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## The Intersections Among Science, Technology, Policy and Law: in Between Truth and Justice

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## Chapter 13

### The Intersections Among Science, Technology, Policy and Law: in Between Truth and Justice

Paolo Davide Farah\* and Justo Corti Varela\*\*

Science and Law are abstractions (i.e, social constructs), which make sense only by the meaning attributed to them. While science delivers ‘objective truth’, law determines justice. Yet, both aim for the attainment of a particular truth by an approach which, in the western tradition, begins with Socrates’ method of distinction between truths and opinions. Both also follow a procedural method which is based on evidence and rationality.<sup>1</sup> The “truth” so achieved is one of the multiple possible outcomes depending on the inputs introduced. Like trials, it is a truth-as-agreement, recognized as such because a procedure accepted by a consensus has been followed. Since evidence could vary, the social acceptance of this method depends basically on the exercise of rationality which, as Aristotle said, is a “habit” or behavior and not something that depends on our will. If rationality is a social practice, it changes over time, and with it, the idea of truth. Truth-as-an agreement is common in law, where judges resolve conflict and determine “truths” that arise from evidence which, previously, have risen to the status of facts as a result of passing through a legal proceeding. In the western legal tradition, this method migrated from law to the natural sciences during the Enlightenment.<sup>2</sup> However, during this shift, the distinction disappeared between things (simple evidence), juridical facts (contrasted evidence and, hence, considered as valid by the legal system, which requires preponderance of the evidence for a civil case and “beyond a reasonable doubt” in a criminal case), and knowledge (contrasted evidence that is considered truth after passing a rational method). Natural science “things”, once identified, were automatically scientific “truth”. As Junker explains,<sup>3</sup> the “mathematization” of knowledge production, and the specialization that

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<sup>1</sup> For a review of how rationality has been framed in the western legal tradition focusing on Weber concept of rational legal authority see: Sebastian Guzman, ‘Rational Legal Authority’ (2007).

<sup>2</sup> To gain insights on the difficult relations between science and law emphasizing the role of rationality, see: Ronald N Giere, *Science Without Laws* (University of Chicago Press 1999).

<sup>3</sup> Kirk Junker, ‘Facts Are the Moveable Furniture of the Legal Mind, Not Stones of Science’ in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).

followed with the enlightenment, reduced the qualification of “science” only to those activities that studied quantifiable “things”, eliminating the necessity of checking whether they really happened (facts) and identified science with knowledge. When the scientific method went back to social science, including law, where things are social constructions, facts were understood automatically as reality. It was not until sociologists (in particular the sociology of knowledge) started to study science as a socially constructed reality,<sup>4</sup> and philosophers and lawyers began to see science as a cultural phenomenon, that other truths (post-truth) and other rationalities (post-rationality) became a possibility. Firstly, digitalization, then the internet and nowadays social networks, have exponentially increased the amount of information available. Therefore, it is becoming even more challenging today to distinguish facts from lies. This saturation of information makes us more prone to forget the ‘habit of’ fact checking and subsequent reasoning. Intuition, or even belief judgements (truthiness), becomes the approach used for assessing the truth in several cases. Belief judgements reaffirm each other by repetition, which, in the best of cases, multiplies the creation of more information that is impossible to process, and in the worst-case, information could lead to the formation of a distorted perception of reality. Irrationality is not a source of shame anymore, as it was in the past, but a reasonable option. This confusion between information and knowledge increases the issue of the democratic deficit involving western societies that will longer be capable of rebuilding consensus agreements.

Hence, the acceptance of well-meaning beliefs, or even malicious alternative facts, is due to the anthropological demand of certainties in an uncertain context where “mathematized” science cannot guarantee truths anymore because of information overload. Communication is replaced by interaction, experience-based memory by database storage, and physical “corporeity” by virtualization and referentiality. By contrast, law and its courts use the evidence-gathering process for distinguishing facts and opinions, and the application of presumptions and premises (for example the burden of proof) to achieve a truth. This truth is not the only possible truth but the best of the possible options. It continues to be a source of knowledge rooted in rationality which seeks to deliver justice.

The evidence-gathering process, however, is not immune to the social context of the discrediting of science. In EU case law, according to the Advocate General's conclusions, it is necessary to create different methods for integrating scientific evidence into trial, sometimes by procedure and other times by a more substantive approach. In the first method, scientific evidence is admitted according to the method in which it was produced, and it could be qualified as sound scientific evidence. This approach, though easier to implement, may lead to an overreliance on experts and the sciences, narrowing the standard of review to the mere assessment on the production of scientific evidence. In the second approach, the scientific method of production is not essential, but the research result itself is. It is assessed and compared with the other available scientific conclusions in order to check its accuracy. This review may reveal epistemic difficulties,

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<sup>4</sup> For a general introduction, see: Peter L Berger and Thomas Luckmann, *The Social Construction of Reality: A Treatise in the Sociology of Knowledge* (Penguin 1991); On the relations between science and knowledge: Vojin Milić, ‘Sociology of Knowledge and Sociology of Science’ (1984) 23 *Social Science Information* 213; HM Collins, ‘The Sociology of Scientific Knowledge: Studies of Contemporary Science’ (1983) 9 *Annual Review of Sociology* 265.

methodological limitations, inaccurate determination of facts, or alternative interpretations among the conclusions that are compared. Consequently, the substantive approach often leads to scientific uncertainty being solved by judges that determine what the truth is for the case in specific. Legal principles, such as the precautionary principle<sup>5</sup>, should be created to address this lack of certainty. Besides helping decision making in these contexts, where scientific evidence is partial or contradictory, the precautionary principle could be integrated in trial, not only by the analysis of evidence, but it could also change the judicial procedure itself. According to the analysis of international case law by Corti Varela,<sup>6</sup> the precautionary principle could be “proceduralized”, and when that happens, it changes the burden of proof and the standard of review. *Actori incumbit probatio* is no longer an immutable rule. In interim orders, for example, a shift of the burden is admissible in cases where the threat of environmental damage is proven. When that happens in the main proceedings, it reduces the standard of proof, using presumptions for accepting mere *prima facie* cases as proven facts.

This statement leads us to the conclusion that the integration of science into judicial proceedings does not always reinforce the legitimacy of judicial decisions. In the past, science has contributed to the legitimization of sentences because it was a socially accepted method for identifying truth. However, now it is increasingly perceived as a source of uncertainty. Hence, those judicial decisions that are based on science are discredited to the public. Moreover, judges cannot only rely on science anymore, nowadays they need to stand up to those who attack it (distinguishing between science and religion in intelligent design trials) or obliging governments to apply scientific criteria in their policy management (climate change and climate justice litigations).

Beyond litigation, science has always been a stable base of support for international law, especially in regard to the eternally difficult issue of defining the source of law. For example, science was integrated into the decision-making process of the UNFCCC.<sup>7</sup> However, it was necessary to establish a “depolicitization” proceeding before science’s incorporation, the duty of which was assigned to the Subsidiary Body for Scientific and Technological Advice. In the Paris Agreement, the integration of science into decision making was based on exchange of information, on the integration of experts in *strictu sensu* decision making, and on impact assessment of its policies. This integration process was designed to compensate for the lack of consensus on which measures should be adopted for fighting against climate change and, consequently, a failure of the law as such. At the end of the day, is international law’s last call for legitimacy in the face of the the

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<sup>5</sup> The precautionary principle emphasizes the need of taking preventive actions when there is uncertainty, especially when public health is involved. It guides legal interpretation in several countries and has been object of extensive literature especially for its role in environmental protection. For an overview of the principle and how it has been used in environmental law see, David Kriebel and others, ‘The Precautionary Principle in Environmental Science.’ (2001) 109 Environmental health perspectives 871; Per Sandin, ‘Dimensions of the Precautionary Principle’ (1999) 5 Human and Ecological Risk Assessment: An International Journal 889; Kenneth R Foster, Paolo Vecchia and Michael H Repacholi, ‘Science and the Precautionary Principle’ (2000) 288 Science 979.

<sup>6</sup> Justo Corti Varela, ‘The Precautionary Principle and the Burden of Proof in International Risk Regulation Trials’ in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).

<sup>7</sup> On the mechanisms used within the UNFCCC to integrate science within policy and decision making see, Dagmar Lohan, ‘Assessing the Mechanisms for the Input of Scientific Information into the UNFCCC’ (2005) 17 Colorado Journal of International Environmental Law and Policy 249.

uncertainty emanating from its loss of those supports it had enjoyed in the past. The hard paradigm, based on the classical model of state and rule of law, in which the principles of international law and their implementation in international customs were the main sources of law, has been changed for a more pragmatic model. In this model, truth is no longer a universal aim in an effort to achieve more than just a contextual description of reality. It also prevents the law becoming just a “regulation”, i.e., a normative technique for achieving circumstantial agreements (international treaties). Much more recently, in the post-modern framework, the truth is no longer the guiding principle of international law, it has been replaced by narrative(s) model(s) of truths. In that model, science-based decision making is just one narrative among others, and inside it there is space for multiple narratives that could be discovered by argumentation. That is why it is not surprising that scientific arguments could be politicized. In this framework, international law does not regulate liquid societies, it merely manages them through ‘multilevel governance’.

Multilevel governance states are no longer the only actors in the international society.<sup>8</sup> The reduction in its importance goes in parallel to its reduction in legitimacy which, in western societies, was one of democracy. Information technologies, through either deliberative or direct democracy tools, could help to facilitate the democratic process, but it would be a form of technological utopianism to think that they could change the general direction of delegitimization. It is true that smartphone applications could be useful in the democratic decision-making process, as Stojanoski and Vukovich<sup>9</sup> say. These applications could help voters to obtain electoral information. They can give advice to voters comparing policy preferences with the programs of running candidates. Moreover, in some countries, smartphones are a way of casting votes (e-voting). However, concern about the reliability of these technologies remains. Blockchain technology is one the most promising technologies for that, but, of course, there are pros and cons.<sup>10</sup> Smartphone applications raise concerns about the protection of fundamental rights (freedom of expression/speech), for example, voters publicly stating their voting choices on social media could undermine the electoral process.

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<sup>8</sup> On the crisis of multilateralism within the international community, see: Jutta Brunnée, ‘Multilateralism in Crisis’ (2018) 112 *Proceedings of the ASIL Annual Meeting* 335; Lukasz Gruszczynski and others (eds), *The Crisis of Multilateral Legal Order: Causes, Dynamics and Consequences* (Routledge 2021); For regional perspective on multilateralism focusing on EU and the US, see for Europe Christian Leffler, ‘Championing Multilateralism’, *The European Union’s New Foreign Policy* (Springer 2020); Mike Smith, ‘The EU, the US and the Crisis of Contemporary Multilateralism’ (2018) 40 *Journal of European Integration* 539; On China, see: Jingyuan Zhou, ‘A New Multilateralism? A Case Study of the Belt and Road Initiative’ [2020] *The Chinese Journal of Comparative Law* cxaa022; Jianfu Chen, ‘Tension and Rivalry: The “Belt and Road” Initiative, Global Governance, and International Law’ (2020) 8 *The Chinese Journal of Comparative Law* 177.

<sup>9</sup> Mihail Stojanoski and Lilla Vukovich, ‘Use of Smartphone Applications in the Democratic Decision-Making Process’ in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).

<sup>10</sup> For an overview of how blockchain technology is being used by local government see, Shaonan Shan and others, ‘Research on Collaborative Governance of Smart Government Based on Blockchain Technology: An Evolutionary Approach’ (2021) 2021 *Discrete Dynamics in Nature and Society* 1; Paolo Davide Farah and Marek Prityi, ‘Public Administration in the Age of Globalization and Emerging Technologies from Theories to Practice Symposium Issue: Blockchain Technology and the Law’ (2019) 88 *UMKC Law Review* 397.

Before, we mentioned that information overload makes it difficult to search for scientific truth through rationality processes and proceedings. Statute Law suffers from this information overload too, particularly when it regulates technology, and the excess of information reduces the speed of decision making. That is why the law is always late in comparing technological transformation.

Hobcraft<sup>11</sup> gives a good example of the application of such timing difficulties using the case of the UK Human Fertilization and Embryology Authority. For dealing with information overload, this authority adopted, according to the circumstances, a proactive or reactive approach in the always evolving field of new fertilization techniques. The proactive approach was used for establishing regulation before the technology was available to the public, including a strict and ethically sensitive follow up, and enabled the development of mitochondrial donation. This shows that, even in complex and information overloaded contexts, it is possible to regulate scientific development. However, as the author says, this regulatory management of science is possible only at the national level. At the international level, such an implementation is much more difficult.

This difficulty is a real problem when necessary to regulate technology is, either because of its dimension or implementation, supranational by nature.<sup>12</sup> This is the case of information technologies (IT). In such cases, law has no alternative but to use soft paradigms, which are much more related to the idea of governance and distant to classical concepts such as sovereignty and the rule of law. Regulation by norms is no longer a possibility, and the law must be content with a set of technical rules that fix merely isolated limitations in contrast to the powerful freedom of technological development.

The precautionary principle could be a good example of how law attempts to deal with uncertainty. The adaptability of the precautionary principle, based on its interactive and evolving nature, permits it to act in a plurality of contexts. By contrast, adaptability can only be implemented through constant negotiation in each individual application. Continuous negotiation and limited accountability are characteristics that make the precautionary principle difficult to implement in practice.

There are other flexibility mechanisms in international law for addressing technological and scientific development beyond the precautionary principle. As suggested by Ibrahim and many other scholars,<sup>13</sup> Art. XX of GATT could be one of those mechanisms. This GATT article was a

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<sup>11</sup> Gemma Hobcraft, 'Assessing the Soundness of Science to Determine Reactive and Proactive Regulatory Change. Human Fertilisation and Embryology Authority, Mitochondrial Donation, Treatment Add-ons and Future Challenges for Regulation' in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).

<sup>12</sup> For a successful case of transnational regulations, see the case of anti-corruption: Régis Bismuth, Jan Dunin-Wasowicz and Philip M Nichols, *The Transnationalization of Anti-Corruption Law* (Routledge 2021).

<sup>13</sup> On the use of Article XX in the protection of human rights, see: Rachel Harris and Gillian Moon, 'GATT Article XX and Human Rights: What Do We Know from the First 20 Years?' (2015) 16 *Melbourne Journal of International Law* 432; Salman Bal, 'International Free Trade Agreements and Human Rights: Reinterpreting Article XX of the GATT' (2001) 10 *Minn. J. Global Trade* 62; Paolo Davide Farah, 'Trade and Progress: The Case of China' (2016) 30 *Columbia Journal of Asian Law* 51; On its use for environmental protection, see: Christopher Tran, 'Using GATT, Art XX to Justify Climate Change Measures in Claims under the WTO Agreements' (2010) 27 *Environmental and Planning Law Journal* 346; Steve Charnovitz, 'Exploring the Environmental Exceptions in GATT Article XX' (1991) 25 *J. World Trade* 37; PD Farah and E Cima, 'Energy Trade and the WTO: Implications for Renewable Energy and

key tool for achieving agreements in disputed cases involving sovereign sensibilities during the previous century. Others are compliance mechanisms, often used in the Paris agreement, which constitute another example of substitution of international norms by soft regulation. Financial technologies, including digital currencies, do not even achieve the category of governance utility, but they are included in a “global sandbox program” for facilitating international cooperation. Lastly, the mechanisms within international water law are not tools but open regulatory frameworks where governance is in constant change depending on the regulatory necessities of science (and not in reverse). Flexibility is not always a way to balance societal and economic concerns within the legal system but also, as in the case of conscientious objection, moral ones.

Antonio Quiros Fons<sup>14</sup> develops a parallelism between conscientious objections in abortion, contraception, assisted reproduction, or sex reassignment surgery cases, that in the old days were founded on ethical reasoning but are now supported on beliefs of the existence of reasonable doubt in issues of sound science. Belief is, consequently, enough for questioning scientific arguments. These doubts deserve protection, based on systems of human rights protection, in particular cases, but it is difficult to say that they alone could be enough for delegitimizing a regulation based on science.

In this new method, technological accountability replaces technological regulation, and when it is supported by international governance, it is possible to do so without sovereignty. Besides the legitimacy question mentioned before, we found a naïve element in the narrative of neoliberal deregulation ideology. Deregulation is founded on confidence in technological progress; however, technology is never neutral. A new technological elite could take advantage of this regulatory deficit, orienting western societies to a neo-democracy pleasant for authoritarian regimes beyond our borders.

Democracy is challenged both by a classical view and a wider one. Climate change is making irrefutably apparent the limitations of the Anthropocene and globalization itself.<sup>15</sup> Ecological modernization, i.e., neoliberal adaptation to climate change that aims to reduce its velocity, but not to truly reverse the trend of degradation, does not guarantee true climate justice. Intergenerational equity calls for more engaged action, founded on the imperative of responsibility as the ethical foundation of climate justice. These actions must overtake the synchronic and anthropocentric vision and, consequently, they should correct not only those damages produced by a science subdued to predatory productivism, but they also should take into account historical and

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the OPEC Cartel’ (2013) 16 *Journal of International Economic Law* 707.

<sup>14</sup> Antonio Quiros Fons, ‘The Precautionary Principle and the Burden of Proof in International Risk Regulation Trials’ in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).

<sup>15</sup> The Anthropocene captured great attention in the past decade being framed and analyzed as the epoch where human activities contributed to radical changes in the environment. On the relations with climate change and the Anthropocene see: Christophe Bonneuil, Jean-Baptiste Fressoz and David Fernbach, *The Shock of the Anthropocene: The Earth, History and Us* (David Fernbach tr, Verso Books 2017); Paolo Farah and Alessio Lo Giudice, ‘Climate Justice in the Anthropocene and Its Relationship with Science and Technology: The Importance of Ethics of Responsibility’ (2023) *Connecticut Law Review* <[https://opencommons.uconn.edu/law\\_review/572](https://opencommons.uconn.edu/law_review/572)>.

geographical differences, between the past and the present, the Global North and the Global South, and between human and non-human subjects, including, of course and chiefly, the Nature.

Going deeper into each chapter made by our book authors and contributors, one could wonder about the real impact of the overall issue and its significance for future research. Junker,<sup>16</sup> for example, highlighted that interplay between law, science, and technology does not necessarily result in the betterment of society. This is because in our “post-truth” era, facts, logic, and reasoning, including legal reasoning, as well as information have lost their importance to citizens that are isolated in their own social media bubbles and subject to a high volume of information, making it difficult for them to assess the quality or correctness of said information. This is in addition to the fact that currently citizens are prone to believe information that supports their own ideals, regardless of its validity and even using terms such as “My Truth”, despite the fact that there can only be one truth. Given this reality, one could wonder about the actual relevance of all the technological and scientific developments that have taken place in the general framework of the Fourth Industrial revolution and the role of law in the regulation of these advances. In that sense, it seems that the individual is becoming less capable of processing facts and information as technology evolves, perhaps out of laziness but certainly out of unwillingness to do so. This can be noticed across the generations and depending on the length of time a person spends using social media. Hence, despite all the achievements made in science and technology, once they got entangled in politics, they were deployed for the establishment of new realities and the protection of echo chambers, instead of being used as a means for reaching political consensus. This is a dangerous phenomenon, where one can claim that truth and facts are subjective, resulting in situations where people deny, for instance, climate change, or claim that vaccines such as COVID-19 have serious negative consequences to offset its actual use.<sup>17</sup> All of these claims are not fully substantiated by relevant scientific basis. It is in this context that scholars are examining this topic, addressing various issues of post-truth and matters such as the Internet and social networks.<sup>18</sup> This is very much needed, given that irrationality and anti-science phenomenon have gained ground in recent years.<sup>19</sup>

Bombelli and Farah<sup>20</sup> preferred to build on the interconnection between science, technology, society, and law. The deconstruction of the classical support between information and knowledge, primarily because of the incapability to process the increased amount of information in complex data societies, leads to a deepening of the democratic deficit and the softening of law. However,

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<sup>16</sup> Junker (n 3).

<sup>17</sup> Jamie L Vernon, ‘Science in the Post-Truth Era’ (2017) 105 *American Scientist* 2, 2.

<sup>18</sup> Anna Visvizi and Miltiadis D Lytras, *Politics and Technology in the Post-Truth Era* (Emerald Publishing Limited 2019).

<sup>19</sup> Michael Lynch, ‘We Have Never Been Anti-Science: Reflections on Science Wars and Post-Truth’ (2020) 6 *Engaging Science, Technology, and Society* 49, 49.

<sup>20</sup> Giovanni Bombelli and Paolo D Farah, ‘The Interlinkages Science-Technology-Law: Information and Communication Society, Knowledge-Based Economy and the Rule of Law’ in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).



technology does not necessarily deny legal structures. New spaces created, for example, in cyberspace (or more recently cryptocurrencies environments) aim at the establishment of their own order, funded on different pre-conditions and consensus. Now, there is no resistance to this process, principally because of, at the political-institutional level, the crisis of mediators (political parties) and the individualization of the deliberative process, producing a decline in political legitimation and consensus mechanisms. Confusion between information and knowledge and the fragmentation of discourse in the post (or neo) democratic age facilitates in western society the spread of political demagoguery (and populism).

Ibrahim<sup>21</sup> addresses the constant technological and scientific changes that are occurring in society and the appropriate legal response to these developments. Law is unable to catch up with these changes. He suggests that only through the use of flexibility mechanisms it will be possible for law to catch up with technology and science. Flexibility mechanisms could both stifle innovations and provide the regulator with much-needed space to deal with constant technological and scientific uncertainties. It is in this context that Ibrahim<sup>22</sup> focuses on specific examples of flexibility mechanisms. These are: 1) Article XX of the GATT Agreement; 2) compliance mechanisms within the Paris Agreement; 3) regulatory sandboxes for the regulation of financial technologies, and 4) flexibility mechanisms within international water law. Such a capacity is needed to address scientific and technological developments, making any law more attractive and efficient. This will also increase the possibility of various actors complying with said law. This is not to say that there aren't downsides for flexibility mechanisms, such as noncompliance due to, for instance economic and political pressures,<sup>23</sup> as well as other limits.<sup>24</sup> Rather, this flexibility is the only potential means of tackling the challenge of ever evolving technologies and sciences, especially as the latter is expected to have problems, while these types of mechanism allow for addressing unforeseen issues<sup>25</sup> through cooperation, both nationally and globally.<sup>26</sup> Indeed, despite these shortcomings, these mechanisms have been incorporated within international agreements such as the Kyoto protocol.<sup>27</sup> This is a trajectory that international environmental agreements have been taking for a while now.<sup>28</sup>

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<sup>21</sup> Imad Antoine Ibrahim, 'Using Flexibility Mechanisms for Addressing Technological and Scientific Developments: Examples from Selected Global Regulatory Frameworks' in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).

<sup>22</sup> Ibid.

<sup>23</sup> Jeffrey L Dunoff and Mark A Pollack (eds), *Interdisciplinary Perspectives on International Law and International Relations: The State of the Art* (Illustrated edition, Cambridge University Press 2012) 175–176.

<sup>24</sup> Sia Spiliopoulou Akermark and Olle Marsater, 'Treaties and the Limits of Flexibility' (2005) 74 *Nordic J. Int'l L.* 509.

<sup>25</sup> Christopher Marcoux, 'Institutional Flexibility in the Design of Multilateral Environmental Agreements' (2009) 26 *Conflict Management and Peace Science* 209.

<sup>26</sup> Jeffrey Kucik and Eric Reinhardt, 'Does Flexibility Promote Cooperation? An Application to the Global Trade Regime' (2008) 62 *International Organization* 477.

<sup>27</sup> Fanny Missfeldt, 'Flexibility Mechanisms: Which Path to Take after Kyoto' (1998) 7 *Rev. Eur. Comp. & Int'l Envtl. L.* 128.

<sup>28</sup> Peter H Sand and Jeffrey McGee, 'Lessons Learnt from Two Decades of International Environmental Agreements: Law' (2022) 22 *International Environmental Agreements: Politics, Law and Economics* 263.

Building upon the concept of postmodernism and its implication for science and technology, as well as upon international law principles, Donati<sup>29</sup> examined the impact of this concept on post-truth and postmodernism, highlighting similar roles to flexibility mechanisms. In this analysis, the precautionary principle is seen in both a positive and negative lens as it can play an important role in furthering science and technology but also may increase confusion and lead to multiple scientific and technological innovations. The precautionary principle is a long-standing term in international law that gained prominence mainly during the 1970s and has since been subject to great analysis and interpretation in the literature and within specific fields such as international environmental law.<sup>30</sup> It is no wonder that this principle was examined in the context of science and technology, given its focus on anticipating and preventing damage from occurring,<sup>31</sup> as such harm may occur given the uncertainties of these fields. In this context, the principle is a means to guide the decision-making process of states looking to regulate scientific and technological developments.<sup>32</sup> In fact, the concept itself is a reminder that science and technology have limits that must be considered within the realm of political debate.<sup>33</sup>

The precautionary principle was also examined by Justo Corti Varela,<sup>34</sup> who stated that it is used as a risk management choice by policymakers seeking a higher level of protection. Legal scholars did not fully address states that do not apply this concept in case of scientific uncertainty, affecting the ability to see it as an adjudication principle. Indeed, upon an examination of the literature, the focus was mainly on the risk management approach, rather than one of adjudication.<sup>35</sup> Hence, this book provided two different methods in the application of the precautionary concept in the general framework of science and technology. The decision-making process in uncertain situations does complicate the use of science in policymaking.<sup>36</sup> Risk management in this context means risk

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<sup>29</sup> Alessandra Donati, 'The Precautionary Principle Under EU Law: A "Post-Modern" Principle in a "Post-Truth" Era' in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).

<sup>30</sup> Arie Trouwborst, 'The Precautionary Principle in General International Law: Combating the Babylonian Confusion' (2007) 16 *Review of European Community & International Environmental Law* 185; Claudia Saladin, 'Precautionary Principle in International Law' (2000) 6 *International Journal of Occupational and Environmental Health* 270; Aline L Jaeckel, *The International Seabed Authority and the Precautionary Principle: Balancing Deep Seabed Mineral Mining and Marine Environmental Protection*, vol 83 (Brill 2017); Sonia Boutillon, 'The Precautionary Principle: Development of an International Standard' (2001) 23 *Mich. J. Int'l L.* 429; Owen McIntyre and Thomas Mosedale, 'The Precautionary Principle as a Norm of Customary International Law' (1997) 9 *J. Env'tl. L.* 221.

<sup>31</sup> Mary Stevens, 'The Precautionary Principle in the International Arena' (2010) 2 *Sustainable Development Law & Policy* 7.

<sup>32</sup> Meinhard Schröder, 'Precautionary Approach/Principle' (2014] *Max Planck Encyclopedia of Public International Law*.

<sup>33</sup> Jacqueline Peel, 'Precaution: A Matter of Principle, Approach or Process?' (2004) 5 *Melbourne Journal of International Law* 483.

<sup>34</sup> Corti Varela (n 6).

<sup>35</sup> On the precautionary approach see, Terje Aven, 'The Cautionary Principle in Risk Management: Foundation and Practical Use' (2019) 191 *Reliability Engineering & System Safety* 106585; Julian Morris, *Rethinking Risk and the Precautionary Principle* (Butterworth-Heinemann 2000); Ronnie Harding and Elizabeth Fisher, *Perspectives on the Precautionary Principle* (Federation Press Sydney 1999).

<sup>36</sup> European Commission, *Future Brief: The Precautionary Principle: Decision-Making under Uncertainty* (Issue 18, September 2017)

<[https://ec.europa.eu/environment/integration/research/newsalert/pdf/precautionary\\_principle\\_decision\\_making\\_un](https://ec.europa.eu/environment/integration/research/newsalert/pdf/precautionary_principle_decision_making_un)

assessment to figure out whether uncertainties are well-understood or familiar, and, if not, to take precautionary measures.<sup>37</sup> Criticisms in relation to this focus on risk management foremost supports other critiques made against this principle, particularly that it ignores science and hampers innovation.<sup>38</sup> Regardless of the validity of these arguments, further research is needed to ensure that this concept serves to better the dissemination of science and technology, considering all the factors and stakeholders involved.

The role of science and technology is examined by Quiros<sup>39</sup> in the context of sexual and reproductive rights. This is a delicate topic, as over the decades the definition of sexual and reproductive rights, the extent of these rights, in particular in regard to abortion, has been subject to great controversy.<sup>40</sup> This fact can be seen most clearly in the United States, for instance, where Republicans and Democrats have different opinions when it comes to these issues.<sup>41</sup> This has been highlighted particularly well in the recent overturning of *Roe vs Wade*, sending shockwaves across the country as well as across the entire Western world.<sup>42</sup> Quiros<sup>43</sup> sets specific guidelines to addressing this topic, considering both sides of the debate, and taking into account human rights, the role of each stakeholder involved, responsibility of public institutions, and even an environmental approach to human life. These guidelines benefit from progress made on the technological and scientific front. In the future, further guidelines and regulations are expected to be developed, benefiting from scientific and technological progress. Still, this much is certain, these advancements do not change the core debate associated with morality, philosophy, and human rights.<sup>44</sup>

Technology and science have affected the democratic decision-making process according to Stojanoski and Vukovich,<sup>45</sup> who examined the use of smartphone applications in the pre-vote, vote, and post-vote stages. They have found that such applications resulted in the propagation of fake news, hampered freedom of expression, and human rights in general. The use of blockchain

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der\_uncertainty\_FB18\_en.pdf>.

<sup>37</sup> Marco Martuzzi, Joel A Tickner and World Health Organization Regional Office for Europe, *The Precautionary Principle: Protecting Public Health, the Environment and the Future of Our Children* (World Health Organization Regional Office for Europe 2004) <<https://apps.who.int/iris/handle/10665/346211>> accessed 18 September 2023.

<sup>38</sup> Sven Ove Hansson, 'How Extreme Is the Precautionary Principle?' (2020) 14 *NanoEthics* 245.

<sup>39</sup> Quiros Fons (n 14).

<sup>40</sup> Renu Addlakha, Janet Price and Shirin Heidari, 'Disability and Sexuality: Claiming Sexual and Reproductive Rights' (2017) 25 *Reproductive Health Matters* 4; Elaine Reis Brandão and Cristiane da Silva Cabral, 'Sexual and Reproductive Rights under Attack: The Advance of Political and Moral Conservatism in Brazil' (2019) 27 *Sexual and Reproductive Health Matters* 76; Wanda Nowicka, 'Sexual and Reproductive Rights and the Human Rights Agenda: Controversial and Contested' (2011) 19 *Reproductive Health Matters* 119.

<sup>41</sup> Françoise Girard, 'Implications of the Trump Administration for Sexual and Reproductive Rights Globally' (2017) 25 *Reproductive Health Matters* 6.

<sup>42</sup> Nicole Huberfeld and Linda McClain, 'Is the End of *Roe v. Wade* Near? Leaked SCOTUS Brief Says Yes' (2022] *BU Today* <[https://scholarship.law.bu.edu/shorter\\_works/150](https://scholarship.law.bu.edu/shorter_works/150)>; Mary Ziegler, 'The End of *Roe v. Wade*' (2022) 22 *The American Journal of Bioethics* 16.

<sup>43</sup> Quiros Fons (n 14).

<sup>44</sup> Jaime Todd-Gher and Payal K Shah, 'Abortion in the Context of COVID-19: A Human Rights Imperative' (2020) 28 *Sexual and Reproductive Health Matters* 1758394.

<sup>45</sup> Stojanoski and Vukovich (n 9).

technology in this context is a questionable solution while the Council of Europe Recommendations on online voting are seen as an adequate first step to regulating this issue. The use of smartphones in the democratic-decision making process is a serious issue that requires further evaluation, given the need to ensure their use for purposes of good governance, especially in the context of rampant globalization.<sup>46</sup> To that end, suggestions were made, for instance, for the establishment of an innovative digital democracy benefiting from a user-centric design.<sup>47</sup> Even authors such as Buchstein introduced the concepts of net-optimism, net-pessimism, and net-neutralism when addressing the potential digital information holds for democracy.<sup>48</sup> Other more relevant terms are the concept of “E-Democracy”, the basis of which is that democracy is practiced through information and communication technology.<sup>49</sup> Hence, smart phones are one facet of e-democracy. In fact, the Arab Spring is considered the first smartphone revolution in which citizens challenged nondemocratic regimes through its use.<sup>50</sup> This is why, it was extremely relevant to have this chapter within the book.

Hobcraft<sup>51</sup> took this topic even further in the context of the Human Fertilization and Embryology Authority, mitochondrial donation, treatment add-ons, and the way to regulate them. The focus was on the United Kingdom (UK) Human Fertilisation and Embryology Authority in its attempt to regulate assisted reproduction, so as to highlight an example of proactive regulation concerning treatment add-ons, contrasted with one of reactive regulation with regard to mitochondrial donation. The UK has been developing various regulations in this context, resulting in a great degree of literature on the topic. All the questions raised in this chapter are extremely complicated, requiring great examination when it comes to the role of the law. Science and technology in this context play an essential role. In fact, they can provide much needed evidence for regulators seeking to minimize existing risks, as well as answering a set of deeply complicated moral and philosophical questions. Even within the existing literature on the topic,<sup>52</sup> it is still not clear whether the legal response is adequate or sufficient, not only in the UK but globally. The focus on the UK in this chapter was due to the relevance of the laws adopted there. Still, while Hobcraft<sup>53</sup> clearly assesses the situation in that state, further work and research is needed globally, especially

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<sup>46</sup> David Simmonds and others, ‘Decision-Making on the Go: Smartphones and Decision-Making in Early 21st-Century Workflow’ (2019) 36 *Business Information Review* 164.

<sup>47</sup> Janne Berg, Jenny Lindholm and Joachim Högväg, ‘How Do We Know That It Works? Designing a Digital Democratic Innovation with the Help of User-Centered Design’ (2021) 26 *Information Polity* 221.

<sup>48</sup> Olaf Winkel, ‘The Perspectives of Democratic Decision-Making in the Information Society’ (2016) 8 *International Journal of Computer Science and Information Technology* 01.

<sup>49</sup> TM Vinod Kumar (ed), *E-Democracy for Smart Cities* (Springer 2017) <<http://link.springer.com/10.1007/978-981-10-4035-1>> accessed 18 September 2023.

<sup>50</sup> Omer Karasapan, *Social Networks and cell phones in the aftermath of the Arab revolutions* (WORLD BANK BLOGS 8 February 2013) <<https://blogs.worldbank.org/arabvoices/social-networks-and-cell-phones-aftermath-arab-revolutions>>.

<sup>51</sup> Hobcraft (n 11).

<sup>52</sup> See for a comparative study: Chokri Kooli, ‘Review of Assisted Reproduction Techniques, Laws, and Regulations in Muslim Countries’ (2019) 24 *Middle East Fertility Society Journal* 8.

<sup>53</sup> Hobcraft (n 11).

in developing countries<sup>54</sup> where laws are not as well developed for that purpose, given the lack of technological, scientific, and human capacity to address these issues.

Molitorisová and Burke<sup>55</sup> addressed the issue of scientific evidence through the opinions of the Advocates-General in the lens of procedural versus substantive approaches. These authors highlighted the increasing complexity of using science in the court system. Despite this fact, science remains essential in the production of proof. This is why the Advocate-General needs to develop a new, sound scientific approach to ensure a fair decision benefiting from current technological developments<sup>56</sup>. Examples of science used include forensics, a field which has been recently seen in a critical eye by the legal community.<sup>57</sup> Indeed, not all legal experts see science as beneficial in the court as some argue that mere junk science is being used in many instances,<sup>58</sup> especially, as the more complex science and technology become, the more difficult it is to use them by lawyers and judges to make decisions. This is not to say that zero efforts are being made to improve this reality, but rather that these fields are evolving very rapidly.<sup>59</sup> This topic has been addressed every decade since the last century, given the scientific and technological developments that routinely took place,<sup>60</sup> resulting in some scholars calling the role science played as ‘disappointing’.<sup>61</sup> This chapter represents another attempt, this time from the legal community, to understand the best ways science and technology can be used, based on the practice and experience of the advocate-general.

Farah and Lo Giudice<sup>62</sup> tackled the interplay between climate justice in the Anthropocene, on the one hand, and science and technology on the other, emphasizing the relevance of ethics and responsibility. These authors argued that ethics of responsibility in the framework of Hans Jonas’ philosophy can be used as a rationale for climate justice and as a means of tackling the relation between science, technology, and society. Climate justice as a concept has gained traction in recent decades globally, despite the need for further clarification about its status and the way it connects

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<sup>54</sup> Frida Simonstein, *Reprogen-Ethics and the Future of Gender* (Springer Science & Business Media 2009).

<sup>55</sup> Ciarán Burke and Alexandra Molitorisová, ‘Procedural versus Substantive Approaches to Scientific Evidence in the Opinions of Advocates-General’ in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).

<sup>56</sup> Stephen Breyer, ‘Science in the Courtroom’ (2000) 16 *Issues in Science and Technology* 52.

<sup>57</sup> Éadaoin O’Brien, Niamh Nic Daeid and Sue Black, ‘Science in the Court: Pitfalls, Challenges and Solutions’ (2015) 370 *Philosophical Transactions of the Royal Society B: Biological Sciences* 20150062.

<sup>58</sup> Joseph M Price and Gretchen Gates Kelly, ‘Junk Science in the Courtroom: Causes, Effects and Controls’ (1995) 19 *Hamline Law Review* 395.

<sup>59</sup> Kelly Servick, ‘Reversing the Legacy of Junk Science in the Courtroom’ *Science* (7 March 2016) <<https://www.science.org/content/article/reversing-legacy-junk-science-courtroom>> accessed 18 September 2023.

<sup>60</sup> Arthur Tompkins, ‘Science in the Courtroom: Is There, and Should There, Be a Better Way?’ (2017) 49 *Australian Journal of Forensic Sciences* 579.

<sup>61</sup> Jim Hilbert, ‘The Disappointing History of Science in the Courtroom: Frye, Daubert, and the Ongoing Crisis of Junk Science in Criminal Trials’ (2018) 71 *Oklahoma Law Review* 759.

<sup>62</sup> Paolo D Farah and Alessio Lo Giudice, ‘Climate Justice in the Anthropocene and its Relationship with Science and Technology The Importance of an Ethics of Responsibility’ in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).

morality, philosophy, and power politics.<sup>63</sup> It falls under the general framework of environmental justice developed in the previous decades.<sup>64</sup> Science and technology played an important role in pushing towards justice for global warming caused by humans.<sup>65</sup> It is through technological development and scientific progress that the Intergovernmental Panel on Climate Change was capable of proving that climate change is taking place.<sup>66</sup> Philosophy and morality remain needed, as even now some still deny its existence.<sup>67</sup> Besides, technology and science are currently being used for climate change adaptation and mitigation purposes in which, once more, morality and philosophy have dictated the way they are being used.<sup>68</sup> It is in this context that this chapter is made extremely relevant, especially for future debate on developments in the climate change sphere made as a result of science and technology.

Finally, Koskina<sup>69</sup> examined the science-based decision-making process of the Paris Agreement. Given that it states that parties to the convention need to implement it, the drafters included specific provisions defining scientifically the means by which a government should fulfill the treaty's obligations. This was the result of years of scientific research, leading to clear and defined commitments in which technology played an important role. In fact, it states in the agreement that the best available science is to be used to ensure a rapid decrease in global emissions and to measure the progressive realization of the convention. Indeed, the agreement creates science based processes for reporting, assessing developments, and increasing signatory state ambitions.<sup>70</sup> Already, scientific expert bodies established in the context of the treaty provide much needed scientific advice and information exchange with treaty-making bodies,<sup>71</sup> in this case the Conference of the Parties. One should not be surprised by this emphasis on the role of science in the agreement given its overall role in the broader field of climate change as highlighted earlier.<sup>72</sup> What is currently happening is simply that this role is being properly legislated within the

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<sup>63</sup> Chukwumerije Okereke, 'Climate Justice and the International Regime' (2010) 1 WIREs Climate Change 462.

<sup>64</sup> David Schlosberg and Lisette B Collins, 'From Environmental to Climate Justice: Climate Change and the Discourse of Environmental Justice' (2014) 5 WIREs Climate Change 359.

<sup>65</sup> Rashmi Verma, *Role of Science, Technology and Innovation in addressing Climate Change* (SCIENCE POLICY FORUM, 2020) <<https://thesciencepolicyforum.org/articles/perspectives/role-of-science-technology-and-innovation-in-addressing-climate-change-a-perspective/>>.

<sup>66</sup> Shardul Agrawala, 'Context and Early Origins of the Intergovernmental Panel on Climate Change' (1998) 39 Climatic Change 605.

<sup>67</sup> 'Global Warming: How Skepticism Became Denial - Spencer Weart, 2011' <<https://journals.sagepub.com/doi/full/10.1177/0096340210392966>> accessed 18 September 2023.

<sup>68</sup> Wai Chee Dimock, 'What AI Can Do for Climate Change, and What Climate Change Can Do for AI' *Scientific American* (5 April 2022) <<https://www.scientificamerican.com/article/what-ai-can-do-for-climate-change-and-what-climate-change-can-do-for-ai/>> accessed 18 September 2023.

<sup>69</sup> Anthi Koskina, 'The Science-Based Decision-Making Process as Established in the Paris Agreement (2015)' in Justo C Varela and Paolo D Farah (eds), *Science, Technology, Policy and International Law* (Routledge 2024).

<sup>70</sup> World Meteorological Organization et al., 'Systematic Observations and the Paris Agreement: Report of the Task Team on the Paris Agreement', (2018) 6.

<sup>71</sup> Joseph Orangias, 'The Nexus between International Law and Science: An Analysis of Scientific Expert Bodies in Multilateral Treaty-Making' (2022) 25 International Community Law Review 60.

<sup>72</sup> Candice Howarth and James Painter, 'Exploring the Science–Policy Interface on Climate Change: The Role of the IPCC in Informing Local Decision-Making in the UK' (2016) 2 Palgrave Communications 1.

provisions of conventions, with the Paris Agreement as progenitor. This approach, as adopted by the international community, represents a new way of thinking based on which innovative mechanisms for compliance and implementation of climate change agreements are being put in place.<sup>73</sup> Only time will tell whether this new strategy is truly effective.

A brief overview of these different contributions highlights that each topic is extremely relevant to the interplay between law, science, and technology, and that each issue deserves an entire manuscript by itself to be addressed properly. The goal of this book is to continue the debate taking place by posing a new set of topics, questions, and analyses that require further examination in future research endeavors. It is worth mentioning that the topics that were addressed are non-exhaustive, and the editors had to carefully select each subject and tailor it for the book, acknowledging that through this research they are merely scratching the surface of an ocean.

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<sup>73</sup> Imad Antoine Ibrahim, Sandrine Maljean-Dubois and Jessica Owley, 'The Paris Agreement Compliance Mechanism: Beyond COP 26' (2021) 11 Wake Forest Law Review Online 147, 26.