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Felix Beck

Self-Spreading Biotechnology and International Law

Prevention, Responsibility, and Liability in a Transboundary Context

Nomos

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Volume 316

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Berlin, June 2022 *Felix Beck*

Overview of Chapters

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Table of Abbreviations

ACHR	American Convention on Human Rights
AHTEG	Ad Hoc Technical Group of Experts
AIA	Advance Informed Agreement
AJIL	American Journal of International Law
Am. J. Trop. Med. Hyg.	The American Journal of Tropical Medicine and Hygiene
Appl. Biosaf.	Applied Biosafety
ARSIWA	Articles on the Responsibility of States for Internationally Wrongful Acts
Asia Pac. JEL	Asia Pacific Journal of Environmental Law
ASIL Proceedings	Proceedings of the American Society of International Law at its Annual Meeting
BCH	Biosafety Clearing-House
BSL	Biosafety Level
BSWG	Open-Ended Ad Hoc Working Group on Biosafety
BWC	Biological Weapons Convention (Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction)
BYIL	British Yearbook of International Law
Canadian YBIL	Canadian Yearbook of International Law
Cas	CRISPR-associated proteins
CBD	Convention on Biological Diversity
CESCR	Committee on Economic, Social and Cultural Rights
CJEU	Court of Justice of the European Union
CMEA	Council for Mutual Economic Assistance
Colum. J. Envt'l L.	Columbia Journal of Environmental Law

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COP	Conference of the Parties
COP-MOP	Conference of the Parties to the Convention on Biological Diversity serving as the meeting of the Parties to the Cartagena Protocol on Biosafety
CP	Cartagena Protocol
CRAMRA	Convention on the Regulation of Antarctic Mineral Resource Activities
CRISPR	Clustered regularly interspaced short palindromic repeats
crRNA	CRISPR RNAs
DARPA	Defense Advanced Research Projects Agency
Denver J. Int'l. L. & Pol'y	Denver Journal of International Law and Policy
DNA	Deoxyribonucleic acid
DSB	Dispute Settlement Body of the World Trade Organization
ECHR	European Convention on Human Rights (Convention for the Protection of Human Rights and Fundamental Freedoms)
ECOSOC	Economic and Social Council of the United Nations
ECtHR	European Court of Human Rights
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EJIL	European Journal of International Law
ELQ	Ecology Law Quarterly
ENB	Earth Negotiations Bulletin
ENMOD Convention	Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques
EU	European Union

EurUP	Zeitschrift für Europäisches Umwelt- und Planungsrecht
FAO	Food and Agriculture Organization of the United Nations
FPIC	Free, Prior and Informed Consent
Front. Bioeng. & Biotechnol.	Frontiers in Bioengineering and Biotechnology
Front. Plant Sci.	Frontiers in Plant Science
Geo. Int'l Envtl. L. Rev.	Georgetown International Environmental Law Review
Geo. Wash. Int'l L. Rev.	George Washington International Law Review
German YBIL	German Yearbook of International Law
GATT	General Agreement on Tariffs and Trade
GM	Genetically modified
GMM	Genetically modified microorganism
GMO	Genetically modified organism
Group of Friends on L&R	Group of the Friends of the Co-Chairs on Liability and Redress in the Context of the Cartagena Protocol on Biosafety
Harv. Int'l L. J.	Harvard International Law Journal
HEA	Habitat equivalency analysis
HDR	Homology-directed repair
HEG	Homing Endonuclease Genes
IACtHR	Inter-American Court of Human Rights
ICAO	International Civil Aviation Organization
ICJ	International Court of Justice
ICLQ	International & Comparative Law Quarterly
ICSID	International Centre for Settlement of Investment Disputes
ICTY	International Criminal Tribunal for Former Yugoslavia
IHR	International Health Regulations
IISD	International Institute for Sustainable Development

ILA	International Law Association
ILC	International Law Commission
ILM	International Legal Materials
Int. Environ. Agreements	International Environmental Agreements
IOPC Funds	International Oil Pollution Compensation Funds
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
Italian YBIL	Italian Yearbook of International Law
ITLOS	International Tribunal for the Law of the Sea
J. Envt'l L.	Journal of Environmental Law
J. Int. Econ. L.	Journal of International Economic Law
JEEPL	Journal for European Environmental & Planning Law
Leiden J. Int'l L.	Leiden Journal of International Law
LMO	Living modified organism
LNTS	League of Nations Treaty Series
LRTAP	Convention on Long-range Transboundary Air Pollution
MEA	Multilateral Environmental Agreement
Medea	Maternal-Effect Dominant Embryonic Arrest
Melb. J. Int'l L.	Melbourne Journal of International Law
Mich. J. Int'l L.	Michigan Journal of International Law
MOP	Meeting of the Parties, see COP-MOP
MPEPIL	Max Planck Encyclopedia of Public International Law
NASEM	National Academies of Sciences, Engineering, and Medicine
Nature Biotech.	Nature Biotechnology
Nature Comms.	Nature Communications
Nature Rev. Genet.	Nature Reviews Genetics
N. Engl. J. Med.	The New England Journal of Medicine

NGO	Non-Governmental Organization
NHEJ	Non-homologous end joining
NLR	Netherlands International Law Review
Nucleic Acids Res.	Nucleic Acids Research
NYL	Netherlands Yearbook of International Law
OIE	World Organisation for Animal Health
OTIF	Intergovernmental Organisation for International Carriage by Rail
Pace Envtl. L. Rev.	Pace Environmental Law Review
PCA	Permanent Court of Arbitration
PCIJ	Permanent Court of International Justice
Philos. Trans. R. Soc. A	Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences
Philos. Trans. R. Soc. B	Philosophical Transactions of the Royal Society B: Biological Sciences
PIC	Prior Informed Consent
PNAS	Proceedings of the National Academy of Sciences of the United States of America
Proc. R. Soc. B	Proceedings of the Royal Society B: Biological Sciences
QIL	Questions of International Law
REA	Resource equivalency analysis
RdC	Recueil des Cours
RECIEL	Review of European Community & International Environmental Law
Rep.	Reports
RIAA	Reports of International Arbitral Awards
RNA	Ribonucleic acid
SAYIL	South African Yearbook of International Law
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice
Sci. Rep.	Scientific Reports
SDN	Site-directed nuclease

SDR	Special Drawing Rights
Ser.	Series
sgRNA	Single guide RNA
SP	Nagoya – Kuala Lumpur Supplementary Protocol on Redress and Liability
SPS	Sanitary and Phytosanitary Measures
Stan. J. Int'l L.	Stanford Journal of International Law
TALENs	Transcription activator-like effector nucleases
TEV	Total Economic Value
tracRNA	Trans-activating crRNA
UN OLA	United Nations Office of Legal Affairs
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNCC	United Nations Compensation Commission
UNCLOS	United Nations Convention on the Law of the Sea
UNCITRAL	United Nations Commission On International Trade Law
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
UNTS	United Nations Treaty Series
VCLT	Vienna Convention on the Law of Treaties
WHO	World Health Organization
WTO	World Trade Organization
Yale L.J.	Yale Law Journal
YB Int'l Env. L.	Yearbook of International Environmental Law
YBIL	Yearbook of International Law
YBILC	Yearbook of the International Law Commission

ZaöRV	Zeitschrift für ausländisches öffentliches Recht und Völkerrecht
ZFN	Zinc-finger nuclease

Introduction

> *'We have thus far been concerned with ultra-hazardous activities arising from the skills and achievements of the physicists, chemists and engineers. The biologists are now entering the picture with experiments which, we are responsibly told, can fundamentally reshape the constituent elements of life, memory and learning. […] There may well be cases in which the current experiments of molecular biologists involve dangers which pose acutely the problem of liability for the objective risks involved in ultra-hazardous activities.'*
> – *C. Wilfried Jenks*[1]

It appears that *Jenks* was far ahead of this time when, in his 1966 lecture at the *Hague Academy of International Law*, he mentioned molecular biology as a potential field of application for international law on liability for ultra-hazardous activities. That same year, the genetic code had been 'cracked' when *Marshall Nirenberg* and others had fully elucidated the chemical structure of *deoxyribonucleic acid* or DNA. It took seven more years for the first transgenic organism to be created, and until 1983 for the first genetically engineered crop to be developed.

Nevertheless, legal scholars had long taken up Jenks' initiative and begun contemplating the role of international law in regulating the potential transboundary effects of molecular biotechnology. Already in 1980, *Cripps* assumed that the problem identified by Jenks was now 'far more acute'.[2] At the same time, she observed that 'there is room for doubt regarding the application of recognised general principles of State responsibility to the release of genetically engineered viruses and organisms which traverse national boundaries'.[3]

The global COVID-19 pandemic has made the need to address potential transboundary effects of biotechnology self-evident.[4] Nevertheless, al-

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1 Liability for Ultra-Hazardous Activities in International Law, 117 (1966) RdC 99, 169.

2 *Yvonne Cripps*, A New Frontier for International Law, 29 (1980) ICLQ 1, 6.

3 *Ibid.*

4 *Jing-Bao Nie*, In the Shadow of Biological Warfare: Conspiracy Theories on the Origins of COVID-19 and Enhancing Global Governance of Biosafety as a Matter of Urgency, 17 (2020) Bioethical Inquiry 567.

though a laboratory escape has been discussed as a potential origin of the SARS-CoV-2 coronavirus,[5] there is currently no evidence that the virus emerged from a deliberate genetic manipulation.[6] Hence, despite the persistent controversy over the risks of genetic engineering, there appears to be no case in which a *genetically modified organism* (GMO) has ever caused significant transboundary harm; there has never been a GMO 'equivalent of the Torrey Canyon disaster or Chernobyl'.[7] Genetically modified crops, which are the most widespread instance of biotechnology released into the environment, are not known to have a direct cause-and-effect relationship with present environmental problems; common issues are rather caused by the agricultural practices associated with – but not exclusive to – the use of such crops, such as monoculture farming and intensive herbicide spraying.[8]

However, recent advances in molecular biology will likely produce entirely new classes of GMOs that may well have transboundary effects in the foreseeable future. These advances are led by the development of *genome editing* techniques, which can modify genetic information on the level of individual *base pairs* (or 'letters') in the DNA of virtually any organism. Compared to conventional genetic engineering techniques applied since the 1970s, genome editing is much more precise, versatile, and cheaper to apply. Moreover, it potentially allows the introduction of genetic modifications without inserting DNA derived from other species (so-called *transgenes*). This challenges existing regulatory frameworks that mostly attach to the presence of transgenic DNA in the resulting organism.

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5 *Filippa Lentzos*, WHO: COVID-19 Didn't Leak from a Lab. Also WHO: Maybe It Did, Bulletin of the Atomic Scientists, 11 November 2021, available at: https://thebulletin.org/2021/02/who-covid-19-didnt-leak-from-a-lab-also-who-maybe-it-did/ (last accessed 28 May 2022); but see WHO, WHO-Convened Global Study of Origins of SARS-CoV-2: China Part (2021), 118–120, concluding that 'a laboratory origin of the pandemic was considered to be extremely unlikely'; *Thomas Gaulkin/Matt Field*, WHO's "Exciting Adventure" to Find the Origins of COVID-19 Runs into Trouble, Bulletin of the Atomic Scientists, 30 March 2021, available at: https://thebulletin.org/2021/03/whos-exciting-adventure-to-find-the-origins-of-covid-19-runs-into-trouble/ (last accessed 28 May 2022).

6 *Kristian G. Andersen* et al., The Proximal Origin of SARS-CoV-2, 26 (2020) Nature Medicine 450; *Stephan Lewandowsky* et al., Conspiracy Theories Made It Harder for Scientists to Seek the Truth, 326 (2022) Scientific American 72.

7 *Kate Cook*, Liability: 'No Liability, No Protocol', in: Christoph Bail/Robert Falkner/Helen Marquard (eds.), The Cartagena Protocol on Biosafety (2002) 371, 373.

8 See NASEM, Genetically Engineered Crops (2016), 97–170; see chapter 1, section B.V.2.

The advent of genome editing also enables new approaches in the development of *self-spreading biotechnology*, by which I refer to genetically modified organisms and viruses specifically engineered to spread rapidly through natural populations. This includes *gene drives*, which are 'selfish' genetic elements that use various molecular mechanisms to bias inheritance in their favour, thus overriding the natural 50 % probability of inheritance commonly found in sexually reproducing organisms.[9] Engineered gene drives can be used to disseminate genetic modifications through natural populations of a particular species, either to change certain characteristics of that species or to reduce its abundance, potentially to the point of extinction. The currently most advanced research in the field of engineered gene drives aims to suppress populations of mosquito species that transmit malaria to humans.[10]

Since gene drives create a *vertical spread* by increasing the rate of their transmission to subsequent generations, it usually takes several generations for the drive construct to become prevalent in a population. In contrast, *horizontal* self-spreading techniques aim for a spread within the same generation of organisms. This can be achieved by genetically engineering pathogens or symbionts so that they perform certain tasks in the target organism once they have reached it. For instance, genetically modified viruses have been used to protect crops against infectious diseases.[11] Moreover, current research aims at developing viruses that perform genome editing directly in their target organism, which potentially allows to genetically modify entire populations or even species of organisms within a single generation.[12] These so-called *horizontal environmental genetic alteration agents* (HEGAAs) also raise concerns about their potential for misuse as biological weapons.[13]

Engineered gene drives and HEGAAs share a feature that distinguishes them fundamentally from conventional approaches to genetic engineering: genetic modification is no longer performed under controlled conditions in a laboratory but takes place directly in the environment. These approaches thus imply a 'shift from the release of a finished and tested

9 Cf. *Luke S. Alphey* et al., Opinion: Standardizing the Definition of Gene Drive, 117 (2020) PNAS 30864; see generally *Austin Burt/Robert Trivers*, Genes in Conflict (2006).
10 See chapter 1, section C.III.1.c).
11 See chapter 1, section E.I.
12 See chapter 1, section D.
13 Cf. *R. Guy Reeves* et al., Agricultural Research, or a New Bioweapon System?, 362 (2018) Science 35.

product to the release of an adjustable tool for genetic modification that is released into ecosystems'.[14] Most existing risk assessment and management frameworks are not yet equipped to address the particular risks that arise from such uncontrolled modification processes.

It appears to be undisputed that the emergence of self-spreading biotechnology presents significant challenges to international law. These challenges are aptly exemplified by the case of live viruses engineered into 'transmissible vaccines'. Around two decades ago, Spanish researchers developed such a transmissible vaccine to protect wild rabbits, which are an endangered species in their native habitat, the Iberian Peninsula.[15] This vaccine, however, protects rabbits against the very same natural viruses used for biological control in Australia, where the European rabbit is an invasive species that has caused devastating effects on local ecosystems.[16] Considering previous examples of unintentional or illegal transboundary movements of biocontrol agents,[17] it would seem just a matter of time until such a vaccine occurred in Australia and undermined biocontrol efforts there.

A similar example is the proposed use of an engineered gene drive to suppress *Palmer amaranth*, which has developed resistance to glyphosate and has become a major agricultural weed in the Southern United States.[18] However, Palmer amaranth can interbreed with related *Amaranthus* species cultivated as food crops in nearby Mexico and elsewhere.[19] An unintended spread of a suppression drive in Palmer amaranth could, therefore, severely impact the production of Amaranth crops.[20] There are numerous similar examples where the use of self-spreading biotechnology by one state may

14 *Samson Simon* et al., Synthetic Gene Drive: Between Continuity and Novelty (2018) EMBO Reports e45760, 2.

15 *Juan M. Torres* et al., First Field Trial of a Transmissible Recombinant Vaccine Against Myxomatosis and Rabbit Hemorrhagic Disease, 19 (2001) Vaccine 4536; see chapter 1, section E.II.

16 *Elena Angulo/Ben Gilna*, When Biotech Crosses Borders, 26 (2008) Nature Biotech. 277, 278–279.

17 See, e.g., *Peter O'Hara*, The Illegal Introduction of Rabbit Haemorrhagic Disease Virus in New Zealand, 25 (2006) Revue scientifique et technique (International Office of Epizootics) 119.

18 Cf. NASEM, Gene Drives on the Horizon (2016), 57–58; *Jacob S. Montgomery* et al., Sex-Specific Markers for Waterhemp (Amaranthus Tuberculatus) and Palmer Amaranth (Amaranthus Palmeri), 67 (2019) Weed Science 412.

19 Cf. *D. M. Brenner* et al., Genetic Resources and Breeding of Amaranthus, in: Jules Janick (ed.), Plant Breeding Reviews, Volume 19 (2000) 227, 239–240.

20 NASEM, Gene Drives on the Horizon (n. 18), 168.

be incompatible with the priorities and interests of other states.[21] Genetic techniques aimed at suppressing or eradicating entire species may even be incompatible with international law altogether.[22]

While it is commonplace that uncontrolled transboundary dispersals and adverse side-effects of self-spreading biotechnology shall be prevented, it is yet uncertain under which conditions accountability can be established when such effects occur nevertheless. Only recently, a paper in the journal *Science* asked: 'Who is responsible, or liable, if self-spreading viruses don't behave as expected or cross national borders?'[23] For this reason, the present study addresses the challenges to international law posed by self-spreading biotechnology not only from the perspective of *prevention* but also gives prominence to the issues of *responsibility* and *liability*.

In the context of hazardous activities such as those at stake, the concept of liability serves two purposes. The most natural and important function of liability is *reparation*, which means that the injury suffered by the victim of a harmful event shall be remedied.[24] The reparative dimension of liability gives effect to the 'polluter-pays principle', seeking to ensure that the injurious consequences of harm should not 'lie where they fall' but be repaired by the party which has caused the damage.[25] In other words, the purpose of reparation is 'to shift the loss unreasonably suffered by the victim to the tortfeasor'.[26] Moreover, reparation also may have a *corrective* function in that it provides a method of enforcing the law *ex post facto*.[27] This is particularly relevant in the context of international law, which provides only limited means to 'punish' states for serious breaches of their obligations.[28]

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21 See *Wendy R. Henderson/Elaine C. Murphy*, Pest or Prized Possession? Genetically Modified Biocontrol from an International Perspective, 34 (2007) Wildlife Research 578; *Angulo/Gilna* (n. 16).

22 *Axel Hochkirch* et al., License to Kill?, 11 (2018) Conservation Letters e12370; see chapter 3, section B.VIII.

23 *Filippa Lentzos* et al., Eroding Norms over Release of Self-Spreading Viruses, 375 (2022) Science 31, 31.

24 *Johan G. Lammers*, International Responsibility and Liability for Damage Caused by Environmental Interferences, 31 (2001) Environmental Policy and Law 42–50 and 94–105, 43.

25 *René Lefeber*, Transboundary Environmental Interference and the Origin of State Liability (1996), 1–3.

26 *Hanqin Xue*, Transboundary Damage in International Law (2003), 277.

27 *Lefeber* (n. 25), 1.

28 See *James Crawford*, International Crimes of States, in: James Crawford/Alain Pellet/Simon Olleson (eds.), The Law of International Responsibility (2010) 405.

Besides its *reparative* function, liability also has a *preventive* effect. It is assumed that the risk of being exposed to liability deters noxious behaviour and provides an incentive to act diligently and prevent damage.[29] In other words, it may be more economical for a party to prevent damage from the outset rather than having to compensate for it later.[30] In the context of molecular biotechnology, it has even been assumed that the prevention of damage was the 'primary goal of liability'.[31]

The prevention of, and responsibility and liability for, transboundary harm under international law is already a thoroughly studied field. The United Nations' *International Law Commission* has spent decades of work on this issue,[32] and the body of scholarly literature in the field is overwhelming.[33] However, the specific problems evoked by self-spreading biotechnology demand a fresh look at the topic. Moreover, the *Nagoya – Kuala Lumpur Supplementary Protocol on Liability and Redress*, which provides dedicated rules and procedures for transboundary damage caused by genetically engineered organisms, entered into force in 2018.[34] This is notable far beyond the present context, as the Supplementary Protocol is the first global treaty on liability for transboundary harm outside the areas

29 *Lammers* (n. 24), 43.

30 *Michael G. Faure/Andri Wibisana*, Liability in Cases of Damage Resulting from GMOs: An Economic Perspective, in: Bernhard A. Koch/Bjarte Askeland (eds.), Economic Loss Caused by Genetically Modified Organisms (2008) 531, 536–537.

31 *Ibid.*, MN. 15. The preventive function of liability is also recognized in the *Nagoya – Kuala Lumpur Supplementary Protocol*, whose stated objective is to 'contribute to the conservation and sustainable use of biological diversity […] by providing international rules and procedures in the field of liability and redress', cf. Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety (15 October 2010; effective 05 March 2018), UN Doc. UNEP/CBD/BS/COP-MOP/5/17, p. 64, Article 1.

32 For a detailed account of the ILC's work, see *Julio Barboza*, The Environment, Risk and Liability in International Law (2011).

33 Leading studies in the field are, to name but a few, *Jenks* (n. 1); *L.F.E. Goldie*, Concepts of Strict and Absolute Liability and the Ranking of Liability in Terms of Relative Exposure to Risk, 16 (1985) NYL 175; *Francesco Francioni/Tullio Scovazzi* (eds.), International Responsibility for Environmental Harm (1991); *Lefeber* (n. 25); *Phoebe N. Okowa*, State Responsibility for Transboundary Air Pollution in International Law (2000); *Edward H. P. Brans*, Liability for Damage to Public Natural Resources (2001); *Lucas Bergkamp*, Liability and Environment (2001); *Xue* (n. 26); *Rebecca M. Bratspies/Russell A. Miller* (eds.), Transboundary Harm in International Law (2006); *Barboza* (n. 32).

34 CBD Secretariat, Press Release: Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress Comes into Force (05 March 2018), available at: http://bch.cbd.int/protocol/e-doc/?news=116175 (last accessed 28 May 2022).

of oil pollution, nuclear damage, and space law that has ever attracted sufficient ratifications to enter into force.[35] The Supplementary Protocol also signifies the result of a 'paradigm evolution' by providing for an 'administrative approach' to liability instead of pursuing the conventional civil liability approach.[36] Nevertheless, it has only received comparatively little scholarly attention since it was adopted in 2010.[37]

While the Supplementary Protocol provides for the liability of 'operators', it leaves the role of states largely unaddressed. In fact, the responsibility and liability of states in the context of transboundary harm caused by biotechnology are still unsettled. The ongoing negotiations about the international regulation of engineered gene drives aptly demonstrate the dire need for conceptual clarity on the obligations, responsibilities, and – ultimately – the liability of states for transboundary harm caused by such techniques.[38] In 2020, two leading Australian and German regulators noted that whether the international law of state responsibility for wrongful acts 'may apply for negative effects caused by [Gene Drive] releases is […] not completely solved yet'.[39] The present study seeks to capture the current state of development of international law by taking stock of the existing rules pertaining to transboundary effects of biotechnology and by carving out the remaining gaps and grey areas.

Part One sets the scene by reviewing the recent developments in biotechnology and the resulting challenges to international law. *Chapter 1* reviews the aforementioned advances in molecular biology, particularly the emergence of self-spreading biotechnology. It also identifies the limitations and risks of these techniques which may potentially give rise to transboundary harm. Subsequently, *chapter 2* briefly introduces key terms and concepts relevant to responsibility and liability for transboundary harm under international law.

Part Two analyses the rules of international law relating to the prevention of harm from conventional and self-spreading biotechnology. The principal instrument in this field is the *Cartagena Protocol on Biosafety*,

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35 On this problem generally, see *Anne Daniel*, Civil Liability Regimes as a Complement to Multilateral Environmental Agreements, 12 (2003) RECIEL 225.

36 *René Lefeber*, The Legal Significance of the Supplementary Protocol: The Result of a Paradigm Evolution, in: Akiho Shibata (ed.), International Liability Regime for Biodiversity Damage (2014) 73; see chapter 2, section G.

37 See the references in chapter 6, n. 6.

38 See chapter 5.

39 *Heidi J. Mitchell/Detlef Bartsch*, Regulation of GM Organisms for Invasive Species Control, 7 (2020) Front. Bioeng. & Biotechnol. 927, 4.

which applies to 'living modified organisms' (LMOs).[40] However, it is currently controversial whether the Protocol's scope extends to genome-edited organisms that do not contain transgenic DNA. Moreover, some authors have contended that the Protocol may not apply to organisms containing engineered gene drives. Therefore, *chapter 3* clarifies the Protocol's scope before assessing its substantive provisions, which focus on the *transboundary movement* of LMOs. The chapter also addresses a range of other relevant instruments, including the *Convention on Biological Diversity* and the *Biological Weapons Convention*.

In addition to international treaties, the general rules of customary international law on the prevention of transboundary harm are highly relevant. On the one hand, this is because several states that are key actors in the field have not ratified the Cartagena Protocol. On the other hand, the general obligation of prevention is only insufficiently incorporated in the aforementioned treaties, thus giving even higher relevance to the general rules of customary international law. *Chapter 4* assesses the pertinent rules of custom relating to the prevention of transboundary harm, including the precautionary principle. The chapter also explores how breaches of these rules can be established.

As previously mentioned, there is currently a vivid debate among states on the general lawfulness of, but also the conditions for, environmental releases of organisms containing engineered gene drives. *Chapter 5* captures the current state of this debate and analyses the consequences of the first set of conditions agreed upon by states in 2018. It also identifies issues that have not yet been adequately addressed, such as the lack of binding standards on laboratory biosafety – an issue that may have become literally virulent as coronaviruses were routinely studied in medium-safety BSL-2 laboratories around the world before the outbreak of COVID-19.[41]

Part Three focuses on the liability of *operators*, which means those state and non-state actors involved in developing, producing and releasing biotechnological products. *Chapter 6* undertakes a thorough analysis of the aforementioned *Nagoya – Kuala Lumpur Supplementary Protocol*. The Supplementary Protocol addresses damage to biological diversity resulting

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40 The Cartagena Protocol as well as the Supplementary Protocol refer to 'living modified organisms' (LMOs) instead of the more common term 'genetically modified organisms' (GMOs). The present study refers to LMOs unless where addressing other national or international instruments that apply to GMOs. See chapter 3, section A.I.1.

41 *Andersen* et al. (n. 6).

from transboundary movements of LMOs and provides for the imposition of operator liability under the domestic legal systems of its state parties. However, it only insufficiently regulates several issues that are crucial in those transboundary situations to which the Protocol applies. In any event, the largest weakness of the Supplementary Protocol lies in its limited membership – as of May 2022, it has only 49 parties, missing many states that are key players in the field of biotechnology.

An alternative approach to operator liability is offered by the *Biodiversity Compact*, a private scheme by which a group of major biotechnology corporations have voluntarily assumed liability for biodiversity damage caused by any of their LMOs. *Chapter 7* examines this instrument and discusses whether it can fill the gaps left by the Supplementary Protocol. Furthermore, it has been suggested that there is an emerging rule of international law that states must ensure 'prompt and adequate compensation' of foreign victims in the event of significant transboundary harm. *Chapter 8* assesses whether this obligation, which aims at the provision of transnational operator liability, is already part of current international customary law.

Part Four addresses the responsibility and liability of states. *Chapter 9* analyses the law of state responsibility for breaches of international law. It thus builds upon the preceding chapters, which have focused on 'primary' obligations of states to prevent transboundary harm and to provide for operator liability when such harm occurs. The chapter analyses the conditions under which states are internationally responsible as well as the consequences and implementation of such responsibility.

Due to the legal nature of the obligation to prevent transboundary harm, the mere occurrence of such harm does not always indicate a breach of international law. Thus, there may well be cases in which transboundary harm occurs but neither the operator nor the state is required to compensate under the aforementioned regimes. Against this background, there are convincing policy arguments in favour of strict state liability, which refers to an obligation of states to compensate for transboundary damage regardless of whether they have breached international law. *Chapter 10* undertakes an analysis of international practice to determine whether strict state liability can be established as a rule of contemporary customary international law.

Finally, a controversial topic cutting across all of the aforementioned instruments and regimes is to which extent international law provides for compensation for environmental damage. The underlying question is whether the intrinsic value of the environment *per se* can be quantified in monetary terms, which is widely seen as a precondition for compensability. But determining the 'nature and quantum' of compensation for environmental damage raises complex problems, as shown by the first-ever judgment on this issue by the *International Court of Justice* in 2018.[42] *Chapter 11* analyses this judgment as well as other international practice and carves out generally accepted principles.

In sum, the present study seeks to provide conceptual clarity on the complex interaction between prevention, responsibility, and liability for transboundary harm under international law. It demonstrates how states are required to prevent transboundary harm from being caused by applications of biotechnology. It establishes that states must ensure that operators who have caused such harm can be held liable under their domestic legal system. States themselves are only responsible for transboundary harm if they have failed to take diligent action towards preventing such harm or if they fail to ensure that foreign victims can obtain prompt and adequate compensation from the responsible operators under their domestic legal system. Thus, although states will rarely be liable themselves, they must still ensure that such harm does not remain unredressed. Clarifying the interplay between primary and secondary obligations in international law as it stands today will help to gradually improve these obligations and to fill the remaining gaps.

42 ICJ, Certain Activities Carried out by Nicaragua in the Border Area (Costa Rica v. Nicaragua), Compensation Owed by Nicaragua to Costa Rica, Judgment of 02 February 2018, ICJ Rep. 15.