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Regulating Geoengineering in International Environmental Law

*Tuomas Kuokkanen and Yulia Yamineva**

Geoengineering can be viewed in two ways: as a potential cause for further environmental harm or as an option for addressing climate change in addition to reducing greenhouse gas emissions. So far, the existing legal response in multilateral environmental agreements has been in the former domain. This article shows that this approach does not necessarily provide comprehensive legal regulation of geoengineering as it appears to leave many governance and regulatory gaps. At the same time, developing a new legal instrument on geoengineering does not seem to be feasible for a number of political and other reasons. Therefore, we propose that the most appropriate option for the time being would be to continue with the current approach but enhance inter-regime cooperation and interaction. The article discusses possible formats for such regime cooperation.

I. Introduction

Problem solving is one of the key functions of international law. In the environmental field, various approaches have been developed to deal with specific problems. In some cases the identification of a particular environmental problem is straightforward, for instance, in the case of marine or air pollution, and this points to a clear problem-solving strategy – reducing the amount of pollutants. In other cases defining a problem is more challenging or even controversial, and hence how to solve it remains unclear. The latter appears to be the case in relation to geoengineering.

Geoengineering is most commonly defined as a large-scale intervention in the Earth's climate system in order to moderate global warming without actually reducing greenhouse gas emissions.¹ Geoengineering techniques can be divided into two

groups: carbon dioxide removal (CDR) and solar radiation management (SRM) techniques.² While CDR techniques aim to remove CO₂ from the atmosphere, SRM approaches seek to reflect a certain portion of the Sun's light and heat back into the space. The purpose of geoengineering activities is therefore to cool the Earth's climate. However, some geoengineering techniques carry unknown and potentially large risks for the environment. There is also a concern that some nations might use these techniques to manipulate the climate for their own benefit.

So far, geoengineering has been regarded mainly as a potential problem rather than a management tool option for addressing climate change in addition to reducing greenhouse gas emissions and adaptation to climate change impacts. This article shows that this approach does not provide a comprehensive legal response to geoengineering, leading to governance and regulatory gaps. In doing so, the article first gives a brief overview of the existing general rules of international law and international environmental law applicable to geoengineering as well as of the specific rules adopted so far under the London Convention/London Protocol and Convention for Biological Diversity. The article then shows how regulating geoengineering activities through existing environmental protection regimes may lead to a governance and legal landscape that is

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¹ See Royal Society, *Geoengineering the Climate: Science, Governance and Uncertainty* (London: Royal Society, 2009), ix and 1.

² Ralph Bodle, "Climate Law and Geoengineering", in Erkki Hollo, Michael Mehling and Kati Kulovesi (eds.), *Climate Change and the Law* (Dordrecht: Springer, 2013), 447, at 450–456.

fragmented, incoherent and incomprehensive. It concludes with the discussion on possible options for enhancing inter-regime cooperation to fill resulting regulatory gaps.

II. Current State of Play

International law does not address geoengineering as such through legally binding instruments. This does not mean that geoengineering activities would be conducted in a legal vacuum. Indeed, both rules and procedures of general international law and of environmental treaties would apply to geoengineering.³

With regard to general international law, one can first refer to jurisdictional rules containing rules of territorial and extra-territorial sovereignty. These general rules deal with legislative, judicial and enforcement jurisdiction. In relation to geoengineering, such jurisdictional rules are relevant as they allocate competence as to which State can exercise authority over whom and in what circumstances.⁴ For example, a private actor might conduct geoengineering activities either on state territory or outside state territory, let us say, on the high seas. In those circumstances, it is important to determine which State is exercising jurisdiction over such a private actor.

Furthermore, general principles of law and rules of customary law would be applicable. For instance, States have a duty to prevent transboundary pollution⁵ and to carry out an environmental impact assessment for all large-scale projects.⁶ In case of a

possible damage, the doctrine of State responsibility would be applicable. Moreover, States could have recourse to dispute settlement means.

In addition to general international rules, States have concluded over the recent years a large number of global and regional multilateral agreements dealing with various environmental problems. Many of these agreements are relevant in relation to geoengineering. For example, with respect to injecting sulphur dioxide into atmosphere or stratosphere, the Convention on Long-range Transboundary Air Pollution and its protocols dealing with sulphur emissions would be relevant.⁷ Similarly, the Vienna Convention and the Montreal Protocol⁸ on the protection of the ozone layer is applicable in relation to techniques that might impact the ozone layer.

As far as specific rules are concerned, to this point, only the parties to the 1996 Protocol of the London Dumping Convention (LC/LP) and to the Convention on Biological Diversity (CBD) have addressed geoengineering. The work of the LC/LP has focused on ocean fertilization. In 2008, the LC/LP adopted a resolution where it agreed that “given the present state of knowledge, ocean fertilization activities other than legitimate scientific research should not be allowed.”⁹ It later also adopted an assessment framework to make decisions on which activities qualify as “legitimate scientific research.”¹⁰ Thereafter, the LC/LP has continued to work towards “providing a global, transparent, and effective control and regulatory mechanism for ocean fertilization activities.”¹¹

3 For a more comprehensive overview of existing international law applicable to geoengineering activities, see Convention on Biological Diversity, Regulatory Framework for Climate-related Geoengineering Relevant to the Convention on Biological Diversity, UN Doc. UNEP/CBD/SBSTTA/16/INF.29, 2 April 2012, available at <www.cbd.int/SBSTTA> (last accessed on 30 April 2013); Catherine Redgwell, “Geoengineering the Climate: Technological Solutions to Mitigation – Failure or Continuing Carbon Addiction”, 5 *Carbon & Climate Law Review* (2011), 178, at 188; Bodle, “Climate Law and Geoengineering”, *supra*, note 2.

4 For a general discussion on allocation of competence, see Rosalyn Higgins, *Problems and Process: International Law and How We Use It* (Oxford: Clarendon Press, 1994), at 56–77.

5 According to customary international law states have an obligation to ensure that activities within their jurisdiction or control do not cause damage to the environment or of areas beyond national jurisdiction. The principle dates back to Roman law principle *sic utere tuo ut alienum*. The principle has been referred to in several decisions by the International Court of Justice as well as in several conventions and declarations.

6 See Case Concerning Pulp Mills on the River Uruguay (Argentina v. Uruguay), Judgement, 20 April 2010, I.J.J. Reports 2010, paras. 204–206.

7 Convention on Long-range Transboundary Air Pollution (CLRTAP), Geneva, 13 November 1979, in force 16 March 1983, 18 *International Legal Materials* (1979), 1442.

8 Convention on the Protection of the Ozone Layer, Vienna, 22 March 1985, in force 22 September 1988, 26 *International Legal Materials* (1987), 1529; Protocol on Substances that Deplete the Ozone Layer, Montreal, 16 September 1987, in force 1 January 1989, *International Legal Materials* (1987), 154.

9 Resolution LC-LP.1 (2008) on the Regulation of Ocean Fertilization, adopted on 31 October 2008, 9 December 2008, Report of the 30th Consultative Meeting of the Contracting Parties to the London Convention and 3rd Meeting of the Contracting Parties to the London Protocol (LC 30/16), Annex 6, para. 8.

10 Resolution LC-LP.2 (2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization, adopted on 14 October 2010, 9 November 2010, Report of the 32nd Consultative Meeting of the Contracting Parties to the London Convention and 5th Meeting of the Contracting Parties to the London Protocol, LC 30/16, Annex 6.

11 See Resolution LC-LP.2 (2010) para. 11, *ibid*.

The CBD adopted a decision in 2010 affirming the approach taken by the LC/LP on ocean fertilization. The decision also addressed geoengineering in general, stating that no climate-related geoengineering with the exception of small scale research should take place until certain conditions are met.¹² In 2012, the CBD adopted a further decision on geoengineering where it mainly confirmed its earlier decision.¹³ However, unlike LC/LP, the CBD so far has not elaborated on criteria for small scale research and conditions under which it is allowed.

III. Challenges Posed by Geoengineering in International Environmental Law

The decisions on regulating geoengineering under the LC/LP and CBD do not, however, address the subject in a comprehensive manner. These decisions reflect concerns over potential adverse effects of geoengineering techniques rather than potential cooling, and thus beneficial, effects of such techniques for the climate. This is understandable taking into account the specific scope of both treaties. The main objective of international environmental regimes is to provide sufficient regulation to protect the environment; therefore, with regard to geoengineering activities their main concern would be to prevent potential negative impacts on the environment. For instance, the London Protocol aims at protecting and preserving the marine environment from all sources of pollution and thus prohibits dumping of waste or any other matter with the exception of those listed in its annex.¹⁴ The objectives of the CBD are conservation and sustainable use of biodiversity in terrestrial, marine and other ecosystems.¹⁵ In regulating geoengineering, these regimes primarily focus on *limiting* geoengineering activities to prevent any possible negative impacts.

This however reflects only one angle to look at geoengineering where geoengineering is itself defined as a problem that may cause environmental harm, for example eutrophication or depletion of the ozone layer, or marine pollution. Another way to consider geoengineering would be to frame it as an option to manage anthropogenic climate change in addition to reducing greenhouse gas emissions and adaptation to climate change impacts. In the former case, geoengineering is a problem itself that should be regulated while in the latter case it rather represents an additional management tool which might have negative impacts. Hence, depending on how geoengineering is defined, it demands one or another regulatory or management philosophy.

So far, the legal response has only been in the domain where geoengineering is framed as a cause of potential negative impacts on the environment. There are no specific rules regulating and managing geoengineering activities as an option to address climate change. We argue that this limited approach leads to an incomprehensive, incoherent and fragmented legal picture. Focusing only on the prevention of potential negative impacts leaves key areas relating to geoengineering activities unregulated. Such regulatory gaps for instance include:

- Governance issues. This includes the question as to where, under which international regime/regimes or institution/institutions, geoengineering is housed and therefore what international body makes decisions relating to geoengineering including risk assessment, environmental impact assessment¹⁶ or even potential large-scale deployment of new technologies. While negotiation of a new international legal instrument on geoengineering may be premature at this point, there is still a pressing need for clarity on what an appropriate policy arena at the international level is where geoengineering issues can be brought up for discussion. Such policy discussion should include issues relating to economic, political,

12 Convention on Biological Diversity, Decision X/33, Biodiversity and Climate Change, UN Doc. UNEP/CBD/COP/DEC/X/33, 29 October 2010, available on the Internet at <<https://www.cbd.int/decision/cop/default.shtml?id=12299>> (last accessed on 30 April 2013).

13 Convention on Biological Diversity, Decision XI/20, Climate-related Geoengineering, UN Doc. UNEP/CBD/COP/DEC/XI/20, 5 December 2012, available on the Internet at <<http://www.cbd.int/decisions/cop/?m=cop-11>> (last accessed on 30 April 2013).

14 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Protocol), London, 7 November 1996, in force 24 March 2006, 36 *International Legal Materials* (1997), 7, Articles 2 and 4.

15 Convention on Biological Diversity, Nairobi, 22 May 1992, in force 29 December, 1993, 31 *International Legal Materials* (1992), 818, Article 1.

16 With the exception of legitimate scientific research on ocean fertilisation regulated under the LP/LC.

- security and moral aspects of conducting activities to engineer the climate. More specifically, it can bring nations and various stakeholders together to elaborate on potential objectives and principles of international regulation of geoengineering.
- Science-policy interface. Scientific and technical input carries a high importance on all matters relating to geoengineering, and hence issues as to how this input is generated and synthesized and how it enters a policy discussion need resolution. The Intergovernmental Panel on Climate Change (IPCC) already covers geoengineering in its Fifth Assessment Report to be finalized in 2013–2014. However, the IPCC may be ill-suited for dealing with novel scientific issues given that it only assesses existing peer-reviewed literature. At the same time, the IPCC report can play a catalyzing role for further scientific research on geoengineering.
 - Reporting and monitoring. There is currently no international body monitoring ongoing geoengineering research projects of all types cutting across CDR and SRM techniques. Similarly, there is no reporting and monitoring structure for collecting information, and most importantly, for analyzing how these activities can potentially contribute to decreasing greenhouse gas concentrations in the atmosphere. At this point, such monitoring functions could be assigned to international bodies according to where geoengineering activities take place – oceans, upper atmosphere etc. If, hypothetically speaking, geoengineering techniques are deployed at a large scale, these monitoring tasks would sit best under the UN Framework Convention on Climate Change (UNFCCC) umbrella not only because of its climate objectives but also in order to take advantage of its extensive and now expanding reporting infrastructure.¹⁷
 - Incentives. It can be argued that simply limiting geoengineering on the grounds of preventing potential negative impacts on the environment does not provide a regulatory environment for promoting technological innovation. This raises a whole array of issues regarding the role of the private sector in developing and deploying geoengineering technologies, such as intellectual property rights, responsible innovation etc. Should certain geoengineering techniques be recognized as eligible for crediting under future

market mechanisms under the UNFCCC, this will require development of new rules, and might potentially lead to conflicts with existing limiting regulations under the LC/LP and CBD.

- Liability, compensation, and insurance issues.¹⁸ While the customary rules on state responsibility provide the general conditions under which a state is responsible for wrongful geoengineering acts or omissions,¹⁹ there would be a need for more specific liability rules. The recent discussion on liability rules for carbon capture and storage might provide some useful examples in this regard.²⁰

IV. Regulatory Options

There are different options to address the above mentioned regulatory and governance gaps. First, an overarching treaty could be elaborated to deal with all geoengineering aspects in a comprehensive manner. Second, one could continue with the current ad hoc approach in regarding existing rules mainly sufficient and elaborating specific rules only to deal with particular techniques. Third, one could continue with the current approach but enhance regime cooperation and interaction. We argue that the last option is the most appropriate one as presented below.

To begin with, there are a number of reasons to counsel against the establishment of an overarching treaty on geoengineering which are explored in more detail elsewhere.²¹ These include potential difficulties in engendering agreement by States on the principles, contents and appropriate negotiating forum for such a treaty. Also, negotiations are likely to be highly polarized and politicized and hence

17 There are however serious considerations against bringing the issue of geoengineering into the UNFCCC domain at the current point of the negotiation process. See Bodle, “Climate Law and Geoengineering”, *supra*, note 2, at 466.

18 CBD, “Regulatory Framework”, *supra*, note 3, at p. 50.

19 See Bodle, “Climate Law and Geoengineering”, *supra*, note 2, at 461.

20 See, e.g., Chris Clarke, “Long-term Liability for CCS: Some Thoughts about Specific Risks, Multiple Regimes and the EU Directive”, in Ian Havercroft, Richard Macrory, and Richard B. Stewart (eds.), *Carbon Capture and Storage: Emerging Legal and Regulatory Issues* (Oxford: Hart Publishing, 2011), 179.

21 See Bodle, “Climate Law and Geoengineering”, *supra*, note 2, at 464–466.

protract for a long time without any meaningful outcome. Furthermore, some argue that commencing negotiations on a treaty on geoengineering would be unwise at the time when the negotiations under the UNFCCC are undergoing a critical stage of developing a future mitigation and adaptation framework. To sum up, in the words of Catherine Redgwell, at this point, “a multilateral geoengineering treaty is neither likely nor desirable.”²²

As geoengineering is still only a plan B option, it appears that there are no compelling reasons at this stage to start elaborating new rules. Indeed, existing general international law and environmental treaties appear to be sufficient to deal with geoengineering issues. In particular, in the UNFCCC context, a new proposal to address geoengineering issues could interfere in a negative manner with the ongoing, already sensitive negotiations on a future instrument. Moreover, such a proposal might give a wrong message that mitigation and adaptation measures are not topical any longer and the focus is shifting towards engineering the climate.

At the same time, continuing with the current approach to address geoengineering issues in various sectorial regimes, like the CBD and the LC/LP, does not appear to be problematic because current and planned geoengineering activities are at a highly limited scale. However, there is a concern that such a sectorial approach might lead to fragmentation which in turn can produce inefficient and even conflicting results in the same way it was pointed out by the study group of the International Law Commission on fragmentation.²³ Discussing the emergence of new and special types of law or regimes, the group noted that “[e]ach rule-complex and ‘regime’ comes with its own principles, its own form of expertise and its own ‘ethos’, not necessarily

identical to the ethos of neighboring specialization.”²⁴ While the study group focused on relations between neighboring regimes, such as environmental and trade law, a fragmented approach might also occur between multilateral environmental agreements.

In order to avoid fragmentation and incoherence, the best option in the current circumstances would be to continue with existing regimes but in a coordinated and interactive manner. Such regimes can include environmental protection regimes such as the LC/LP, the CBD and others, and the UNFCCC regime. Regime interaction has gained more prominence in the recent years both in practice and theory.²⁵ It is now common that multilateral environmental regimes cooperate with treaties that operate in the same field. International environmental law and the existing synergies provide several formats for regime cooperation.

Joint liaison groups are one way for inter-regime interaction. For example, the UNFCCC has a wide range of cooperative activities with other conventions and bodies. With regard to environmental agreements, such activities include cooperation with the two other Rio Conventions, these being the CBD and the United Nations Convention to Combat Desertification.²⁶ A Joint Liaison Group among the three conventions was established in 2001 and has focused primarily on information exchange.²⁷

Another example of enhancing synergies among multilateral environmental regimes is provided by the chemicals’ agreements - the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal,²⁸ Rotterdam Convention on Prior Informed Consent²⁹ and Stockholm Convention on Persistent Organic Pollu-

22 Redgwell, “Geoengineering the Climate”, supra, note 3, at 188.

23 For a comprehensive discussion, see Martti Koskenniemi, *Fragmentation of International Law: Difficulties Arising from the Diversification and Expansion of International Law. Report of the Study Group of the International Law Commission* (Helsinki: Erik Castrén Institute, 2007). The publication contains the final report of the International Law Commission’s Study Group on Fragmentation. See also Harro van Asselt, “Managing the Fragmentation of International Climate Law”, in Erkki J. Hollo, Kati Kulovesi, Michael Mehling (eds.), *Climate Change and the Law* (Dordrecht: Springer, 2013), 329 et seq.

24 Koskenniemi, *Report of the Study Group*, supra, note 23.

25 For a comprehensive discussion, see Margaret A. Young (ed.), *Regime Interaction in International Law: Facing Fragmentation* (Cambridge: Cambridge University Press, 2012).

26 United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and or Desertification, Particularly in Africa, Paris, 17 June 1994, in force 26 December 1996, 33 *International Legal Materials* (1994), 1309.

27 Farhana Yamin and Joanna Depledge, *The International Climate Change Regime: A Guide to Rules, Institutions and Procedures* (Cambridge: Cambridge University Press, 2004), 525–527.

28 Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, Basel, 22 March 1989, in force 5 May 1992, 28 *International Legal Materials* (1989), 657.

29 Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, Rotterdam, 11 September 1998, in force 24 February 2004, 38 *International Legal Materials* (1999), 1.

tants.³⁰ The synergies process was launched in 2006 and 2007 through separate but similar decisions in each of the three conventions. The process led first to the establishment of an ad hoc joint working group among the three Conventions³¹ and, subsequently, to extraordinary simultaneous meetings of the COPs of the Rotterdam, Basel and Stockholm Conventions.³² The objective of holding the meetings in a coordinated manner among the three Conventions has been, inter alia: to strengthen the implementation of the three conventions at the national, regional and global levels; promote coherent policy guidance; and allow for a more effective and coherent decision-making on policy, technical and budget matters which will help identify new concrete areas where synergies can be achieved.³³ While the synergies process among the three conventions has been innovative, it is still too early to say whether that process would provide a model for enhancing synergies among multilateral environmental agreements (MEAs) on other issues, such as for instance geoengineering.

Another interesting recent development with respect to international environmental governance at large is the strengthening and upgrading of the United Nations Environment Programme (UNEP). The UN General Assembly adopted in December 2012 a resolution to that effect and also established universal membership of its governing body.³⁴ The increasing role of UNEP might provide opportunities for UNEP to address new global issues, such as geoengineering. For example, UNEP could kick start an international policy discussion on geoengineering and more technical work on the issue.

UN-wide initiatives can also be an option for coordinating issues related to geoengineering

across various conventions and bodies. The UN System Chief Executives Board for Coordination is the highest-level forum for coordination of activities of various UN bodies. Its High-Level Committee on Programs has for example established three inter-agency mechanisms to increase coherence across the UN system: UN-Water, UN-Energy, and UN-Oceans.³⁵ In 2000, it also established a Working Group on Climate Change with the aim, inter alia, “to facilitate a coherent approach and joint action of the UN system on climate change.”³⁶

When considering any of these approaches, their limitations should also be kept in mind. Effectiveness of different formats varies and depends on a mandate, working modalities, leadership, oversight and other elements. Simply setting an arrangement for regime cooperation does not necessarily lead to enhanced cooperation as many factors, like for example inter-institutional competition, can hinder the progress. Nevertheless, in the absence of one overarching instrument on geoengineering, increased cooperation among MEAs can promote a more comprehensive and coherent approach to regulating geoengineering and help avoid further fragmentation of law and governance. In addition, it is important to ensure an appropriate coordination of the MEA issues at the national level.

V. Conclusions

There are various rules of international law such as principles, customary international law, environmental treaties and specific rules addressing geoengineering under the LC/LP and CBD that are applicable to geoengineering activities. So far, the

30 Convention on Persistent Organic Pollutants, Stockholm, 22 May 2001, in force 17 May 2004, 40 *International Legal Materials* (2001), 532.

31 Report of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal on its Eighth Meeting, Annex I, Decision VIII/8 (2007); Report of the Conference of the Parties to the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade on the Work of its Third Meeting, Decision RC-3/8 (2006).

32 The first simultaneous extraordinary meeting of the Conferences of the Parties (COP) of the three Conventions were held in Bali, Indonesia, in 2010 while the second round of simultaneous COPs was held in Geneva in May 2013. On the work of the AHJWG, see, for example, Kerstin Stendahl, “Enhancing Cooperation and Coordination among the Basel, Rotterdam and Stockholm Conventions”, in Tuula Kolari and Ed Couzens (eds),

International Environmental Lawmaking and Diplomacy Review 2007 (Joensuu: University of Joensuu, 2008), 127–141.

33 See the homepage on synergies among the Stockholm, Rotterdam and Basel Conventions, available on the Internet at <<http://synergies.pops.int/2013COPsExCOPs/Overview/tabid/2914/mctl/ViewDetails/EventModID/9163/EventID/297/xmid/9411/language/en-US/Default.aspx>> (last accessed on 30 April 2013).

34 See 67th Session of the UNGA, Resolution 67/213, Report of the Governing Council of the United Nations Environment Programme on its Twelfth Special Session and the Implementation of Section IV.C, entitled “Environmental Pillar in the Context of Sustainable Development”, of the outcome document of the United Nations Conference on Sustainable Development.

35 See website of the UN System Chief Executives Board for Coordination, available on the Internet at <<http://www.unsceb.org>> (last accessed on 30 April 2013).

36 *Ibid.*

environmental regimes have responded to geoengineering as a threat, a potential cause for further environmental damage. In this prism, existing specialized norms on geoengineering have a limiting nature. This approach appears to leave key areas relating to geoengineering unregulated and thereby may lead to an incomprehensive and distorted legal and governance picture.

At the same time, commencing negotiations on a new legal instrument is not feasible at this point for a number of reasons. Nevertheless, there is a need for more coherence in the approach taken by MEAs.

This can be done through increased regime cooperation and a variety of formats is available in this regard.

Reducing emissions of greenhouse gases should be the primary aim of a current policy response to climate change. This said, there may be a pressing need in future for an international policy arena to engage nations and stakeholders in deliberating on economic, political, security, environmental and moral aspects of engineering the climate. While in the foreseeable future developing a new legal instrument on geoengineering is not necessary, initiating a policy discussion and catalyzing research are of key importance. This policy debate can provide a basis for any further regulation or legal instrument should those be deemed necessary in the future. Commencing a wide policy discussion on geoengineering options as early as possible will help avoid “the pacing problem” whereby technologies develop faster than corresponding legal and ethical responses.³⁷

³⁷ “The pacing problem” has been researched in relation to emerging technologies such as biotechnology, genetic testing, nanotechnology and others. See, for example, Gary Elvin Marchant, Braden R. Allenby, and Joseph R. Herkert (eds), *The Growing Gap Between Emerging Technologies and Legal-Ethical Oversight: The Pacing Problem* (Dordrecht: Springer, 2011).