

# Exploring the Analytical, Normative and Transformative Dimensions of Earth System Law

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**Abstract.** In this article we argue that international environmental law cannot continue to exist in its present form for the purpose of the Anthropocene. We show that analytically, international environmental law and its lawyers are unable to fully understand and respond to the complex governance challenges arising from a complex Earth system. Normatively, international environmental law has failed to provide appropriate norms to prevent humans from encroaching on Earth system limits. In a transformative sense, international environmental law has not been sufficiently ambitious to achieve the type of radical transformations necessary to ensure planetary integrity and socio-ecological justice. We need a new legal paradigm that is better suited for the purpose of the Anthropocene that must address international environmental law's analytical, normative and transformative concerns. We call this new paradigm earth system law. Building on our recent work, we offer here some preliminary thoughts about what we think the analytical, normative, and transformative dimensions of earth system law could and should entail, and why they would be more appropriate for the purpose of governing a complex Earth system in the Anthropocene.

**Keywords:** International environmental law, sustainable development, Anthropocene, earth system law, earth system governance

## 1. Introduction

We are witnessing unprecedented levels of Earth system destruction and intensifying patterns of injustice at all levels and scales. This is likely to

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\*We are grateful for the generous financial support from the South African National Department of Higher Education and Training University Capacity Development Programme, which was provided by the Research Support Department, North-West University, South Africa. This support enabled the research for this paper and its open access publication. All views expressed in this paper are our own and cannot be attributed to the Research Support Department, the Department of Higher Education and Training, or to the North-West University.

lead, if it has not already done so, to the transgression of critical tipping points in the Earth system, which are predicted to cascade and accelerate Earth system transformations into a deep Anthropocene.<sup>1</sup> The magnitude and severity of Earth system destruction clearly reveal, among others, the deficiencies and failures of our social regulatory institutions that have been designed to prevent, minimize and remedy such destruction. This is particularly true for the 50-year-old international environmental law paradigm. Our thesis is that international environmental law that was developed in the context of the Holocene,

cannot continue to exist in its present form for the purpose of the Anthropocene, especially if we were to maintain Holocene-like conditions conducive to all life on Earth.

While this thesis is deceptively straightforward, its potential implications for international environmental law, and global environmental governance more generally, are not, especially insofar as it shifts our attention to a number of interrelated concerns about international environmental law that arise from within an analytical, normative and transformative context. It implies, first, that international environmental law's scholars and practitioners have not yet fully appreciated the importance and value of embracing an interdisciplinary systems approach to better *analyse*, understand and respond to the multiple complex governance challenges arising from an integrated, dynamic and complex Earth system.<sup>2</sup> Second, international environmental law has failed to provide an appropriate *normative* framework that is sufficiently geared towards preventing humans from encroaching on critical Earth system limits that define "stable" or "harmonious" Holocene conditions.<sup>3</sup> Third, it implies that the ongoing incremental international environmental law reforms (of international environmental law internally and of the social processes this body of law seeks to influence externally) have not been sufficiently ambitious to achieve the type of thoroughgoing, radical *transformations* that are critically necessary to enable planetary integrity and socio-ecological justice.<sup>4</sup>

These considerations arguably foreshadow the end of international environmental law as we know it.<sup>5</sup> Going forward, many agree that we need a new legal paradigm that is better able to respond to the multiple governance complexities of the Earth system.<sup>6</sup> This insight has recently prompted us to propose the notion *earth system law*, which we consider a new legal paradigm that is better fit for purpose in the Anthropocene.<sup>7</sup> Earth system law is both a continuous process and an outcome of our ongoing scientific efforts to improve on the analytical, normative and transformative concerns associated with, among others, international environmental law by: (i) facilitating interdisciplinary analysis and co-learning alongside an Earth system perspective to better understand and formulate regulatory responses for the type of complex governance challenges emanating from a

complex Earth system; (ii) offering a new set of appropriate norms that are able to restrain human behaviour and avoid transgression of Earth system limits; and (iii) providing innovative options for ambitious and radical reforms that can achieve meaningful transformations in pursuit of planetary integrity and socio-ecological justice.

In this paper, we offer a brief elaboration of the analytical, normative and transformative dimensions of earth system law. We do so, first, by reflecting on why we believe international environmental law has reached the end of its shelf life. We show that while international environmental law might have been a ground-breaking paradigm 50 years ago, it has since become unfit for purpose from an analytical, normative and transformative point of view. Essentially, earth system law will have to respond to the analytical, normative and transformative concerns we raise in relation to international environmental law.

The paper then offers a brief definition and description of earth system law, and elaborates what the analytical, normative and transformative dimensions of earth system law could entail. Throughout this part of the discussion, we will show that these three dimensions are very different from those of international environmental law. We also endeavour, where possible, to highlight some of the practical implications of our future vision of earth system law's analytical, normative and transformative dimensions. We believe it is only through the radically different approach introduced by earth system law that law, as a regulatory institution, will be able to remain valid, legitimate and ultimately *useful* in the Anthropocene.

## 2. The End of International Environmental Law

International environmental law has come a long way since its foundations were first formally elaborated during the 1972 United Nations (UN) Conference on the Human Environment. As far as we know, no thoroughgoing empirical studies have yet been conducted to determine the exact extent to which international environmental law, broadly conceived, has actually managed to maintain and improve planetary integrity since that time.<sup>8</sup> One must therefore draw on a range of other analyses

and observations to get some sense of international environmental law's contribution to the outcomes of global environmental governance. While such a suggestive assessment will inevitably be generalized, it is further complicated by the fact that international environmental law is by no means the only social regulatory institution that has a potential steering effect and influence on planetary integrity (others are religion, politics, economics, corporate practices, and so forth).<sup>9</sup> Yet, it needs little arguing that international environmental law plays a key role in the overall global environmental governance effort, and there is accordingly every reason to believe that it will at least be partially implicated in the victories and failures of global environmental governance.<sup>10</sup>

So, in the absence of empirical evidence to this effect, has international environmental law actually managed to contribute to maintaining and/or improving planetary integrity and socio-ecological justice the past 50 years? We would suggest that on balance, it has not. Evidence emanating from earth system science, and elsewhere, convincingly shows unprecedented and accelerating levels of Earth system decay, and associated deepening inter and intra-generation socio-ecological injustices that affect humans and more-than-humans.<sup>11</sup> We see this in terms of epistemic frameworks such as the Anthropocene and other predictions showing that we are fast approaching a Sixth Mass Extinction event; all as a result of unrestrained human behaviour.<sup>12</sup>

Yet, we do not need even to engage with scientific assessments to appreciate the extent of human domination of the Earth system and the inability of international environmental law to counter the ever-expanding human encroachment on planetary limits. We are now able to “consciously connect events that happen on vast, geological scales—such as changes to the whole climate system of the planet—with what we might do in the everyday lives of individuals, collectivities, institutions, and nations (such as burning fossil fuels).”<sup>13</sup> As a result of such systemic changes, we can now vividly experience, over the course of a human lifetime (as opposed to the historically deep geological timescale), accelerated global environmental disruptions in our everyday lives. Anthropogenic climate change, for example, is clearly happening (despite the efforts of climate denialists to show otherwise),<sup>14</sup> and is occurring much faster and has

far more (often irreversible) debilitating impacts than initially thought. We now see on a daily basis that it is causing massive socio-economic instability and ecological disasters, with billions of vulnerable people left to fend for themselves, while a privileged few selectively advance their own entrenched short-term interests through predatory, exploitative politics, policies and laws that impact planetary integrity and socio-ecological justice.<sup>15</sup>

If this offers a snapshot of the extent of Earth system destruction and the deepening socio-ecological crisis, to what extent is international environmental law implicated (as one of many socio-regulatory institutions) in causing and deepening this destruction and crisis; and has it been able to prevent, minimize and rectify this destruction and crisis? We approach these questions by reflecting on international environmental law's failures and deficiencies that reveal themselves from within analytical, normative and transformative contexts.

### 2.1. Analytical Context: Pursuing Linear “Environmental” Protection Through One Dimensional “International” State-Based “Law”

Obviously, we can only adequately respond to and solve a problem if we can properly analyze and fully understand it. Such tasks of analyzing and understanding problems and responding thereto are usually that of scientists and those responsible for governance. What are some of the main concerns related to international environmental law that continue to bedevil a proper analysis and understanding of planetary challenges and the formulation of proper responses to these challenges in the appropriate Earth system context?

First, international environmental law has served its purpose well in the 1970s as it aligned with and drew on the momentum of a promising post-World War II international legal order, which offered new possibilities to address human rights abuses; that lay the foundations for international trade, travel and commerce; and that inaugurated a new era of greater cooperation globally. The focus of *international* environmental law comfortably aligned with our simple understanding at the time of international environmental problems, such as the ozone layer and transboundary pollution concerns that can be

governed by top-down inter-State laws. This narrow focus on the international inter-State level and on issues within “defined spatial boundaries”<sup>16</sup> such as oceans, cultural heritage and pollution, however, gradually expanded in the last decade with a shift to the *global*, and more recently, the *transnational* context. The emergence of “global environmental law”<sup>17</sup> and “transnational environmental law”,<sup>18</sup> provided much-needed alternatives to international environmental law’s tunnel vision, especially to the extent that these new paradigms offer a more honest and realistic reflection of the regulatory reality that law is currently confronted with in the light of the most recent understanding of Earth system governance challenges.

These “more than international environmental law” approaches show, for example, that: (i) there are many more actors involved with governing the Earth system than only the State; (ii) there are many more types of “law” involved in governing Earth system processes in addition to those emanating from the traditional sources of international law; (iii) there are several other alternative governance processes available than only the trite top-down mode of international environmental law; and (iv) international environmental law is only one part of a much larger body of laws that are relevant for governing the Earth system.<sup>19</sup> The natural progression from international environmental law to global/transnational environmental law signals the potential of, and need to continue with, efforts to think about a new legal paradigm that departs from global/transnational environmental law and that is analytically better suited to the type of interconnected earth system governance challenges we observe through the Anthropocene trope.

Second, analytical efforts pertaining to international environmental law predominantly focus on “protecting”, “preserving”, and “conserving” a pristine “environment” or “nature”.<sup>20</sup> The environment is seen to be an isolated and autonomous entity that exists somewhere out there for the benefit of humans by providing, among many others, ecosystem services. This view derives from a “humanist bifurcation of natural history and human history”,<sup>21</sup> in terms of which humans are disconnected from the environment, and elevated as masters thereof. For example, in order to promote sustainable development (an issue to which we return below), environmental “resources” and ecosystem “services” must be protected in order to sustain

human life, and not for the sake of preservation itself; the environment is quite literally seen as a “resource” in the “service” of humans. Climate change must be addressed because of the impacts it has on sustainable development, and on the quality of human life, and not for the reason that maintaining climate integrity is inevitably critical to ensure the continued integrity of all life and other interlinked planetary processes. In stark contrast to such approaches, the key message of the Anthropocene trope is instead that “international environmental law can ... no longer be concerned with preserving an external and insensate environment, for there is no such entity”.<sup>22</sup> It is rather the case that humans are deeply entwined with the entire Earth system, and able to change it because we (*Anthropos*) have become a geological force. In terms of such a description, international environmental law often fails to see the bigger picture because, generally, it does not embrace systems thinking and more specifically, the *Earth system* as its regulatory object. It remains focused on a linear, one-dimensional understanding of the environment as its regulatory object; there is “little reflection in international environmental law texts of the character of the Earth as a dynamic system”.<sup>23</sup>

Third, because an Earth system approach rejects international environmental law’s one-dimensional focus on an “environment” that needs to be “protected” by its human masters so that we can benefit from environmental resources and services, it also rejects the type of epistemologies of mastery that international environmental law and its analytical efforts continue to underwrite.<sup>24</sup> Sam Adelman argues that epistemologies of mastery “are successful to the extent that they become naturalized and viewed as common sense, which is achieved when they become dominant or hegemonic by marginalizing, silencing or repressing alternative ways of knowing”.<sup>25</sup> International environmental law’s narrative of sustainable development has been particularly successful in achieving exactly this, not only in the normative and transformative domains as we shall see below, but also as far as international environmental law’s analytical dimensions “reinforce the false assumption that humanity can exercise dominion over nature without repercussions”.<sup>26</sup>

Fourth, earth system governance challenges are notoriously difficult to understand, and hence to respond to, because the Earth system is a complex phenomenon. The Earth system is seen to be a

collection of all complexly interacting physical, chemical, and biological global-scale cycles and energy fluxes which provide the conditions necessary to enable and sustain life on Earth. It is a materially closed system consisting of interlinked physical, chemical and biological processes that cycle materials and energy in non-linear, complex and dynamic ways within the system; all living organisms are active participants in (not simply passive respondents to) this system and vis-à-vis the range of other non-living Earth system components; and the time scales of global change are highly variable.<sup>27</sup> It is not altogether clear that international environmental law, and its scholars in particular, have really managed to embrace and respond to such complexity. For example, Fisher *et al.* show there are four methodological challenges related to environmental law scholarship, which also reveal how difficult it is to respond analytically to Earth system complexity.<sup>28</sup> These are: “dealing with the speed and scale of legal/regulatory change, engaging with the interdisciplinary nature of the subject, addressing the heavy reliance in environmental law on a diverse range of governance arrangements and tackling the multijurisdictional nature of the subject”.<sup>29</sup> International environmental law, as a scholarly endeavour, remains a distinct mono-disciplinary endeavour, despite its arguably being the most likely candidate of all areas of international law to benefit from interdisciplinarity. The reality is that “in the Anthropocene, social scientists must become geophysicists, and geophysicists must become social scientists”;<sup>30</sup> but this penny has not yet dropped for international environmental law.

## 2.2. Normative Context: Inappropriate Norms to Constrain Human Behaviour

The normative context reflects on the extent to which international environmental law provides the type of norms that are in fact appropriate for, fully able to, and properly geared towards, constraining human behaviour vis-à-vis other Earth system components and processes. Given its main rationale (already articulated in the 1972 Stockholm Declaration on the Human Environment),<sup>31</sup> one might be forgiven for assuming that international environmental law should offer the type of norms that set legal limits that are actually able to prevent humans from exceeding the limits of Earth’s life

support systems. One useful way to visualize Earth system limits (despite critique),<sup>32</sup> is through the planetary boundaries framework. This framework identifies and quantifies a set of nine planetary boundaries that “define the safe operating space for humanity with respect to the Earth system and [that] are associated with the planet’s biophysical subsystems or processes”.<sup>33</sup> If these boundaries are crossed, the chance of maintaining the relatively stable Holocene-like state for human existence significantly diminishes as we step closer to “dangerous levels”, or where applicable, “tipping points” in Earth system processes. To this end, the planetary boundaries act as,

values for control variables that are either at a “safe” distance from thresholds - for processes with evidence of threshold behaviour - or at dangerous levels - for processes without evidence of thresholds. Determining a safe distance involves *normative judgements* of how societies choose to deal with risk and uncertainty.<sup>34</sup>

Law is a social regulatory institution and is uniquely placed to restrain, steer, coerce, punish and to reward; in other words, “law is a purposeful vehicle for shaping behavior to achieve desired ends”.<sup>35</sup> International environmental law, *being law*, therefore has an important role to play in shaping the “normative judgements” that must ultimately determine a “safe distance” from critical thresholds. To this end, international environmental law’s norms must “act as legal boundaries that prevent human activities from reaching and breaching planetary boundaries”; including “legal boundaries [that] must translate the physical reality of a finite world into law and thereby delimit acceptable levels of human activity”.<sup>36</sup>

Earth system science-based evidence shows that we have already crossed four of nine planetary boundaries,<sup>37</sup> which suggests that, on balance and with few exceptions, international environmental law does not offer the norms we need to remain within the Earth system’s safe operating space.<sup>38</sup> Mindful of the risk of oversimplifying a hugely complex issue, one prominent example suffices for present purposes: the international climate law regime is the principal binding and globally agreed upon legal response to address climate change. In terms of the planetary boundaries framework, global climate change is only successfully addressed if the climate change boundary is not crossed.<sup>39</sup> Because

we have already crossed the climate change planetary boundary, and hence entered the zone of uncertainty where “dangerous anthropogenic interference with the climate system”<sup>40</sup> is highly likely, one can assume that international environmental law in general (and its climate regime in particular), is at least complicit in, if not exclusively responsible for, failing to prevent such a breach.

The main concern in this respect is not so much the quantity of international environmental law norms, but rather the quality of these norms (as some say: “the problem is not too little environmental law but too much”).<sup>41</sup> International environmental law is the “textual embodiment of the international institutions that have been developed to address global environmental challenges”,<sup>42</sup> and it remains the densest area of international law, with more global conferences, regional and international treaties, and corresponding governance institutions than any other area of international law.<sup>43</sup> While this impressive growth signifies the increased prominence of environmental concerns in society and in global environmental politics, it also highlights concerns related to the *content* of these norms and what they strive to achieve. The deepening socio-ecological crisis arguably cannot adequately be addressed simply by creating ever more path-dependent norms that might be optically (and especially *politically*) appealing and appeasing, but that have little decisive impact. Such norms merely scratch the surface by facilitating “prevention” and “precaution” and creating liability regimes that aim to force “polluters to pay”, among others.<sup>44</sup> The socio-ecological crisis must also be addressed through more appropriate norms that stand in relation to the scale, depth and nature of the challenge they seek to tackle, namely *Earth system destruction*. The magnitude, depth, severity and urgency of Earth system destruction is so significant that neither “soft” law principles of prevention, precaution and polluter pays, nor “hard” law obligations prohibiting, for example, cross-border environmental harm, will suffice any longer to address human destruction of the Earth system at a planetary scale.

We also need to be clear that much of what is wrong with international environmental law’s norms, is because of the idea of *sustainable development*, which is the guiding mantra principle of international environmental law. A “deceptively simple idea”<sup>45</sup> that seems to pursue environmental

protection, sustainable development is, however, not an environmentally friendly principle or process. It is instead a convenient but fictitious ideological palliative that international environmental law has created and that it underwrites,<sup>46</sup> that legitimizes and helps humans rationalize Earth system altering practices. Sustainable development is now so ubiquitous in many of our social systems, including the law, that it “has become ingrained as the rationale for social and economic policies and, as such, is rarely challenged, but accepted as necessary and inevitable”.<sup>47</sup> The Sustainable Development Goals, the new poster child of global governance and politics, is an apt example in this respect. But sustainable development only continues to offer a smokescreen without having any ability whatsoever to achieve the type of deep and meaningful internal and external transformations that are necessary to promote planetary integrity. With the blanket endorsement of this haloed but deeply deceiving and politically appeasing principle, international environmental law has only managed to further promote the human social system’s exploitative, neoliberal, development-biased anthropocentrism through its inappropriate norms that are inevitably unable to confront ongoing predatory efforts squarely focused on selectively promoting the self-interests of some humans at the expense of an increasingly vulnerable living order.<sup>48</sup>

### 2.3. Transformative Context: Too Little Too Late?

A recent sobering study suggests that planetary integrity has been negatively impacted to such an extent that “deliberate management of humanity’s relationship with the rest of the Earth System [is required] if the world is to avoid crossing a planetary threshold [including] a *deep transformation based on a fundamental reorientation of human values, equity, behavior, institutions, economies, and technologies*”.<sup>49</sup> International environmental law is supposed to be centrally concerned with the “deliberate management of humanity’s relationship with the rest of the Earth System”. Yet, the analysis immediately above suggests that international environmental law has at best only made a minor contribution to halt the growing human encroachment on the biogeophysical limits of the Earth system, while it is unable to offer plausible opportunities for future adaptation to irreversible change.

Directly related to the normative concerns raised above, it is rather the case that international environmental law has not managed to facilitate the type of paradigm-shifting transformations that we already should have seen decades ago, and that we now need more than ever in order to address the full extent of Earth system destruction and the resultant socio-ecological crisis. It is true that law generally, and international environmental law specifically, can only do so much to instigate, drive and deepen transformations in and of societies. International environmental law, after all, is not a magic cure for all the world's ills and certainly not the sole driver of social transformations. But it is also true that it plays an important role in such an endeavour, and that whatever little international environmental law has managed to do over the course of half a century, it could and should have done much better.

For one, international environmental law has not been, and still is not, sufficiently ambitious to deal with the planetary crisis and with the myriad socio-ecological injustices arising from human domination of the Earth system and of the vulnerable living order.<sup>50</sup> For example, while climate change is a clear threat to all life on Earth, and despite overwhelming evidence to this effect, international environmental law has neither managed to meaningfully transform its own norms, objectives, processes and institutions internally, nor as a result, the behaviour of social actors and processes externally that contribute to global climate change. This much is clear from the recent Intergovernmental Panel on Climate Change (IPCC) *Special Report on Global Warming of 1.5 Degrees Celsius*, which predicts that climate change is only set to worsen if the current regulatory trajectory will be followed.<sup>51</sup> Admittedly, international environmental law has managed to achieve some internal and external transformations and reforms, such as in the case of the international ozone law and governance regime.<sup>52</sup> But these success stories are few and far between and arguably insufficient to suggest that international environmental law has actually managed to achieve thoroughgoing transformations that are in fact able to advance planetary integrity.

For international environmental law to achieve deep structural transformations externally, it must itself be fundamentally transformed internally; in other words, only a fully transformed version of international environmental law can transform the

behaviour of society in such a way so as to stay within Earth system limits. To this end, several commentators have suggested various options to achieve such internal transformations. Some proposals include to ecologize international environmental law with the adoption of rights of nature and of the principle *in dubio pro natura*.<sup>53</sup> to develop peremptory global environmental “constitutional” norms or a global environmental constitution;<sup>54</sup> to adopt a global right to a healthy environment;<sup>55</sup> to adopt the principle of ecological sustainability;<sup>56</sup> and to develop an all-embracing, higher-order framework treaty which entrenches the principle of ecological integrity as a *Grundnorm*.<sup>57</sup> Regrettably few of these proposals have actually managed to filter down into the actual practice of international environmental law-making and reform. The closest the world came to laying the foundations to drive the type of transformations required by such proposals, was with the endorsement of the World Charter for Nature by the United Nations General Assembly in 1982.<sup>58</sup> The ambitious ecologically-inclined Charter certainly was a step in the right direction, but while it could have marked a turning point in the evolution of international environmental law, or even a “global environmental constitutional moment”,<sup>59</sup> the Charter has all but disappeared from the scene.

A more recent initiative is the widely publicised Global Pact for the Environment, on which a lot of hope seems to be pinned to drive transformation of international environmental law itself and of society.<sup>60</sup> But as critical commentators have shown,<sup>61</sup> very little in the existing draft text of the Pact and its continuously evolving wish list actually introduces the type of radical and ambitious norms required to drive radical and ambitious internal and external transformations. The Pact remains firmly embedded in the sustainable development paradigm and everything that goes with this impulse.<sup>62</sup> Having now been reduced to a mere non-binding political statement to be issued in 2022 to coincide with the 50<sup>th</sup> anniversary of the 1972 Stockholm Conference on the Human Environment,<sup>63</sup> the Pact cannot drive the type of transformations that are actually required and it is not a solution for the prevailing planetary crisis.

Regrettably, the entire process surrounding the Pact,<sup>64</sup> including the work of the expert group that was responsible for the draft text, the high-level political negotiations, and the international environmental law gap report that was drafted to

inform the creation of the Pact, only reinforce the omnipresence and force of sustainable development in continuing efforts to reform international environmental law. As one of the Pact's main proponents, Yann Aguila, recently declared in a telling statement that clearly reveals the path-dependency of the Pact and its development process: "a Global Pact will serve as a unifying symbol to demand ambitious action from states and private sector actors to protect the planet *and to create a sustainable development economy*".<sup>65</sup> This is simply old wine in new bottles.

In sum, international environmental law has not been able to achieve any meaningful transformations the past 50 years through its non-radical, unambitious and path-dependant norms that pursue sustainable development. And if the Pact is "the Logical Outcome of 50 Years of International Environmental Law",<sup>66</sup> as Yann Aguila believes it is, then it does not bode well for ongoing efforts that must try and achieve meaningful transformations in and through international environmental law for the next 50 years.

### 3. The Dimensions of Earth System Law

It is in the light of these numerous concerns that we have proposed the notion of earth system law. We consider earth system law to be an essential part of earth system governance, or "organised human responses to earth system transformation, in particular the institutions and agents that cause global environmental change and the institutions, at all levels, that are created to steer human development in a way that secures a 'safe' co-evolution with natural processes".<sup>67</sup> Instead of taking Holocene stability for granted, as international environmental law does, earth system law departs from long-term planetary dynamism and fully embraces, and seeks to actively create and maintain, Holocene-like conditions, while at once creating opportunities for adaptation where Earth system changes have become inevitably irreversible. It does so by responding to the Earth system's key characteristics such as complexity, instability and unpredictability. Revolving on a systems perspective as it does, earth system law is therefore fully anchored in the Anthropocene's planetary context.

We define earth system law as an innovative legal imaginary that is rooted in the Anthropocene's planetary context and its perceived socio-ecological crisis. Earth system law is aligned with, and responsive to, the Earth system's functional, spatial and temporal complexities; and the multiple earth system science and social science-based governance challenges arising from a no-analogue state in which the Earth system currently operates. Earth system law seeks to respond to the Earth system's instability and unpredictability through a continuous norm development process that drives meaningful transformations as well as interdisciplinary learning and deliberation. Fully embracing the need to guide the making of desirable planetary futures, Earth system law therefore offers: (i) an interdisciplinary analytical framework to better understand and respond to the legal dimensions of earth system governance; (ii) the normative foundations to govern the full spectrum of Earth system relationships in a way that promotes planetary integrity and justice in their fullest sense; and (iii) the legal means to facilitate transformative earth system governance for long-term sustainability.<sup>68</sup>

#### 3.1. Analytical Dimension

The nature, magnitude and depth of Earth system transformations, and the socio-ecological crisis associated therewith, have become so complex that we need new and innovative analytical tools to understand the type of governance challenges emanating from a complex Earth system. It is only once we properly understand these earth system governance challenges, that we will be able to devise appropriate institutional, and more specifically *legal*, responses that might have some prospect of success.

In an analytical sense, earth system law offers a framework to critique the current deficiencies of international environmental law, and to reimagine international environmental law; to open up the hitherto "closed" epistemologies of earth system science for lawyers while at once illuminating the juridical aspects of earth system governance for earth system scientists; to reveal the regulatory implications of the Earth system metaphor for law; and to serve as a new crosscutting theme of scientific enquiry for scholars working in the area of sustainability.<sup>69</sup> A key guiding question for the analytical dimension of earth system law is, therefore: what are the implications of the Earth



system perspective for existing international environmental law and its law-making processes?

Scholars have done preliminary analyses in this respect,<sup>70</sup> some of which explicitly draw on the insights of earth system governance research and its emphasis on the problem of institutional fit.<sup>71</sup> A key conclusion is that we are missing global institutions for addressing planetary-scale challenges,<sup>72</sup> such as those stemming from interacting planetary boundaries.<sup>73</sup> As we have shown earlier, neither international environmental law, nor even global or transnational environmental law, fully respond to a planetary perspective. The concept of earth system law has therefore emerged “beyond” these categories of law to fill this gap, and it is increasingly being recognized among a growing group of scholars as a viable alternative to international environmental law.<sup>74</sup> To this end, earth system law is informed by a planetary perspective and analysis that transcends geographical and jurisdictional boundaries.<sup>75</sup> Therefore, the geographical and jurisdictional boundaries of earth system law (if there are any such boundaries), are informed by both ecological and socio-economic processes that are elaborated by earth system governance and earth system science.<sup>76</sup>

Temporally, the planetary perspective implies going beyond human and ecological timescales in order to align human affairs with geological timescales.<sup>77</sup> Earth system law, for example, is less focused on addressing the problem of climate change through quick fixes such as solar radiation management, and instead fully takes into account the lifetime of carbon dioxide in the atmosphere for long-term solutions.<sup>78</sup> While more analysis is required to explore what earth system law attuned to geological timescales might look like, some parallels can already be drawn with the existing laws regulating radioactive waste storage and disposal, for example, which need to be managed over the timespan of tens of thousands of years.

Relatedly, another consideration is that earth system law cannot have either humanity or nature as a central reference point. This is because, the yet unknown “natural” or stable state of the Earth system in the Anthropocene is unlikely to be tenable or conducive to the survival of life as we know it. The Holocene-like conditions will become impossible to maintain through “natural” means, for example, by simply reducing the degree of anthropogenic interference with the Earth system. In other words, the environment will no longer exist as

an object for “protection” from human interference in a deep Anthropocene. The still unknown purpose of earth system law will therefore need to be clarified.<sup>79</sup>

### 3.2. Normative Dimension

In a normative sense, earth system law must better respond to the type of planetary governance challenges that the dynamic and complex Earth system presents, while at once offering solutions aimed at increasing Earth system resilience and reducing vulnerabilities. In other words, earth system law provides a framework within which it would be possible to design better laws to better govern a complex Earth system. Therefore, the contents of a new normative framework will be tied with the analytical dimension. It is not the aim of our paper to define the normative framework by, for example, pointing to key principles of law for the Anthropocene. A more detailed treatment of this issue can be found elsewhere.<sup>80</sup> For the sake of brevity, we only highlight here some of the planetary justice and its related earth system governance democracy considerations that contribute to defining the normative dimension of earth system law.<sup>81</sup>

Planetary justice considerations depart from the acknowledgement that there will be winners and losers in the Anthropocene. The role of earth system law, and indeed earth system governance more broadly, is then to provide a normative framework for prioritizing the needs and interests of the marginalized and vulnerable within a paradigm of planetary stewardship. Such prioritization will involve addressing difficult and complex allocation challenges both within and between countries and among the rich and the poor in these countries.<sup>82</sup> But the allocation challenges also go beyond the short-term, anthropocentric dimension to include those between the current and future generations as well as between humans and non-humans. Addressing these allocation challenges for planetary justice will form a core part of earth system law, and it could help to define a democratic form of earth system governance that this law will contribute to.<sup>83</sup>

The controversies surrounding global goal setting usefully illustrate our point. On the one hand there are global goals such as the Aichi Biodiversity Targets and the Sustainable Development Goals that are agreed upon through intergovernmental

negotiation processes with representation from all governments and, to a lesser extent, civil society.<sup>84</sup> Despite the shortcomings of international environmental law, this form of global goal-setting is generally seen to have been carried out through legitimate processes. On the other hand, global goals set by “self-appointed” scientists are increasingly influential. The planetary boundaries theory (discussed above) that was developed by a group of 29 such scientists is an example. The planetary boundaries have more recently reincarnated as “earth system targets” that are being negotiated and developed by an Earth Commission consisting of 19 scientists that have not been democratically elected or appointed through the usual intergovernmental processes. Will this “private” scientific commission manage to provide the democratic legitimacy to earth system targets which planetary boundaries have failed to secure? It remains to be seen to what extent the commission will represent the voices of the marginalized in the Global South.<sup>85</sup>

It is challenges such as these that would require earth system law scholarship to provide a critical perspective on the role of law in entrenching or disrupting patterns of planetary injustice and earth system governance democracy. In this context, it would be key for the notion of justice to be expanded and to become applicable to questions of inequality, for example, between human and more-than-humans. After all, as difficult as this might be to do, should we not also be listening to the voices of the voiceless when defining earth system targets and pursuing planetary justice for “everyone”? Answers to questions such as these will need to be found through open and inclusive deliberation, and through legitimate and democratic earth system governance institutions, and then ultimately institutionalized in earth system law, which could guarantee future generations and non-human species a seat at the table, as it were.

### 3.3. *Transformative Dimension*

The transformative dimension of earth system law involves both reforming existing international environmental law alongside the governance demands of a complex Earth system (internal transformations), as well as pursuing initiatives that

are fully embedded in an earth system law paradigm that can trigger and steer societal transformation towards planetary integrity and justice (external transformations). These two objectives are intricately intertwined. Earth system law will remain difficult to realize unless societies show signs of change, and societal transformation will unlikely materialize unless legal paradigms start shifting. The main challenge in this respect (and this is a challenge that earth system law will have to overcome), is that we are facing “double complexity”: both the complex object of regulation (the Earth system) and the complex regulatory system that must respond to this object (the law) must be transformed.<sup>86</sup>

One way to confront this challenge is to adaptively manage complex adaptive legal systems which could be used to adaptively manage the complex adaptive Earth system.<sup>87</sup> Such adaptive management of the regulatory object through adaptive management of our regulatory systems will need to be an ongoing, iterative, and interactive process. Earth system law can therefore not be too rigid, and will rather have to constantly adapt by responding to the dynamics of an Earth system that is always in flux. In this sense, it will be important to strike a fine balance between stability and flexibility of the rule of law.<sup>88</sup> This may seem at odds with the necessity to “bolster legal boundaries” for the sake of staying within planetary boundaries,<sup>89</sup> but it is not. Legal boundaries can be strict, but these boundaries can be revised periodically to allow for flexibility. Having multiple institutions and/or legal boundaries will also help as institutional redundancy could provide a safety net in case some legal boundaries fail.<sup>90</sup> To this end, JB Ruhl argues that we need to harness, rather than reduce, legal complexity,<sup>91</sup> while we should also make more deliberate use of institutional diversity.

The transformative dimension of earth system law will clearly need to be in constant dialogue with its analytical and normative dimensions. For the purpose of guiding earth system transformations through earth system law, we will presumably first need to identify and analyse pathways through which legal institutions guide, shape, and/or block societal transformations. This will enable us to constantly develop, implement, and critically reflect on reform proposals such as the constitutionalization of international environmental law mentioned above.

#### 4. Conclusion

Our brief analysis suggests that international environmental law might have a burgeoning body of norms with a singular focus on an externalised “environment” that needs protection at the international level, but these norms that mainly operate at the inter-State level are not rationally connected with and responsive to biogeophysical Earth system limits and the complex interrelated nature of Earth system processes. Instead of aligning with Earth system limits and the Earth system’s many complex governance challenges, international environmental law remains a fragmented, one-dimensional, anthropocentric construct with a dualist Cartesian ontology, which renders it incapable to meaningfully confront the destruction caused by some privileged humans through the perpetuation of shortermist, neoliberal and pro-growth self-interests. International environmental law therefore has not been all that successful in preventing humans from crossing planetary boundaries, from becoming a major geological power equalling the disruptive force of volcanoes, and from destroying the living foundations of all life, including our own.

We therefore suspect Sand might have spoken too soon in his 2007 assessment that “international law for the environment has coped rather well with the challenges of global change. It seems a little too soon, therefore, to predict ‘the end of environmental law’”.<sup>92</sup> Our analysis rather supports the more sobering view that “the current system of international environmental law and governance ... is considered to be unsuitable for navigating the Anthropocene”.<sup>93</sup> It is clear that “fresh thinking is required to move beyond the (transitory) answers provided by the broad concept of sustainable development. This is perhaps the most important frontier in contemporary international environmental law”.<sup>94</sup> In this paper, we offered our version of “fresh thinking” that we situate in the paradigm of earth system law. Earth system law must, alongside all other governance interventions, ultimately contribute to enable desirable futures for all Earth system components and processes, including human and more-than-human entities. It therefore offers a new, innovative paradigm for law to facilitate the type of transformations that are in step with a continuously transforming Earth system, and that would be needed to fully confront the socio-ecological crisis of the Anthropocene.

#### Endnotes

<sup>1</sup> See, for example, Robèrt, K.-H., Broman, G.I. and Basile, G. 2013. “Analyzing the Concept of Planetary Boundaries from a Strategic Sustainability Perspective: How does Humanity Avoid Tipping the Planet?” *Ecology and Society* 18 : 1-9.

<sup>2</sup> Stephens, T. 2018. “What is the Point of International Environmental Law Scholarship in the Anthropocene?” In: Pedersen, O. (ed). *Perspectives on Environmental Law Scholarship: Essays on Purpose, Shape and Direction*, at 121-139. Cambridge: Cambridge University Press.

<sup>3</sup> Steffen, W. et al. (eds). 2004. *Global Change and the Earth System: A Planet under Pressure*. Berlin: Springer.

<sup>4</sup> Kotzé, L. 2019. “International Environmental Law’s Lack of Normative Ambition: An Opportunity for the Global Pact for the Environment?” *Journal for European Environmental and Planning Law* 16 : 213-236.

<sup>5</sup> See, generally, Kotzé, L. (ed). 2017. *Environmental Law and Governance for the Anthropocene*. Oxford: Hart.

<sup>6</sup> Viñuales, J. 2018. “The Organization of the Anthropocene in Our Hands?” *International Legal Theory and Practice* 1 : 1-81.

<sup>7</sup> Kotzé, L. and Kim, R.E. 2019. “Earth System Law: The Juridical Dimensions of Earth System Governance”. *Earth System Governance* 1 : 1-12. See also, Kotzé, L. 2020. “Earth System Law for the Anthropocene: Rethinking Environmental Law alongside the Earth System Metaphor”. *Transnational Legal Theory* 11 : 75-104; Kotzé, L. 2019. “Earth System Law for the Anthropocene”. *Sustainability* 11 : 1-13.

<sup>8</sup> This will no doubt be a difficult study to undertake, although it has been done for other regulatory institutions such as the Sustainable Development Goals. See Zeng, Y. et al. 2020. “Environmental Destruction Not Avoided with the Sustainable Development Goals”. *Nature Sustainability* 3 : 795-798.

<sup>9</sup> See, for example, Young, O. (ed). 1999. *The Effectiveness of International Environmental Regimes: Causal Connections and Behavioral Mechanisms*. Cambridge, Mass.: MIT Press.

<sup>10</sup> As Bodansky puts it, international environmental law might be called a “thirty-percent solution”. Bodansky, D. 2010. *The Art and Craft of International Environmental Law*, at 15. Cambridge, Mass.: Harvard University Press.

<sup>11</sup> United Nations Environment Programme. 2019. *Global Environmental Outlook 6: Healthy Planet, Healthy People*. Cambridge: Cambridge University Press.

<sup>12</sup> Briggs, J. 2017. “Emergence of a Sixth Mass Extinction?” *Biological Journal of the Linnean Society* 122 : 243-248.

<sup>13</sup> Chakrabarty, D. 2018. “Anthropocene Time”. *History and Theory* 57 : 5-32, at 6.

<sup>14</sup> Norgaard, K.M. 2011. “Climate Denial: Emotion, Psychology, Culture, and Political Economy”. In: Dryzek, J., Norgaard, R. and Schlosberg, D. (eds). *The Oxford Handbook of Climate Change and Society*, at 399-413. Oxford: Oxford University Press.

<sup>15</sup> Malm, A. and Hornborg, A. 2014. “The Geology of Mankind? A Critique of the Anthropocene Narrative”. *The Anthropocene Review* 1 : 62-69; Kotzé, L. 2019. “International Environmental Law and the Anthropocene’s Energy Dilemma”. *Environmental and Planning Law Journal* 36 : 437-458.

<sup>16</sup> Stephens, *supra*, note 2, at 124.

<sup>17</sup> Yang, T. and Percival, R. 2009. “The Emergence of Global Environmental Law”. *Ecology Law Quarterly* 36 : 615-664.

<sup>18</sup> Heyvaert, V. and Ducic-Paoli, L-A. 2020. *Research Handbook on Transnational Environmental Law*. Cheltenham: Edward Elgar.

<sup>19</sup> Kim, R.E. 2016. "Transnational Sustainability Law: Whither International Environmental Law?" *Environmental Policy and Law* 46: 405-408.

<sup>20</sup> All terms that are typically used in international environmental law instruments and textbooks.

<sup>21</sup> Stephens, T. 2017. "Reimagining International Environmental Law in the Anthropocene". In: Kotzé, L. (ed). 2017. *Environmental Law and Governance for the Anthropocene*, at 54. Oxford: Hart.

<sup>22</sup> *Ibid.*

<sup>23</sup> Stephens, *supra*, note 2, at 128.

<sup>24</sup> Adelman, S. 2015. "Epistemologies of Mastery". In: Grear, A. and Kotzé, L. (eds). 2015. *Research Handbook on Human Rights and the Environment*, at 9-27. Cheltenham: Edward Elgar.

<sup>25</sup> *Ibid.*, at 10.

<sup>26</sup> *Ibid.*, at 9.

<sup>27</sup> Kotzé, "Earth System Law", *supra*, note 7, at 8-9.

<sup>28</sup> Fisher, E. *et al.* 2009. "Maturity and Methodology: Starting a Debate about Environmental Law Scholarship". *Journal of Environmental Law* 21: 213-250.

<sup>29</sup> *Ibid.*, at 215.

<sup>30</sup> Stephens, *supra*, note 21, at 54.

<sup>31</sup> The Declaration states, for example: "A point has been reached in history when we must shape our actions throughout the world with a more prudent care for their environmental consequences. Through ignorance or indifference we can do massive and irreversible harm to the earthly environment on which our life and well being depend. Conversely, through fuller knowledge and wiser action, we can achieve for ourselves and our posterity a better life in an environment more in keeping with human needs and hopes". Declaration of the United Nations Conference on the Human Environment, UN Doc. A/RES/2994 (adopted 15 December 1972), at Preamble para 6.

<sup>32</sup> Biermann, F. and Kim, R.E. 2020. "The Boundaries of the Planetary Boundary Framework: A Critical Appraisal of Approaches to Define a 'Safe Operating Space' for Humanity". *Annual Review of Environmental Resources* 45: 497-521.

<sup>33</sup> Rockström, J. *et al.* 2009. "A Safe Operating Space for Humanity". *Nature* 461: 472-475; and more recently, Steffen, W. *et al.* 2015. "Planetary Boundaries: Guiding Human Development on a Changing Planet". *Science* 347: 1259855.

<sup>34</sup> *Ibid.*, at 472-473. Own emphasis.

<sup>35</sup> Hadfield, G. and Weingast, B. 2012. "What is Law? A Coordination Model of the Characteristics of a Legal Order". *Journal of Legal Analysis* 4(2): 471-514, at 473.

<sup>36</sup> Chapron, G. *et al.* 2017. "Bolster Legal Boundaries to Stay within Planetary Boundaries". *Nature, Ecology and Evolution* 1: 1-5, at 1.

<sup>37</sup> Rockström *et al.*, *supra*, note 33, at 472; Steffen *et al.*, *supra*, note 33.

<sup>38</sup> French, D. and Kotzé, L. (eds). 2021. *Research Handbook on Law, Governance and Planetary Boundaries*. Cheltenham: Edward Elgar.

<sup>39</sup> UN Framework Convention on Climate Change [(1992) 31 ILM 849], at Article 2.

<sup>40</sup> Mann, M. 2009. "Defining Dangerous Anthropogenic Interference". *Proceedings of the National Academy of Sciences* 106(11): 4065-4066.

<sup>41</sup> Bodansky, *supra*, note 10, at 35.

<sup>42</sup> Stephens, *supra*, note 21, at 47.

<sup>43</sup> Kim, R.E. 2013. "The Emergent Network Structure of the Multilateral Environmental Agreement System". *Global Environmental Change* 23: 980-991; Mitchell, R.B. *et al.* 2020. "What We Know (and Could Know) about International Environmental Agreements". *Global Environmental Politics* 20: 103-121.

<sup>44</sup> While there are others, the preventive, precautionary and polluter pays principles are examples of the most prominent principles of international environmental law. See, more generally, Krämer, L. and Orlando, E. (eds). 2018. *Principles of Environmental Law*. Cheltenham: Edward Elgar.

<sup>45</sup> Adelman, S. 2018. "The Sustainable Development Goals, Anthropocentrism and Neoliberalism". In: French, D. and Kotzé, L. (eds). *Sustainable Development Goals: Law, Theory and Implementation*, at 21. Cheltenham: Edward Elgar.

<sup>46</sup> Richardson, B. 2011. "A Damp Squib: Environmental Law from a Human Evolutionary Perspective". *Osgoode Hall Law School Comparative Research in Law and Political Economy Paper Series* 7(3): 1-42, at 31.

<sup>47</sup> Hursh, D. and Henderson, J. 2011. "Contesting Global Neoliberalism and Creating Alternative Futures". *Discourse: Studies in the Cultural Politics of Education* 32(2): 171-185, at 178.

<sup>48</sup> Adelman, *supra*, note 45, at 15-40.

<sup>49</sup> Steffen, W. *et al.* 2018. "Trajectories of the Earth System in the Anthropocene". *Proceedings of the National Academy of Sciences* 115(33): 8252-8259, at 8258. Own emphasis.

<sup>50</sup> Kotzé, *supra*, note 4.

<sup>51</sup> Available at <https://www.ipcc.ch/sr15/>.

<sup>52</sup> Du Toit, L. 2021. "Stratospheric Ozone Depletion". In: French, D. and Kotzé, L. (eds). 2021. *Research Handbook on Law, Governance and Planetary Boundaries*. Cheltenham: Edward Elgar.

<sup>53</sup> Bryner, N. 2015. "Applying the Principle in *Dubio Pro Natura* for Enforcement of Environmental Law". In: Organization of American States. 2015. *Inter-American Congress on the Environmental Rule of Law: Selected Essays*, at 166-173. Montego Bay: OAS.

<sup>54</sup> Kotzé, L. 2016. *Global Environmental Constitutionalism in the Anthropocene*. Oxford: Hart.

<sup>55</sup> UN Human Rights Council "Report of the Special Rapporteur on the Issue of Human Rights Obligations Relating to the Enjoyment of a Safe, Clean, Healthy and Sustainable Environment", UN Doc. A/HRC/37/59 (2018), at para. 46; Kotzé, L. 2018. "In Search of a Right to a Healthy Environment in International Law". In: Knox, J. and Pejan, R. (eds). *The Human Right to a Healthy Environment*, at 136-154. Cambridge: Cambridge University Press.

<sup>56</sup> Bosselmann, K. 2016. *The Principle of Sustainability: Transforming Law and Governance*. Florence: Taylor and Francis.

<sup>57</sup> Kim, R.E. and Bosselmann, K. 2013. "International Environmental Law in the Anthropocene: Towards a Purposive System of Multilateral Environmental Agreements". *Transnational Environmental Law* 2: 285-309; Bridgewater, P., Kim, R.E. and Bosselmann, K. 2014. "Ecological Integrity: A Relevant Concept for International Environmental Law in the Anthropocene?" *Yearbook of International Environmental Law* 25: 61-78; Kim, R.E. and Bosselmann, K. 2015.

“Operationalizing Sustainable Development: Ecological Integrity as a *Grundnorm* of International Law”. *Review of European, Comparative & International Environmental Law* 24 : 194-208.

<sup>58</sup> UN General Assembly, UN Doc. A/RES/37/7 (adopted 28 October 1982). See more generally, Burhenne, W. and Irwin, W. 1986. *Beiträge zur Umweltgestaltung: The World Charter for Nature: Legislative History*. Berlin: Erich Schmidt Verlag.

<sup>59</sup> Kotzé, L. 2019. “A Global Environmental Constitution for the Anthropocene?” *Transnational Environmental Law* 8 : 11-33; Kotzé, L. 2015. “The Anthropocene’s Global Environmental Constitutional Moment”. *Yearbook of International Environmental Law* 25 : 24-60.

<sup>60</sup> UN General Assembly “Towards a Global Pact for the Environment”, UN Doc. A/RES/72/277 (adopted 10 May 2018).

<sup>61</sup> Biniaz, S. 2019. “The UNGA Resolution on a ‘Global Pact for the Environment’: A Chance to Put the Horse before the Cart”. *Review of European, Comparative and International Environmental Law* 28 : 33-39; Kotzé, L. and French, D. 2018. “A Critique of the Global Pact for the Environment: A Stillborn Initiative or the Foundation for *Lex Anthropocenae*?” *International Environmental Agreements: Politics, Law and Economics* 18 : 811-838.

<sup>62</sup> See, for example, article 3 of the draft text of the Pact. Available at <https://globalpactenvironment.org/uploads/EN.pdf>.

<sup>63</sup> Available at <https://globalpactenvironment.org/uploads/GPREcomFINAL.pdf>.

<sup>64</sup> See, for a timeline, <https://globalpactenvironment.org/en/the-pact/where-are-we-now/> and for an incisive discussion, Petersmann, M. “I Wish there was a Treaty We could Sign: An Inquiry into the Making of the Global Pact for the Environment” (submitted for review, available on request from the author).

<sup>65</sup> Aguila, Y. 2020. “A Global Pact for the Environment: The Logical Outcome of 50 Years of International Environmental Law”. *Sustainability* 12 : 1-17, at 1. Own emphasis.

<sup>66</sup> *Ibid.*, at 1-17.

<sup>67</sup> Biermann, F. 2007. “‘Earth System Governance’ as a Crosscutting Theme of Global Change Research”. *Global Environmental Change* 17 : 326-337, at 328.

<sup>68</sup> Kim, R.E. and Kotzé, L.J. 2021. “Planetary Boundaries at the Intersection of Earth System Law, Science and Governance: A State-of-the-Art Review”. *Review of European, Comparative and International Environmental Law* 30 : 3-15.

<sup>69</sup> Clark, W.C. and Harley, A.G. 2020. “Sustainability Science: Toward a Synthesis”. *Annual Review of Environment and Resources* 45 : 331-386.

<sup>70</sup> See, for example, Sterner, T. *et al.* 2019. “Policy Design for the Anthropocene”. *Nature Sustainability* 2 : 1-8; Lim, M. (ed). 2019. *Charting Environmental Law Futures in the Anthropocene*. Singapore: Springer; Vidas, D. 2011. “The Anthropocene and the International Law of the Sea”. *Philosophical Transactions of the Royal Society A* 369 : 909925.

<sup>71</sup> Young, O.R. 2002. *The Institutional Dimensions of Environmental Change: Fit, Interplay, and Scale*. Cambridge, Mass.: MIT Press; Galaz, V. *et al.* 2008. “The Problem of Fit between Governance Systems and Environmental Regimes”. In: Young, O.R., King, L.A. and Schroeder, H. (eds). 2008. *Institutions and Environmental Change: Principal Findings, Applications, and Research Frontiers*, at 147-186. Cambridge, Mass.: MIT Press.

<sup>72</sup> Walker, B. *et al.* 2009. “Looming Global-Scale Failures and Missing Institutions”. *Science* 325 : 1345-1346.

<sup>73</sup> Steffen, W., Rockström, J. and Costanza, R. 2011. “How Defining Planetary Boundaries Can Transform our Approach to Growth”. *Solutions* 2 : 59-65.

<sup>74</sup> Earth System Governance. 2020. “Task Force on Earth System Law”. Available at <https://earthsystemgovernance.net/research/taskforce-on-earth-system-law/>.

<sup>75</sup> See, for example, Schellnhuber, H.J. 1999. “‘Earth System’ Analysis and the Second Copernican Revolution”. *Nature* 402 : 19-23; Lenton, T.M. *et al.* 2008. “Tipping Elements in the Earth’s Climate System”. *Proceedings of the National Academy of Sciences* 105(6): 1786-1793; Steffen *et al.*, *supra*, note 49.

<sup>76</sup> For a review of earth system science, see Steffen, W. *et al.* 2020. “The Emergence and Evolution of Earth System Science”. *Nature Reviews Earth & Environment* 1 : 1-10.

<sup>77</sup> Richardson, B.J. 2017. *Time and Environmental Law: Telling Nature’s Time*. Cambridge: Cambridge University Press.

<sup>78</sup> See, for example, Barrett, S. *et al.* 2011. “Climate Engineering Reconsidered”. *Nature Climate Change* 4 : 527-529; Archer, D. *et al.* 2009. “Atmospheric Lifetime of Fossil Fuel Carbon Dioxide”. *Annual Review of Earth and Planetary Sciences* 37 : 117-134.

<sup>79</sup> Stephens, *supra*, note 2.

<sup>80</sup> See, for example, Robinson, N.A. 2014. “Fundamental Principles of Law for the Anthropocene?” *Environmental Policy and Law* 33 : 13-27.

<sup>81</sup> Biermann, F. and Kalfagianni, A. 2020. “Planetary Justice: A Research Framework”. *Earth System Governance*. Available at <https://doi.org/10.1016/j.esg.2020.100049>.

<sup>82</sup> Kashwan, P. *et al.* 2020. “Planetary Justice: Prioritizing the Poor in Earth System Governance”. *Earth System Governance*. Available at <https://doi.org/10.1016/j.esg.2020.100075>.

<sup>83</sup> See, for example, Dryzek, J.S. and Stevenson, H. 2011. “Global Democracy and Earth System Governance”. *Ecological Economics* 70 : 1865-1874.

<sup>84</sup> Sénit, C.-A. 2020. “Transforming Our World? Discursive Representation in the Negotiations on the Sustainable Development Goals”. *International Environmental Agreements: Politics, Law and Economics* 20 : 411-429.

<sup>85</sup> Pickering, J. and Persson, Å. 2020. “Democratising Planetary Boundaries: Experts, Social Values and Deliberative Risk Evaluation in Earth System Governance”. *Journal of Environmental Policy & Planning* 22 : 59-71.

<sup>86</sup> Galaz, V. 2011. “Double Complexity: Information Technology and Reconfigurations in Adaptive Governance”. In: Boyd, E. and Folke, C. (eds). *Adapting Institutions: Governance, Complexity and Social-Ecological Resilience*, at 193-215. Cambridge: Cambridge University Press. See also Kim, R.E. 2020. “Complex Systems”. In: Morin, J.-F. and Orsini, A. (eds). *Essential Concepts of Global Environmental Governance*, at 47-49. New York: Routledge.

<sup>87</sup> Ruhl, J.B. 2012. “Panarchy and the Law”. *Ecology and Society* 17(3). Available at <https://www.ecologyandsociety.org/vol17/iss3/art31/>. See also Kim, R.E. and Mackey, B. 2014. “International Environmental Law as a Complex Adaptive System”. *International Environmental Agreements: Politics, Law and Economics* 14 : 5-24.

<sup>88</sup> Ebbesson, J. 2010. “The Rule of Law in Governance of Complex Socio-Ecological Changes”. *Global Environmental Change* 20 : 414-422.

<sup>89</sup> Chapron *et al.*, *supra*, note 36, at 1-5.

<sup>90</sup> Low, B. *et al.* 2003. "Redundancy and Diversity: Do They Influence Optimal Management?" In: Berkes, F., Colding, J. and Folke, C. (eds). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*, at 83-114. Cambridge: Cambridge University Press.

<sup>91</sup> Ruhl, J.B., Katz, D.M. and Bommarito, M.J. II. 2017. "Harnessing Legal Complexity". *Science* 355 : 1377-1378.

<sup>92</sup> Sand, P. 2007. "The Evolution of International Environmental Law". In: Bodansky, D., Brunnée, J. and Hey, E. (eds). *The Oxford Handbook of International Environmental Law*, at 42. Oxford: Oxford University Press.

<sup>93</sup> Kim and Bosselmann, *supra*, note 57, 286.

<sup>94</sup> Dupuy, P.-M. and Viñuales, J. 2018. *International Environmental Law*, at 24. Second edition. Cambridge: Cambridge University Press.