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Legal Challenges of Cross-Border Environmental Harm: State Responsibility and the Development of International Environmental Law

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Abstract

Cross-border environmental harm presents legal difficulties when cumulative environmental injury involves multiple contributors, overlapping obligations, and uncertain causal relationships. Existing scholarship addresses prevention, attribution, and remedies extensively but provides insufficient methodological integration across conventional transboundary pollution and global environmental harm. This study examines the interaction between primary environmental obligations and the secondary rules of State responsibility. A normative-doctrinal approach evaluates treaties, International Law Commission instruments, and selected international jurisprudence through September 2026, applying structured legal interpretation and comparative analysis. Particular attention is given to the 2024 ITLOS and 2025 Inter-American Court and ICJ climate advisory opinions. The findings establish that the no-harm principle and due diligence remain complementary preventive obligations, while contemporary jurisprudence clarifies their application to cumulative environmental risks. Attribution of State conduct must be distinguished from scientific causation, legal causation, and allocation of compensable injury. Concurrent environmental and human-rights obligations do not automatically establish jurisdiction, procedural standing, or proportional liability. The study develops a four-stage doctrinal framework separating primary obligations, breach and conduct attribution, causal contribution and allocation, and invocation of responsibility and remedies. This framework provides a systematic method for evaluating complex environmental responsibility while distinguishing established legal requirements from unresolved questions of collective causation and reparation.

Keywords: Cross-Border Harm, Due Diligence, Environmental Law, State Responsibility, Transboundary Pollution.



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INTRODUCTION

Cross-border environmental harm presents a persistent challenge to international law because ecological damage frequently originates from activities conducted within one State while producing consequences beyond its territorial jurisdiction. Conventional transboundary environmental harm generally concerns identifiable activities generating significant environmental risks or injury in another State or areas beyond national jurisdiction, whereas global environmental harm involves cumulative processes affecting shared ecological systems through contributions from multiple jurisdictions. These categories are legally distinguishable, although they may overlap when geographically dispersed activities produce environmental consequences extending across national boundaries. Transboundary haze, marine pollution, hazardous waste movements, and offshore oil spills illustrate the conventional problems of territorial control and cross-border environmental effects, while climate change represents a global environmental process involving cumulative greenhouse-gas emissions and geographically distributed impacts. Climate change is examined within the present study because its transboundary consequences engage questions concerning the prevention of significant environmental harm, the regulation of activities within State jurisdiction or control, and the legal consequences of internationally wrongful conduct, notwithstanding its distinctive causal and institutional characteristics (Duvic-Paoli & Gervasi, 2023). The no-harm principle and the requirement of due diligence provide an established normative foundation for these questions,

requiring States to adopt preventive measures appropriate to foreseeable environmental risks rather than guaranteeing the complete absence of environmental damage (McDonald, 2019). Prevention, cooperation, environmental impact assessment, and regulatory supervision consequently constitute established components of international environmental obligations whose application becomes increasingly demanding as environmental risks acquire cumulative and geographically dispersed characteristics (Craik, 2020). The principal legal difficulty concerns how these existing obligations interact with the secondary rules of State responsibility when environmental injury results from multiple activities, differentiated governmental conduct, and causal processes extending beyond a conventional bilateral dispute.

The distinction between primary environmental obligations and secondary rules of international responsibility is essential to assessing these developments. Primary obligations establish the conduct required of States, including prevention, regulation, cooperation, notification, and environmental assessment, whereas the law of State responsibility determines the legal consequences of conduct attributable to a State that constitutes a breach of an applicable international obligation (International Law Commission, 2001). The distinction becomes especially important when environmentally harmful activities are undertaken by private corporations, State-owned enterprises, or other actors operating within complex production and regulatory arrangements. Environmental damage caused by a private operator does not automatically establish State responsibility, since the attribution of private conduct and responsibility for a State's own regulatory omissions involve separate legal assessments. A State may nevertheless breach an applicable primary obligation by failing to adopt or implement the preventive measures required by due diligence, even where the underlying harmful activity cannot itself be attributed to that State. Marine plastic pollution illustrates the difficulty of connecting dispersed sources with particular environmental injuries and determining the legal significance of cumulative contributions (Tanaka, 2023). Transboundary water pollution similarly requires consideration of ecological interdependence and the legal obligations governing shared environmental resources rather than exclusive reliance on territorially isolated assessments of damage (McIntyre, 2020). Regional experience with transboundary haze in Southeast Asia further demonstrates the limitations of prevention and enforcement arrangements when pollution-producing activities, affected populations, and competent regulatory authorities are distributed across different jurisdictions (Alam & Nurhidayah, 2017). These problems expose an analytical weakness in approaches that address preventive obligations, attribution, causation, and compensation without consistently separating their respective legal requirements. Existing scholarship has developed these doctrinal questions extensively, but a systematic account of their interaction across conventional transboundary pollution and cumulative global environmental harm remains insufficiently articulated.

Recent international climate jurisprudence provides an important basis for examining this doctrinal problem without treating climate-related obligations as an entirely new system of environmental responsibility. The established requirement of due diligence remains an obligation of conduct whose specific content depends on the seriousness of foreseeable harm, available scientific knowledge, relevant regulatory capabilities, and the obligations applicable to the State concerned (Mayer, 2022b). In its 2024 Advisory Opinion on Climate Change and International Law, the International Tribunal for the Law of the Sea determined that anthropogenic greenhouse-gas emissions constitute pollution of the marine environment under the United Nations Convention on the Law of the Sea and examined the corresponding obligations of States to prevent, reduce, and control that pollution (International Tribunal for the Law of the Sea, 2024). The Tribunal's characterization of the applicable due-diligence standard as stringent reflects the seriousness of climate-related environmental risks, without converting the underlying obligation of conduct into a general guarantee against environmental injury. The relationship between such treaty-specific requirements and general international law remains particularly significant because the existence of specialized climate obligations does not necessarily exclude the concurrent application of customary prevention obligations or the secondary rules of State responsibility. Whether a particular treaty provision operates as *lex specialis* depends on its content, scope, and relationship with the general rule concerned, rather than merely on the existence of a specialized climate regime (Klerk, 2025). The development of climate litigation has consequently intensified judicial examination of the interaction among international environmental law, climate treaties, human-rights obligations, and the general law of international responsibility (Mayer & van Asselt, 2023). These developments indicate greater

specification of established preventive duties in response to global environmental risks rather than a categorical replacement of earlier no-harm and due-diligence principles.

The International Court of Justice's 2025 Advisory Opinion on the Obligations of States in Respect of Climate Change has particular significance for the relationship between preventive obligations and responsibility for internationally wrongful conduct. The Court's examination of applicable international obligations places climate-related State conduct within a broader legal framework encompassing treaty obligations, customary international law, and the general principles governing international responsibility (Foster, 2025). This approach requires careful distinction between the concurrent application of different sources of international law and the separate question of whether a specialized rule modifies the content or consequences of a general obligation. It also requires differentiation between establishing a breach of an obligation of conduct and proving the causal connection necessary to obtain reparation for a particular injury. The characterization of certain climate-related obligations as *erga omnes* or *erga omnes partes* further raises questions concerning the entitlement of States to invoke responsibility for violations of obligations owed to the international community or to the parties to a treaty collectively (Jackson & Paddeu, 2026). Such characterization must nevertheless be distinguished from procedural standing before a particular international court or tribunal, which remains subject to the applicable jurisdictional instrument and procedural requirements. Developments in international human-rights law introduce additional dimensions concerning the protection of individuals exposed to serious environmental risks and the relationship between environmental degradation and protected rights (Borràs-Pentinat, 2025). The interaction of these legal regimes demonstrates that identifying a substantive obligation does not independently resolve attribution, jurisdiction, invocation of responsibility, causation, or the availability of particular remedies. A coherent analysis must therefore distinguish the existence and breach of an international obligation from the separate legal conditions governing adjudication and reparation.

The jurisdictional dimension is particularly important where activities undertaken within one State generate environmental consequences affecting individuals outside its territory. In Advisory Opinion OC-23/17, the Inter-American Court of Human Rights examined the circumstances in which a State's control over activities producing transboundary environmental harm may establish a jurisdictional relationship with persons affected beyond its borders (Inter-American Court of Human Rights, 2017). This approach demonstrates the legal relevance of control over harmful activities, but it does not establish an unrestricted rule of extraterritorial jurisdiction applicable to every environmental or human-rights proceeding. The proceedings in *Sacchi v. Argentina et al.* illustrate the distinction between recognition of potential transboundary effects and the procedural conditions governing the examination of individual complaints, including the requirement to exhaust domestic remedies (Suedi, 2022). European human-rights jurisprudence has adopted a comparatively restrictive approach to certain extraterritorial climate claims while recognizing obligations concerning climate protection within established jurisdictional relationships (Heri, 2024). These differences reveal that environmental causation, State jurisdiction, and access to adjudicatory mechanisms are governed by related but distinct legal standards. Comparable differentiation is required when assessing the evidentiary significance of scientific attribution in cases involving cumulative environmental injury. Scientific methods can establish relationships between emissions, environmental changes, and the probability or severity of particular consequences, but scientific findings do not independently determine whether conduct is legally attributable to a State or whether the conditions for reparation have been satisfied (Otto et al., 2022). Theories of collective responsibility offer possible approaches to distributed environmental contributions, although their application to State responsibility continues to raise questions concerning legal authority, individual contributions, and the allocation of reparative obligations (Hormio, 2023). The Montara oil spill further illustrates the practical significance of examining environmental responsibility through both remedial measures and obligations intended to prevent the recurrence of comparable transboundary harm (Allain & Prihandono, 2026). These considerations establish the need to distinguish attribution of conduct, scientific evidence of causal contribution, legal causation, allocation of responsibility, and the determination of appropriate remedies.

The research gap addressed in this article concerns the absence of a sufficiently differentiated analytical method for applying the established law of State responsibility to environmental harm involving multiple contributors, overlapping legal regimes, and complex causal relationships. Existing

research has separately examined the no-harm principle, due diligence, international environmental adjudication, extraterritorial human-rights obligations, climate attribution, and compensation for environmental injury. Such analyses provide substantial doctrinal foundations but do not always establish the sequence of legal determinations required to distinguish a State's failure to comply with a primary obligation from the attribution of conduct, the causal contribution of that conduct to environmental injury, and the conditions governing invocation of responsibility and reparation. The resulting risk is that uncertainty concerning the allocation of environmental damage may be treated as preventing the identification of an independently established breach, or that proof of environmental damage may be incorrectly regarded as sufficient to establish international responsibility. The original contribution of this study is a structured four-stage analytical framework that differentiates: the identification and interpretation of applicable primary obligations; the determination of breach and attribution of State conduct; the examination of causal contribution and the legally supportable allocation of environmental injury; and the conditions governing invocation of responsibility and available remedies. Unlike approaches that combine these issues within a general assessment of environmental liability, the proposed framework assigns distinct legal questions and evidentiary requirements to each stage while identifying the relationships necessary to connect them. It also distinguishes existing international legal requirements from contested interpretations and proposed mechanisms for addressing distributed environmental injury. The framework is intended as a doctrinal analytical method rather than a claim that international law has already established a comprehensive system of proportional liability for cumulative environmental harm.

The study addresses three research questions. First, how do the no-harm principle, due diligence, and related procedural obligations apply to conventional transboundary environmental harm and cumulative global environmental risks, particularly in light of recent international jurisprudence? Second, how should attribution of State conduct, breach of international obligations, scientific and legal causation, and allocation of environmental injury be distinguished when environmental damage results from multiple contributors? Third, how can the interaction among international environmental law, climate law, human-rights obligations, and the secondary rules of State responsibility be structured to determine the conditions for invoking responsibility and identifying legally available remedies? These questions are examined through normative-doctrinal analysis of international treaties, customary international law, International Law Commission materials, and relevant international and regional jurisprudence, with particular attention to the 2024 ITLOS Climate Advisory Opinion and the 2025 climate advisory opinions of the International Court of Justice and Inter-American Court of Human Rights. The inquiry addresses the interpretation and interaction of existing legal obligations, the limits of current doctrine, and the analytical treatment of unresolved questions concerning cumulative causation, standing, allocation, and reparation. Its scope is confined to the international legal responsibility of States and does not presume that the attribution of private conduct, quantification of environmental damage, or establishment of jurisdiction follows automatically from the occurrence of cross-border or global environmental harm. By separating established legal requirements from disputed doctrinal propositions, the study develops a method for evaluating State responsibility that accommodates the complexity of contemporary environmental injury without disregarding the distinct conditions governing breach, legal causation, and remedies.

RESEARCH METHODS

This study employed a non-empirical normative-doctrinal research design integrating treaty interpretation, analysis of customary international law, jurisprudential examination, and structured comparison across international environmental law, climate law, the law of the sea, and international human-rights law. The methodological approach was directed toward identifying the legal requirements governing State conduct, the conditions for establishing internationally wrongful acts, and the consequences of responsibility for conventional transboundary and cumulative global environmental harm. Primary legal materials comprised relevant international treaties, customary-law authorities, judicial decisions, advisory opinions, and instruments developed by the International Law Commission (ILC). The principal documentary sources included the United Nations Convention on the Law of the Sea, the United Nations Framework Convention on Climate Change, the Paris Agreement, applicable human-rights instruments, the Articles on Responsibility of States for Internationally Wrongful Acts (2001), and the Draft Articles on Prevention of Transboundary Harm

from Hazardous Activities (2001). The ILC Draft Principles on the Allocation of Loss in the Case of Transboundary Harm Arising out of Hazardous Activities (2006) were examined separately as non-binding principles relevant to the development of approaches to environmental loss allocation, rather than as independently binding obligations (International Law Commission, 2001). Official legal materials were identified through the United Nations Treaty Collection, United Nations and ILC documentation, and published institutional records of the International Court of Justice, International Tribunal for the Law of the Sea, Inter-American Court of Human Rights, and other relevant international and regional adjudicatory bodies. Secondary sources consisted of peer-reviewed scholarship and authoritative legal analyses addressing due diligence, prevention, attribution, causation, environmental assessment, jurisdiction, collective responsibility, and reparation. The documentary examination covered materials available through September 2026, while earlier authorities were retained where they established foundational propositions necessary for interpreting contemporary international obligations (Schmalenbach, 2023).

Legal materials were selected according to four substantive criteria: their relevance to environmental obligations extending beyond territorial jurisdiction; their treatment of State conduct, prevention, attribution, causation, or remedies; their legal authority within the applicable international regime; and their contribution to identifying doctrinal convergence, disagreement, or unresolved legal questions. Judicial decisions and advisory opinions were included where their reasoning directly addressed preventive duties, the interpretation of environmental obligations, extraterritorial jurisdiction, or the application of general rules of State responsibility. Particular analytical attention was assigned to the 2024 ITLOS Climate Advisory Opinion, the 2025 Inter-American Court Advisory Opinion on the Climate Emergency and Human Rights, and the 2025 ICJ Advisory Opinion on the Obligations of States in Respect of Climate Change because these authorities directly address the application and interaction of environmental, climate, and human-rights obligations in response to cumulative environmental risks. Earlier authorities, including *Pulp Mills on the River Uruguay*, the ITLOS Seabed Advisory Opinion, and Inter-American Court Advisory Opinion OC-23/17, were examined as doctrinal reference points for assessing continuity and differentiation in the interpretation of prevention and due diligence (McDonald, 2019). Secondary scholarship was selected for its direct engagement with the identified legal questions, doctrinal specificity, and capacity to explain competing interpretations rather than merely provide general descriptions of environmental governance. Materials addressing environmental issues without a substantive connection to international obligations, State responsibility, or the legal consequences of environmental harm were excluded from the core doctrinal analysis. The selection procedure prioritized authoritative primary legal texts over secondary interpretations when determining the current content of international legal obligations.

The interpretive procedure distinguished treaty obligations, customary international law, general rules of State responsibility, and non-binding normative instruments according to their respective legal status and function. Treaty interpretation followed the ordinary meaning of legal provisions in their context and in light of the relevant treaty's object and purpose, with attention to other applicable rules of international law where legally appropriate. Customary-law propositions were assessed through relevant judicial formulations, recognized international legal materials, and the distinction between evidence of existing legal rules and proposals for progressive development. Judicial decisions and advisory opinions were examined through their operative conclusions, relevant legal reasoning, jurisdictional foundations, and treatment of applicable obligations. Where authorities presented different approaches, their relative significance was evaluated by reference to the applicable legal instrument, the jurisdiction of the adjudicatory body, the factual and legal questions considered, and the extent to which a proposition formed part of the tribunal's reasoning rather than subsequent scholarly interpretation. Advisory opinions were treated as authoritative judicial interpretations without equating their legal effects with those of binding judgments in contentious proceedings. The analysis of due diligence distinguished obligations of conduct from guarantees of environmental outcomes and assessed preventive requirements according to foreseeability, seriousness of risk, available scientific knowledge, and relevant State capabilities (Mayer, 2022b). Similarly, the existence of a specialized treaty regime was not treated as sufficient to displace general international law without examining the relationship between the relevant obligations and the conditions governing any applicable *lex specialis* rule.

Comparative legal analysis was conducted through a common doctrinal matrix examining the source and legal status of obligations, their material and jurisdictional scope, the standard of State conduct, the requirements for establishing breach, the attribution of conduct, the treatment of causation, the entitlement to invoke responsibility, and the availability of remedies. These criteria were applied to international environmental law, the law of the sea, climate treaties, and regional human-rights jurisprudence to identify convergence where separate regimes adopted compatible legal standards and fragmentation where their jurisdictional conditions, substantive requirements, or remedial consequences differed (Bellinkx et al., 2022). Jurisprudential synthesis then examined the relationship between established principles and developments reflected in the 2024–2025 climate advisory opinions, distinguishing determinations supported by judicial reasoning from emerging academic interpretations and proposed legal mechanisms. The resulting findings were organized within a four-stage analytical framework comprising the identification of primary obligations, determination of breach and attribution of State conduct, assessment of causal contribution and allocation of environmental injury, and examination of the invocation of responsibility and legally available remedies. The framework maintained the distinction between attribution of conduct under the general law of State responsibility and scientific or legal causation concerning environmental injury. It also separated responsibility arising from a State's own failure to exercise due diligence from circumstances in which the conduct of a private actor may be attributable to the State under applicable legal rules. Doctrinal conclusions were assessed through cross-comparison of primary legal authorities, relevant international instruments, and scholarly interpretations, while unresolved questions of proportional allocation, collective invocation, and reparative mechanisms were expressly distinguished from established international legal requirements.

RESULTS AND DISCUSSION

From the No-Harm Rule to Stringent Due Diligence

The contemporary law governing cross-border environmental harm begins from the customary proposition that a State must ensure that activities within its jurisdiction or control do not cause significant environmental damage to other States or to areas beyond national jurisdiction (International Court of Justice, 1996). The Stockholm Declaration and the Rio Declaration express this principle by linking sovereign authority over natural resources with responsibility for environmental effects extending beyond national boundaries (United Nations, 1972). The rule is not generally understood as imposing strict liability for every harmful environmental outcome because international responsibility ordinarily turns on the adequacy of State conduct in responding to foreseeable risk (McDonald, 2019). The ILC Draft Articles on Prevention of Transboundary Harm consequently frame prevention through authorization, assessment, notification, consultation, and other measures expected from a State exercising due diligence over hazardous activities (International Law Commission, 2001). Climate adjudication has expanded the functional importance of the prevention principle because globally cumulative harm cannot be contained within the classical bilateral model of one source State causing identifiable injury to one affected State (Duvic-Paoli & Gervasi, 2023). The resulting architecture places the no-harm rule at the level of the protected legal interest while due diligence determines whether the measures adopted by a State were legally adequate in light of the relevant environmental risk (Schmalenbach, 2023).

The operational content of due diligence became substantially clearer in *Pulp Mills on the River Uruguay*, where the International Court of Justice linked prevention with appropriate regulation, administrative control, enforcement, and environmental impact assessment where there is a risk of significant transboundary harm (International Court of Justice, 2010). The judgment is doctrinally significant because it separates an obligation to take reasonable preventive measures from any guarantee that environmental damage will never occur (Craik, 2020). The 2011 ITLOS Seabed Advisory Opinion further characterized due diligence as a variable standard whose content can change according to the level of risk, available scientific knowledge, technological development, and the capabilities of the State concerned (International Tribunal for the Law of the Sea, 2011). This flexibility should not be confused with unrestricted governmental discretion because the legal standard becomes more demanding as the probability or gravity of environmental damage increases (McDonald, 2019). A State may therefore incur responsibility for an omission even where the immediate polluting activity was undertaken by a private operator, since failure to establish and

enforce adequate regulatory controls constitutes conduct attributable to the State itself (Lorteau, 2023). Due diligence consequently functions as the doctrinal mechanism through which international law transforms the general obligation of prevention into assessable duties of legislation, licensing, supervision, monitoring, enforcement, and inter-State cooperation (Gemalmaz, 2023).

The development of climate jurisprudence has intensified this risk-sensitive understanding of State conduct by applying traditional preventive principles to cumulative greenhouse-gas emissions and threats to common environmental systems (Foster, 2024). In its 2024 Climate Advisory Opinion, ITLOS treated anthropogenic greenhouse-gas emissions as capable of constituting pollution of the marine environment within the meaning of UNCLOS and required States to take measures directed at preventing, reducing, and controlling such pollution (International Tribunal for the Law of the Sea, 2024). The Tribunal described the applicable due-diligence standard as stringent because climate-related harm to the marine environment may be serious, widespread, and irreversible (Mayer, 2025). Roeben and Guo interpret this formulation as developing a result-oriented conception of due diligence in which the obligation remains one of conduct but the legal adequacy of that conduct is assessed in relation to the environmental objective that the regime seeks to achieve (Roeben & Guo, 2026). The distinction remains important because a stringent standard does not convert international environmental obligations into automatic liability whenever climate damage occurs (Klerk, 2025). It instead raises the quality, consistency, and scientific responsiveness of the regulatory measures that a State must demonstrate when the foreseeable consequences of inadequate action are exceptionally severe (Mayer, 2022b).

Table 1. Normative Architecture of Cross-Border Environmental Harm

Norm / instrument	Legal function	Trigger	Core requirement
No-harm prevention principle	Primary customary obligation	Risk of significant environmental harm	Use due diligence to prevent or minimize significant harm
ILC Prevention Articles (2001)	Codification / progressive development	Hazardous activities involving significant transboundary risk	Authorization, risk assessment, notification, consultation, prevention
UNCLOS Part XII	Treaty-based marine protection	Pollution or risk to marine environment	Prevent, reduce, control; cooperate; monitor; assess
UNFCCC / Paris Agreement	Climate-specific mitigation and cooperation	Anthropogenic GHG emissions and climate risk	Mitigation planning, progression, highest possible ambition, cooperation
Human-rights law	Protection of persons affected by environmental degradation	Real and foreseeable risk to protected rights	Respect, protect, guarantee rights; regulate harmful activities
ARSIWA (2001)	Secondary rules of responsibility	Attributable breach of an international obligation	Cessation, non-repetition, reparation where conditions are met

Table 1 demonstrates that cross-border environmental law cannot be reduced to a single rule of liability because it combines primary preventive obligations with secondary rules governing the legal consequences of breach (International Law Commission, 2001). The no-harm principle and the ILC prevention framework regulate significant transboundary risk, while UNCLOS imposes more specific duties to prevent, reduce, and control pollution of the marine environment (United Nations, 1982). Climate treaties add obligations of mitigation planning, progression, cooperation, and highest possible ambition without displacing other applicable rules of international environmental law (Rajamani, 2024). Human-rights law further broadens the protected interests by requiring States to address real and foreseeable environmental threats to life, health, private life, culture, and other protected rights (McCluskey, 2022). ARSIWA operates at a different doctrinal level because it does

not define the substantive environmental duty but identifies consequences once an attributable breach of a primary international obligation has been established (International Law Commission, 2001). Keeping these normative levels separate permits a tribunal to identify a preventive breach before resolving the more difficult questions of quantifying environmental injury, causal contribution, or appropriate reparation (Schmalenbach, 2023).

The increasing stringency of due diligence also requires differentiation among States without allowing differences in capacity to become a general justification for regulatory inaction (Wewerinke-Singh, 2026). Scientific knowledge, technological availability, financial resources, regulatory capacity, and the magnitude of foreseeable harm are relevant to determining what measures are reasonably expected from a particular State (Ritz, 2023). The 2025 ICJ Climate Advisory Opinion reinforces this approach by connecting climate obligations with prevention, cooperation, best available science, and the differentiated capacities of States while maintaining the demanding character of the underlying duty (International Court of Justice, 2025). Differentiation consequently concerns the content and implementation of the obligation rather than the existence of a common legal duty to address foreseeable environmental risk (Wewerinke-Singh, 2026). This formulation is especially important for climate change because identical numerical measures cannot automatically be required from States whose historical emissions, development conditions, technological capabilities, and present contributions differ significantly (Mayer, 2024). At the same time, the concept of capability cannot excuse failure to adopt reasonably available measures where scientific evidence demonstrates a serious risk and effective regulatory options remain within governmental control (Mayer, 2022b).

Table 2. Jurisprudential Development of Prevention and Due Diligence

Authority		Year	Development	Significance for Cross-Border Harm
Trail Smelter Arbitration		1941	State duty regarding serious transboundary air pollution	Classical source-control model
Corfu Channel (ICJ)		1949	Duty not knowingly to allow territory to be used contrary to rights of others	Knowledge and territorial control
Pulp Mills (ICJ)		2010	Due diligence includes regulation, enforcement, administrative control; EIA required where significant risk exists	Operationalizes prevention
ITLOS Seabed Advisory Opinion		2011	Due diligence is variable and risk-sensitive	Standard evolves with knowledge and risk
South China Sea Arbitration		2016	Marine environmental obligations apply broadly and protect collective interests	Extends preventive logic beyond bilateral injury
IACtHR OC-23/17		2017	Environmental due diligence linked to extraterritorial human-rights effects	Connects environment and human rights
ITLOS Climate Advisory Opinion		2024	GHG emissions can be marine pollution; due diligence is stringent	Applies prevention to global cumulative pollution
ICJ Climate Advisory Opinion		2025	Customary prevention applies to climate system; due diligence stringent; general responsibility rules remain applicable	Consolidates general international-law obligations

The jurisprudential sequence in Table 2 illustrates a gradual movement from classical territorial source control toward preventive governance of increasingly complex and collective environmental risks (Duvic-Paoli & Gervasi, 2023). *Trail Smelter* supplied the classical transboundary-pollution paradigm, while *Corfu Channel* reinforced the relevance of knowledge and

territorial control to obligations concerning harmful activities (International Court of Justice, 1949). *Pulp Mills* and the ITLOS Seabed Advisory Opinion transformed those principles into operational duties by emphasizing regulatory vigilance, environmental assessment, enforcement, and the variability of due diligence according to risk (International Tribunal for the Law of the Sea, 2011). The South China Sea Arbitration and IACtHR OC-23/17 further extended preventive reasoning toward collective environmental interests and environmental effects on persons located outside the territory of the source State (Inter-American Court of Human Rights, 2017). The 2024 ITLOS and 2025 ICJ climate advisory opinions mark a further doctrinal step by applying stringent preventive duties to a cumulative global phenomenon that cannot be attributed to a single territorial source (Foster, 2025). These developments confirm that the contemporary no-harm rule is best understood as the foundation of a risk-governance system in which increasingly stringent due diligence translates foreseeable environmental danger into concrete regulatory obligations while preserving the distinction between an obligation of conduct and strict liability (Roeben & Guo, 2026).

Attribution, Causation, and Shared Environmental Injury

State responsibility for cross-border environmental harm requires a clear distinction between the physical source of environmental damage and the conduct that international law legally attributes to a State (International Law Commission, 2001). Articles 4 and 5 of ARSIWA attribute conduct to State organs and, in defined circumstances, to entities empowered to exercise governmental authority, while conduct of ordinary private operators does not automatically become conduct of the State (International Law Commission, 2001). Environmental responsibility may nevertheless arise from the State's own omission where licensing systems, regulatory standards, supervision, monitoring, or enforcement fail to satisfy an applicable due-diligence obligation (Schmalenbach, 2023). This distinction is particularly important where privately owned corporations generate emissions or pollution because the legally relevant breach may consist of inadequate governmental control rather than direct attribution of corporate conduct (Lorteau, 2023). State-owned enterprises create a more complex inquiry because their formal ownership does not itself determine attribution unless their conduct satisfies the relevant rules concerning State organs, governmental authority, direction, or control (International Law Commission, 2001). A coherent analysis must therefore separate physical source attribution, legal attribution of conduct, and breach of the primary environmental obligation before examining whether the resulting injury supports reparation (Mayer, 2022b).

Cumulative environmental injury complicates causation because no single source may be either necessary or sufficient to produce the total environmental harm experienced across borders (Tanaka, 2023). Marine plastic pollution, regional haze, greenhouse-gas accumulation, and other diffuse environmental processes arise from multiple actors operating across different jurisdictions and over different periods (Alam & Nurhidayah, 2017). In such circumstances, requiring proof that one State independently caused the entire injury would make responsibility structurally difficult to invoke even where several States have demonstrably breached preventive obligations (Robinson, 2025). The legally relevant question should instead examine whether identifiable State conduct or omission breached an applicable obligation and contributed to the harmful process in a manner sufficient for the specific legal consequence claimed (Schmalenbach, 2023). Shared responsibility does not remove the need for causation because contribution must still be demonstrated through legally relevant evidence connecting State conduct with environmental risk or injury (Tigre & Wewerinke-Singh, 2023). It instead rejects an exclusively binary model of causation that assumes international responsibility can arise only where one State is proved to be the sole producer of an indivisible environmental outcome (Hormio, 2023).

Scientific attribution increasingly enables courts and claimants to identify how anthropogenic activities contribute to long-term environmental change and to the probability or severity of particular harmful events (Otto et al., 2022). Climate attribution science can estimate the contribution of anthropogenic forcing, quantify changes in event probability, and distinguish background variability from climate-related influences without itself determining legal responsibility (Mayer, 2022a). Legal causation remains a normative inquiry because courts must decide which scientific relationships satisfy the relevant threshold for breach, injury, standing, or reparation within the applicable legal regime (Mayer, 2022a). The 2025 ICJ Climate Advisory Opinion is significant because it confirms that the complexity of cumulative climate causation does not exclude application of the general law of

State responsibility where its legal conditions are established (International Court of Justice, 2025). Scientific uncertainty should consequently affect the evaluation and weight of evidence rather than operate as an automatic jurisdictional or doctrinal barrier to environmental responsibility (Foster, 2025). A modular approach is preferable because science identifies contribution and increased risk while international law determines the legal significance attached to that contribution (Otto et al., 2022).

Table 3. Distinguishing Attribution and Causation in Cross-Border Environmental Harm

Question	Object of Proof	Typical Evidence	Legal Consequence
Source attribution	Which physical sources contributed?	Monitoring, inventories, modelling, source attribution science	Identifies factual contributors
State attribution	Is relevant conduct legally attributable to a State?	ARSIWA rules; status and functions of actor	Links conduct to State
Breach	Did the State fail to meet the primary obligation?	Regulation, enforcement, risk knowledge, available measures	Establishes internationally wrongful act
General causation	Did the harmful process produce the type of injury?	Scientific consensus, event/trend attribution, ecological evidence	Links process to category of damage
Specific causation	Did the wrongful act contribute sufficiently to claimed injury?	Counterfactuals, contribution analysis, probabilistic evidence	Supports reparation claim
Allocation	How should responsibility be divided among contributors?	Relative contribution, capacity, temporal factors, equity	Determines proportional or shared consequences

The distinction between causation relevant to breach and causation required for reparation is particularly important where the primary obligation is one of prevention or due diligence (McDonald, 2019). A State may breach such an obligation when its regulatory conduct falls below the required standard even before a claimant can identify a precise percentage of final environmental injury caused by that failure (Mayer, 2022b). Reparation presents a different problem because compensation ordinarily requires legally cognizable injury and a sufficient causal connection between the internationally wrongful act and the loss claimed (International Law Commission, 2001). The distinction prevents environmental responsibility from collapsing into a single causation inquiry and preserves the independent legal significance of preventive obligations triggered by serious foreseeable risk (Duvic-Paoli & Gervasi, 2023). Recent climate scholarship accordingly examines proportional contribution, probabilistic evidence, and shared responsibility as possible means of addressing cumulative harm without abandoning the requirement of legal causation (Tigre & Wewerinke-Singh, 2023). The 2025 ICJ opinion reinforces this analytical separation by maintaining the applicability of general State-responsibility rules while leaving particular questions of causal allocation to the facts and legal consequences of individual claims (Foster, 2025).

Historical contribution creates an additional temporal dimension because past emissions or pollution may affect present environmental conditions even though the applicable legal duties have developed over time (Wewerinke-Singh, 2026). Historic contribution can remain relevant to equity, foreseeability, capability, differentiated responsibilities, and the allocation of remedial burdens without automatically establishing breach of a contemporary legal obligation (Hormio, 2023). A State with a relatively small historical contribution may still violate current international law if it fails to adopt reasonable measures against a major foreseeable environmental risk within its jurisdiction or control (Mayer, 2024). Conversely, extensive historical emissions cannot by themselves establish an internationally wrongful act without identification of the primary obligation applicable at the relevant time and the conduct constituting its breach (Robinson, 2025). Legal analysis must consequently connect each claim to a defined obligation, temporal period, attributable act or omission, causal

pathway, alleged injury, and requested remedy (Schmalenbach, 2023). This sequence keeps the law of responsibility distinct from purely political or moral allocation while still allowing historical and cumulative contribution to inform legally relevant questions of causation and remedy (Tigre & Wewerinke-Singh, 2023).

Table 4. Evidentiary Challenges Across Major Types of Transboundary Harm

Harm Type	Causal Structure	Main Legal Difficulty	Most Relevant Doctrinal Response
Industrial / river pollution	Localized and traceable	Threshold and proof of ecological injury	EIA, monitoring, notification, due diligence
Transboundary haze	Multiple fires and private actors	Source identification and enforcement across jurisdictions	Regional cooperation plus domestic regulatory diligence
Marine plastic pollution	Diffuse, multi-State, persistent	Shared responsibility and apportionment	Due diligence, regime interaction, cooperative compliance
Offshore oil spill	Discrete event with transboundary impacts	Attribution, valuation, non-repetition	State responsibility, restoration, guarantees of non-repetition
Climate change	Global, cumulative, long-latency	Multiple contributors, probabilistic impacts, temporal mismatch	Stringent due diligence, attribution science, proportional allocation

Table 4 demonstrates that evidentiary requirements should respond to the causal structure of the environmental harm rather than impose a single proof model across fundamentally different transboundary processes (Bhat, 2023). Localized river pollution and offshore oil spills frequently allow closer identification of sources and causal pathways, whereas haze, marine plastics, and climate change require analysis of multiple contributors and geographically dispersed effects (Tanaka, 2023). Due diligence remains particularly important for diffuse harm because regulatory failure can be assessed through evidence of inadequate prevention, monitoring, enforcement, or cooperation even where final injury cannot be assigned exclusively to one source (McIntyre, 2020). Attribution science strengthens the evidentiary foundation for climate claims, but proportional allocation still requires legal criteria capable of translating quantified contribution into specific consequences of responsibility (Otto et al., 2022). The most defensible doctrinal development is therefore a contribution-based model that preserves attribution, breach, and causation as distinct inquiries while allowing responsibility to be shared where several States have materially contributed to a cumulative harmful process (Robinson, 2025). Such an approach accommodates the physical reality of contemporary environmental harm without transforming international environmental law into strict collective liability or dispensing with the individualized legal conditions required by the law of State responsibility (Schmalenbach, 2023).

Procedural Duties, Cooperation, and Extraterritorial Human Rights

The maturation of international environmental law is particularly visible in the development of procedural obligations that convert the prevention principle into concrete administrative conduct capable of legal scrutiny (Craik, 2020). In *Pulp Mills on the River Uruguay*, the International Court of Justice recognized environmental impact assessment as a requirement of general international law where a proposed activity creates a risk of significant adverse transboundary impact (International Court of Justice, 2010). Environmental impact assessment should not be understood as an isolated technical document because its preventive function depends upon the quality of information generated before authorization or implementation of a hazardous activity (Bhat, 2023). Prior notification and consultation complement assessment by allowing potentially affected States to evaluate risk, communicate objections, and negotiate preventive or mitigating measures before significant harm materializes (International Law Commission, 2001). Monitoring extends those duties beyond the initial authorization stage because environmental conditions, technological knowledge, and the

magnitude of risk may change during the operation of a hazardous activity (Gemalmaz, 2023). Procedural obligations consequently provide auditable evidence of whether a State exercised the degree of vigilance required by due diligence rather than merely asserting that preventive measures existed in formal law (McCluskey, 2022).

The 2024 ITLOS Climate Advisory Opinion considerably strengthens this procedural architecture by applying UNCLOS Part XII to anthropogenic greenhouse-gas emissions affecting the marine environment (International Tribunal for the Law of the Sea, 2024). The opinion requires States to adopt measures for prevention, reduction, and control while also addressing cooperation, monitoring, scientific assessment, and environmental impact assessment within the marine-protection regime (Klerk, 2025). These obligations remain legally autonomous under UNCLOS even where the same physical phenomenon is also governed by the UNFCCC and the Paris Agreement (Klerk, 2025). The Paris Agreement may nevertheless influence the interpretation of environmental obligations outside the climate regime by supplying relevant standards concerning mitigation progression, scientific ambition, and international cooperation (Voigt, 2023). Rajamani similarly argues that the Paris Agreement must be interpreted within its wider normative environment rather than treated as an isolated and exhaustive code governing all climate-related legal questions (Rajamani, 2024). The interaction between UNCLOS and climate law consequently supports cumulative application of compatible obligations rather than a presumption that specialized climate treaties automatically displace broader duties of environmental protection (Mayer, 2025).

Human-rights law introduces an additional procedural dimension because environmental degradation can interfere with life, health, private life, culture, information, participation, and access to an effective remedy (United Nations General Assembly, 2022). The United Nations General Assembly's recognition of the right to a clean, healthy and sustainable environment in Resolution 76/300 strengthened the normative basis for integrating environmental protection with existing international human-rights guarantees (United Nations General Assembly, 2022). That resolution did not itself establish a new treaty-based enforcement mechanism, which means that its practical legal significance depends substantially on its interaction with already binding human-rights obligations and institutional procedures (Heri, 2024). Regional human-rights jurisprudence has developed further by requiring States to prevent foreseeable environmental harm, facilitate access to information, permit meaningful participation, and maintain access to justice for affected persons (Inter-American Court of Human Rights, 2017). These procedural guarantees are especially important where environmental harm remains uncertain because rights may be protected through preventive decision-making before physical injury becomes irreversible or impossible to remedy (Savaresi, 2024). Human-rights law therefore reinforces environmental due diligence by requiring State decision-making processes to account not only for ecological risk but also for the persons and communities exposed to the consequences of environmentally harmful activities (Fraser & Henderson, 2022).

Table 5. Procedural Obligations in Contemporary Cross-Border Environmental Law

Procedural Duty	Typical Trigger	Function	Failure May Indicate
Risk / environmental impact assessment	Plausible risk of significant adverse transboundary effects	Identify impacts, alternatives, mitigation, uncertainty	Deficient due diligence
Prior notification	Foreseeable significant transboundary risk	Inform potentially affected States before authorization or implementation	Failure to cooperate
Consultation	Affected State raises concerns or treaty/custom requires dialogue	Seek mutually acceptable risk-management measures	Procedural breach even absent final damage
Monitoring	Ongoing hazardous or high-risk activity	Detect changes, verify compliance, update controls	Failure of vigilance
Information disclosure /	Decisions affecting environmental or	Enable scrutiny and meaningful participation	Rights and governance deficit

participation	human-rights interests			
Emergency	Accident or imminent	Contain harm, share data,	Aggravation	of
cooperation	serious harm	coordinate response	responsibility	and
			remedial exposure	

The territorial reach of environmental human-rights obligations remains contested because regional and treaty bodies have adopted materially different approaches to jurisdiction in cases involving transboundary climate effects (Teshome, 2026). In *Sacchi v. Argentina et al.*, the Committee on the Rights of the Child accepted in principle that emissions originating within State control could contribute to foreseeable rights impacts on children situated abroad (Suedi, 2022). The jurisdictional reasoning in *Sacchi* therefore relied partly on control over the source of environmental harm rather than requiring physical control over the affected person outside national territory (Bellinkx et al., 2022). The European Court of Human Rights adopted a substantially more restrictive position in *Duarte Agostinho* by rejecting the proposed extension of Convention jurisdiction to applicants located outside the respondent States (Teshome, 2026). By contrast, *KlimaSeniorinnen* strengthened positive climate-protection obligations toward persons situated within Switzerland's jurisdiction without endorsing a comparable extraterritorial jurisdictional model (Heri, 2024). The divergence demonstrates that international human-rights law has not yet developed a uniform test for determining when control over environmentally harmful activities is sufficient to establish jurisdiction toward persons affected across national borders (Bellinkx et al., 2022).

The Inter-American Court's 2025 Advisory Opinion OC-32/25 advances a broader integration of climate change, environmental protection, and human-rights obligations within the Inter-American system (Inter-American Court of Human Rights, 2025). The opinion characterizes climate change as a human-rights emergency and articulates duties involving prevention, adaptation, information, participation, access to justice, and differentiated protection for groups exposed to heightened vulnerability (Borràs-Pentinat, 2025). Its reasoning builds upon OC-23/17, which had already connected control over environmentally harmful activities with obligations toward persons suffering transboundary environmental effects (Inter-American Court of Human Rights, 2017). This effects-oriented approach differs from the more territorially restrictive position reflected in the European Court's climate jurisprudence and demonstrates continuing institutional fragmentation concerning extraterritorial jurisdiction (Teshome, 2026). The divergence does not eliminate a common preventive core because the relevant institutions increasingly require States to regulate foreseeable environmental risks, provide information, enable participation, and maintain effective remedies within the limits of their respective jurisdictional doctrines (Savaresi, 2024). The developing jurisprudence therefore suggests stronger substantive convergence on environmental protection than on the jurisdictional rules determining which affected persons may invoke those obligations against a particular State (Bellinkx et al., 2022).

Table 6. Divergent Approaches to Extraterritorial Environmental Human Rights

Authority		Approach		Jurisdictional logic	Implication
IACtHR	OC-23/17	Expansive	for	Control over activities causing effects abroad can ground jurisdiction	Links prevention duties to persons outside territory
CRC Committee, <i>Sacchi</i>		Recognized causal-control theory in principle		Emissions under State control may foreseeably affect children abroad	Opens extraterritorial route, subject to admissibility rules
ECtHR, <i>Duarte Agostinho</i>		Restrictive		Rejected proposed extension to persons outside respondent States	Limits ECHR extraterritorial climate claims
ECtHR, <i>KlimaSeniorinnen</i>		Domestic obligations	positive	Jurisdiction based on applicants within Switzerland	Strengthens internal climate-protection duties
IACtHR	OC-	Integrated climate and		Prevention, cooperation,	Deepens rights-based

32/25	human-rights obligations	differentiated protection	environmental diligence	due
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The comparison in Table 6 confirms that proceduralization has advanced more consistently than the law governing extraterritorial human-rights jurisdiction (Teshome, 2026). Environmental impact assessment, notification, consultation, monitoring, information disclosure, and emergency cooperation can be triggered by foreseeable risk even where a claimant cannot yet prove completed transboundary injury (Craik, 2020). Due diligence supplies the substantive intensity of the care required from the State, while procedural obligations provide the institutional evidence necessary to determine whether that degree of care was actually exercised (McDonald, 2019). Human-rights law adds a further layer by requiring preventive governance to consider affected individuals and communities rather than treating cross-border environmental protection solely as an inter-State relationship (McCluskey, 2022). The most coherent contemporary model therefore combines substantive prevention, procedural cooperation, and rights-based safeguards while allowing each regime to retain its own jurisdictional and remedial structure (Savaresi, 2024). Such an integrated approach strengthens international environmental law by enabling legal scrutiny at the stage of foreseeable risk, when assessment, cooperation, mitigation, and participation can still prevent irreversible cross-border harm (Gemalmaz, 2023).

State Responsibility, Remedies, and the Emerging International Environmental Order

The law of State responsibility does not itself create substantive environmental obligations but determines the legal consequences that follow once an attributable breach of an international obligation has been established (International Law Commission, 2001). Article 30 of ARSIWA requires the responsible State to cease a continuing internationally wrongful act and, where circumstances require, to offer appropriate assurances and guarantees of non-repetition (International Law Commission, 2001). Cessation is particularly important in environmental disputes because the continuation of unlawful licensing, inadequate regulatory standards, or environmentally harmful governmental practices may compound ecological injury over time (Schmalenbach, 2023). Guarantees of non-repetition perform a complementary preventive function by requiring structural changes capable of reducing the likelihood that similar transboundary harm will recur (Allain & Prihandono, 2026). The Montara oil-spill experience demonstrates that regulatory reform, monitoring mechanisms, emergency-response capacity, and institutional correction may be legally more consequential for future environmental protection than retrospective financial compensation alone (Allain & Prihandono, 2026). State responsibility therefore performs both corrective and preventive functions by linking an established breach to cessation, institutional reform, and measures designed to prevent recurrence of environmentally harmful conduct (International Law Commission, 2001).

Reparation becomes relevant where an internationally wrongful act has caused legally cognizable injury and the causal requirements applicable to the claimed form of relief have been satisfied (International Law Commission, 2001). Article 34 of ARSIWA recognizes restitution, compensation, and satisfaction as forms of full reparation, whether individually or in combination according to the nature of the injury (International Law Commission, 2001). Restitution is conceptually primary under Article 35, but ecological degradation may make restoration to the precise pre-injury condition materially impossible where species, ecosystems, or cultural resources have been irreversibly lost (International Law Commission, 2001). Compensation under Article 36 can address financially assessable loss, including certain restoration expenses, economic damage, and ecosystem-service losses where reliable valuation is possible (International Law Commission, 2001). Satisfaction under Article 37 may respond to non-material injury through acknowledgment of breach or other appropriate forms of recognition, although it cannot substitute for physical ecological restoration (International Law Commission, 2001). Cross-border environmental disputes consequently require remedial approaches that respect the principle of full reparation while acknowledging scientific uncertainty, ecological irreversibility, and the difficulty of assigning monetary values to complex environmental losses (Robinson, 2025).

Climate loss and damage illustrates the institutional distinction between cooperative environmental finance and the secondary rules governing responsibility for internationally wrongful acts (Vanhala, 2023). The UNFCCC process has progressively developed institutional and financial

arrangements addressing climate-related loss and damage without making access to those arrangements dependent upon an adjudicated finding of State responsibility (Tietjen & Gopalakrishnan, 2023). This distinction matters because negotiated climate finance reflects cooperation and burden sharing, whereas State responsibility requires identification of an applicable obligation, attributable breach, injury, and the causal relationship necessary for a particular legal consequence (Damanik et al., 2024). The political development of the loss-and-damage regime has relied substantially on constructive ambiguity concerning liability and compensation, enabling institutional progress while preserving disagreement among States regarding the legal characterization of historical climate contributions (Vanhala, 2023). Vulnerable States have nevertheless maintained that institutional responses to loss and damage must address actual and irreversible harms rather than remain confined to mitigation and adaptation measures directed toward future risk (Toussaint, 2024). Cooperative funding and State responsibility can therefore coexist because they respond to different legal and institutional questions within the broader international response to environmental injury (Tigre & Wewerinke-Singh, 2023).

Table 7. Legal Consequences of State Responsibility for Environmental Harm

Consequence	Legal Purpose		Environmental Application		Principal Limitation
Cessation	Stop	continuing wrongful conduct	End authorization, unlawful emissions policy, discharge, or regulatory omission		Depends on identifying continuing breach
Guarantees of non-repetition	Reduce	recurrence risk	Reform licensing, monitoring, emergency response, enforcement		Content often case-specific
Restitution restoration	/	Re-establish prior condition where possible	Habitat restoration, remediation, rehabilitation		Ecological irreversibility may make full restitution impossible
Compensation	Repair	financially assessable injury	Cleanup costs, property/economic loss, ecosystem-service loss where measurable		Causal allocation and valuation
Satisfaction	Address injury	non-material	Acknowledgment, declaration of breach, apology where appropriate		Limited direct ecological repair
Cooperative institutional finance	/	Mobilize collective response outside strict litigation	Loss-and-damage funds, adaptation support, technical assistance		Not equivalent to adjudicated responsibility

The 2025 ICJ Climate Advisory Opinion materially clarifies the relationship between specialized climate obligations and the general law of State responsibility by rejecting the proposition that the climate treaty regime necessarily excludes other applicable international rules (International Court of Justice, 2025). The Court's reasoning confirms that legally binding obligations may arise concurrently from the UNFCCC, the Paris Agreement, customary international law, and other relevant international legal regimes (Foster, 2025). Climate treaties therefore do not operate as an exhaustive *lex specialis* that automatically displaces the ordinary consequences of internationally wrongful conduct when the requirements of State responsibility are otherwise satisfied (Foster, 2025). The opinion is also significant for collective environmental interests because the characterization of certain obligations as *erga omnes* or *erga omnes partes* may affect which States possess a legal interest in invoking responsibility (Jackson & Paddeu, 2026). This development situates the ICJ opinion within a wider body of climate jurisprudence that increasingly connects the law of the sea, human-rights law, climate treaties, and general international law (Peel, 2026). The emerging

international environmental order is consequently characterized less by one exclusive climate regime than by interpretive interaction among several bodies of law addressing the same global environmental risk (Rajamani, 2024).

The principal unresolved problems increasingly concern implementation, causal allocation, access to adjudication, and the quantification of remedies rather than the existence of a basic preventive duty (Robinson, 2025). International law now contains comparatively well-developed rules concerning prevention, increasingly stringent due diligence, environmental assessment, cooperation, and the consequences of an attributable breach (Wewerinke-Singh, 2026). Greater uncertainty remains over how compensation should be apportioned where environmental injury results from cumulative conduct by numerous States and private actors over long temporal periods (Tanaka, 2023). Questions concerning standing and invocation also remain important because collective environmental interests do not automatically provide an effective procedural forum in which every affected State or community can obtain a remedy (Jackson & Paddeu, 2026). Corporate participation adds another institutional difficulty because international State-responsibility rules and domestic or transnational private-liability mechanisms address legally distinct actors even when they concern the same environmental harm (Schmalenbach, 2023). The most defensible doctrinal development is therefore to refine contribution-based causation, proportional reparation, cooperative invocation, and guarantees of non-repetition rather than replace the existing architecture with universal strict liability (Robinson, 2025).

Table 8. Development of International Environmental Responsibility after the Climate Advisory Opinions

Issue	Pre-2024 Position	Development 2024-2026	Remaining Legal Gap
Scope of no-harm rule	Strongest in bilateral transboundary settings	Applied to climate system and global environmental interests	Precise threshold across different global harms
Due diligence	Variable obligation of conduct	Stringent where risk is serious/irreversible; science and capability shape content	Operational metrics for compliance
Treaty interaction	Risk of fragmentation / <i>lex specialis</i> arguments	UNCLOS, climate treaties, custom, and human-rights law treated as mutually relevant	Conflict rules where obligations diverge
Human-rights reach	Territorial model dominant	IACtHR/CRC expand effects-based reasoning; ECtHR remains restrictive	Common test for extraterritorial climate jurisdiction
State responsibility	General rules available but rarely applied to global harms	ICJ confirms general responsibility rules are not displaced by climate treaties	Causal share and quantification of reparation
Collective interests	Standing historically constrained by bilateralism	Growing use of <i>erga omnes</i> / <i>erga omnes partes</i> characterization	Procedural avenues for invocation and enforcement

The trajectory summarized in Table 8 demonstrates a transition from a predominantly bilateral model of transboundary environmental responsibility toward a more integrated framework capable of addressing global and cumulative environmental interests (Peel, 2026). The no-harm rule and due diligence remain obligations of conduct, yet their practical intensity has increased as international tribunals have confronted scientifically established risks of severe and irreversible environmental damage (Roeben & Guo, 2026). Treaty interaction has likewise shifted from debates over normative displacement toward an approach in which UNCLOS, climate treaties, customary law, and human-rights obligations can inform one another while retaining distinct legal foundations (Klerk,

2025). The continuing weakness lies in translating these increasingly coherent primary obligations into effective consequences where numerous contributors, complex causal chains, jurisdictional limitations, and irreversible ecological losses complicate traditional remedial models (Foster, 2025). Contribution-based causation, proportional allocation, guarantees of non-repetition, and cooperative institutional mechanisms provide the most plausible legal tools for bridging the gap between collective environmental injury and individualized rules of responsibility (Tigre & Wewerinke-Singh, 2023). Contemporary international environmental law is therefore developing toward a responsibility framework in which prevention, procedural diligence, shared environmental interests, and proportionate remedies operate together without abandoning the foundational requirements of attribution, breach, causation, and legally established consequences (Wewerinke-Singh, 2026).

CONCLUSION

The study establishes that the legal treatment of cross-border environmental harm requires differentiated analysis of preventive obligations, State conduct, causal relationships, and the consequences of internationally wrongful acts. Regarding the first research question, the no-harm principle and due diligence remain complementary components of international environmental law, while their application to cumulative global risks requires increasingly demanding preventive measures proportionate to foreseeable environmental harm. The 2024 ITLOS and 2025 ICJ climate advisory opinions reinforce the legal significance of science-informed prevention, regulatory supervision, cooperation, and environmental assessment without establishing a general system of strict State liability for environmental damage. Regarding the second research question, attribution of State conduct, determination of breach, scientific attribution of environmental effects, legal causation, and allocation of reparative obligations constitute distinct assessments. Harmful activities undertaken by private operators do not automatically engage State responsibility, although failures of governmental regulation or enforcement may constitute independently attributable breaches of applicable due-diligence obligations. A breach of a preventive obligation may be established without quantifying a particular environmental injury, whereas compensation for resulting damage requires satisfaction of the relevant causal and remedial conditions. Regarding the third research question, international environmental law, climate treaties, the law of the sea, and human-rights obligations may apply concurrently without necessarily displacing the general rules of State responsibility. The application of *lex specialis* nevertheless requires examination of the particular provisions concerned, while the *erga omnes* or *erga omnes partes* character of an obligation does not independently establish jurisdiction or universal procedural standing. The study's principal doctrinal contribution is a four-stage analytical framework separating primary obligations, breach and attribution of State conduct, causal contribution and allocation of injury, and invocation of responsibility and remedies. This framework provides a structured method for identifying the legal requirements applicable at each stage and prevents evidentiary uncertainty concerning environmental damage from being conflated with the independent assessment of preventive compliance.

The findings also establish important limits to the present international legal framework. Although preventive obligations and general rules of responsibility are comparatively well developed, the allocation of reparative burdens among multiple contributors, valuation of irreversible ecological loss, establishment of legal causation, and availability of effective adjudicatory procedures remain subject to substantial doctrinal and institutional uncertainty. Scientific attribution can inform assessments of causal contribution but cannot independently resolve the legal requirements governing responsibility, standing, or compensation. The proposed framework addresses these limitations through analytical differentiation rather than the assumption that proportional liability or collective reparation has already become an established rule of international law. Its practical implication is that legal assessments of cumulative environmental harm can identify governmental failures to prevent foreseeable risks independently from subsequent disputes over the distribution of compensable injury. Further doctrinal development may examine contribution-sensitive approaches to causation, legally justified allocation of reparation, cooperative invocation of responsibility for collective environmental interests, and guarantees of non-repetition adapted to continuing environmental risks. Such approaches remain proposals requiring appropriate legal foundations, evidentiary standards, and jurisdictional arrangements rather than automatic consequences of existing international obligations. Priority should also be assigned to the development of reliable procedures for assessing ecological

restoration, quantifying compensable environmental loss, and distinguishing international responsibility from cooperative financial mechanisms that operate independently of an established wrongful act. These directions preserve the established requirements of attribution, breach, causation, and reparation while providing a more precise basis for the application and progressive development of international environmental responsibility in cases of cumulative transboundary and global environmental harm.

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