CADERNOS DE DEREITO ACTUAL
www.cadernosdedereitoactual.es

© ***Cadernos de Dereito Actual*** Nº 31. Núm. Ordinario (2026), pp. 153-175
·ISSN 2340-860X - ·ISSNe 2386-5229

# Toward a sustainable international legal framework for protecting the marine environment from plastic waste pollution

# Hacia un marco jurídico internacional sostenible para la protección del medio ambiente marino frente a la contaminación por residuos plásticos

**Doaa Mohamed Ibrahim Badran**[1,*]
*King Khalid University*
**Naser Alsherman**[2]
*American University in the Emirates*
**Mohammad A. Alsalmi**[3]
*University of Tabuk*
**Ehab Alrousan**[4]
*Umm al Quwain University*
**Bandar Nasser Alhamdan**[5]
*Al-Baha University*
**Mahmoud Abdelgawwad Abdelhady**[6]
*King Khalid University*

[1] King Khalid University, Saudi Arabia. ORCID ID: 0009-0004-9565-5807; E-mail: dbadran@kku.edu.sa (corresponding author).
[2] American University in the Emirates. ORCID: 0000-0003-4365-842X; E-mail: Naser.sherman@aue.ae.
[3] University of Tabuk, Saudi Arabia. ORCID ID: 0009-0003-7302-0184; E-mail: m.alsalmi@ut.edu.sa.
[4] Umm al Quwain University, United Arab Emirates. ORCID: 0000-0002-9888-1111; Email: drehab.alrousan@uaqu.ac.ae.
[5] Al-Baha University. ORCID: 0000-0002-5161-2803; E-mail: b.alhamdan@bu.edu.sa.
[6] King Khalid University, Saudi Arabia. ORCID ID: 0009-0004-2177-6147; E-mail: mabdelgawwad@kku.edu.sa.

**Abstract:** Plastic waste represents one of the most critical environmental challenges facing marine ecosystems due to its profound and long-lasting impacts on biodiversity, marine sustainability, and global ecological balance. This study aims to analyze the international legal framework governing the protection of the marine environment from plastic waste pollution by examining relevant international and regional conventions and assessing their effectiveness in addressing this escalating problem. The research adopts a descriptive–analytical methodology that integrates the examination of legal texts with their interpretation in light of current environmental realities, focusing particularly on the United Nations Convention on the Law of the Sea (UNCLOS) as a cornerstone of the international maritime legal system.The findings reveal that current international legal frameworks, while foundational in establishing marine environmental protection principles, remain limited in enforceability and binding effect due to the absence of a dedicated international instrument specifically addressing marine plastic pollution. Furthermore, disparities in economic and technological capacities among states hinder the effective implementation of existing international commitments. The study emphasizes the urgent need to establish a stricter and more comprehensive legal mechanism that integrates concepts of the circular economy, biodegradable materials, and innovation-driven waste management solutions. The study concludes that effective marine environmental protection requires reconfiguring the international legal system to better align with the United Nations Sustainable Development Goals (SDGs), particularly Goal 14—Life Below Water—by promoting cohesive global legal and institutional cooperation. Through this integration of legal governance and sustainable innovation, the study offers a comprehensive strategic vision aimed at safeguarding marine biodiversity and ensuring the sustainability of natural resources for future generations.

**Keywords:** International Environmental Law, Marine Plastic Pollution, UNCLOS, Environmental Governance, Sustainability

**Resumen:** Los residuos plásticos representan uno de los desafíos ambientales más críticos que enfrentan los ecosistemas marinos debido a sus profundos y duraderos impactos en la biodiversidad, la sostenibilidad marina y el equilibrio ecológico global. Este estudio tiene como objetivo analizar el marco jurídico internacional que rige la protección del medio ambiente marino contra la contaminación por residuos plásticos, examinando los convenios internacionales y regionales pertinentes y evaluando su eficacia para abordar este problema creciente. La investigación adopta una metodología descriptiva-analítica que integra el examen de los textos legales con su interpretación a la luz de las realidades ambientales actuales, centrándose particularmente en la Convención de las Naciones Unidas sobre el

Derecho del Mar (UNCLOS) como piedra angular del sistema jurídico marítimo internacional. Los hallazgos revelan que los marcos jurídicos internacionales actuales, si bien son fundamentales para establecer los principios de protección del medio ambiente marino, siguen siendo limitados en cuanto a su aplicabilidad y efecto vinculante debido a la ausencia de un instrumento internacional específico que aborde la contaminación marina por plásticos. Además, las disparidades en las capacidades económicas y tecnológicas entre los Estados dificultan la implementación efectiva de los compromisos internacionales existentes. El estudio subraya la necesidad urgente de establecer un mecanismo legal más estricto y completo que integre los conceptos de economía circular, materiales biodegradables y soluciones de gestión de residuos basadas en la innovación. El estudio concluye que la protección efectiva del medio ambiente marino requiere la reconfiguración del sistema jurídico internacional para que se ajuste mejor a los Objetulos de Desarrollo Sostenible (ODS) de las Naciones Unidas, en particular al Objetivo 14—Vida Submarina—, promoviendo una cooperación jurídica e institucional global coherente. Mediante esta integración de la gobernanza jurídica y la innovación sostenible, el estudio ofrece una visión estratégica integral destinada a salvaguardar la biodiversidad marina y garantizar la sostenibilidad de los recursos naturales para las generaciones futuras.

**Palabras clave**: Derecho Ambiental Internacional, Contaminación Marina por Plásticos, UNCLOS, Gobernanza Ambiental, Sostenibilidad

## 1. Introduction

The marine environment constitutes one of the fundamental pillars of the global ecosystem, serving as an indispensable source for sustaining life on Earth[7]. It provides oxygen, food, and natural resources that are essential for maintaining ecological balance and ensuring environmental sustainability. The world's oceans and seas form an integrated biological sphere that hosts an immense diversity of living organisms, making them a cornerstone for both climate stability and the global economy.

However, this delicate system has, in recent decades, come under increasing pressure from mounting environmental threats—chief among them plastic pollution [8], which has emerged as one of the most severe and pervasive challenges affecting marine ecosystems worldwide[9]. The accumulation of plastic waste in marine habitats represents a significant manifestation of modern ecological risk[10]. Due to the durability of plastics and their resistance to natural degradation, plastic debris remains in oceans for extended periods, disrupting water circulation and releasing toxic chemical compounds harmful to marine life at all trophic levels. These impacts are not confined to the marine environment alone; they extend across the entire

[7] Delphi, W., Melbourne-Thomas, J., Evans, K., Green, M., McCormack, P. C., Camilla, N., ... & Cayne, L. (2022). Safeguarding marine life: conservation of biodiversity and ecosystems. Reviews in Fish Biology and Fisheries, 32(1), 65–100. https://doi.org/10.1007/s11160-022-09700-3

[8] Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P. K., ... & Vara Prasad, P. V. (2021). Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. Sustainability, 13(17), 9963. https://doi.org/10.3390/su13179963

[9] Sarwar, F., Ali, S., Bhatti, S. H., & ur Rehman, S. (2021). Legal Approaches to Reduce Plastic Marine Pollution: Challenges and Global Governance. Annals of Social Sciences and Perspective, 2(1).https://doi.org/10.52700/assap.v2i1.32

[10] Dimassi, S. N., Hahladakis, J. N., Yahia, M. N. D., Ahmad, M. I., Sayadi, S., & Al-Ghouti, M. A. (2022). Degradation-fragmentation of marine plastic waste and their environmental implications: A critical review. Arabian Journal of Chemistry, 15(11), 104262. https://doi.org/10.1016/j.arabjc.2022.104262

food chain and ultimately affect human health, rendering plastic pollution an escalating threat to global ecological balance[11].

Growing awareness of environmental preservation has placed marine plastic pollution at the forefront of global environmental priorities[12]. As a multidimensional problem with ecological, economic, and social implications, it demands urgent and coordinated international intervention. Beyond its ecological consequences, plastic pollution has evolved into a complex legal and regulatory dilemma[13], necessitating the development of comprehensive legislative frameworks capable of regulating plastic production, consumption, and disposal through binding legal mechanisms supported by effective enforcement systems[14]. From a legal perspective, addressing marine plastic pollution requires broad international cooperation, as plastic debris moves freely across jurisdictional boundaries through ocean currents. Yet, implementation continues to face significant obstacles, including insufficient funding, limited technological capacity, and weak monitoring and enforcement mechanisms—factors that collectively undermine global mitigation efforts[15].

Despite the presence of international environmental instruments concerned with marine protection, the current legal structure remains fragmented and lacks explicit provisions dealing specifically with marine plastic waste. This gap raises the critical question of whether existing global legal instruments are sufficiently equipped to address a problem of such transboundary character and magnitude. Accordingly, this study seeks to examine and analyze the international legal framework governing marine plastic pollution, assess the effectiveness of existing conventions, and identify the main legal and procedural gaps limiting their enforceability.

The central question addressed is to what extent are current international legal instruments effective in combating marine plastic pollution and ensuring sustainable marine environmental protection?

To answer this question, the study proceeds through four main sections. The first section provides an overview of marine plastic pollution and its environmental impacts[16].

The second section reviews international and regional legal frameworks concerning marine environmental protection. The third section analyzes regulatory gaps, weaknesses in implementation, and governance challenges. The final section presents conclusions and offers recommendations aimed at enhancing the effectiveness of international legal responses to marine plastic pollution.

---

[11] Smith, M., Love, D. C., Rochman, C. M., & Neff, R. A. (2018). Microplastics in seafood and the implications for human health. Current Environmental Health Reports, 5(3), 375–386. https://doi.org/10.1007/s40572-018-0206-z

[12] Baechler, B. R., De Frond, H., Dropkin, L., Leonard, G. H., Proano, L., & Mallos, N. J. (2024). Public awareness and perceptions of ocean plastic pollution and support for solutions in the United States. Frontiers in Marine Science, 10. https://doi.org/10.3389/fmars.2023.1323477

[13] Bel Hassen, M., Bellaaj Zouari, A., Abdennadher, M., Assaf, J. C., Nakad, M., Abboud, R., ... & Hamd, W. (2025). Plastics pollution: pathways, impacts, and regulatory challenges in marine environments. Frontiers in Environmental Science, 13. https://doi.org/10.3389/fenvs.2025.1635230

[14] Badran, D. M. I., & Abdelhady, M. A. (2024). Legislación sobre energía sostenible: la piedra angular para lograr la sostenibilidad medioambiental y económica. REICE Revista Electrónica De Investigación En Ciencias Económicas, 12(24), 21–38. https://doi.org/10.5377/reice.v12i24.20055

[15] Aklin, M., & Mildenberger, M. (2020). Prisoners of the wrong Dilemma: Why distributive conflict, not collective action, characterizes the politics of climate change. Global Environmental Politics, 20(4), 4–27. https://doi.org/10.1162/glep_a_00578

[16] Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223), 768–771. https://doi.org/10.1126/science.1260352

## 2. Literature review

Recent scholarship increasingly recognizes marine plastic pollution as a complex environmental and governance challenge that requires structural legal reform rather than incremental policy responses[17]. A recurring conclusion in contemporary research is that global regulatory approaches continue to rely predominantly on maritime regulatory instruments—such as International Maritime Organization frameworks and MARPOL annexes—despite mounting evidence that most plastic waste entering marine ecosystems originates from land-based activities[18]. Although regional initiatives, particularly European Union directives addressing single-use plastics and abandoned fishing gear, have demonstrated measurable environmental benefits, their geographically limited scope prevents them from functioning as universally enforceable solutions[19]. Consequently, regulatory responses remain geographically fragmented rather than supported by globally binding obligations capable of addressing the transboundary character of plastic pollution[20].

Governance-focused scholarship further indicates that international environmental law still lacks a unified legal instrument capable of ensuring coherent and enforceable protection for marine ecosystems against plastic pollution. Comparative studies examining implementation practices across jurisdictions demonstrate that regulatory effectiveness varies significantly depending on economic capacity, institutional readiness, and political commitment, thereby weakening collective global action. Scholars increasingly advocate for a legally binding international convention under UNEA, arguing that voluntary mechanisms alone cannot ensure long-term accountability[21].

Research examining technological solutions similarly suggests that material innovation, although valuable, cannot substitute for effective legal governance. Assessments of bioplastics and biodegradable materials show that without globally standardized certification and lifecycle regulation, claims of sustainability may create misleading expectations while failing to address microplastic persistence and chemical toxicity. Technological innovation therefore requires complementary regulatory frameworks governing production, consumption, and waste management across the plastic lifecycle[22].

Broader environmental governance literature frames marine plastic pollution as part of a wider failure in global environmental coordination, driven by economic

---

[17] Raubenheimer, K., & McIlgorm, A. (2017). Is the Montreal Protocol a model that can help solve the global marine plastic debris problem? Marine Policy, 81, 322–329. https://doi.org/10.1016/j.marpol.2017.04.014

[18] United Nations Environment Programme. (2021). From Pollution to Solution: A Global Assessment of Marine litter and Plastic pollution. Avaliable at: https://library.sprep.org/sites/default/files/2021-11/from-pollution-solution.pdf (accessed on 15 October 2025).

[19] Official Journal of the European Union. (2019). Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment (Text with EEA relevance). pp. 1-19. Avaliable at: https://eur-lex.europa.eu/eli/dir/2019/904/oj (accessed on 15 October 2025).

[20] Wang, S. (2023). International law-making process of combating plastic pollution: Status Quo, debates and prospects. Marine Policy, 147, 105376. https://doi.org/10.1016/j.marpol.2022.105376

[21] McMahon, M. (2022). Tides of plastic: Using international environmental law to reduce marine plastic pollution. Hastings Environmental Law Journal, 28, 49.

[22] Wang, G., Huang, D., Ji, J., Völker, C., & Wurm, F. R. (2021). Seawater-Degradable Polymers—Fighting the marine plastic pollution. Advanced Science, 8(1), 2001121. https://doi.org/10.1002/advs.202001121

interests, uneven regulatory capacities, and the predominance of voluntary commitments[23].

Scholars emphasize that meaningful solutions must incorporate binding commitments supported by monitoring and compliance mechanisms capable of ensuring implementation[24].

Recent studies increasingly highlight the necessity of shifting regulatory attention from downstream waste management toward upstream preventive governance targeting production, supply chains, and consumption patterns[25]. Extended Producer Responsibility and circular economy strategies are widely proposed as mechanisms capable of redistributing environmental costs across the value chain while encouraging sustainable production practices. However, implementation remains uneven and regionally confined, preventing globally harmonized standards[26].

At the same time, contemporary scholarship recognizes that marine plastic pollution governance must be evaluated in light of ongoing negotiations toward a legally binding global plastics treaty. These negotiations represent a significant development in environmental governance, reflecting growing consensus that fragmented frameworks cannot adequately address the transboundary nature of plastic pollution[27]. Nevertheless, treaty effectiveness will depend on balancing environmental ambition with developmental equity and technological assistance mechanisms[28].

Taken collectively, the literature demonstrates expanding academic engagement while simultaneously revealing governance and enforcement gaps. Existing research provides valuable insights into policy tools and governance challenges but often stops short of proposing a comprehensive legal architecture capable of harmonizing obligations across jurisdictions. Accordingly, this study builds upon existing scholarship by critically assessing current legal frameworks and advancing the need for a more coherent and enforceable global legal regime capable of ensuring long-term protection of marine ecosystems[29].

## 3. Methodology

This study adopts a doctrinal legal research methodology supported by descriptive and analytical approaches in order to examine the international legal

---

[23] Kanter, D. R., Winiwarter, W., Bodirsky, B. L., Bouwman, L., Boyer, E., Buckle, S., ... & Zurek, M. (2020). A framework for nitrogen futures in the shared socioeconomic pathways. Global Environmental Change, 61, 102029. https://doi.org/10.1016/j.gloenvcha.2019.102029

[24] Dauvergne, P. (2023). The necessity of justice for a fair, legitimate, and effective treaty on plastic pollution. Marine Policy, 155, 105785. https://doi.org/10.1016/j.marpol.2023.105785

[25] Lau, W. W., Shiran, Y., Bailey, R. M., Cook, E., Stuchtey, M. R., Koskella, J., ... & Palardy, J. E. (2020). Evaluating scenarios toward zero plastic pollution. Science, 369(6510), 1455–1461. https://doi.org/10.1126/science.aba9475

[26] Zhou, J., & Luo, D. (2024). The global governance of marine plastic pollution: rethinking the extended producer responsibility system. Frontiers in Marine Science, 11. https://doi.org/10.3389/fmars.2024.1363269

[27] Porzeżyńska, M. (2021). Case C‐24/19 (A and others): How to ensure effet utile of the Strategic Environmental Assessment Directive? Review of European Comparative & International Environmental Law, 31(1), 140–145. https://doi.org/10.1111/reel.12424

[28] Beltran, M., Tjahjono, B., Suoneto, T. N., Tanjung, R., & Julião, J. (2023). Rethinking marine plastics pollution: Science diplomacy and multi-level governance. International Review of Administrative Sciences, 90(1), 237–258. https://doi.org/10.1177/00208523231183909

[29] Bertolazzi, S., Cuttitta, A., & Pipitone, V. (2024). Addressing marine plastic pollution: a systematic literature review. Current Opinion in Environmental Sustainability, 68, 101428. https://doi.org/10.1016/j.cosust.2024.101428

framework governing marine plastic pollution. The doctrinal method is appropriate for this research because the study primarily relies on the examination and interpretation of international legal instruments, conventions, and regulatory frameworks addressing marine environmental protection.

The descriptive component is employed to outline the relevant international and regional legal instruments and to present the environmental context within which marine plastic pollution has developed. Building on this foundation, the analytical stage evaluates the provisions of existing agreements, assesses their effectiveness in addressing plastic pollution challenges, and identifies legal and implementation gaps that limit regulatory performance. Through this combined approach, the study aims to develop recommendations that contribute to improving international cooperation and strengthening legal responses to marine plastic pollution within a more coherent and enforceable global governance framework.

## 4. Under the weight of pollution: The implications of plastic on the marine environment and public health

The crisis of marine plastic pollution has evolved into one of the most complex[30] and pressing global environmental challenges of the modern era.

Rather than constituting a discrete environmental concern, it reflects a systemic governance failure in regulating production, consumption, and waste flows across[31].

It is no longer merely an ecological issue but a multidimensional crisis encompassing legal, health, and economic dimensions that jeopardize the sustainability of marine ecosystems and human well-being alike.

This convergence of risks demonstrates that plastic pollution should be understood as a transboundary regulatory problem requiring coordinated legal intervention rather than fragmented environmental management.

Scholars concur that this phenomenon poses a growing threat[32] to global environmental security due to its cascading impacts on biodiversity, public health, and sustainable development[33]. Despite international and regional efforts to address the issue, the absence of a binding international treaty with clear standards for accountability has left oceans and seas vulnerable to massive and ongoing inflows of plastic waste that interact in harmful and persistent ways[34].

This regulatory vacuum effectively externalizes environmental costs, allowing plastic-producing economies to shift ecological burdens onto the global commons.

The accumulation of plastic debris within marine environments has devastating consequences for ecological balance. Marine organisms suffer suffocation or death

---

[30] Leal Filho, W., Barbir, J., May, J., May, M., Swart, J., Yang, P., ... & Azadi, H. (2025). Towards more sustainable oceans: A review of the pressing challenges posed by marine plastic litter. Waste Management & Research the Journal for a Sustainable Circular Economy, 43(9), 1358–1377. https://doi.org/10.1177/0734242x251313927

[31] Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A review of Global issues. International Journal of Environmental Research and Public Health, 16(6), 1060. https://doi.org/10.3390/ijerph16061060

[32] Avio, C. G., Gorbi, S., & Regoli, F. (2016). Plastics and microplastics in the oceans: From emerging pollutants to emerged threat. Marine Environmental Research, 128, 2–11. https://doi.org/10.1016/j.marenvres.2016.05.012

[33] Guggisberg, S. (2024). Finding equitable solutions to the land-based sources of marine plastic pollution: Sovereignty as a double-edged sword. Marine Policy.https://doi.org/10.1016/j.marpol.2023.105960

[34] Wu, H. H. (2022). A study on transnational regulatory governance for marine plastic debris: Trends, challenges, and prospect. Marine Policy, 136.https://doi.org/10.1016/j.marpol.2020.103988

due to ingestion of plastic particles or entanglement in plastic-based fishing nets, leading to the collapse of food chains and disruptions in reproductive habitats[35].

Such ecological disruption is not merely biological but legally significant, as it undermines states' obligations to preserve marine biodiversity under contemporary environmental law.

The disintegration of plastics into microplastics compounds the threat further, as these particles infiltrate the tissues of marine organisms and enter the human food chain through contaminated seafood[36], This pathway illustrates a legally relevant chain of harm linking environmental degradation to human exposure, thereby strengthening arguments for recognizing plastic pollution as a matter of public health governance[37].

Thereby becoming an integral component of human dietary exposure. From a human health perspective, exposure to microplastics poses serious risks. Research indicates that these particles can accumulate within human tissues and vital organs, potentially causing hormonal imbalances, immune dysfunctions, and chronic diseases such as cancer and cardiovascular disorders[38].

The growing medical evidence narrows the traditional divide between environmental risk and human injury, supporting the emergence of a precautionary regulatory approach[39].

Furthermore, toxins released during plastic degradation intensify chemical contamination in water and food, amplifying long-term health and social challenges worldwide. Failure to regulate such risks may engage questions of state responsibility where foreseeable harm is insufficiently mitigated[40].

Growing evidence showing microplastics in human tissue and projections that plastics may outweigh fish by 2050 indicate that the crisis extends beyond ecology to public health and global food systems.

These projections are legally consequential because they transform plastic pollution from a conservation issue into a threat to food security and intergenerational equity[41]. Accordingly, urgent international action is needed to establish a binding legal framework that defines state obligations, strengthens enforcement, and promotes scientific cooperation. Absent such a framework,

---

[35] Worm, B., Lotze, H. K., Jubinville, I., Wilcox, C., & Jambeck, J. (2017). Plastic as a persistent marine pollutant. Annual Review of Environment and Resources, 42(1), 1–26. https://doi.org/10.1146/annurev-environ-102016-060700

[36] Mederake, L., & Knoblauch, D. (2019). Shaping EU Plastic Policies: The Role of Public Health vs. Environmental Arguments. International Journal of Environmental Research and Public Health, 16(20), 3928. https://doi.org/10.3390/ijerph16203928

[37] Landrigan, P. J., Raps, H., Cropper, M., Bald, C., Brunner, M., Canonizado, E. M., ... & Dunlop, S. (2023). The Minderoo-Monaco commission on plastics and human health. Annals of Global health, 89(1), 23. Avaliable at: https://annalsofglobalhealth.org/articles/10.5334/aogh.4056 (accessed on 15 October 2025). 38 Abbas, G., Ahmed, U., & Ahmad, M. A. (2025). Impact of microplastics on human health: risks, diseases, and affected body systems. Microplastics, 4(2), 23. https://doi.org/10.3390/microplastics4020023

[39] Seewoo, B. J., Goodes, L. M., Mofflin, L., Mulders, Y. R., Wong, E. V., Toshniwal, P., ... & Dunlop, S. A. (2023). The plastic health map: A systematic evidence map of human health studies on plastic-associated chemicals. Environment International, 181, 108225. https://doi.org/10.1016/j.envint.2023.108225

[40] Conferences Environment and Sustainable Development. Avaliable at: https://www.un.org/en/conferences/environment/rio1992 (accessed on 15 October 2025).

[41] Aheeyar, M., Jayathilake, N., Bucatariu, C., Reitemeier, M., Bandara, A., Thiel, F., & Drechsel, P. (2023). Governance analysis for urban wholesale to household's food waste prevention and reduction in Sri Lanka. Colombo, FAO and IWMI. https://doi.org/10.4060/cc0174en

existing commitments risk remaining programmatic rather than operational[42]. In this context, marine plastic pollution may be regarded as a potentially existential threat, requiring a unified and legally grounded global response[43].

## 5. Marine environment pollution by plastic materials: Legal gaps and the need for enhanced international cooperation

The current framework of international cooperation to combat marine plastic pollution remains largely anchored in general principles of international environmental law, without evolving into a coherent and enforceable legal regime[44].

This structural reliance on soft coordination mechanisms reveals a deeper tension between state sovereignty and collective environmental protection[45].

Although several international instruments address marine pollution in a broad sense—such as the United Nations Convention on the Law of the Sea (UNCLOS) and the MARPOL Convention—there is still no specific and binding international treaty that directly and comprehensively addresses marine plastic pollution[46].

The absence of lex specialis regulation contributes to interpretive ambiguity and uneven compliance[47].

This fragmentation stems from the coexistence of multiple international and regional instruments addressing marine pollution from different perspectives, often without unified standards or coordinated enforcement mechanisms.Consequently, governance operates through a patchwork architecture that prioritizes flexibility over legal certainty[48].

states operate under varying obligations and reporting systems, leading to inconsistent implementation and limited cooperation across jurisdictions[49].

As a result, the global community continues to rely on a fragmented set of initiatives and mechanisms encompassing legal, environmental, and institutional dimensions, creating coordination gaps, enforcement challenges, and weak accountability structures[50]. Such divergence weakens collective action by

---

[42] United Nations. (2001). Responsibility of states for internationally wrongful acts. In Yearbook of the International Law Commission. Available at: https://legal.un.org/ilc/texts/instruments/english/draft_articles/9_6_2001.pdf (accessed on 15 October 2025).

[43] Borrelle, S. B., Rochman, C. M., Liboiron, M., Bond, A. L., Lusher, A., Bradshaw, H., & Provencher, J. F. (2017). Why we need an international agreement on marine plastic pollution. Proceedings of the National Academy of Sciences, 114(38), 9994–9997. https://doi.org/10.1073/pnas.1714450114

[44] Erawati, L. (2024). The Government's Responsibility in Enforcing the Law on Plastic Pollution in The Sea. Eduvest-Journal of Universal Studies, 4(3), 947-958. https://doi.org/10.59188/eduvest.v4i3.1084

[45] Lysén, G. (1997). State responsibility and international liability of states for lawful acts: A Discussion of Principles. Uppsala: Iustus förlag, 1997. p. 220.

[46] Abirami, A. (2024). Marine Pollution and Waste Management. Journal of Law and Legal Research Development. Avaliable at: https://jllrd.com/index.php/journal/article/view/10 (accessed on 15 October 2025).

[47] Peters, A. (2017). The refinement of international law: From fragmentation to regime interaction and politicization. International Journal of Constitutional Law, 15(3), 671–704. https://doi.org/10.1093/icon/mox056

[48] Biermann, F., Pattberg, P., Van Asselt, H., & Zelli, F. (2009). The Fragmentation of Global Governance Architectures: a Framework for Analysis. Global Environmental Politics. https://doi.org/10.1162/glep.2009.9.4.14

[49] Kirk, E. A., & Popattanachai, N. (2018). Marine plastics: Fragmentation, effectiveness and legitimacy in international lawmaking. Review of European Comparative & International Environmental Law, 27(3), 222–233. https://doi.org/10.1111/reel.12261

[50] Al-Sherman, N. (2024). Crimes of the breaches of trust and equity in financial securities trading. Pakistan Journal of Criminology, 16.2, 501–514. https://doi.org/10.62271/pjc.16.2.501.514

incentivizing regulatory arbitrage, whereby pollution-intensive activities migrate toward less stringent regimes[51].

The limitations of existing mechanisms become apparent when considering their enforceability. Although obligations may sometimes be inferred implicitly, as illustrated by the ITLOS Advisory Opinion on climate change, plastic pollution presents a context in which implicit duties alone have proven insufficient. Frameworks such as UNCLOS, MARPOL Annex V, and UNEA resolutions outline broad environmental responsibilities, yet they do not impose concrete, binding obligations requiring states to reduce plastic production or implement national waste-management strategies.The resulting compliance gap reflects the classic problem of obligation without operationalization[52].

This lack of explicit legal duties weakens compliance incentives and restricts the capacity of monitoring bodies to assess violations or mandate corrective action[53].

Most agreements also address marine litter only in general terms, without defining plastic pollution as a distinct category or recognizing its persistence, fragmentation, and bioaccumulation.

As a result, responsibility allocation remains ambiguous, and enforcement mechanisms are limited. The governance gap therefore lies in the absence of specific, enforceable commitments supported by monitoring, accountability measures, and reporting requirements.

Bridging this gap requires shifting from declaratory environmental norms toward rule-based regulatory architecture[54].

In light of these challenges, a dedicated international convention is needed—one that establishes clear obligations, ensures enforcement, and strengthens global cooperation to protect marine ecosystems for future generations[55].

Such an instrument should prioritize measurable reduction targets, lifecycle regulation of plastics, and shared but differentiated responsibilities to reflect disparities in technological and financial capacity[56].

## 6. The United Nations Convention on the Law of the Sea

The United Nations Convention on the Law of the Sea (UNCLOS) represents the principal international legal instrument governing the relationship between states and the marine environment and serves as the foundational framework of the law of the sea[57]. While its widespread acceptance among states underscores its central

---

[51] Daniel C. Esty. (1994). Greening the GATT: Trade, Environment, and the Future. Avaliable at: https://www.piie.com/bookstore/greening-gatt-trade-environment-and-future (accessed on 15 October 2025).

[52] Young, O. R. (2011). Effectiveness of international environmental regimes: Existing knowledge, cutting-edge themes, and research strategies. Proceedings of the National Academy of Sciences, 108(50), 19853–19860. https://doi.org/10.1073/pnas.1111690108

[53] Wang, G. X., Huang, D., Ji, J. H., Völker, C., & Wurm, F. R. Seawater-degradable polymers—fighting the marine plastic pollution. 2021. Ibid.

[54] Dauvergne, P. (2018). Why is the global governance of plastic failing the oceans? Global Environmental Change, 51, 22–31. https://doi.org/10.1016/j.gloenvcha.2018.05.002

[55] Gjerde, K. M., & Yadav, S. S. (2021). Polycentricity and Regional Ocean Governance: Implications for the emerging UN Agreement on Marine Biodiversity Beyond National Jurisdiction. Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.704748

[56] UNEP. Environment Assembly. (2022). 5/14. End plastic pollution: towards an international legally binding instrument: resolution/adopted by the United Nations Environment Assembly. Avaliable at: https://digitallibrary.un.org/record/3999257?ln=en&utm_source=chatgpt.com&v=pdf (accessed on 15 October 2025).

[57] Tanaka, Y. (2019). The International Law of the Sea (3rd ed.). Cambridge: Cambridge University Press. Avaliable at:

role in regulating maritime spaces, treaty ratification alone does not automatically confer customary international law status. Rather, many of its core provisions are widely regarded as reflecting customary international law insofar as they are supported by consistent state practice and opinio juris.

This dual character enhances the Convention's normative authority while simultaneously expanding expectations of state conduct[58].

Within this framework, UNCLOS establishes general and binding obligations for state parties, most notably under Article 192, which enshrines the duty to protect and preserve the marine environment, thereby providing the legal basis under which marine plastic pollution may be addressed within the broader system of marine environmental protection, even though practical implementation and enforcement continue to face significant challenges in addressing contemporary forms of pollution such as plastic waste[59].

Protection of the marine environment within UNCLOS is primarily governed by Part XII, which applies across all maritime zones and establishes the overarching framework for state obligations concerning marine environmental protection. Within this structure, Article 192 articulates the general obligation of states to protect and preserve the marine environment. This interpretation has been reinforced in recent jurisprudence, notably in the 2024 Advisory Opinion of the International Tribunal for the Law of the Sea, which confirmed that state obligations concerning marine environmental protection extend to contemporary forms of pollution even where specific pollutants are not explicitly identified in treaty provisions[60].

In addition, Article 194 requires states to take "all measures necessary" to prevent, reduce, and control pollution of the marine environment, including pollution originating from land-based sources. Although the text does not explicitly reference plastic pollution, Article 1(1) (4) offers a broad definition of pollution of the marine environment as the introduction of substances or energy resulting in harm to living resources, hazards to human health, hindrance to marine activities, or degradation of seawater quality. Under this wide conceptual definition, plastic waste clearly fits within the scope of marine pollution, especially given its toxicity, persistence, and biological accumulation[61].

Notably, recent jurisprudence reinforces this interpretation. In its Advisory Opinion (ITLOS, 2023) concerning climate-related marine impacts, the Tribunal affirmed that states may bear environmental obligations even in the absence of explicit textual mention, provided that the activity falls within the general pollution framework of UNCLOS. This reasoning is directly transposable to plastic debris, thereby supporting an interpretive approach that recognizes the legal applicability of Articles 192 and 194 to plastic pollution.

Despite this legal potential, practical implementation remains limited. The obligations contained in UNCLOS are general in nature and lack specific procedural

---

https://assets.cambridge.org/97811084/40103/frontmatter/9781108440103_frontmatter.pdf (accessed on 15 October 2025).

[58] Abbott, K. W., Keohane, R. O., Moravcsik, A., Slaughter, A., & Snidal, D. (2000). The concept of legalization. International Organization, 54(3), 132–151. https://doi.org/10.1162/002081800551271

[59] Khaskheli, M. B., Wang, S., Zhang, X., Shamsi, I. H., Shen, C., Rasheed, S., Ibrahim, Z., & Baloch, D. M. (2023). Technology advancement and international law in marine policy, challenges, solutions and future prospective. Frontiers in Marine Science, 10. https://doi.org/10.3389/fmars.2023.1258924

[60] ADVISORY OPINION. (2024). Request for an advisory opinion submitted by the commission of small island states on climate change and international law. Avaliable at: https://www.itlos.org/fileadmin/itlos/documents/cases/31/Advisory_Opinion/C31_Adv_Op_21.05.2024_orig.pdf?utm_source=chatgpt.com (accessed on 15 October 2025).

[61] Worm, B., Lotze, H. K., Jubinville, I., Wilcox, C., & Jambeck, J. Plastic as a persistent marine pollutant. 2017. Ibid.

duties or binding reduction targets for plastic production and waste management. Moreover, the Convention does not articulate enforcement mechanisms strict enough to guarantee compliance, nor does it address monitoring, traceability, or producer-responsibility in the context of plastics. The absence of explicit obligations requiring states to adopt national plastic mitigation strategies creates ambiguity around accountability, leaving enforcement dependent on voluntary measures and domestic capacity—an issue particularly evident among developing states with limited technological and financial resources[62].

Consequently, UNCLOS offers an essential legal base yet remains insufficient as a standalone regime for combating marine plastic pollution, reinforcing the necessity for a specialized, binding global instrument that operationalizes Articles 192 and 194 with enforceable standards, measurable targets, and shared responsibilities among states.

## 7. Regional agreements

Regional agreements constitute an important intermediate layer in the governance of marine plastic pollution, offering region-specific cooperation mechanisms, monitoring platforms, and policy coordination among geographically adjacent states[63]. Notable examples include the Barcelona Convention for the Mediterranean (1976), the Helsinki Convention for the Baltic Sea (1974), the Bucharest Convention for the Black Sea (1992), and the Regional Convention for the Protection of the Marine Environment[64] of the Arabian Sea (1982). Collectively, these instruments have contributed to reducing certain forms of marine pollution by promoting recycling technologies, improving waste-management facilities, and encouraging information exchange and legislative development. Some protocols under these frameworks have even begun to restrict non-biodegradable plastics or incentivize biodegradable alternatives[65].

However, despite these advancements, their actual capacity to address marine plastic pollution remains structurally constrained[66]. Their jurisdiction is limited to member states, while plastic debris frequently originates outside regional boundaries and enters through transboundary ocean currents[67]. This means that even highly effective regional measures cannot prevent external plastic inflow, weakening long-term outcomes[68]. Moreover, most regional agreements lack binding

---

[62] Wang, S. International law-making process of combating plastic pollution: status quo, debates and prospects. 2023. Ibid.

[63] Comte, A., Pendleton, L. H., Bailly, D., & Quillérou, E. (2018). Conceptual advances on global scale assessments of vulnerability: Informing investments for coastal populations at risk of climate change. Marine Policy, 99, 391–399. https://doi.org/10.1016/j.marpol.2018.10.038

[64] Ma, P., Ye, G., Peng, X., Liu, J., Qi, J., & Jia, S. (2017). Development of an index system for evaluation of ecological carrying capacity of marine ecosystems. Ocean & Coastal Management, 144, 23–30. https://doi.org/10.1016/j.ocecoaman.2017.04.012

[65] Han, Y., Lam, J. C., Li, V. O., & Reiner, D. (2020). A Bayesian LSTM model to evaluate the effects of air pollution control regulations in Beijing, China. Environmental Science & Policy, 115, 26–34. https://doi.org/10.1016/j.envsci.2020.10.004

[66] Fonseca, T., Agostinho, F., Pavão, J., Sulis, F., Maceno, M., Almeida, C., & Giannetti, B. (2024). Marine plastic pollution: A systematic review of management strategies through a macroscope approach. Marine Pollution Bulletin, 208, 117075. https://doi.org/10.1016/j.marpolbul.2024.117075

[67] Pattiaratchi, C., Van der Mheen, M., Schlundt, C., Narayanaswamy, B. E., Sura, A., Hajbane, S., ... & Wijeratne, S. (2022). Plastics in the Indian Ocean – sources, transport, distribution, and impacts. Ocean Science, 18(1), 1–28. https://doi.org/10.5194/os-18-1-2022

[68] Bank, M. S., Swarzenski, P. W., Duarte, C. M., Rillig, M. C., Koelmans, A. A., Metian, M., ... & Ok, Y. S. (2021). Global Plastic Pollution Observation System to aid Policy. Environmental

reduction targets for plastic production and consumption, rely heavily on voluntary compliance, and do not enforce unified monitoring or reporting systems. As a result, implementation varies significantly based on national economic capacity, political will, and institutional readiness, leading to uneven enforcement across regions[69].

Moreover, several of the world's major producers and consumers of plastics fall outside certain regional marine protection arrangements, which limits the practical effectiveness of these frameworks in addressing plastic pollution at its source[70].

A further limitation is that regional conventions generally focus on downstream waste management rather than upstream preventive governance—leaving production[71], trade, and global supply chains largely unregulated. While useful, these frameworks therefore function primarily as mitigation tools[72], not comprehensive regulatory regimes. Their fragmentation also prevents cross-regional coordination, limiting learning transfer and cumulative effectiveness.

Consequently, regional agreements play a valuable[73] but inherently supplementary role in global efforts. They can support capacity building, promote scientific cooperation, and accelerate local interventions, yet they cannot independently address the global circulation of plastic waste, nor establish uniform liability or accountability standards. Their limitations illustrate the necessity of a globally binding legal instrument capable of harmonizing standards, ensuring enforcement, and integrating regional advancements into a coherent international framework[74].

In parallel with these limitations, ongoing negotiations under the United Nations Environment Assembly have initiated the development of a legally binding global instrument addressing plastic pollution across its full life cycle. This process reflects growing international consensus that existing regulatory frameworks remain insufficient to tackle the transboundary and systemic nature of plastic pollution. The following discussion therefore situates the identified governance challenges within this evolving global regulatory context[75].

## 8. Challenges associated with combating marine plastic pollution

Science & Technology, 55(12), 7770–7775. https://doi.org/10.1021/acs.est.1c00818

[69] Melidis, M., & Gouglas, A. (2025). Laggard by intent or constraint? Rethinking environmental implementation deficits in Greece through the Capacity–Intentionality Framework. Environmental Policy and Governance, 35(5), 914–927. https://doi.org/10.1002/eet.70011

[70] Yu, R., Yang, Y., & Singh, S. (2023). Global analysis of marine plastics and implications of control measure strategies. Frontiers in Marine Science, 10. https://doi.org/10.3389/fmars.2023.1305091

[71] Zhou, J., & Luo, D. The global governance of marine plastic pollution: rethinking the extended producer responsibility system. 2024. Ibid.

[72] Johansson, N., & Corvellec, H. (2018). Waste policies gone soft: An analysis of European and Swedish waste prevention plans. Waste Management, 77, 322–332. https://doi.org/10.1016/j.wasman.2018.04.015

73 Shomuyiwa, D. O., Onukansi, F. O., Ivanova, M., & Lucero‐Prisno, D. E. (2023). The Plastic treaty: What is in it for Africa? Public Health Challenges, 2(2), e83. https://doi.org/10.1002/puh2.83

[74] Thushari, G. G. N., Senevirathna, J. D. M. (2020). Plastic pollution in the marine environment. In Heliyon. Avaliable at: https://www.cell.com/heliyon/pdf/S2405-8440(20)31552-8.pdf (accessed on 15 October 2025).

[75] Intergovernmental Negotiating Committee on Plastic Pollution. (2022). Avaliable at: https://www.unep.org/inc-plastic-pollution (accessed on 15 October 2025).

Global efforts to combat marine plastic pollution face a range of intertwined legal, administrative, and technical challenges, making it a complex transboundary issue that requires collective international action[76].

The most critical challenges are not only the lack of a unified global treaty, but also structural governance gaps that continue to weaken compliance, accountability, and implementation across states. The main challenges can be reformulated as follows:

### 8.1. Absence of comprehensive legal frameworks

The lack of cohesive and binding global rules represents a foundational governance gap. Although several international agreements address marine pollution broadly, none provide explicit and enforceable obligations targeting plastic production, consumption, or disposal, leading to fragmented regulation across states. This gap is significant because it allows the continuation of unsustainable industrial practices, encourages dependency on voluntary commitments, and leaves regulation of the plastic life-cycle to inconsistent domestic approaches[77].

To bridge this gap, a comprehensive international framework must integrate environmental, economic, trade, and industrial policies, with binding reduction targets, lifecycle regulations, and common reporting standards.

### 8.2. Transboundary legal complexities

Marine plastic pollution is inherently transboundary; waste generated in one state frequently washes ashore in another. This raises questions of jurisdiction, responsibility allocation, cross-border compensation, and liability, particularly when national laws differ significantly.

The legal significance of this gap lies in the difficulty of attributing responsibility for damage and enforcing compensation under existing frameworks. Addressing this requires clear legal rules for attribution, shared monitoring systems, and a mechanism for dispute resolution and liability assignment consistent with the principle of common but differentiated responsibilities.

### 8.3. Weak enforcement and implementation

Earlier parts of the paper highlighted the absence of a unified global treaty. This point does not contradict, but rather explains why enforcement is weak—existing instruments lack mandatory compliance measures. Even where national legislation exists, enforcement remains inconsistent due to limited political will, weak sanction systems, and insufficient monitoring resources, reducing deterrence and enabling continued harmful practices[78].

Thus, the gap here is two-layered: (1) no binding global legal framework, and (2) weak enforcement of existing national/regional regimes, which collectively limit accountability and reduce the effectiveness of protection strategies[79].

## 9. Limited liability and accountability mechanisms

---

[76] Badran, D. M. I., Al-Amari, K. B. S. Y., & Abdelhady, M. A. (2024). The legal Challenges in environmental Protection and Accountability: A study in Saudi Law. Revista De Gestão Social E Ambiental, 18(9), e6536. https://doi.org/10.24857/rgsa.v18n9-060

[77] Aare, F. F., Tekaron, O. A., Ntor, G. G., & Ogiri, T. O. (2024). Strategic management of plastic pollution in Nigeria: Balancing best approaches. https://doi.org/10.22271/civillaw.2024.v4.i1a.58

[78] Pyć, D. (2024). Liability for Pollution Damage to the Marine Environment. In Managing Environmental Risks through Insurance: Legal and Economic Aspects (pp. 389-404). Cham: Springer Nature Switzerland.https://doi.org/10.1007/978-3-031-47602-0_15

[79] Dauvergne, P. Why is the global governance of plastic failing the oceans? 2018. Ibid.

Many legal frameworks lack traceability tools and liability pathways across the plastic value chain, making it difficult to hold producers, importers, distributors, and users accountable[80].

This gap is crucial because pollution responsibility becomes diffused, and remediation costs fall disproportionately on coastal states rather than polluters. Adoption of Extended Producer Responsibility (EPR) can redistribute costs fairly and promote upstream prevention policies.

**10. Deficient monitoring and reporting systems**

The absence of a unified monitoring system prevents accurate assessment of plastic leakage into marine ecosystems. Without systematic data, policy evaluation, enforcement, and transboundary accountability remain limited[81].

A global monitoring and reporting framework with standardized metrics, satellite-based tracking, and open data exchange mechanisms is needed to support evidence-based decision-making.

**11. Diversity and expansion of pollution sources**

Plastic pollution arises from industrial activities, fisheries, maritime transport, tourism, household waste, and new technological systems such as autonomous vessels.

The multiplicity and mobility of sources make enforcement fragmented and highly resource-dependent.

This diversity reduces the ability of states to trace pollutants back to their origin and complicates liability assignment, calling for technology-assisted monitoring, port-state controls, and cross-border waste-tracking systems.

**12. Proposed solutions to combat marine plastic pollution**

Addressing marine plastic pollution requires innovative and coordinated global strategies that integrate legal, technical, and institutional measures. The complexity of this crisis necessitates comprehensive approaches capable of balancing environmental protection with sustainable development objectives. The key proposed solutions include the following.

**12.1. Establishing an international convention on plastic pollution**

Creating a dedicated international convention on plastic pollution would represent a pivotal step toward strengthening global efforts to mitigate this escalating environmental threat[82]. Such a convention would unify global actions under a coherent and binding legal framework, enhancing coordination among states and ensuring standardized measures for prevention and remediation[83].

---

[80] Apriandini, D., Azizah, T. N. A., Kirana, K. C., & Nugroho, M. F. A. (2024). Environmental Law Enforceent Against Plastic Waste Disposal Based on Law Number 18 of 2008 Concerning Waste Management. At-Tasyrih: jurnal pendidikan dan hukum Islam, 10(1). https://doi.org/10.55849/attasyrih.v10i1.189

[81] Onyeabor, E., & Obuka, U. (2024). Building collaboration and synergy among regional blocs to reduce marine plastic waste pollution: A case for the Gulf of Guinea region. Marine Pollution Bulletin, 198. https://doi.org/10.1016/j.marpolbul.2023.115829

[82] Dauvergne, P. The necessity of justice for a fair, legitimate, and effective treaty on plastic pollution. 2023. Ibid.

[83] Putri, R. W., & Sabatira, F. (2023). The paradox of ASEAN way in marine plastic pollution: the challenge of compliance among member states. Journal of Liberty and International Affairs, 9(3), 248-264.

The rationale for establishing this convention includes: (1) Consolidating international efforts within a comprehensive legal structure that enhances global responsiveness. (2) Imposing binding obligations on states, increasing pressure for more effective national actions. (3) Directing financial and technical assistance to regions most affected by plastic pollution. (4) Allowing flexibility for states to design national policies aligned with their economic and developmental capacities.

This international treaty would thus serve not only as a legal mechanism but also as a catalyst for promoting global environmental justice and sustainable governance[84].

### 12.2. Developing legal and policy frameworks

Strengthening environmental laws and policies at both international and national levels is essential for ensuring consistent and effective action. At the international level, uniform standards are needed to regulate plastic production, use, and disposal, supported by global cooperation under institutions such as the United Nations Environment Programme (UNEP).

National legislation, on the other hand, provides the operational framework for implementation through measures such as restrictions on single-use plastics, recycling mandates, and effective licensing and monitoring systems. The synergy between international guidance and national enforcement ensures that legal commitments are translated into tangible results[85].

### 12.3. Adopting alternative technologies

Transitioning to biodegradable and reusable alternatives to plastic offers a practical and sustainable solution to marine pollution. Governments can incentivize this shift by introducing fiscal and policy mechanisms—such as tax exemptions, subsidies, and research grants—to encourage private sector investment in environmentally friendly technologies[86]. Moreover, embedding obligations related to alternative materials within international environmental and sustainable development agreements would enhance global adoption and compliance[87].

### 12.4. Promoting recycling and sustainability

Encouraging recycling is a cornerstone of sustainable plastic waste management. Recycling reduces demand for virgin raw materials and mitigates the accumulation of marine litter[88]. International law can play a central role in advancing recycling and sustainability through:

Establishing binding international agreements regulating plastic use and promoting sustainable alternatives[89].

---

[84] Beltran, M., Tjahjono, B., Suoneto, T. N., Tanjung, R., & Julião, J. Rethinking marine plastics pollution: Science diplomacy and multi-level governance. 2023. Ibid.

[85] Tanaka, Y. (2023). Shared State Responsibility for Land-Based Marine Plastic Pollution. Transnational Environmental Law, 12(2), 244-269. https://doi.org/10.1017/S2047102522000462

[86] Wang, G. X., Huang, D., Ji, J. H., Völker, C., & Wurm, F. R. Seawater-degradable polymers—fighting the marine plastic pollution. 2021. Ibid.

[87] Anjana, K., Hinduja, M., Sujitha, K., & Dharani, G. (2020). Review on plastic wastes in marine environment–Biodegradation and biotechnological solutions. Marine Pollution, 150, 110733. https://doi.org/10.1016/j.marpolbul.2019.110733

[88] Kumar, S., Kumar, S., Kumar, S., Yadav, T., Dhapola, P. S., & Singh, P. K. (2024). Reducing Environmental Plastic Pollution by Designing Polymer Materials for Managed End-of-Life. In Macromolecular Symposia, 413(1). https://doi.org/10.1002/masy.202300146

[89] Schmaltz, E., Melvin, E. C., Diana, Z., Gunady, E. F., Rittschof, D., Somarelli, J. A., ... & Dunphy-Daly, M. M. (2020). Plastic pollution solutions: emerging technologies to prevent and

Setting unified standards for plastic production and utilization that minimize environmental impacts[90].

Enhancing international cooperation for knowledge sharing, technical support, and investment in sustainable waste management technologies[91].

Collectively, these solutions provide a multidimensional roadmap for addressing marine plastic pollution. They integrate legal, institutional, and technological dimensions while emphasizing the principle of shared but differentiated responsibility, ultimately fostering a sustainable and equitable marine environment for future generations.

## 13. Discussion and findings

International cooperation in addressing marine plastic pollution relies primarily on the general principles and mechanisms of international environmental law; however, no specific and binding international treaty has yet been established to directly and comprehensively tackle this issue.

UNCLOS constitutes the foundational legal framework for the law of the sea—distinct from maritime law, which primarily governs commercial shipping and private maritime relations rather than state responsibilities for marine environmental protection. As a near-universal treaty whose core provisions are widely recognized as reflecting customary international law, UNCLOS carries strong normative authority. However, although it provides broad environmental duties, it does not impose explicit, binding obligations requiring states to reduce plastic production or adopt national waste-management strategies, thereby limiting its practical effectiveness in addressing plastic pollution.

Regional conventions, such as those dedicated to the protection of seas and oceans, can act as temporary yet effective legal tools to enhance cooperation among states in combating marine plastic pollution and protecting coastal ecosystems.

Although general legal frameworks exist to address marine pollution, legal and enforcement challenges related to plastic waste remain unresolved, including weak implementation, lack of specific obligations, and overlapping jurisdictional responsibilities.

Promoting innovation in alternative plastic technologies and fostering a culture of recycling and sustainability are key components of global efforts to mitigate this crisis.

Strengthened international cooperation and multilevel coordination remain vital to achieving tangible progress in protecting marine ecosystems and ensuring their sustainability for future generations.

The findings of this study indicate that marine plastic pollution has evolved from a local environmental concern into a complex global challenge with intertwined legal, economic, and ecological dimensions, requiring coordinated responses at both international and regional levels. The analysis further shows that existing legal instruments—such as the United Nations Convention on the Law of the Sea (UNCLOS) and regional agreements—play an important role in marine environmental protection but remain insufficient, on their own, to comprehensively

---

collect marine plastic pollution. Environment international, 144. https://doi.org/10.1016/j.envint.2020.106067

[90] Tumu, K., Vorst, K., & Curtzwiler, G. (2023). Global plastic waste recycling and extended producer responsibility laws. Journal of Environmental Management, 348. https://doi.org/10.1016/j.jenvman.2023.119242

[91] Kurniawan, S. B., Abdullah, S. R. S., Imron, M. F., & Ismail, N. I. (2021). Current state of marine plastic pollution and its technology for more eminent evidence: a review. Journal of cleaner production, 278. https://doi.org/10.1016/j.jclepro.2020.123537

and effectively address marine plastic pollution due to persisting legislative and enforcement gaps.

Comparative analysis shows that the absence of a binding international legal framework specifically targeting plastic pollution has perpetuated the crisis despite scattered efforts. Many states approach the issue through narrow environmental lenses, often failing to integrate it into broader economic, industrial, and trade policies—thereby weakening policy coherence. Furthermore, disparities in technological and financial capacity among nations complicate the implementation of international environmental obligations, leaving many developing countries unable to comply fully with global plastic reduction standards despite recognizing the gravity of the issue.

Institutionally, the study highlights that weak international monitoring and enforcement mechanisms constitute a major barrier to progress. Although environmental conventions are legally binding, they often lack effective compliance tools. The system of sanctions and incentives under international environmental law remains underdeveloped, reducing the deterrent effect of legal commitments.

Legally, the "common but differentiated responsibilities" principle stands as a cornerstone in addressing the issue but raises challenges in practice, particularly when assigning liability to industrialized nations that are primary contributors to global plastic waste. The absence of clear mechanisms for burden-sharing and accountability perpetuates the gap between verbal commitments and tangible action.

The study further emphasizes that tackling marine plastic pollution requires rethinking the human–marine environment relationship through the lens of environmental justice and sustainability. The issue is not merely ecological—it reflects structural imbalances in global production and consumption patterns. Therefore, genuine solutions must integrate international law, economic policy, and green technologies within a holistic approach.

Ultimately, the study concludes that transitioning toward a comprehensive international legal framework for combating marine plastic pollution is not merely an environmental necessity but a strategic imperative. Maintaining the current fragmented legal order will accelerate biodiversity loss, disrupt marine ecosystems, and undermine food security, public health, and the blue economies of coastal nations.

## 14. Conclusion

In conclusion, the global challenge of addressing plastic waste in marine environments transcends environmental concern alone; it constitutes a critical test of the international community's capacity to safeguard the planet's shared resources. Marine plastic pollution threatens not only marine biodiversity but also food security, public health, and the foundations of sustainable development. Consequently, an effective response requires an integrated approach that harmonizes legal, environmental, and economic dimensions within a framework of equitable and responsible international cooperation.

Implementing robust national legislation and binding international policies, coupled with the development of accurate monitoring and financing mechanisms, represents the practical foundation for mitigating this escalating crisis. Equally important is the promotion of environmental awareness among individuals, institutions, and industries to encourage a global shift toward sustainable production and consumption patterns that minimize single-use plastics.

International cooperation remains the cornerstone of success, as no nation can combat marine plastic pollution in isolation. The future of the world's oceans depends on the global community's ability to unite under a shared legal framework that embodies the principle of "common responsibility for a common destiny."

Ultimately, collective will and genuine commitment to change form the keystone for building a cleaner and more sustainable marine environment—one that preserves this vital natural heritage for present and future generations alike.

## 15. References


Aare, F. F., Tekaron, O. A., Ntor, G. G., & Ogiri, T. O. (2024). Strategic management of plastic pollution in Nigeria: Balancing best approaches. https://doi.org/10.22271/civillaw.2024.v4.i1a.58

Abbas, G., Ahmed, U., & Ahmad, M. A. (2025). Impact of microplastics on human health: risks, diseases, and affected body systems. Microplastics, 4(2), 23. https://doi.org/10.3390/microplastics4020023

Abbott, K. W., Keohane, R. O., Moravcsik, A., Slaughter, A., & Snidal, D. (2000). The concept of legalization. International Organization, 54(3), 132–151. https://doi.org/10.1162/002081800551271

Abirami, A. (2024). Marine Pollution and Waste Management. Journal of Law and Legal Research Development. Avaliable at: https://jllrd.com/index.php/journal/article/view/10 (accessed on 15 October 2025).

ADVISORY OPINION. (2024). Request for an advisory opinion submitted by the commission of small island states on climate change and international law. Avaliable at: https://www.itlos.org/fileadmin/itlos/documents/cases/31/Advisory_Opinion/C31_Adv_Op_21.05.2024_orig.pdf?utm_source=chatgpt.com (accessed on 15 October 2025).

Aheeyar, M., Jayathilake, N., Bucatariu, C., Reitemeier, M., Bandara, A., Thiel, F., & Drechsel, P. (2023). Governance analysis for urban wholesale to household's food waste prevention and reduction in Sri Lanka. Colombo, FAO and IWMI. https://doi.org/10.4060/cc0174en

Aklin, M., & Mildenberger, M. (2020). Prisoners of the wrong Dilemma: Why distributive conflict, not collective action, characterizes the politics of climate change. Global Environmental Politics, 20(4), 4–27. https://doi.org/10.1162/glep_a_00578

Al-Sherman, N. (2024). Crimes of the breaches of trust and equity in financial securities trading. Pakistan Journal of Criminology, 16.2, 501–514. https://doi.org/10.62271/pjc.16.2.501.514

Anjana, K., Hinduja, M., Sujitha, K., & Dharani, G. (2020). Review on plastic wastes in marine environment–Biodegradation and biotechnological solutions. Marine Pollution, 150, 110733. https://doi.org/10.1016/j.marpolbul.2019.110733

Apriandini, D., Azizah, T. N. A., Kirana, K. C., & Nugroho, M. F. A. (2024). Environmental Law Enforceent Against Plastic Waste Disposal Based on Law Number 18 of 2008 Concerning Waste Management. At-Tasyrih: jurnal pendidikan dan hukum Islam, 10(1). https://doi.org/10.55849/attasyrih.v10i1.189

Avio, C. G., Gorbi, S., & Regoli, F. (2016). Plastics and microplastics in the oceans: From emerging pollutants to emerged threat. Marine Environmental Research, 128, 2–11. https://doi.org/10.1016/j.marenvres.2016.05.012

Badran, D. M. I., & Abdelhady, M. A. (2024). Legislación sobre energía sostenible: la piedra angular para lograr la sostenibilidad medioambiental y económica. REICE Revista Electrónica De Investigación En Ciencias Económicas, 12(24), 21–38. https://doi.org/10.5377/reice.v12i24.20055

Badran, D. M. I., Al-Amari, K. B. S. Y., & Abdelhady, M. A. (2024). The legal Challenges in environmental Protection and Accountability: A study in Saudi Law. Revista De Gestão Social E Ambiental, 18(9), e6536. https://doi.org/10.24857/rgsa.v18n9-060

Baechler, B. R., De Frond, H., Dropkin, L., Leonard, G. H., Proano, L., & Mallos, N. J. (2024). Public awareness and perceptions of ocean plastic pollution and support for solutions in the United States. Frontiers in Marine Science, 10. https://doi.org/10.3389/fmars.2023.1323477

Bank, M. S., Swarzenski, P. W., Duarte, C. M., Rillig, M. C., Koelmans, A. A., Metian, M., ... & Ok, Y. S. (2021). Global Plastic Pollution Observation System to aid Policy. Environmental Science & Technology, 55(12), 7770–7775. https://doi.org/10.1021/acs.est.1c00818

Bel Hassen, M., Bellaaj Zouari, A., Abdennadher, M., Assaf, J. C., Nakad, M., Abboud, R., ... & Hamd, W. (2025). Plastics pollution: pathways, impacts, and regulatory challenges in marine environments. Frontiers in Environmental Science, 13. https://doi.org/10.3389/fenvs.2025.1635230

Beltran, M., Tjahjono, B., Suoneto, T. N., Tanjung, R., & Julião, J. (2023). Rethinking marine plastics pollution: Science diplomacy and multi-level governance. International Review of Administrative Sciences, 90(1), 237–258. https://doi.org/10.1177/00208523231183909

Bertolazzi, S., Cuttitta, A., & Pipitone, V. (2024). Addressing marine plastic pollution: a systematic literature review. Current Opinion in Environmental Sustainability, 68, 101428. https://doi.org/10.1016/j.cosust.2024.101428

Biermann, F., Pattberg, P., Van Asselt, H., & Zelli, F. (2009). The Fragmentation of Global Governance Architectures: a Framework for Analysis. Global Environmental Politics. https://doi.org/10.1162/glep.2009.9.4.14

Borrelle, S. B., Rochman, C. M., Liboiron, M., Bond, A. L., Lusher, A., Bradshaw, H., & Provencher, J. F. (2017). Why we need an international agreement on marine plastic pollution. Proceedings of the National Academy of Sciences, 114(38), 9994–9997. https://doi.org/10.1073/pnas.1714450114

Comte, A., Pendleton, L. H., Bailly, D., & Quillérou, E. (2018). Conceptual advances on global scale assessments of vulnerability: Informing investments for coastal populations at risk of climate change. Marine Policy, 99, 391–399. https://doi.org/10.1016/j.marpol.2018.10.038

Conferences Environment and Sustainable Development. Avaliable at: https://www.un.org/en/conferences/environment/rio1992 (accessed on 15 October 2025).

Daniel C. Esty. (1994). Greening the GATT: Trade, Environment, and the Future. Avaliable at: https://www.piie.com/bookstore/greening-gatt-trade-environment-and-future (accessed on 15 October 2025).

Dauvergne, P. (2018). Why is the global governance of plastic failing the oceans? Global Environmental Change, 51, 22–31. https://doi.org/10.1016/j.gloenvcha.2018.05.002

Dauvergne, P. (2023). The necessity of justice for a fair, legitimate, and effective treaty on plastic pollution. Marine Policy, 155, 105785. https://doi.org/10.1016/j.marpol.2023.105785

Delphi, W., Melbourne-Thomas, J., Evans, K., Green, M., McCormack, P. C., Camilla, N., ... & Cayne, L. (2022). Safeguarding marine life: conservation of biodiversity and ecosystems. Reviews in Fish Biology and Fisheries, 32(1), 65–100. https://doi.org/10.1007/s11160-022-09700-3

Dimassi, S. N., Hahladakis, J. N., Yahia, M. N. D., Ahmad, M. I., Sayadi, S., & Al-Ghouti, M. A. (2022). Degradation-fragmentation of marine plastic waste and their environmental implications: A critical review. Arabian Journal of Chemistry, 15(11), 104262. https://doi.org/10.1016/j.arabjc.2022.104262

Erawati, L. (2024). The Government's Responsibility in Enforcing the Law on Plastic Pollution in The Sea. Eduvest-Journal of Universal Studies, 4(3), 947-958. https://doi.org/10.59188/eduvest.v4i3.1084

Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A review of Global issues. International Journal of Environmental Research and Public Health, 16(6), 1060. https://doi.org/10.3390/ijerph16061060

Fonseca, T., Agostinho, F., Pavão, J., Sulis, F., Maceno, M., Almeida, C., & Giannetti, B. (2024). Marine plastic pollution: A systematic review of management strategies through a macroscope approach. Marine Pollution Bulletin, 208, 117075. https://doi.org/10.1016/j.marpolbul.2024.117075

Gjerde, K. M., & Yadav, S. S. (2021). Polycentricity and Regional Ocean Governance: Implications for the emerging UN Agreement on Marine Biodiversity Beyond National Jurisdiction. Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.704748

Guggisberg, S. (2024). Finding equitable solutions to the land-based sources of marine plastic pollution: Sovereignty as a double-edged sword. Marine Policy.https://doi.org/10.1016/j.marpol.2023.105960

Han, Y., Lam, J. C., Li, V. O., & Reiner, D. (2020). A Bayesian LSTM model to evaluate the effects of air pollution control regulations in Beijing, China. Environmental Science & Policy, 115, 26–34. https://doi.org/10.1016/j.envsci.2020.10.004

Intergovernmental Negotiating Committee on Plastic Pollution. (2022). Avaliable at: https://www.unep.org/inc-plastic-pollution (accessed on 15 October 2025).

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223), 768–771. https://doi.org/10.1126/science.1260352

Johansson, N., & Corvellec, H. (2018). Waste policies gone soft: An analysis of European and Swedish waste prevention plans. Waste Management, 77, 322–332. https://doi.org/10.1016/j.wasman.2018.04.015

Kanter, D. R., Winiwarter, W., Bodirsky, B. L., Bouwman, L., Boyer, E., Buckle, S., ... & Zurek, M. (2020). A framework for nitrogen futures in the shared socioeconomic pathways. Global Environmental Change, 61, 102029. https://doi.org/10.1016/j.gloenvcha.2019.102029

Khaskheli, M. B., Wang, S., Zhang, X., Shamsi, I. H., Shen, C., Rasheed, S., Ibrahim, Z., & Baloch, D. M. (2023). Technology advancement and international law in marine policy, challenges, solutions and future prospective. Frontiers in Marine Science, 10. https://doi.org/10.3389/fmars.2023.1258924

Kirk, E. A., & Popattanachai, N. (2018). Marine plastics: Fragmentation, effectiveness and legitimacy in international lawmaking. Review of European Comparative & International Environmental Law, 27(3), 222–233. https://doi.org/10.1111/reel.12261

Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P. K., ... & Vara Prasad, P. V. (2021). Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. Sustainability, 13(17), 9963. https://doi.org/10.3390/su13179963

Kumar, S., Kumar, S., Kumar, S., Yadav, T., Dhapola, P. S., & Singh, P. K. (2024). Reducing Environmental Plastic Pollution by Designing Polymer Materials for Managed End-of-Life. In Macromolecular Symposia, 413(1). https://doi.org/10.1002/masy.202300146

Kurniawan, S. B., Abdullah, S. R. S., Imron, M. F., & Ismail, N. I. (2021). Current state of marine plastic pollution and its technology for more eminent evidence: a review. Journal of cleaner production, 278. https://doi.org/10.1016/j.jclepro.2020.123537

Landrigan, P. J., Raps, H., Cropper, M., Bald, C., Brunner, M., Canonizado, E. M., ... & Dunlop, S. (2023). The Minderoo-Monaco commission on plastics and human health. Annals of Global health, 89(1), 23. Avaliable at: https://annalsofglobalhealth.org/articles/10.5334/aogh.4056 (accessed on 15 October 2025).

Lau, W. W., Shiran, Y., Bailey, R. M., Cook, E., Stuchtey, M. R., Koskella, J., ... & Palardy, J. E. (2020). Evaluating scenarios toward zero plastic pollution. Science, 369(6510), 1455–1461. https://doi.org/10.1126/science.aba9475

Leal Filho, W., Barbir, J., May, J., May, M., Swart, J., Yang, P., ... & Azadi, H. (2025). Towards more sustainable oceans: A review of the pressing challenges posed by marine plastic litter. Waste Management & Research the Journal for a Sustainable Circular Economy, 43(9), 1358–1377. https://doi.org/10.1177/0734242x251313927

Lysén, G. (1997). State responsibility and international liability of states for lawful acts: A Discussion of Principles. Uppsala: Iustus förlag, 1997. p. 220.

Ma, P., Ye, G., Peng, X., Liu, J., Qi, J., & Jia, S. (2017). Development of an index system for evaluation of ecological carrying capacity of marine ecosystems. Ocean & Coastal Management, 144, 23–30. https://doi.org/10.1016/j.ocecoaman.2017.04.012

McMahon, M. (2022). Tides of plastic: Using international environmental law to reduce marine plastic pollution. Hastings Environmental Law Journal, 28, 49.

Mederake, L., & Knoblauch, D. (2019). Shaping EU Plastic Policies: The Role of Public Health vs. Environmental Arguments. International Journal of Environmental Research and Public Health, 16(20), 3928. https://doi.org/10.3390/ijerph16203928

Melidis, M., & Gouglas, A. (2025). Laggard by intent or constraint? Rethinking environmental implementation deficits in Greece through the Capacity–Intentionality Framework. Environmental Policy and Governance, 35(5), 914–927. https://doi.org/10.1002/eet.70011

Official Journal of the European Union. (2019). Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment (Text with EEA relevance). pp. 1-19. Avaliable at: https://eur-lex.europa.eu/eli/dir/2019/904/oj (accessed on 15 October 2025).

Onyeabor, E., & Obuka, U. (2024). Building collaboration and synergy among regional blocs to reduce marine plastic waste pollution: A case for the Gulf of Guinea region. Marine Pollution Bulletin, 198. https://doi.org/10.1016/j.marpolbul.2023.115829

Pattiaratchi, C., Van der Mheen, M., Schlundt, C., Narayanaswamy, B. E., Sura, A., Hajbane, S., ... & Wijeratne, S. (2022). Plastics in the Indian Ocean – sources, transport, distribution, and impacts. Ocean Science, 18(1), 1–28. https://doi.org/10.5194/os-18-1-2022

Peters, A. (2017). The refinement of international law: From fragmentation to regime interaction and politicization. International Journal of Constitutional Law, 15(3), 671–704. https://doi.org/10.1093/icon/mox056

Porzeżyńska, M. (2021). Case C‐24/19 (A and others): How to ensure effet utile of the Strategic Environmental Assessment Directive? Review of European Comparative & International Environmental Law, 31(1), 140–145. https://doi.org/10.1111/reel.12424

Putri, R. W., & Sabatira, F. (2023). The paradox of ASEAN way in marine plastic pollution: the challenge of compliance among member states. Journal of Liberty and International Affairs, 9(3), 248-264.

Pyć, D. (2024). Liability for Pollution Damage to the Marine Environment. In Managing Environmental Risks through Insurance: Legal and Economic Aspects (pp. 389-404). Cham: Springer Nature Switzerland.https://doi.org/10.1007/978-3-031-47602-0_15

Raubenheimer, K., & McIlgorm, A. (2017). Is the Montreal Protocol a model that can help solve the global marine plastic debris problem? Marine Policy, 81, 322–329. https://doi.org/10.1016/j.marpol.2017.04.014

Sarwar, F., Ali, S., Bhatti, S. H., & ur Rehman, S. (2021). Legal Approaches to Reduce Plastic Marine Pollution: Challenges and Global Governance. Annals of Social Sciences and Perspective, 2(1).https://doi.org/10.52700/assap.v2i1.32

Schmaltz, E., Melvin, E. C., Diana, Z., Gunady, E. F., Rittschof, D., Somarelli, J. A., ... & Dunphy-Daly, M. M. (2020). Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. Environment international, 144. https://doi.org/10.1016/j.envint.2020.106067

Seewoo, B. J., Goodes, L. M., Mofflin, L., Mulders, Y. R., Wong, E. V., Toshniwal, P., ... & Dunlop, S. A. (2023). The plastic health map: A systematic evidence map of human health studies on plastic-associated chemicals. Environment International, 181, 108225. https://doi.org/10.1016/j.envint.2023.108225

Shomuyiwa, D. O., Onukansi, F. O., Ivanova, M., & Lucero‐Prisno, D. E. (2023). The Plastic treaty: What is in it for Africa? Public Health Challenges, 2(2), e83. https://doi.org/10.1002/puh2.83

Smith, M., Love, D. C., Rochman, C. M., & Neff, R. A. (2018). Microplastics in seafood and the implications for human health. Current Environmental Health Reports, 5(3), 375–386. https://doi.org/10.1007/s40572-018-0206-z

Tanaka, Y. (2019). The International Law of the Sea (3rd ed.). Cambridge: Cambridge University Press. Avaliable at: https://assets.cambridge.org/97811084/40103/frontmatter/9781108440103_frontmatter.pdf (accessed on 15 October 2025).

Tanaka, Y. (2023). Shared State Responsibility for Land-Based Marine Plastic Pollution. Transnational Environmental Law, 12(2), 244-269. https://doi.org/10.1017/S2047102522000462

Thushari, G. G. N., Senevirathna, J. D. M. (2020). Plastic pollution in the marine environment. In Heliyon. Avaliable at: https://www.cell.com/heliyon/pdf/S2405-8440(20)31552-8.pdf (accessed on 15 October 2025).

Tumu, K., Vorst, K., & Curtzwiler, G. (2023). Global plastic waste recycling and extended producer responsibility laws. Journal of Environmental Management, 348. https://doi.org/10.1016/j.jenvman.2023.119242

UNEP. Environment Assembly. (2022). 5/14. End plastic pollution: towards an international legally binding instrument: resolution/adopted by the United Nations Environment Assembly. Avaliable at: https://digitallibrary.un.org/record/3999257?ln=en&utm_source=chatgpt.com&v=pdf (accessed on 15 October 2025).

United Nations Environment Programme. (2021). From Pollution to Solution: A Global Assessment of Marine litter and Plastic pollution. Avaliable at: https://library.sprep.org/sites/default/files/2021-11/from-pollution-solution.pdf (accessed on 15 October 2025).

United Nations. (2001). Responsibility of states for internationally wrongful acts. In Yearbook of the International Law Commission. Available at: https://legal.un.org/ilc/texts/instruments/english/draft_articles/9_6_2001.pdf (accessed on 15 October 2025).

Wang, G., Huang, D., Ji, J., Völker, C., & Wurm, F. R. (2021). Seawater-Degradable Polymers—Fighting the marine plastic pollution. Advanced Science, 8(1), 2001121. https://doi.org/10.1002/advs.202001121

Wang, S. (2023). International law-making process of combating plastic pollution: Status Quo, debates and prospects. Marine Policy, 147, 105376. https://doi.org/10.1016/j.marpol.2022.105376

Worm, B., Lotze, H. K., Jubinville, I., Wilcox, C., & Jambeck, J. (2017). Plastic as a persistent marine pollutant. Annual Review of Environment and Resources, 42(1), 1–26. https://doi.org/10.1146/annurev-environ-102016-060700

Wu, H. H. (2022). A study on transnational regulatory governance for marine plastic debris: Trends, challenges, and prospect. Marine Policy, 136.https://doi.org/10.1016/j.marpol.2020.103988

Young, O. R. (2011). Effectiveness of international environmental regimes: Existing knowledge, cutting-edge themes, and research strategies. Proceedings of the National Academy of Sciences, 108(50), 19853–19860. https://doi.org/10.1073/pnas.1111690108

Yu, R., Yang, Y., & Singh, S. (2023). Global analysis of marine plastics and implications of control measure strategies. Frontiers in Marine Science, 10. https://doi.org/10.3389/fmars.2023.1305091

Zhou, J., & Luo, D. (2024). The global governance of marine plastic pollution: rethinking the extended producer responsibility system. Frontiers in Marine Science, 11. https://doi.org/10.3389/fmars.2024.1363269