

Shams Al Din AL HAJJAJI

*Where Oceans Converge:
Governing the Suez Canal in the Age of Sustainability*

DOI: [https://doi.org/10.34625/issn.2183-2705\(40.1\)2026.ic-7](https://doi.org/10.34625/issn.2183-2705(40.1)2026.ic-7)

Secção

Investigação Científica / Scientific Research*

* Os artigos presentes nesta secção foram sujeitos a processo de revisão segundo o método *blind peer review* / The articles in this section have undergone a blind peer review process.

Where Oceans Converge: Governing the Suez Canal in the Age of Sustainability

Onde os Oceanos Convergem: A Governação do Canal do Suez na Era da Sustentabilidade

Shams Al Din AL HAJJAJI*

ABSTRACT: This article argues that the governance of the Suez Canal is undergoing a structural transformation from classical navigational neutrality toward a model of “sustainable neutrality,” in which open maritime transit is preserved while environmental compliance becomes an integral condition of canal access. This evolution reflects broader changes in global maritime law driven by climate regulation, decarbonization policies, and emerging carbon-market pressures affecting international shipping. The topic is significant because strategic maritime chokepoints increasingly function not only as commercial corridors but also as regulatory nodes capable of shaping global sustainability practices. The study examines how the Suez Canal Authority operationalizes this transition through administrative regulation, statutory incentives, and infrastructure investments aligned with international environmental commitments, including the IMO greenhouse-gas reduction strategy and regional carbon-pricing regimes. Using a comparative doctrinal, empirical and institutional legal analysis supported by recent operational and policy data (2024–2026), the paper evaluates how canal governance interacts with international maritime law, administrative law mechanisms, and evolving economic pressures within global shipping.

KEYWORDS: Suez Canal, Canal Governance, Sustainable Neutrality, Maritime Decarbonization, UNCLOS, EU-ETS

RESUMO: Este artigo defende que a governação do Canal do Suez está a sofrer uma transformação estrutural, evoluindo da neutralidade navegacional clássica para um modelo de "neutralidade sustentável", no qual o livre trânsito marítimo é preservado, ao mesmo tempo que a conformidade ambiental se torna uma condição integrante do acesso ao canal. Esta evolução reflete mudanças mais amplas no direito marítimo global, impulsionadas pela regulação climática, pelas políticas de descarbonização e pelas crescentes pressões do mercado de carbono que afetam o transporte marítimo internacional. O tema reveste-se de importância porque os pontos de estrangulamento marítimos estratégicos funcionam cada vez mais não apenas como corredores comerciais, mas também como nós reguladores capazes de moldar as práticas de sustentabilidade a nível global. O estudo examina como a Autoridade do Canal do Suez operacionaliza esta transição através da regulação administrativa, de incentivos legais e de investimentos em infraestruturas alinhados com os compromissos ambientais internacionais, incluindo a estratégia de redução de gases com efeito de estufa da OMI e os regimes regionais de fixação de preços do carbono. Recorrendo a uma análise jurídica doutrinal, empírica e institucional comparada, apoiada em dados operacionais e de políticas recentes (2024-2026), o artigo avalia como a governação do canal interage com o direito marítimo internacional, com os mecanismos de direito administrativo e com as crescentes pressões económicas no transporte marítimo global.

PALAVRAS-CHAVE: Canal do Suez, Governação do Canal, Neutralidade Sustentável, Descarbonização Marítima, CNUDM (UNCLOS), CELE (EU-ETS).

* Assistant Professor, Public Law Department, College of Law, and Humanities and Social Sciences Research Centre (HSSRC), Ajman University, Ajman, United Arab Emirates. ORCID: 0000-0003-4363-9499. Email: s.alhajjaji@ajman.ac.ae; salhajjaji@berkeley.edu

1. Introduction

The accelerated reduction of Arctic sea-ice extent and thickness is reconfiguring global shipping geometry by introducing viable "route optionality" through northern passages.¹ This structural shift directly impacts the Suez Canal, a critical maritime hinge handling approximately 12%–15% of global trade, creating a dual pressure of economic competition and environmental accountability.² As Arctic shipping activity transitions from hypothetical projections to a measurable governance reality, it necessitates a critical re-evaluation of how strategic international waterways adapt.³ Sustainability, in this context, must transcend mere ecological protection, evolving into a structural principle that informs the administrative and regulatory frameworks of canal governance in an era of climate-induced navigational shifts.⁴

The urgency of this governance shift is underscored by the dramatic volatility in transit metrics observed between 2023 and 2025. By May 2025, tonnage through the Suez Canal remained approximately 70% below 2023 levels due to geopolitical diversions, resulting in estimated monthly revenue losses for the Egyptian government of nearly \$800 million.⁵ Concurrently, the environmental cost of route substitution has become a measurable burden. Rerouting vessels around the Cape of Good Hope increases voyage distances and ton-miles, leading to a spike in global maritime CO2 emissions.⁶ In response, the Suez Canal Authority (SCA) has pivoted toward a "Green Canal 2030" strategy, which includes a \$133 billion investment framework for green hydrogen and renewable energy clusters within the Suez Canal Economic Zone

¹ CONSTABLE, A. J.; HARPER, S.; DAWSON, J.; HOLSMAN, K.; MUSTONEN, T.; PIEPENBURG, D.; ROST, B. Cross-Chapter Paper 6: Polar Regions. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Cambridge: Cambridge University Press, 2022, pp. 2319-2368. <https://doi.org/10.1017/9781009325844.023>

² United Nations Conference on Trade and Development (UNCTAD). Red Sea, Black Sea and Panama Canal: UNCTAD raises alarm on global trade disruptions. Geneva: UNCTAD, 26 January 2024. <https://unctad.org/news/red-sea-black-sea-and-panama-canal-unctad-raises-alarm-global-trade-disruptions>

³ ARCTIC COUNCIL. Arctic Shipping Update: 40% Increase in Ships in the Arctic. Tromsø: Arctic Council Secretariat, 12 February 2026. <https://arctic-council.org/news/increase-in-arctic-shipping/>

⁴ BORGERSON, Scott G. The Arctic Meltdown: The Economic and Security Implications of Global Warming. *Foreign Affairs*. 2008, vol. 87, no. 2, pp. 63-77. <https://library.arcticportal.org/1570/1/BorgersonForeignAffairsarticle.pdf>.

⁵ UNCTAD. Maritime trade under pressure – growth set to stall in 2025. Geneva: UNCTAD, 24 September 2025. <https://unctad.org/news/maritime-trade-under-pressure-growth-set-stall-2025>

⁶ REUTERS. Egypt's Suez Canal monthly revenue losses around \$800 million, Sisi says. Cairo: Reuters, 17 March 2025. <https://www.reuters.com/world/africa/egypt-suez-canal-monthly-revenue-losses-around-800-million-sisi-says-2025-03-17/>.

(SCZONE).⁷ These figures demonstrate that the canal's sustainability is no longer an abstract policy goal but a financial and environmental imperative, as the waterway competes with Arctic routes that offer up to a 24% reduction in shipping emissions through more direct, albeit ecologically sensitive, northern passages.⁸

These developments raise a fundamental governance question that transcends immediate economic fluctuations: whether strategic waterways, specifically the Suez Canal, should continue to be regulated primarily as neutral transit infrastructures or increasingly as sustainability-sensitive institutions embedded within the architecture of global environmental governance. While international law, principally through the UNCLOS, establishes baseline obligations concerning freedom of navigation and marine environmental protection,⁹ the day-to-day administration of canal operations remains largely anchored in domestic regulatory frameworks. This creates a potential risk of normative fragmentation between international sustainability commitments, such as the IMO's GHG reduction strategies,¹⁰ and their administrative implementation at the state level. Consequently, this article examines the extent to which the governance of the Suez Canal and its SCZONE can evolve toward a structural sustainability principle without undermining its vital economic and geopolitical functions. It argues that an integrated approach, one that bridges international environmental obligations with adaptive administrative regulation, is essential to maintaining both the canal's competitiveness and its legitimacy within an increasingly climate-sensitive maritime order.¹¹

The governance of international canals has traditionally been examined within the framework of navigational neutrality and the strategic balancing of sovereign control against international access. Foundational scholarship, led by authorities such as O'CONNELL and JESSUP, has focused on the legal status of artificial waterways,

⁷ ELSONBATY, Ehab; SARHAN, Alan; SELIM, Ahmed. Logistics, green hydrogen, and manufacturing: Investment considerations in the Suez Canal Economic Zone. DLA Piper, 4 February 2026. <https://www.dlapiper.com/en-lu/insights/publications/2026/02/investment-considerations-in-suez-canal-economic-zone>

⁸ EGU BLOGS. Navigating the polar frontier: exploring the effects of sea-ice decline on shipping and sea routes in the Arctic. 7 March 2025. <https://blogs.egu.eu/divisions/cr/2025/03/07/navigating-the-polar-frontier-effects-of-sea-ice-decline-on-shipping-and-sea-routes/>

⁹ UNITED NATIONS. United Nations Convention on the Law of the Sea (UNCLOS). Montego Bay: United Nations, 1982.

¹⁰ INTERNATIONAL MARITIME ORGANIZATION (IMO). Initial IMO Strategy on Reduction of GHG Emissions from Ships. London: IMO, 2018. <https://www.imo.org/en/ourwork/environment/pages/vision-and-level-of-ambition-of-the-initial-imo-strategy.aspx>

¹¹ VOIGT, Christina. Sustainable Development as a Principle of International Law: Resolving Conflicts between Climate Measures and WTO Law. Leiden: Martinus Nijhoff Publishers, 2009.

emphasizing treaty regimes, such as the 1888 Convention of Constantinople, and the principle of non-discrimination in transit.¹² More recent analysis has extended this by examining the Suez Canal as a global economic crossroads, yet the literature largely continues to treat canals as static infrastructural corridors rather than dynamic regulatory institutions subject to evolving environmental obligations.¹³

Parallel to this, an expanding corpus of climate and Arctic scholarship has analyzed the implications of sea-ice decline for global shipping geometry. Research by the IPCC and a growing body of Arctic-shipping scholarship highlights the potential efficiency gains of northern passages while warning of ecological vulnerability and regulatory uncertainty in polar regions.¹⁴ While this literature is robust, it often operates in a silo, rarely considering the institutional adaptation requirements of established maritime chokepoints such as the Suez Canal in response to Arctic competition. Furthermore, maritime economists such as STOPFORD have detailed the cyclical nature of shipping and the cost-benefit pressures of route selection, but often without

¹² CONVENTION OF CONSTANTINOPLE (SUEZ CANAL), 29 October 1888, 79 British and Foreign State Papers 18.; O'CONNELL, Daniel Patrick. *The International Law of the Sea*. Vol. II. Oxford: Clarendon Press, 1984; JESSUP, Philip C. *The Law of Territorial Waters and Maritime Jurisdiction*. New York: G.A. Jennings Co., 1927.

¹³ WAN, Zheng; SU, Yingyu; LI, Zimu; ZHANG, Xin; ZHANG, Qiang; CHEN, Jihong. Analysis of the impact of Suez Canal blockage on the global shipping network. *Ocean & Coastal Management*. 2023, vol. 245, 106868. <https://doi.org/10.1016/j.ocecoaman.2023.106868>; EUROPEAN INSTITUTE OF THE MEDITERRANEAN (IEMed). *The Economic Impacts of the New Suez Canal*. <https://www.iemed.org/publication/the-economic-impacts-of-the-new-suez-canal/>; TUREKULOVA, Zhuldyz; BAITUREYEVA, Klara. The Suez Canal and Its Role in Formation of New International Political and Economic Relations in the XX Century. *Oriente Moderno*. 2020, vol. 100, no. 1, pp. 93–105. <https://www.jstor.org/stable/48593095>; ZUMBRÄGEL, Tobias; KEGEL, Anna. Green tides: the Suez Canal as key hub and green corridor for a hydrogen future between the Middle East and Europe. *Frontiers in Energy Research*. 2025, vol. 13, 1538792. <https://doi.org/10.3389/fenrg.2025.1538792>

¹⁴ IPCC. *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Geneva: IPCC, 2022. <https://www.ipcc.ch/report/ar6/wg2/>; MAHMOUD, Mohamed Rami; ROUSHDI, Mahmoud; ABOELKHEAR, Mostafa. Potential benefits of climate change on navigation in the northern sea route by 2050. *Scientific Reports*. 2024, vol. 14, 2771. <https://doi.org/10.1038/s41598-024-53308-5>; BUIXADÉ FARRÉ, Albert; STEPHENSON, Scott R.; CHEN, Linling; et al. Commercial Arctic shipping through the Northeast Passage: routes, resources, governance, technology, and infrastructure. *Polar Geography*. 2014, vol. 37, no. 4, pp. 298–324. <https://doi.org/10.1080/1088937X.2014.965769>; ZHAO, Pengjun; LI, Yunlin; ZHANG, Caixia; et al. Arctic Sea Route access reshapes global shipping carbon emissions. *Nature Communications*. 2025, vol. 16, 8431. <https://doi.org/10.1038/s41467-025-64437-4>; CHEN, Chujun; YUAN, Xiang; YE, Zhiyi; LIU, Yu-an; ZHOU, Yutian. Testing Arctic exceptionalism under global tensions: climate change, geopolitics, and the strategic value of the Northern Sea Route. *Humanities and Social Sciences Communications*. 2026, vol. 13, 823. <https://doi.org/10.1057/s41599-026-07384-9>; HANAČEK, Ksenija; APOSTOLOPOULOU, Elia; KRÖGER, Markus; et al. Climate change, extractivist infrastructure and environmental conflicts at the Northern Sea-Polar Silk Road intersection. *Energy Research & Social Science*. 2026, vol. 133, 104600. <https://doi.org/10.1016/j.erss.2026.104600>; ASLESEN, Henrik; FAGERENG, Amund; SAEED, Naima. The risks and opportunities of sailing the Northern Sea Route: a Norwegian stakeholder perspective. *WMU Journal of Maritime Affairs*. 2026. <https://doi.org/10.1007/s13437-026-00402-2>.

integrating the administrative law requirements of the canal authorities themselves.¹⁵

Finally, a third strand of literature examines sustainability as a structural principle within international legal orders. As VOIGT and SANDS argue, sustainable development has evolved from a peripheral policy objective into a normative driver shaping constitutional interpretation and administrative discretion.¹⁶ Despite this evolution, and the emergence of "Green Shipping" discourse in the work of CHIRCOP, a significant gap remains: limited attention has been devoted to how these principles transform the administrative governance of international canals operating at the intersection of global trade and environmental responsibility.¹⁷

This study employs a doctrinal and analytical methodology centred on the normative interpretation of international maritime law (IML), environmental legal instruments, and the domestic regulatory frameworks governing canal administration. The research synthesizes primary legal sources, principally the UNCLOS, with the evolving body of "soft law" and sustainability standards emerging from the IMO.¹⁸ This doctrinal foundation is complemented by a policy-oriented evaluation of institutional effectiveness that incorporates empirical data on global trade flows and maritime emissions. By situating legal analysis within these measurable economic and environmental realities, the article adopts an interdisciplinary perspective to assess the feasibility of adaptive governance. This mixed-method approach allows the proposed regulatory developments to be evaluated not only for their legal coherence but also for their institutional credibility within an increasingly climate-sensitive global maritime order.

The scope of this analysis is focused on the Suez Canal as a paradigmatic case of a strategic artificial waterway operating at the intersection of international navigation and domestic administrative authority.¹⁹ While comparative references to Arctic routes

¹⁵ STOPFORD, Martin. *Maritime Economics*. 3rd ed. London: Routledge, 2009.

¹⁶ SANDS, Philippe and PEEL, Jacqueline. *Principles of International Environmental Law*. 4th ed. Cambridge: Cambridge University Press, 2018. VOIGT, Christina. *Sustainable Development as a Principle of International Law*. Leiden: Martinus Nijhoff, 2009; ANDRIOLI JR., Renato. *Direito Internacional do Ambiente: a Responsabilidade no Antropoceno*. *Revista Jurídica Portucalense*. 2020, no. 28, pp. 106-123. [https://doi.org/10.34625/issn.2183-2705\(28\)2020.ic-05](https://doi.org/10.34625/issn.2183-2705(28)2020.ic-05)

¹⁷ CHIRCOP, Aldo. *The IMO's Work on Environmental Protection and Global Ocean Governance*. In: ATTARD, David Joseph; FITZMAURICE, Malgosia; MARTINEZ, Norman; HAMZA, Riyaz (eds.). *The IMLI Manual on International Maritime Law*. Vol. III: *Marine Environmental Law and Maritime Security Law*. Oxford: Oxford University Press, 2016.

¹⁸ UNCLOS (see note 9), and IMO (See note 10)

¹⁹ JESSUP, Philip C. *The Law of Territorial Waters and Maritime Jurisdiction*. New York: G.A. Jennings Co., 1927.

are introduced to contextualize competitive pressures in global shipping, the article does not undertake a full comparative study of alternative canals. Instead, it examines how the Suez Canal's governance model may evolve in response to sustainability imperatives within a changing geopolitical and climatic landscape. The significance of this inquiry lies in its contribution to understanding whether sustainability can function not merely as a policy objective but as a structural principle shaping the administration of global maritime chokepoints.²⁰

2. Sustainability Governance of the Suez Canal in a Transforming Maritime Order

2.1. The Changing Maritime Context: Suez Canal in a Transforming Global Navigation System

Historically, the Suez Canal's strategic primacy rested upon its role as the principal corridor linking Europe, Asia, and Africa, offering distance savings that reduce voyages by thousands of nautical miles and 10 to 15 days compared to the Cape of Good Hope.²¹ Consequently, the canal serves as a critical node, handling 12–15% of global trade and a significant share of energy and containerized flows.²² Under this traditional paradigm, the SCA operated primarily as a facilitator of high-volume transit within a stable geopolitical framework, with governance defined by "throughput efficiency."²³

This model is currently being eroded by a convergence of geopolitical volatility and climate-induced navigational shifts. By mid-2024, Suez tonnage plummeted by approximately 70% due to security disruptions, triggering a record 6% surge in global ton-mile demand as vessels diverted around Africa.²⁴ This rerouting materially amplifies fuel consumption and CO₂ emissions, reinforcing the environmental cost of route substitution.²⁵ Simultaneously, accelerated Arctic sea-ice decline has

²⁰ OXMAN, Bernard H. *The Territorial Temptation: A Siren Song at Sea*. *American Journal of International Law*. 2006, vol. 100, no. 4, pp. 830-851.

²¹ UNCTAD. *Review of Maritime Transport 2024*. Geneva: UNCTAD, 2024, <https://unctad.org/publication/review-maritime-transport-2024>

²² UNCTAD. *Navigating troubled waters: Impact to global trade of disruption of shipping routes*. UNCTAD/OSG/INF/2024/2, 2024. <https://unctad.org/publication/navigating-troubled-waters-impact-global-trade-disruption-shipping-routes-red-sea-black>

²³ On throughput as the defining metric of canal performance, see STOPFORD (note 15). See also UNCTAD. *Review of Maritime Transport 2024*. Geneva: UNCTAD, 2024.

²⁴ UNCTAD. *Maritime trade under pressure – growth set to stall in 2025*. Geneva: UNCTAD, 24 September 2025. <https://unctad.org/news/maritime-trade-under-pressure-growth-set-stall-2025>

²⁵ REUTERS. *Red Sea shipping diversions boost container sector emissions*. 17 January 2024. <https://www.reuters.com/markets/commodities/red-sea-shipping-diversions-boost-container-sector->

transitioned the Northern Sea Route (NSR) from a theoretical alternative to a commercial reality. Capable of reducing transit times between Northern Europe and East Asia by up to 15 days,²⁶ the NSR creates an "Arctic-Suez nexus" where climatic change directly alters the canal's competitive environment.²⁷ Recent operationalization of China-Europe Arctic legs underscores that "route optionality" is no longer hypothetical, despite persistent infrastructural constraints.²⁸

These constraints are more than logistical. The China-Europe Arctic service marketed as the Arctic Express completes the voyage in roughly eighteen to twenty days, a saving that has drawn commercial attention. The route also carries a structural disadvantage that the Suez Canal does not. The entire Northern Sea Route lies within the Russian exclusive economic zone, and several of its straits are treated by Russia as internal waters. Foreign commercial vessels must therefore obtain prior permission from the Russian Northern Sea Route Administration, accept compulsory icebreaker and pilotage support, and pay the associated fees. Russia grounds this regime in Article 234 of UNCLOS, which permits coastal states to regulate navigation in ice-covered areas. Permission may be refused, and the cost of escort is high. The Suez Canal faces no comparable gatekeeper, since transit is guaranteed to all vessels under the 1888 Convention of Constantinople. The competitiveness of the northern route is thus conditioned by a sovereign control point that the canal, by treaty design, does not impose.²⁹

These developments generate a "competitiveness-sustainability paradox": the canal's institutional stability is no longer secured by geography alone, but is increasingly evaluated through the lens of environmental accountability. Regulatory

emissions-2024-01-17/; INTERNATIONAL MARITIME ORGANIZATION (IMO). Fourth IMO GHG Study 2020. London: IMO, 2020. <https://www.imo.org/en/ourwork/environment/pages/fourth-imo-greenhouse-gas-study-2020.aspx>

²⁶ IPCC. (see note 14).

²⁷ BEKKERS, E.; FRANCOIS, J. F.; ROJAS-ROMAGOSA, H. Melting Ice Caps and the Economic Impact of Opening the Northern Sea Route. *The Economic Journal*. 2018, vol. 128, no. 610, pp. 1095–1127.

²⁸ REUTERS. Chinese freighter halves EU delivery time on maiden Arctic voyage. 14 October 2025, <https://www.reuters.com/sustainability/climate-energy/chinese-freighter-halves-eu-delivery-time-maiden-arctic-voyage-uk-2025-10-14/>

²⁹ On the Article 234 basis and the permission, pilotage and fee requirements of the Northern Sea Route Administration, see RUSSIAN FEDERATION. Rules of Navigation in the Water Area of the Northern Sea Route, 2020. See also OXFORD INSTITUTE FOR ENERGY STUDIES. The Northern Sea Route. Energy Insight 105. Oxford: OIES, 2021. <https://www.oxfordenergy.org/publications/the-northern-sea-route-a-state-priority-in-russias-strategy-of-delivering-arctic-hydrocarbons-to-global-markets/>; On the China-Europe transit timing see note 14. On the free-passage regime of the Suez Canal, see the Convention of Constantinople (note 12).

legitimacy now depends on the canal's ability to align transit management with global decarbonization trajectories, specifically the IMO's 2023 Strategy targeting net-zero emissions by or around 2050.³⁰ The governance challenge thus transcends mere volume preservation. It requires a transition from a passive transit regime to a sustainability-sensitive institution capable of mitigating the environmental externalities of maritime reconfiguration while maintaining legal predictability and economic viability.³¹

2.2. Sustainability Dimensions of Canal Governance

The sustainability of the Suez Canal has evolved into a triadic framework of environmental integrity, economic resilience, and institutional legitimacy, repositioning the waterway from a transit corridor to a "regulatory ecosystem."³²As maritime transport accounts for approximately 3% of global GHG emissions, the canal serves as a high-density "emissions corridor" where the SCA now acts as an environmental governance actor.³³ Through its "Green Canal 2030" strategy, the SCA operationalizes international decarbonization targets, specifically the IMO's 2023 Strategy, via administrative incentives, such as fee reductions for vessels utilizing LNG, methanol, or ammonia.³⁴ This illustrates a pivotal shift where domestic administrative discretion serves as the implementation bridge for international climate commitments.³⁵

Economically, sustainability is pursued through the diversification of the SCZONE, which has secured over \$100 billion in framework agreements for green

³⁰ INTERNATIONAL MARITIME ORGANIZATION. 2023 IMO Strategy on Reduction of GHG Emissions from Ships. London: IMO, 2023.

³¹ VOIGT, (See note 11).

³² UNCTAD. (See note 23) and SANDS and PEEL (See note 16).

³³ IMO. Fourth IMO Greenhouse Gas Study 2020. London: IMO, 2020. <https://www.imo.org/en/ourwork/environment/pages/fourth-imo-greenhouse-gas-study-2020.aspx>; SUEZ CANAL AUTHORITY. The Green Canal Strategy. Ismailia: SCA, 2024. <https://www.suezcanal.gov.eg/English/About/SuezCanal/Pages/greencanal.aspx>

³⁴ IMO (see note 30).; INTERNATIONAL ENERGY AGENCY (IEA). Agreements to develop green hydrogen projects in the Suez Canal Economic Zone. Updated 5 September 2025. <https://www.iea.org/policies/27694-agreements-to-develop-green-hydrogen-projects-in-the-suez-canal-economic-zone>

³⁵ VOIGT, C. Sustainable Development as a Principle of International Law. Leiden: Martinus Nijhoff, 2009. See also: MOREIRA, Fátima Castro; MATOS, André Pereira. A governança multinível na proteção do direito fundamental ao ambiente da União Europeia: o Pacto Ecológico Europeu e o projeto Cities Mission. *Revista Jurídica Portucalense*. 2022, no. 32, pp. 364-400. [https://doi.org/10.34625/issn.2183-2705\(32\)2022.jm-01](https://doi.org/10.34625/issn.2183-2705(32)2022.jm-01); MOREIRA, Fátima Castro. O papel da União Europeia na gestão sustentável dos oceanos. In: TEIJO GARCÍA, Carlos; JORGE URBINA, Julio (coords.). *Sostenibilidad ambiental y aprovechamiento de los recursos marinos*. Cizur Menor: Aranzadi La Ley, 2026, pp. 195-222.

hydrogen and renewable-energy clusters.³⁶ This structural transition from a rent-based toll economy to an integrated industrial hub is codified in Egyptian Law No. 2 of 2024, which provides tax exemptions and long-term usufruct rights to align national policy with global climate governance.³⁷ By functioning as a strategic bunkering hub for low-emission fleets, the canal seeks to decouple institutional stability from volatile transit revenues.³⁸

This transition faces significant localized pressures, necessitating sophisticated oversight of marine pollution and ballast-water risks.³⁹ In 2025, the SCA formalized integrated waste-management services via administrative circulars, operationalizing sustainability norms at the domestic level.⁴⁰ Yet, this regulatory evolution risks "normative fragmentation," as domestic measures must remain compatible with UNCLOS provisions on navigational freedom and non-discrimination.⁴¹ The resulting tension between localized administrative implementation and international maritime obligations remains a central analytical concern of this study.⁴²

2.3. Structural Challenges to Sustainable Canal Governance

The transition toward a sustainability-oriented governance model for the Suez Canal encounters structural frictions embedded in the architecture of IML and global trade economics.

The first challenge concerns normative fragmentation between the classical law of transit and emerging environmental regulatory obligations. The UNCLOS prioritizes freedom of navigation and prohibits discriminatory practices that hamper transit,

³⁶ ELSONBATY, Ehab; SARHAN, Alan; SELIM, Ahmed. Logistics, green hydrogen, and manufacturing: Investment considerations in the Suez Canal Economic Zone. DLA Piper, 4 February 2026. <https://www.dlapiper.com/en-lu/insights/publications/2026/02/investment-considerations-in-suez-canal-economic-zone>

³⁷ ARAB REPUBLIC OF EGYPT. Law No. 2 of 2024 (Green Hydrogen Incentives). Official Gazette, issue No. 4, 27 January 2024. Unofficial English summary available at <https://ccfranco-arabe.fr/wp-content/uploads/2024/02/Law-no2-2024-English-summary.pdf>

³⁸ STOPFORD, (see note 15).

³⁹ SOTO-LÓPEZ, Verónica; MENENDEZ-TELEÑA, Deva; GARCIA-VAZQUEZ, Eva; BARTOLOMÉ, Marlene. Risk analysis of invasive species by ballast water: case study in the Port of Gijón, Bay of Biscay. *Journal of Marine Systems*. 2025, vol. 252, 104148. <https://doi.org/10.1016/j.jmarsys.2025.104148>; REGIONAL MARINE POLLUTION EMERGENCY RESPONSE CENTRE FOR THE MEDITERRANEAN SEA (REMPEC). Study on Trends and Outlook of Marine Pollution from Ships and Activities and of Maritime Traffic and Offshore Activities in the Mediterranean. Floriana: REMPEC, 2021. <https://www.rempec.org/en/knowledge-centre/online-catalogue/studyontrends2022.pdf>

⁴⁰ SUEZ CANAL AUTHORITY. Circular No. 2/2025 (Waste Management). Ismailia: SCA, 2025

⁴¹ UNCLOS (see note 9); JESSUP, P. C. *The Law of Territorial Waters*. New York: G.A. Jennings, 1927.

⁴² KOSKENNIEMI, M. *The Fragmentation of International Law*. Helsinki: Erik Castrén, 2006.

particularly in straits used for international navigation.⁴³ Articles 24, 26, and 42 underscore that coastal states may not impose charges or regulations that effectively impair innocent passage beyond narrowly defined parameters.⁴⁴ At the same time, Part XII of UNCLOS imposes duties upon states to protect and preserve the marine environment.⁴⁵ This dual structure generates interpretative tension when canal authorities introduce green incentives, differentiated toll structures, or mandatory environmental service fees. Measures such as SCA Circular No. 2/2025 on integrated waste management, while environmentally justified, may invite scrutiny if perceived as altering cost structures in a manner affecting equal transit conditions.⁴⁶ The broader theoretical debate on fragmentation of international law highlights precisely such tensions between specialized environmental regimes and general navigation principles.⁴⁷ This fragmentation extends to the question of jurisdiction itself, since the allocation of competence among UNCLOS dispute-settlement bodies determines which forum may reconcile competing environmental and navigational claims.⁴⁸ Within maritime governance scholarship, Tanaka and Sands & Peel have observed that environmental protection norms increasingly penetrate traditional law-of-the-sea doctrines, yet without eliminating interpretative ambiguity.⁴⁹ The Suez Canal thus becomes a site where harmonization is legally required but doctrinally underdeveloped.

The second structural friction arises from the competitiveness–decarbonization tension amplified by “route optionality.” UNCTAD reports that disruptions in the Red Sea corridor during 2024 reduced Suez Canal transits by approximately 70%, while ton-mile demand for global container shipping rose by a record 6% due to longer

⁴³ UNCLOS (see note 9).

⁴⁴ *Ibid.*, Arts. 24–26, 42.

⁴⁵ *Ibid.*, Part XII. See also: ZANELLA, Tiago Vinicius. The United Nations Convention on the Law of the Sea and the marine environment: a contribution to the analysis of the regulation of the protection and preservation of the marine environment in UNCLOS. *Revista Jurídica Portucalense*. 2024, no. 35, pp. 68-90. [https://doi.org/10.34625/issn.2183-2705\(35\)2024.ic-04](https://doi.org/10.34625/issn.2183-2705(35)2024.ic-04)

⁴⁶ SCA (see note 40).

⁴⁷ INTERNATIONAL LAW COMMISSION. Fragmentation of International Law: Difficulties Arising from the Diversification and Expansion of International Law. UN Doc A/CN.4/L.682, 2006.

⁴⁸ DA SILVA, Daniela Martins Pereira. Analysis of jurisdiction under the United Nations Convention on the Law of the Sea: an expansionist vocation? *Revista Jurídica Portucalense*. 2018, no. 23, pp. 49-100. <https://revistas.rcaap.pt/juridica/article/view/12248>

⁴⁹ TANAKA, Yoshifumi. *The International Law of the Sea*. 3rd ed. Cambridge: Cambridge University Press, 2019. SANDS, Philippe; PEEL, Jacqueline. *Principles of International Environmental Law*. 4th ed. Cambridge: Cambridge University Press, 2018.

rerouting patterns.⁵⁰ This shift demonstrates the elasticity of maritime route selection under geopolitical and cost pressures. Concurrently, economic modelling of the NSR indicates that Arctic passages may reduce Europe–Asia transit times by up to 10–15 days under favourable seasonal conditions.⁵¹ Although Arctic shipping remains constrained by infrastructural, insurance, and ecological risks, its growing operationalization introduces competitive pressure on traditional chokepoints.⁵² Maritime economics literature confirms that shipping markets are highly responsive to marginal cost variations, including fuel price fluctuations and port charges.⁵³ Consequently, the introduction of environmental compliance measures that increase immediate transit costs, absent coordinated global standards, could accelerate diversion toward alternative routes. Paradoxically, such diversion may increase aggregate global emissions due to longer sailing distances, thereby undermining the very decarbonization objectives sustainability policies seek to achieve.⁵⁴ This dynamic underscores the need for regulatory calibration that aligns environmental ambition with competitive realism.

A third structural constraint concerns institutional capacity and the durability of administrative instruments. The current sustainability measures adopted by the SCA largely rely on administrative circulars, tariff incentives, and executive directives rather than a consolidated statutory sustainability framework. While such instruments allow regulatory flexibility, governance theory emphasizes that soft and fragmented instruments may lack the legal certainty required to anchor long-term capital investments, particularly in emerging hydrogen and ammonia clusters within the SCZONE.⁵⁵ SCZONE reports indicate framework agreements exceeding \$100 billion

⁵⁰ UNCTAD. Review of Maritime Transport 2024. Geneva: UNCTAD, 2024. <https://unctad.org/publication/review-maritime-transport-2024>

⁵¹ BEKKERS, Eddy; FRANCOIS, Joseph F.; ROJAS-ROMAGOSA, Hugo. Melting Ice Caps and the Economic Impact of Opening the Northern Sea Route. *The Economic Journal*. 2018, vol. 128, no. 610, pp. 1095–1127

⁵² See note 28.

⁵³ STOPFORD, (see note 15).

⁵⁴ INTERNATIONAL MARITIME ORGANIZATION. Fourth IMO GHG Study 2020. London: IMO, 2020. <https://www.imo.org/en/ourwork/environment/pages/fourth-imo-greenhouse-gas-study-2020.aspx>

⁵⁵ OECD/THE WORLD BANK. Leveraging De-Risking Instruments and International Co-ordination to Catalyse Investment in Clean Hydrogen. Green Finance and Investment. Paris: OECD Publishing, 2024. <https://doi.org/10.1787/9a377303-en>; ELSONBATY, Ehab; SARHAN, Alan; SELIM, Ahmed. Logistics, green hydrogen, and manufacturing: Investment considerations in the Suez Canal Economic Zone. DLA Piper, 4 February 2026, <https://www.dlapiper.com/en-lu/insights/publications/2026/02/investment-considerations-in-suez-canal-economic-zone>

in projected green hydrogen investments,⁵⁶ yet the stability of such commitments depends upon predictable regulatory architecture and coherent alignment with international maritime decarbonization pathways, including the IMO's 2023 Revised GHG Strategy targeting net-zero emissions by or around 2050.⁵⁷

Furthermore, reliance on toll-based revenue remains economically vulnerable in a market characterized by cyclical freight rates and energy transition volatility.⁵⁸ Shifts in global energy geopolitics compound this exposure, as the reordering of energy flows and resource competition reshapes the trade patterns on which canal revenue depends.⁵⁹ Stopford's analysis of maritime economics demonstrates that shipping cycles can significantly alter canal revenue flows within short periods, exposing infrastructure authorities to fiscal instability.⁶⁰ In this context, administrative capacity is not merely a managerial concern but a structural determinant of sustainability legitimacy: without durable regulatory codification and revenue diversification, canal governance risks oscillating between reactive compliance and strategic uncertainty.

Collectively, these three structural frictions, normative fragmentation, competitiveness-decarbonization tension, and institutional capacity constraints, define the analytical terrain upon which the canal's sustainability transition must be constructed. The following section therefore advances an integrated governance model designed to reconcile transit law with environmental obligations, align competitiveness with decarbonization, and consolidate administrative instruments into sustainability regulatory architecture.

3. Harmonizing Maritime Law and Administrative Governance: Toward an Integrated Sustainability Framework

3.1. From Navigational Neutrality to Sustainable Neutrality

The reinterpretation of navigational neutrality governing international waterways increasingly reflects measurable changes in maritime governance following the IMO's

⁵⁶ DAILY NEWS EGYPT. Suez Canal Economic Zone secures \$64bn in green hydrogen investments. 23 December 2024. <https://www.dailynewsegyp.com/2024/12/23/suez-canal-economic-zone-secures-64bn-in-green-hydrogen-investments/>

⁵⁷ IMO (see note 30).

⁵⁸ UNCTAD. Global Trade Update (December 2025). Geneva: UNCTAD, 2025. <https://unctad.org/publication/global-trade-update-december-2025-global-trade-poised-record-breaking-2025-flows>

⁵⁹ GOUCHA SOARES, António. Energy and Geopolitics: Global Power and the Struggle for Energy Resources. *Revista Jurídica Portucalense*. 2026, vol. 1, no. 39, pp. 1-26. [https://doi.org/10.34625/issn.2183-2705\(39.1\)2026.ic-1](https://doi.org/10.34625/issn.2183-2705(39.1)2026.ic-1)

⁶⁰ STOPFORD, (see note 15).

2023 Revised Strategy on the Reduction of GHG Emissions from Ships. Traditionally, neutrality implied the non-discriminatory facilitation of transit, rooted in classical canal regimes and reinforced by Articles 24 and 26 of the UNCLOS, which prohibit discriminatory restrictions and unauthorized transit charges.⁶¹ However, UNCLOS simultaneously imposes environmental obligations under Part XII, requiring states to protect and preserve the marine environment.⁶² Through the principle of systemic integration articulated in Article 31(3)(c) of the Vienna Convention on the Law of Treaties, these provisions are increasingly interpreted as mutually reinforcing rather than conflicting.⁶³ In this context, environmental charges introduced by canal authorities, including waste-management service fees implemented by the SCA in 2025, may be understood as permissible cost-recovery mechanisms linked to identifiable environmental services rather than prohibited transit taxes.⁶⁴ This interpretation aligns with evolving IML scholarship emphasizing ecological integration within traditional navigational freedoms.⁶⁵

Empirical developments in global shipping patterns reinforce the need for this doctrinal recalibration. Disruptions affecting the Suez route between late 2023 and 2025 produced a substantial decline in canal revenues, from approximately USD 10.25 billion in 2023 to about USD 3.99 billion in 2024, accompanied by significant reductions in vessel traffic during peak geopolitical instability.⁶⁶ Concurrently, rerouting around the Cape of Good Hope increased voyage distances and global ton-mile demand. UN trade assessments indicate that such diversions raised global ton-miles by a record 6% in 2024, nearly three times faster than the growth in trade volume, reflecting longer sailing times and higher fuel consumption.⁶⁷ These developments have direct environmental implications in a sector responsible for roughly 3% of global greenhouse-gas emissions and responsible for transporting over 80% of world trade

⁶¹ UNITED NATIONS. United Nations Convention on the Law of the Sea. Montego Bay, 1982.

⁶² *Ibid.*, Part XII.

⁶³ McLACHLAN, Campbell. The Principle of Systemic Integration and Article 31(3)(c) of the Vienna Convention. *International and Comparative Law Quarterly*. 2005, vol. 54, no. 2, pp. 279–320, <https://doi.org/10.1093/iclq/lei001>

⁶⁴ SCA (see note 40).

⁶⁵ TANAKA, (see note 49).

⁶⁶ EGYPT TODAY. Egypt's Suez Canal revenues go down by 61% to \$3.9 billion in 2024 due to Red Sea tensions. 17 April 2025, <https://www.egypttoday.com/Article/3/139635/Egypt%E2%80%99s-Suez-Canal-revenues-go-down-by-61-to-3>

⁶⁷ UNCTAD. Review of Maritime Transport 2025: Staying the Course in Turbulent Waters. Geneva: UNCTAD, 2025. <https://unctad.org/publication/review-maritime-transport-2025>.

by volume.⁶⁸ The environmental externalities associated with chokepoint disruptions therefore demonstrate that canal governance cannot remain detached from climate considerations.

Parallel developments in Arctic navigation further illustrate the structural pressures shaping canal governance. Although the NSR offers potential distance reductions of 30–40% on certain Asia–Europe routes, equivalent to approximately 10–15 sailing days, its operational scalability remains constrained by seasonal ice variability, limited port infrastructure, insurance risks, and environmental protection requirements.⁶⁹ These limitations contrast with ongoing developments in the SCZONE, where investments in alternative-fuel bunkering, green hydrogen production, and maritime logistics infrastructure, estimated in the tens of billions of dollars, seek to position the canal within emerging low-carbon shipping corridors.⁷⁰ Such initiatives indicate that canal competitiveness increasingly depends not only on geographic advantage but also on regulatory credibility in environmental governance.

Within this evolving legal and economic landscape, the concept of “sustainable neutrality” emerges as a doctrinal refinement rather than a departure from classical neutrality. Transit remains open and non-discriminatory. However, access is conditioned upon objective environmental standards consistent with internationally recognized frameworks such as the IMO decarbonization strategy. Where environmental measures are transparent, proportionate, and equally applicable irrespective of flag, they operationalize the Convention’s environmental obligations rather than violating Article 24 of UNCLOS.⁷¹ Sustainable neutrality therefore reframes canal governance from passive facilitation of maritime transit toward active stewardship of environmentally responsible infrastructure, preserving navigational freedom while aligning strategic waterways with global sustainability commitments.

3.2. The "Circular" as an Instrument of Environmental Cost-Internalization

The regulatory evolution of the SCA demonstrates a transition from traditional

⁶⁸ IMO (see note 33).

⁶⁹ BEKKERS, Eddy; FRANCOIS, Joseph F.; ROJAS-ROMAGOSA, Hugo. Melting Ice Caps and the Economic Impact of Opening the Northern Sea Route. *The Economic Journal*. 2018, vol. 128, pp. 1095–1127, <https://doi.org/10.1111/eoj.12460>

⁷⁰ ZUMBRÄGEL, Tobias; KEGEL, Anna. Green tides: the Suez Canal as key hub and green corridor for a hydrogen future between the Middle East and Europe. *Frontiers in Energy Research*. 2025, vol. 13, 1538792. <https://doi.org/10.3389/fenrg.2025.1538792>.

⁷¹ SANDS, Philippe; PEEL, Jacqueline; FABRA, Adriana; MACKENZIE, Ruth. *Principles of International Environmental Law*. 4th ed. Cambridge: Cambridge University Press, 2018.

navigational guidance to a "de facto" transnational enforcement regime. This is most visibly operationalized through Circular No. 2/2025 (issued April 17, 2025), which mandates integrated solid waste management fees for all transiting vessels, regardless of service utilization.⁷² Unlike previous advisory bulletins, this circular establishes a graduated fee structure based on Suez Canal Net Tonnage (SCNT): smaller vessels (<10,000 SCNT) incur a mandatory USD 200 charge, while VLCCs and mega-container ships (>120,000 SCNT) are levied USD 1,200.⁷³ By decoupling these fees from optional use, the SCA has effectively institutionalized a "pollution-readiness" levy that internalizes the environmental externalities of maritime traffic within the canal's ecological corridor.

Further extending this administrative reach, Circular No. 1/2024 (enforced May 1, 2024) redefined mooring protocols, transitioning 70% of the convoy to shore-based mooring systems. This logistical shift is backed by a punitive enforcement mechanism: vessels assigned to onboard mooring that refuse or are unable to comply are charged an additional due of USD 5,000, while non-compliant electrical searchlight connections trigger a USD 5,000 penalty from the second transit onward.⁷⁴ ⁷⁵ These high-quantum penalties illustrate that SCA "Rules of Navigation" are no longer merely domestic protocols. They function as a form of "Chokepoint Governance," where local administrative standards compel global shipowners to retroactively upgrade vessel hardware to maintain access to the shortest East-West maritime route, a passage that reduces voyage distance by roughly 40–45% compared with the Cape of Good Hope alternative.⁷⁶

This regulatory model achieves "Sustainable Neutrality" by aligning domestic

⁷² SCA (see note 40).

⁷³ KADMAR SHIPPING. Circular No. 23/2025: SCA Integrated Waste Management Fees Schedule. Alexandria, 2025, <https://kadmar.com/kadmar-circular-no-23-2025-sca-circular-no-2-2025-concerning-providing-integrated-waste-management-services-within-suez-canal-waters/>

⁷⁴ SUEZ CANAL AUTHORITY. Circular No. (1/2024): Regulations and Costs of Mooring Boats and Services. 10 March 2024, https://www.suezcanal.gov.eg/English/Navigation/NavigationCirculars/Pages/Cir1-2024_10-3-2024.aspx.

⁷⁵ WILHELMSSEN PORT SERVICES. Suez Canal: New Mooring Regulations Effective May 1st, 2024. 2024. <https://www.wilhelmsen.com/port-services/newsletter/port-news/2024/suez-canal-new-mooring-regulations-effective-may-1st-2024/>.

⁷⁶ HAMDAN, Sadeque; FEILLET, Dominique; CHEAITOU, Ali; CARIOU, Pierre; BRAHIMI, Nadjib. Optimizing Asia-Europe Container Network: The Suez Canal and Cape of Good Hope Routes in a Changing World. *European Journal of Operational Research*. 2025, vol. 325, no. 1, pp. 167–188. <https://doi.org/10.1016/j.ejor.2025.03.008>; OLSON, Kenneth R.; CHERNYANSKII, Sergey S. Historical, Economical and Environmental Impacts of Suez Canal Connecting the Mediterranean Sea and Red Sea. *Journal of Water Resource and Protection*. 2025, vol. 17, no. 2, pp. 68–95. <https://doi.org/10.4236/jwarp.2025.172005>

administrative law with international mandates. By incorporating IMO 2023 Strategy benchmarks into these mandatory circulars, the SCA transforms the canal from a passive transit facilitator into a regulatory node. Consequently, technical compliance with Suez-specific rules, ranging from the Suez Stern Light requirements to waste-management tiers, effectively diffuses global sustainability norms across the maritime industry, irrespective of the vessel's flag state or port of origin,⁷⁷ particularly in light of maritime transport's estimated contribution of about 3% of global greenhouse-gas emissions, which has prompted intensified regulatory coordination through the IMO decarbonization framework.⁷⁸

3.3. Institutionalizing the Green Transition: From Administrative Rules to Statutory Infrastructure

While the SCA circulars demonstrate operational regulatory power, the durability of its sustainability governance depends on statutory entrenchment. Egypt's Law No. 2 of 2024 serves as the structural anchor, transitioning the canal from a fee-collecting entity to a fiscal-incentive hub for the global energy transition.⁷⁹ Under Article 3 of this law, the Egyptian state provides a mandatory cash incentive ranging from 33% to 55% of the income tax paid on green hydrogen projects, specifically those established within the SCZONE.⁸⁰ Critically, this law requires that 70% of project financing must be sourced from foreign currency offshore, ensuring that the canal's "green infrastructure" is decoupled from local economic volatility and remains resilient within the international financial architecture.

The scale of this legislative ambition is evidenced by the \$40 billion in private investment agreements signed during the 2024–2025 cycle, targeting a production capacity of 5.6 million tons per year by 2040.⁸¹ These agreements, involving global consortia like Masdar, AMEA Power, and EDF Renewables, position the canal as a

⁷⁷ R. STAHL TRANBERG. Navigating the Suez Canal at Night: Lighting Regulations. <https://stahl-tranberg.com/navigating-suez-canal-lighting-regulations/>.

⁷⁸ IMO Strategy 2023 (see note 30).

⁷⁹ ARAB REPUBLIC OF EGYPT. Law No. 2 of 2024 Concerning Incentives for Green Hydrogen Production Projects and its Derivatives. Official Gazette, issue No. 4, 27 January 2024. Unofficial English summary available at <https://ccfranco-arabe.fr/wp-content/uploads/2024/02/Law-no2-2024-English-summary.pdf>

⁸⁰ DELOITTE MIDDLE EAST. Law No. 2 of 2024 Summary. 7 February 2024. <https://www.deloitte.com/middle-east/en/services/tax/perspectives/law-no2-of-2024-summary.html>.

⁸¹ BAKER MCKENZIE. Global Hydrogen Policy Tracker: Egypt National Low Carbon Hydrogen Strategy. 2025 <https://resourcehub.bakermckenzie.com/en/resources/hydrogen-heat-map/emea/egypt/topics/hydrogen-developments>.

primary production node for zero-emission fuels (ammonia and methanol).⁸² This statutory move directly operationalizes the IMO's 2023 Strategy, which necessitates a localized supply of "near-zero-emission fuels" at strategic chokepoints. In contrast to the Panama Canal's primary reliance on a variable "Water Surcharge" (exceeding USD 10,000 during 2024 drought peaks) to manage environmental scarcity,⁸³ the Suez model utilizes "Sustainability Capitalization." It uses sovereign tax exemptions and 30% maritime service fee reductions to lower the entry cost for the decarbonized fleet of the future.⁸⁴

This layered governance approach, combining administrative penalties (Circulars 1/2024 and 2/2025) with statutory subsidies (Law No. 2 of 2024), strengthens the canal's institutional legitimacy. By the end of 2025, the SCA reported a 17% year-on-year revenue increase for October alone, driven by a 16% rise in vessel transits as confidence in the canal's modernized, "green" infrastructure returned.⁸⁵ This data suggests that the canal's sustainability transition is no longer a theoretical policy. It is a legally codified industrial strategy that stabilizes the waterway's role as a transnational regulatory actor.

3.4. Comparative Regulatory Effectiveness: Incentive-Based Versus Scarcity-Driven Canal Governance

Contemporary canal governance is bifurcating into two distinct regulatory archetypes: (i) scarcity-based resource pricing (Panama) and (ii) incentive-based sustainability capitalization (Suez). The ACP has institutionalized a "scarcity-adaptive" model via the Fresh Water Surcharge (FWS, which internalizes hydrological risk directly into vessel costs.⁸⁶ Under the 2024–2026 tariff schedule, the FWS consists of

⁸² INTERNATIONAL ENERGY AGENCY (IEA). Agreements to develop green hydrogen projects in the SCZONE. Updated 05 September 2025, <https://www.iea.org/policies/27694-agreements-to-develop-green-hydrogen-projects-in-the-suez-canal-economic-zone>.

⁸³ PANAMA CANAL AUTHORITY (ACP). Advisory to Shipping A-15-2024: Transit Adjustment and Water Surcharges. Panama City, 2024., <https://pancanal.com/en/maritime-services/advisory-to-shipping/>.

⁸⁴ ARAB REPUBLIC OF EGYPT. Law No. 2 of 2024 Concerning Incentives for Green Hydrogen Production Projects and its Derivatives (30% maritime port and transport service fee reduction, Art. 5). Official Gazette, issue No. 4, 27 January 2024. Unofficial English summary available at <https://adsero.me/wp-content/uploads/2024/02/Law-No.22024-Investment-Incentives-Green-Hydro-Projects-PDF.pdf>.

⁸⁵ STATE INFORMATION SERVICE (SIS), ARAB REPUBLIC OF EGYPT. Suez Canal revenues expected to grow 7.6% in 2025. Cairo: SIS, November 2025. <https://sis.gov.eg/en/media-center/news/suez-canal-revenues-expected-to-grow-76-in-2025/>.

⁸⁶ PANAMA CANAL AUTHORITY. Maritime Tariff: Item 1500.0000 Fresh Water Surcharge. Panama City: ACP, 2025, <https://pancanal.com/wp-content/uploads/2021/08/1500-0000.pdf>.

a USD 10,000 fixed fee plus a variable component tied to Gatun Lake levels, ranging from 1% to 10% of total tolls.⁸⁷ This model prices immediate climatic constraints to manage demand in a freshwater-dependent lock system, essentially functioning as a demand-side management tool for a capacity-constrained infrastructure under ecological stress.⁸⁸

In contrast, the Suez model employs a supply-side "industrial ecosystem" strategy. While Suez faced a severe "route substitution shock" in 2024, with revenue dropping to USD 3.99 billion and traffic falling to 13,213 vessels, its recovery strategy has been predicated on administrative resilience and green-tech entrenchment rather than scarcity surcharges.⁸⁹ Recent performance metrics validate this approach: in Q4 2025, the Suez Canal recorded a 24.5% revenue increase and a 24.2% rise in cargo tonnage compared to the same period in 2024.⁹⁰ This upward trajectory accelerated into January 2026, with dollar revenues rising 18% year-on-year, bolstered by the return of ultra-large container vessels like the CMA CGM Seine (250,000 GT) which leverage the canal's new integrated waste services and green bunkering incentives.⁹¹

The comparative lesson lies in the regulatory rationality of each authority. Panama's sustainability governance is expressed through scarcity-driven charges that can increase transit costs by over 30%, reinforcing its role as a capacity-managed passage.⁹² Conversely, Suez governance uses administrative rulemaking, such as the Circular No. 2/2025 waste tiers and Circular No. 6/2025 unified berthing tariffs, to

⁸⁷ WILHELMSEN. Panama Toll Calculator: FWS Variable Component Sigmoidal Function. 2026, <https://www.wilhelmsen.com/tollcalculators/panama-toll-calculator/CalculatePanama?PcUms=10000&LockType=Neopanamax&VesselType=FullContainerShip&ShipStatus=Laden&Loa=300&Beam=15&Teu=10000>.

⁸⁸ PANAMA CANAL AUTHORITY (ACP). Panama Canal Adjusts Fresh Water Surcharge. Balboa: ACP, 25 September 2023. <https://pancanal.com/en/panama-canal-adjusts-fresh-water-surcharge/>.

⁸⁹ EGYPT TODAY. Egypt's Suez Canal revenues go down by 61% to \$3.9 billion in 2024 due to Red Sea tensions. 17 April 2025. <https://www.egypttoday.com/Article/3/139635/Egypt%E2%80%99s-Suez-Canal-revenues-go-down-by-61-to-3>,

⁹⁰ AHARAM ONLINE. Suez Canal Revenue Climbs 24.5% in Q4 2025. 8 February 2026, <https://english.ahram.org.eg/Ui/Front/Inner.aspx?NewsContentID=562003>.

⁹¹ HELLENIC SHIPPING NEWS WORLDWIDE. Suez Canal revenue climbs 24.5%, vessel traffic rises 9% in Q4 2025. 10 February 2026. <https://www.hellenicshippingnews.com/suez-canal-revenue-climbs-24-5-vessel-traffic-rises-9-in-q4-2025/>; EGYPT TODAY. CMA CGM SEINE, one of world's largest container vessels, successfully transits Suez Canal. 29 January 2026. <https://www.egypttoday.com/Article/1/144744/CMA-CGM-SEINE-one-of-world%E2%80%99s-largest-container-vessels-successfully>.

⁹² INCHCAPE SHIPPING SERVICES (ISS). How to handle the Panama Canal's basket of new surcharge adjustments. 2024. <https://www.iss-shipping.com/how-to-handle-the-panama-canals-basket-of-new-surcharge-adjustments/>.

condition global transit behaviour toward a low-carbon, service-integrated model.⁹³ This strengthens the article's claim that strategic waterways are evolving into hybrid regulatory regimes that utilize domestic administrative instruments to shape the "green" trajectory of the global maritime industry.

4. Maintaining Competitiveness in a Decarbonizing Maritime Economy

4.1. The Cost of Decarbonization and the Risk of Route Substitution

The structural tension in sustainable canal governance lies in the widening cost differential between conventional heavy fuel oil and emerging zero-emission alternatives. Industry reports from early 2026 estimate that green methanol and ammonia command a "green premium" of 2 to 4 times the price of conventional bunker fuels.⁹⁴ This is further amplified by the EU Emissions Trading System phase-in: as of January 2026, shipping lines must surrender allowances for 100% of their covered emissions (up from 70% in 2025 and 40% in 2024), significantly increasing the carbon-compliance surcharges on the Asia–Europe route.⁹⁵ These costs create a highly price-sensitive environment where even modest canal-side environmental fees may incentivize route substitution if not properly calibrated.

Empirical evidence from the 2024 Red Sea security crisis illustrates this vulnerability. The SCA reported a revenue collapse from a record USD 10.25 billion in 2023 to approximately USD 3.99 billion in 2024, a loss of roughly USD 7 billion, as tonnage fell by 66.5% due to diversions around the Cape of Good Hope.⁹⁶ This 60%+ decline demonstrates the high elasticity of canal-dependent trade. However, recent data from Q4 2025 and January 2026 indicates a stabilization. Revenues for the July–November 2025 period reached USD 1.97 billion, a 17.5% increase compared to the

⁹³ SUEZ CANAL AUTHORITY. Circular No. (6/2025): Unified Berthing and Stay Dues Tariff. 9 November 2025. https://www.suezcanal.gov.eg/English/Navigation/NavigationCirculars/Pages/cir_6_2025.aspx.

⁹⁴ WORLD ECONOMIC FORUM. Closing the green fuels price gap can decarbonize the maritime sector. 2 December 2023. <https://www.weforum.org/stories/2023/12/closing-price-gap-green-fuels-decarbonize-maritime-sector/>; GLOBAL MARITIME FORUM / GETTING TO ZERO COALITION. Annual Progress Report on Green Shipping Corridors 2024. Copenhagen: GMF, 19 November 2024. <https://globalmaritimeforum.org/report/annual-progress-report-on-green-shipping-corridors-2025/>.

⁹⁵ EUROPEAN COMMISSION. Reducing emissions from the shipping sector. Brussels: DG Climate Action, 2025. https://climate.ec.europa.eu/eu-action/transport-decarbonisation/reducing-emissions-shipping-sector_en.

⁹⁶ EGYPT TODAY. Egypt's Suez Canal revenues go down by 61% to \$3.9 billion in 2024 due to Red Sea tensions. 17 April 2025. <https://www.egypttoday.com/Article/3/139635/Egypt%E2%80%99s-Suez-Canal-revenues-go-down-by-61-to-3>; REUTERS. Egypt's Suez Canal monthly revenue losses around \$800 million, Sisi says. 17 March 2025. <https://www.reuters.com/world/africa/egypt-suez-canal-monthly-revenue-losses-around-800-million-sisi-says-2025-03-17/>.

same period in 2024, as navigation confidence slowly returns.⁹⁷

Despite these shocks, the Suez route maintains a decisive structural advantage. Rerouting via the Cape increases voyage distance by 30–40%, adding approximately 10 to 14 days to transit times and substantially raising fuel consumption and insurance premiums.⁹⁸ Meanwhile, the NSR remains a "seasonal niche" rather than a systemic threat. Despite record transits in 2025, it remains constrained by a limited open-water window and a lack of large-scale bunkering infrastructure.⁹⁹ To maintain its competitive edge, the SCA has extended its transit fee rebates (up to 75% for certain long-distance trades) until June 30, 2026, successfully balancing its environmental mandate with the economic realities of a volatile maritime market.¹⁰⁰

4.2. Competitive Sustainability: Pricing, Incentives, and Market Signaling

The Suez Canal's competitiveness in a decarbonizing economy is secured by a "price-performance" equilibrium that preserves its distance advantage while internalizing environmental costs. As of February 2026, this model has reached a critical inflection point: the Gemini Cooperation (Maersk and Hapag-Lloyd) announced a structural return to the Suez route for its ME11 service, deploying state-of-the-art dual-fuel vessels such as the Albert Maersk (16,592 TEU).¹⁰¹ This shift signals that the canal's "Green Corridor" value proposition, supported by 30% maritime service fee reductions for alternative-fuel vessels, is successfully offsetting the heightened insurance premiums and security costs of the Red Sea transit.¹⁰²

Unlike reactive scarcity pricing, the SCA's administrative framework uses selective cost-recovery to drive technological standards. Under Circular No. 2/2025,

⁹⁷ AGENZIA NOVA. The Suez Canal recovers from the crisis: revenues growing as maritime traffic regains confidence. 26 December 2025. <https://www.agenzianova.com/en/news/il-canale-di-suez-si-rialza-dalla-crisi-ricavi-in-crescita-mentre-il-traffico-marittimo-riacquista-fiducia/>.

⁹⁸ UNCTAD. Review of Maritime Transport 2024. Geneva: UNCTAD, 2024. <https://unctad.org/publication/review-maritime-transport-2024>.

⁹⁹ CENTRE FOR HIGH NORTH LOGISTICS (CHNL). Main Results of NSR Transit Navigation in 2025. Murmansk/Oslo: CHNL, 9 December 2025. <https://chnl.no/news/main-results-of-nsr-transit-navigation-in-2025/>.

¹⁰⁰ GAC. Rebate circulars extended. Hot Port News, 17 November 2025. <https://www.gac.com/hot-port-news/rebate-circulars-extended-2>.

¹⁰¹ MAERSK. Structural Change to the Gemini Cooperation's ME11 Service: First Gemini service to transit the Red Sea. 3 February 2026, <https://www.maersk.com/news/articles/2026/02/03/first-gemini-service-to-transit-the-red-sea>

¹⁰² ELSONBATY, Ehab; SARHAN, Alan; SELIM, Ahmed. Logistics, green hydrogen, and manufacturing: Investment considerations in the Suez Canal Economic Zone. DLA Piper, 4 February 2026. <https://www.dlapiper.com/en-lu/insights/publications/2026/02/investment-considerations-in-suez-canal-economic-zone>.

the mandatory waste-management tiers (capping at USD 1,200) are intentionally marginal compared to the USD 1.5 million+ in additional fuel and carbon-compliance costs incurred by the Cape of Good Hope detour.¹⁰³ By keeping environmental fees below 0.5% of total transit dues, the SCA ensures that its "Green Canal 2030" strategy does not trigger route elasticity. Furthermore, the canal's integration with the SCZONE's \$133 billion green hydrogen cluster transforms it into a "Regulatory Hub" rather than a mere transit point, offering 20% discounts on port land usufruct fees for storage.¹⁰⁴ Rotterdam and Singapore have only recently begun to replicate through their 2030 Green Corridor pilots.¹⁰⁵

Finally, the canal's competitiveness is stabilized by its role as a hedge against EU ETS volatility. Shipping consultancies report that diverting a large container vessel around the Cape of Good Hope rather than transiting Suez can nearly triple its EU ETS allowance cost, rising from around EUR 98,000 to EUR 285,000 per voyage at 2024 allowance prices, a premium the Suez routing avoids.¹⁰⁶ ¹⁰⁷ This "Environmental Arbitrage" means that the canal can actually afford to increase its domestic environmental fees as long as they remain lower than the carbon taxes saved by choosing the shorter route. The Suez model thus achieves institutional resilience by aligning its fee structure with the global carbon-pricing trajectory, positioning sustainability as an economic asset rather than a regulatory burden.

4.3. Regulatory Coordination and the Prevention of Carbon Leakage

The effectiveness of "Sustainable Neutrality" ultimately depends on preventing carbon leakage, the strategic rerouting of vessels toward less regulated corridors to avoid compliance costs. While the 2024–2025 Red Sea disruptions were security-driven, they provided a "stress test" for route elasticity, resulting in a USD 7 billion

¹⁰³ SCA (see note 73). See also: UNCTAD. Review of Maritime Transport 2025. Geneva: UNCTAD, 2025. https://unctad.org/system/files/official-document/rmt2025_en.pdf.

¹⁰⁴ EGYPT OIL & GAS. SCZONE, Netherlands Explore Cooperation in Green Hydrogen and Renewables. 27 January 2026, <https://egyptoil-gas.com/news/sczone-netherlands-explore-cooperation-in-green-hydrogen-and-renewables/>.

¹⁰⁵ WORLD ECONOMIC FORUM. Case Study: The Rotterdam-Singapore Green Shipping Corridor. 24 November 2025, <https://initiatives.weforum.org/global-foresight-network/case-study-details/green-shipping-corridors-%28rotterdam-singapore-green-corridor%29/aJYTG000000wdV4AQ>.

¹⁰⁶ OFFSHORE ENERGY. Shipping's EU ETS costs could nearly triple due to Red Sea crisis, OceanScore says. 12 March 2024. <https://www.offshore-energy.biz/shippings-eu-ets-costs-could-nearly-triple-due-to-red-sea-crisis-oceanscore-says/>

¹⁰⁷ ZIS, Thalís P. V. The enhanced role of canals and route choice due to disruptions in maritime operations. *Maritime Business Review*. 2024, vol. 9, no. 2, pp. 98–112. <https://doi.org/10.1108/MABR-01-2023-0008>

revenue loss as tonnage diverted to the Cape.¹⁰⁸ This vulnerability reinforces the necessity of the SCA functioning as a "Compliance Bridge" rather than a unilateral tax-collector, aligning with regional and global decarbonization mandates.

This coordination is most evident in the canal's role as a hedge against the EU ETS. As of January 2026, the EU ETS has reached its final phase-in stage, requiring surrender of allowances for 100% of covered emissions, with coverage extending to the full emissions of intra-EEA voyages and to half the emissions of voyages into or out of the EEA.¹⁰⁹ Because the Suez route reduces Asia–Europe distance by approximately 40%, the resulting fuel savings translate into a materially lower EU ETS allowance liability per voyage for a ULCV at current allowance prices.¹¹⁰ Consequently, the SCA's marginal environmental fees, such as the USD 1,200 waste-management cap, are strategically positioned as negligible when compared to the USD 168 per container ETS surcharge vessels face on longer, non-Suez routes.¹¹¹

At the global level, the SCA's administrative practice addresses the regulatory vacuum created by the October 2025 adjournment of the IMO's Net-Zero Framework negotiations.¹¹² By operationalizing "Green Corridor" technical standards and providing 15% fee rebates for vessels meeting Carbon Intensity Indicator benchmarks through mid-2026, the SCA provides a predictable compliance environment during a period of international treaty stagnation.¹¹³ This pragmatic alignment allows the canal to function as a compliance gateway, where domestic administrative law, rather than a new global treaty, facilitates the diffusion of sustainability norms across the global fleet.

Ultimately, the Suez Canal's recovery in early 2026, generating USD 449 million in revenue in the first five weeks of the year, up from USD 368 million in the same

¹⁰⁸ REUTERS. Suez Canal chief says Red Sea crisis did not create sustainable alternative route. 19 February 2025, <https://www.reuters.com/world/africa/suez-canal-chief-says-red-sea-crisis-did-not-create-sustainable-route-replace-2025-02-19/>.

¹⁰⁹ HAPAG-LLOYD. Update on the European Emission Trading System (EU ETS) – Full Implementation from 2026. 24 November 2025, [https://www.europarl.europa.eu/legislative-train/carriage/update-of-the-eu-emissions-trading-system-\(eu-ets\)/report?sid=10001](https://www.europarl.europa.eu/legislative-train/carriage/update-of-the-eu-emissions-trading-system-(eu-ets)/report?sid=10001).

¹¹⁰ SHIP & BUNKER. Analysis: Shipping's Jump in EU-ETS Costs Will Offset Bunker-Price Decline in 2026. 1 January 2026, <https://shipandbunker.com/news/world/877058-analysis-shippings-jump-in-eu-ets-costs-will-offset-bunker-price-decline-in-2026>.

¹¹¹ WANG, Junjin; ZHANG, Baiyu; ZHU, Qinghua; LIU, Jiaguo. Emission surcharge in the European Union Emissions Trading System: A competitive analysis for shipping companies. *Transportation Research Part E: Logistics and Transportation Review*. 2025, vol. 202, 104338. <https://doi.org/10.1016/j.tre.2025.104338>.

¹¹² IMO. IMO net-zero shipping talks to resume in 2026. 17 October 2025, <https://www.imo.org/en/mediacentre/pressbriefings/pages/imo-net-zero-shipping-talks-to-resume-in-2026.aspx>

¹¹³ SUEZ CANAL AUTHORITY. Circular: Extension of Transit Fee Reductions until June 2026. Ismailia, 2025, https://www.suezcanal.gov.eg/English/Navigation/NavigationCirculars/Pages/PC_22_2026.aspx.

period of 2025, demonstrates that sustainability governance reinforces commercial viability.¹¹⁴ By synchronizing its fee structure with the carbon-arbitrage economics of the EU ETS and IMO targets, the canal minimizes the risk of route substitution. Competitive sustainability is thus achieved by ensuring that the "Suez Shortcut" remains not only a geographic necessity but a primary financial instrument for maritime decarbonization.

5. Conclusion

The evolution of the Suez Canal's governance model illustrates a broader transformation in the legal and economic function of strategic maritime chokepoints. This article has argued that the classical doctrine of navigational neutrality, grounded in the 1888 Convention of Constantinople and reflected in UNCLOS, no longer operates in isolation from environmental obligations and decarbonization pressures. Instead, neutrality is being reinterpreted as "Sustainable Neutrality": open and non-discriminatory access conditioned by objective environmental standards that align with international climate commitments.

The first part of the paper situated the canal within a transforming maritime order marked by geopolitical volatility, carbon-pricing regimes, and technological shifts in fuel systems. It demonstrated that sustainability governance is no longer peripheral to canal administration but structurally embedded in operational and economic realities. The second part examined how this transformation is institutionalized through domestic administrative instruments and statutory frameworks. Circular-based environmental cost internalization, graduated waste-management fees, mooring reforms, and statutory incentives under Law No. 2 of 2024 collectively illustrate how the Suez Canal Authority operates as an emerging transnational regulatory actor. These measures do not replace IML. Rather, they operationalize it within a geographically constrained corridor that exerts disproportionate influence on global shipping behaviour.

The final section evaluated whether sustainability measures undermine competitiveness. Empirical evidence from 2024–2026 demonstrates that route

¹¹⁴ ANADOLU AGENCY (AA). Egypt's Suez Canal posts revenue rebound, earning \$449 million since start of 2026. 8 February 2026 (figures for 1 January to 8 February 2026). <https://www.aa.com.tr/en/middle-east/egypt-s-suez-canal-posts-revenue-rebound-earning-449-million-since-start-of-2026/3824222>

substitution risks are real but conditional. When environmental measures are calibrated relative to voyage economics, synchronized with regional carbon-pricing regimes such as the EU ETS, and combined with temporary pricing incentives, canal competitiveness can be preserved. The Suez Canal's structural distance advantage continues to outweigh marginal environmental charges, particularly when regulatory coordination reduces carbon-leakage incentives.

The broader implication of this study is that maritime chokepoints are becoming strategic climate infrastructures. Their governance increasingly combines administrative law, international environmental obligations, and economic instruments in ways that influence fleet behaviour beyond national jurisdiction. The Suez experience suggests that regulatory synchronization, not deregulation or unilateral environmental taxation, offers the most viable pathway for balancing neutrality, sustainability, and commercial resilience. In this sense, the future of canal governance lies in adapting neutrality to the structural realities of a decarbonizing global maritime economy.

References

- AGENZIA NOVA. The Suez Canal recovers from the crisis: revenues growing as maritime traffic regains confidence. 26 December 2025. Available from: <https://www.agenzianova.com/en/news/il-canale-di-suez-si-rialza-dalla-crisi-ricavi-in-crescita-mentre-il-traffico-marittimo-riacquista-fiducia/> [Accessed 28 June 2026].
- AHRAM ONLINE. Suez Canal Revenue Climbs 24.5% in Q4 2025. 8 February 2026. Available from: <https://english.ahram.org.eg/UI/Front/Inner.aspx?NewsContentID=562003>. [Accessed 28 June 2026].
- ANADOLU AGENCY. Egypt's Suez Canal posts revenue rebound, earning \$449 million since start of 2026. 8 February 2026. Available from: <https://www.aa.com.tr/en/middle-east/egypt-s-suez-canal-posts-revenue-rebound-earning-449-million-since-start-of-2026/3824222>. [Accessed 28 June 2026].
- ANDRIOLI JR., Renato. Direito Internacional do Ambiente: a Responsabilidade no Antropoceno. *Revista Jurídica Portucalense*. 2020, no. 28, pp. 106-123. ISSN 2183-5705. Available from: [https://doi.org/10.34625/issn.2183-2705\(28\)2020.ic-05](https://doi.org/10.34625/issn.2183-2705(28)2020.ic-05). [Accessed 28 June 2026].
- ARAB REPUBLIC OF EGYPT. *Law No. 2 of 2024 Concerning Incentives for Green Hydrogen Production Projects and its Derivatives*. Official Gazette, issue No. 4, 27 January 2024. Unofficial English summary available from: <https://ccfranco-arabe.fr/wp-content/uploads/2024/02/Law-no2-2024-English-summary.pdf> [Accessed 28 June 2026].
- ARCTIC COUNCIL. Arctic Shipping Update: 40% Increase in Ships in the Arctic. Tromsø: Arctic Council Secretariat, 12 February 2026. Available from: <https://arctic-council.org/news/increase-in-arctic-shipping/> [Accessed 28 June 2026].
- ASLESEN, Henrik; FAGERENG, Amund; SAEED, Naima. The risks and opportunities of sailing the Northern Sea Route: a Norwegian stakeholder perspective. *WMU Journal of Maritime Affairs*. 2026. ISSN 1654-1642. Available from: <https://doi.org/10.1007/s13437-026-00402-2>. [Accessed 28 June 2026].
- BAKER MCKENZIE. Global Hydrogen Policy Tracker: Egypt National Low Carbon Hydrogen Strategy. 2025. Available from: <https://resourcehub.bakermckenzie.com/en/resources/hydrogen-heat-map/emea/egypt/topics/hydrogen-developments>. [Accessed 28 June 2026].
- BEKKERS, Eddy; FRANCOIS, Joseph F.; ROJAS-ROMAGOSA, Hugo. Melting Ice Caps and the Economic Impact of Opening the Northern Sea Route. *The Economic Journal*. 2018, vol. 128, no. 610, pp. 1095-1127. ISSN 0013-0133. Available from: <https://doi.org/10.1111/eoj.12460>.

- [Accessed 28 June 2026].
- BORGERSON, Scott G. The Arctic Meltdown: The Economic and Security Implications of Global Warming. *Foreign Affairs*. 2008, vol. 87, no. 2, pp. 63-77. ISSN 0015-7120. Available from: <https://library.arcticportal.org/1570/1/BorgersonForeignAffairsarticle.pdf>. [Accessed 28 June 2026].
- BUIXADÉ FARRÉ, Albert; STEPHENSON, Scott R.; CHEN, Linling; et al. Commercial Arctic shipping through the Northeast Passage: routes, resources, governance, technology, and infrastructure. *Polar Geography*. 2014, vol. 37, no. 4, pp. 298-324. ISSN 1088-937X. Available from: <https://doi.org/10.1080/1088937X.2014.965769>. [Accessed 28 June 2026].
- CENTRE FOR HIGH NORTH LOGISTICS. Main Results of NSR Transit Navigation in 2025. Murmansk/Oslo: CHNL, 9 December 2025. Available from: <https://chnl.no/news/main-results-of-nsr-transit-navigation-in-2025/> [Accessed 28 June 2026].
- CHEN, Chujun; YUAN, Xiang; YE, Zhiyi; LIU, Yu-an; ZHOU, Yutian. Testing Arctic exceptionalism under global tensions: climate change, geopolitics, and the strategic value of the Northern Sea Route. *Humanities and Social Sciences Communications*. 2026, vol. 13, art. 823. ISSN 2662-9992. Available from: <https://doi.org/10.1057/s41599-026-07384-9>. [Accessed 28 June 2026].
- CHIRCOP, Aldo. The IMO's Work on Environmental Protection and Global Ocean Governance. In: ATTARD, David Joseph; FITZMAURICE, Malgosia; MARTINEZ, Norman; HAMZA, Riyaz (eds.). *The IMLI Manual on International Maritime Law. Vol. III: Marine Environmental Law and Maritime Security Law*. Oxford: Oxford University Press, 2016.
- CONSTABLE, Andrew J.; HARPER, Sandra; DAWSON, Jackie; HOLSMAN, Kirstin; MUSTONEN, Tero; PIEPENBURG, Dieter; ROST, Björn. Cross-Chapter Paper 6: Polar Regions. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Cambridge: Cambridge University Press, 2022, pp. 2319-2368. Available from: <https://doi.org/10.1017/9781009325844.023>. [Accessed 28 June 2026].
- Convention of Constantinople (Suez Canal)*, 29 October 1888, 79 British and Foreign State Papers 18.
- DA SILVA, Daniela Martins Pereira. Analysis of jurisdiction under the United Nations Convention on the Law of the Sea: an expansionist vocation? *Revista Jurídica Portuguesa*. 2018, no. 23, pp. 49-100. ISSN 2183-5705. Available from: <https://revistas.rcaap.pt/juridica/article/view/12248>. [Accessed 28 June 2026].
- DAILY NEWS EGYPT. Suez Canal Economic Zone secures \$64bn in green hydrogen investments. 23 December 2024. Available from: <https://www.dailynewsegypt.com/2024/12/23/suez-canal-economic-zone-secures-64bn-in-green-hydrogen-investments/> [Accessed 28 June 2026].
- DELOITTE MIDDLE EAST. Law No. 2 of 2024 Summary. 7 February 2024. Available from: <https://www.deloitte.com/middle-east/en/services/tax/perspectives/law-no2-of-2024-summary.html>. [Accessed 28 June 2026].
- ELSONBATY, Ehab; SARHAN, Alan; SELIM, Ahmed. Logistics, green hydrogen, and manufacturing: Investment considerations in the Suez Canal Economic Zone. DLA Piper, 4 February 2026. Available from: <https://www.dlapiper.com/en-lu/insights/publications/2026/02/investment-considerations-in-suez-canal-economic-zone>. [Accessed 28 June 2026].
- EGU BLOGS. Navigating the polar frontier: exploring the effects of sea-ice decline on shipping and sea routes in the Arctic. 7 March 2025. Available from: <https://blogs.egu.eu/divisions/cr/2025/03/07/navigating-the-polar-frontier-effects-of-sea-ice-decline-on-shipping-and-sea-routes/> [Accessed 28 June 2026].
- EGYPT OIL & GAS. SCZONE, Netherlands Explore Cooperation in Green Hydrogen and Renewables. 27 January 2026. Available from: <https://egyptoil-gas.com/news/sczone-netherlands-explore-cooperation-in-green-hydrogen-and-renewables/> [Accessed 28 June 2026].
- EGYPT TODAY. CMA CGM SEINE, one of world's largest container vessels, successfully transits Suez Canal. 29 January 2026. Available from: <https://www.egypttoday.com/Article/1/144744/CMA-CGM-SEINE-one-of-world%E2%80%99s-largest-container-vessels-successfully>. [Accessed 28 June 2026].
- EGYPT TODAY. Egypt's Suez Canal revenues go down by 61% to \$3.9 billion in 2024 due to Red Sea tensions. 17 April 2025. Available from: <https://www.egypttoday.com/Article/3/139635/Egypt%E2%80%99s-Suez-Canal-revenues-go-down-by-61-to-3>. [Accessed 28 June 2026].
- EUROPEAN COMMISSION. Reducing emissions from the shipping sector. Brussels: DG Climate Action, 2025. Available from: https://climate.ec.europa.eu/eu-action/transport-decarbonisation/reducing-emissions-shipping-sector_en. [Accessed 28 June 2026].
- GAC. Rebate circulars extended. *Hot Port News*. 17 November 2025. Available from: <https://www.gac.com/hot-port-news/rebate-circulars-extended-2>. [Accessed 28 June 2026].

- GLOBAL MARITIME FORUM. Annual Progress Report on Green Shipping Corridors 2024. Copenhagen: Global Maritime Forum / Getting to Zero Coalition, 19 November 2024. Available from: <https://globalmaritimeforum.org/report/annual-progress-report-on-green-shipping-corridors-2025/> [Accessed 28 June 2026].
- GOUCHA SOARES, António. Energy and Geopolitics: Global Power and the Struggle for Energy Resources. *Revista Jurídica Portucalense*. 2026, vol. 1, no. 39, pp. 1-26. ISSN 2183-5705. Available from: [https://doi.org/10.34625/issn.2183-2705\(39.1\)2026.ic-1](https://doi.org/10.34625/issn.2183-2705(39.1)2026.ic-1). [Accessed 28 June 2026].
- HAMDAN, Sadeque; FEILLET, Dominique; CHEAITOU, Ali; CARIOU, Pierre; BRAHIMI, Nadjib. Optimizing Asia-Europe Container Network: The Suez Canal and Cape of Good Hope Routes in a Changing World. *European Journal of Operational Research*. 2025, vol. 325, no. 1, pp. 167-188. ISSN 0377-2217. Available from: <https://doi.org/10.1016/j.ejor.2025.03.008>. [Accessed 28 June 2026].
- HANAČEK, Ksenija; APOSTOLOPOULOU, Elia; KRÖGER, Markus; et al. Climate change, extractivist infrastructure and environmental conflicts at the Northern Sea-Polar Silk Road intersection. *Energy Research & Social Science*. 2026, vol. 133, art. 104600. ISSN 2214-6296. Available from: <https://doi.org/10.1016/j.erss.2026.104600>. [Accessed 28 June 2026].
- HAPAG-LLOYD. Update on the European Emission Trading System (EU ETS) – Full Implementation from 2026. 24 November 2025. Available from: <https://www.hapag-lloyd.com/en/services-information/news/2025/11/update-on-the-european-emission-trading-system--eu-ets----full-i.html>. [Accessed 28 June 2026].
- HELLENIC SHIPPING NEWS WORLDWIDE. Suez Canal revenue climbs 24.5%, vessel traffic rises 9% in Q4 2025. 10 February 2026. Available from: <https://www.hellenicshippingnews.com/suez-canal-revenue-climbs-24-5-vessel-traffic-rises-9-in-q4-2025/> [Accessed 28 June 2026].
- INCHCAPE SHIPPING SERVICES. How to handle the Panama Canal's basket of new surcharge adjustments. 2024. Available from: <https://www.iss-shipping.com/how-to-handle-the-panama-canal-basket-of-new-surcharge-adjustments/> [Accessed 28 June 2026].
- INTERNATIONAL ENERGY AGENCY. Agreements to develop green hydrogen projects in the Suez Canal Economic Zone. Updated 5 September 2025. Available from: <https://www.iea.org/policies/27694-agreements-to-develop-green-hydrogen-projects-in-the-suez-canal-economic-zone>. [Accessed 28 June 2026].
- INTERNATIONAL LAW COMMISSION. *Fragmentation of International Law: Difficulties Arising from the Diversification and Expansion of International Law*. Finalized by Martti Koskenniemi. UN Doc A/CN.4/L.682. Geneva: United Nations, 13 April 2006.
- INTERNATIONAL MARITIME ORGANIZATION. *Fourth IMO GHG Study 2020*. London: IMO, 2020. Available from: <https://www.imo.org/en/ourwork/environment/pages/fourth-imo-greenhouse-gas-study-2020.aspx>. [Accessed 28 June 2026].
- INTERNATIONAL MARITIME ORGANIZATION. *Initial IMO Strategy on Reduction of GHG Emissions from Ships*. London: IMO, 2018. Available from: <https://www.imo.org/en/ourwork/environment/pages/vision-and-level-of-ambition-of-the-initial-imo-strategy.aspx>. [Accessed 28 June 2026].
- INTERNATIONAL MARITIME ORGANIZATION. IMO net-zero shipping talks to resume in 2026. 17 October 2025. Available from: <https://www.imo.org/en/mediacentre/pressbriefings/pages/imo-net-zero-shipping-talks-to-resume-in-2026.aspx>. [Accessed 28 June 2026].
- INTERNATIONAL MARITIME ORGANIZATION. *2023 IMO Strategy on Reduction of GHG Emissions from Ships*. London: IMO, 2023.
- INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Geneva: IPCC, 2022. Available from: <https://www.ipcc.ch/report/ar6/wg2/> [Accessed 28 June 2026].
- JESSUP, Philip C. *The Law of Territorial Waters and Maritime Jurisdiction*. New York: G.A. Jennings Co., 1927.
- KADMAR SHIPPING. Circular No. 23/2025: SCA Integrated Waste Management Fees Schedule. Alexandria, 2025. Available from: <https://kadmar.com/kadmar-circular-no-23-2025-sca-circular-no-2-2025-concerning-providing-integrated-waste-management-services-within-suez-canal-waters/> [Accessed 28 June 2026].
- MAERSK. Structural Change to the Gemini Cooperation's ME11 Service: First Gemini service to transit the Red Sea. 3 February 2026. Available from: <https://www.maersk.com/news/articles/2026/02/03/first-gemini-service-to-transit-the-red-sea>. [Accessed 28 June 2026].
- MAHMOUD, Mohamed Rami; ROUSHDI, Mahmoud; ABOELKHEAR, Mostafa. Potential benefits of

- climate change on navigation in the northern sea route by 2050. *Scientific Reports*. 2024, vol. 14, art. 2771. ISSN 2045-2322. Available from: <https://doi.org/10.1038/s41598-024-53308-5>. [Accessed 28 June 2026].
- McLACHLAN, Campbell. The Principle of Systemic Integration and Article 31(3)(c) of the Vienna Convention. *International and Comparative Law Quarterly*. 2005, vol. 54, no. 2, pp. 279-320. ISSN 0020-5893. Available from: <https://doi.org/10.1093/iclq/lei001>. [Accessed 28 June 2026].
- MOREIRA, Fátima Castro. O papel da União Europeia na gestão sustentável dos oceanos. In: TEIJO GARCÍA, Carlos; JORGE URBINA, Julio (coords.). *Sostenibilidad ambiental y aprovechamiento de los recursos marinos*. Cizur Menor: Aranzadi La Ley, 2026, pp. 195-222.
- MOREIRA, Fátima Castro; MATOS, André Pereira. A governança multinível na proteção do direito fundamental ao ambiente da União Europeia: o Pacto Ecológico Europeu e o projeto Cities Mission. *Revista Jurídica Portucalense*. 2022, no. 32, pp. 364-400. ISSN 2183-5705. Available from: [https://doi.org/10.34625/issn.2183-2705\(32\)2022.jm-01](https://doi.org/10.34625/issn.2183-2705(32)2022.jm-01). [Accessed 28 June 2026].
- O'CONNELL, Daniel Patrick. *The International Law of the Sea. Vol. II*. Edited by I. A. Shearer. Oxford: Clarendon Press, 1984. ISBN 9780198254690.
- OFFSHORE ENERGY. Shipping's EU ETS costs could nearly triple due to Red Sea crisis, OceanScore says. 12 March 2024. Available from: <https://www.offshore-energy.biz/shippings-eu-ets-costs-could-nearly-triple-due-to-red-sea-crisis-oceanscore-says/> [Accessed 28 June 2026].
- OLSON, Kenneth R.; CHERNYANSKII, Sergey S. Historical, Economical and Environmental Impacts of Suez Canal Connecting the Mediterranean Sea and Red Sea. *Journal of Water Resource and Protection*. 2025, vol. 17, no. 2, pp. 68-95. ISSN 1945-3094. Available from: <https://doi.org/10.4236/jwarp.2025.172005>. [Accessed 28 June 2026].
- OXFORD INSTITUTE FOR ENERGY STUDIES. *The Northern Sea Route. Energy Insight 105*. Oxford: OIES, 2021. Available from: <https://www.oxfordenergy.org/publications/the-northern-sea-route-a-state-priority-in-russias-strategy-of-delivering-arctic-hydrocarbons-to-global-markets/> [Accessed 28 June 2026].
- OXMAN, Bernard H. The Territorial Temptation: A Siren Song at Sea. *American Journal of International Law*. 2006, vol. 100, no. 4, pp. 830-851. ISSN 0002-9300.
- PANAMA CANAL AUTHORITY. Advisory to Shipping A-15-2024: Transit Adjustment and Water Surcharges. Panama City: ACP, 2024. Available from: <https://pancanal.com/en/maritime-services/advisory-to-shipping/> [Accessed 28 June 2026].
- PANAMA CANAL AUTHORITY. *Maritime Tariff: Item 1500.0000 Fresh Water Surcharge*. Panama City: ACP, 2025. Available from: <https://pancanal.com/wp-content/uploads/2021/08/1500-0000.pdf>. [Accessed 28 June 2026].
- PANAMA CANAL AUTHORITY. Panama Canal Adjusts Fresh Water Surcharge. Balboa: ACP, 25 September 2023. Available from: <https://pancanal.com/en/panama-canal-adjusts-fresh-water-surcharge/> [Accessed 28 June 2026].
- REUTERS. Chinese freighter halves EU delivery time on maiden Arctic voyage. 14 October 2025. Available from: <https://www.reuters.com/sustainability/climate-energy/chinese-freighter-halves-eu-delivery-time-maiden-arctic-voyage-uk-2025-10-14/> [Accessed 28 June 2026].
- REUTERS. Egypt's Suez Canal monthly revenue losses around \$800 million, Sisi says. 17 March 2025. Available from: <https://www.reuters.com/world/africa/egypt-suez-canal-monthly-revenue-losses-around-800-million-sisi-says-2025-03-17/> [Accessed 28 June 2026].
- REUTERS. Red Sea shipping diversions boost container sector emissions. 17 January 2024. Available from: <https://www.reuters.com/markets/commodities/red-sea-shipping-diversions-boost-container-sector-emissions-2024-01-17/> [Accessed 28 June 2026].
- REUTERS. Suez Canal chief says Red Sea crisis did not create sustainable alternative route. 19 February 2025. Available from: <https://www.reuters.com/world/africa/suez-canal-chief-says-red-sea-crisis-did-not-create-sustainable-route-replace-2025-02-19/> [Accessed 28 June 2026].
- R. STAHL TRANBERG. Navigating the Suez Canal at Night: Lighting Regulations. Available from: <https://stahl-tranberg.com/navigating-suez-canal-lighting-regulations/> [Accessed 28 June 2026].
- REGIONAL MARINE POLLUTION EMERGENCY RESPONSE CENTRE FOR THE MEDITERRANEAN SEA. *Study on Trends and Outlook of Marine Pollution from Ships and Activities and of Maritime Traffic and Offshore Activities in the Mediterranean*. Floriana: REMPEC, 2021. Available from: <https://www.rempec.org/en/knowledge-centre/online-catalogue/studyontrends2022.pdf>. [Accessed 28 June 2026].
- RUSSIAN FEDERATION. *Rules of Navigation in the Water Area of the Northern Sea Route*. 2020.
- SANDS, Philippe; PEEL, Jacqueline; FABRA, Adriana; MACKENZIE, Ruth. *Principles of International Environmental Law*. 4th ed. Cambridge: Cambridge University Press, 2018. ISBN

- 9781108431125.
- SHIP & BUNKER. Analysis: Shipping's Jump in EU-ETS Costs Will Offset Bunker-Price Decline in 2026. 1 January 2026. Available from: <https://shipandbunker.com/news/world/877058-analysis-shippings-jump-in-eu-ets-costs-will-offset-bunker-price-decline-in-2026>. [Accessed 28 June 2026].
- SOTO-LÓPEZ, Verónica; MENENDEZ-TELEÑA, Deva; GARCIA-VAZQUEZ, Eva; BARTOLOMÉ, Marlene. Risk analysis of invasive species by ballast water: case study in the Port of Gijón, Bay of Biscay. *Journal of Marine Systems*. 2025, vol. 252, art. 104148. ISSN 0924-7963. Available from: <https://doi.org/10.1016/j.jmarsys.2025.104148>. [Accessed 28 June 2026].
- STATE INFORMATION SERVICE, ARAB REPUBLIC OF EGYPT. Suez Canal revenues expected to grow 7.6% in 2025. Cairo: SIS, November 2025. Available from: <https://sis.gov.eg/en/media-center/news/suez-canal-revenues-expected-to-grow-76-in-2025/> [Accessed 28 June 2026].
- STOPFORD, Martin. *Maritime Economics*. 3rd ed. London: Routledge, 2009. ISBN 9780415275583.
- SUEZ CANAL AUTHORITY. *Circular No. (1/2024): Regulations and Costs of Mooring Boats and Services*. 10 March 2024. Available from: https://www.suezcanal.gov.eg/English/Navigation/NavigationCirculars/Pages/Cir1-2024_10-3-2024.aspx. [Accessed 28 June 2026].
- SUEZ CANAL AUTHORITY. *Circular No. 2/2025 (Waste Management)*. Ismailia: SCA, 2025.
- SUEZ CANAL AUTHORITY. *Circular No. (6/2025): Unified Berthing and Stay Dues Tariff*. 9 November 2025. Available from: https://www.suezcanal.gov.eg/English/Navigation/NavigationCirculars/Pages/cir_6_2025.aspx. [Accessed 28 June 2026].
- SUEZ CANAL AUTHORITY. *Circular: Extension of Transit Fee Reductions until June 2026 (PC 22/2026)*. Ismailia, 2025. Available from: https://www.suezcanal.gov.eg/English/Navigation/NavigationCirculars/Pages/PC_22_2026.aspx. [Accessed 28 June 2026].
- SUEZ CANAL AUTHORITY. *The Green Canal Strategy*. Ismailia: SCA, 2024. Available from: <https://www.suezcanal.gov.eg/English/About/SuezCanal/Pages/greencanal.aspx>. [Accessed 28 June 2026].
- TANAKA, Yoshifumi. *The International Law of the Sea*. 3rd ed. Cambridge: Cambridge University Press, 2019. ISBN 9781108440103.
- TUREKULOVA, Zhuldyz; BAITUREYEVA, Klara. The Suez Canal and Its Role in Formation of New International Political and Economic Relations in the XX Century. *Oriente Moderno*. 2020, vol. 100, no. 1, pp. 93-105. ISSN 0030-5472. Available from: <https://www.jstor.org/stable/48593095>. [Accessed 28 June 2026].
- UNITED NATIONS. *United Nations Convention on the Law of the Sea*. Montego Bay: United Nations, 1982.
- UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT. *Global Trade Update (December 2025)*. Geneva: UNCTAD, 2025. Available from: <https://unctad.org/publication/global-trade-update-december-2025-global-trade-poised-record-breaking-2025-flows>. [Accessed 28 June 2026].
- UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT. Maritime trade under pressure – growth set to stall in 2025. Geneva: UNCTAD, 24 September 2025. Available from: <https://unctad.org/news/maritime-trade-under-pressure-growth-set-stall-2025>. [Accessed 28 June 2026].
- UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT. *Navigating troubled waters: Impact to global trade of disruption of shipping routes*. UNCTAD/OSG/INF/2024/2. Geneva: UNCTAD, 2024. Available from: <https://unctad.org/publication/navigating-troubled-waters-impact-global-trade-disruption-shipping-routes-red-sea-black>. [Accessed 28 June 2026].
- UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT. Red Sea, Black Sea and Panama Canal: UNCTAD raises alarm on global trade disruptions. Geneva: UNCTAD, 26 January 2024. Available from: <https://unctad.org/news/red-sea-black-sea-and-panama-canal-unctad-raises-alarm-global-trade-disruptions>. [Accessed 28 June 2026].
- UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT. *Review of Maritime Transport 2024*. Geneva: UNCTAD, 2024. Available from: <https://unctad.org/publication/review-maritime-transport-2024>. [Accessed 28 June 2026].
- UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT. *Review of Maritime Transport 2025: Staying the Course in Turbulent Waters*. Geneva: UNCTAD, 2025. Available from: <https://unctad.org/publication/review-maritime-transport-2025>. [Accessed 28 June 2026].
- VOIGT, Christina. *Sustainable Development as a Principle of International Law: Resolving Conflicts*

- between Climate Measures and WTO Law*. Leiden: Martinus Nijhoff, 2009. ISBN 978-90-04-16697-4.
- WAN, Zheng; SU, Yingyu; LI, Zimu; ZHANG, Xin; ZHANG, Qiang; CHEN, Jihong. Analysis of the impact of Suez Canal blockage on the global shipping network. *Ocean & Coastal Management*. 2023, vol. 245, art. 106868. ISSN 0964-5691. Available from: <https://doi.org/10.1016/j.ocecoaman.2023.106868>. [Accessed 28 June 2026].
- WANG, Junjin; ZHANG, Baiyu; ZHU, Qinghua; LIU, Jiaguo. Emission surcharge in the European Union Emissions Trading System: A competitive analysis for shipping companies. *Transportation Research Part E: Logistics and Transportation Review*. 2025, vol. 202, art. 104338. ISSN 1366-5545. Available from: <https://doi.org/10.1016/j.tre.2025.104338>. [Accessed 28 June 2026].
- WILHELMSSEN. Panama Toll Calculator: FWS Variable Component Sigmoidal Function. 2026. Available from: <https://www.wilhelmsen.com/tollcalculators/panama-toll-calculator/> [Accessed 28 June 2026].
- WILHELMSSEN PORT SERVICES. Suez Canal: New Mooring Regulations Effective May 1st, 2024. 2024. Available from: <https://www.wilhelmsen.com/port-services/newsletter/port-news/2024/suez-canal-new-mooring-regulations-effective-may-1st-2024/> [Accessed 28 June 2026].
- WORLD ECONOMIC FORUM. Case Study: The Rotterdam-Singapore Green Shipping Corridor. 24 November 2025. Available from: <https://initiatives.weforum.org/global-foresight-network/case-study-details/green-shipping-corridors-%28rotterdam-singapore-green-corridor%29/aJYTG000000wdV4AQ>. [Accessed 28 June 2026].
- WORLD ECONOMIC FORUM. Closing the green fuels price gap can decarbonize the maritime sector. 2 December 2023. Available from: <https://www.weforum.org/stories/2023/12/closing-price-gap-green-fuels-decarbonize-maritime-sector/> [Accessed 28 June 2026].
- ZANELLA, Tiago Vinicius. The United Nations Convention on the Law of the Sea and the marine environment: a contribution to the analysis of the regulation of the protection and preservation of the marine environment in UNCLOS. *Revista Jurídica Portucalense*. 2024, no. 35, pp. 68-90. ISSN 2183-5705. Available from: [https://doi.org/10.34625/issn.2183-2705\(35\)2024.ic-04](https://doi.org/10.34625/issn.2183-2705(35)2024.ic-04). [Accessed 28 June 2026].
- ZHAO, Pengjun; LI, Yunlin; ZHANG, Caixia; et al. Arctic Sea Route access reshapes global shipping carbon emissions. *Nature Communications*. 2025, vol. 16, art. 8431. ISSN 2041-1723. Available from: <https://doi.org/10.1038/s41467-025-64437-4>. [Accessed 28 June 2026].
- ZIS, Thalís P. V. The enhanced role of canals and route choice due to disruptions in maritime operations. *Maritime Business Review*. 2024, vol. 9, no. 2, pp. 98-112. ISSN 2397-3757. Available from: <https://doi.org/10.1108/MABR-01-2023-0008>. [Accessed 28 June 2026].
- ZUMBRÄGEL, Tobias; KEGEL, Anna. Green tides: the Suez Canal as key hub and green corridor for a hydrogen future between the Middle East and Europe. *Frontiers in Energy Research*. 2025, vol. 13, art. 1538792. ISSN 2296-598X. Available from: <https://doi.org/10.3389/fenrg.2025.1538792>. [Accessed 28 June 2026].

Data de submissão do artigo: 23/02/2026

Data de aprovação do artigo: 28/06/2026

Edição e propriedade:

Universidade Portucalense Cooperativa de Ensino Superior, CRL

Rua Dr. António Bernardino de Almeida, 541 - 4200-072 Porto

Email: upt@upt.pt