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EVALUATING THE EFFECTIVENESS OF THE EU ETS IN REDUCING GREENHOUSE GAS EMISSIONS IN THE SHIPPING SECTOR

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ABSTRACT:

The European Union Emissions Trading System (EU ETS) is designed to reduce greenhouse gas (GHG) emissions by setting a cap on the total emissions allowed from included sectors and allowing companies to buy and sell emission allowances, to meet their compliance obligations. Expanding the EU ETS to cover the maritime shipping sector, already in use from start of 2024, could be an effective tool for reducing GHG emissions in maritime transport. The EU ETS can be an effective mechanism for reducing GHG emissions in the maritime shipping sector, especially when combined with other decarbonization strategies such as technology investment, fuel innovation, and regulatory frameworks. Based on case studies the paper examines the cost aspect of the EU ETS implementation on the various ship types and shipping companies, showing that the success of the newly introduced framework depends on several factors that must be considered. This paper reveals that while the system holds potential, the financial impact on shipping companies varies significantly depending on ship size and route. Additionally, the success of the EU ETS relies on overcoming challenges related to carbon leakage, administrative complexity, and global cooperation.

KEY-WORDS: Decarbonization in maritime shipping, GHG, CO_2 emissions, EU Emission Trading Systems.

1. INTRODUCTION

The concept of emissions trading began to take shape in the United States during the 1970s with the Clean Air Act Amendments. The Environmental Protection Agency (EPA) experimented with emissions trading to control air pollution, which led to the establishment of the US Acid Rain Program under the Clean Air Act Amendments of 1990. This became one of the first large-scale applications of emissions trading in the world at the time. The program is aiming at reducing sulfur dioxide (SO_2) and nitrogen oxides (NOx) emissions from power generation plants1[1].

Building on the success of earlier emissions trading systems, the EU ETS was introduced in 2005 to target greenhouse gas emissions across various sectors, and as of 2024, it includes the maritime shipping sector. On the other hand, the European Union Emissions Trading System (EU ETS), already in place since 2005[2], is a key policy instrument for reducing greenhouse gas (GHG) emissions in the EU, and it has been increasingly considered for the maritime shipping sector as well. The EU ETS is a cap-and-trade system where a cap is set on the total amount of GHG emissions that can be emitted by companies operating in sectors included in the scheme. Companies receive allowances for free (each allowance provides the right to emit 1 ton of CO_2 equivalent green-house gases within a year) or must purchase them via auctions or in secondary market, selling their surplus allowances or purchasing more depending on their annual emissions needs. Over time, the total cap is reduced, leading to lower emissions across the covered sectors.

EU ETS currently covers more than 10,000 industrial and power installations and airline companies operating flights in and between EU airports only, across the 27 EU member states, Iceland, Norway, and Liechtenstein (and there is a link with the Swiss ETS framework)[3].

The objective of the ETS is to reduce GHG emissions from power generation installations and other energy intensive industries by a certain percentage every year (referencing the key scheme variable called the Linear Reduction Factor – LRF, essentially setting the overall cap reduction rate per year)[4]. As of 2013, the annual LRF was set at 1.74% to achieve an overall reduction of GHG emissions in the included sectors of 21% by 2020, compared to 2005 levels.

The central question this paper aims to explore is: Is the EU ETS an effective mechanism for reducing greenhouse gas emissions in the maritime shipping sector[5], and what are the economic implications for different types of shipping companies? This research analyzes the system potential impact and assess its success in reducing maritime emissions.

2. METHODOLOGY

Authors apply a structured approach that combines comprehensive and systematic literature review of the Institutional Framework[6], as it is applied and affects real operating and voyage costs. Primary data retrieved for indicative vessel sizes and routes[7], as monitored via the established and approved MRV procedures for certain shipping companies. Geographical trading areas cover Trans-Atlantic and Trans-Pacific trading routes to EU and from EU countries, to explore all the possible trading routes that EU ETS is applied[8]. This approach allows for an in-depth, contextual exploration of EU ETS implementation in the shipping industry, as limited by the institutional framework.

By exploring real case studies, authors prove that - considering real time costs associated with the EU ETS provisions - different ship types absorb the increased costs in a different way, raising the issue of fair competition between various ship segments. Comparative data analysis among tonnage segments, prove that smaller ships are likely to face greater financial strain under the EU ETS. The cost of compliance, including purchasing

[1] https://www.epa.gov/clean-air-act-overview/1990-clean-air-act-amendment-summary

[2] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC

[3] https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/scope-eu-ets_en

[4] Directive (EU) 2018/410 of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814

[5] Regulation (EU) 2023/957 of the European Parliament and of the Council of 10 May 2023 amending Regulation (EU) 2015/757 in order to provide for the inclusion of maritime transport activities in the EU Emissions Trading System and for the monitoring, reporting and verification of emissions of additional greenhouse gases and emissions from additional ship types

[6] Review of the existing EU and IMO legislative framework

[7] Reference to private shipping operating companies that provided real yet confidential figures from various chartered vessels

[8] Round voyages from / to EU countries as well as intra EU trading

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emissions allowances and implementing emission-reduction measures, could be a higher percentage of operational expenses for smaller vessels. Larger ships, which are generally more fuel-efficient per unit of cargo, may have an easier time absorbing the additional costs.

3. THE EVOLUTION OF EMISSION TRADING SYSTEMS – EU ETS I & EUTS II

Maritime shipping is responsible for approximately 3% of global carbon dioxide (CO_2) emissions, with around 90% of global cargo transported by sea. As the shipping industry is essential for global trade, its emissions contribute significantly to climate change. Given its international nature, regulating emissions in the sector presents unique challenges, making it a key focus for decarbonization strategies under international and regional frameworks like the EU ETS.

Between 2021 and 2030 the LFR was set to decrease at an annual rate of 2.2%. The Linear Reduction Factor was set in 2018 to align with the previous EU targets of cutting all greenhouse gas emissions by at least 40% by 2030 compared with 1990 levels.

Importantly, however, the 2023 reform of the ongoing phase 4 of the EU ETS (2021-2030) introduced more ambitious goals. The new goals target an overall emissions reduction of 62% by 2030, compared to 2005 levels. Therefore, the annual LRF is raised to 4.3% for the 2024-2027 period, and then to 4.4% from 2028 onwards.

This trajectory is envisaged that it will bring the cap to zero by 2039 (this does not account for small batches of allowances for the aviation and maritime sectors). Once the EU decides on a climate target for 2040, it will also set out to further adjust the ETS[9].

In 2023, the EU decided to extend the ETS to the maritime sector, which is responsible for about 3% of global CO_2 emissions, and for transporting around 90% of global cargo volumes. The inclusion of maritime shipping in EU ETS is decided to take place via a phase-in approach (instead of providing a % of free allowances as was the case with other industries in the past) starting in 2024, with full implementation by 2026. The shipping industry will be required to purchase allowances to cover a portion of their emissions from voyages within the European Economic Area (EEA) and half of their emissions from international voyages into and out of the EEA.

This phased approach mirrors the way other sectors, such as aviation and power generation, were gradually integrated into the EU ETS. For instance, the aviation sector was included in the ETS in 2012, but only intra-European flights are currently covered. Lessons learned from the aviation sector's integration can be valuable for the maritime industry, particularly in managing carbon leakage and monitoring emissions across jurisdictions. Similarly, the power sector's experience with emissions trading highlights the importance of adapting to the evolving carbon market and investing in cleaner technologies to remain competitive. The maritime industry may face similar challenges, such as the risk of carbon leakage, where shipping companies reroute activities to non-EU ports to avoid compliance costs, and the high initial costs of implementing cleaner technologies (Christodoulou et al., 2021).

In mid-2021, the European climate law came into force. It set a binding target of a net greenhouse gas emissions reduction (emissions after deduction of removals) by at least 55% by 2030 compared to 1990 levels.

To achieve this new ambitious goal, the EU presented its "Fit for 55"[10] package of new rules and legislative proposals in July 2021 – including a renewal of the EU ETS.

After negotiations, the European Parliament, member state governments in the EU Council, and the Commission reached a deal in December 2022 to reform the existing ETS I and introduce a second system for transport and heating fuels, namely ETS II. The final acts were signed in the middle of 2023.

The key changes that increase the uncertainty regarding the decarbonization targets, technologies and impact, are summarized below:

- Amended 2030 target for ETS emissions is -62% (previously -43%) compared to 2005 levels.

[9] https://www.cleanenergywire.org/factsheets/understanding-european-unions-emissions-trading-system

[10] European Commission, Communication on 'Fit for 55': delivering the EU's 2030 climate target on the way to climate neutrality, COM/2021/550 final

- New Linear Reduction Factor of 4.3% from 2024 to 2027 and 4.4% from 2028 to 2030.
- Member States should spend the entirety of their emissions trading revenues on climate-related activities.
- Maritime Shipping emissions are to be included within the scope of the EU ETS. While the emissions for ships arriving from outside the EU or departing to a port outside the union will only be covered by half (50%), any emissions from intra-EU maritime transport are fully covered under the ETS (100%). The EU agreed on a gradual phase-in of obligations for shipping companies to surrender allowances: 40% for verified emissions for 2024, 70% for 2025, and 100% for 2026 onwards. Currently, only offshore vessels of 5,000 gross tons and above will be included in the scheme, but there are discussions to lower this threshold going forward.
- **Free allocations and CBAM:** The rules for companies receiving free emission allowances will change, phasing these out step by step for products that fall under the Carbon Border Adjustment Mechanism (CBAM) by 2034. These product categories include for example cement, steel, and fertilizers (2026: 2.5%, 2027: 5%, 2028: 10%, 2029: 22.5%, 2030: 48.5%, 2031: 61%, 2032: 73.5%, 2033: 86%, and 2034: 100%). From 2026, free allocation of emission allowances should be conditional on investments in techniques to increase energy efficiency and reduce emissions.
- In the Aviation sector, currently, the EU ETS applies only for intra-European flights. The EU decided to phase out the free allocation of allowances to aircraft operators and to move to full auctioning of allowances by 2026 to create a stronger price signal. In addition, the so-called non-CO_2 effects of aviation will be included in the ETS I from 2025, initially through monitoring and later probably also with the obligation to surrender allowances. To deal with extra-European flights to and from third countries, the global Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) will be integrated into the ETS.
- Emissions from burning waste are to be monitored from 2024 onwards and likely included in the ETS from 2028 (member states can push this to 2030).
- **Market Stability Reserve reform:** 24% of all ETS allowances will continue to be placed in the Market Stability Reserve – MSR. This mechanism is intended to reduce the historical surplus of allowances available in the market, and on the other hand, enables the EU ETS I to be more flexible to future supply and demand shocks. Based on the total number of allowances in circulation, the MSR mechanism removes allowances from the market or distributes them by adjusting the auction volumes in subsequent years[11].

4. FACTORS THAT AFFECT THE EFFECTIVENESS OF THE EU ETS FOR THE SHIPPING MARKET

The inclusion of the maritime shipping sector in the EU ETS is a step towards combating GHG emissions. It offers market-based incentives to reduce emissions and promotes innovation. However, its overall effectiveness will depend on how it is implemented, the cooperation of global shipping actors, and how it interacts with other policy measures (like fuel standards or port regulations). To achieve concrete decarbonization in the shipping sector, the EU ETS will likely need to be complemented by other regulatory or technological initiatives.

The effectiveness of the EU ETS for the shipping industry has become a matter of ongoing debate and depends on several factors, such as:

- **Incentives for Emission Reductions:** By putting a price on emissions, the ETS encourages shipping companies to adopt more efficient technologies, use cleaner fuels (like LNG or biofuels), or reduce operational inefficiencies. This could accelerate the sector's shift towards decarbonization.
- **Cap on Emissions:** The ETS sets a limit on emissions that decrease over time, helping ensure that absolute reductions are achieved. This regulatory framework provides certainty to companies and investors about the future direction of climate policy.

[11] https://www.cleanenergywire.org/factsheets/understanding-european-unions-emissions-trading-system

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- **Scope and Global nature of Shipping:** The shipping industry is inherently global, with ships frequently operating outside the EU's jurisdiction. This could create loopholes, where companies reroute shipping to avoid EU waters or emissions monitoring. Since only voyages within or into the EEA are covered, the system leaves much of global shipping emissions unchecked.

- **Expanding on Solutions to Carbon Leakage and Administrative Complexity:** To address the risk of carbon leakage, where companies may reroute shipping activities to avoid EU waters and regulations, a potential solution lies in fostering international collaboration. The EU could work more closely with other major shipping nations and regions to harmonize emissions trading schemes or introduce a global carbon pricing mechanism for shipping. For example, aligning the EU ETS with the International Maritime Organization (IMO) decarbonization efforts could create a more comprehensive, global system that reduces the incentive for companies to avoid compliance by rerouting vessels (Lagouvardou et al., 2022). Additionally, strengthening the monitoring, reporting, and verification (MRV) framework through digital solutions such as blockchain and artificial intelligence could reduce administrative burdens while ensuring accurate tracking of emissions across global routes. This would simplify comply with shipping companies and ensure a more transparent, tamper-proof reporting process.

- **Potential Mitigation Strategies:** Another approach to mitigating carbon leakage is to introduce incentives or rewards for shipping companies that go beyond compliance, such as offering reduced fees or faster port clearance for ships that adopt green technologies or alternative fuels. Moreover, introducing transitional financial support, such as subsidies or tax incentives, for smaller shipping companies or developing regions could ensure that compliance with the EU ETS does not disproportionately burden certain players in the market, thereby avoiding unfair competitive disadvantages. Global initiatives, like the proposed Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which is designed to tackle aviation emissions, may serve as a model for similar initiatives in the shipping sector. A harmonized or global emissions trading system would make it harder for companies to exploit regional regulatory differences, creating a more level playing field internationally.

- **Risk of Carbon Leakage:** If the EU ETS makes shipping within the EEA more expensive, companies might shift their activities to non-EU ports, leading to "carbon leakage" where emissions are not reduced but simply moved outside the EU.

- **Administrative Complexity:** Monitoring, reporting, and verifying emissions from ships, especially across multiple jurisdictions, could be administratively burdensome and costly for both regulators and shipping companies.

- **Limited Immediate Impact on Fuel Prices:** The ETS price signal might not be strong enough in the short term to make more expensive zero-carbon fuels (e.g., hydrogen, ammonia) competitive with conventional fuels like heavy fuel oil. This means that while the ETS may incentivize incremental efficiency improvements, it might not lead to a rapid transition to zero-emission fuels without additional policy measures.

- **Revenue Generation for Innovation:** The auctioning of allowances generates revenue that can be reinvested into green technologies, including sustainable shipping solutions and alternative fuels like LNG, methanol, or ammonia. In 2023, the EU ETS generated a total of 43.6 billion euros in auction revenue. For instance, the revenues generated from EU ETS auctions are being reinvested into the EU Innovation Fund, which supports the development and deployment of cutting-edge low-carbon technologies. In the maritime sector, this has resulted in projects focused on alternative fuels, such as hydrogen and ammonia, which have the potential to significantly reduce the industry carbon footprint. A notable example is the Horizon 2020-funded project 'HySHIP,' which is building a demonstration vessel powered by liquid hydrogen, intended to showcase the feasibility of zero-emission shipping.

Additionally, some of the revenue has been used to support port infrastructure upgrades that accommodate alternative fuel bunkering, enabling ships to refuel with cleaner energy sources like liquefied natural gas (LNG). Ports in Rotterdam and Hamburg, for example, have already begun investing in LNG bunkering facilities, reducing the carbon intensity of shipping operations.

Beyond fuel innovations, part of the revenue is also allocated to initiatives aimed at improving vessel efficiency, such as retrofitting older ships with more efficient engines and propulsion systems. This reinvestment strategy helps shipping companies, particularly smaller operators, reduce compliance costs by giving them access to newer technologies that lower emissions and improve fuel efficiency.

Looking ahead, auction revenues are expected to play a pivotal role in accelerating research into next-generation maritime technologies, such as carbon capture and storage (CCS) systems on vessels and autonomous, fully electric ships. These investments not only support the decarbonization of the shipping sector but also create opportunities for economic growth by positioning the EU as a global leader in maritime innovation.

To illustrate these points, case studies from early adopters of EU ETS regulations in shipping provide valuable insights. For example, Maersk has introduced an "Emission Surcharge" for voyages subject to the EU ETS to cover the costs of emissions allowances, but also offers customers "eco delivery" options, using greener fuels to minimize emissions for specific bookings. This adjustment is designed to help them meet stricter environmental regulations while controlling operational costs. Hapag-Lloyd has similarly incorporated emissions surcharges, adjusting pricing based on emissions-related costs. Similarly, Vale, which operates a fleet of bulkers, has begun investing in energy-efficient technologies and exploring alternative fuels like LNG to meet the regulatory requirements (Ajsa Habibic, Offshore Energy, 2022).

On the Rotterdam–Tubarao route, initial estimates suggest that the cost of compliance with the EU ETS will add approximately 5-15% to the overall cost of transporting dry bulk cargo, depending on the price of emission allowances. Larger vessels, such as Capesize ships, are better positioned to absorb these additional costs due to economies of scale, while smaller ships, such as Supramax vessels, may face more significant economic burdens (Bernacki. D 2021). Similarly, based on the real costs the authors examined in the paper, in a scenario where the price of EU emission allowances (EUAs) reaches €80-100 per tonne, the cost of compliance per tonne of cargo transported on these vessels is projected to range from €1.40 to €1.80, depending on the ship size and the phase-in level of emissions covered.

5. CASE STUDY: THE IMPACT OF EU ETS ON THE OPERATIONAL COSTS OF VARIOUS SEGMENTS

In the below comparative table[12], the authors depict the total cost evolution for each chosen round voyage and dry cargo vessel type, but also the EU ETS compliance cost per tonne of cargo for different EUA price levels, for all current and future phase-in eligible emissions levels.

[12] Tubarao in Brazil is a major loading port region for Iron Ore but also other dry bulk commodity cargoes, serviced depending on commodity category by Capesize (~180k dwt), Kamsarmax (~82k dwt) and Supramax (~54k dwt, geared) dry bulk vessels).
Round Voyage: vessel ballasts from Rotterdam to Tubarao, load in Tubarao, transport laden to Rotterdam, discharge to Rotterdam and deliver to owner again in Rotterdam.

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Table 1: The Cost of emissions for the round trip Tubarao – Rotterdam (several segments)

Rotterdam to Tubarao Round Voyage (NL->BR->NL)									
	2024 40% Emissions			2025 70% Emissions			2026 100% Emissions		
EUA Price (EUR)	69.55	80	100	69.55	80	100	69.55	80	100
	Total costs (USD. EUR/USD = 1.1)								
Capesize	68,997	79,364	99,205	120,745	138,887	173,609	172,493	198,411	248,013
Kamsarmax	37,682	43,344	54,180	65,944	75,852	94,815	94,205	108,360	135,450
Supramax	30,982	35,637	44,547	54,219	62,365	77,957	77,456	89,094	111,367
	As % of Cargo (per t)								
Capesize	0.43	0.49	0.61	0.75	0.86	1.07	1.06	1.22	1.53
Kamsarmax	0.51	0.58	0.73	0.89	1.02	1.28	1.27	1.46	1.82
Supramax	0.54	0.62	0.78	0.95	1.09	1.36	1.36	1.56	1.95

Source: data based on the round trip Tubarao - Rotterdam, as compiled by Authors

As one can see from table 1, in the very moderate scenario of a price of EUAs between 80 and 100 EUR in the future, and after the full phase-in of the scheme in the year 2026, the cost per tonne of cargo transported for EU ETS compliance, will range from 1.40 to 1.80 USD, which for the specific route chosen, it is anything between 5-15% of the per tonne of cargo transportation cost. This is a significant and inelastic increase in all cases, being around 2 to 3 times higher than the current expected EUA cost under the 40% - 2024 emissions phase.

As is obvious from the economies of scale in shipping, the larger vessels (Capesize vessels in this example) will deliver a lower per tonne of cargo EU ETS compliance cost at all times, but the flexibility and choice of vessel type, have much more to do with vessel availability, general freight levels, port restrictions and other operational parameters, and less to do with the cost of EU ETS compliance per tonne of cargo, at least for now.

While larger vessels benefit from economies of scale, smaller shipping companies, particularly those operating Supramax and Kamsarmax vessels, face greater financial pressure from the EU ETS compliance costs. These smaller companies are often less able to absorb the costs associated with purchasing allowances or investing in new, energy-efficient technologies, making them more vulnerable to rising operational expenses. For instance, a small shipping company with a limited fleet may see the cost of compliance rise by 10-20% of its operating budget, significantly affecting its profitability.

The increased cost of compliance is likely to trickle down through the supply chain, ultimately impacting the cost of goods for consumers. In the dry bulk market, for example, higher shipping costs driven by the EU ETS could lead to increased prices for essential commodities such as iron ore, coal, and agricultural products. This is especially critical for routes heavily dependent on shipping, like those between Europe and developing countries, where such price increases could have broader economic implications, potentially affecting trade balances and consumer prices globally.

Furthermore, large multinational shipping companies with diversified fleets and access to more capital may be better equipped to manage these increased costs by passing them on to customers or investing in cleaner technologies. In contrast, smaller companies may struggle to remain competitive unless they receive financial support or incentives to make necessary adjustments. This raises concerns about market consolidation, where smaller players could be forced out of business, leading to reduced competition and higher costs across the board.

6. CONCLUSION

With regards to the EU ETS framework, which is by far the most extensive and far-reaching for the Maritime industry, simply put, compliance is another cost item in the value chain that must be appropriately monitored, calculated and assigned to market participants cost list.

The maritime industry despite some initial friction and uncertainty with regards to implementation, seems to have been very efficient in adopting the necessary technical parts of the regulation, as well as effectively operating to fully comply with the regulation.

At a micro level, the industry seems to have almost entirely decided to pass the cost down the value ladder to the final consumer of the goods transported, even though the regulation essentially points to the EU compliance entity, the ship registered owner.

BIMCO clauses and market practice via data exchange on verified emissions essentially monitor, calculate and verify the appropriate cost items that must be transferred across the value chain.

At the shipowner level, the EU ETS, already essentially initiated via the MRV regulation, is a regulatory and operational burden, with data collection and management a key part of the process. The operational burden is required not only to comply with the regulation, but also to efficiently pass through the final cost to the end user of the transportation service.

While the EU ETS provides a framework for reducing greenhouse gas emissions in the maritime sector, its long-term success depends on several key policy adjustments. Firstly, to ensure that carbon leakage does not undermine the effectiveness of the system, the EU could work towards greater international cooperation, particularly with non-EU shipping nations, to create a more harmonized global carbon pricing mechanism. Additionally, incentives for the early adoption of alternative fuels and low-carbon technologies should be expanded, especially for smaller shipping companies that may face financial challenges during the transition period.

Policymakers should also consider creating more flexible mechanisms for addressing the unique challenges of global shipping, such as including more international routes and emissions within the ETS scope. This would prevent companies from rerouting to avoid compliance and encourage broader decarbonization across the industry.

Given that most shipping companies have already familiarized themselves with the adoption of new regulations and the increased need to monitor reporting and verification of data systems, the future is probably less demanding from an operational point of view. The picture is, however, different with regards to the future costs of compliance, but also the additional operating costs that forthcoming regulatory frameworks like FuelEU Maritime will necessitate.

Further research is needed to explore the long-term economic impacts of the EU ETS on different segments of the shipping industry, particularly smaller operators and companies based outside the EU. Investigating the effectiveness of specific alternative fuels, such as hydrogen or ammonia, in the context of large-scale maritime operations will also be crucial for determining the most viable pathways for the industry decarbonization. Additionally, research into the potential for integrating carbon capture and storage technologies on ships could open new avenues for reducing maritime emissions.

By addressing these policy and research gaps, the EU ETS can evolve into an even more effective tool for decarbonizing the global shipping industry, ensuring that it aligns with the broader goals of reducing global emissions and mitigating climate change.

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