2011), p. 13-14.

[392] See Callies (2011), Art. 191 para. 27 with further references.

[393] See Callies(2011), Art. 191 para. 48 with reference to ECJ, C-284/95 (Safety HiTech), para. 36.

[394] COM(2000) 1 final, p. 9.

[395] ECI, case T-13/99 (Pfizer Animal Health).

[396] Meßerschmidt (2011), chapter 3 para. 108 with a further reference.

According to the ECI in this case[397], the precautionary principle applies in situations in which there is a scientific uncertainty. In such a situation, a preventive measure may only be taken if the risk, although the reality and extent thereof have not been ´fully´ demonstrated by conclusive scientific evidence, appears nevertheless to be adequately backed up by the scientific data available at the time when the measure was taken. The resulting risk assessment is a two-fold task: First, the Community institutions have to determine the level of protection which they deem appropriate for society (political component). Depending of the individual case, the authorities may thereby take into account, inter alia, of the severity of the impact on human health were the risk to occur, including the extent of possible adverse effects, the persistency or reversibility of those effects and the possibility of delayed effects as well as of the more or less concrete perception of the risk based on available scientific knowledge. Second, a scientific risk assessment must be carried out before any preventive measures are taken (scientific component). Such an assessment has to be entrusted to experts and be based on the principles of excellence, independence and transparency to ensure the scientific objectivity of the measures adopted. It must also enable the competent authority to decide, in relation to risk management, which measures appear to it to be appropriate and necessary to prevent the risk from materializing. Thus, decisions of the Community institutions are to be taken in the light of the best scientific information available and to be based on the most recent results of international research. If a full risk assessment is impossible because of the inadequate nature of the available scientific data, the competent authority must weigh up its obligations and decide either to wait until the results of more detailed scientific research become available or to act on the basis of the scientific information available.

A similar approach, encompassing both the political and the scientific component, is taken by the Commission in its Communication on the precautionary principle of 2.2.2000.[398]

According to *Krämer*, however, risk assessment as a requirement for preventive action under the precautionary principle could only be introduced by way of legislation.[399] He thereby refers to the decision of the ECJ in the *Afton Chemical* case[400], where the court did not consider a risk assessment necessary.

These criteria may thus be taken into consideration for preventive measures against geoengineering as a technology potentially harmful to the environment. However, the issue that geoengineering itself might be a preventive measure against the possible harms of climate change – in general: that a potentially harmful action might be necessary to prevent another potential harm - does not appear to be reflected in EU case law on the precautionary principle.

The precautionary principle under German law for the most part has similar legal implications as the EU principle.[401] It is detailed in specific laws which make it applicable to the single case.

Furthermore, geoengineering is relevant to the principle of the protection of the environment and basic individual rights. The former is laid down in Article 37 CFREU and Article 20 a of the German constitution (Federal Basic Law of Germany: Grundgesetz – GG). On both levels, no

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[397] The following is drawn from para. 142-163 of the case.

[398] COM(2000) 1 final, p. 2-3.

[399] Krämer (2011), chapter 1 para. 28.

[400] ECJ, case C-343/09.

[401] See Meßerschmidt (2011), chapter 3 Para. 132.

right to a healthy environment is created, but a principle to be observed by the Union respectively the German State authorities. Again, it has to be beared in mind that geoengineering is not only a potential threat to the environment, but aims at protecting the climate as part of the environment.

Basic individual rights at stake in relation to EU activities include Articles 2 (right to life) and Article 3 CFREU (right to the integrity of the person), corresponding to Article 2 (2) GG in relation to German State authorities. In a decision concerning a genetic installation, the Higher Administrative Court of Hessen deduced from the obligation of the State to protect life and the integrity of the person according to Article 2 (2) GG that specific legislation was necessary for the establishment and operation of such an installation, thus ruling out the application of the 4th Federal Immission Control Ordinance in the case.[402] It has also been claimed in the context of geoengineering that specific legislation by the German Parliament was generally required to allow such activities.[403] However, as far as an activity falls under the scope of an existing Act of Parliament, the activity is already regulated by a parliamentary decision, which may be further specified by the courts in interpreting this legislation. If the existing legislation is considered outdated or insufficient, it is the legislative bodies´ political decision to provide for new legislation.[404] The situation is only different if the existing legislation does not sufficiently take account of basic rights or other constitutional law involved in the activity at stake. In this case, contrary to the decision of the Higher Administrative Court of Hessen, it is up to the German Constitutional Court to declare the existing legislation void and request new legislation.

On the other hand, basic individual rights relevant to geoengineering also include the right to freedom of research granted by Art. 13 CFREU and Article 5 (3) GG. Scientific research, which includes all kind of research activities by any actor[405], shall be free of constraints. According to Article 52 (1) CFREU, the rights and freedoms granted by the CFREU may be limited by law if these restrictions are necessary and genuinely meet objectives of general interest recognized by the Union or the need to protect the rights and freedoms of others. Thus, limitations may also be based on the principle of the protection of the environment (Article 37 CFREU).[406] In the context of geoengineering, limitations may in particular comprise codes of conduct and similar requirements related to research activities. However, Article 5 (3) GG does not amount to a right to research funding.[407]

In contrast with Article Art. 13 CFREU, freedom of research granted by Article 5 (3) GG may only be limited by other constitutional provisions such as the above-mentioned rights to life or to the integrity of the person according to Article 2 (2) GG. Although the principle to protect the environment under Article 20a GG is a constitutional provision as well, there is an argument that it may only act as a limit to freedom of research if it is detailed by specific laws.[408]

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[402] Decision of 6 November 1989 – 8 TH 685/89.

[403] Winter (2011), p. 460.

[404] See Sendler (1990), p. 233-234.

[405] See e.g. Ruffert (2011), Art. 13 GRCh para. 8.

[406] Kingreen(2011), Art. 52 GRCh para. 67.

[407] Ginzky (2012), p. 450.

[408] Bethge(2007) para. 223 with reference to other positions.

Other general provisions relevant to geoengineering techniques include rights to information and to participation, in particular EU and German legislation implementing the Aarhus Convention such as Directive 2003/4/EC on the right of access to environmental information and Directive 2003/35/EC on the participation of the public in certain environmental decision-making processes. Of particular interest for German law is the recent decision of the ECJ in the *Trianel* case[409], which allowed non-governmental organisations a wide access to justice in matters of EU environmental law and rejected the narrow interpretation implemented in the Federal Environmental Remedies Act.

5.2.3 Stratospheric aerosol injection

The injection of sulfate aerosols into the stratosphere above state territory is subject to state jurisdiction, as the stratosphere is part of national territory. Thus, German law and possibly EU law are applicable.

The injection of sulfate aerosols into the stratosphere may be relevant to legislation protecting the ozone layer as well as legislation protection the atmosphere in general.

The core legislation on the protection of the ozone layer, Regulation 1005/2009/EC, does not include SO_2 as a regulated substance. Thus, EU law on the protection of the ozone layer does not prohibit sulfate aerosol injection, nor does German law supplementing this part of EU law.

Relevant legislation protecting the atmosphere in general may consist of legislation on the improvement of air quality, on the protection of the environment and human health against certain emissions, and on regulation of pollution from installations.

Improvement of air quality is primarily intended by Directive 2008/50/EC on ambient air quality and cleaner air for Europe, which has been transposed into German law by the 39th Federal Immission Control Ordinance. It contains immission limit values for the protection of human health as well as information and alert thresholds for sulphur dioxide (SO_2).[410] However, Article 2 (1) defines ‘ambient air’ as outdoor air in the troposphere, thus excluding exposition in the stratosphere.

Directive 2001/81/EC on national emission ceiling for certain atmospheric pollutants aims at limiting emissions of acidifying and eutrophying pollutants and ozone precursors in order to protect the environment and human health. It was adopted following the Gothenburg Protocol to the UNECE Convention on long-range transboundary air pollution to abate acidification, eutrophication and ground-level ozone. By 2010 at the latest, Member States shall limit their annual emissions inter alia of SO_2 to amounts not greater than the emission cealing of Annex I, which for Germany is 520 kilotonnes of SO_2, through national programmes. The Directive does not cover emissions from international maritime traffic and aircraft emissions beyond the landing and take-off cycle. Concerning sulfate injection from airplanes, it is not clear whether they have to be considered ‘aircraft emissions’. Arguably only the usual emissions resulting from aircraft traffic, not intended emissions by means of planes, shall be excluded, in line with the principle that exceptions must be interpreted in a narrow sense. Accordingly, the injection of large amounts of sulfate aerosols into the stratosphere above Member States´ territory falls into the scope of the Directive. It might be argued that such an activity would be contrary to

[409] ECJ, C-115/09.

[410] See Annex XI and Annex XII.

the objective of the Directive to limit SO_2 emissions (Article 1)[411] and the duty to adopt national programmes for the progressive reduction of national emissions (Article 6), but on strictly legal terms, it is permissible as long as it does not substantially contribute to exceeding the national emission ceiling. As already stated in the context of public international law (see section 5.1.3), this depends on the amount of SO_2 injected into the stratosphere. If sulfate aerosol injection would indeed substantially contribute to exceeding the national emission ceiling, it may be forbidden or restricted as part of the policies and measures to be included in the national programmes mentioned above. Accordingly, sulfate injection may also be permitted under the 39th Federal Immission Control Ordinance which transposed the Directive into German law.[412]

The applicability of Directive 2001/81/EC does not exclude the application of EU legislation regulating SO_2 emissions from specific sources, as evidenced by recital 19 of the Directive. The IPPC Directive and the succeeding IE Directive[413] list SO_2 and other sulphur compounds as pollutants for which emission limit values shall be fixed.[414] However, neither airplanes nor installations for injection of substances into the atmosphere on planes, ships or on the ground are listed in the categories of installations enumerated in Annex I of both directives. Under German law they may, however, be subject to the Federal Immission Control Act as installations not subject to licensing, if they correspond to the definition of 'installation' in section 3 (5) Federal Immission Control Act. According to section 1 (1) of this Act, the atmosphere is protected, which also contains the outer layers, e.g. the stratosphere with the ozone layer.[415] While installations on planes, ships or on the ground may be considered as installations according to section 3 (5) Federal Immission Control Act without any problem, the same applies to planes only if they are not used for passanger traffic, but e.g. as transport means for a plant or as working tool.[416] According to section 22 of the Federal Immission Control Act, installations not subject to licensing shall be constructed and operated in such a way that harmful effects on the environment are, with the use of the best available techniques, prevented or kept to minimum if unavoidable. According to point 1 (5) of the Technical Instructions on Air Quality Control, the immission limit values in point 4.4.1 for SO_2 may be used as basis for determining whether the requirements of section 22 Federal Immission Control Act are complied with. It has to be pointed to the fact, though, that the regulations of the Federal Immission Control Act are devised for emissions as side-effects of certain activities, not for emissions as main intention of an activity in order to influence the composition of the atmosphere. This may be an argument for regulation going beyond a mere amendment of that Act.

Finally, the injection of sulfate aerosols into the stratosphere by airplanes is generally forbidden by section 7 (1) of the Federal Air Traffic Ordinance, according to which it is not permissible to

[411] For a similar argument, see above with references.

[412] Formerly 33th Federal Immission Control Ordinance. While transposing Directive 2008/50/EU into German law, the provisions of the 33th Ordinance transposing Directive 2001/81/EC were integrated into the 39th Ordinance.

[413] Details on these two Directives are provided in the context of CCS at 279.

[414] See e. g. Annex II Directive 2010/75/EU.

[415] Dietlein (2010), section 1 BImSchG para. 15.

[416] Kutscheidt (2010), section 3 BImSchG para. 27b.

dump or discharge objects or substances out of or from aircraft. However, the competent authority may allow for exceptions if any danger for human safety or property is excluded.[417]

5.2.4 Carbon Capture and Storage (CCS)

In the context of geoengineering, CCS is of special interest. First, there is divergence of opinion on CCS as a form of geoengineering (see above); second, it is more developed, both technically and legally, than other CDR techniques.[418]

Turning to the legal development of CCS, the EU established a CCS framework in Directive 2009/31/EC (`CCS Directive´) as part of the Climate and Energy Package in 2009. The CCS Directive primarily establishes a legal framework for the environmentally safe geological storage of CO_2, to contribute to the fight against climate change (Art. 1 (1)). It requires the following main elements to provide for safe storage:

- Storage permit: The operation of a storage site is not allowed without a storage permit. The competent authority will only issue such a permit if, after consideration of the assessment of the expected security of the storage, she is convinced that there is no risk of leakage
- Reporting and inspections: The operator has to carry out monitoring at least once a year, and the competent authority has to carry out routine inspections at least once a year and non-routine inspections under certain conditions
- Corrective measures: In case of leakage or significant irregularities, the operator and the competent authority shall take the necessary corrective measures
- Closure and post-closure obligations: The operator remains responsible for monitoring, reporting and corrective measures after the storage site has been closed, on the basis of a post-closure plan
- Financial security: As part of the application for the storage permit, the operator has to present financial security in order to ensure that all obligations arising under the permit can be met
- Liability provisions: For the operation of the storage site, the operator is liable according to the Directive on Environmental Liability (2004/35/EC) , which for that aim has been amended
- Transfer of responsibility: After a minimum period of at least 20 years and after the site has been sealed and the injection facilities removed, the competent authority shall take over responsibility of the site, if all available evidence indicates that the stored CO_2 will be completely and permanently contained.

According to Article 2 (2), the Directive does not apply to geological storage of CO_2 with a total intended storage below 100 kilotonnes, undertaken for research, development or testing of new products and process. Furthermore, the storage of CO_2 in the water column is not permitted (Article 2 (4)). In cases of transboundary storage sites or complexes (as well as transboundary transport of CO_2), the competent authorities of the Member States concerned

[417] Accordingly Czarnecki (2008), p. 136, for the ‘vaxination’ of clouds.

[418] Srivastava (2011), p. 190.

shall jointly meet the requirements of the CCS Directive and other relevant Community legislation (Article 24).

Other aspects of CCS, especially relating to capture of CO_2, are regulated by other legal instruments, in particular Directive 2008/1/EC concerning integrated pollution prevention and control (IPPC Directive), Directive 2001/80/EC (Large Combustion Plant Directive) and Directive 85/337/EC on Environmental Impact Assessment (EIA Directive), which to that aim have been amended by the CCS Directive (Art. 31-37). To incentivise CCS, Article 12 (3) lit. a ETS Directive states that allowances do not have to be surrendered for emissions captured and stored according to the CCS Directive.

The IPPC Directive and its successor Directive 2010/75/EU on industrial emissions (IE Directive), which will enter into effect in 2013, lay down framework rules for the national permitting systems with regard to certain categories of large industrial installations listed in Annex I. These rules especially comprise the fixing of emission limit values based on the best available techniques. The CCS Directive includes an amendment of Annex I to the IPPC so as to include capture of CO_2 streams from installations covered by this Directive for the purpose of geological storage according to the CCS Directive. Of particular interest is Article 9a of the Large Combustion Plant Directive, corresponding to Article 36 of the IE Directive, according to which operators of plants with a rated electrical output of 300 megawatts or more must assess whether storage sites and transport facilities are available and whether CO_2 capture retrofitting is feasible. If this is the case, the operator has to provide suitable space on the installation site for the equipment necessary to capture and compress CO_2. Thus, large combustion plants have (already) to be constructed ‘capture-ready’, although CCS is not (yet) compulsory according to the CCS Directive.

It has to be noted that point 1 of Annex 1 of the IPPC Directive and Article 2 (2) of the IE Directive exclude research activities from their respective scope of application. Thus, geo-engineering techniques would be excluded as long as they are still at the research stage.

The EIA Directive requests Member States to make an environmental impact assessment for projects which are likely to have significant environmental impact effects. Directive 2001/42/EC foresees a corresponding obligation for plans and programmes, thus for an earlier planning stage as compared to specific projects. These requirements, culminating in an environmental report, are procedural in nature and shall be taken into account in the administrative decision on the application for a permit or a plan or programme. Basically, both Directives provide for the participation or consultation of administrative bodies dealing with the protection of the environment and the possibility for the public concerned or interested to express an opinion. As a result, the possible environmental impact of certain projects, plans and programmes are highlighted before the final decisions are taken.

Projects for which a mandatory assessment is needed are listed in Annex I, projects for which only conditional assessment is requested are listed in Annex II. In the context of CCS, pipelines for the transport of CO_2 streams for the purposes of geological storage, storage sites, installations for the capture of CO_2 streams for the purposes of geological storage have been included partly in Annex I, partly in Annex II.[419]

Directive 2004/35/EC (Environmental Liability Directive) basically provides for the restoration of the environment where it has been damaged in a certain way by certain types of activity. As a rule, liability rests upon the polluter. There are, however, a number of limitations to the

[419] See for more details points 16, 23 and 24 of Annex I and points 3 (j), 10 (i) of Annex II.

obligation of restoration. Of importance in the context of geo engineering is the possibility for Member States to decide whether they allow the defence for development risks which intend to limit economic operator´s risk in areas of new technologies (Article 8 (4) lit.b). As already mentioned above, the operator of a storage sites according to the CCS Directive is liable for damages covered by the Environment Liability Directive (point 14 of Annex III).

Other EU legislation related to CCS of minor importance is not analysed in this study.

Until now, EU Directives on CCS have been transposed into German law only to a small extent, e.g. concerning the exclusion of CO_2 storage for CCS purposes in the new Federal Closed Substance Cycle Management Act. In particular, the CCS Directive has yet to be transposed. After the failure of a bill on CCS regulation in 2009, the Bundestag approved a CCS Act in 2011.[420] The scope of the CCS Act is limited to demonstration projects, to be applied for before the end of 2016 and allowing for annual storage capacities of an individual site not exceeding 3 million tons of CO_2 per year and 8 million tons of CO_2 in total. The federal states may designate areas where CCS pilot projects are allowed and areas where they are prohibited. The government shall report on the experience gained by the end of 2017, whereupon the Bundestag may decide on further legislative measures. The Bundesrat rejected the bill in September 2011, whereupon the Federal Government and the Bundesrat invoked the mediation procedure to find a compromise, also in order to avoid an infringement procedure for non-implementation of the CCS Directive. The length and uncertainty of result of this procedure has already led to the withdrawal of a CCS pilot plant planned in Jänschwalde (Brandenburg) by Vattenfall. Recently, Bundestag and Bundesrat reached a compromise, which consists in reducing the storage capacity to 1.3 million tons of CO_2 per year and storage site and in enabling the Bundesländer to prevent storage sites on their territory under certain circumstances.

Under current German law, CO_2 storage may be governed in some circumstances by mining law and water law, while the transport of the captured CO_2 is covered by the legal regime for pipelines according to the Federal Environmental Impact Assessment Act, requesting a plan determination procedure or a plan approval procedure.[421]

Thus, CCS is the only technology associated with geoengineering which until now has been explicitely regulated. However, doubts have already been raised whether traditional models such as BATs, environmental impact assessments and liability are sufficient in addressing concerns emanating from CCS.[422]

5.2.5 Carbon capture from air (‚Artificial Trees')

Air capture installations are complex technical facilities relevant to the environment (energy needed to extract the CO_2 from the atmosphere, necessity to dispose of the extracted CO_2). Therefore, in general, the usual requirements of EU and German law for installations are applicable.

Accordingly, installations with a significant impact on the environment require licensing, provided that they fall under the categories of installations listed in the relevant annexes of the

[420] http://www.bmu.de/gesetze_verordnungen/bmu-downloads/doc/43640.php.

[421] See Mißling (2008), p. 290-292; Much (20), p. 132-135.

[422] Srivastava (2011), p. 192-194.

IPPC Directive (to be replaced by the IE Directive) and of the 4th Federal Immission Control Ordinance. However, air capture installations are not explicitly included in any of these categories. One may ask whether they fall under the new category 'installations for the capture of CO_2 streams for the purpose of geological storage according to Directive 2009/31/EC from installations not covered by this Directive' included in the above-mentioned Directives in the context of the CCS Directive. However, as evidenced by recital 4 of the CCS Directive, which mentions 'industrial installations' and 'fossil fuel power plants', air capture is a different technology which cannot be treated as 'CCS'. Furthermore, it is not allowed to draw an analogy to an included category like CCS installations, as the enumeration of the categories is concluding.[423] Thus, air capture installations are not covered by the legislation mentioned above. They would thus not be subject to environmental licensing and the corresponding obligations of operators, in particular the observance of emission and immission limit values. They are not included in the list of categories of the EIA Directive, neither, so that an environmental impact assessment would not be required.

However, the Federal Immission Control Act is also applicable to installations not subject to licensing, if they correspond to the definition of 'installation' in section 3 (5) Federal Immission Control Act. The latter is the case, as air capture installations, as noted above, may have a relevant impact on the environment. According to section 22 Federal Immission Control Act, installations not subject to licensing shall be constructed and operated in such a way that harmful effects on the environment are, with the use of the best available techniques, prevented or kept to minimum if unavoidable, and that wastes produced during the operation of such installations can be properly disposed of. It is disputed whether this means that the precautionary principle does not apply to such installations.[424] Specific requirements for such installations are entailed in several ordinances and to some extent in the Technical Instructions on Air Quality Control.[425]

Of particular relevance for air capture installations appears to be the obligation in section 22 (1) No. 3 Federal Immission Control Act to be able to dispose of the produced waste in a proper way, since this may apply to the extracted CO_2.[426] It is doubtful that the CCS Directive is applicable to the storage of CO_2 stemming from air capture installations, as it was designed for the capture of CO_2 from industrial installations, in particular fossil fuel power plants (see above). Arguably, the exclusion of CO_2 from the Waste Framework Directive 2006/12/EC as well as from the new Federal Closed Substance Cycle Management Act for the purpose of CCS cannot be applied to the extraction of CO_2 by air capture installations.. Thus, the legal situation may be similar to the status of CCS before the CCS Directive. It could, however, be remedied by extending German CCS legislation to the storage of CO_2 from air capture installations.

Finally, the building regulations of the federal states are applicable to air capture installations, and may require a building permit. However, the above-mentioned German rules which apply to air capture installations may not be sufficient to adequately cover the pollution risks of

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[423] For EU Law see Meßerschmidt (2011), chapter 10 Para. 29; for German Law see Dietlein (2010), section 4 BImSchGpara. 12.

[424] See for different opinions Kloepfer (2004), chapter 14 para. 206.

[425] See point 1 (5) of the Instructions.

[426] This depends primarily on whether the CO_2 is stored in gaseous or liquid form, and if in gaseous form, whether it is cased in a recipient or not, see section 2 No. 8 of the Federal Closed Substance Cycle Management Act and Much (2007), p. 134.

chemicals involved in the process (see above). This may necessitate legislation amending the EU and German rules on installations subject to licensing, which are designed to cover more significant pollution risks, in order to include these installations.

5.2.6 Biomass and biochar

Regarding biomass and biochar techniques, existing legislation concerning the deposition of biomass into or on soils, and legislation concerning the transformation of biomass into biochar have to be considered.

The transformation of biomass into biochar may take place on a centralised, large-scale level or on a decentralised, small-scale level.

The former is an industrial process possibly regulated by the IPPC Directive, the Waste Incineration Directive 2000/76/EC (WI Directive) and the successor IE Directive on EU level, and by the Federal Immission Control Act on German level and relevant Federal Immission Control Ordinances. Thus, Article 3 (4) of the WI Directive refers to any thermal treatment of wastes with or without recovery of the combustion heat generated, including pyrolysis. However, Article 2 of the Directive excludes from its scope vegetable wastes from agriculture and forestry and other categories of bio-waste, in particular virgin wood wastes. Thus, at least virgin biomass resources may not fall under the provisions of the WI Directive, leading to the plant not being considered as waste incineration plant but as power plant subject solely to the IPPC Directive (and the relevant provisions in the IE Directive).[427] According to point 8.2 Annex I of the 4th Federal Immission Control Ordinance, the pyrolysis of virgin wood waste and certain categories of treated wood waste is categorized as a power plant subject to licensing if the thermal output is 1 megawatt or more. For such a plant, an impact assessment would be required only with a thermal output of 50 megawatt or more, or as result of a pre-assessment of the individual case based on the particularities of the location of the plant.[428]

Transformation of biomass into biochar on a decentralised, small-scale level are regulated by the provisions of the Federal Immission Control Act concerning installations not subject to licensing (section 22 and following) and may be subject to the specific requirements of the 1st Federal Immission Control Ordinance on small and medium-scale combustion plants, and to some extent to the Technical Instructions on Air Quality Control.

The deposition of biochar on soils aims not only at storing CO_2 but also at using the biochar as fertiliser. Thus, this technique primarily raises questions relating to its permissibility according to EU and German legislation on fertilisers, but may also involve issues relating to legislation on wastes, waters and soils. On EU level, the use of fertilisers is subject to Regulation 2003/2003/EC regulating the placing on the market and the use of ‘EC fertilisers’ and to waste or other legislation such as the Sewage Sludge Directive 86/278/EC. In German law, the use of fertilisers is regulated by the Federal Fertiliser Act, the Federal Fertiliser Ordinance, the Federal Fertilising Ordinance and waste legislation, in particular the Federal Sewage Sludge Ordinance and the Federal Bio-Waste Ordinance. Legislation on fertilisers and waste legislation generally stakes precedence over the provisions of the Federal Soil Protection Law. Under certain

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[427] See Shackley and Sohi (2010), p. 62.

[428] See point 8.2 Annex 1 of the Federal Environmental Impact Assessment Act.

conditions, fertilisation of soil may require permission from the water authorities according to section 8 (1) in conjunction with section 9 (2) No. 2 of the Federal Water Act.[429]

Charcoal made of wood which has not been treated chemically is included in the list of generally allowed substances of the Federal Fertiliser Ordinance (Table 7.1.10), being a traditional means for soil amelioration in private gardens. Apart from that, up to now no explicit regulation exists for the use of biochar as fertiliser.[430] As a consequence, there is no sound legal basis for the use of 'new' biochar as fertiliser.[431] There are initiatives working on a classification of biochar with the aim to establish a certification system. [432]

According to EU and German waste law, biochar appears to be waste rather than a product[433]. On this basis, using biochar for fertilising soils is a form of recovery, which appears to be allowed if there is no risk that hazardous substances are accumulated in the soil. It is unclear, however, if any of the existing regulations on hazardous substances is applicable to biochar, making an assessment difficult. [434] Furthermore, the composition of the biochar under consideration might be decisive for the result of that assessment. [435]

In contrast to the 'open' deposition of biochar on soils with fertilising effects, direct airproof deposition of biomass into soils with the only aim to store CO_2 is primarily a matter of waste legislation, subject to the Waste Framework Directive and the Federal Closed Substance Cycle Management Act as well as to specific regulations for landfill (Landfill Directive 1999/31/EC and Federal Landfill Ordinance). To the extent that German waste legislation entails provisions regarding the licensing and operation of waste management installations for waste disposal that regulate impacts on soil, the Federal Soil Protection Act is not applicable.[436] According to section 28 (1) of the Federal Closed Substance Cycle Management Act, waste disposal is generally allowed only in licensed facilities. However, a prime objective of Directive 1999/31/EC on the landfill of waste (Landfill Directive) is to reduce the production of methane gas from landfills through the reduction of landfill of biodegradable waste, which has to be treated before being disposed of.[437] While biochar is the result of a treatment of biomass, this is not the case for biomass to be disposed of directly. Furthermore, according to the Federal Landfill Ordinance, underground storage is only permitted for hazardous waste, while biodegradable waste is generally non-hazardous waste. Finally, according to the waste hierarchy in Article 4 of the Waste Framework Directive,[438] waste disposal is generally subordinated to waste prevention

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[429] See Kotulla (2011), § 9 Para. 51.

[430] Ökometric/Holweg (2011), p. 1.

[431] Ökometric/Holweg (2011), p. 2, 5-6, use different pieces of legislation and their limit values as orientation for an assessment of the environmental impact of the use of biochar as fertilizer.

[432] See Biochar Science Network (2010).

[433] See Shackley and Sohi (2010), p. 61-62.

[434] Ökometric/Holweg (2011), p. 2, 5-6, use different pieces of legislation and their limit values as orientation for an assessment of the environmental impact of the use of biochar as fertiliser.

[435] Ökometric/Holweg (2011), p. 14.

[436] See section 3 (1) No. 2 of the Federal Soil Protection Act and for details Kloepfer (2004), § 12 para. 112-118.

[438] For German Law, see section 6 of the Federal Closed Sustance Cycle Management Act.

as well as all forms of waste recovery. As a result, bearing in mind that there is strong competition between the various biomass uses, biomass disposal is generally not permissible according to EU Waste law and German Waste law into which the former law has been transposed.

5.2.7 Enhanced weathering

Weathering is difficult to assess for the variety of different techniques proposed. Common denominators are the necessity of major mining and processing operations and an increase of the pH value of soils and waters (rivers and marine seas).[439] While the former activities may be included in provisions on mining and processing activities, the latter could interfere with EU and German legislation on soils and water. Concerning legislation on water, Article 4 (1) lit.a of the Water Framework Directive 2000/60/EC and section 27 (1) of the Federal Water Act require that any adverse changes to the ecological and chemical status of surface waters[440] must be avoided, and that a good ecological and chemical status must be preserved or attained. Details are contained in Directive 2008/105/EC on environmental quality standards in the field of water policy and in the Federal Surface Waters Ordinance. According to these pieces of legislation, the pH value is an important criterion to determine overall physical-chemical water quality.[441] In a recent study of the Alfred Wegener Institute on olivine weathering on land, the authors concluded that it had to be examined precisely how the predicted local pH value changes impact river ecosystems and adjacent habitats.[442] If, as result of such further examinations, a deterioration of the ecological and chemical quality of rivers may be caused by weathering techniques, the use of these techniques[443] will not be permitted in Germany according to sections 8 (1) and 12 (1)No. 1 of the Federal Water Law. [444]

As to soils, section 7 of the Federal Soil Protection Act contains an obligation to take precautions against the occurrence of harmful soil changes, that has been specified in section 9 of the Federal Soil Protection and Contaminated Sites Ordinance in conjunction with the precautionary values in Annex 2 No. 4 of that Ordinance which also account for the ph value of soils. These provisions are also relevant for the application and introduction of materials onto or into a root-permeable soil layer according to section 6 of the Federal Soil Protection Act and section 12 (2) lit. a of the Federal Soil Protection and Contaminated Sites Ordinance. According to section 12 (3) of the Ordinance, the materials have to be examined beforehand according to the methods in Annex 1.

[439] See Royal Society (2009), p. 14.

[440] 'Surface waters' in the Framework Directive and in the Federal Surface Waters Ordinance covers also coastal waters, which are regulated in section 44 of the Federal Water Law, thereby referring to inter alia section 27.

[441] See Annex I Part B point 3b of Directive 2008/115/EC and Annex 3 and Tables thereto of the Federal Surface Waters Ordinance.

[442] Köhler et al. (2010), p. 20232.

443 Corresponding to water use defined in section 9 (2) No. 2 as any measures likely to cause permanent and not only inconsiderable harmful changes to the physical, chemical or biological properties of the water.

[444] Section 12 (1.1) Federal Water Law prohibits harmful water changes as defined in section 3 (10), which itself refers to other provisions of the Federal Water Law. This includes the requirements of section 27 (1) of the Federal Water Law, see Kotulla (2011), § 3 Para. 93.

Within the scope of this study, it cannot be assessed whether weathering methods may lead to such harmful soil changes. If there is concern that they can occur, the application or introduction of weathering materials onto or into the soil shall be avoided or reduced according to section 7 sentence 3 of the Federal Soil Protection Act and the principle of proportionality.

5.3 Conclusions on existing law

5.3.1 International law

Most of international law was developed before geoengineering was a significant issue and, as such, does not currently contain explicit references to geoengineering approaches. The ENMOD Treaty is a special case, as it addresses large scale modifications of the environment, albeit in the context of international humanitarian law. Recent developments under the LC/LP and the CBD have produced pertinent rules specifically on geoengineering in general or particular techniques. However, some of these rules have been adopted in the form of decisions by treaty bodies and are not binding in the strict legal sense.

Geoengineering is currently not as such prohibited by international law. Potential application of specific rules and restriction on geoengineering would depend on specific actual or potential impacts, depending on the rule in question. Whether such impacts would actually occur is difficult to assess or predict at this stage.[445]

There is minimal common legal ground regarding cross-cutting legal rules and principles that could apply to geoengineering. Customary law provides few rules applicable to all states and all geoengineering concepts. Their content is not specific enough to provide clear guidance as to specific geoengineering techniques. In addition, customary rules are subject to and can be derogated from by special rules agreed between states.[446] For instance, arguably a state that is party to and complies with a particular environmental treaty regime would probably not be in breach of the customary rule on preventing transboundary environmental harm if the activity falls within the scope of the treaty and the state complies with it.

The precautionary principle or approach does not help in resolving the problem of determining the "lesser evil", i.e. choosing between the potential impacts of geoengineering and facing the impacts of climate change that are inevitable or assumed to happen without geoengineering.

The text of most treaties does not appear to provide for taking into account the overall "net" effects on the broader environment in comparison to harm avoided and there are no corresponding decisions on who would evaluate such impacts and over what scale.[447]

The CBD decisions on geoengineering do not mean that the question of whether and how to consider international geoengineering governance is resolved.

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[445] Bodle (et al (2012) para 182 and 186.

[446] Unless the rules have ius cogens status, which would raise additional questions. However, none of the rules discussed here are isu cogens.

[447] Bodle et al (2012) 144.

Virtually all treaties examined impose procedural obligations on geoengineering activities falling within their scope of application.[448] Most of them include some kind of reporting obligations regarding the implementation of the treaty, which could include geoengineering activities. There are several treaties with an obligation to conduct an impact assessment regarding certain activities, and ICJ has stated that there is a corresponding obligation under customary law. It is also argued that there is a general customary duty to cooperate, but it is unclear to what extent and under which conditions this would entail specific procedural obligations for a state pursuing in geoengineering activities.

In legal terms, the mandate of the CBD COP and many international regimes and institutions would allow them to address geoengineering, or some aspects of it, even if they have not done so to date. This raises questions regarding different treaties or institutions potentially competing for addressing geoengineering with overlapping or inconsistent rules or guidance.[449]

The overall findings do not substantially deviate from the previous main legal studies. Differences in detail are mostly academic.

5.3.2 EU and German law

With the exception of CCS there is currently no explicit regulation of geoengineering in EU law or in German law. However, existing environmental rules and standards of EU and German law do already apply to geoengineering techniques to some extent.

General provisions of EU and German law applicable to each of these techniques include the precautionary principle, the principle of the protection of the environment, basic individual rights including the right to freedom of research.

The injection of large amounts of sulfate aerosols into the stratosphere above Member States´ territory is permissible as long as it does not substantially contribute to exceeding the national emission ceiling according to Directive 2001/81/EC and the 39th Federal Immission Control Ordinance transposing the Directive into German law. This depends on the amount of SO_2 injected into the stratosphere. However, the discharge of substances as sulfate aerosols out of or from aircraft is generally forbidden by section 7 (1) of the Federal Air Traffic Ordinance, but may be allowed for if any danger for human safety or property is excluded.

CCS is of special interest, as it is more developed, both technically and legally, than other CDR techniques. CCS is regulated by the CCS Directive including amendments to other Directives, which as of yet have been transposed to German law only to a small extent.

Air capture installations are not included in the annexes of EU and German legislation governing installations subject to licensing, but are regulated by the rules of the Federal Immission Control Act concerning installations not subject to licensing, especially the obligation to be able to dispose of the produced waste in a proper way. However, this may not be sufficient to adequately cover the pollution risks of the chemicals involved in the process.

Biomass and biochar techniques are regulated to some extent by EU and German legislation on installations as well as legislation concerning the deposition of biomass into or on soils. With the exception of charcoal made of wood which has not been treated chemically, no sound legal

[448] Bodle et al (2012) 144.

[449] Bodle (2010) 321.

basis exists for the use of biochar as fertiliser. Biomass disposal without fertilising effect is generally not permissible according to EU and German Waste laws.

The increase of the pH value of waters as a result of enhanced weathering might interfere with EU and German legislation on waters requiring the preservation or attainment of a good ecological and chemical status of surface waters. Further examination is also required for an assessment of the conformity of this technique with Federal soil legislation.

6 Regulatory options and proposals

6.1 Introduction

Although the debate about geoengineering is still largely driven by scientists, it is gaining attention at the policy interface.[450] In addition, while many geoengineering techniques are at the conceptual or modelling stage, there have also been field experiments followed by an emerging public debate. These developments raise the question of whether a governance framework is needed over and above the current framework, and what it should look like.

The geoengineering debate has taken international law somewhat by surprise. The main legal studies so far show an emerging consensus that -details aside- existing international law hardly addresses the potential impacts of geoengineering or related key questions (see above section 4).[451] The CBD decisions on geoengineering and the developments under the LC/LP do not necessarily mean that the question of whether and how address geoengineering is resolved.

More generally, the question of governance encompasses more than binding legal rules. In this sense, our understanding of "governance" is broader than "regulation". [452] We also include formal and informal, implicit and explicit processes, procedures and institutions, the sum of which relating to geoengineering could be labelled a "regime".[453] In an analytical sense, the concept of governance is a tool for describing these elements of the political process. In a normative sense, the concept of "good" governance is intended to contribute to specific objectives and is applied to assess and design governance accordingly.[454]

Governance, meant in this broader sense, is not necessarily restrictive. It can also provide legal certainty and political legitimacy, or fulfil pragmatic functions such as coordination. Options for governance design presuppose objectives and functions that such governance is to fulfil, as well as the choices made regarding a particular governance design. However, the geoengineering debate for the most part has not addressed this issue. Most geoengineering governance proposals are not explicit about their underlying assumptions and criteria regarding the objectives and functions they seek to address or leave unaddressed.

This section (project work package 3) analyses *why* governance of geoengineering should be pursued as well as *how* such governance should be designed. It sets out reasons for governance of geoengineering, and proposes a set of objectives to be pursued as well as functions to be fulfilled, taking into account particular characteristics of geoengineering. We address these issues by the general term "criteria", in the sense of standards or principles by which

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[450] Bodle (2013) 469.

[451] Bodle (2013) 463.

[452] On the concepts and definitions of governance see Pierre and Peters (2005); Kjaer (2004); Rothstein (2003) 49-71. Cf also the World Bank's use of the concept, http://go.worldbank.org/G2CHLXX0Q0.

[453] Cf. the definition by Krasner (1983) 2: "sets of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge in a given area of international relations", Regimes are based on horizontal cooperation between states (and other relevant actors), but usually also address the vertical division of labour.

[454] Cf. Rothstein (2003); Grindle (2004).

geoengineering governance design is assessed, and with the help of which governance options are developed.[455]

On the basis of these objectives and criteria, and the analysis in sections 4 and 5 (project work packages 1 and 2), we assess gaps in the current framework and develop and assess scenarios and options for future governance of geoengineering. Although ocean fertilisation was not within the scope of the legal analysis in section 5, the current regulatory regime for ocean fertilisation is highly relevant for the emerging overall governance of geoengineering and for the analysis in this section.

Section 6.2 provides an overview of governance proposals in the geoengineering literature. It aims at capturing key ideas but does not intend to be fully comprehensive in terms of all literature. In section 6.3 we analyse the reasons for geoengineering governance, and set out objectives and criteria it should fulfil. This includes an analysis of reasons why governance is also in the interest of states that could have the means to pursue geoengineering unilaterally. A general key question is how to balance political feasibility with containing risks and preventing impacts. In addition, a cross-cutting aspect is how to address research. Section 6.4 outlines our general approach to developing regulatory options and identifies main governance options: From a normative perspective, issues include the available and appropriate legal, regulatory and other governance instruments and techniques. From an institutional perspective, we look at the interplay between existing institutions addressing geoengineering, as well new procedures or institutions, for instance, the suitability of CBD as a central (but not necessarily sole) institution, and the role of the work under the LC/LP. An overarching aspect is to what extent governance should differentiate between different geoengineering concepts and their stages of development. This is linked to the question of defining geoengineering for normative purposes. Special thought and emphasis is given on how to address research. This cross-cutting issue is currently one of the key questions relating to geoengineering. We analyse whether and to what extent research is a category distinct from so-called deployment and whether it should be subject to different rules and governance. Section 6.5 analyses the current international legal framework from a specific governance perspective by providing a gap assessment for each geoengineering technique against the governance criteria developed in section 6.3. and the governance design options developed in section 6.4. On this basis, section 6.6 develops options for filling the governance gaps outlines scenarios for future governance of geoengineering and assesses governance options. Section 6.7 summarises our conclusions.

6.2 Governance proposals

Proposals for geoengineering governance rose significantly in the late 2000s, alongside interest in the subject of geoengineering. Such proposals commonly cover key characteristics and principles for governance of research and deployment. Proposals are split between informal and formal governance methods, though fewer offer concrete and actionable frameworks. On the whole, geoengineering scholarship concurs that the existing international law framework does not fully or sufficiently constrain field research or deployment of contemplated techniques, and therefore some form of additional governance is needed. An overview of existing proposals is provided in the annex.

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[455] Cf. the similar definitions in the Oxford and Cambridge Dictionaries, <
http://oxforddictionaries.com/definition/english/criterion?q=criterion>;
<http://dictionary.cambridge.org/dictionary/british/criterion?q=criterion>.

6.2.1 Historical overview

Proposals for geoengineering governance began to rise along with interest in the concept of geoengineering in the mid- to late- 2000s and as international climate change negotiations became more entrenched, with only a handful of papers and analyses on geoengineering governance before that time.[456] The concept of geoengineering, however, existed long before this increase in attention and geoengineering techniques were proposed as a response to anthropogenic climate change as early as the 1960s.[457]

While discussion on geoengineering initially existed largely within the scientific community, increasing attention has come from policymakers, academics, and social scientists.[458] Likewise, the late 2000s saw a number of geoengineering governance initiatives arise. For instance, in 2008, the Royal Society established a working group of international experts to provide an assessment of geoengineering proposals, including examination of governance aspects.[459] In 2009, a group of academics submitted the "Oxford Principles" on the regulation of geoengineering research to the UK House of Commons Science and Technology Select Committee, which later endorsed the principles, as did the UK government.[460] In 2010, a group of experts gathered at the Asilomar Conference to address geoengineering risks and research standards, recalling earlier efforts that produced voluntary research guidelines on recombinant DNA.[461] The Solar Radiation Management Research Governance Initiative (SRMGI), an international NGO-led project focusing on governance of SRM, was created in 2010 in response to the Royal Society's 2009 report.[462]

Alongside these efforts were government-led initiatives examining geoengineering risks and governance. A joint inquiry on geoengineering was initiated in 2009 by the Science and Technology committees of the U.S. House of Representatives and the U.K. House of Commons, with attention to domestic and international governance issues.[463]

6.2.2 Common features of existing governance proposals

Almost all governance proposals view geoengineering as a "last-resort" and maintain that attention should not deviate from mitigation efforts, although most consider that additional research should be performed and governance mechanisms explored. There are notable exceptions, such as Jay Michaelson (1998) calling for abandoning efforts towards a binding mitigation agreement and shifting attention instead towards investment in a "Climate Change

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[456] Lin (2009); Parson and Ernst (2012).

[457] Keith (2000); Parson and Ernst (2012).

[458] Virgoe (2007).

[459] Royal Society (2009).

[460] 'Oxford Principles, History' http://www.geoengineering.ox.ac.uk/oxford-principles/history/.

[461] Asilomar (2010).

[462] "SRMGI Solar Radiation Management Research Governance Initiative", www.srmgi.org/about-srmgi/

[463] "The Regulation of Geoengineering - Science and Technology Committee," http://www.publications.parliament.uk/pa/cm200910/cmselect/cmsctech/221/22111.htm

Manhattan Project" on geoengineering. On the other end of the spectrum is the ETC Group, calling for a strict moratorium on all geoengineering experimentation and concluding that geoengineering violates international law.[464]

Options for geoengineering governance are generally grouped into categories of: unilateral state action; review and authorisation by an international consortium; and prohibition on activity.[465] Of these alternatives, the majority of proposals advocate for governance through a multilateral association of states, of sufficient size to foster a sense of legitimacy within the international community. Unilateral action is seen as an outcome to be avoided, and one that adequate governance mechanisms would circumvent. A complete ban on geoengineering activity is generally undesirable, too, as limited research is commonly supported and deployment may become a necessary option in the future, though it has been suggested that imposing a ban would be "easier" than developing an international regulatory regime.[466]

Governance may be either formal (e.g. binding measure through new or existing treaties or under domestic regulation[467]) or informal (e.g. through voluntary codes of conduct, principles, and soft law measures[468]) in nature. Consideration of these two options is split. Some proposals advocate for regulation through modification of existing frameworks or by creating a new framework. Others suggest that preliminary steps should first be taken through less binding, soft law approaches. Voluntary codes of conduct and "bottom-up" efforts are frequently proposed to serve as a foundation for establishing norms and consensus while avoiding political barriers. This is usually discussed in the context of research, rather than deployment. Advocates of formal regulation lean towards supporting the use of existing instruments versus crafting a new geoengineering-specific agreement, as existing instruments already possess clear decision-making authority and would entail less financial and political costs. On the other hand, some scholars feel that the use of existing instruments will result in a patchwork, ineffective, and insufficiently-integrated approach, and that a new instrument, at least for SRM, could better cover novel geoengineering issues and concerns.[469]

Some proposals address "geoengineering" as a whole, though distinctions are made between governance of CDR and SRM as well as for individual techniques.[470] CDR tends to be viewed as less threatening and correspondingly, governance proposals for CDR are often less strict and receive less focus.[471]

Governance principles that are commonly cited for geoengineering include, *inter alia*:

- Public participation and consultation in decision-making

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[464] ETC Group (2010).

[465] See e.g. Bodansky (1996); Virgoe (2007).

[466] Bodansky (1996).

[467] "Although some of this literature has considered domestic law and governance, the main focus of interest and concern is at the international level, due to the global scale of effects of both climate change and potential CE interventions." Parsons (2012).

[468] See e.g. Banargee (2011); SRMGI (2011).

[469] See e.g. Zedalis (2010).

[470] See e.g. House of Commons (2010); Scott (2010).

[471] See e.g. SRMGI; Royal Society (2009); Morgan and Ricke (2010).

- Evaluation of impacts (e.g. environmental, social, economic, cultural)
- Disclosure and transparency in research, and assessment and supervision of research progress
- International cooperation
- Compensation and remediation for damage
- Precautionary principle
- Decision-making based on best scientific evidence
- Flexibility

At the international level the CBD has explicitly called for some criteria for a regulatory framework, namely that it be "global", "science-based", "transparent", and "effective".[472]

Potential governance forums suggested include, *inter alia*, the United Nations (UN), United Nations Framework Convention on Climate Change (UNFCCC), United Nations Environment Programme (UNEP), World Meteorological Organisation (WMO), UN Commission on the Peaceful Uses of Outer Space, LRTAP Executive Body, UN Commission for Sustainable Development, and London Convention/London Protocol – either for all geoengineering activity categories (e.g. CDR or SRM), or for individual techniques. The UN is often cited as a forum for governance, at least in part because the UN could seemingly provide legitimacy in the form of a multilateral mandate.[473] Proposals for considering governing geoengineering under the UNFCCC, such as through a new protocol, are also common. Reasons for doing so include the UNFCCC's existing jurisdiction over climate change, established expert bodies such as the SBSTA, use of the CDM and JI mechanisms to address CDR, UN-based legitimacy, and hope that addressing geoengineering in conjunction with climate change mitigation would lessen the risk of the "moral hazard."[474]

Many proposals for geoengineering governance focus on research, rather than deployment.[475] Parson and Ernst (2012) suggest that there is consensus in the literature that research and informal international research collaboration are the most immediate geoengineering needs, that research requires governance, and that informal international consultation and collaboration on research governance should begin soon. Regulation of research presents a natural first, and likely easier, step prior to consideration of deployment.[476] Further, many believe that governance of research could act as a platform for establishing processes and principles for future regulation of deployment and would avoid "lock in" as environmental, technological, and political circumstances evolve. Frequent suggestions are for voluntary governance by the scientific community or states, using principles and codes of conduct, and establishing processes for transparency and coordination of research efforts and results.

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[472] On these criteria see Bodle et al (2012) 108-109.

[473] See e.g. Virgoe (2007).

[474] Lin (2009); Barrett (2010); Scott (2010); Rickels et al (2011); UBA (2011); House of Commons (2009); Royal Society (2009).

[475] See e.g. Oxford Principles, Asilomar (2010); Morgan and Ricke (2010).

[476] Bodansky (2012).

According to Parson and Ernst (2012), there are major gaps in the existing literature: most geoengineering proposals give only negative guidance, are limited to governance of research and avoid questions of deployment, favour elaboration of normative principles without consideration of factors such as states' interests and political risks, and fail to define practical aspects of implementation.

6.3 Objectives and criteria for international geoengineering governance

This section develops and explains reasons, objectives and functions for geoengineering governance. To some extent these considerations can be distinguished by whether they address the "*why*" or the "*how*" of geoengineering governance. However, these distinctions are not always straightforward and also overlap. For ease of reference therefore address these issues by the general term "criteria". For the purpose of this study this encompasses standards or principles by which geoengineering governance design is assessed, and with the help of which governance options are developed.

We do not simply assume a need for regulation and governance. It is not self-evident that a governance framework for all geoengineering techniques is needed at the *international* level. For instance, there are land-based geoengineering concepts that are unlikely to have a transboundary impacts and that could be addressed at national (or EU) level with no or minimal international guidance.

Of course the reasons for regulating or not regulating geoengineering, as well as for favouring particular governance designs and instruments, are normative and show political premises and judgment. For instance, we state the objective to bring also those states on board of a governance framework which could unilaterally pursue geoengineering research and deployment. Possible ways to involve such states relies on political judgment. It is important to analyse and compile the assumptions and premises underlying governance assessments and proposals.

In addition, trade-offs will have to me made. Although the objectives and criteria are to some extent complementary, it is unlikely that all of them can be fulfilled to the same degree by a particular governance framework. For instance, there might be a trade-off between aiming at participation and acceptance by many states and other objectives and criteria.

6.3.1 Particular characteristics of geoengineering relevant to governance

Geoengineering has particular characteristics that cause particular challenges to international governance. To some extent these may resemble those of other high-risk or controversial technologies such as genetic modified organisms, nuclear power and perhaps nanotechnology. Yet geoengineering is also different and unique in several respects, including the following:

For most, geoengineering is viewed as a potential particular and provisional solution to a particular problem: climate change. It is conceived by most, but not all, as a plan B to mitigation, as an fallback option to emission reductions that is not desirable as such, but which could be further explored in order to at least find out whether it is viable as a last resort.

There is a broad range and diversity of techniques addressed under the term geoengineering. In addition, each technique is quite different depending on which scale we address. The impacts and risks associated with the individual techniques vary. Most techniques become high-risk in terms of physical impacts only when deployed at large scale, and not all may have immediate significant transboundary impacts.

There is scientific uncertainty and on-going technological development. This applies to climate change as the underlying issue as well as to geoengineering techniques as one potential means to address it. It may be difficult to seek more knowledge about geoengineering without endorsing it or causing a political lock-in effect.

Another aspect is an apparent distinction between research and deployment. Whether and how to address geoengineering research is a fundamental and cross-cutting problem that occurs for every geoengineering technique and for every potential governance option. We address research in separate sections (see section 6.3.2, 6.4.3.3).

Despite some field experiments and increasing public and media interest, geoengineering could still be a storm in a teacup. The technical and economic feasibility might be confounded at early stages rather than after years of research and gradually scaled-up experiments. In addition, geoengineering might not be politically viable. The potential for polarisation suggests adding political legitimacy and responsibility to a largely science-driven debate.

6.3.2 Reasons for geoengineering governance

6.3.2.1 Avoid negative environmental and health risks and impacts

This is probably the most obvious and self-explanatory purpose of a geoengineering governance structure. Given the factual and scientific uncertainties regarding geoengineering techniques, this criterion is closely linked to the precautionary approach. A governance framework should ensure as far as possible that potential environmental and health impacts resulting from pursuing geongineering are avoided or kept to a minimum. There are further obvious links to other criteria such as avoiding conflicts, which could arise from real, assumed or even potential impacts. The objective of avoiding negative environmental and health impacts also applies to research.

6.3.2.2 Avoid political conflicts and legal disputes / Avoid unilateral action

As it is likely that at least some geoengineering concepts could be tested and deployed by a single state, a state capable of doing so might prefer to address geoengineering in its domestic jurisdiction only, and be reluctant to wait for or subject itself to international agreement. However, all states, including all states pursuing geoengineering (research), have an interest in participating in an international governance framework in order to (1) prevent others from engaging in unilateral and uncoordinated geoengineering and (2) avoid international political tensions that are likely to arise from the potential for transboundary impacts of geoengineering. Such political tensions may arise *regardless of whether any impacts can be proven* to be caused by the geoengineering activities in question. Geoengineering governance should curb this potential for political tension.

Avoiding unilateral action is the flipside of avoiding political conflicts. Where there is potential for unilateral action, a governance framework should avoid it. This objective reinforces the need for political feasibility. A state could be part of a regime, but that regime might not prevent unilateral action. Conversely, a further aspect is how to provide incentives for states that are not part of the regime to nevertheless abide by the main principles.

6.3.2.3 Co-ordinate science and research

There are technical aspects to research that would at least at a potential later stage require some form of governance of research and science. Depending on the particular geoengineering

concept, at some stages research activities might need to be coordinated at the international level in order to ensure that data can be correctly attributed to particular experiments and to ensure validity of results. A need for e.g. prior information and co-ordination requirements could arise when field experiments could interfere with each other's validity.[477] This scenario probably relates to experiments at large scale, and perhaps is most pertinent for SRM. Assuming that more than one state would engage in further research, each state's research could be susceptible to such interference. Avoiding this through some form of governance might also facilitate willingness to join a general governance regime. In addition, transparency and information sharing could also avoid duplication of research. This is a scientific rather than a political rationale for international governance and should be discussed with the scientific community. These more technical points do not necessarily mean that elaborate governance structures are needed at this stage for this particular objective. The science community is self-organising to a large degree. At some stage there may be a need to compile and synthesise the individual research results in order to provide focused input to political decision-making (see sections 6.5, 06.6.3)

Science coordination also has policy relevance in that it enhances the quality of scientific input to the political level. Better scientific knowledge can defuse potential political tensions and add legitimacy to decisions. Science coordination can also avoid governance conflicts between institutions addressing the same or different geoengineering concepts, and with geoengineering activities and other activities.

Apart from these potential technical needs for governance, some argue that enabling research could be a specific objective of a governance framework in a broader sense. There are two aspects to this: First, "enabling research" could merely mean that a governance framework for a certain topic should generally not stifle desired and acceptable research, a concern that has been raised in the governance debate.[478] Second, it could also mean that a governance framework should actively foster more geoengineering research. The reasoning is a scenario in which inadequate research funding leads to the inability to respond to catastrophic events. On this basis it is argued that *international* governance should be designed to encourage national spending, develop cost-sharing arrangements even such as international burden-sharing, and incentivize private investment. In addition, it is argued that international governance would generate legitimacy for this research area.[479] From a general governance perspective, this approach could mean a trade-off in which geoengineering research gains legitimacy, awareness and funding. In return, the public gains some transparency and control over what is happening in this area.

However, making this much broader objective of actively fostering research a governance objective appears to presuppose the policy choice that research should be pursued actively and strategically for the specific purpose of being ready for using geoengineering. Although the distinction between merely not stifling research and actively pursuing it might be difficult to draw, the latter appears to be close to the "slippery slope" argument and lock-in scenario, in which research at least factually paves the way for future deployment as a desirable outcome. This could send an important policy signal away from mitigation and imply another trade-off.

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[477] Lane (2010) 53.

[478] Bracmort et al (2010) 19-20; Gordon (2010) ii.

[479] Bodansky (2012) 10.

In order to leave this implicit policy choice open, we do not consider actively fostering research to be a governance objective.

6.3.3 How to regulate and design governance

The reasons for geoengineering governance outlined above are based on the current scientific knowledge on geoengineering concepts as well as the current public debate and an assessment of their wider implications e.g. for environmental risks and climate policy. Against this background, we would disagree that "it is almost impossible to determine governance requirements until the shape of any of the technologies under consideration is better known."[480] A number of governance requirements already follow from the reasons outlined above as to why governance is considered necessary or desirable.

6.3.3.1 Precautionary approach

The scientific uncertainties regarding most geoengineering concepts, combined with their purpose of having global impacts and their different transboundary risks, call for a precautionary approach. This is not a self-standing objective but a means to the closely linked end of avoiding environmental and other impacts. It is less relevant for research at the modelling and laboratory stage, but already applies to field experiments. The intensity of safeguards required will mainly depend on the geoengineering technique and the scale of the activity in question.

While this is a central aspect of geoengineering governance, the different views regarding its specific implications and its normative anchoring in international law have implications for governance design, e.g. when considering political buy-in. There is a risk that a specific governance approach clearly or implicitly endorses a particular but controversial aspect of the precautionary approach. This could jeopardise the buy-in from states and other actors that have different views. This risk has to be considered. On this basis, and for the purpose of developing governance options, it might be appropriate to detach the specific legal problems regarding the precautionary approach and instead see it as general approach to deal with scientific uncertainty. It at least provides reason and guidance for establishing procedural safeguards for dealing with scientific uncertainty regarding the potential impacts of geoengineering.

From a broader perspective, the precautionary principle on its own does not resolve a conflict between the objectives of avoiding the effects of global climate change vis a vis avoiding the risks of geoengineering. This is likely to be a political choice.

6.3.3.2 Political feasibility and buy-in

An international governance framework should in principle aim at bringing on board as many states and other actors as possible, in particular those states that are likely to be capable and willing of pursuing geoengineering. This could contribute to avoiding impacts as well as to avoiding political conflict. Of course this criterion involves political assumptions, assessments and judgments about what could politically be feasible. More specifically aiming at buy-in in the sense of "acceptance" of the governance framework has several aspects, e.g. participation in the regime in the first place as well as acceptance of decisions taken within the regime and ensuring its implementation. In addition, governance can gain acceptance and buy-in across

[480] Rayner (2010) 62.

instruments, e.g. parties to the LC that are not also parties to the LP could for political reasons nevertheless consider to adhere to governance measures under the latter instrument.

However, political buy-in is only a means to an end and might also be subject to trade-offs. If other governance criteria and objectives needed to be unacceptably compromised, then the costs of ensuring participation could be considered to be prohibitive. It needs to be considered under which conditions it could be worth it *not* to have some key actors on board - because the trade-off between ensuring their participation and not fulfilling other governance criteria might be unacceptable.

6.3.3.3 Climate context and „moral hazard"

Geoengineering governance should avoid undermining efforts to reduce emissions. Most proponents of geoengineering stress that it is no substitute for reducing emissions, and that geoengineering proposals are primarily considered as complementary to other efforts to limit human-induced climate change.[481] In a 2012 decision, the CBD's COP emphasised "that climate change should primarily be addressed by reducing anthropogenic emissions by sources and by increasing removals by sinks of greenhouse gases under the United Nations Framework Convention on Climate Change, noting also the relevance of the Convention on Biological Diversity and other instruments."[482]

This criterion is to address a plausible "moral hazard" argument that a geoengineering debate and activities have the potential to send political signals towards a departure from emission reductions, and to obstruct the climate change negotiations. For instance, introducing geoengineering would add another layer to the already over-complex climate negotiations.

The link between geoengineering activities and reducing emissions is further complicated by a potential scenario in which states might push for crediting some geoengineering techniques. This is closely related to the question how geoengineering activities would fit into the established categories of "mitigation" and "adaptation" in international climate change law, in particular the few rules under the UNCCC and the Kyoto Protocol that could be of relevance to geoengineering.[483] A narrow view might hold that geoengineering does not easily fit into these categories: While all geoengineering techniques are intended to counteract climate change and its effects, they do not address emission reductions, and basically they do not address how to adapt to a changed climate.[484] Yet the strict distinction is not always clear: Some geoengineering approaches could be considered as climate change mitigation or adaptation, or even both, for example, some ecosystem restoration activities.[485] In addition, the Kyoto Protocol has recently opened the traditional distinction to some extent by allowing CCS into

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[481] Bodle (2012) 119; ff., for instance, Williamson et al (2012) 8: „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 humaninduced climate change and its impacts."

[482] Decision XI/20, para 4

[483] As well as technology development and transfer, capacity buidling and finance, which are not of relevance here.

[484] Bodle (2013) 469. Cf. USGAO (2011) viii, which classifies geoengineering as an response to climate change "other" than mitigation and adaptation.

[485] Williamson et al (2012) 20.

the CDM, although CCS does not reduce the production of CO_2 . Against this background, if geoengineering were to move forward, there could be pressure to credit certain geoengineering activities that do not fit easily into the mitigation category. In addition, treating geoengineering as mitigation or adaptation could for instance have implications for funding institutions and their eligibility criteria.[486]

6.3.3.4 Legitimacy, transparency and participation - Avoid a polarised public

The international governance framework should also aim at avoiding a polarised public in particular through transparency and participation. The latter are considered elements of "good" governance and can contribute to a sense of legitimacy of geoengineering decisions. A polarised debate, perhaps similar to instances regarding climate change, would make it difficult for a state to adopt and implement any policy on geoengineering.[487] Legitimacy in that sense can be facilitated by a designing processes that are transparent and include appropriate participation. Transparency of process and geoengineering activities could be one of the means to achieve this end as well as to reduce the risk of political tension. Regarding the latter, transparency of geoengineering activities could involve e.g. requirements for publicity and reporting by states.

6.3.3.5 Flexibility

A governance structure needs to allow for some flexibility in order to be able to react to new developments, because (i) there is a lack of scientific knowledge regarding geoengineering as well as climate science, and (ii) the public debate and interest at policy level is at the beginning. Flexibility in this sense should maintain an appropriate level of normative legal certainty and clarity. There are many options and potential elements for combining legal certainty with flexibility, including institutional arrangements and procedures for feeding in and discussing new scientific knowledge, for providing interpretative guidance (regarding e.g. the scope and content of the governance regime), and for decision-making and amending rules.

6.4 General approach and main governance options

This section describes our general approach to governance options from an institutional and normative perspective. Based on the governance criteria and the current state of geoengineering, it provides a preliminary assessment which governance elements might be most appropriate from both perspectives. The cross-cutting issue of addressing research is analysed in a separate sub-section.

6.4.1 The normative perspective: Instruments and techniques

From a normative perspective, there is a broad range of binding and non-binding instruments and legal techniques that could be used for fulfilling the governance criteria developed above. Potential instruments and regulatory techniques include, for instance: guiding principles; establishing appropriate procedures for the relevant states and actors to agree on common ground and scientific basis; transparency obligations regarding procedure and information,

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[486] Bodle (2013) 469.

[487] Bodle (2013) 465.

e.g. impact assessments or reporting; and specific obligations such as permissions, restrictions or prohibitions. Some of these elements already exist and apply to some or all geoengineering techniques (see above section 5 on the existing legal framework).

The normative tools and instruments at the international level provide a broad and flexible range in several aspects, for instance:

- the legal status, e.g. rules binding under international law or not (e.g. COP decisions);
- whether the subject of governance is the *activity* in question or the *effects* of an activity (see above section 4);
- the degree to which an aspect is governed at the international level or left to the national level or to self-regulation by non-state actors;
- the normative level of specificity and detail, e.g. clear permissions or prohibitions, more general guiding principles, scope for discretion in implementation, procedural and substantive aspects, rules and exceptions.

In contrast to international law, EU law and domestic legal systems at least in principle provide a clear allocation of legal competences and established mechanisms for implementation and enforcement. International law offers a particular range of instruments the political aspects of which have to be considered as well when assessing their suitability. For example establishing new binding rules usually requires some form of specific consent of the party to be bound, different rules and governance arrangements may overlap, and governance arrangements that are not formally binding under international law may still be politically effective.

There are links between the normative and the institutional perspective (see below): For instance, both perspectives need to consider whether there should be general rules or guidance that apply to all geoengineering techniques (centralised approach) or whether there should be separate rules for particular geoengineering techniques (decentralised). Similarly, the issue of potential normative conflicts has to be addressed. Another parallel to the institutional perspective is that there are several legal orders in which normative instruments could be anchored: international law, EU law and domestic legal orders, plus self-regulating approaches (by non-state actors) within these spheres.

6.4.2 The institutional perspective: The emerging institutional complex of geoengineering

The international governance framework for geo-engineering can be understood as an emerging institutional complex. The analysis of international governance has increasingly moved from the exploration of specific institutions to the investigation of "institutional complexes", "regime complexes" or "governance architectures".[488] An institutional complex can be defined as a set of two or more international institutions (including international regimes and international organisations) that co-govern a particular issue area in international relations.[489] Many if not most issue areas of global governance have become to be affected significantly by more than one international institution. The analysis above shows that the emerging issue area of geo-engineering is also addressed by various institutions (including the CBD, the London Convention/London Protocol and others).

[488] Raustiala and Victor 2004; Biermann et al. 2009; Oberthür and Stokke 2011; Keohane and Victor 2011.

[489] Ibid.

Institutional complexes can take different shapes. In this respect, a first important criterion for differentiating between them is the level of centralisation, viz. institutional integration.[490] At the more integrated end of the spectrum, institutional complexes may be dominated by one core institution that defines the guiding principles and determines the general policy direction that is accepted and implemented by other elemental regimes and organisations. The leading role of the core institution may, but does not have to be expressly defined in normative terms. The World Trade Organisation (WTO) may be considered a prime example in international trade. In the field of environmental governance, the Montreal Protocol may be considered as an example as regards the protection of the ozone layer.[491] At the other end of the spectrum, institutional complexes may encompass various unrelated regimes and organisations. For example, it has been argued that the international governance of plant genetic resources is shared between various international institutions, including the WTO, the FAO International Treaty on Plant Genetic Resources for Food and Agriculture, the UPOV Convention, the World Intellectual Property Organization (WIPO) and the CBD, in ways that lack integration.[492] Many institutional complexes fall somewhere in between these extremes in providing for some degree of integration.

For example, the CBD regime for access to and benefit-sharing from genetic resources (ABS) as further elaborated through the 2010 Nagoya Protocol provides some general guidance to other institutions. At the same time, the Nagoya Protocol explicitly provides that any specialised international ABS instrument takes precedent over the Nagoya Protocol within its scope of application and for its parties, but only provided that the special instrument “is consistent with, and does not run counter to the objectives of the Convention and this Protocol” (Art. 4.4).[493] The Nagoya Protocol elaborates and specifies the normative *lex specialis* rule. Two aspects are particularly interesting: First, the Nagoya Protocol explicitly recognises that a subsequent specialised instrument takes priority over the Nagoya Protocol. This provides clarity and avoids legal uncertainty over conflicting regimes. Second, the Nagoya Protocol steps back only on the condition that its general policy direction is not jeopardised. It thus provides freedom to establish separate regimes, but combined with the implicit threat that it will continue to apply if parties do not design the non-central regime compatible with the central regime of the Nagoya Protocol.

Institutional complexes can be characterized by different types of divisions of labour among the institutions comprising it. For example, different elemental institutions may specialise on various regulatory subsets or sectors of the overall issue area. In climate governance, for example, the International Civil Aviation Organization (ICAO) focuses on emissions from international aviation while the Montreal Protocol for the protection of the ozone layer addresses certain industrial greenhouse gases.[494] Institutions within a complex may also specialise on the supply of certain governance functions such as the creation of knowledge, regulation, capacity building, or enforcement, as is apparent in Arctic governance.[495]

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[490] Biermann et al. 2009; Keohane and Victor 2011.

[491] Biermann et al. 2009, 20.

[492] Raustiala and Victor 2004; Jungcurt 2008.

[493] See Oberthür and Pozarowska 2013.

[494] Keohane and Victor 2011; Liu 2011.

[495] Stokke 2011.

Furthermore, elemental institutions my spatially apply to or specialise on certain geographic regions, as is implicated in the differentiation under the CBD (areas under national jurisdiction), UNCLOS (maritime zones), and the Antarctic Treaty System (Antarctica). In principle, the degree of centralisation/integration could also be considered a type of a division of labor.

Another important characteristic of the relationship of the different elemental institutions of a broader governance architecture is the level of inter-institutional conflict or competition. The level of synergy and conflict between institutions is not least rooted in the degree of compatibility or competition of their objectives. For example, the relationship between the WTO and multilateral environmental agreements employing environmental trade restrictions has been described as conflicting not least because there is a tension between the respective institutional objectives of free trade and environmental protection. The level of inter-institutional conflict/competition is likely to have an impact on efforts to enhance governance within an institutional complex.[496]

The co-governance of an issue area by various institutions can be shaped by political decision-making. Institutional complexes were traditionally described as having evolved “naturally”, i.e. without much deliberate political design of the relationship between the elemental institutions. However, this changed with the increasing awareness of states and other actors that more frequently than not multiple institutions affect the governance of individual issue areas. Today, there is increasing attention to actively shape and manage inter-institutional relationships. One potential objective is to achieve an appropriate division of labour between the various institutions, including an adequate level of centralisation. However, there is no institution with the authority and mandate to assign and prescribe a division of labour to other institutions. The means for such collective governance of institutional complexes are mainly confined to decision-making within the individual institutions and, to a lesser extent, include cooperation among them.[497]

6.4.3 Preliminary choice of main governance options

In this section we assess and chose, on the basis of the objectives and criteria developed above, appropriate governance elements. This preliminary and abstract assessment is the basis for the subsequent analysis of whether the existing international governance of geoengineering adequately contains these elements and which gaps remain.

6.4.3.1 Assessment from normative perspective

From a normative perspective, based on an initial and cursory assessment of the governance criteria, in particular the scientific uncertainty and the need to avoid political conflict, a general restriction in principle of geoengineering activities, combined with clear criteria for exemptions seems to best match the objectives and criteria developed above.

Geoengineering activities are potentially high risk because of their intended impact at global scale. The risk relates to the potential environmental and human health impacts as well as political tension. The latter is particularly relevant because it can materialise regardless of the scientific proof of potential environmental or health impacts.

[496] Oberthür and Pozarowska (2013).

[497] Oberthür and Stokke (2011).

A further argument for a restriction in principle is based on the climate context and the criteria of not undermining efforts to reduce emissions: While there are scientific methodologies to analyse and explain physical risks at least approximately, the risk that geoengineering developments would lead countries and other actors to be less committed to mitigation is socio-political in nature. As such, this risk is particularly difficult to counter and is likely to be persist for any future governance arrangement that permits geoengineering: Any means mitigating the impacts of climate change is almost certain to reduce the pressure to advance mitigation efforts. From this perspective, a restriction in principle could serve as a political signal that emission reductions are the default climate policy and geoengineering would only be an exception, which could serve as a safeguard against a potential slippery slope away from emission reductions.

On the other hand, most techniques are currently at the conceptual, modelling or small field experiment stage. Ocean fertilisation might be regarded as having reached regional scale, and some experiments have sparked considerable public and political debate. In addition, many geoengineering techniques are, if applied under national jurisdiction, currently unlikely to have significant transboundary impacts (see also section 6.5.1). This could require less or no international restrictions. More generally, there are concerns about stifling what might be regarded as legitimate research, a concern which ultimately is about attracting broad participation in a governance regime. The challenge is therefore to address concerns about the potential environmental, human health and political impacts and climate context, while not being overly restrictive. Of course, what is "overly" is a matter for debate. Generally, the concerns can be adequately and sufficiently addressed through defining exceptions to the general rule that geoengineering activities should in principle be prohibited. But these concerns do not seem strong enough to abandon the general rule or reverse rule and exception.[498]

Therefore, the main choice in our preliminary regulatory approach, in simplified terms, is the assessment that the particular characteristics of geoengineering and the objectives and reasons for governance warrant a prohibition of geoengineering activities as a general rule *combined with* exceptions under well-defined circumstances.[499] As we argue below, this includes research activities such as field experiments.

For this approach of general prohibition with exception(s), taking into account the current potential of transboundary impacts of geoengineering techniques, there are many options for designing a restriction in terms of substance and procedure. Unless a total ban is intended, a restriction would mean that some form of permission has to be obtained before the activity can take place. This approach allows for normative certainty while keeping options open for regulatory fine-tuning through setting more or less elaborate and strict requirements for the granting of permits. A corresponding design option at the level of decision-making rules could be e.g. positive approval, silence procedure, a certain majority in order to deny the permission or requiring only a minimum number of supporters to grant the permission. As to general legal form, non-binding approaches can be considered in view of other factors such as

[498] In the context of the precautionary principle and pesticide regulation, cf. the interview with executive director of the European Environment Agency, "EEA chief: 'Scientific uncertainty is not a justification for inaction'", 4 March 2013, http://www.euractiv.com/climate-environment/eea-chief-scientific-uncertainty-interview-518183.

[499] For a default presumption against geoengineering deployment cf. Lin (2009) 23.

participation in and political weight of the regime in question, with a view to evolving into binding law over time.[500]

It is important to note at the outset that this general approach does not mean that all details need to be set at the international level. Nor does the governance framework at the international level necessarily have to be binding. Geoengineering as an international issue does not (yet) seem mature enough for a new, separate binding instrument, although there are proposals under the LP to amend this instrument and establish binding rules for ocean fertilisation that could also be extended to other marine geoengineering (see section 6.5.1). In any event, soft law could be developed further so that if and when the time is ripe, it could be incorporated into binding rules.

Another issue to consider from a normative perspective is whether to provide for taking into account such overall "net" effects of a geoengineering activity. In general terms the geoengineering debate is often framed as setting the potential impacts of geoengineering against avoiding the potential impacts of climate change. In essence this is a cost-benefit approach that appears to be limited to measurable impacts (caused or avoided). The precautionary principle on its own does not resolve the conflict between avoiding the effects of global climate change vis a vis avoiding the risks of geoengineering. Most potentially applicable environmental treaties do not appear to provide for this (see section 5 on the existing legal framework). Arguing for a "netting" approach when applying these existing rules would in many cases ignore the policy choices that were already made in establishing the rule in question. Another problem in incorporating a "netting" approach into the normative design of a governance framework would be the assumption that there is either perfect knowledge that enables conclusive "netting" *in advance*, or the belief that the "not perfect but the best available knowledge *at this stage*" is a sufficient and legitimate basis for decision-making. Against this background, we do not support anchoring the netting approach in a governance framework. It is part of a wider debate and a political decision that our approach does not impede or prejudge.

A general prohibition with exemptions is a particular challenge in respect of a definition of geoengineering. The restrictive nature of this regulatory technique calls for clarity and legal certainty, so that states implementing the governance and the relevant actors, but also the public, know what to expect. Potentially negative implications of being classified as "geoengineering", in particular for regulatory purposes, play a role as well. Yet due to the broad range of geoengineering techniques, any overarching definition for regulatory purposes is unlikely to be sufficiently comprehensive to capture all relevant techniques while being sufficiently precise to exclude uncontroversial techniques or scale of activities. The political weight of overarching guidance as well as the guidance across specialised regimes would benefit from clarity and legal certainty in this respect, even where governance is not binding. As argued in section 4, we suggest that *any* overarching definition, including the CBD's, that is used as a basis for a regulatory purpose would have to be complemented by further details on determining and measuring broad terms such as scale.

This can be achieved in several ways. One approach, also addressing the difficulty of crafting a sufficiently broad definition to cover a wide range of methods, would be to complement the definition with a positive list that expressly mentions specific techniques -or activities- which are considered geoengineering. Such a list could be comprehensive and exclusive, or non-exclusive, allowing for adaptation and interpretation as new methods and scenarios develop.

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[500] Cf. Ginzky (2011) 478.

Another option is to envisage a process or institution providing further guidance in advance or on a case by case basis. For the sake of legal certainty and a level playing field, in any specialised governance regime an overarching definition framing the regulatory context should be combined with a positive list. To provide for flexibility, clear procedures and criteria for amending this positive list should be established.

A particular technical issue regarding a definition of geoengineering is whether it should include the element of large scale (see above section 4 on definition). If it did, an activity that is small scale would strictly speaking not fulfil the definition, therefore not qualify as geoengineering and from the outset not fall under the governance framework. Again, this shows the importance of distinguishing different purposes and contexts of a definition as part of a governance framework: It may be useful to have a definition that describes geoengineering in general terms, such as the CBD expert group's in order to define *the issue,* in particular to provide guidance in a decentralised approach. However, such a definition would not be fit to serve the specific normative purpose of providing legal certainty, clarity and sufficient predictability of which specific activities are subject to the governance framework and a general prohibition. In addition, past experience and current debate show that geoengineering raises concerns at stages prior to large-scale activities, whether relating to environmental and health impacts, political tension or public unease. Against this background, the governance framework with the prohibition in principle should apply regardless of scale, while leaving open the possibility of making a small scale a core criterion for granting an exemption. A positive list complementing a general definition would provide clarity in this respect. To some extent, this would leave the case-specific implementation of deciding what is "small-scale" to states granting exemptions.

A key component of the governance framework is to clearly separate scientific input and political decision-making. The particular characteristics of geoengineering that lead us to choosing a restriction in principle as a main governance element also mean that this normative element has a strong political aspect. It is not a question of mere scientific input. The governance framework comprises both scientific and political functions. Political legitimacy lies at the heart of resolving conflicts between environmental objectives. It is essentially a political decision whether pursuing climate protection can justify the potential and actual risks posed by geoengineering activities. The same goes for more technical issues such as what qualifies as geoengineering and should be addressed by international governance. The political governance function works both ways and could also legitimise an otherwise controversial geoengineering activity.

The form, mandate and powers of the political level as well as the measures available to it need to be carefully considered in order to aim at broad participation, retain flexibility to adapt to future developments, ensure meaningful scientific input and facilitate compliance. A political function does not mean over-regulation in that there has to be a political decision on each individual proposed geoengineering activity. The political guidance can take a variety of forms, from mere consideration of scientific input by a political forum or body such as a COP, to authoritative and binding decisions on whether a specific activity is permitted or not. Governance at the international level could merely consist of clear guidance and rules laying down the conditions under which geoengineering activities are permitted or prohibited. For the scientific community, it might be difficult to accept that this issue is discussed, possibly misunderstood and simplified by delegates with political mandates. However, the distinction between scientific input and political decision-making has been a common feature of virtually all modern international environmental treaties and institutions. Although uncommon, specific

procedural safeguards at the political level could be considered if need be, such as requiring consensus or a specific majority for not following scientific opinion or proposals.

In parallel to the political function of international governance, one objective and function of international governance is facilitating the coordination of research activities in order to avoid cross-interference and to ensure the validity of results. Science coordination also has policy relevance (see above). As international (and national) governance of geoengineering advances, demand for international scientific and technological assessments is likely to grow. From a normative perspective, it is useful to distinguish between three aspects international governance could address:

a) The general current state of knowledge on geoengineering and its risks: While it seems useful to have more general overviews in this respect, it does not seem to be a necessary element of international governance to be prescribed or regulated. It might be sufficient to rely on the work in the various national and international research programmes. However, a mandate to regularly compile and perhaps assess the current knowledge could be useful;

b) Specific scientific input to underpin other governance functions, e.g. in order to update or amend general guidance or rules: International governance, in particular political functions and decision-making, should be informed by sound scientific knowledge and input. Scientific input should be separate from political decision-making (see above). Based on the experience with existing regimes, this might be more of an institutional rather than a normative issue.

c) Input to specific individual assessments and decisions such as permits: In order to fulfil the objectives and criteria developed above, it does not currently seem indispensable that the *international* level provides more than general guidance as to the conditions under which the national level should allow for exemptions from the general prohibition, e.g. the quality of the assessments required. The assessment framework developed under the LC/LP is an example of quite detailed and comprehensive guidance.

The criteria of legitimacy, transparency and participation call for some elements that provide information to other states, the governance institutions and the public. This should take the form of appropriate structures for reporting and monitoring of national-level decisions and activities. This regulatory instrument is generally well-established at the international level, and virtually all potentially applicable treaties impose some procedural obligations on geoengineering activities falling within their regulatory scope.

6.4.3.2 Assessment from institutional perspective

Governance of geoengineering in all likelihood also requires institutions over and above bare rules. Assuming a need for at least minimal international governance, under which regimes or in which fora should governance be exercised?

The emerging set of existing institutions that co-govern geoengineering does not yet display a clear inter-institutional division of labour or have a clear "centre of gravity". Rudiments of a sectoral and/or spatial specialisation may be discerned in activities within the LC/LP and possibly OSPAR regarding marine geo-engineering techniques. While discussions under the CBD have so far had the broadest scope, it is unclear whether the CBD may head towards forming a centre of an emerging governance architecture. While awareness of the multi-

institutional involvement has been rising,[501] the institutional complex is still very much to be shaped.

In this respect, core questions to be investigated are (1) which functions the overall governance architecture will have to fulfil (partly related to the objectives and criteria discussed above), (2) which of these functions should and could be performed by a central regime (or a limited set of regimes) forming the core of the governance architecture, and (3) which functions could be performed to what extent by various existing institutions and how their relationship to each other may be shaped. In a first step, it may be important to clarify whether it would be useful to have a central institution in the governance architecture, and if so, for which functions. In such a scenario, the question arises of whether a new or an existing institution could best fulfill the necessary functions.

A core rationale for a central institution, or for a limited number of institutions building this core, would be to provide overarching political guidance, and possibly the elaboration of uniform standards to be applied, globally and across sectors, which would also ensure that potential gaps that may emerge from a patchwork of specialised regulations are minimized. The mandate of many international regimes and institutions would allow them to address geoengineering or some aspects of it. Some of these institutions have already started to address geoengineering. This could lead to different treaties or institutions potentially competing for addressing geoengineering with overlapping or inconsistent rules or guidance. Given the common feature of intended global climate impacts and the ensuing political significance, there are good reasons for a central institution providing overarching functions and guidance. In addition, the CBD has already addressed geoengineering in an overarching manner. Although it is difficult to say whether and to what extent the CBD might continue to further develop this guidance, the decisions are in place and have to some extent occupied the field.

At the same time, there is a rationale for delegating governance tasks to specialised institutions and thus institutional decentralisation. Even with a central institution, the diversity of geoengineering techniques, their stages of development and their potential impacts will remain a challenge. The greater expertise of specialised institutions may enable the elaboration of tailor-made solutions for particular sectors and areas, and the strengthening of particular governance functions such as the creation of scientific knowledge. Such specialised institutions may also spearhead governance developments that might at first be impossible to initiate in an overarching regime, but which might be taken up at a later stage. Political and legal barriers may obviously limit the feasibility of a "rational design" of the governance architecture along these rationales and therefore also require attention. Similarly, specialisation is already enshrined to some extent in the existing governance architecture, most importantly through the initiatives of the LC/LP.

Against this background, and based on the criteria developed above, in abstract the following governance design would seem appropriate from an institutional perspective:

- A central institution recognised as a first point of contact providing the opportunity for actors to discuss crosscutting issues, develop overarching guidance (across other relevant institutions) and raise emerging issues; developing general principles and perspectives, and facilitating the exchange of information. This does not exclude division of labour with specialised regimes.

[501] Cf. the CBD study on the regulatory framework: Bodle et al (2012), and the recent mandate by CBD COP11 to the Executive Secretary to disseminate and update the studies, decision XI/20 para 13 and 16(a).

- Flexibility to respond to new knowledge and political developments. This is particularly challenging for binding rules, but also for institutional structures. This element would seem to require an institutional structure and procedures with a permanent or at least regular ability to meet, discuss and update existing governance. At the international level, treaty regimes with institutions such as COPs and subsidiary bodies provide a potential model, in addition to organisations that are established as part of and in order to implement a specific normative treaty.
- Ability to address potential regime conflicts - e.g. through more or less formalised or informal linkages and coordination, or voluntary normative division of labour.
- A clear separation of scientific input from political decision-making could also be relevant from the institutional perspective in that it might be facilitated through institutional arrangements. It is a means to reconcile the scientific uncertainty and need for updated scientific input with the potential for political tension and the need for political legitimacy and responsibility (see above).

6.4.3.3 Research as a cross-cutting issue

A key question in the geoengineering debate is whether and how to address further geoengineering research as part of a governance framework. The main concern relating to research is that governance of geoengineering would stifle further research.[502] Generally, freedom of research is highly valued and legally protected in many jurisdictions. A specific aspect is related to the specific purpose of geoengineering, as some argue that research is needed in order to obtain reliable information about feasibility and risks. Are there reasons for governing research at the international level? Should there be a distinction between research and deployment? Are there useful and feasible criteria for this distinction? Should there be a separate governance structure?

While research is a cross-cutting issue across all criteria and all geoengineering techniques, not all objectives and criteria developed above may seem equally suitable for addressing research. For instance, it could be explored to what extent the objectives of political buy-in and avoiding political conflict might be significantly affected by research. The same goes for ensuring continuing mitigation efforts - e.g. in relation to funding for geoengineering research. However, key objectives and criteria for international governance also apply to research activities, notably avoiding environmental and health impacts (and political tension). Finding out more about the feasibility, risks and impacts of geoengineering will at some stage require real-world field experiments that would have to be gradually scaled up in order to know the impacts of a particular technique and whether it is effective. There have already been field experiments, most prominently on ocean fertilisation, but also on SRM.[503] To what extent should international law privilege research activities even if they could cause severe impacts, on the grounds that this is the only way to know for sure that a geoengineering technique causes such impacts?

At the heart of this challenge is the question of what constitutes research and what could be a reason for privileging it. The geoengineering debate has so far distinguished research and field

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[502] See for instance the views collected by USGAO (2011) 49-69.

[503] Markus and Ginzky (2011); “Geoengineering experiment cancelled amid patent row”, Nature online, 15 may 2012, doi:10.1038/nature.2012.10645; Izrael (2009); “World's biggest geoengineering experiment 'violates' UN rules, *The Guardian*, 15. October 2012, http://www.guardian.co.uk/environment/2012/oct/15/.

trials from deployment mainly implicitly by referring to an activities' impacts, its scale, its purpose (e.g. commercial or not), or the method of preparing and conducting it.

One key rationale for governance derives from the (actual, potential or alleged) environmental and health impacts, and applies regardless of whether the activity is carried out as "research" or not.[504] For field experiments, the physical impacts of the actual activity are the same. Once the modelling and "indoor" stage is left behind, the distinction between research and deployment becomes increasingly artificial and at some scale there will factually be no difference to deployment. The Solar Radiation Management Governance Initiative distinguishes between large field trials and deployment on the basis of whether the activities lead to environmental effects of a sufficient magnitude, spatial scale or duration that affect climate significantly.[505] Apart from the problem of determining "significant" effects, in particular in advance, this criterion is not useful from a governance perspective because it is retrospective: If it is the very purpose of field trials to find out whether such effects occur, then it will be known only after the activity is carried out. In this sense it does not seem desirable nor practicable to apply different rules for the same type of activity depending on whether it is for a "good" scientific purpose or a "bad" deployment purpose.

Distinguishing research by the scale of the activity could be a way of avoiding significant impacts. However, this poses the same problems as generally defining geoengineering by the scale of the activity (see above). In addition, it seems obvious that research can be large-scale. Scale is therefore not useful in determining in abstract whether an activity is research or not. However, scale could generally be one useful element amongst others in deciding which activities could be permitted - similar to the LC/LP's concept of "legitimate" research (see below the section on ocean fertilisation).

The same goes for distinguishing research from deployment by the purpose of the activity, notably whether the activity pursues a "commercial" purpose. A non-commercial purpose would not on its own avoid or contain harmful impacts or contain the risk thereof. Depending on scale, this could also be true for potential political tensions. However, a commercial purpose might generally be a useful element amongst others in deciding which activities could be permitted.

Against this background, for governance purposes research could be privileged on the basis of a combination of elements that could seek to reduce or minimise impacts and risks as well as political tension. Useful elements include scale, commercial purpose, and generally whether the activity follows certain procedures and implementing safeguards, e.g. prior impact assessments, transparency of planning, implementation and results.

It has been suggested that governance for research should be addressed separately from governance for deployment.[506] However, this seems problematic from the perspective of institutional economy and political feasibility. A separate governance structure would also require the determination whether an activity qualifies as research or not. It is more plausible to address in general all govern geoengineering activities by a prohibition in principle and on this basis define exceptions or other special governance aspects for research. This also appears

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[504] House of Commons (2010) 38; Gordon (2010) 32.

[505] Solar Radiation Management Governance Initiative, CALL FOR SUBMISSIONS 2 (2010), http://www.srmgi.org/downloads/.

[506] USGAO (2010) 36.

to be in line with most existing rule systems under international law, which do not usually make a principled distinction between research and deployment regarding the prohibited conduct or impacts, although they do at times define – not unproblematic – exemptions for scientific research.[507]

In conclusion, any international governance arrangement should in principle include research and apply from the early stages of field experiments. A completely separate governance regime for research prior or in parallel to a governance arrangement for deployment is not advisable. Instead, reasons favour of addressing research as part of a general governance arrangement include institutional economy, normative consistency, and that governance of research is likely to pre-determine subsequent governance of "deployment". Under the LC/LP, research and deployment are de facto also not separate. Research beyond modelling and "indoor" activities should in principle fall under the general prohibition but also be included as a potential exemption under clearly defined conditions. There is no single criterion that can usefully define in abstract and advance what should qualify as an exempt research activity. Instead, for governance purposes a combination of elements should be defined at the international level as guidance for determining exemptions. Useful elements include scale, commercial purpose, and generally whether the activity follows certain procedures and implementing safeguards, e.g. prior impact assessments, transparency of planning, implementation and results.

This approach strikes an appropriate balance between scientific, environmental and also political concerns and not stifling research. The restrictions on research are very small compared to the concerns and risks that are addressed by this proposal: It needs to be stressed again that the general prohibition would not be absolute: The only restriction research is subjected to is the requirement for obtaining a permit at the national level, to be granted in implementation of and in accordance with clear general criteria agreed at the international level. This provides ample space for taking into account parameters such as the scale of the project, or its expected negligible environmental impacts, do not require burdensome or bureaucratic structures and procedures. The permitting requirement defines default and exception and basically ensures that the policy level (i.e. the permitting authority) is in charge and responsible, which will provide a significant element of legitimacy to permitted research. The alternative opposite governance scenario, in which certain research activities would be allowed *in abstract* and in principle unless prohibited, pose risks that outweigh the restriction imposed by a permitting requirement. They pose significantly greater risks of further public polarisation, provide far less certainty to the public as well as problems of monitoring and enforcement.

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[507] For instance, as an exemption to the general whaling ban, Article VIII of the International Convention for the Regulation of Whaling (1946) allows any member state to grant to its nationals a special permit to take whales for research purposes. The proposed permits are submitted to the Scientific Committee which reviews the necessity and proportionality of the research methods. The review takes place in a small specialist workshop with invited experts. The workshop report is circulated to the Scientific Committee and subsequently to the Commission. The ommission can comment on the research permit proposal by passing a resolution but the final decision rests with the member state.

Table 1: Overview: Objectives and criteria for governance of deployment and research

Objectives and criteria for governance	Deployment	Research
Avoid negative environmental and health risks and impacts	X	X
Avoid political conflict and disputes	X	(X)
Co-ordinate science	-	X
Precautionary approach	X	X
Political feasibility and buy-in	X	(X)
Climate context	X	(X)
Legitimacy, transparency, participation	X	X

X relevant; - not relevant; (X) relevant only potentially or to limited extent

6.4.3.4 Summary of main governance elements

On the basis of the objectives and criteria as well as the analysis above the following governance elements seem appropriate:

a) A general restriction in principle of geoengineering activities, combined with clear criteria for exemptions seems to best match the objectives and criteria developed above. There are many options for designing a restriction and exemptions in terms of substance and procedure.

b) Research activities beyond modelling and "indoor" activities should in principle fall under the general prohibition but also be included as a potential exemption under clearly defined conditions. For governance purposes a combination of elements should be defined at the international level as guidance for determining exemptions.

c) Not all details need to be set at the international level, nor does the governance framework at the international level necessarily have to be binding. Soft law could be developed further so that if and when the time is ripe, it could be incorporated into binding rules.

d) No closed definition determining normative consequences. A general definition could be combined with a positive list of activities addressed.

e) A clear separation of scientific input and political decision-making.

f) The possibility to include or refer to international scientific and technological assessments.

g) Appropriate structures for reporting and monitoring of national-level decisions and activities.

h) A central institution recognised as a first point of contact. This does not exclude a division of labour with specialised regimes.

i) An institutional structure and procedures with a permanent or at least regular ability to meet, discuss and update existing governance, in order to provide flexibility to respond to new knowledge and political developments.

j) The ability to address potential regime conflicts.

6.5 Current governance: analysis and assessment

This section provides a multi-dimensional gap analysis from a specific governance angle. We assess for each geoengineering technique the current international legal framework against the governance objectives and criteria developed in section 6.3, as well as against the governance design options developed in section 6.4. This analysis of the existing gaps and weaknesses of the current system provides the basis for developing options for filling the governance gaps in the subsequent section.

6.5.1 Assessment of the existing governance

Drawing on the analysis of the existing legal framework in section 5, this section assesses the extent to which the existing international governance for each geoengineering technique corresponds to the objectives and criteria for international governance in section 6.3 and our preliminary choice of main governance options and elements in section 6.4. Against this background, the following questions seem most relevant in order to identify significant governance gaps that could call for being addressed at the international level:

- To what extent is the particular geoengineering technique addressed by international governance?
- If yes, is the governance in accordance with the preliminary choice of main governance options developed above?
- What is the risk of unilateral action causing ensuing political implications - noting that the risk might change, e.g. in light of technological developments?
- What is the likelihood of serious transboundary (environmental) impacts?

These questions will be addressed for each geoengineering technique.

6.5.1.1 Sulfate aerosols in atmosphere

Sulfate aerosols in atmosphere are basically not covered by international governance - apart from the general guidance in the CBD decisions decisions X/33 and the follow-up XI/20 (which are assessed in the next section). The existing rules on protecting the atmosphere, mainly the ozone regime, the LRTAP Convention and the climate regime, do not provide normative guidance regarding sulfate aerosol injection. A different perspective might arise from new insights into the potential effects of sulfate aerosol injection on the ozone layer, but based on current knowledge and estimates such injection would not per se contravene the relevant rules. Geoengineering via sulfate aerosols is also not addressed by international institutions under these or other regimes (see above section 5).

At the present stage of knowledge this SRM technique appears to have the most potential to be effective, as well as technically and economically feasible. The latter potential also points to the risks of unilateral action and potential political repercussions and their related costs.[508] In addition, SRM techniques such as sulfate aerosol injection could have serious transboundary environmental impacts, including a likely significant geographical redistribution of climatic effects in the case of uniform dimming.[509] While the likelihood of such impacts is difficult to

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[508] Cf. Macnaghten and Szerszynski 2013.

[509] Cf. Williamson (2012) 44-45 with further references.

predict, their nature and magnitude appear to be serious enough to raise concern at smaller levels of likelihood. The mere possibility of such impacts are in turn likely to increase the potential for political conflict *regardless* of whether such impacts occur or, if they do, were actually caused or exacerbated by the injection. The latter point is also of relevance for research with field experiments at relatively small scale.

6.5.1.2 Cloud brightening from ships

Cloud brightening from ships is generally covered by the CBD decisions. Apart from this general governance, it is difficult to assess in abstract whether and to what extent cloud brightening would be permitted or prohibited (see section 5). General obligations regarding environmental protection under UNCLOS might apply, but are too general in nature to correspond to our main governance elements. Under the LC/LP, so far there is no discernible attempt by parties LP to interpret it as covering cloud brightening.

Given the current state of research and knowledge about this technique, there does not seem to be much incentive to engage in cloud brightening at this stage. While states would probably be technically be able to pursue this technique unilaterally, the costs and uncertainties involved in doing so in order to make an impact are likely to be strong disincentives at present. If cloud brightening from ships was pursued unilaterally, we would assume medium potential for international political tension, depending on where it would take place and e.g. implications for shipping routes as well as local and regional weather. A large-scale application of this technique is likely to have significant environmental impacts in terms of atmospheric and oceanic perturbations which could affect precipitation and ocean productivity, although there is considerable uncertainty regarding likely negative or positive effects.[510]

6.5.1.3 Desert reflectors

Desert reflectors are only addressed by the general guidance provided by the CBD decisions (see section 5). Given the current state of research and knowledge about this technique, there does not seem to be much incentive to engage in desert reflectors. Although states with suitable areas would probably technically be able to pursue this technique unilaterally, it would have to be deployed over very large areas to have a significant effect on the global climate.[511] In addition, the potential for international political conflict arising from such activities appears to be small. The same goes for the potential transboundary environmental impact, as impacts are likely to be local or regional, although potentially very high on ecosystems e.g. if vegetation was changed at large scale.[512]

6.5.1.4 Installations in outer space

SRM techniques in outer space are barely covered by space law, which provides interesting liability concepts, but otherwise its rules are rudimentary and have not been used in practice (see section 5). The potentially applicable rules do not correspond to our main governance elements, as they are far too general to provide guidance regarding which activities would be allowed or not. In addition, there is no suitable institutional structure in place. SRM by space

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[510] Williamson et al (2012) 51 with further references.

[511] Williamson et al (2012) 52-53.

[512] Williamson et al (2012) 52-53.

installations is addressed only by the general guidance provided by the CBD decisions (see see sections 5.1.2 and 0).

The potential for unilateral action is currently low, given the costs involved and technological requirements and uncertainties. The same goes for field experiments, which are more difficult and costly to conduct in order to generate solid knowledge about feasibility and risks. If it was pursued unilaterally, the potential would be appear to be limited to few states with the necessary technological expertise and financial means, although the possibility of going into space has in recent years become more commercially available. If SRM via space installations was pursued, the potential for political tension and conflict could be even higher than with atmospheric SRM, because activities in outer space might be more difficult to stop, and the technical and financial inability of many states to access outer space might add to that. There would also be potentially large environmental impact, as with stratospheric SRM techniques (see above).[513]

6.5.1.5 Carbon capture and storage (CCS)

While CCS on land is subject to some existing national and EU rules, it is not addressed by specific *international* legal rules. In contrast, there are specific and detailed rules under the LC/LP and OSPAR regarding CCS in the ocean's water column, on or under the seabed. There is a general prohibition of CCS under the LC and a general permission for sub-seabed CCS under the LP, subject tot certain conditions. Sub-seabed CCS is also permissible under OSPAR for those parties to which relevant amendments have entered into force. In addition, the climate regime has opened the CDM to CCS under Kyoto Protocol, where the prospect of obtaining credits could provide an incentive to pursue this technique. The CBD has explicitly excluded CCS from fossil fuels from its definition of geoengineering and thus from its general guidance - although it should be noted that all CDR techniques involve carbon capture and some geoengineering techniques may involve the same or similar processes of managed carbon storage.[514]

The impacts and risks of CCS on the environment vary and depend on the technical process in the individual case. Environmental risks include leakage and ground or sea water pollution and acidification, as well as destroying deep seafloor organisms. Other potential risks could arise from infrastructure and transport needs of CCS. There could also be conflicts arising from competitive usages of the underground and its reservoirs (cf. section 5). The potential for unilateral action could be regarded as high, as some states such as Germany and the EU are pursuing CCS and have passed legal frameworks for it. However, commercial application in practice is developing more slowly than expected.[515]

6.5.1.6 Ocean liming

Ocean liming is not directly addressed under current international law regimes. Although it could fall under provisions restricting "dumping" under several international instruments, it is

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[513] Williamson et al (2012) 44: "The projected positive and negative impacts that are common to all techniques involving reduction in incoming solar irradiance (as would result from space- or atmospheric-based SRM".

[514] Williamson et al (2012) 8 and 24.

[515] For the UK see https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/carbon-capture-and-storage-ccs; for the US see http://www.fossil.energy.gov/programs/sequestration/industrial/industrial_ccs.html and http://www.epa.gov/climatechange/ccs/index.html.

not clear whether it could qualify as "placement" under these instruments and thus be exempt from the definition of dumping. As a geoengineering technique, ocean liming is currently addressed only by the general guidance provided by the CBD decisions (see sections 5.1.2 and 0).

The potential for unilateral action seems low, given the likely low effectiveness and efficiency at least in the absence of crediting or other incentives. Transboundary impacts would also seem low unless it was applied at large scale. An additional consideration would stem from the positive benefit of offsetting acidification caused by climate change (see section 5).

6.5.1.7 Ocean biomass storage

Ocean sequestration of biomass is not directly addressed under current international law. Similar to ocean liming, some instruments on ocean pollution could apply depending on whether the activity qualifies as "dumping" - at least under the LC/LP, ocean biomass storage could be exempt. The general provisions of UNCLOS on protecting the marine environment also apply (see section 5).

The potential for unilateral action at a level that could cause concern seems currently low, at least in the absence of crediting or other incentives. Transboundary impacts would also seem low unless it was applied at large scale, although impacts are still poorly understood due to limited understanding of deep sea ecosystems (see section 5).

6.5.1.8 Biomass and biochar on land

International law does not prohibit the production of biomass, of biochar, or the application of biochar on soil as such, and there does not seem to be pertinent international law on land use or land use change relevant for biomass and biochar. However, the amount of biomass and biochar and the scale of land use changes required to have a significant climate impact could be subject to and confict with rules of international law, e.g. rules on biodiversity, ecosystems and habitats or human rights In addition, it is conceivable to imagine moves towards crediting certain types of LULUCF under the KP's flexible mechanisms or in future new market-based mechanisms. As a geoengineering technique, ocean liming is currently addressed only by the general guidance provided by the CBD decisions (see sections 5.1.2 and 0)

The potential for unilateral action at a level that could cause concern seems currently low, at least in the absence of crediting or other incentives. Transboundary impacts would also seem low unless it was applied at very large scale, although there is a lack of knowledge regarding the environmental impacts of applying biochar on soil.[516]

6.5.1.9 Enhanced weathering

The existing legal framework for enhanced weathering on land is similar to that applying to biomass and biochar (see above). In absence of specific international law on land use or land use change relevant for enhanced weathering, the rules on the protection of biodiversity, ecosystems and habitats, as well as potentially human rights law, indirectly provide rules regarding areas that could be affected by large-scale land use that would be part of this geoengineering technique. As a geoengineering technique, ocean liming is currently addressed only by the general guidance provided by the CBD decisions (see sections 5.1.2 and 0).

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[516] Williamson et al (2012) 57, 65, 66-67.

The potential for unilateral action at a level that could cause concern seems currently low, at least in the absence of crediting or other incentives, and would also appear to entail a low risk of international political tension. Transboundary impacts would also seem low unless it was applied at very large scale.

6.5.1.10 Air capture of CO_2 ("artificial trees")

Currently there appear to be no requirements in international law of specific interest for geoengineering by artificial trees. Although air capture installations could generally be regarded as carbon sinks, there is currently no indication of accepting them as sinks under the UNFCCC and KP regime and process. As a geoengineering technique, ocean liming is currently addressed only by the general guidance provided by the CBD decisions (see sections 5.1.2 and 0).

There is virtually no incentive at present for unilateral action that could cause international political tension or conflict. In addition, apart from the problem of storing the CO_2 after capture the impact and undesirable consequences on the environment in general and on the environment of other states is arguably very low.

6.5.1.11 Ocean fertilisation

Although the terms of reference of this study do not include ocean fertilisation in terms of developing regulatory options, the governance of ocean fertilisation under the LC/LP and CBD provides an important precedent and potential governance model.

In 2008 the LC/LP treaty bodies agreed that the scope of the LC/LP includes ocean fertilisation activities and that ocean fertilisation activities involve "dumping" within the meaning of the LC/LP and are subject to the permitting regime.[517] Although this could be regarded as a collective interpretation by parties of the LC/LP treaty text,[518] there seems to be a common understanding that the resolution is not binding.[519] In 2010, the Parties adopted resolution LC-LP.2(2010) on the "Assessment Framework for Scientific Research Involving Ocean Fertilization".[520] The LC/LP Assessment Framework is not legally binding in form or in wording, but it guides Parties as to how proposals they receive for ocean fertilisation research should be assessed. It provides criteria for an initial assessment of such proposals and detailed steps for completion of an environmental assessment, including risk management and monitoring.

Ocean fertilisation was also addressed by the United Nations General Assembly[521] and UNESCO's IOC, without, however, proving additional guidance or governance elements. The CBD has referred to and incorporated this and the LC/LP's work in its own decisions, which extended the application of the guidance beyond the smaller number of Parties to the London Convention

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[517] Resolution LC-LP.1 (2008), para. 1. For background and analysis cf. Freestone and Rayfuse (2008), Verlaan (2009), and Ginzky (2010).

[518] Article 31(3) of VCLT,

[519] Markus/Ginzky (2011) 480 Fn. 20.

[520] Resolution LC-LP.2 (2010) on the assessment framework for scientific research involving ocean fertilization, adopted on 14 October 2010.

[521] The UNGA merely recalled the outcome of the work by the LC/LP and the CBD, cf. U.N. GA Res. A/RES/62/215, U.N. GA Res. A/RES/63/111, para 115-116, U.N. GA Res. A/RES/64/71, para 132-133, U.N. GA Res. A/RES/65/37, para 149-152 (draft doc. A/65/L.20 adopted).

and London Protocol. The LC/LP Assessment Framework was incorporated by reference in CBD decisions on ocean fertilisation.[522]

In 2010, the LC/LP agreed to continue its work towards providing "a global, transparent and effective control and regulatory mechanism for ocean fertilisation activities and other activities that fall within the scope of the London Convention and London Protocol and have the potential to cause harm to the marine environment".[523] In its own view, the LC/LP "governing bodies have steadily moved towards developing a more binding regulation of ocean fertilization".[524] In 2012 a proposal was submitted containing a new LP article directed at regulating marine geo-engineering activities and two new annexes: one listing those marine geo-engineering activities that are regulated, with only ocean fertilisation listed so far, and another annex referring to a generic placement assessment framework for marine geo-engineering activities.[525]

The current, non-binding governance of ocean fertilisation and the amendment proposal under the LC/LP for a binding regime would by and large correspond to our proposed main governance elements: The elaborate framework and permit structure provides for a general prohibition[526] of ocean fertilisation (and other listed geoengineering activities under the amendment proposal) with the possibility for exempting legitimate research according to conditions and criteria also set forth in the framework.

The risk of unilateral action on ocean fertilisation could be high, as it has already materialised in the public controversy over the LOHAFEX experiment[527] and in an experiment in 2012 by a private actor off the Canadian coast.[528] However, it is a different question to what extent this risk remains if the LC/LP governance framework is implemented in more detail or becomes binding. The potential impacts of ocean fertilisation on the environment and human health are still largely unknown or ambivalent.[529]

6.5.1.12 Governance of research

There are several suggestions from outside international institutions on governance of research. For instance, scientists have drafted a set of five "high-level principles" that should

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[522] CBD COP decision IX/16 C; X/29 para 13(e) and 57-62; X/33 para 8(w)-(x).

[523] Resolution LC-LP.2(2010), para. 5; IMO (2010).

[524] Report of the 34th Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter , LC Doc LC 35/15 of 23 November 2012, para 4.3.

[525] Report of the 34th Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter , LC Doc LC 35/15 of 23 November 2012, para 4.5.

[526] Currently though the definition of "placement". By defining the scope of what it *outside* the scope of the LP, parties implicitly define what would be covered by it.

[527] Although this and other experiments were not designed for geoengineering purposes, Williamson et al (2012) 58.

[528] Report of the 34th Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter , LC Doc LC 35/15 of 23 November 2012, para 4.1-4.3 and annex 3; for media reaction to the experiment cf. also "World's biggest geoengineering experiment 'violates' UN rules, *The Guardian*, 15. October 2012, http://www.guardian.co.uk/environment/2012/oct/15/.

[529] Markus/Ginzky (2011) 478; Williamson et al (2012) 58-61.

guide and govern geoengineering research.[530] These five “Oxford principles” include geoengineering to be regulated as a public good, public participation in decision making, disclosure of geoengineering research and open publication of results, independent assessment of impacts and having in place clear governance arrangements before deployment. The principles are fairly general in the sense that their content is not (yet) geoengineering-specific as they could be proposed in relation to many potentially risky and controversial new technologies and concepts. They could reasonably apply to any research involving potential risks to the environment, and they partly overlap with the established legal rules in terms of transparency and participation. While they are intended to serve as a starting point for discussing how geoengineering research should be conducted,[531] they appear as yet inadequate to address the particular challenges presented here. For instance, the crucial question of which research activities should perhaps not be allowed appears to be not addressed or left to an undefined public interest and the requirement that the public be involved in determining it. The fifth principle, that governing arrangements be made clear prior to any actual use of the technologies, implicitly entrenches the distinction between research and “actual use” without a clear rationale for it. More generally, the Oxford Principles do not appear adequate for fulfilling the political aspects of governance necessary to achieve the objectives outlined above. The same goes for the five similar principles recommended as the outcome of the Asilomar conference in March 2010.[532] However, as a starting point for governance they demonstrate that the science community is aware of the wider implications and of the need to act responsibly within a political context. The Oxford principles are currently being developed further in a UK research project.[533] The Solar Radiation Management Governance Initiative (SRMGI)[534] has taken these ideas further and provided a more detailed assessment of governance needs for different research activities. The general approach taken by the SRMGI proposals is to identify in abstract categories of research that could require more or less stringent governance at the different governance levels. The recommendations so far do not represent consensus, but attempts to stake out the grounds of discussions so far. On this basis it identified little support for a ban on “indoors” research.[535]

Generally these initiatives have so far focused on more abstract principles and considerations without linking them to specific international governance design proposals.

[530] Rayner (2009); Rayner (2010) 13; http://geoengineering-governance-research.org/the-oxford-principles.php.

[531] The UK Parliament Committee Report endorsed the Oxford Principles as a starting point for developing future governance arrangements, while concluding that some aspects of the suggested five key principles needed further development, , House of Commons Science and Technology Committee (2010) 35.

[532] International Conference on Climate Intervention Technologies, Asilomar Conference Center, March 22-26, 2010, Pacific Grove, USA, http://www.climate.org/resources/climate-archives/conferences/asilomar.html.

[533] Geoengineering Governance Research - CGG, http://geoengineering-governance-research.org/.

[534] http://www.srmgi.org/.

[535] Workshop Ecologi Institute, Berlin, 5./6. November 2012.

6.5.1.13 Overview table

As a summary of this section, the following table provides a simplified overview of the assessment of current governance of geoengineering techniques:

Table 2: Overview: Assessment of current governance of geoengineering techniques

	Addressed by international governance?	In line with general normative approach?	risk of unilateral action raising political concern	Likelihood of serious transboundary impacts[536]
Sulfate aerosols in atmos.	CBD	very basically through CBD	high	high
Cloud brightening from ships	CBD	very basically through CBD	low-medium	medium-high
Desert reflectors	CBD	very basically through CBD	low	low537
Installations in outer space	CBD	very basically through CBD	low	high
Carbon capture and storage (CCS)	LC/LP partly OSPAR partly UNFCCC partly	partly	medium-high	medium
Ocean liming	CBD (potentially LC/LP)	very basically through CBD	low	low-medium
Ocean biomass storage	CBD (potentially LC/LP)	very basically through CBD	low-medium	low-medium
Biomass and biochar on land	CBD	very basically through CBD	low	low-medium
Enhanced weathering	CBD	very basically through CBD	low	low
Air capture of CO_2 ("artificial trees")	CBD	very basically through CBD	low	low
Ocean fertilisation	CBD LC/LP	yes	high	low-medium

Simplified summary overview

6.5.2 Gaps in the existing governance

From a normative perspective, there are some legal rules of international law that apply to all or some geoengineering techniques and might regulate them. However, the scope and effect of these rules depend on the potential environmental impact of the activity, which is currently difficult to assess or predict (see section 5). A key shortcoming of these rules for governance purposes is their lack of specificity and thus legal certainty, and their retroactive nature: They

[536] Acknowledging scientific uncertainty regarding the available knowledge.

[537] Higher if vegetation was changed at large scale.

are mainly suitable for being invoked after the geoengineering activity has taken place, but they are insufficient for providing guidance regarding procedures and safeguards in advance of a geoengineering activity - whether research or deployment. In addition, the customary rules are not embedded in an institutional structure that could provide a forum and procedures for agreement and decision-making.

There already are regimes that specifically address geoengineering, although there is no clear central structure (see above). In contrast, several regimes could address geoengineering or have briefly done so but do not appear active in governance terms. For instance, the Rio+20 outcome briefly mentioned only ocean fertilisation in a brief paragraph, but clearly made no governance effort.[538] Another example is the ENMOD Convention, the rules of which would apply to geoengineering only in armed conflict, and which has no institutional underpinning to provide guidance at present. The gap analysis therefore focuses on the few regimes that are active in this regard.

From a pragmatic point of view, political feasibility is an important aspect. This would have to take into account the extent to which existing structures are likely to continue to address geoengineering. In particular, it requires assessing to what exent the current and potential future work of the CBD and LC/LP are legally and factually occupying the field, and how this pre-determines the choice of fora and content. This section focuses on CBD and LC/LP since these seem to be the only institutions that have adopted relevant and specific regulation/rules. OSPAR has addressed some specific aspects of CCS in the ocean, but is regionally limited to a specific region and does not seem to be taking geoengineering issues further.

6.5.2.1 CBD decisions as overarching governance

With the explicit exclusion of CCS, the CBD's general decision X/33 of 2010 and the follow-up decision XI/20 in principle address *all* geoengineering techniques that fall within its broad definition - although the definition is a shortcoming. The CBD decisions are partially in line with our general normative approach: They explicitly pursue a precautionary approach and the text shows the intention to prohibit geoengineering activities in principle, subject to exceptions. The CBD also has broad participation with almost universal participation, which could help in avoiding unilateral action, although the US is not a party to the CBD. The CBD is also in line with our approach in that decision XI/20 emphasises that climate change should primarily be addressed through mitigation under the UNFCCC,[539] and in noting that governance should focus on activities that have the potential to cause significant transboundary harm.[540] It generally notes the difficulty of governing geoengineering, especially since current geoengineering approaches are not sufficiently effective, safe and affordable.[541]

However, there are also several shortcomings (see section 4): On the basis that the decisions are not binding as such, the chapeau's wording in para 8 of decision X/33 is weak and does not

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[538] "The future we want", UN GA Res. 66/288, para 167: "We stress our concern about the potential environmental impacts of ocean fertilization. In this regard, we recall the decisions related to ocean fertilization adopted by the relevant intergovernmental bodies, and resolve to continue addressing with utmost caution ocean fertilization, consistent with the precautionary approach".

[539] XI/20, para. 4.

[540] XI/20, para. 8.

[541] XI/20, para. 6

provide much normative or political weight. Further, the wording of para 8 in decision X/33 is ambiguous in places. The definition only includes large-scale activities and is too broad to adequately serve normative purposes on its own. The additional definitions in the follow-up decision confuse the issue rather than clarify. The exemptions regarding research activities are ambiguous in that they refer to the scale of the activity with weak additional guidance. Decision X/33 also introduces the new and potentially problematic concept of "justified" scientific research, leaving unclear whether it is meant to be different from the concept of "legitimate" research used in the CBD and LC/LP decisions on ocean fertilisation.[542]

The follow-up decision XI/20 of 2012 addresses these main shortcomings only in some minimal respect. It reaffirms decision X/33 but does not add normative content, except in noting that the precautionary approach and customary international law are an insufficient basis for regulation. In some respects the decision might be regarded as a step backwards in terms of clarity. While decision X/33 included a preliminary definition of geoengineering, the 2012 decision lists four possible options, including the previous preliminary definition of 2010, a definition provided by the expert groups, and two different IPCC definitions. The CBD does not express any preference for a definition.[543] The main normative gap remains that the unclear definition and wording do not provide adequate certainty which activities are intended to be restricted or allowed.

In other respects, the CBD has made small first steps towards providing an international forum for assessing and further developing scientific knowledge and guidance. Following the 2012 reports, CBD COP11 provided a mandate for distributing this information to other regimes, for updating the reports and for making available voluntary reporting by parties through the clearing-house mechanism.[544] The CBD also requests SBSTTA to consider the outcome of the IPCC Fifth Assessment Report.[545]

Regarding institutional design, the CBD has a permanent institutional structure with regular meetings for further developing guidance. Its structures and procedures are similar to most COPs under multilateral environmental treaties. There is a subsidiary body for providing technical input, while COP decisions are adopted in public by consensus of party delegates with political mandates. There have been concerns among scientists about the CBD process,[546] but these would seem to be based on a general uneasiness about translating scientific views into political negotiations and the political compromises decisions - which is perhaps regrettable but normal in the context of negotiating a specific COP decision under a major and large multilateral regime. Besides its general guidance, however, the CBD has not established or outlined procedures for dealing with geoengineering activities and left the implementation of its guidance to the parties.

Generally, the CBD has at least factually, to a small extent legally and to a larger extent politically occupied the field by providing general and overarching governance covering all geoengineering activities in principle. The nascent governance elements in the follow-up

[542] CBD COP decisions X/33, para 8(x) and X/29, para 59; cf. Royal Society (UK) (2009) 41.

[543] XI/20, para. 5

[544] XI/20, paras. 9 and 15

[545] XI/20, para. 14

[546] At the Workshop on International Governance of Geoengineering, Ecologic Institute, Berlin, 5-6 November 2012 - see the summary in Annex II.

decision XI/20 in 2012 indicate that the CBD seeks or is willing to play a central role. On the other hand, the CBD has relied heavily on the work done under the LC/LP, adding its own guidance while at the same time referring back to the LC/LP. Therefore the institutional set-up and the guidance are not fully clear and the place of the CBD in the international governance of geoengineering is not fully established. One ensuing question is whether the CBD is capable of further developing its governance, in particular of further differentiating between different geoengineering techniques, which might be necessary, depending on further developments.

6.5.2.2 LC/LP

In terms of substance, the LC/LP has factually and to a large extent politically occupied the field for ocean fertilisation governance:

The handling by the LC/LP of the 2012 ocean fertilisation experiment could be an indication that the governance framework in place avoids potential political conflict.[547] The assessment framework also appears to address potential environmental and health impacts as far as possible at this stage. It also incorporates a precautionary approach and seems to be without prejudice to climate policy. The framework addresses research through elaborate criteria for "legitimate research" that is exempt from the prohibition and the proposed amendments would allow for flexibility regarding different marine geoengineering techniques. The parties have also begun to address the need for science overviews on ocean fertilisation and consider developing a web-based repository of references relating to the application of the Assessment Framework, which the US supports.[548]

However, there are general and technical shortcomings: In terms of participation the LC/LP is a relatively small and specialised regime that does not include the US,[549] although it covers a significant part of global shipping.[550] The small number of parties may have contributed to what so far appears to be a largely science-driven approach. The proposed governance framework is flexible in that it could include other marine geoengineering techniques, although it remains to be seen to what extent the amendment proposals are adopted and enter into force. Even then, the LC/LP is generally limited to marine geoengineering techniques. Although the general normative approach under the LC/LP for ocean fertilisation is similar to our general normative approach of a general prohibition with exemptions, under the amendment proposal marine geoengineering activities would first have to be included in the list of restricted activities.

The fact that the LC/LP is a small and more technical regime under the UNCLOS might be a reason why its work does not appear to have attracted much publicity in the media and in the

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[547] Report of the 34th Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter , LC Doc LC 35/15 of 23 November 2012, para 4.1-4.3 and annex 3; for media reaction to the experiment cf. also "World's biggest geoengineering experiment 'violates' UN rules, *The Guardian*, 15. October 2012, http://www.guardian.co.uk/environment/2012/oct/15/.

[548] Report of the 34th Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter , LC Doc LC 35/15 of 23 November 2012, para 4.25-4.27

[549] There were 87 Parties to the London Convention and 42 Parties to the London Protocol as of 29 October November 2012. The US is party to the LC and has signed but not ratified the LP.

[550] The Parties represent about two thirds and one third, respectively, of global merchant shipping tonnage (IMO press briefing 50/2010, 20 October 2010).

eye of the general public. This might have been beneficial so far as it might have enabled focused and less politicised work, but this could change with growing interest in geoengineering. As a more technical matter in terms of transparency, ? it is difficult to find and access documents via the IMO.

6.5.3 Conclusions from gap analysis: Which geoengineering techniques should be subject to international governance?

The analysis above shows the current institutional and normative approach to be as follows: The main gaps are that certain techniques, in particular atmospheric SRM by aerosol injection, are not covered by governance and regulatory structures that are adequate according to our proposed main governance elements. Although it may be tempting to seek legal guidance from cross-cutting general rules and principles of international law, and to apply them to new issues such as geoengineering, there is a risk of imputing the desired normative content into such rules. Overburdening general rules in this manner could be detrimental to their acceptance and legal value.[551] In this respect the existing legal hooks do not carry the political weight of geoengineering.[552]

There is a central and almost global forum, the CBD, with provisional overarching governance ambition. There also are specific fora, mainly LC/LP and to some extent OSPAR, which within their mandate have extended their application to ocean fertilisation and ocean CCS. The central forum draws on the work in one of the specific fora. However, the institutional set-up and the guidance are not fully clear and the place of the CBD in the international governance of geoengineering is not fully established. The LC/LP is much advanced from a normative perspective, but it is a specialised and comparatively small regime with limited material scope. Although its work has been taken on by other regimes in the past, it is not clear to what extent this could continue. The overarching international governance structure is also weak in terms of providing or compiling scientific assessments, providing a common forum for keeping developments under review and discussing common approaches.

6.6 Options for filling the governance gaps

This section explores options for filling the normative and institutional governance gaps identified above. The suitability of existing institutional and normative elements for filling these gaps depends on the geoengineering technique in question and the governance objectives and criteria. Only a few institutions are viable options. On the basis of existing governance efforts, one key question is whether and to what extent the CBD and the LC/LP could realistically fill the remaining governance gaps, perhaps with the LC/LP as a sectoral and model regime within the emerging regime complex. We will also analyse other institutions such as the UNFCCC.

The weaknesses of the existing governance also pose the question whether *new* institutions could or should step in and assume governance functions. If new institutions appeared to be necessary, it would have to be analysed whether they should or would be able to have a central or complementary role. This could not only lead to competing institutions and forum shopping,

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[551] Bodle (2013) 464.

[552] Bodle (2010) 321.

but also to forum shifting, where a new institution de facto takes over functions from existing institutions.[553]

The existing and potential new regimes should be moulded into a coherent framework that fulfils the governance criteria effectively and efficiently. Particular aspects to be addressed include:

- institutional anchoring and co-ordination, in particular the degree to which governance should be embedded in institution(s), mandate and flexibility;
- relationship between policy level and science level;
- incentive for states to join the regime complex.

6.6.1 Options for overarching functions

6.6.1.1 Is there a need for an overarching institution addressing geoengineering?

It has been suggested that the main types of geoengineering, SRM and CDR, were so different that to formulate an overarching governance framework covering all geoengineering research and deployment was neither practicable nor desirable.[554] In contrast, some favor a centralised approach, with one institution or treaty, such as an additional protocol to the UNFCCC, addressing geoengineering.[555] Regarding a potential role of a central institution in the design of the governance regime complex for geoengineering, the basic general options are:

- A central institution fulfilling overarching functions.
- No (additional) overarching functions and central institution (bearing in mind that the CBD has already started providing initial elements of overarching geoengineering governance).
- Intermediate forms: One scenario could be incremental change through the CBD plus complementary institutions providing other governance functions. Such institutions could be (i) a new, small and flexible political forum providing impulses to existing fora; or (ii) e.g. more specialised expertise in sectoral fora such as oceans or atmosphere.

Some of the gaps identified above could suggest a need for one or more central institutions institution assuming at least some overarching governance functions. Useful overarching functions include:

- Expressing the general prohibition in principle combined with specific exemptions;
- Developing other general overarching principles;
- Providing a first-stop shop for relevant issues;

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[553] The International Renewable Energy Agency might be regarded as an example.

[554] House of Commons Science and Technology Committee (UK), *supra* note 18 at para 30.

[555] Barrett, *supra* note 16 at 10-11.; Karen N. Scott, *Marine Geo-engineering: A New Challenge for the Law of the Sea*, *in* 18th Annual Australia New Zealand Society of International Law (ANZSIL) Conference (2010), http://hdl.handle.net/10092/4878 ; Lin, *supra* note 14 at 18.

- Providing coherence and coordination of specialised and sectoral arrangements: How can the individual institutions and norms fit together in order to form a working institutional complex;
- Regular scientific and regulatory review.

It is important to stress that by "central" we mean overarching but not supervisory. The task would basically be to "manage" the institutional complex so that its different elements create synergy rather than conflict with each other. The CBD has already assumed some of these functions, but only to some extent. Whether new or existing institutions are used for geoengineering governance, or whether a central approach is preferred, there will be a need for coordination with other institutions. Establishing a new set or rules or pursuing geoengineering governance through a particular institution does not repeal or override the mandate of existing institutions. Other institutions could still address geoengineering in a different manner. States can act differently in different fora, depending e.g. on internal responsibilities, different balances of power or public interest.

However, the risks of fragmentation do not necessarily speak in favour of a completely centralised regime. There is empirical evidence suggesting that institutional fragmentation and interaction can produce synergies and improve governance.[556] In the case of ocean fertilisation governance, the interaction between the groundwork by the LC/LP, the CBD building on the LC/LP and the UN General Assembly recalling their outcomes could be regarded as an example of existing institutions coordinating their work and aiming at avoiding inconsistency.[557]

Yet generally, governance conflicts arising from differing objectives, membership or means of governance could arise and should be avoided as much as possible.[558] Lack of coordination or a deliberately decentralised framework could lead to a fragmented governance with potentially competing or conflicting rules, unclear legal status and different political weight or scientific underpinnings. While e.g. UNESCO seeks to serve as an "honest broker" in a global discussion of geoengineering,[559] there has been open dispute about which role UNESCO's IOC should have besides the LC/LP. At the IOC Assembly meeting in 2010, several member states suggested that there was no need to evaluate ocean fertilisation experiments and operations, because of the on-going work in other fora.[560] The US preferred that the legal aspects be exclusively dealt with by LC/LP and opposed IOC participation other than scientific and technical input[561] - which the IOC subsequently produced.[562]

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[556] Gehring and Oberthür (2006) 318-321.

[557] UNESCO Intergovernmental Oceanographic Commission (IOC), Report of the Twenty-fifth Session of the Assembly. Paris, 16–25 June 2009. UNESCO Doc. IOC-XXV/3 para 385-386, 395 (2009), http://ioc-unesco.org.

[558] Gehring and Oberthür (2006) 313.

[559] UNESCO, *Experts advocate geoengineering research programme- Summary of UNESCO expert meeting on 12 November 2011*, 9 A World of Science (UNESCO), 11 (2011).

[560] UNESCO Doc. IOC-XXV/3 para 142.

[561] UNESCO Intergovernmental Oceanographic Commission (IOC), Report of the Forty-third Session of the Executive Council. Paris, 8–16 June 2010. UNESCO Doc. IOC/EC-XLIII/3 para 155 and Annex IX p. 19 (2010), http://ioc-unesco.org. India and the UK also noted their position in this respect in the official report.

[562] DWR Wallace et al., Ocean Fertilization. A Scientific Summary for Policy Makers. IOC/UNESCO, Paris (IOC/BRO/2010/2) (2010), http://unesdoc.unesco.org/images/0019/001906/190674e.pdf.

Therefore the need for coordination with other treaties and institutions will remain. For example, the role of the UNFCCC would logically be to possibly provide incentives for certain technologies (e.g. through CDM under the KP or other market mechanisms), but this role should respect the general approach of the CBD or other central geoengineering institution.

6.6.1.2 Who could perform overarching functions?

Since there is a range of different geoengineering concepts with potentially wide-ranging but mostly unknown effects, several international environmental or scientific institutions with governance functions could arguably address geoengineering on the basis that it falls within their respective remit. Most existing multilateral environmental agreements have established permanent institutional structures with broad mandates to implement the treaty. Although none of these treaties were drafted with geoengineering in mind, parties are in principle free to agree on an interpretation of the treaty provisions, for instance, by clarifying its scope, the mandate of the COP, or by giving special meaning to terms.[563]

It has been argued that at present, no international treaties or institutions exist with a sufficient mandate to regulate the full spectrum of possible geoengineering activities.[564] However, some of the existing rules[565] and institutions could encompass the full range of geoengineering concepts. For instance, as for institutions there is no reason why the mandate of UNEP, for example, should not cover all geoengineering concepts currently discussed. Whether the means and instruments at the disposal of these institutions and regimes are regarded as adequate or sufficient is of course a different matter. So far only the CBD has already explicitly addressed the full range of geoengineering from a governance perspective, provided that it affects biodiversity. From a global perspective, the different existing regimes and institutions that could address geoengineering have different legal and political weight, depending on various factors such as their respective levels of participation.

The following analysis focuses mostly on institutions that have been active in some form or other in geoengineering, and it excludes many non-active institutions as clearly unsuitable for overarching governance (e.g. the regime on outer space).

CBD

The CBD appears willing to assume a central role in the governance of geoengineering and has already adopted initial steps in this regard. The CBD fulfils some functions of our proposed governance elements at least to some extent (see gap analysis above).

Pursuing this role is not outside the CBD's mandate. The decisions were adopted by consensus within the framework of a treaty with near universal participation. At least politically this has made redundant potential concerns about whether the CBD's mandate actually covers all geoengineering techniques.[566] Legally, the decisions could be regarded as an implicit interpretation of the mandate by parties. Besides, it is difficult to conceive of geoengineering

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[563] Article 31(3(a), (b) and (4) of the VCLT.

[564] Lattanzio and Barbour (2010) 3; Barrett (2008).

[565] Cf. chapter 3.

[566] Concerns were raised at the Workshop on International Governance of Geoengineering, Ecologic Institute, Berlin, 5-6 November 2012 - see the summary in Annex II.

activities within CBD's definition that may not at least potentially affect biodiversity and thus not fall within one of the CBD's objectives, i.e. the conservation of biodiversity.

Apart from the shortcomings of the actual decisions on geoengineering analysed above (see sections 5.1.2 and 0), there are more general points that might argue against the CBD and which might be trade-offs to consider. One is that the US is not a party.

There are also concerns about scientific views being absorbed in CBD's political process, as well as concerns that the CBD may be an ineffective "talking shop". To some extent these concerns appear to be rooted in the normal process within a big multilateral regime with a very broad mandate (see above). In addition, the overarching functions we propose do not necessarily require a more solid and effective regime. By adopting the decisions on geoengineering the CBD may have already demonstrated that compared to other comparably large regimes is sufficiently flexible and pragmatic, e.g. in starting a process, inviting experts and providing basic guidance on an emerging specific issue.

Another question relates to how the overarching institution could relate to the other institutions (a) that are already involved in geoengineering governance and (b) that could become involved in future. Like the other overarching institutions, the CBD started by addressing ocean fertilisation, and drawing on work and expertise from specialised regimes such as the LC/LP. For the CBD as a central geoengineering governance institution, there is a governance gap in respect of formalising its link to other institutions in the field and clarifying the CBD's role, e.g. for sharing research results. The current pragmatic approach and informal links are likely to work only as long as geoengineering stays at relatively low level politically.

In respect of the climate context, the CBD's governance is on the face of it without prejudice to climate policy. However, the logic underpinning the CBD is different from the climate regime under the UNFCCC: Protecting biodiversity is different from reducing emissions and adapting to climate change (see above). These different paradigms could eventually lead to regime conflicts. In other areas, such as the Nagoya Protocol on ABS, the CBD regime adopted an approach whereby the CBD instrument stated that other institutions who are involved or want to be involved in governing this area should respect the CBD framework.[567] Adopting this approach for geoengineering governance would require careful consideration due to its potential for entrenching rather than mitigating or resolving regime conflicts.

In the emerging regime complex, the CBD is the only institution that has addressed geoengineering in general and provided overarching political guidance. There is also a mandate for the CBD bodies to do further work on the basis of the existing guidance. However, the CBD debate has been politicised to some degree and its intention about its future direction is not clear. It is also not clear whether there will be political impetus to actively develop further the guidance in a normative manner. The CBD has outlined further work on geoengineering governance but also acknowledged that regulatory mechanisms may not be best placed under it. It remains to be seen whether the shortcomings are outweighed by the advantage of having taken the initiative and having recourse to a strong institutional backbone including a scientific and a political level.[568]

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[567] Cf. Article 4.1-4.3 of the Nagoya Protocol.

[568] CBD decision X/33, para 9 (l)-(m); see also decisions X/29, para 57-62, X/13, para 4.

Climate regime - UNFCCC / KP

The climate regime seems to be an obvious candidate for addressing geoengineering. Apart from its mandate to address climate change, the regime has a strong institutional structure and a scientific underpinning linked to the work of the IPCC, which is providing scientific work on geoengineering in AR5 due in 2014. In addition, the US are party to the UNFCCC (albeit not to the KP). Accordingly, there have been suggestions outside the climate negotiations to address geoengineering under the UNFCCC, for instance by a new protocol. However, the UNFCCC and Kyoto Protocol have not addressed geoengineering concepts or governance. There were but few instances where geoengineering was mentioned in a marginal manner:[569] At one point the Executive Secretary of the UNFCCC warned that carbon dioxide removal techniques might have to be developed due to the slow process of the negotiations. A planned Joint IPCC Expert Meeting of several Working Groups on geoengineering sparked a submission by Bolivia to the UNFCCC demanding that the meeting's agenda be changed so as not to consider it as an "option within the portfolio of mitigation options".[570] Geoengineering was also included in a 2012 submission by the group of least developed countries containing a list of themes to be addressed at the regular research dialogue. However, the UNFCCC/KP still is the central regime for international climate policy and we address it as a potential central institution for geoengineering governance.

The climate regime -currently most likely the UNFCCC, potentially a new agreement adopted in 2015- would introduce a logic to geoengineering governance that is different from the current approach under the CBD and specialised regimes. The UNFCCC's focus is on maximising effectiveness against climate change, combined with some environmental and other safeguards. The UNFCCC logic would be to focus on creating incentives for maximising CO_2 sinks, as it does with forests and recently CCS. It is also highly likely to seek to combine this approach with market mechanisms and some environmental safeguards, as it does with the CDM and the currently developed so-called new market mechanisms. In addition, under the logic of the climate regime states would seek to obtain credits for doing geoengineering, e.g. by defining accounting rules that quantify geoengineering activities as sinks. This pragmatic and specific approach could appear more attractive than the different logic underpinning the CBD, and states might be more comfortable with using the UNFCCC's institutional setup:

One possible scenario is that geoengineering would evolve not towards actual global deployment, but, for instance under the UNFCCC logic, towards being just another set of possible ways to address climate change. In this perspective, the UNFCCC logic could have the long-term positive effect of taking the political edge out of some aspects. The participation of the US would be an important additional factor. However, it remains doubtful whether the UNFCCC is also suitable for providing *overarching central* governance of geoengineering, as it is based on and deeply rooted in the mitigation and adaptation distinction. While the CDR techniques may fit into the category of sinks, SRM does not fit easily into these categories. The difficulty of fitting the key geoengineering techniques that most necessitate governance into the mitigation or adaptation structure of the climate regime could be an argument for keeping central and overarching geoengineering governance out of the climate regime. However, if and when crediting for geoengineering becomes a technical and political possibility, it could to this extent be addressed by flexible mechanisms under the KP or other crediting mechanisms

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[569] On these instance see Bodle (2013) 466.

[570] Bolivian Submission to Joint Workshop of Experts on Geoengineering", para 15; available at http:// unfccc.int.

under the UNFCCC or potential 2015 agreement, even if geoengineering is otherwise addressed elsewhere by a different instrument or institution.

There are also good reasons why the climate regime should continue to focus on its already highly complex body of rules and on-going negotiations on a future regime. At this stage all options for introducing geoengineering could seriously jeopardize the current climate negotiations and make geoengineering part of the trade-offs that are part of them. This could politicise geoengineering more than in the CBD, where it so far has not been made part of the bigger political packages.

Irrespective of the institutional governance structure, politically geoengineering is not separable from climate policy and the climate regime. If other fora begin or continue to address geoengineering, the need for co-ordination and consistency with climate objectives and law should be assessed. It could be that the existing formal and informal channels between the treaty regimes and international fora involved are sufficient.

UNEP

UNEP is a further potential forum and actor for future geoengineering governance. It could come into play as an alternative or complementary to the CBD, and for overarching or specific geoengineering governance.

Since 1972 UNEP has served as the central UN body in the field of the environment with a mandate to "promote international co-operation in the field of the environment and to recommend, as appropriate, policies to this end".[571] Although UNEP has been an important player in catalyzing the negotiation of international agreements, its work has been hampered by a number of factors, including its broad mandate[572], its status as a subsidiary programme (as opposed to e.g. a specialised agency) and its limited resources.[573]

In the course of the debates over recent years on improving UNEP's organisational structure, two major options for institutional reform evolved: either upgrade UNEP to a UN specialised agency[574] or to strengthen UNEP *within* its legal status as a subsidiary programme. The outcome document of the Rio+20 Earth summit in 2012 followed the latter option: It invites the UNGA at its 67th session to "strengthen and upgrade" UNEP by *inter alia* establishing universal membership of the Governing Council,[575] providing for more secure funding, and strengthening engagement in key UN coordination bodies, the science-policy interface, information sharing, capacity building and technology access, participation of stakeholders.[576] In December 2012 the UNGA did establish universal membership and requested the Governing

[571] UN GA resolution 2997 (XVII), 15 December 1972

[572] von Moltke (2001) argued that UNEP was given an impossible mandate.

[573] For example, UNEP receives only a small contribution from the UN Regular Budget, accounting for less that 4% of UNEP financial resources. Apart from that, UNEP relies entirely on voluntary contributions, through the Environment Fund or in the form of earmarked funding for specific programme activities. These contributions are however highly variable. The total annual budget for 2012 was USD 239 million, UNEP Annual Report 2012, p. 113.

[574] See Article 57 and 63 UN Charter.

[575] The UNEP GC was originally composed of 58 member states representing the five UN regions.

[576] UN Doc. A/CONF.216/L.1, "The future we want", para 88.

Council to initiate the implementation of reforms proposed in the Rio+20 outcome document and to decide on future arrangements for the envisaged Global Ministerial Environment Forum.[577] The first session of the newly structured Governing Council was held in February 2013 and decided, inter alia, that future meetings will conclude with a high-level segment which is to provide strategic guidance, and that an open-ended Committee of Permanent Representatives is to function as an intersessional body. Furthermore, the Governing Council undertakes to ensure stakeholder participation and to promote a strong science-policy interface.[578] The Governing Council also agreed on its rules of procedure[579] and recommended that it be renamed "United Nations Environment Assembly".

Despite restraints that significantly hampered the fulfilment of its objectives,[580] UNEP has played a significant normative role in catalyzing the negotiations of multilateral environmental agreements and in developing soft law instruments. Based on sequential ten-year Montevideo Programmes on Environmental Law, UNEP undertook the initiative to negotiate some of the most important instruments of international environmental law.[581] Its flagship project is the Regional Seas Programme which was launched in 1974 and has resulted in more than 30 regional conventions and protocols addressing the sustainable management and use of the marine and coastal environment.[582] UNEP also contributed significantly to the negotiation of the Ozone Convention and the Montreal Protocol, the CBD, CITES, the Convention on the Conservation of Migratory Species of Wild Animals, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, the Rotterdam Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, and the Stockholm Convention on Persistent Organic Pollutants.[583] For a number of these conventions, UNEP is carrying out secretariat functions. More recently, negotiations on an international agreement on mercury were initiated by UNEP in 2009[584] and completed under its auspices in January 2013. With regard to soft law instruments, UNEP has developed a number of guidelines and principles of conduct on environmental law. For example, a joint working group of UNEP and WMO prepared the 1980 Guidelines for National Legislation concerning Weather Modification,[585] which might provide impulses for future

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[577] UNGA Res. 67/213.

[578] UNEP GC, Draft decision prepared by the working group on institutional arrangements and rules of procedure, UNEP/GC.27/L.6. The officially adopted versions were not available at the time of writing.

[579] UNEP GC, Draft decision prepared by the working group on institutional arrangements and rules of procedure, UNEP/GC.27/L.5.

[580] Bauer (2007), notably limited autonomy and budget constraints.

[581] Timoshenko (1994) 17; Petsonk (1990).

[582] UNEP, Regional Seas Conventions. Online avaialble: http://www.unep.org/regionalseas/programmes/conventions/default.asp

[583] Sands (2003) 83; Bauer (2007).

[584] UNEP GC Decision 25/5 of 20 February 2009.

[585] UNEP GC Decision 8/7/A of 29 April 1980.

geoengineering governance. Many of the UNEPs guidelines and principles have influenced the outcome of the negotiations on legally binding agreements.[586]

As a potential forum for the regulation of geoengineering, UNEP has demonstrated its ability to identify environmental challenges at an early stage and to promote the development of international instruments. UNEP has the capacity to set the agenda, to provide scientific and legal input and to open a forum for negotiations. Many of the UNEPs initiatives for the negotiation of international environmental agreements have proven successful. More specifically, UNEP has addressed issues that are related to geoengineering, such as the 1980 Guidelines on Weather Modification, and the Ozone Convention and Montreal Protocol.

Despite this track record, given its background and the very recent beginning of institutional reform, questions remain as to UNEP's ability and political weight regarding governance and normative functions in respect of geoengineering. While it is an option for overarching guidance, there is a risk that it will be unable to perform this function adequately, because it is slowed down by the need to implement its institutional reform, because it might be hesitant to touch this controversial topic, and because it might not have mustered sufficient political weight despite its reforms. Moreover, regime conflicts would have to be resolved as the CBD decisions are likely to remain in place and it is unclear whether UNEP activity would lead CBD to self-restraint.

UN General Assembly

The UN General Assembly has addressed geoengineering but so far it merely reiterated work under the LC/LP and the CBD.[587]

On paper, the UNGA has high political legitimacy, which might be the added value provided by reiterating the work under the CBD and LC/LP. A simple majority is generally sufficient to adopt resolutions, which could be an advantage compared to the largely consensus-based procedures under the other relevant treaty regimes. On this basis the UNGA could define main governance pillars, e.g. a clear mandate for CBD to provide overarching guidance. However, resolutions adopted against some states risk dividing the international community on this issue.

Generally, the UNGA does not seem fit for governance of a science-driven issue: The UNGA has many issues to deal with and is over-politicised. Previous examples of the UNGA more or less successfully engaging in specific governance are quite long ago, for instance the normative work in space law and the New International Economic Order, which however were not science-driven and not successful in providing institutional structures for follow-up.

UNCLOS and IMO

The UNCLOS regime has potential normative value, but does not have a institutional setup with permanent bodies and regular meetings similar to a COP under other regimes. Instead, UNCLOS delegates implementation to the competent international organisations such as IMO,

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[586] Cf. the 1985 Montreal Guidelines for the Protection of the Marine Environment Against Pollution from Land-based Sources, UNEP/WG.120/3-; the 1989 London guidelines for exchange of information on chemicals in international trade, UNEP GC Decision 15/30 of 25 May 1989; the 1987 Cairo Guidelines and Principles for the Environmentally Sound Management of Hazardous Wastes, UNEP GC Decision 14/30 of 17 June 1987.

[587] See UN GA Res. 62/215, para. 97–98, 14 March 2008; Res. 63/111, paras. 115–116, 12 February

2009; Res. 64/71, paras. 132–133, 12 March 2010; Res. 65/37, para. 149, 17 March 2011

or general diplomatic conference, and is without prejudice to specialised regimes such as LC/LP. The main normative and regulatory work regarding ocean fertilisation has been carried out by the specialised regime of LC/LP. In addition, UNCLOS is limited to marine issues and it would be difficult to see SRM governance being anchored under it. The same goes for IMO, which has considerable normative experience, albeit with a more technical focus. Both UNCLOS and IMO are unsuitable candidates for overarching geoengineering governance.

UNESCO's Intergovernmental Oceanographic Commission (IOC)

UNESCO's Intergovernmental Oceanographic Commission (IOC) is one of the four UN institutions working on geoengineering.[588] Established in 1960, its mandate is to promote international cooperation in marine research and to further develop ocean governance. Increasing the understanding of the ocean's role in climate mitigation and adaptation is currently listed as one of the IOC's high-level objectives.[589] With the exception of a short policy brief on geoengineering in general,[590] the IOC has so far mainly considered the implications and regulation of ocean fertilisation, stressing the importance of the precautionary principle.[591] Following the ocean fertilisation experiment by a private actor off the Canadian coast in 2012, it issued a statement that only legitimate research in accordance with the LC/LP should be allowed.[592]

Generally the IOC is a scientific body that in respect of governance has mainly referred to the LC/LP's work. Its mandate is limited to marine issues and its future direction in respect of geoengineering is unclear. It deferred consideration of the legal aspects of ocean fertilisation since the future of the responsible body, the IOC Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), was still to be decided.[593] While in 2012, the Executive Council decided that the body will continue its work, no decision was taken on the consideration of the issue.[594] Due to its unclear and in any event limited mandate, and lack of political weight, IOC is not s suitable forum for to perform overarching governance functions.

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[588] Next to CBD, LC/LP and UNCLOS.

[589] IOC Resolution EC-XXXIX, IOC DRAFT MEDIUM-TERM STRATEGY (2008–2013), Thirty-ninth Session of the Executive Council,Paris, 21–28 June 2006.

[590] Based on a workshop in November 2010 organised by the IOC and other UNESCO divisions , UNESCO-SCOPE-UNEP (2011): Engineering the climate. Research questions and policy implications. UNESCO-SCOPE-UNEP Policy Briefs Series. November 2011.

[591] Wallace et al (2010).; IOC 25th Assembly 2009, IOC 43rd Executive Council in 2010, IOC 26th Assembly in 2011.

[592] Statement by the Intergovernmental Oceanographic Commission of UNESCO regarding Ocean Fertilization, UNESCO, 19 October 2012. Online available: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/IOC_statement_Ocean_fertilization.pdf

[593] IOC, Report of the Twenty-sixth Session of the Assembly Paris, 21 June–5 July 2011, UNESCO, IOC-XXVI/3. Para. 112.

[594] IOC Executive Council, Decision EC-XLV/Dec.4.3, Review of the IOC Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS). Forty-fifth Session of the Executive Council Paris, 26–28 June 2012.

IPCC

The IPCC is a body for scientific assessment and currently working on geoengineering for its forthcoming fifth Assessment Report (AR5).[595] Besides the potential effects of geoengineering, the mandate includes the possible role, options, risks, and status of geoengineering as a response option. The IPCC's scientific input is likely to be influential in the international policy debate and negotiations, and its institutional setup could be a model for providing science input for geoengineering where there is a lack of such input. However, the mandate, institutional setup and procedures are geared towards generating a basis for subsequent policy decisions rather than making them. The IPCC is unsuitable for providing governance in a normative, regulatory or political sense.

LC/LP and OSPAR

Although in terms of content the work under the LC/LP is elaborate and corresponds to many of our proposed main governance elements, the regime is too limited in spatial and material scope to provide overarching governance functions for geoengineering. Participation in the London Convention and London Protocol is also not comparable to the CBD or the UNFCCC, for instance, in terms of number of Parties. The same reasons apply to OSPAR. However, LC/LP might serve as a specialised regime within the geoengineering regime complex, and perhaps spearhead governance models in the marine sector (see section 6.6.2).

WMO

WMO mandate is to promote international cooperation in weather, climate, hydrology and water resources and related environmental issues.[596] It has experience relevant to geoengineering through its long-standing work on weather modification. WMO has been undertaking research on weather modification since the 1950s and specifically aims at encouraging research projects.[597] In 2006, it established an Expert Team on Weather Modification Research (ET-WRM) to promote scientific practices in weather modification research. The ET-WRM meets annually and observes relevant research and reviews regularly the WMO Statement on Weather Modification and the WMO Guidelines for the Planning of Weather Modification.[598] Additionally, every four years a scientific conference on weather modification is organised.[599] The WMO also holds a registry of weather modification activities.

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[595] IPCC, "Scope, Content and Process for the Preparation of the Synthesis Report (SYR) of the IPCC Fifth Assessment Report (AR5)", IPCC-XXXII/Doc. 4 (2010), at 3, available at http://www.ipcc.ch/meetings/session32/syr_final_scoping_document.pdf. Previous IPCC reports briefly mentioned geoengineering, see Williamson et al (2012) 21 fn 15.

[596] 1947 Convention of the World Meteorological Organization (WMO Convention)

[597] WMO Weather Modification Statement and Guidelines (last updated at ET meeting March 2010), para1.1, www.wmo.int.

[598] WMO Weather Modification Statement and Guidelines (last updated at ET meeting March 2010).

[599] At its 2011 meeting, the ET-WRM notes serious funding problems and welcomed a proposel by UAE to establish an International Center for Weather Modification Research which would inter alia sponsor the ET-WRM meeting and the quadrennial scientific conferences.

However, in 2011 only eight countries had responded to the questionnaires sent out for the 2008-2010 period.[600]

The WMO activities amount to basic elements of international governance regarding weather modification, coming from within a science organisation: regular assessment of current scientific knowledge guidelines on research, guidelines on how to conduct research. These basic elements could be relevant input for SRM, in particular aerosol injection, which is conceptually similar to common weather modification techniques.

However, the WMO notes that although weather modification is still an emerging technology, since the 1980s there has been a decline in support for weather modification research, and a tendency to move directly into operational projects.[601] More generally, the weather modification statement and guidelines are quite general and in their current form unlikely to be a suitable model for SRM.

While there are tentative beginnings of considering geoengineering as part of weather modification, the future direction of WMO is not clear. The WMO Congress, the supreme governing body of WMO, mandated ET-WRM to consider geoengineering in its work.[602] In turn, ET-WRM encouraged the WMO to state a position on geoengineering, but also noted that geoengineering in its totality was not part of the mandate of the ET-WRM and should not be part of the Weather Modification Statement.[603] However, the ET-WRM group is too small and scientifically specialised to address the broader political and governance questions regarding geoengineering in general or SRM in particular. The WMO in general, while being an option for providing scientific input, does not have the political weight and regulatory experience that are likely to be required for performing overarching governance functions regarding atmospheric SRM or geoengineering in general.

A new institution

Overarching governance functions could also be performed by a new institution that is especially designed for this purpose. However, there is no blueprint for an ideal international institution and setting up a new institution from scratch always involves a degree of unpredictability. Although existing governance frameworks might provide ideas on how particular functions could be designed by geoengineering governance, even partial analogues might be misleading. Structures and elements that function well for other institutions and settings might not work in a new framework and for the functions to be performed.

A key consideration in this option is assessing the likelihood that states would agree on a new institution in this field. Setting up a new institution with functions at the international level is usually a major political effort requiring political buy-in. What reasons would make it attractive

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[600] Meeting of the CAS Expert team on Weather Modification Research (ET-WMR) Report, 7 October 2011, Bali. Online available: http://saive.com/WXMOD/2011_MEETING_OF_THE_CAS_EXPERT_TEAM_ON_WEATHER.pdf

[601] WMO Weather Modification Statement and Guidelines (last updated at ET meeting March 2010), para1.3.

[602] **WMO Congress** 2011, Report, para 2.5.38, WMO Doc 1077, Document Cg-XVI/Doc. 3.3, REV. 1, APPENDIX A, 127**.**

[603] The ET-WRM also consideres preparing a paper on "Lessons Learned In Weather Modification Relevant to the Climate Change Geo-Engineering Debate", Meeting of the CAS Expert team on Weather Modification Research (ET-WMR) Report, 7 October 2011, Bali. Online available: http://saive.com/WXMOD/2011_MEETING_OF_THE_CAS_EXPERT_TEAM_ON_WEATHER.pdf

to make the effort and join a new geoengineering governance institution, in particular in the light of existing governance? One reason could be that avoiding the shortcomings of and gaps in the existing overarching governance, notably the CBD, outweighs the political effort and risk involved in setting up a new institution. A new institution's clear mandate for and focus on geoengineering, combined with flexibility and a light touch approach to governance, could be attractive compared to the complexity of the CBD regime and other potential candidates. On the other hand, a purely light touch approach could lead to a merely administrative body lacking the necessary political weight. In addition, a single focus on geoengineering could perhaps make this issue too prominent for some states. Besides these considerations, we do at this stage not see compelling reasons why states would prefer to create and join a new institution.

In any event, if a new overarching institution were to be created, it would have to be considered how it should relate to the other institutions (a) that are already involved and (b) that could become involved in geoengineering governance. This would primarily include the design of the relationship with the CBD in addition to other institutions.

6.6.1.3 Conclusion

There are good reasons for overarching governance functions to be performed. There is a risk of governance conflicts arising from differing objectives, membership or means of governance. The overarching governance functions should manage the emerging institutional complex in this regard, although they do not necessitate a completely centralised regime. The CBD has already assumed some of these functions, but only to some extent.

If there is to be an overarching institution performing overarching governance functions addressing geoengineering, we see the following main options:

- a new institution or
- the CBD.

The main advantage of using existing institutions such as the CBD is institutional economy: saving time and political energy against setting up new ones, and making use of their political standing, experience and expertise. A potential disadvantage is that the limitations and shortcomings also apply to geoengineering governance from the outset. For instance, a mainly scientific body might not have the necessary political experience or standing and vice versa. A new function such as geoengineering governance could also disrupt or overburden an otherwise functioning treaty regime. Geoengineering might become sidelined or taken hostage in the negotiations on other issues within that institution.

Other institutions with mandates for potential overarching governance, such as the UNGA, UNEP or the UNFCCC, have so far provided no guidance or merely recalled guidance by other regimes on specific geoengineering techniques. However, while the UNFCCC has important drawbacks, the trade-off underlying the assessment of the UNFCCC, in particular viv-a-vis the CBD, is a difficult one. The advantages of the UNFCCC are not easily outweighed, and institutional economy on its own might not be reason enough to choose the CBD, unless there is also confidence that the governance provided by the CBD is implemented and effective. UNEP might be a second-best solution for overarching governance, as it is the only relevant overarching international environmental institution and might assume a strengthened role in the course of its current reform.

Whether new or existing institutions are used for geoengineering governance, or whether a central approach is preferred, there will be a need for coordination with other institutions. For

better or worse, any forum chosen for geoengineering governance will have to take into account the existing work of the CBD and the LC/LP. Other regimes could be fitted into the regime complex e.g. by reporting to the CBD. The CBD has made a first start in its 2012 decision on geoengineering by "inviting" parties to report the implementation of its previous guidance and requesting the Secretariat to make this information available through the clearing house mechanism.

There is no governance design that guarantees that regime conflicts will be completely avoided. Effective coordination with other institutions and consistency can be formally prescribed only to a limited extent, although it can evolve dynamically from within the institutions. A key objective particularly in a governance structure that includes a central institution should be broad participation including at least the key actors and potential geoengineering states, and also those that may be affected. The risk of rivalry or conflicts can also be reduced by ensuring that political decisions are taken on the basis of a broadly shared scientific input, e.g. from other institutions.

6.6.2 Options for addressing in more detail the gaps for specific geoengineering techniques

We identified in particular atmospheric SRM by aerosol injection as the main governance gap, as it is not covered by governance and regulatory structures that are adequate according to our proposed main governance elements. Which institution could address in more detail the gaps for atmospheric SRM?

The CBD could be considered as an option because is has to some extent started to occupy the field of overarching governance. Its mandate would cover atmospheric SRM, unless it is argued that such SRM would not have potential impacts on biodiversity and its conservation.[604] The CBD also fulfils some functions of our proposed governance elements at least to some extent (see above). However, the reasons that speak in favour of the CBD performing overarching governance functions do not necessarily apply to specialised governance of atmospheric SRM. For instance, while the scientific input generated within the CBD and the wide spectrum of tasks could be sufficient for providing overarching governance functions for geoengineering, it might be more difficult for the CBD to feed in the more specialised knowledge and agree on measures for a particular geoengineering technique. In the case of ocean fertilisation, the CBD basically followed the lead by the LC/LP. Despite these caveats, in view of the current governance gap for SRM activities, the CBD may also be the most appropriate forum for pursuing more concrete governance arrangements.

Similar considerations as for the CBD apply to the UNFCCC. In addition, from past experience it is difficult to imagine the UNFCCC performing governance of a particular activity in the sense of establishing permitting requirements etc. If the UNFCCC addressed atmospheric SRM, under its current design and logic it would most likely be as a crediting issue. On its own this would not be adequate in meeting the governance challenges posed by atmospheric SRM and in performing the governance elements outlined above.

The ozone regime, i.e. the 1985 Ozone Convention and the 1987 Montreal Protocol, could be considered, as it is a regime specialised on protecting the ozone layer and the injection of H_2S and SO_2 into the stratosphere could result, at least seasonally and regionally, in increased ozone

[604] A problem with this argument is that, consequently, it would mean that the existing CBD decisions on geoengineering governance were adopted ultra vires.

depletion (see section 5 on the existing framework). Both treaties have almost universal participation including all states considered relevant for geoengineering. However, the scientific knowledge of the impacts of atmospheric SRM on the ozone layer is incomplete, in particular of substances other than sulphur. Although the Ozone Convention's mandate would allow it to establish further knowledge and provide guidance, it may be unusual for this general framework convention structure to do so, given the limited role it has so far played regarding specific activities.[605] The Montreal Protocol is the instrument with specific obligations regarding ozone-depleting substances and is widely acknowledged as one of the most successful multilateral environmental agreements. Potential problems regarding the scope of these instruments could probably be addressed to some extent by interpretative action of the parties, similar to the LC/LP. However, this would probably not be possible in respect of SRM techniques that do not affect the ozone layer, i.e. presumably not for space installations and perhaps not for cloud brightening. In addition, previous attempts to broaden the interpretation of the mandate of the Montreal Protocol in respect of certain substances politicised that issue, which is an important risk if tried for geoengineering. On this basis, the ozone regime is not from the outset a more promising option, as its suitability depends on improved knowledge of the effects of atmospheric SRM on the ozone layer, and also on the political risk described above.

The recently amended LRTAP regime could be a further alternative, as its more technical approach to air pollution, developed over time through specialised and updated protocols, could be regarded as a successful governance example (see section 5). On the other hand, the LRTAP regime is only a regional regime complex for the UNECE region, the most recent protocol of which includes only about 25 parties and which excludes states such as India or China. A further point of caution is that governing atmospheric geoengineering might risk overburdening the LRTAP regime, although the opposite argument might be made that a small specialised regime could facilitate governance development. Bearing these caveats in mind, regional action under the LRTAP regime could complement or perhaps even spearhead global governance efforts.

The WMO has a broad mandate in respect of the atmosphere, but does not seem appropriate for the same reasons outlined above in respect of overarching governance functions, mainly the lack or normative experience and political weight.

As outlined above for overarching governance functions, UNEP could also be considered. Launching a process under UNEP on atmospheric SRM may be a second-best alternative at the international level and might avoid some of the shortcomings and risks of the CBD. While some of UNEP's shortcomings in respect of overarching governance functions also apply to specific governance of atmospheric SRM, they may be less significant for filling a specific governance void, or be overcome e.g. by linking UNEP with in ad-hoc governance (see next paragraph).

For a new institution, the same considerations apply as above in respect of overarching governance functions. Given the concerns and disadvantages regarding the existing institutions, and the risks in setting up an entirely new institution, ad-hoc governance is also an option to be explored for governance of atmospheric geoengineering. International climate policy has seen the establishment of several loosely-knit initiatives in recent years, such as the

[605] Bodle et al (2012) 129.

Climate and Clean Air Coalition.[606] These political fora seek progress on specific issues more or less outside and in parallel to the existing treaty regimes and formal negotiations. This type of ad-hoc governance could be explored as an alternative for atmospheric SRM if existing fora such as UNEP by themselves turn out to be not viable for governance functions.[607]

6.6.3 Options for special scientific/technological tasks, e.g. coordination of research:

As international (and national) governance of geoengineering advances, demand for international scientific and technological assessments is likely to grow. In particular, demand for regular assessments may arise in respect of the creation and development of geoengineering techniques.

It is useful to distinguish between different types and functions of scientific assessments and input:

a) The general current state of knowledge on geoengineering and its risks: This does not need to be specifically prescribed or regulated as part of international governance. There are several research programmes as well as overview reports such as the CBD study.[608] The IPCC will also address geoengineering in its Fifth Assessment Report (see above).

b) Specific scientific input as part of the international governance framework, e.g. in order to update or amend general guidance or rules: The main active institutions so far, the CBD and the LC/LP, have prepared their political decisions on scientific input coming from subsidiary bodies within its regime. As this function underpins other governance functions, e.g. in order to update or amend general guidance or rules, it is crucial that it is separate from political decision-making, in order to maintain scientific credibility and political legitimacy and responsibility.

c) Input to specific individual decisions such as permits: It does not currently seem necessary that the *international* level provides more than general guidance as to the conditions under which the *national* level should allow for exemptions from the general prohibition. There is no need for international governance to provide input to individual permit decisions. This might change if experiments become larger in scale or potential impact.

Some treaty regimes such as the UNFCCC, CBD and LC/LP organise and produce their own scientific input and have an institutional backbone with scientific sub-bodies preparing the decisions of the political bodies such as the COP. Alternatively, the function of coordinating science and research could be performed separately from and outside of institutions making political decisions and implementing rules. Scientific assessments and other input could also be performed by separate existing institutions such as the IPCC, IPBES, UNEP and WMO, or new institutions or a lose network of scientific institutions. As with filling other governance gaps, the current reform of UNEP might suggest that it also takes a leading role in performing or providing scientific assessments, with other competent institutions contributing. UNEP has

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606 http://www.unep.org/ccac/.

607 For a game theroy approach see Ricke et al (2013).

608 Williamson et al (2012). In 2012 the CBD COP adopted a mandate to update it, although this is subject to funding.

done so in other areas, e.g. on climate change in its Emissions Gap Reports.[609] While some of the reservations about UNEP outlined above also apply, it might be more easy for UNEP to engage in this governance function. For the scientific function, using the IPCC is another option due to its thematic mandate, its centralising overview and its established practice and experience. Geoengineering and its potential effects will also be part of the IPCC's fifth Assessment Report, including the possible role, options, risks and status of geoengineering as a response option.[610] However, the IPCC might be too big a structure and (unwillingly) too close to the polarised climate change debate to have a suitable focus and the necessary standing for a geoengineering governance framework.

Scientific coordination could also be left as an essentially self-organizing process. A self-organizing scientific network could be a viable alternative, provided that the link to the political level is defined, perhaps in the simple form of databases under an existing regime, as is envisaged under the LC/LP.[611] In any event, the specific scientific input that underpins other governance functions, e.g. in order to update or amend general guidance or rules, should be separate from political decision-making.

6.7 Conclusions and proposals

Academic and political discussion on geoengineering governance should be based on explicit objectives and criteria that any proposed governance arrangements are meant to pursue, balance and fulfil. There is no shortage of proposals concerning international governance arrangements. However, the rationales and goals to be pursued by them have hardly been made explicit. There is no obvious panacea for the international governance of geoengineering and no obviously superior set of criteria and objectives. We suggest, however, that making the criteria and objectives explicit facilitates a debate about such goals and rationales, which present an important guideline for designing feasible, effective and appropriate governance arrangements. It is important to disaggregate the debate into objectives and means of governance that are available for achieving these objectives.

We therefore suggest a set of explicit objectives and criteria of international governance arrangements. In this respect, three overarching objectives can guide us:

a) to avoid negative transboundary environmental and health risks and impacts;

b) to avoid political tension and conflicts, in particular resulting from unilateral action, as well as legal disputes; and

c) as a more technical matter, to coordinate scientific research.

In addition, and on this basis, we suggest that the international governance of geo-engineering should be guided by the following more concrete criteria:

[609] http://www.unep.org/publications/ebooks/emissionsgap2012/; http://www.unep.org/publications/ebooks/emissionsgapreport/

[610] Scope, Content and Process for the Preparation of the Synthesis Report (SYR) of the IPCC Fifth Assessment Report (AR5), p.3 . IPCC AR4 had mentioned geoengineering in WGII 19.4.3 and WGIII 11.2.2.

[611] LC/LP Report of the 34th Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter , LC Doc LC 35/15 of 23 November 2012, para 4.25-4.27

a) It should implement a precautionary approach in respect of the risks of geoengineering;

b) It should facilitate broad international participation and acceptance;

c) It should avoid or at least minimize any direct or indirect undermining of climate mitigation efforts;

d) It should aim at a high level of legitimacy, including through (public) participation and transparency , in particular with respect to (i) general rule-making, (ii) case-specific decision-making on any proposed concrete geoengineering activity in the field, and (iii) any actual permitted geoengineering activity, e.g. through monitoring and reporting; and

e) It should allow for a sufficient level of flexibility in order to be able to respond to new scientific knowledge as well as the evolving public debate on geoengineering.

We base our thinking about appropriate arrangements for the international governance of geoengineering on these criteria and objectives, bearing in mind the potential for trade-offs between them (especially as regards international participation and acceptance).

In view of these objectives and criteria, in particular two types of geoengineering techniques pose significant direct risks of transboundary effects (i.e. effects on other countries or areas beyond national jurisdiction) and, consequently, political tension, and thus are in need of international governance: marine techniques such as ocean fertilisation or ocean liming, and atmospheric solar radiation management such as injection of sulphate aerosols into the atmosphere. Other techniques, in particular those encapsulating or removing carbon from the atmosphere, such as "artificial tress" or enhanced weathering, would not appear to have similar transboundary effects. The international governance of marine geoengineering techniques and solar radiation management techniques thus deserves, according to current knowledge, priority attention.

As regards the normative approach, we recommend a general prohibition of geoengineering activities that entail significant transboundary risks, combined with the possibility of exemptions. The prohibition would in principle also apply to research activities such as field experiments, but not to e.g. modelling (on research see also below). In general, there is a broad range of binding and non-binding tools, instruments and legal techniques to choose from, with the general approach ranging from a general prohibition (with exemptions) to a general permission (with specific restrictions). A general prohibition with exemptions on the basis of clear criteria would best reflect a precautionary approach in (a) minimizing environmental and health risks, including minimising the risk of undermining climate mitigation efforts, as well as (b) defusing the potential for international conflicts and disputes. This overall approach could be specified as follows:

a) Clarity on which activities are prohibited could best be achieved by a positive list of the geoengineering techniques covered by the prohibition. Although an overall definition covering *all* geoengineering techniques might be useful as a political and normative reference point, it would inevitably be vague and would, on its own, not provide sufficient normative certainty. In order to build in flexibility and as guidance to states, the governance regime could provide a non-exhaustive list of the criteria used in establishing the prohibition and determining its scope in combination with a regular review of the positive list.

b) The clear framing of the exemptions should enable legitimate research to proceed (see below) and thus facilitate international acceptance of the governance approach.

Exemptions should be granted based on a transparent decision-making process applying strict and clear criteria.

c) Decision-making on both the positive list of prohibited geoengineering activities (including its review) and exemptions (including applicable criteria) should facilitate broad participation in decision-making. Depending on the circumstances, a non-binding approach could be considered with a view to its evolving into binding law over time.

This approach does not necessarily mean that the actual decision-making needs to be centralised at the *international* level. For instance, the general prohibition and the criteria for exemptions could be stated at the international level, while leaving implementation of the corresponding rules, standards and procedures, including case-specific decisions to the national level. Such a vertical division of labour could facilitate acceptance and address concerns about international micro-management. At the same time, it would require appropriate structures for reporting and monitoring of national-level decisions and activities.

We suggest that the governance of geoengineering research best be integrated into the general governance arrangements. Research in the form of field experiments or other activities in the real world should *not* be addressed separately from, and earlier than, any "deployment" of geoengineering techniques. Such a separation of governance structures (and implied sequencing of their elaboration) seems problematic and non-advisable because (1) there is no clear-cut separation of the application of geoengineering techniques “for research” from the application “for other purposes” and (2) any such separate governance structures for research would be likely to provide an important precedent and blueprint for the governance of deployment (for other purposes). Instead, the governance of geoengineering research can be integrated into general governance arrangements. In our design, research would fall within the scope of the general governance and the prohibition, but it could proceed on the basis of case-specific exemptions, based on an environmental impact assessment, independent expert advice, and provided it implies a small-scale intervention only. This approach would not restrict or stifle research beyond what is necessary to minimise the risks that are posed by research activities in the same way as by any geoengineering activities for other purposes. At the same time, our approach could enhance transparency and legitimacy of research activities.

Existing international institutions only partially cover the issue area of geoengineering and fall short of providing a comprehensive governance framework that fulfils the objectives and criteria mentioned above. The London Convention/London Protocol has developed a soft-law approach for the governance of geoengineering regarding marine techniques and is in the process of further developing this system and providing a more stable framework under international law. The normative approach pursued seems to be largely in line with the "general prohibition with exemptions" approach advocated here. However, the current proposals have yet to be adopted and enter into force. There might also be concern about whether the procedures and assessments are over-burdensome and the conditions difficult to satisfy in practice. Generally, the LC/LP is a comparatively small regime and the framework is limited to marine geoengineering techniques. The same is true for the limited activities under OSPAR, which are also limited in their regional scope. In part building on the approach of the London Convention/London Protocol, the CBD has developed some broader guidance and has served as a forum for more general discussions on geoengineering and its governance. The CBD framework does, however, not yet provide a stable basis and is not yet generally recognised as a or the central institution for discussing international governance of geoengineering. At the same time, other international institutions have hardly addressed

geoengineering to a significant extent yet. This is s significant gap in particular regarding SRM techniques, especially atmospheric SRM such as aerosol injection.

Therefore, current international governance of geoengineering is characterised by the involvement of several institutions (mainly CBD, LC/LP, OSPAR). They form the beginning of an institutional complex with significant gaps/shortcomings and with an emerging inter-institutional division of labour in need of further clarification. First, the institutional landscape does not yet provide for a central institution that is clearly recognised as the central point of contact, providing the opportunity for actors to discuss crosscutting issues, develop overarching guidance (across other relevant institutions) and raise emerging issues; developing general principles and perspectives, and facilitating the exchange of information. Second, the existing institutional complex lacks regulation of SRM techniques. Increased regulatory capacity in international geoengineering governance also raises the question of how appropriate scientific input into decision-making can be provided. In addition, if geoengineering field experiments were to increase in number and scale, there would be scope for better international coordination of research and related exchange of information.

Our discussion of options for filling these governance gaps and for progressing towards a coherent and encompassing structure for international geoengineering governance is further premised on the following considerations. First, we focus on the use of existing institutions, rather than the creation of new ones, for reasons of "institutional economy" and because, in our assessment, international discussions on geoengineering have not yet reached a level that would likely support the creation of major new institutions in this field. Working with existing institutions may also yield results more quickly. We are also guided by an evolutionary approach that further develops and elaborates (and possibly expands) the existing institutional complex of international geoengineering governance, rather than a revolutionary centralisation in one institution.

In our assessment, the UN Framework Convention on Climate Change (UNFCCC) does not provide a suitable or promising governance framework for fulfilling any of the governance tasks identified above. The main reasons are, first, that negotiations under the UNFCCC are already characterised by a very high level of complexity and being politicised. Adding geoengineering as another item on the UNFCCC negotiating agenda is likely to suffer a similar fate as others before, namely being deadlocked, being used as a negotiating chip, or not receiving appropriate attention. Second, and perhaps more importantly, the institutional logic of the UNFCCC is directed at combatting climate change. Avoiding other negative impacts on e.g. biodiversity or other environmental objectives is addressed only to a marginal extent, , e.g. in respect of the economic consequences of addressing climate change. As a result, it might be intrinsically difficult for the current climate regime to pursue a precautionary approach that is *restrictive* to geoengineering. In addition, geoengineering does not fit easily with the overall approach of the UNFCCC aimed at mitigating greenhouse gas emissions and adapting to the impacts of climate change. The UNFCCC may thus best be considered a complementary forum that may be suitable for incentivising any "encapsulated" geoengineering activities that have significant climate benefits while having insignificant environmental and health risks.

We consider the CBD the prime candidate for becoming the central institution recognised as a first point of contact. The CBD already fulfils this function to some extent, although not at a stable and prominent basis. Although its mandate is not unlimited, in particular the mandate to protect biological diversity allows pursuing a sufficiently broad precautionary approach, which could be further broadened if considered warranted by parties. Making the CBD the central institution in the field would appear to first of all suggest a conscious decision of its parties to establish appropriate stable structures (possibly including a work programme) to

pursue targeted discussion of geoengineering on a regular basis. The establishment of such structures may help address concerns about a lack of priority and expertise in the CBD framework.

There is no obvious other candidate for becoming the central institution in the international governance of geoengineering. As mentioned, the UNFCCC has important drawbacks, and other institutions have neither been active so far nor would their more limited mandates or political setup make them promising candidates. However, the trade-off underlying the assessment of the UNFCCC, in particular viv-a-vis the CBD, is a difficult one. The advantages of the UNFCCC are not easily outweighed, including its role as a central forum for international climate diplomacy, the participation of the US, and the climate regime's experience in setting up institutions for specific tasks. Against this backdrop, institutional economy on its own might not be reason enough to choose the CBD, unless there is also confidence that the governance provided by the CBD is implemented and effective. In any event, irrespective of the institutional governance structure, *politically* geoengineering is not separable from climate policy and the climate regime.

UNEP might be a second-best solution, as it is the only relevant overarching international environmental institution and might assume a strengthened role in the course of its current reform. Although it does not usually engage directly in international regulation, it might launch a related initiative if no further action can be taken through the CBD, and contribute to scientific and technological assessment (see below).

The CBD may also be the most appropriate forum for pursuing more concrete governance arrangements for SRM activities. Again, it could build on the existing work already undertaken in elaborating a more concrete "prohibition with exemptions" framework. Such a framework could be established by means of a decision of the Conference of the Parties to the CBD. If a binding framework was considered warranted, a related Protocol to the CBD could in principle be elaborated. The 1985 Vienna Convention for the Protection of the Ozone Layer and its 1987 Montreal Protocol do not constitute a very promising alternative since their mandate is limited to the protection of the ozone layer, whereas not all relevant SRM techniques clearly affect the ozone layer. In addition, previous attempts to broaden the interpretation of the mandate of the Montreal Protocol in respect of a different issue politicised that issue, which is an important risk if tried for geoengineering. The World Meteorological Organization (WMO) does not have a clear regulatory mandate or significant experience and may thus only be able to contribute to related scientific and technological assessments (see below). If action on SRM activities proved impossible under the CBD, launching a related process under UNEP may be a second-best alternative at the international level. Complementing global efforts, regional action could be explored in a European context under the UNECE's LRTAP regime, which might serve to advance global action.

As international (and national) governance of geoengineering advances, demand for international scientific and technological assessments is likely to grow. At the international governance level, a mandate to regularly compile and perhaps assess the current knowledge could be useful. Where there is specific scientific input to underpin other governance functions, e.g. in order to update or amend general guidance or rules, scientific input should be separate from political decision-making. In respect of individual decisions, e.g. on permits, it does not currently seem necessary that the *international* level provides more than general guidance as to the conditions under which the national level should allow for exemptions from the general prohibition.

7 Annex I: Overview of selected governance proposals

Table 3: Overview of selected governance proposals

Year Author Title	Proposal
1996 **Daniel Bodansky** May We Engineer the Climate?	Bodansky identifies the general risks of geoengineering and raises questions for governance, such as who gets to participate in decision-making, how to make decisions with a sound scientific basis, and how to account for potential damage. He finds that the absence of an effective process for making international decisions is more likely to frustrate proposals as countries would be unwilling to incur political costs from proceeding without international approval. UNEP Weather Modification Guidelines and ENMOD are briefly examined as precedents for climate engineering, and development of ATS decision making processes is later compared (proving it is easier to prohibit than regulate). General principles of IEL described and options for space shields, ocean fertilisation, atmospheric proposals, and reforestation are briefly looked at. In general, there are three categories of possible geoengineering regulation: unilateral action subject to international standards; international review and authorisation; and prohibition. Existing laws and norms are inadequate and should be applied cautiously, as they were not designed to address geoengineering. The UNFCCC could serve as a forum to look at climate engineering and the SBSTA could review proposals. Multilateral discussions could take place in numerous fora such as, for example, UNFCCC, UNEP, WMO, the UN Commission on the Peaceful Uses of Outer Space, the ATS, or the LRTAP Executive Body; however, none of these bodies have clear decision-making authority and collective regulation would require development of a new mechanism. Adopting a ban may be easier than developing an international regulatory regime.
1998 **Jay Michaelson** Geoengineering: A Climate Change Manhattan Project	As successful regulation of climate change for mitigation is increasingly unfeasible, efforts should shift away from creating a mitigation-based climate regulatory regime and towards developing a "Climate Change Manhattan Project," covering geoengineering research, funding, and implementation. First, this would require prioritizing geoengineering research, from international, top-down efforts to incentivizing private research. Second, the project should cover development and deployment of feasible proposals, giving consideration to international coordination and monitoring. Geoengineering minimizes the problems of climate regulation and is monetarily, socially, and politically cheaper, more fair in allowing countries that value climate stability more to pay more, administratively

simpler, less contentious, and avoids the Tragedy of the Commons.

2007 **John Virgoe** International governance of a possible geoengineering intervention to combat climate change	Virgoe identifies characteristics of geoengineering which might influence governance models (relationship between geoengineering and mitigation; number of actors needed for a geoengineering intervention; externalities, risks, and distributional issues; and long-term undertakings), and discusses three broad approaches: through the United Nations, by one state unilaterally, and through a consortium of states. Arguments in favor of a UN process are that it would provide legitimacy through a multilateral process and could work with the IPCC and UNFCCC SBSTA, though this process would likely be slow-moving and perhaps not favoured by some private actors or powerful nations. A unilateral approach has political risks, but the benefit of speedy execution. A voluntary consortium could follow the model of the 2003 Carbon Sequestration Leadership Forum or the ITER fusion reactor consortium, and makes sense for research and advocacy, but less so for deployment. Any geoengineering agreement would need to: provide a participatory, consensus-based process for deployment; designate an agency for implementation; designate an inclusive, high-level governing body to set guidelines and budgets; address difficult questions regarding the 'correct amount' of geoengineering;and resolve questions of cost-sharing, externalities, liability, and compensation, perhaps including a dispute–settlement mechanism The article argues for early exploration of the technological, environmental, political and regulatory issues raised by geoengineering, which might best be done through the consortium model. Virgoesurveys a number of prior proposals looking at existing mechanisms
2008 **David G. Victor** On the regulation of geoengineering	Victor argues that norms to govern deployment of geoengineering will be needed soon and standard instruments for establishing norms, such as treaties, are unlikely to be effective in constraining geoengineers because the interests of key players diverge and it is relatively easy for countries to avoid inconvenient international commitments and act unilaterally. Efforts to design regulations at this stage will probably fail to yield useful outcomes and may create a taboo against geoengineering. Instead, efforts to craft new norms 'bottom up' will be more effective. Such an approach, which would change the underlying interests of key countries and make them more willing to adopt binding norms in the future, will require active, open research programmes and assessments of geoengineering. Standard methods for international assessment by the IPCC are unlikely to yield useful evaluations because the most important areas for assessment lie in the improbable and unexpected side effects of geoengineering, not the 'consensus science' that IPCC does well. Treaties and trade sanctions will have little impact when benefits compel action. For countries not engaged in geoengineering, the best response to unilateral geoengineering might be

	a sharp increase in their own geoengineering efforts to gain information and help re-establish norms.
2009 **Albert Lin** Geoengineering Governance	Lin describes the obstacles of climate change mitigation, and thus why geoengineering may be increasingly attractive, though also explains why focus should remain on mitigation while enhancing understanding of geoengineering. Potential geoengineering should be regulated via a UNFCCC protocol and governance should follow adaptive management. UNFCCC already has jurisdiction over geoengineering and has an established forum and technical bodies such as the IPCC and SBSTA. Given that geoengineering can be a substitute for emissions reduction, the two should be addressed in concert. As a consensus model of decision-making could limit the ability to quickly respond, non-consensus processes, such as rules providing for passage of measures by a supermajority, should be considered. A ban against hostile uses, following ENMOD as a model, should also be established.
2009 **Steve Rayner, Catherine Redgwell, Julian Savulescu, Nick Pidgeon, and Tim Kruger** Memorandum on draft principles for the conduct of geoengineering research (Oxford Principles)	Geoengineering research should be guided by five key principles: regulation as a public good; public participation; disclosure of research and open publication of results; independent assessment of impacts; and governance before deployment.
2009 **The Royal Society** Geoengineering the climate: Science, governance and uncertainty	The 2009 Royal Society report provided a detailed look at aspects of geoengineering. Further research and development are needed to investigate the potential of low-risk methods. CDR methods are preferable to SRM as a way to augment mitigation, however SRM may provide useful short-term backup if rapid reductions in global temperatures are needed. Prior to large-scale experimentation or deployment, the following principles should be considered: legality; effectiveness; timeliness (implementation and climate effect); environmental, social, and economic impacts; costs (financial and carbon life cycle); funding mechanisms; public participation; and reversibility (technological, political, social, and economic). For governance of geoengineering, the report recommended that: (1) Governance challenges should be explored in detail and policy processes established to resolve them; (2) An international body such as the UN Commission for Sustainable Development should commission a review of international and regional mechanisms to: a) Consider the roles of UNCLOS,

	the LC/LP, CBD, LRTAP, Montreal Protocol, Outer Space Treaty, Moon Treaty, UNFCCC/KP, and ENMOD; b) Identify existing mechanisms that could be used to regulate research and deployment; c) Identify regulatory gaps for proposed methods; and d) Establish a process for development of mechanisms to address these gaps; and (3) The UNFCCC should establish a working group to: a) Specify conditions under which CDR methods could be considered as mechanisms under UNFCCC; and b) Establish the conditions that CDR would need to be eligible under the CDM and JI. The report also recommended that the Royal Society collaborate to develop a code of practice for research and recommendations to the international scientific community for a voluntary research governance framework that would include: a) Consideration of types and scales of research that require regulation including validation and monitoring; b) The establishment of a de minimis standard for regulation of research; c) Guidance on the evaluation of methods.
2010 **Asilomar Scientific Organizing Committee** The Asilomar Conference Recommendations on Principles for Research into Climate Engineering Techniques	Five basic principles on geoengineering research should be followed: (1) promoting the collective benefit of humankind and the environment; (2) governments must clarify responsibilities for, and, where necessary, create new mechanisms for governance of large-scale research; (3) open and cooperative research with international support; (4) independent technical assessments of research progress; (5) and public participation and consultation.
2010 **Scott Barrett** Geoengineering's Governance: Written Statement for the US House of Representatives Committee on Science and Technology	The primary policy options for deployment include: a geoengineering ban; focusing on geoengineering in place of emissions reductions; considering geoengineering and emissions reductions jointly; or saving geoengineering as a last-resort tactic. A UNFCCC protocol for geoengineering should be adopted to provide a restraining influence, serve as a forum for conflict resolution, and help balance risks. Such a protocol could: establish widely applicable normative limits to restrain behavior; require notification prior to deployment; recognize states' right to safeguard their own citizens and duty not to harm other states; use consensus-based cooperation to resolve conflicts; and promote cooperation and transparency in research and development.
2010 **ETC Group** Geopiracy: The Case Against Geoengineering	A moratorium on geoengineering experimentation is required. Bodies such as the CBD, UNEP, and the UN General Assembly should seek ICJ confirmation that geoengineering would violate ENMOD. Geoengineering should be addressed at the Rio+20 Summit. UN treaties and bodies dealing geoengineering should work to adopt a multilateral treaty providing an assessment framework, early warning system, and monitoring, and regulation of new and emerging technologies based on the following principles: the precautionary principle; no unilateralism; environmental integrity; consideration of social, cultural and environmental impacts; transparency; civil society participation; representation and participation of developing countries; and international human rights and environmental law. A framework for a proposed treaty governing new technologies, the International Convention for the Evaluation of New Technologies (ICENT), is outlined.

2010 **Harald Ginzky** Ocean Fertilization as Climate Change Mitigation Measure — Consideration under International Law	Ginzky assesses ocean fertilisation and options for regulation. He concludes that ocean fertilisation will probably not be a suitable instrument to mitigate climate change, and that the debate should focus on governance of research activities. A prior governmental control in form of a permission regime is reasonable whereby the legitimacy and the environmental impacts are assessed. Such a permission regime would be in line with the provisions of UNCLOS and the German Constitution. Regulation must balance environmental, research, and commercial interests.
2010 **M. Granger Morgan and Katharine Ricke** Cooling the Earth Through Solar Radiation Management: The need for research and an approach to its governance	SRM research and policy development must start immediately. First, an international research program coordinated informally within the scientific community should be created to examines SRM performance, costs, impacts, and risks. Second, the foreign policy community should identify and assess SRM governance approaches. Modest low-level field studies should be transparent, but not subject to international authorisation, which may be difficult to enforce and impede research. However, what is and is not “modest low-level” must be better defined, both to create clear scientific norms and inform regulation and implementation of “large-scale” activities. One possible approach is to create research “allowed zones.” Investments should be made in observational infrastructure to support field studies in the case of l natural experiments such as volcanic eruptions. Governments should discourage private, for-profit funding of SRM research. For CDR, an international governance framework is unnecessary, as it is inherently local, slow, and similar to conventional abatement strategies.
2010 **House of Commons Science and Technology Committee** The Regulation of Geoengineering	[Recommendations for UK domestic and international approach] Regulatory regimes should be tailored to geoengineering techniques: those scoring low against criteria such as transboundary and environmental effects require no additional regulation, while those scoring high should be subject to additional controls. CDR should be raised on the agenda of the UNFCCC and other instruments. New regulatory regimes must be created for SRM techniques falling outside of the current framework. Small-scale SRM development should generally be allowed provided that research principles - such as disclosure, public participation, and impact assessment - are followed, environmental impacts are negligible, and there are no transboundary effects. Regulation of both CDR and SRM should proceed via the UN and follow the following principles: regulation as a public good, public participation, disclosure of research and results, impact assessment, governance before deployment, decision-making based on best scientific evidence, including social science, rapid response, flexibility, and prohibition for military purposes. An international consortium should be established to explore options and build a community of researchers. International collaboration should continue.
2010 **United States Government Accountability Office** Climate Change:	[Recommendations for US domestic approach] GAO recommends that the appropriate federal executive offices develop a coordinated approach to geoengineering research in the context of a climate change strategy that: defines geoengineering; has federal agencies collect information and coordinate research in a transparent manner; and, if the administration decides to establish a formal geoengineering research

A Coordinated Strategy Could Focus Federal Geoengineering Research and Inform Governance Efforts	program, sets clear research priorities to inform decision-making and future governance efforts.
2010 **Karen N. Scott** Marine Geo-engineering: A New Challenge for the Law of the Sea	A UNFCCC protocol should be developed, applying common principles to research and mitigation activities and establishing appropriate institutions for advice and policy decision-making. The protocol should designate subsidiary bodies for communication and coordination. For ocean fertilisation and similar techniques, the London Protocol is the appropriate regulatory body. The IMO may be an appropriate body to regulate techniques using pipes. Space activities should be governed by the UN Committee on the Peaceful Uses of Outer Space.
2010 **Ralph Bodle** "Geoengineering and International Law: The search for common legal ground"	Current international law applicable to all geoengineering techniques but would be an incomplete basis for international governance. For future governance, in legal terms the mandate of e.g. the CBD or the UNFCCC is sufficiently broad to address all geoengineering concepts. It should be born in mind that the different regimes and institutions that could assume governance roles have different legal and political weight. It is not necessary to introduce distinguish between research and deployment at a regulatory level. The borderline between research experiments and deployment becomes artificial once a certain scale is reached. Below that scale, the general rules do not require states to impose an unreasonable restriction on scientific research.
2010 **Rex J. Zedalis** Climate Change and the National Academy of Sciences' Idea of Geoengineering: One American Academic's Perspective on First Considering the Text of Existing International Agreements	Zedalis first looks at the existing legal framework as applicable to geoengineering techniques. He concludes that rather than a patchwork approach, what is needed is a detailed and precise new international agreement that indicates what is and is not permitted and requires comprehensive monitoring, transparent reporting, and mechanisms to halt activity and initiate restoration where needed. While such an agreement would be difficult to negotiate, this price is preferable to letting the potential risks of geoengineering remain untouched. The least that can be expected is an agreement on monitoring and immediate obligatory restorative action in the case of failure.
2011 **Bidisha Banerjee** The Limitations of Geoengineering Governance In A World of Uncertainty	Banarjee evaluates techniques and leading proposals for geoengineering governance through Sheila Jasanoff's "technologies of humility" rubric, and looks at two broad categories - treaty-based governance and voluntary codes of conduct. She draws on historical examples such as ENMOD, the 1972 Asilomar conference, and the emergence of the IAEA to examine the limitations of voluntary codes of conduct and treaties as the most popular approaches to governing geoengineering. Banarjee also examines the relevance of environmental assurance bonds, which would require geoengineers or their funders to post a guarantee price equivalent to the worst-case threats posited by a particular deployment scheme. See chart on

page 19 for 'Major positions on geoengineering governance taken by proponents of geoengineering.'

2011 **Bipartisan Policy Center Task Force On Climate Remediation Research** Geoengineering: A national strategic plan for research on the potential effectiveness, feasibility, and consequences of climate remediation technologies	[Recommendations for US domestic approach] The US federal government should initiate a coordinated domestic research program based on: protection of the public and environment; recognizing that field deployment of SRM and of CDR pose significant environmental risks and would be inappropriate at this stage; advice from experts inside and outside of the government; public engagement; transparency; international cooperation; and adaptive research programs. Research should be integrated across natural and social sciences. An interdisciplinary executive-level advisory commission should help oversee research. The US should continue to cooperate internationally to establish common norms and expectations and to facilitate future agreements addressing deployment.
2011 **Harald Ginzky and Till Markus** Regulating climate engineering: Paradigmatic aspects of the regulation of ocean fertilization	The regulatory approach under the LC/LC can serve as a model for geoengineering governance in general. "Commercial" deployment should be prohibited, whereas research should be subject to a permit. Whether research is "legitimate" is determined on the basis of an assessment framework which requires "proper scientific attributes" in order to distinguish research from deployment. The framework also includes an environmental impact assessment and an obligation to publish the results. Sectoral regulation and soft law approaches should prepare the ground for global and binding governance in the long term.
2011 **Wilfried Rickels, Gernot Klepper, and Jonas Dovern** Large-Scale Intentional Interventions into the Climate System? Assessing the Climate Engineering Debate	The report from the Kiel Earth Institute provides a wide-reaching and detailed look at aspects of the climate engineering debate, including the legal framework and international coordination and regulation. International regulation of climate engineering should ideally (i) encompass an incentive system that solves the free-rider problem, (ii) create a compensatory mechanism, and (iii) limit the side-effects of research. Research, as well as deployment, requires an institutional embedding which creates sufficient acceptance and links it to existing regulations. Only multilateral regulation within the framework of a global climate regime will allow for climate engineering to be linked to emissions reduction in such a way that moral hazard and problem of termination can be dealt with. Climate engineering should be embedded within the UNFCCC process in order to avoid long-term damage to emission reduction efforts and to avoid any self-reinforcing implementation dynamic (the slippery slope argument). Only a small number of techniques could be successfully be deployed unilaterally or by a small coalition of states, but these create significant opposition and thus international coordination is desirable. The authors summarize some past proposals of climate engineering governance

	(see page 115). The requirements for international regulation are defined as: (i) international coordination of research and technical evaluation (a coalition which could be embedded in the UNFCCC); (ii) independent supervisory authority (research could be under or similar to the IPCC; would also have EIA function); (iii) definition of international norms and rules; (iv) comparability of emission control and climate engineering deployment (e.g. contributions by states to the costs arising from CE deployment should not be measured in terms of climatic impact, but according to how much the same deployment of resources would have achieved when invested in GHG reduction); (v) coordination of research with regard to the slippery-slope problem, such as a time-limited moratorium; and (vi) definition of terms for phasing out the use of CE technologies (e.g. to prevent states from unilaterally pulling out of SRM efforts).
2011 **Arunabha Gosh and Jason Blackstock** SRMGI Background Paper: Does geoengineering need a global response — and of what kind? International Aspects of SRM Research Governance	[Addresses SRM only] There are four broad categories of SRM regulatory options: national governance; use of a collection of ad-hoc principles, soft law, and codes of conduct; use of existing international organisations and treaties; and creating a new international organisation or treaty. Research must follow the basic principles of precaution, inclusiveness, capacity, flexible funding, transparency, review, public engagement, and public ownership of intellectual property. The Rio+20 Summit could offer a potential forum for addressing geoengineering. UNEP is a strong candidate forum as well. Other informal options include coordinated dialogues between individuals within international organisations and governments or a coordinated clearinghouse of SRM information and activities.
2011 **Umweltbundesamt (UBA)** Geoengineering — effective climate protection or megalomania?	Geoengineering should be an emergency option and is not a substitute for mitigation and adaptation. A key disadvantage is that economic incentives cannot be set for emissions producers and measures will likely be financed by the state, amounting to taxpayer-financed treatment of symptoms. Geoengineering also poses risks to developing countries, whereas developed countries bear particular responsibility for climate change. In assessing individual techniques, the following aspects should be considered: climate protection potential; technology development; costs and benefits; risks to humans and the environment; societal acceptance; and legal control regime. Authorisation must follow the precautionary principle, consider regional effects, require research of risks, and be linked to effectiveness, using a comprehensive energy balance that covers preparation, realisation, and withdrawal. A new statutory framework is required, either through a new regime or under UNFCCC; however, to reduce costs and complexity, it may be expedient to use existing agreements. New regulations must ensure that affected states are informed and consulted and that unilateral measures are prohibited.

2012 **Daniel Bodansky** The Who, What, and Wherefore of Geoengineering Governance	Bodansky discusses the purpose, possible forms for, and characteristics (e.g. legal form, precision, legitimacy, incentive to violate, ability to comply, subjects, case-by-case decision-making processes, decentralised approach, etc), as well as different scenarios under which regulation is needed or desired. The 'purpose' of geoengineering governance is essentially to be able to control the desired level of geoengineering. Currently, a number of existing legal principles and treaties apply to geoengineering, and these rules could presumably constrain activity through self-implementation and self-compliance by state, sub-national, or private actors, or could help influence the debate for future governance mechanisms. Bodansky describes four different scenarios that raise geoengineering governance challenges: (1) inadequate research funding; (2) premature rejection/ over-regulation; (3) "Greenfinger", and (4) unilateral state action. Bodansky concludes that creating a governance structure for research is easier than for deployment, and that in practice, regulation is more likely to come from extensions of existing mechanisms than a comprehensive new framework - however, dispersion of authority to different institutions will make it difficult to consider geoengineering in an integrated manner.
2012 **Edward Parson, Lia Ernst** International Governance of Climate Engineering	Climate engineering technologies raise high stakes that pose acute and novel challenges to international governance, which are not addressed under current international law and institutions. Climate engineering can be characterized as "fast, cheap, and imperfect." To avoid substantial risks related to climate engineering, governance structures will be needed at or before the point when serious proposals for large-scale climate engineering deployment are first advanced. There is a current consensus that research and informal international research collaboration are the most immediate needs, and that research needs governance. Three distinct kinds of governance functions are required: regulatory and operational decision making, scientific research and assessment; and management of security risks. No current multilateral regime has demonstrated capability to provide all three functions. Near-term governance questions to focus on are: 1) Development of shared norms to guide future decision-making, such as through a body for scientific collaboration. This should not only be scientific in its participation, mandate or operations, as it must integrate additional societal and political factors in its deliberations. A senior consultative body of people with deep and diverse experience in government, diplomacy, science and other fields – a "World Commission on Climate Engineering" – could be a model (either elite advisory body or educational body or a forum eliciting broad stakeholder and citizen input or a convener of more exploratory investigations of potential climate engineering uses and risks). 2) Climate engineering should link to and complement between international mitigation efforts. One useful approach could be for governments to announce, before starting negotiations on climate engineering, that they are provisionally suspending any claims of legal rights to conduct climate engineering interventions above some specified scale, to promote constructive multilateral agreement on comprehensive management of climate change.

2012 **Ralph Bodle, with Homan, G., Schiele, S., and E. Tedsen.** The Regulatory Framework for Climate-Related Geoengineering Relevant to the Convention on Biological Diversity (CBD Technical Series No. 66).	In legal terms, the mandate of several major treaties or institutions is sufficiently broad to address some or all geoengineering concepts. This could lead to potentially overlapping or inconsistent rules or guidance. The Assessment Framework established by the LC/LP provides an elaborate and comprehensive governance effort for scientific research projects. There are but few specific rules on responsibility and liability. A distinction between research and deployment could be difficult to make from a regulatory point of view. A positive list of concepts or technologies that are considered to be geoengineering might be a useful regulatory approach. The list could be drawn up as a supplement to a general defnition. It would need to allow for timely updating in order to provide the flexibility required for scientific and political developments.
2013 **Ralph Bodle** Climate Law and Geoengineering, in: Hollo, Erkki, Kati Kulovesi and Michael Mehling (eds.), Climate Change and the Law: A Global Perspective, Berlin: Springer, p. 447-470, forthcoming 2013 (submitted May 2012)	The existing rules and guidance are unlikely to be able to contain the risks posed by geoengineering. Any overarching definition for regulatory purposes is unlikely to be sufficiently comprehensive to capture all relevant techniques while being sufficiently precise to exclude uncontroversial techniques or scale of activities. Even for those states with the potential to pursue geoengineering unilaterally, there are compelling reasons why it is in the national interest to partici pate in an international governance framework ks posed by geoengineering or be able to avoid related political conflicts. At this stage the climate regime is unsuitable because introducing geoengineering could seriously jeopardize the current climate negotiations and make geoengineering part of the trade-offs that are part of them. If geoengineering were to move forward, there could be pressure to credit certain geoengineering activities that do not fit easily into the mitigation category If the objective of governance is to address risks and potential impacts of an activity, then activities involving the same risks and potential impacts should be treated the same regardless of whether an activity is carried out as "science" or as "deployment". A key component is to clearly separate scientific input and political decision-making.
2013 **Parsons, Edward and Keith, David W.**, End the deadlock on governance of geoengineering research	Scientific self-regulation is insufficient to manage risks.There should be a moratorium on large-scale geoengineering. Two technical thresholds are defined, based on the strength of the solar radiation perturbation. Interventions above the first threshold should be subject to a moratorium, while those below the second threshold should be generally permitted. The article explicitly avoids the hard governance issue that lie in the middle.

8 Annex II: Expert Workshop 5./6. November 2012

As part of the project, Ecologic organised an international workshop on geoengineering governance. This annex includes the discussion paper distributed to the participants prior to the workshop and a summary of the main points discussed.

8.1 Discussion paper

5-6 November 2012, Ecologic Institute, Berlin, Germany

Discussion Paper, 22 October 2012

- not for distribution-

8.1.1 Introduction: The UBA research project

This discussion paper for the workshop on international governance of geoengineering aims at stimulating discussion. The workshop is part of a research project for the German Federal Environment Agency, in which Ecologic Institute develops specific proposals for governance of geoengineering at the international level. Based on a comprehensive analysis of the existing regulatory framework and its gaps, the study identifies general options and specific recommended actions for the effective governance of geoengineering. A key consideration is that the recommendations can be implemented in practice.

Although the debate about geoengineering is still largely driven by scientists, it is gaining attention at the policy interface. In addition, while many geoengineering techniques are at the conceptual or modelling stage, there have also been field experiments followed by an emerging public debate. These developments raise the question of whether a governance framework is needed over and above the current framework, and what it should look like.

8.1.2 State of play in geoengineering governance

The geoengineering debate has taken international law somewhat by surprise. The main legal studies so far show an emerging consensus that -details aside- existing international law hardly addresses the potential impacts of geoengineering or related key questions.

Geoengineering is currently not as such prohibited by international law. Potential application of specific rules and restriction on geoengineering would generally depend on specific actual or potential impacts, depending on the rule in question. Such impacts are difficult to assess or predict at this stage.

Neither the UNFCCC nor the Kyoto Protocol prohibit geoengineering as such. Although the objective of the climate regime according to Article 2 UNFCCC is to stabilise greenhouse gas concentrations in the atmosphere, this “ultimate” aim of stabilising greenhouse gas concentrations does not necessarily mean that the UNFCCC or the Kyoto Protocol prohibit other measures intended to prevent global warming. The precautionary principle embodied in Art. 3.3 UNFCCC is binding, but its wording allows for interpreting it as not precluding geoengineering. The few other provisions in the climate regime that could apply to geoengineering, such as Articles 3.1, 3.3, 4.1 and 4.2(a) UNFCCC, are general in wording and normative content. Apart from CCS, the Kyoto Protocol does not address or prohibit geoengineering. There is a thematic overlap with land use change and sinks, as the Kyoto Protocol provides incentives to generate sinks from land-use and forestry projects.
The ENMOD Convention addresses environmental modification techniques having widespread, long-lasting or severe effects. The definition provided in the treaty would cover geoengineering techniques. However, the ENMOD Convention’s applicability to geoengineering is limited by its material scope (military or other hostile use), its limited number of parties and the lack of practice to draw from. It does not prohibit geoengineering in peacetime nor does it expressly permit it.

Besides international rules provided by specific treaties or regimes, there is minimal common legal ground regarding cross-cutting legal rules and principles that could apply to geoengineering. Customary law provides few rules applicable to all states and all geoengineering concepts. These are the duty to respect the environment, the general obligation to carry out an environmental impact assessment and the rules on state responsibility. The precautionary principle or approach is also of particular relevance. Although there is no consensus on its legal status and content in customary law, it is embedded in several treaties, notably in the operative part of the UNFCCC, which has near universal application including the US. However, the content of these cross-cutting rules is not specific enough to provide clear guidance as to specific geoengineering techniques. In addition, customary rules are subject to and can be derogated from by special rules agreed between states.

The precautionary principle (or: “approach”) is frequently underlying arguments in favour of and against geoengineering. However, there is no uniform formulation or usage for the precautionary principle and its legal status in customary international law has not yet been clearly established, although it has been invoked several times.

Other general principles or concepts such as sustainable development or inter-generational equity also play a role in the considerations and debate on geoengineering. However, from a legal point of view other rules are not universally recognized as legal obligations on states, or their content is too open to provide commonly accepted legal ground of international law relevant to geoengineering.

In legal terms, the mandate of the CBD COP and many international regimes and institutions would allow them to address geoengineering, or some aspects of it, even if they have not done so to date. This raises questions regarding different treaties or institutions potentially competing for addressing geoengineering with overlapping or inconsistent rules or guidance.

Recent developments under the London Convention/Protocol (LC/LP) and the CBD have produced pertinent rules specifically on geoengineering in general or particular techniques. However, some of these rules have been adopted in the form of decisions by treaty bodies and are not binding in the strict legal sense. At CBD COP10 in 2010, the parties went beyond previous decisions addressing ocean fertilisation and adopted a decision addressing geoengineering in general. Although it is not binding in form or language, CBD COP decision X/33, para 8(w) appears to be the only all-encompassing governance measure at this level to date. Although the language and grammar of decision X/33 are not entirely clear, it does intend to generally restrict geoengineering, subject to three conditions, which are linked to knowledge and governance gaps and uncertainty. In November 2012 CBD COP11 has reaffirmed this decision, without adding new relevant substance or guidance. Under the LC/LP there is a proposal for a binding amendment that could potentially apply to all marine geoengineering techniques. Once listed, an activity would be generally prohibited unless permitted by terms of the listing.

There are several current research projects and programmes regarding geoengineering. Two incidents have recently raised public attention and exemplify some of the governance issues addressed in this paper: In 2011, a planned experiment on the feasibility of aerosol injection as part of the SPICE project was put on hold following public objections. A couple of days ago it emerged that a large-scale ocean fertilisation experiment was conducted off the Canadian coast in the summer of 2012.

8.1.3 Criteria for geoengineering governance

Governance, meant in a broader sense than regulation, is not necessarily restrictive. It can also provide legal certainty and political legitimacy, or fulfil pragmatic functions such as coordination. Yet most geoengineering governance proposals are not explicit about their underlying assumptions and criteria regarding the objectives and functions they seek to address or leave unaddressed.

Geoengineering has particular characteristics that cause particular challenges to international governance. To some extent these may resemble those of other high-risk or controversial technologies such as genetic modified organisms, nuclear power and perhaps nanotechnology. Yet geoengineering is also different and unique in several respects, including:

- Geoengineering is supposedly a particular and provisional solution to a particular problem. It is conceived as a plan B to mitigation, as an unasked-for fallback option that is not desirable as such, but which could be further explored in order to at least find out whether it is viable as a last resort.
- There is a broad range and diversity of techniques addressed under the term geoengineering. In addition, each technique is quite different depending on which scale we address. The impacts and risks associated with the individual techniques vary. Most techniques become high-risk in terms of physical impacts only when deployed at large scale, and not all may have immediate significant transboundary impacts.

- Uncertainty and on-going technological developments. This applies to climate change as the underlying issue as well as to geoengineering techniques as one potential means to address it. It may be difficult to seek more knowledge about geoengineering without endorsing it or causing a political lock-in effect.
- The distinction between research and deployment. Whether and how to address geoengineering research is a fundamental and cross-cutting problem that occurs for every geoengineering technique and for every potential governance option.

Against this background, geoengineering governance should fulfil the following criteria: Integrate the precautionary approach: The scientific uncertainties regarding most geoengineering concepts, combined with their purpose of having global impacts and their different transboundary risks, call for a precautionary approach. While this is a central aspect of geoengineering governance, the different views regarding its specific content and its normative anchoring in international law have implications for governance design, e.g. when considering political buy-in.

Avoid negative environmental and health risks and impacts: This is probably the most obvious and self-explanatory purpose of a geoengineering governance structure. Given the factual and scientific uncertainties regarding geoengineering techniques, this criterion is closely linked to the precautionary approach.

Ensure political feasibility and buy-in: A governance framework should aim at bringing on board as many states and other actors as possible, including those states that are likely to be capable and willing of pursuing geoengineering at a relevant large scale. However, if other governance criteria and objectives needed to be unacceptably compromised, then the costs of ensuring participation could be considered to be prohibitive . A related problem would be how to provide incentives for states that are not formally part of the governance regime to nevertheless abide by the main principles.

Prevent undermining or weakening of mitigation efforts (climate context): All proponents of geoengineering stress that it is no substitute for reducing emissions, and that geoengineering proposals are primarily considered as complementary to other efforts to limit human-induced climate change. Nevertheless, there is a plausible “moral hazard” argument that geoengineering does have the potential to obstruct the climate change negotiations and detract from emission reductions. Governance should ensure that geoengineering remains a “plan B” and that geoengineering avoids undermining emission reduction efforts.

Avoid political conflicts and legal disputes, e.g. due to unilateral action: As it is likely that at least some geoengineering concepts could be tested and deployed by a single state, a state capable of doing so might prefer to address geoengineering in its domestic jurisdiction only, and be reluctant to wait for or subject itself to international agreement. However, all states, including all states pursuing geoengineering (research), have an interest in participating in an international governance framework in order to (1) prevent others from engaging in unilateral and uncoordinated geoengineering and (2) avoid international political tensions that are likely to arise from the potential for transboundary impacts of geoengineering. Such political tensions may arise *regardless of whether any impacts can be proven* to be caused by the geoengineering activities in question. Geoengineering governance should curb this potential for political tension. This objective reinforces the need for political feasibility.

Political legitimacy and acceptance: International governance could provide legitimacy to a states' own policy. A polarised debate, perhaps similar to instances regarding climate change, would make it difficult for a state to adopt and implement any policy on geoengineering.

Transparency of process and geoengineering activities could be one of the means to achieve this end as well as to reduce the risk of political tension.

Co-ordinate science and research: Depending on the particular geoengineering concept, at some stages research activities might need to be coordinated at the international level in order to ensure that data can be correctly attributed to particular experiments and to ensure validity of results. However, this does not necessarily mean that elaborate governance structures are needed at this stage for this particular objective. The science community is self-organising to a large degree. A need for e.g. prior information and co-ordination requirements could arise when field experiments could interfere with each other's validity. This should be discussed with the scientific community. A further, specific governance problem arises when scientific experiments reach a scale that by itself has the potential to cause significant transboundary impacts.

Allow for flexibility: A governance structure needs to allow for some flexibility in order to be able to react to new developments, because (i) there is scientific uncertainty in geoengineering as well as climate science, and (ii) the public debate and interest at policy level is at the beginning. Flexibility in this sense should maintain an appropriate level of normative legal certainty and clarity.

Suitability for addressing research: Not all criteria developed above are suitable for addressing research. For instance, we suggest that the criterion of ensuring continuing mitigation efforts is not affected by research - perhaps with the exception of funding. Further, it could be explored to what extent the criteria of political buy-in and avoiding political conflict are relevant for research.

Questions:
Question 1: Do the criteria cover the most important aspects?

Tentative Answer: The criteria appear to address the particular characteristics of geoengineering at this stage. We welcome additional ideas

Question 2: Are the criteria equally important?

Tentative Answer: Avoiding negative environmental and health risks and impacts is an overarching concern. However, it has been suggested that the environmental and health risks from geoengineering should be balanced against the risks that could arise from climate change not addressed by geoengineering. The ensuing main challenge for governance design appears to be to create political buy-in while establishing appropriate safeguards against these risks. In addition, avoiding undermining of mitigation efforts would appear to be another overarching objective.

Question 3: To what extent are the criteria suitable for addressing research as well?

Tentative Answer: Ensuring continuing mitigation efforts is not affected by research. Further, it could be explored to what extent the criteria of political buy-in and avoiding political conflict are relevant for research governance, or whether research poses similar governance concerns.

8.1.4 Assessment and Options

Existing and potential future geoengineering governance can be explored from an institutional and from a normative perspective, on the understanding that these two categories are useful tools for analysis rather than clear-cut and exclusive distinctions.

8.1.4.1 Institutional perspective

From an institutional perspective, the analysis of international governance has increasingly moved from the exploration of specific institutions to the investigation of "institutional complexes", "regime complexes" or "governance architectures". An institutional complex can be defined as a set of two or more international institutions, such as international regimes and international organisations, that co-govern a particular issue area in international relations. The emerging issue area of geoengineering is already addressed by several institutions, most notably the CBD and the LC/LP. This international governance framework for geoengineering - although it is in early stages- can be understood as an emerging institutional complex. Important aspects from the institutional perspective include:

- The degree of institutional integration and centralisation: For instance, is or should geoengineering governance be dominated by one core institution that defines the guiding principles and determines the general policy direction that is accepted and implemented by other elemental regimes and organisations?
- Different types of divisions of labour among the institutions comprising the institutional complex. For example, different elements of the governance complex for geoengineering may specialise on various regulatory subsets or sectors, or on the supply of certain governance functions (such as knowledge creation, regulation, enforcement, etc.), or on different spatial areas.
- The level of inter-institutional conflict or competition. The level of synergy and conflict between institutions is not least rooted in the degree of compatibility or competition of their objectives.

The co-governance of an issue area such as geoengineering by various institutions can be shaped by political decision-making. One potential objective would be to achieve an appropriate division of labour between the various institutions, including an adequate level of centralisation. However, there is no institution with the authority and mandate to assign and prescribe a division of labour to other institutions. The means for such collective governance of institutional complexes are mainly confined to decision-making within the individual institutions and, to a lesser extent, on cooperation among them.

8.1.4.2 Normative perspective

From a normative perspective, there is a broad range of binding and non-binding tools, instruments and legal techniques that could be used for fulfilling the governance criteria developed above - to the extent that such instruments are needed. One of the core issues regarding geoengineering governance is to balance political feasibility and buy-in with the precautionary approach. In terms of substance and procedure, there are many normative options for designing this balance. Some of these elements already exist and apply to some or all geoengineering techniques. The portfolio of normative governance elements includes, for instance:

- Unless a total ban is intended, a balance could be achieved by defining the appropriate levels of restrictions and permissions in terms of rules and exceptions. Basic types include a general prohibition combined with exemptions that can be more or less easy to obtain. Conversely, the approach could be to generally allow activities but have procedures that could impose restrictions relatively easily. A general-prohibition approach that makes exemption relatively easy may not be that far apart from a general-permission approach that makes prohibition relatively easy. Procedural design can further alleviate concerns about being too restrictive or too permissive. For instance,

a corresponding design option at the level of decision-making rules could be e.g. that a certain majority or consensus (not including the applicant) is needed in order to deny the permission.

- In addition, the normative spectrum includes not only permissions and restrictions, but also other instruments such as guiding principles and procedures. For instance, there could be procedures for establishing and providing knowledge and scientific input in decision-making.
- Transparency regarding procedure and information: Procedural approaches can be used a self-standing or complementary instruments. Key instruments include obligations regarding reporting and information exchange, impact assessments and participatory approaches
- There are several legal orders in which normative instruments could be anchored: international law, EU law and domestic legal orders. At least some of the governance criteria mentioned above appear to call for action at the international level, e.g. in order to avoid and defuse international political conflict.
- So-called "soft law" approaches are available besides the traditional sources of international law;
- Whether or not to differentiate between different geoengineering techniques and possibly spatial areas;
- A framework for further developing the governance system. Given the current state of geoengineering knowledge and debate, a governance framework does not have to, and perhaps should not be all-encompassing from the start. Like most modern governance frameworks it could allow for implementation and some degree of further normative development from within the framework. On this basis, how much governance design is needed so that details can develop during implementation?

In addition, there are two cross-cutting issues: First, there is again the question to what extent research should be addressed, perhaps separately. To what extent should international law endorse research activities even if they could cause severe impacts, on the grounds that this is the only way to know for sure that a geoengineering technique causes such impacts? Are there useful and feasible criteria for this distinction between research and non-research? Second, there is the question of a definition of geoengineering for normative purposes. Due to the broad range of geoengineering techniques, any overarching definition for regulatory purposes is unlikely to be sufficiently comprehensive to capture all relevant techniques while being sufficiently precise to exclude uncontroversial techniques or scales of activities. In a regulatory context, a definition would have to be complemented by further details on determining and measuring unspecific elements such as scale. Some governance approaches would not necessarily require a single cross-cutting definition. In addition to these technical challenges, the potentially negative implications of being classified as “geoengineering” also play a role. For instance, classifying forestry techniques as geoengineering might affect programmes such as REDD+.

8.1.4.3 Existing Framework

At the international level, there are currently two leading institutions, i.e. the CBD with global and comprehensive scope and the LC/LP focused on marine techniques. Other institutions and fora have so far been involved only marginally and have limited prospect for making a

significant (positive) contribution, including the UNFCCC, IPCC, the UN General Assembly and OSPAR.

Convention on Biological Diversity (CBD)

The CBD has addressed ocean fertilisation and geoengineering in general through decisions. The CBD is an almost universal regime and its scope is spatially unlimited. All geoengineering techniques, if employed at an effective scale, are likely to have impacts on biodiversity and could be addressed by the CBD. Leaving aside the on-going debate on semi-legal and de facto implications of COP decisions within treaty regimes, the decision under a treaty with near universal membership, such as the CBD sends a political signal that would be difficult to ignore in practice. However, the US is a signatory and observer, but not a party to the CBD, which has implications for political feasibility and buy-in of a major player in the current geoengineering debate.

The CBD decisions on ocean fertilisation mainly incorporate the work under the LC/LP, adding own guidance while at the same time referring back to the LC/LP. Decision X/33 and the recent COP11 decision provide a comprehensive but legally soft and basic framework for geoengineering in general. The regulatory approach is an intended general restriction of geoengineering, based on the precautionary approach. The intended restriction is subject to three provisos, namely (i) that the restriction as a whole is a transitional measure intended to apply in the absence of regulatory mechanisms with specified attributes, (ii) that the restriction is to apply "until there is an adequate scientific basis on which to justify" geoengineering activities, which includes a comprehensive risk assessment, and (iii) that small-scale scientific research studies are exempted under certain conditions. However, the decision leaves it to parties to determine whether the conditions for some of the exceptions are met. The CBD also has not established few firm procedures such as reporting. There has also been little advancement on specific research and science so far, over and above the work under the LC/LP.

The logic underpinning the CBD -protecting biodiversity- is different from the UNFCCC - reducing emissions and adapting to climate change. While there is little danger that the CBD would be used as trade-off for mitigation, the different logic could also lead to conflicts. The CBD seems to seek a central role, and appears to have a mandate to do so, but the institutional set-up, the guidance provided so far and the future direction are not clear. In addition, the COP takes place only every two years. Against this background, the CBD decision on geoengineering does not mean that the question of whether and how address geoengineering is resolved. The existing rules and guidance are unlikely to be able to contain the risks posed by geoengineering or be able to avoid related political conflicts. The CBD has good potential for future development, but it is questionable whether it is suitable as the only, central regime governing geoengineering. The relationship to other fora should be further explored, e.g. the LC/LP.

There could also be a specific forum, e.g. technical scientific assessments of particular activities, but currently there is no institution that appears suitable. The IPCC is an established institution, but slow and ill-suited for case-by-case work, and it might be too close to the climate regime (see below). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is in the process of being established and will probably take years before it could be considered for such a role.

London Convention/Protocol

Ocean fertilisation experiments are now regulated quite comprehensively under the LC/LP including a risk assessment framework. The CBD has referred to and incorporated this work in

its own decisions, which extended the application of the guidance beyond the smaller number of Parties to the LC/LP. In 2010, the LC/LP agreed to continue its work towards providing a more comprehensive “control and regulatory mechanism” for ocean fertilisation.

Even though the parties enjoy a wide discretion for interpreting the LC/LP’s mandate, the LC/LP is limited to marine techniques. Although it includes major shipping states, it is a small regime with just over 40 parties and does not include the US. The LC/LP is spatially and materially limited to “dumping” activities in marine waters other than internal waters. However, in practice the LC/LP has been given a much wider scope by the parties in respect of ocean fertilisation, because the parties decided to further regulate “placement” rather than “dumping”. By defining the scope of what is *outside* the scope of dumping (placement), parties implicitly define what would be covered by it.

Currently the regulatory approach is a general prohibition through the definition of “placement” with the possibility of an exemption subject to certain procedural an material requirements combined in an "assessment framework". The framework are a normative effort to define "legitimate" research, but there could be concerns that the criteria are too numerous and restrictive as to be manageable without further elaborate procedures.

The governance efforts appear to be science-driven and the work of the LC/LP is lacking in transparency regarding e.g. access to documents.

However, the LC/LP has been the most dynamic regime regarding geoengineering so far, and its previous work has been successful in providing standards. There are recent proposals for a amendments to the LC/LP that would basically transform the current regulatory approach into a binding regime with a mandate to address all marine geoengineering techniques. Marine geoengineering techniques included in a positive list would be prohibited unless the listing provides that the activity or the subcategory of an activity may be authorized under a permit, which is subject to conditions contained in an annex. The proposal only lists ocean fertilisation. The proposed definition of marine geoengineering is markedly different from other definitions in that it refers to the potential to manipulate natural processes and, similar to the ENMOD Convention, to the potential for widespread, long-lasting or severe effects. The LC/LP does not seem suitable for a central regime covering geoengineering in general, but its technical work on ocean fertilisation could be taken up or provide a model for other specialised regimes.

The climate regime (UNFCCC/KP)

The climate regime (UNFCCC/KP) seems to be an obvious candidate for addressing geoengineering. The regime is global and the UNFCCC includes the US, and it has a strong institutional structure and a scientific underpinning linked to the work of the IPCC. Accordingly, there have been suggestions outside the climate negotiations to address geoengineering under the UNFCCC, for instance by a new protocol. However, the climate regime has not done any notable or systematic work on geoengineering yet. At this stage all options for introducing geoengineering could seriously jeopardize the current already over-complex climate negotiations and make geoengineering part of the trade-offs that are part of them. For instance, states might push for crediting some geoengineering techniques.

The climate regime is not well-suited for avoiding repercussions for mitigation. First, the regime is in a difficult phase of. Geoengineering could seriously disrupt the already over-complex negotiations. Second, allowing offsets and credits is part of the regime's core logic. International climate law is based on distinguishing mitigation and adaptation. Geoengineering does not easily fit into these categories. While all geoengineering techniques are intended to counteract climate change and its effects, they do not address emission

reductions, or how to adapt to a changed climate. Nevertheless, several geoengineering approaches can also be considered as climate change mitigation or adaptation, or both, for example, some ecosystem restoration activities. Geoengineering could for instance be addressed by the flexible mechanisms under the KP even if it is otherwise addressed elsewhere by a different instrument or institution. In this regard, the Kyoto Protocol has recently allowed CCS into the CDM, although CCS does not reduce the production of emissions. Apart from the issue of crediting, treating geoengineering as mitigation or adaptation could for instance have implications for funding institutions and their eligibility criteria. Finally, avoiding environmental and health impacts of action taken on climate change is not a prominent objective of the UNFCCC/KP.

To the extent that the CBD and other fora continue to address geoengineering, the need for co-ordination and consistency with climate objectives and law should be assessed.

Other institutions / fora

The OSPAR Convention is a regional environmental convention with limited spatial scope and 16 contracting parties not including the US. Its annexes differentiate between methods of pollution placement/activities, and its governance approach is similar to the distinction under the LC/LP between "dumping" and "placement". Decisions by the overarching OSPAR Commission can become binding through an opt-out procedure. Amendments of 2007 to allow for CCS in sub-seabed formations under certain conditions are in force for eight parties and are accompanied by further guidance. Ocean CO_2 storage in the water column and storage of CO_2 on the seabed (not: *under* the seabed) continue to be prohibited. Although OPSAR is a modern and flexible regime, and could potentially be relevant to ocean fertilisation and ocean liming, so far its main relevance is for sub-seabed CCS in relation to a limited number of parties and in a specific marine region.

Geoengineering will be part of the IPCC's Fifth Assessment Report. However, the first order drafts available so far made virtually no contribution to the governance debate, although the IPCC has the mandate to address issues beyond the mere physical science of geoengineering.

The UN General Assembly has a broad mandate and potentially high political legitimacy. However, it has done little work on geoengineering so far apart from endorsing the work on geoengineering under the LP/LP and the CBD. The sheer amount of topics it addresses and its often politicised work make it an unlikely candidate for specific geoengineering governance. However, it could potentially provide general guidance.

8.1.5 Options for Future Framework

From a governance perspective, the existing legal hooks are not strong enough to carry the political weight of geoengineering. We may think of different models of international geoengineering governance. First, geoengineering governance may be centralised in one institution, existing or new. Second, we may think of a system of specialised institutions developing next to each other without much coordination, for instance in respect of marine techniques, space, and atmosphere. Third, a central institution could establish global (minimum) standards comprehensively to be applied as a default, while leaving room for compatible, more specialised regimes. The existing framework seems to tend towards the third model, with the CBD as a central, but not sole comprehensive framework and LC/LP as specialised regimes. As the CBD and LC/LP have legally and politically occupied the field to

some extent, it might be useful to think along those lines for future governance.
Questions:

Generally Which governance structure would be able to fulfil the necessary governance criteria and functions while at the same time providing sufficient buy-in from actors who might be sensitive to perceived over-regulation or overly burdensome structures and requirements?

Question 1: Do we need an overarching international institutional framework, i.e. an international institution that addresses geoengineering comprehensively (all techniques, all aspects)?

Tentative Answer: A central institution has important advantages, in particular because it could establish minimum standards comprehensively across all geoengineering techniques. This would not necessarily mean that other institutions could not play a (more specialised) role.

Question 2: Could the CBD be/become this central institution or would we need to create it from scratch?

Tentative Answer: The CBD has already occupied the field to a certain extent and is the centre of gravity in current governance. It has started addressing geoengineering in general, from an overarching perspective. It might be logical to build on the CBD’s work. It is somewhat uncertain whether and to what extent the CBD framework could fulfill the governance criteria in the future, e.g. whether it would be possible to develop a more binding framework. However, the CBD's weaknesses do not seem sufficient reason to depart from the CBD at present. What institutional features/capacities are currently lacking in international geoengineering governance and how might they best be provided? Is the CBD well-suited to fulfill all necessary functions? How would the CBD need to be further developed?

Question 3: What role for other institutions (e.g. the LC/LP)?

Tentative Answer: Other institutions with a more specialised mandate such as the LC/LP as regards marine geoengineering techniques could allow to complement and deepen the global governance system selectively where there is particular demand, and they could provide important impulses for the further development of the global framework. However, are there promising candidates for all priority areas? Are there any major gaps that would need to be filled? How could potential conflicts and overlaps be addressed? What else might be needed to shape the relationship between relevant institutions (especially between the central and specialised ones)? How would the LC/LP and other specialised regimes need to be further developed? For instance, do we need more guidance in respect of aerosol injection techniques, where they are outside the scope of e.g. the LC/LP?

Question 4: Do we need a separate institution for (coordination of) scientific research/assessment? Which existing institution might be able to fulfill such a function? Is there a governance gap?

Tentative Answer: Research could be governed completely separately from deployment, but that would not seem to make much sense. It is more plausible to govern deployment and on this basis define exceptions or other special governance aspects for research. This requires clarity regarding what qualifies as "deployment" in contrast to research. Criteria could include the intention, the method employed, the scale of the activity, the physical risk or the funding. From the perspective of the physical risk of an activity, a large-scale research activity will pose the same physical risks as "deployment": only the method and purpose will be “scientific”, but the activity's potential impacts will be the same as deployment. On the other hand, it might be argued that following certain procedures and implementing safeguards is what constitutes research, and that therefore such activities should be treated differently.

Question 5: Which arrangements would be best suited to avoid the "moral hazard", i.e. how can geoengineering governance avoid incentives for reducing mitigation efforts or ambition?

Tentative Answer: Certainty on this point would possibly require amending the crediting rules under the climate regime. However, there is a high risk of opening the can of worms instead of sealing it more tightly. It might therefore be useful to elaborate geoengineering governance outside the climate regime that may be expected to frame geoengineering in terms of offsets against mitigation.

Question 6: What are other significant shortcomings or gaps in the current governance framework and how can it be improved?

Tentative Answer: Some suggested particular gaps include:

- Clearly separating scientific input and political decision-making. These two functions do not necessarily have to be performed at the same governance level.
  Where deployment does not seem to raise serious problems, e.g. with artificial trees, there is no need for governing research and also no need for defining the boundary between research and deployment.
- The US is not a party to the main regimes in the emerging governance complex.
- Another problem is that the context in which geoengineering is discussed in not reflected in the current normative framework: In general terms the debate is often framed as setting the potential impacts of geoengineering against avoiding the potential impacts of climate change. However, the text of most environmental treaties does not appear to provide for taking into account such overall “net” effects of an activity, and there are no corresponding decisions on who would evaluate such impacts and over what scale. The precautionary principle on its own does not resolve the conflict between avoiding the effects of global climate change vis a vis avoiding the risks of geoengineering.
- Aerosol injection is one of the potentially more realistic geoengineering techniques. However, it probably falls outside the scope of the LC/LP is not addressed by the specialised regimes for air quality.

Question 7: Is there a special need to specifically address private actors (based on the recent ocean fertilisation experiment off the Canadian coast)?

Tentative Answer: International law generally does not address private actors (exceptions are irrelevant here). Clear guidance regarding the obligations of states regarding private actors is desirable, e.g. a permit requirement.

8.2 Summary

Summary report of the Workshop on International Governance of Geoengineering, 5-6 November 2012, Ecologic Institute, Berlin, Germany. It was held as part of the UBA research project “Approaches to regulating the research and deployment of geoengineering” (FKZ 3711 11 101).

8.2.1 Introduction

The objective of the workshop was to discuss and assess specific governance options and proposals at the international level. A discussion paper was distributed before the workshop.

The workshop was under Chatham House rules and did not aim at reaching a consensus view on specific issues. The following minutes reflect views raised and discussed during the workshop. This summary does not report in detail the presentations given by speakers, which are collected as separate files and are part of the this report, as is the list of participants.

The workshop discussed and touched upon a number of issues in more or less depth. Some of the issues that were not discussed in detail are reported in bullet point format.

8.2.2 Background presentations

After presenting the background and aims of the workshop, a number of presentations set the scene for discussing specific issues. Ralph Bodle (Ecologic Institute) presented an overview of the state-of-play in selected fora, including an overview on existing international legal rules and regimes that are potentially relevant for geoengineering. Simone Schiele (CBD secretariat) explained the developments on geoengineering under the CBD, including decision X/20 of COP11 in October 2012. Harald Ginzky (UBA) presented the developments under the LC/LP, including its key resolutions (of 2008 and 2010), the adoption of a risk assessment framework for ocean fertilisation activities, and current proposals for a binding framework. Andy Parker (Harvard Kennedy School) presented the Solar Radiation Management Governance Initiative (SRMGI), an NGO-driven initiative with the aim to accelerate progress on the governance of geoengineering.

8.2.3 General points

General points discussed included:

- Geoengineering concepts had dual-use potential and therefore the intention behind a particular activity mattered for governance purposes.
- Geoengineering concepts could be classified into “encapsulated” activities, e.g. artificial trees, and open interventions with the physical environment.
- The criteria and objectives for governance design should distinguish between those that were essential and those that were merely desirable.
- The “criteria” in the discussion paper were not all criteria in the strict meaning of the term. Some were presumptions and objectives. Some were normative, some were political assessments, some both.
- It was noted that not all governance criteria listed in the discussion paper can be achieved at the same time and to the same degree. Different governance designs were likely to fulfil different criteria and objectives to different degrees. It was a political choice to be made, based on an assessment of these design options.
- There was a tension in the criteria between their purpose of restricting or facilitating geoengineering.

8.2.4 Governance design

Participants made the following points and discussed the following issues:

- It was clarified that the range of governance design options included more than the simple alternatives of either one central, general regime or specialised regimes without a centre of gravity. These were just basic options and did not imply a "one size fits all" governance structure. The institutional perspective was broader than just treaties.
- There was a governance gap in respect of SRM and atmospheric geoengineering.
- Some participants argued that a technique-specific governance was best, because specialised regimes were effective. It was also argued that it could be left open whether a central institution was needed.
- Any division of labour between governance regimes would ultimately require some form of coordination, regardless of preferred or actual roles. Forum shopping was likely, but regime conflict was not necessarily a bad thing. It could mean more compliance and enforcement opportunities and more options for trying out different governance designs.
- The ILC was mentioned as a possible option for developing rules and principles, possibly as part of their new mandate to work on protection of the atmosphere. However, the ILC might take a long time to develop such guidance and it might not be sufficiently specific to be more than a contributory guidance regarding useful for geoengineering
- An international geoengineering agency with a comprehensive mandate was highly unlikely
- Several participants stressed transparency and public participation as elements of "good governance". One participant argued that existing mechanisms were not very participatory.

The UNFCCC was at least an option, because the US is a party, it had a strong institutional structure and mechanisms. However, is had not been very successful in achieving its primary objective. Moreover, addressing geoengineering under the UNFCCC regime could open a can of worms (as argued in discussion paper).

8.2.5 In particular: CBD

The current and potential future role of the CBD was a recurrent issue during the workshop. Some participants questioned whether the CBD's mandate and expertise was sufficiently broad to address geoengineering in general and to give general guidance in this respect. It could be regarded as a sectoral agreement that is assuming a role it is unable to fulfil. For instance, small-scale research had no impact on biodiversity. In particular, how much further could CBD guidance go if in the medium-term there was no risk to biodiversity? In addition, geoengineering might benefit biodiversity, which could call into question the CBD's credibility. Participants also questioned the CBD's suitability from a technical and scientific point of view. For instance, the COP9 decision did not make scientific sense and used unsuitable terms such as "coastal waters". Some regarded the previous processes under the CBD as being politicised to an extent that might suggest regulatory capture. Others argued that it was for parties to decide whether an issue could be addressed by the CBD. Although not every party had been

comfortable with the CBD as a forum during the negotiations on previous decisions on geoengineering, no party was prepared to contend that the CBD was not an appropriate forum.

Some participants argued that the CBD was unsuitable because it did not include the US. However, no participant questioned the work under the LC/LP on these grounds.

Other issues raised included:

- The problems identified with the CBD were not structural, but due to political will.

8.2.6 Normative perspective

One participant questioned the premise that current international law did not prohibit geoengineering as such. The duty to prevent transboundary harm required due diligence that is proportionate to the potential harm. For ultra-hazardous activities such as geoengineering, this amounted to an obligation of *result*. The nature of geoengineering was such that it was impossible to exclude damages with sufficient certainty. From that point of view, geoengineering was prohibited without needing recourse to the precautionary principle. However, others challenged the notion that any geoengineering activity could be classified as ultra-hazardous.

One participant argued that a reversal of the burden of proof was impossible from a scientific point of view because it was impossible to prove a negative. However, it was pointed out that this was not true from a legal point of view, because the legal concept of "proof" was not necessarily the same as the scientific concept. It was possible and not uncommon in legal terms to require, and to perform, proving a negative, in order to e.g. obtain a permit or avoid liability.

A new treaty seemed was an unlikely option, as it was too complex and time consuming to negotiate. Existing mechanisms were the appropriate option. However, some new law-making would be required and could be not much faster to achieve than a new treaty. In addition, the ad hoc approach applied by the existing regimes so far led to governance gaps, e.g. regarding liability. A mechanism was needed to identify such gaps. Moreover, the existing governance regimes were not designed for close monitoring and dispute resolution, as this was unusual in environmental regimes. Arms control might provide examples and models in this regard.

Other issues raised included:

- Binding rules could be used as a "backstop"
- The LC/LP and the recent proposals under this regime showed the possible development of geoengineering governance from soft law to hard law
- Whether customary law was actually of *practical* relevance.
- There are different negotiating cultures in different regimes, which are e.g. influenced by which ministry is leading at the national level.

8.2.7 Moral hazard

Some particpants questioned why one of the objectives of geoengineering governance should be to ensure that geoengineering remained a "plan B". If geoengineering techniques pproved to be safe and effective, there was no reason to refrain from using them as measures to adrress climate change. This would be not be a precautionary approach. To the contrary, it was also

precautionary to gain more knowledge about whether geoengineering could be an option. However, it was also argued that governance should prevent a lock-in. An exit strategy should be part of the governance structure.

Others clarified that an objective to keep geoengineering as a “plan B” did not necessarily mean strict sequencing in the sense of prohibiting geoengineering research until the point when geoengineering was needed or wanted. Instead, “plan B” was meant as indicating a political priority. It was also noted that so far almost all reports and policy suggestions emphasise that reducing emissions should be the priority. This could be undermined if, for instance, funding for research would be redirected significantly towards geoengineering. Even if the funding going towards geoengineering was considerably less than that for mitigation, such redirection could send an important policy signal away from mitigation.

One specific instance of the moral hazard could be potential demands for obtaining credits for geoengineering activities, e.g. under the climate regime. It was argued that the LC/LP approach had solved this problem within its remit, because deployment was not allowed a permit for research required that there was no (commercial) gain from the research activity.

Other points raised inclued:

- Whether the chance of securing intellectual property rights were a different type of moral hazard. It was suggested that this could be another reason for differentiating between geoengineering techniques.
- One way to address the moral hazard could be that for each amount of funding for geoengineering, another set amount had to go into mitigation.

8.2.8 Research

Participants discussed whether there was a premature focus on governance of deployment instead of governance of research. One participant described the relationship in terms of control of research and prohibition of deployment. How to address research was not a irrelevant, as it had implications for where funding might go to. On the other hand it was pointed out that this was an issue for funding bodies and that funding for geoengineering was currently only a fraction of funding for research into mitigation and adaptation. One participant said that there were examples of research restrictions under international law and that there was no general privilege for research. A stepwise approach as in EU regulation of GMO could be a suitable model.

Other points discussed included:

- A clear line was needed that indicated which activities were allowed without prior permission. Whether the objective to coordinate science and research in order to obtain valid results was a minor issue compared to other, more relevant governance objectives.
- UNCLOS provided detailed rules on research.
- The work under LC/LP had brought together different actors and discipines
- A suggested governance model for research presented by participants. The regulatory approach was general prohibition pending a permit. The concept was based on the LC/LP for marine issues , while leaving open the forum for SRM and atmospheric techniques. It suggested binding decisions for marine geoengineering and recommendations for SRM and atmospheric techniques.

- Some participants suggested that the science community generally had concerns about the CBD.

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9.2 List of treaties

Short title	Official Title	Source
Basel Convention	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 22 March 1989, entered into force on 5 May 1992	United Nations Treaty Series, vol.1673, p. 57.
Cartagena Protocol	Cartagena Protocol on Biosafety to the Convention on Biological Diversity, 29 January 2000, entered into force 11 September 2003	United Nations Treaty Series, vol. 2226, p. 257.
CBD	Convention on Biological Diversity, 5 June 1992, entered into force on 29 December 1993	United Nations Treaty Series, vol. 1760, p. 79
CCD	Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa, 14 October 1994, entered into force on 26 December 1996	United Nations Treaty Series , vol. 1954, p. 3
Chicago Convention	Convention on International Civil Aviation , 7 December 1944, entered into force on 26 January 1973	United Nations Treaty Series, vol. 15, p. 295
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora, 3 March 1973, entered into force 1 July 1975	United Nations Treaty Series, vol. 993, p. 243
CMS	Convention on the Conservation of Migratory Species of Wild Animals, 23 June, 23 June 1973, entered into force on 1 July 1975	United Nations Treaty Series, vol. 1651, p. 355.
ENMOD Convention	Convention on the Prohibition of Military Use of Environmental Modification Techniques, 10 December 1976, entered into force on 5 October 1978	United Nations Treaty Series, vol. 1108, p. 151
Espoo Convention	Convention on Environmental Impact Assessment in a Transboundary Context, 25 February 1991, entered into force on 10 September 1997	United Nations, Treaty Series, vol. 1989, p. 309
Gothenburg Protocol	Protocol to the 1979 Convention on Long-range Transboundary Air Pollution	Document of the Economic and Social Council EB.AIR/1999/1

	to Abate Acidification, Eutrophication and Ground-level Ozone, 30 November1999, entered into force on 17 May 2005	
Helsinki Protocol	Protocol to the 1979 Convention on Long-Range Transboundary Air pollution on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent, 14 June 1985, entered into force on 2 September 1987	United Nations Treaty Series , vol. 1480, p. 215.
ICSECR	International Covenant on Economic, Social and Cultural Rights, 16 December 1966, entered into force on 23 March 1976	United Nations Treaty Series, vol. 993, p. 3
International Air Services Transit Agreement	International Air Services Transit Agreement	www.state.gov (the US is the depositary)
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture, 3 November 2001, entered into force on 29 June 2004	United Nations Treaty Series, vol. 2400, p. 303
KP	Kyoto Protocol to the United Nations Framework Convention on Climate Change, 11 December 1997, entered into force 15 February 2005	United Nations, Treaty Series, vol. 2303, p. 148
LC	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 29 December 1972, in force on 30 August 1975	United Nations Treaty Series, vol 1046, p. 120
Liability Convention	Convention on International Liability for Damage Caused by Space Objects, 29 November 1971, entered into force on 1 September 1972	United Nations Treaty Series, vol. 961, p. 187
LP	Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 07 November 1996, entered into force on 24 March 2006	36 ILM (1997)
LRTAP Convention	Convention on Long-range Transboundary Air Pollution, 13 November 1979, entered into force on 16 March 1983	United Nations Treaty Series , vol. 1302, p. 217.
MARPOL	International Convention for the Prevention of Marine Pollution from	United Nations Treaty Series, vo. 1340, p. 184

	Ships, 2 November 1973, entered into force on 2 October 1983	
Montreal Protocol	Montreal Protocol on Substances that Deplete the Ozone Layer, 16 September 1987, entered into force 1 January 1989	United Nations Treaty Series , vol. 1522, p. 3
Moon Treaty	Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, 5 December 1979, entered into force on 11 July 1984	United Nations Treaty Series, vol. 1363, p. 3
Nagoya Protocol	Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity, 29 October 2010, not yet in force	Doc.: UNEP/CBD/COP/DEC/X/1 of 29 October
Oslo Protocol	Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Further Reduction of Sulphur Emissions, 14 June 1994, entered into force on 5 August 1998	United Nations Treaty Series, vol. 2030, p. 122; Doc. EB.AIR/R.84; E/ECE/ENHS/001/2002/l (Adoption of adjustments).
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic, 22 September 1992, entered into force 25 March 1998	United Nations Treaty Series, vol. 2354, p. 67
Outer Space Treaty	Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 19 December 1966, entered into force on 10 October 1967	United Nations Treaty Series, vol. 610, p. 205
Ozone Convention	Vienna Convention for the Protection of the Ozone Layer, 22 March 1985, entered into force 22 September 1988	United Nations Treaty Series, vol. 1513, p. 293.
Ramsar Convention	Convention Convention on Wetlands of International Importance, 2 February 1971, entered into force on 21 December 1975	United Nations Treaty Series, vol. 996, p. 245
Rotterdam Convention	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, 10 September 1998, entered into force on 24 February 2004	United Nations Treaty Series, vol. 2244, p. 337.
SEA Protocol	UNECE Protocol on Strategic Environmental Assessment to the	UN Doc. ECE/MP.EIA/2003/2

	Convention on Environmental Impact Assessment in a Transboundary Context, 21 March 2003, entered into force on 11 July 2010	
Stockholm Convention	Stockholm Convention on Persistent Organic Pollutants, 22 May 2001, entered into force on 17 May 2004	United Nations Treaty Series, vol. 2256, p. 119.
UNCCD	United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa, 14 October 1994, entered into force on 26 December 1996	United Nations Treaty Series , vol. 1954, p. 3
UNCLOS	United Nations Convention on the Law of the Sea, 10 December 1982, entered into force on 16 November 1994	United Nations Treaty Series , vol. 1833, p. 3
UNFCCC	United Nations Framework Convention on Climate Change, 9 May 1992, entered into force 21 March 1994	United Nations Treaty Series , vol. 1771, p. 107
UPOV Convention	International Convention for the Protection of New Varieties of Plants, 2 December 1961, entered into force on 10 August 1968	United Nations Treaty Series, vol. 815, p. 89
VCLT	Vienna Convention on the Law of Treaties, 23 May 1969, entered into force on 27 January 1980.	United Nations, Treaty Series, vol. 1155, p. 331
World Heritage Convention	Convention Concerning the Protection of the World Cultural and Natural Heritage, 16 November 1972, entered into force 17 December 1975	United Nations Treaty Series, vol. 1037, p. 151