

Sustainable Future Ports And Maritime Logistics: Main Trends And Long Term Challenges

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Abstract

This paper provides an overarching analysis of the key elements of the future ports and maritime logistics, particularly from sustainability perspective. This is followed by a discussion of current, emerging and potential strategies, covering main trends and long term challenges to realize more sustainable practices, the different interest groups involved and also the importance and changing nature of ports and maritime logistics regulation. Research inductive and deductive methods are used in order to express the main scientific aspects of sustainability of future ports and maritime logistics.

Keywords: Sustainable ports, green port, future port, maritime logistics, long term challenges.

Introduction

There are new green technologies and low- or zero-carbon alternatives to fossil fuels and energy-intensive terminal infrastructure, while ports' definitions of "sustainable" operations vary. International maritime and shipping consortia are bringing supply chain participants together globally to collaborate on lowering energy use and carbon emissions [4], [26], [22].

In ports and maritime transportation, some of the most important sustainable efforts are currently under progress [27], [7], [29]: electricity-powered, Low- and zero-emission fuels, Intermodal, and Digitalization. The five major goals of green havens are to: foster inclusive and sustainable growth, create centres for international commerce and investment, support an equitable transition to a net-zero economy, and promote regeneration and job creation.

The article will analyze future ports and maritime logistics main long-term challenges and directions regards the sustainable future ports.

Main methods: there has been used theoretic approach and synthesis of the scientific literature as well as deductive analysis of case studies of international, mainly European ports. Induction method has been used for formulating research outcomes and main findings.

The incorporation of eco-friendly practices into port operations, management, and activities is the definition of "sustainability" for ports. In other words, sustainably: Each development minimizes its negative effects and contributes to the advancement of measures and controls for the quality of the air, water, noise, and waste.

The Ports of the Future are dedicated to environmental protection while generating income for both the present and the future. In order to achieve this, development strategies and plans will place port sustainability above "systems and policies." This may be the most crucial action ports can take to build a more sustainable business and provide the groundwork for future growth [12], [9]. Future ports can be realized through sustainable planning that includes the five essential components of efficient port operation, environmental conservation, human factor, radiant future planning, and port communities [7], [5]. Because the majority of ports and terminals are situated close to cities, seaports are one of the leading sources of environmental pollution worldwide. Since 1996, the EcoPorts project and the European Shipping and Ports Organization (ESPO) have continuously tracked the top environmental goals of European port authorities. The framework for policies and activities for a sustainable future might be helped by identifying the most important environmental concerns in the EU.

Research Methodology

Reviews of the available literature are intended to summarize, assess, and pinpoint prospective research holes that might indicate knowledge gaps [21]. According to scholars [15], an organized approach should be used to scan resources, create a mind map to organize a literature review, write a study, and assemble a bibliography. An iterative cycle of selecting pertinent search terms, conducting literature searches, and finishing the analysis is used to accomplish structured literature reviews [17]. Through the four processes of material collection, descriptive analysis, category selection, and material evaluation, Seuring and Gold [19] provide content analysis as a useful technique for carrying out an organized and transparent examination of the literature.

A deductive and inductive methodology will be used to analyze data and thoroughly evaluate the field in order to identify the most influential research, pinpoint current areas of current research interest, and offer insight into current research interests and directions for future research in this area. This methodology is inspired by the work of [15] and [19]. The format of the document is similar to a theoretical concept paper.

Contemporary Ports and Their Economic Performance Review

Nowadays, ports handle more than only cargo at the wharves. Their sources of rivalry and the breadth of their impact reach far into the hinterland and over the ocean. Stakeholders at numerous levels and in many different areas, from local to global and from business to government, have an impact on their management and operational strategies [3]. The function of ports in global transportation networks can have an impact on their social and environmental performance. While many ports just follow the local, regional, or national environmental laws and regulations, in many instances they have made use of their capacity to address social and environmental externalities.

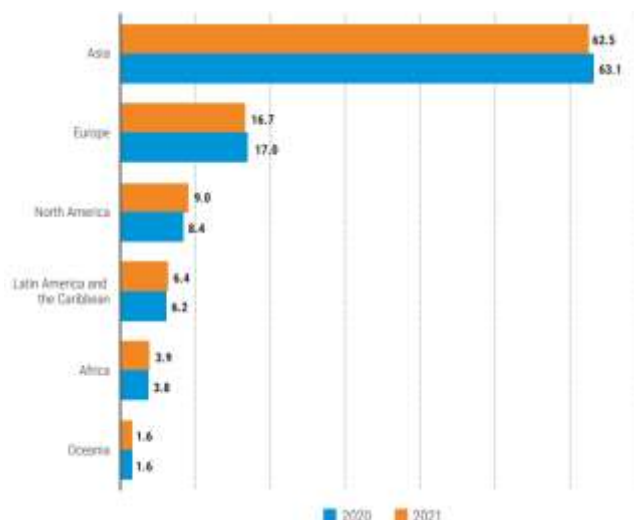
Global container port traffic climbed 6.8% in 2021 to a total tonnage of 857 million TEUs, according to Drewry Maritime Research [23] (Figure 1). With 62.5% of the world's container port capacity located in Asian ports, Asia continues to hold a dominant position (see Figure 1).

Figure 1. Global container port throughput by region, 2020–2021 (millions of 20-foot units and annual percentage change)

	20-foot equivalent units		Annual percentage change 2020–2021
	2020	2021	
Asia	506	535	6%
Europe	136	143	5%
North America	67	77	14%
Latin America and the Caribbean	49	55	11%
Africa	30	33	10%
Oceania	13	14	8%
World total	802	857	7%

Asia is home to nine of the top ten largest ports in the world by capacity, with Shanghai, Singapore, and Ningbo-Zhoushan leading the way (see Figure 2). Additionally, North America's port throughput increased quickly by 14.4%. The capacity of container ports in Europe rose by 5%. While Antwerp's volume growth stagnated due to terminals' struggles with schedule interruptions, Rotterdam recorded a 7.7% increase in volume. African ports experienced strong growth of 9.5%, and ports in Australia and New Zealand experienced similarly strong growth of 7.7%. The amount of cargo passing through container ports in Latin America and the Caribbean increased by 10.5%.

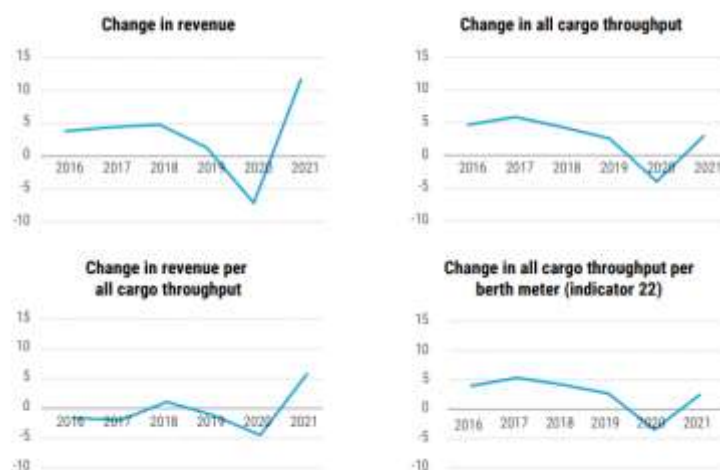
Figure 2. Global container port throughput by region (in 20-foot units), 2020–2021, percentage of total volume



Source: [14]

Cargo throughput increased by four to six percent annually during the pre-pandemic period. Prior to its recovery in 2021, the industry saw a steep drop brought on in part by the epidemic and some capacity growth. The pandemic decimated the entire world's cruise fleet in March 2020, with dire repercussions for cruise lines, their staffs, and management groups. But over the course of its more than 50-year existence, the cruise industry has proven to be very resilient (see Figure 3), and by the end of 2023, it is anticipated to reach 2019 levels.

Figure 3. Revenue and transshipments 2016-2021 (mean year-on-year percentage change across all ports)



Source: [14]

The health of the local population is negatively impacted by ship emissions, especially those of SO_x, NO_x, and PM, which are of growing concern. Cold pressing techniques, the use of LNG, and lowering ship speeds in ports are the key solutions to the issue of emissions from ships in ports [3]. The use of LNG aboard incoming ships and in the port area is another appealing possibility for decreasing emissions, similar to its use on the high seas [20].

Although the actual emissions from port operations make up a lesser fraction of overall emissions, they can still be reduced using a variety of techniques. However, in general, very few ports really measure their emissions. Wilmsmeier and Spengler [28] looked studied ways to improve energy efficiency through the use of energy management systems, more up-to-date handling facilities, and alternative port and terminal fees. Other scholars [1] have talked about ports using energy demand management techniques and producing their own clean energy on-site (e.g., wind turbines, solar panels, thermal power plants), and they have demonstrated that ports do not always regard electricity creation as such. Being an external energy source, controlling supply and demand can save costs and have a positive impact on the environment.

Players in the maritime supply chain are attempting to be more sustainable and responding to new trends. Shippers are requesting longer contracts or switching to alternate modes of transportation like rail and the air as costs climb. Additionally, ports and shipping corporations are growing their fleets and expanding the services they provide, such as air freight, last-mile transportation, and e-commerce. To gain more control over the supply chain, shipping giants are buying up logistics, e-commerce, and transportation firms. They are also making a name for themselves in the hinterland, connecting with clients, and providing integrated door-to-door logistics. For air transportation, Maersk and CMA CGM have purchased a fleet of aircraft. By implementing end-to-end logistics and engaging in international mergers and acquisitions, ports are also attempting to gain more control over supply chains. UNCTAD on capacity building and resilience of ports [22] recommends five actions:

I. Determining the dangers posed by a variety of anthropogenic and natural disturbances unique to a certain port.

By identifying port-specific threats, risk exposure levels, and potential repercussions of the threat, you may II. assess vulnerabilities and potential impacts.

III. Create mitigation and reaction plans for port management and operational procedures as well as port infrastructure. These actions could be proactive and geared toward prevention, or they could be reactive, adaptive, and geared at quickening recovery.

IV. Set priorities for appropriate responses and corrective measures, such as: B. cost-benefit analyses and the distribution of financial, human, and other resources.

V. Putting intervention and mitigation measures into action. The evaluation procedure should then determine how effective they were and make any required adjustments.

Sustainable Future Ports Concept and Main Trends for Development

The concept of "sustainability" at ports refers to the incorporation of ecologically friendly port operations, management, and practices. In other words, sustainably: each intervention minimizes its negative effects and helps to increase the monitoring and management of the quality of the air, water, noise, and waste.

Ports of the Future works to be environmentally friendly and guarantee the welfare of both present and future generations. In order to achieve this, development strategies and plans beyond "systems and policies" will be based on sustainable port development. This could be the most significant move ports take toward becoming more sustainably run businesses and laying the groundwork for expansion in the future. The future port approach can be realized by sustainable planning that addresses the five crucial areas of intelligent port operations, environmental protection, human considerations, sound future planning, and port communities.

Sustainability plans should be dynamic in nature and therefore reviewed annually to ensure that ports are updated with new industry trends and new technologies [23], [29], [13], [14]:

1. Adaptation to new marine economic models and evolving global value chains. Agencies that are more accustomed to operating in silos must significantly alter their organizational structures in order to coordinate digital solutions. For instance, there are frequently discrepancies between the administrative needs of customs clearance and the speed and flexibility requirements of the shipping and logistics industries. Governments should make sure that laws and rules governing land and maritime transportation are up to date and commensurate with current requirements.
2. Digital solutions. According to the ESCAP study on paperless cross-border trade, full implementation of digital trade facilitation measures outside of the TFA of the WTO could lower average trade costs in the region by more than 13%, which is seven percentage points less than would be anticipated from the WTO's implementation of the TFA measures. [8].

Organizational structures and port operations are evolving as a result of digitalization and data interchange. Multiple Port Community Systems

(PCS) are the result of this. All port or airport systems are connected via an electronic platform called APCS. It is a social system that various organizations and agencies have jointly developed, structured, and shared. To construct a port, PCS can optionally connect agencies across different ports.

The intelligent technology of Community has made it possible for data and information to flow across the trade facilitation ecosystem, allowing traders to organize, plan, and get rid of potential bottlenecks. Whether at the national or regional level, government authorities should have a clear and coordinated approach to trade facilitation measures and offer relevant, visible, and transparent processes through trade portals and universal government helpdesks. The government might collaborate with marine indices and regional cargo observatories at the regional level to gather information, track key performance metrics, and enhance the transparency of cargo transiting through ports. For instance, connection with the hinterland was hampered in East Africa as a result of pandemic-related restrictions and controls. In response, the East African Community developed a trade portal based on the methodical approach of UNCTAD and released COVID-19 principles to enable traders to prepare for to meet border crossing requirements [23]. In the maritime sector, governments and the maritime industry are closely interdependent, so reforms must be based on collaboration between the public and private sectors.

The potential for port authorities to contribute to the transformation of our ports into sustainable profiles is tremendous, particularly in Europe. Many of them play several functions, including those of regional managers, property owners, actors in the supply chain, administrators, local regulators, developers and managers of the infrastructure, operators, etc. Social companions. The position of Port Sustainability Manager (PSM) might be specified within the port authority's organizational structure in the future's sustainable ports. Coordination of the future vision with stakeholders, port spatial planning, planning for the expansion of port infrastructure, cooperative strategic planning of the hinterland with rival ports, and creation of an adaptive port perspective master plan should be the main priorities. The PMS could be someone who oversees environmental protection for the port or as the head of the port's environmental protection department.

Key Trends for Maritime Logistics

Four fundamental ideas—harmonization, standardization, simplification, and transparency—underlie the facilitation of product commerce (see Figure 4). Supply chain delays can be reduced by applying these ideas to ports and inland transportation systems, especially in developing nations where ports have constrained capacity. The majority of the advantages can be found in emerging [2] and low-income nations, where trade expenses can be cut by 14%.

Figure 4. Four principles of trade facilitation



Source: [24]

Real-time data tracking solutions for cargo give traders transparency, predictability, and security while ensuring regulatory compliance with customs laws. In multimodal land transportation, where delays worsen port congestion, traders and border guards can eliminate bottlenecks by having quick access to information. Particularly at danger are landlocked nations whose transport routes need passing through ports and one or more frontiers. The creation of an electronic version of the Transport International Router (TIR) brochure is a recent development. By enabling real-time data interchange for multimodal shipping and advancing knowledge about commodities, this speeds up trade operations at ports.

The maritime and commercial industry has seen numerous setbacks and now needs to adjust to more structural changes, especially those brought on by climate change. A new norm that incorporates low greenhouse gas emissions, renewable energy, more sustainable supply chains, digitization, and data-driven business models must be adopted throughout the sector. Additionally, it must adapt to changing consumer demand and consumption patterns as well as, when necessary, to operational and business environments that are more fragmented, localized, or regional.

1. Energy transition and decarbonization

The amount of post-pandemic recovery money spent to cut greenhouse gas emissions was only approximately 6%. The current conflict in Ukraine and its effects may push decarbonization farther lower on the list of priorities. In fact, switching from natural gas to coal or reducing the use of biofuels could result in an increase in greenhouse gas emissions [13]. Fossil fuels account for about 40% of shipping. The need for maritime transportation will therefore change, as will the types and sizes of ships, as well as the fuels used by ports and ships [12]–[14]. Along with the ports that accommodate large ships, maritime transport patterns and networks also need to be reformed. Best versus

lowest cost decisions and national security issues influence supply chains.

The pandemic in 2020 started a movement against globalization. Global value chains (GVCs) have responded to disturbances as a result, as seen by shifting market shares in GVC areas [16]. But the epidemic has brought to light the just-in-time model's flaws, which have also been put to the test by other disruptors including earthquakes, floods, canal bottlenecks, trade conflicts, and trade restrictions.

Companies looking to improve the resilience, integrity, and continuity of their supply chains are debating whether to reshoring, offshore, outsourcing, proximity, or extend the same support and end management to the end of the supply chain in order to bring production locally or closer to home [18].

2. New consumption patterns as e-commerce becomes more widespread

The pandemic has sped up shifts in consumer tastes and behavior, leading to an increase in internet purchases of consumer products, frequently done in containers. The percentage of global retail sales made up 15% in 2019 but climbed to 21% in 2021 [14]. Changes in procurement models, port and warehouse operations, as well as changes in the entire logistics sector and supply chain participants, are all being influenced by these trends. The fields of smart ports, predictive analytics, port connectivity optimization, and end-to-end visibility and communication are equally relevant for IT and digital solution providers.

3. Digitalization

Trade and maritime transportation must adjust to the growing role of technology. For instance, digital purchases will increase trade, despite the fact that other technologies, like automation, may lessen the need for manufacturing and international trade flows or have inconsistent results. Additionally, it's critical to close the global digital gap. At the beginning of the pandemic, the majority of developing nations lacked adequate internet infrastructure, making it challenging for them to slow the economic collapse.

Many of them continue to experience poor business logistics, low utilization, and connectivity rates. Entrepreneurs who are comfortable using digital payments frequently lack these abilities or confidence [12], [14], and [26]. Poor nations often have little financial options to support new businesses and small- and medium-sized enterprises.

4. Develop resilience

Companies are now diversifying their operations by incorporating risk management and readiness into their operations to distribute risk and decrease susceptibility to disruption to their main business. They must pursue "sustainability by design" and move past pressing issues and

quick fixes [21], [25]. In order to uncover fresh opportunities and business models, this calls for strategic thinking. Long-term sustainability standards must be incorporated into the planning and frameworks of supply chains and the underlying transportation and logistical networks [26]. Resilience should be seen as a continuing strategy and process for ports, for instance, that may be adopted gradually and tailored to the unique infrastructure, economic, and management contexts of each port.

These disruptions have reignited the debate about the future of globalization and the continued relevance of the efficient supply chain model in the face of self-sufficiency and national security.

Key Sustainable Initiatives in Ports and Maritime Logistics

Based on a Port Technology Team's major observations on what constitutes a green port [27], the main motivating factors for the future sustainable port are identified.

A major aspect in lowering emissions may be expanding power activities in ports. Many ports are thinking about investing in shore power, which would enable docking vessels to link to generator sets located within the port complex, lessening the need to use generators and saving fuel. A major aspect in lowering emissions may be expanding power activities in ports. Many ports are thinking about investing in shore power so they may "connect" docked vessels to the generator sets situated in the port complex, decreasing the need to use generators and saving fuel.

As ports work to cut carbon emissions, electrified cranes for zero-emission yard equipment cranes will become more prevalent. Stakeholders in the port community are funding electrification more and more.

Fuels with little or no emissions. Low and zero-emission fuels can affect ports in a number of ways, including boat fuels made from renewable sources, cargo handling machinery, and business models for storage, generation, and transport. Green hydrogen is created by renewable electrolysis and has no pollution. Fossil fuels are used to create blue hydrogen, but the carbon emissions are carefully absorbed and stored. In ports, hydrogen is being developed for cargo handling machinery and, conceivably, hydrogen-powered ships in the future. Greater supply chain participants are also putting money into hydrogen to cut emissions.

The demand for liquefied natural gas (LNG) fuel for use in ships is rising on a global scale. LNG significantly lowers the amount of greenhouse gases (GHG) released into the atmosphere and cuts nitrogen oxides by 85%. In the near future, LNG bunkering at the port might be utilized for completely carbon-neutral LNG versions, such as liquid biogas produced from organic waste or liquid synthetic methane produced from green hydrogen and collected CO₂. Methanol manufacturing, ammonia bunkering, and biofuels for vessels are further renewable fuel sources.

Contrary to fossil fuel-powered trucks operating in terminal yards, intermodal freight train transportation of goods offers a low-carbon answer for the supply chain. The Port of Valencia is investing heavily in multimodal transportation while cutting its carbon emissions by 30% between 2008 and 2019 despite continuing to expand cargo throughput. Stakeholders are increasingly choosing to transport goods by inland rail freight; in early September 2021, shipping line MSC unveiled a new direct railway connection linking Ludwigshafen, Germany, and Trieste, Italy. The Lehrte MegaHub, which connects Kiel to Verona in northern Italy, started providing extra intermodal cargo services during the same week.

In order to reduce port carbon consumption, many in the business have emphasized investing in intermodal freight solutions rather than transportation.

The Georgia Ports Authority (GPA) claims that as e-commerce compels importers and exporters to move their supply chains closer to target consumers, intermodal trade is becoming more and more significant to U.S. container ports. Ports that understand their carbon footprint and know how to cut energy consumption for all port stakeholders can experience transformational improvements as a result of digitalization and digital investments. Honeywell's Enacto Carbon and Energy Management data visualization system, which tracks and evaluates each user's resource usage as well as the numerous energy consumption sensors and indicators at the port, has been implemented in the Port of Esbjerg's facilities.

Similar to this, the Port Authority of Valencia (PAV) has set up two environmental monitoring booths that measure noise and air quality in real time and alert port managers to potential hotspots for emissions.

Long Term Environmental Concerns of the European Ports

Due to the fact that the majority of ports and terminals are situated close to urban areas, seaports have one of the greatest global environmental impacts. The prevalence of environmental issues at sea, including emissions, is greater than in ports, and numerous research on shipping-related emissions have been published recently.

Since 1996, the European port authorities' top environmental concerns have been routinely monitored in Europe by the European Maritime Transport and Ports Organization (ESPO) and the EcoPorts program. The framework for policies and activities for a sustainable future can be helped by identifying high-priority environmental challenges in the EU.

ESPO has made the decision to start publishing an annual environmental report on the European port sector in 2016. This is done in an effort to further increase the transparency and accountability of the European port industry and to improve the connections of ports with local communities. The EcoPorts initiative, the foremost green port initiative

in Europe, includes the ESPO environmental report [6]. For decision-makers and stakeholders, including local communities, civil society, researchers, and business, the study provides qualitative data on the environmental performance of ports and acts as a resource. 97 ports took part in the report in 2022.

Figure. Top 10 environmental priorities of European ports for 2020 and 2022



Source: [6]

The research also mentions that ports' environmental management will continue to advance in 2022, enabling them to better satisfy their top priority than in the past. However, the ranking of these top priorities for the environment remained the same as it was in 2020.

The "green" development of seaports, with a focus on environmental preservation and energy efficiency, is the subject of European Union Directives. The terms "sustainable development" and "green" are interconnected, as stated in the EU Ports and Maritime Transport Directives. European ports serve as gateways and link Europe's transport corridors to the rest of the globe, making them essential to the continent's economy. 74% of commodities entering or leaving Europe are transported by sea. Additionally, ports are crucial for facilitating the internal market's flow of products and services as well as for tying remote and island regions to the rest of Europe. The European Commission announced a plan in 2013 to enhance 329 important seaports' port operations and add new transportation links.

Following are a number of legislative and non-legislative actions [19]–[24], [26], [28]:

- Regulation (EU) 2017/352, which establishes standards for the financial transparency of ports and a framework for the delivery of port services.
- Implementation and updating of state aid regulations within the framework of competition policy.
- Encourage and support social discussion among dock workers in Europe and their training.
- Encourage better port infrastructure design, funding, and finance, as well as its connection to the trans-European network.
- Programs that encourage the sharing of best practices in order to improve the port environment. In order to encourage innovation in ports and linkages between port towns, the Commission established the Horizon 2020 "Port of the Future" call in 2016.

Policymakers must handle several fronts and keep in mind long-term objectives [14] while addressing the urgent issues of war and pandemics, such as increasing maritime trade and enabling resilient and sustainable transport networks.

1. *Control the COVID-19 pandemic and lessen its effects*, especially in developing nations, by enhancing access to immunizations, diagnostics, and treatment. Make sure that additional limitations and lockdowns don't harm their economy.
2. *Strengthening the macroeconomic framework* – encouraging economic expansion by use of liberal financial rules. Reduce financial vulnerabilities, manage inflation, lessen the impact of shocks on society's most vulnerable groups, coordinate international debt relief, and assist the most vulnerable by minimizing food insecurity and lowering poverty rates.
3. *Ensure smooth trade* – Abstain from export and import restrictions. Import demand may rise during a crisis, and exports may help to maintain stability. maintain access to funding and contract enforcement while facilitating commerce and streamlining procedures. promoting trade within global and regional frameworks, with a particular emphasis on the Regional Comprehensive Economic Partnership (RCEP) [29].
4. *Help transform the maritime industry* – Support the digitization and acceleration of decarbonization and energy transition projects in business while assuring readiness and sustainability. To ensure a level playing field, keep an eye on trends in industrial assets and services. Maintain the industry's value creation and reach expansion without damaging smaller companies, such as shippers in emerging nations.
5. *Collaborate multilaterally* – Promote coordinated and multilateral approaches and solutions. Prevent fragmentation in the face of

geopolitical threats. Coordinate actions to address the climate crisis and enable the transition to low-emission development. Multilateral cooperation is also necessary to quickly end the war in Ukraine.

6. *Build Resilience* – By approaching sustainability holistically and proactively from the beginning. Aid developing nations in creating more dependable logistics and transportation networks, especially the most vulnerable. Accelerate their digitalization upgrade in particular to harness e-commerce's potential and assure smart maritime logistics.
7. *Reconfiguring supply chains*: striking a balance between security, autonomy, autonomy, and resilience on the one hand, and efficiency and cost on the other.

All of these tactics are concerned with minimizing environmental pollution, which is a means of combating climate change. However, adaptation that considers effects like sea level rise and current storm surges should be taken into account [3]. According to researchers [11], the assets of significant coastal cities that are vulnerable to climate change were valued at \$3 trillion in 2005 and are projected to increase to \$35 trillion, or 9% of global GDP, by 2070. In recent years, research on port climate change adaptation has grown significantly [10].

To develop future port concepts, numerous thematic projects, platforms, and worldwide efforts are in operation. They mainly explore approaches to facilitate the transition of EU ports to a low-carbon and sustainability-focused economy.

The port of the future, which is understood to be in the near future (2030), will be defined, for instance, by DocksTheFuture (DTF), an initiative of the European Commission. This port will have to overcome challenges such as streamlining and digitalizing processes, deepening, reducing emissions, transforming, electrification, smart grids, city-port interface, and use of renewable energy management. Project's Purpose The following aspects are intended to be covered by the research and innovation activities:

- Multimodal procedures that are flexible, cost-effective, and optimized in the terminal and the larger port area.
- Durable upkeep, restoration, and reconfiguration.
- Better performance management while saving money and space.
- Low environmental impact, adaptation and mitigation to climate change, and the move to a circular economy.
- Highly effective links and integration in urban, industrial, and socioeconomic situations

- Efficient connections with the internal transport network, contributing to greater use of the most energy efficient modes of transport, in particular railways.

Conclusion

For both politics and business, mitigating and adapting to global climate change are essential concerns. Seaports and other vital transportation infrastructure must be swiftly and successfully adapted to climate change in vulnerable developing nations. However for developing nations, securing sufficient and reasonable financing for infrastructure adaptation continues to be a significant difficulty.

To enhance both the supply and demand of alternative fuels and develop a low-emission fleet, public-private initiatives involving ports, shipping corporations, and various marine supply chain actors were launched in recent years. This would transform the low-carbon shipping market's competitive environment, but it might also lead to a two-tier port system where few would be prepared to adopt alternative energy sources. It will therefore be important to help ports in developing countries adopt best practices and take advantage of the opportunities presented by the energy transition.

Governments, ports, and logistics hubs can improve efficiency, draw investors, and open up new opportunities through a successful digital trade facilitation ecosystem. Governments, ports, and businesses must collaborate closely in order to do this, and the following steps are advised.

Many nations have made efforts to lessen vulnerabilities by encouraging local delivery of marine and associated services, altering laws and incentives to bolster national registries, and enhancing the adaptability of their sabotage systems. However, retaining top-notch neighborhood services at affordable rates also calls for upgrading the marine industry as a whole and making investments in port efficiency, workforce training, and infrastructure.

The need to plan for and manage significant dangers from a variety of hazards is especially necessary for vulnerable nations that largely rely on maritime transport networks and access to international markets. By making investments in risk management and crisis response, they must safeguard ports and larger maritime supply chains in order to build durable and resilient marine transport systems.

Ports and maritime systems must gather data and information and develop scenarios to anticipate, plan for, cope with, foresee, and anticipate uncertainties. They also require emergency procedures to lessen the effects, guarantee recuperation, and enable them to adjust to the tactical adjustments anticipated in the "new normal".

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